ENG.20071016.0005

QA: QA

000-3DR-MGR0-00100-000-007

October 2007

Project Design Criteria Document

Prepared for:
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Office of Repository Development
1551 Hillshire Drive
Las Vegas, Nevada 89134-6321

Prepared by:
Bechtel SAIC Company, LLC
1180 Town Center Drive
Las Vegas, Nevada 89144

Under Contract Number
DE-AC28-01RW12101

BSC	1. Project Design Criteria Document **Coversheet** Complete only applicable items.	2. QA: QA Page iii of 2780 DSR 10/15/07
3. DI: 000-3DR-MGR0-00100-000 Project Design Criteria Document		4. Rev 007

5. REVIEWS AND APPROVAL			
Printed Name	Title	Signature	Date
5a. Preparer: David Rhodes	System Engineering Discipline Engineering Manager	[signature]	10-15-07
5b. Concurrence: Richard Foster	Manager of Discipline Engineering	[signature]	10/15/07 DSR 10/15/07
5c. Concurrence: N/A	Project Engineering Manger	N/A	N/A
5d. Approval: Barbara Rusinko	Engineering Manager	[signature]	10/15/07

6. Remarks:

Coordination review of this document as defined in EG-PRO-3DP-G04B-00001, *Design Criteria*, Section 3.3, documents individual discipline and Project concurrence in accordance with EG-PRO-3DP-G04T-00913, *Review of Engineering Documents*.

BSC	1. Project Design Criteria Document **Change History** Complete only applicable items.	2. QA: QA Page iv of 27~~1~~0
3. DI: 000-3DR-MGR0-00100-000-007 Project Design Criteria Document		
7. Revision No:	8. Description of Change:	
000	Initial issue. An impact review per AP-2.14Q, *Review of Technical Products and Data*, is not required because this is the initial issue of the Project Design Criteria Document.	
001	The entire Project Design Criteria document is being revised (per Section 5.6 (2) of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria*) to incorporate additional design criteria, codes and standards, etc., that have been identified since the issuance of Revision 0. Changes from the previous issuance are not uniquely identified with change lines because the entire document has been revised. All revised sections are within the scope of preliminary design efforts necessary to support the license application. An impact review per AP-2.14Q, *Revision of Technical Products and Data*, was not performed because the providers of inputs and checkers of the Project Design Criteria Document, Revision 1, are from the same discipline organizations and comprised of personnel who would have participated in the AP-2.14Q review of the document (Section 5.3 of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria*), including those from a different discipline or functional organization. Any organization potentially affected by the Project Design Criteria Document is included in the checking and review process and this checking and review process essentially included aspects of an impact review per AP-2.14Q. An interdisciplinary review per Section 5.3.2 of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria*, was not performed because the disciplines/organizations (that are outside the Repository Design Project organization) providing the input were included as part of the discipline checking and review performed in accordance with Section 5.3.1of LP-3.25Q-BSC, Rev.1, ICN 2, *Design Criteria.* ES&H and Public Address organizations, which are external to Repository Design Project, were included in Block #5 as Checkers but were not included in Block #7 as Engineering Group Supervisors/Discipline Lead Engineer.	
002	The Project Design Criteria Document is being updated to include design criteria that have been revised to conform to the evolving design. Sections 4, 5, and 6 have extensive changes which include changes to codes and standards lists, editorial changes including re-numbering of sections, re-numbering other criteria, updating the references wherever appropriate. Section 1 has minor changes to reflect the current state of the design. Section 7 has extensive changes to update the documents and codes and standards that have been updated or deleted from the previous revision. Appendix A has been revised to provide an updated licensing position on the regulatory guides listed. Specifically, changes occurring in the following pages: 1-3, 5-7, 9-11, 13-358 and all of Appendices A and B.	
003	This revision of the Project Design Criteria is focused on aligning information in the Project Design Criteria with the License Application Safety Analysis Report. Updated information has been included in various sections as marked by the change bar. - Sections 5.2.1, 5.5.1, and 5.7.1 were revised to correct the version of ASME NQA-1-2000 (DIRS 159544) that defines the requirements for cleaning and packaging, shipping, storage, and handling of items (Condition Report 3366). - The source for track layout information in Section 4.2.1.3.3 and thermal goals in 6.3 is being tracked by TBV (Condition Report 3507). - References to Regulatory Guide 8.8 were added (Condition Report 2582). This is a complete revision. Change bars indicate the changes and all pages are affected in this complete revision.	
004	This revision addresses technical direction for Design and Engineering in "Contract No. DE-AC28-01RW1201 – Response to Contracting Officer Authorization Letter No. 05-001, Improvements and Refinements in the Technical Bases that Support the Safety Analysis Report (SAR)" (Mitchell 2005 [DIRS 173265]), which includes the aging system, first-of-a-kind important to safety equipment, waste package transporter, waste package emplacement gantry, remediation, throughput models, fire protection in moderator control areas, and thermal management (waste package and drift loading plans) and changes to codes and standards. Commercial spent nuclear fuel in air will be addressed in a later revision. Additionally, minor corrections were made to content. Sections 4.9.1.1 and 4.9.1.5 were revised to correct the version of ANSI/ANS-6.1.1 to 1977 in response to Condition Report Action Number 4306-002. Section 4.6.4.29 was modified to provide rationale for the requirement for instrumentation grade air to be oil free in response to Condition Report 5175. This is a complete revision. Change bars in the margin indicate the changes and pages iii-v, 1-3, 5-7, 9-11, 13, 15-18, 20-55, 60-100, 102-122, 124-126, 128-158, 161-166, 172-191, 193-194, 199, 201-204, 206-218, 220-260, 262-329, 330-349, 351, 353-360, 361, 363-387, 389-395, A-3, A-5-A-24, A-26-A-32, A-34-A-46, B-3 are affected in this revision.	
005	This revision is required to ensure alignment of the PDC with recently revised system description documents, facility description documents, and the safety analysis report. Changes are also made to add additional regulatory documents that apply. Section 4.8.4.5 was added to identify criteria regarding Management of Loose Radioactive materials to address issues associated with Condition Report 5929. Organizational responsibilities have also been updated.	
006	The entire Project Design Criteria document is being revised to incorporate additional design criteria, codes and standards, etc., that have been identified since the issuance of Revision 5.	

BSC	1. Project Design Criteria Document **Change History** Complete only applicable items.	2. QA: QA Page v of 270
3. DI: 000-3DR-MGR0-00100-000-007 Project Design Criteria Document		
7. Revision No:	8. Description of Change:	
	Section 7.0, *Preclosure Safety Analysis Criteria*, has been added to this revision of the Project Design Criteria document. The resolutions to Criteria/Basis Change Notices 000-3DR-MGR0-00100-000-005-CBCN001 through CBCN012 was incorporated into this revision of the Project Design Criteria document.	
007	This revision is a major re-write. No annotations of changes are used. The Project Design Criteria document was revised to incorporate CBCN-001 thru CBCN-017 and the addition of Regulatory Guidance Agreements (RGAs) that are applicable to the repository design. Deleted Appendix A and Appendix B of the PDC (Sections 9 and 10 respectively) since they were replace by the (RGAs). Approximately 100 RGAs were incorporated in the applicable sections of the PDC. Made editorial and other non-technical corrections. References were updated to later revision as necessary. The following Criteria/Basis Change Notices were incorporated into this revision of the PDC: 000-3DR-MGR0-00100-000-000-CBCN001 - Added heliport location design criteria in Section 4.2.5. 000-3DR-MGR0-00100-000-000-CBCN002 - Added design criteria for clearances and setback for security purposes in Section 4.2.1.5. 000-3DR-MGR0-00100-000-000-CBCN003 - Revised wording of Section 4.9.5 to correctly address water well criteria. 000-3DR-MGR0-00100-000-000-CBCN004 - Revised Section 1.7 to incorporate IEEE/ASTM SI-10-2002 in response to Condition Report (CR) action 6657-005. 000-3DR-MGR0-00100-000-000-CBCN005 - Revised Sections 5.2, 5.5, and 5.7 to incorporate ASME NQA-1-2004 as the latest version of the QA requirement to supplement the QMD. Although the CBCN requires incorporation of ASME NQA-1-2004, BSC has elected to utilize the ASME NQA-1-2000 version. 000-3DR-MGR0-00100-000-000-CBCN006 - Revised Section 6.1.10.2.3 in response to CR 9975. The necessary wording from NUREG-0800 is now included in the criteria. Other document changes for CR 9975 are not included in this CBCN. 000-3DR-MGR0-00100-000-000-CBCN007 - Revised PDC Section 6.1.10.1.1 in response to Condition Report (CR) 9623. This CBCN incorporates 800-IED-MGR0-00701-000-00A in Section 6.1.10.1.1, and by inclusion incorporates the associated DTN. 000-3DR-MGR0-00100-000-000-CBCN008 - Revised Sections 4.2.13.5, 6.1.1, 6.1.3, 6.1.6, and 6.1.7 in response to Condition Report (CR) 9623. This CBCN incorporates 100-IED-WHS0-00201-000-00A and 800-IED-MGR0-00505-000-00A in the affected sections of the PDC, and by inclusion incorporates the associated DTN. 000-3DR-MGR0-00100-000-000-CBCN009 - Revised Section 4.3.3.1 in response to Condition Report (CR) action 9877-001. Corrected typographical error for switchyard voltage from 13.8 kV to 138 kV 000-3DR-MGR0-00100-000-000-CBCN010 - Revised PDC to incorporate TMRB-2004-051. Section 4.10.3.7 was revised to include the radiation classification zone chart. 000-3DR-MGR0-00100-000-000-CBCN011 - Replaced Sections 4.2.11.5.3 and 4.2.13.2.4 reference to ANSI/AISC 2005 [DIRS 176320] with the previously referenced ANSI/AISC 1989 [DIRS 159157]. 000-3DR-MGR0-00100-000-000-CBCN012 - Revised PDC Section 4.6.2.6.2 and added new criteria (Section 4.6.2.4.6) in response to Condition Report (CR) 10376. 000-3DR-MGR0-00100-000-000-CBCN013 - Added ASME NUM-1-2004 [DIRS 180437] code for jib crane in Section 4.8.1.2.4. 000-3DR-MGR0-00100-000-000-CBCN014 - Incorporate Regulatory Guidance Agreement (RGA) REG-CRW-RG-000010, Agreement for Regulatory Guide 1.12, Rev. 0 into the Sections 4.6.1.13 and 4.6.3.4. 000-3DR-MGR0-00100-000-000-CBCN015 - Revised PDC Sections 5.1.1 and 5.1.2 to include by reference the Waste Package Component Methodology Report, 000-30R-WIS0-00100-000-002, in response to CR action 10202-001. 000-3DR-MGR0-00100-000-000-CBCN016 - Revised Sections 4.2.12, 4.2.13, 4.9.1, 4.10.2, and 4.12.2 in response to Condition Reports (CRs) 10501, 10514, 10685, and 10688. 000-3DR-MGR0-00100-000-000-CBCN017 - Revised Sections 4.2.11, 4.2.12, 4.3.7, 4.6.1, and 4.9.2 to incorporate the Emergency Response Facilities (ERF) functions as provided in Regulatory Guidance Agreement REG-CRW-RG-000455, *Agreement for NUREG-0696, Functional Criteria for Emergency Response Facilities – Final Report*.	

INTENTIONALLY LEFT BLANK

Contents

1 Introduction

1.1 Purpose and Scope

The *Project Design Criteria Document* (PDC) provides the design criteria necessary to support the development of preliminary and detailed design for all repository structures, systems, and components (SSCs). The PDC satisfies requirement 3.2.1.K of the *Civilian Radioactive Waste Management System Requirements Document (CRD)*, DOE/RW-0406 [DIRS 176715] as flowed down through requirement 3.1.1.R of the *Monitored Geologic Repository Systems Requirements Document* (MGR-RD), YMP/CM-0026 (DOE 2006 [DIRS 177491]), which requires that all repository SSCs be designed in accordance with applicable industry codes, standards, engineering principles, and practices.

The PDC identifies the appropriate codes and standards for all repository SSCs, including those that are associated with safety categories (items important to safety [ITS] and important to waste isolation [ITWI]) as determined from the 000-3DR-MGR0-00300-000-001, *Basis of Design for the TAD Canister-Based Repository Design Concept* (BOD) (BSC 2007 [DIRS 182131]). As the design evolves, the PDC will be revised in accordance with the evolving design and safety categories for repository systems as provided in changes to the BOD. The BOD classifications will not be repeated or referenced in this document. As the design evolves, application of specific sections of these codes and standards for particular applications will be determined during the design process and used in the development of design products.

The PDC is organized along traditional discipline lines and comprised of sections that contain general design criteria or generic discipline design criteria, design load combinations, design acceptance limits, design load cases, site conditions, and applicable codes, standards, and regulations for each discipline in Engineering.

The PDC provides constraints to the design in the form of applicable codes, standards, and regulatory guidance positions. The *Requirements Management Program*, RQ-DIR-10*,* Figure 1, Section 4.1 provides an explanation of the requirements management program flowdown.

1.2 Regulatory Guidance Document Applicability

The U.S. Nuclear Regulatory Commission (NRC) requires, in 10 CFR 63.21(c)(2), *Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada* [DIRS 180319], that the safety analysis report (SAR) include information relative to codes and standards that the U.S. Department of Energy (DOE) proposes to apply to the design and construction of the geologic repository operations area (GROA). This document provides the information relative to codes and standards for inclusion of reference in the SAR for the repository.

Design engineers will use the codes, standards, regulatory guides, and technical reports stated in this document. Changes to those documents used herein will be addressed, as necessary, in future revisions during the design process and will be approved by the Engineering Manager. This document will provide the code of record for the identified NRC regulated activities and repository facilities and systems.

NRC regulatory guidance documents, such as regulatory guides, interim staff guidance, and technical reports (NUREGs), provide guidance to licensees and applicants on implementing specific parts of the NRC regulations, techniques used by the NRC staff in evaluating specific problems or postulated accidents, and data needed by the staff in its review of applications for permits or licenses.

The selection of regulatory guides, interim staff guidance, and NUREGs, previously provided in Appendix A, was based on applicability to support the development of design products. Appendix A has been deleted and the documentation of the rationale for selecting the guidance documents are co-located with the criterion in the body of the PDC. A formal screening of a majority of the regulatory guidance documents has been conducted in accordance with licensing procedure LS-PRO-3005, *Regulatory Guidance Agreements* (RGAs). Additional screening will eventually address the remaining documents with RGAs as well as updating the initial screening of regulatory positions as design progresses.

Many regulatory guides are written for other NRC licensed activities, but very few have been specifically written for Yucca Mountain. Some regulatory guides, codes, and standards have been identified in the *Yucca Mountain Review Plan Final Report*, NUREG-1804 (NRC 2003 [DIRS 163274]). The RGA agreement for NUREG 1804, REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]), was "Adopted with Clarification". Even though the RGA did not identify Engineering as being impacted, NUREG-1804 is referred to throughout the PDC. The RGA will be revised to add Engineering as an impacted organization.

Any of the referenced documents that are not being used for repository design were previously detailed in Appendix B. Since the RGAs identify the applicability of the regulatory guides, codes, and standards, Appendix B has been deleted. Only those regulatory guides, codes, and standards that are identified as applicable are included in the PDC. The RGAs are located in the associated rationale statement.

1.3 U.S. Department Of Energy Directives Applicability

DOE HQ O 250.1-1998, *Civilian Radioactive Waste Management Facilities -- Exemption from Departmental Directives* (DOE 1998 [DIRS 159140]), provides for the exemption of Office of Civilian Radioactive Waste Management (OCRWM) facilities from certain DOE directives. The exemption applies to DOE directives that overlap or duplicate requirements of the NRC regarding radiation protection, nuclear safety (ITS and ITWI) for the Yucca Mountain Project (YMP), including quality assurance, safeguards and security of nuclear material in the design, construction, operation, and decommissioning of radioactive waste (OCRWM) facilities. Exemptions apply to requirements in directives that overlap or duplicate NRC requirements and ensure the precedence of NRC requirements.

OCRWM facilities include structures, equipment, systems, processes, or activities associated with the acceptance, transportation, storage, and disposal of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) pursuant to the Nuclear Waste Policy Act of 1982 [DIRS 101681] and NRC regulations, where applicable. Examples include interim storage structures and technologies, repository facility structures, and waste acceptance and transportation activities.

Exemptions do not apply to requirements for which the NRC defers to the DOE or does not exercise regulatory jurisdiction. DOE directives that provide criteria applicable to the non-nuclear portion of the repository facility will be addressed per the Bechtel SAIC Company, LLC (BSC) contract.

Applicable DOE guidance documents (Guide, Handbooks, and Standards) are used in sections of the PDC.

1.4 National Codes And Standards Applicability

DOE O 252.1, *Technical Standards Program* [DIRS 159139], requires the use of voluntary consensus standards by the DOE in a manner consistent with National Technology Transfer and Advancement Act of 1995, Public Law 104-113, 110 Stat. 775 [DIRS 159251], and OMB Circular No. A-119, *Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities* [DIRS 159250].

Consensus standards are the product of a standards developing organization operating with openness, balance of interests, due process, an appeals process, and a consensus that represents general agreement but not necessarily unanimity.

The integration of national codes and standards into the NRC regulatory process is achieved through:

(a) incorporating codes and standards by reference in regulations
(b) endorsing codes and standards in regulatory guides as acceptable methods for implementing regulation
(c) referencing of codes and standards as a technical basis in standard review plans, technical specifications, generic communications, and inspection manuals.

Although (a) is the prime example of a mandatory requirement, (b) and (c) are the primary mechanisms for allowing voluntary use of consensus standards by licensees.

Regulation 10 CFR 63 does not provide prescriptive design criteria; instead it allows the DOE to develop design criteria and demonstrate their appropriateness. Therefore, the DOE has flexibility to use any codes, standards, and methodologies it demonstrates to be applicable and appropriate in the repository design.

When codes or standards are in conflict with each other, the specific issue will be presented to the appropriate manager for resolution. The design authority can authorize interim changes in the PDC for use until the next revision.

1.5 Quality Assurance

The PDC is written in accordance with EG-PRO-3DP-G04B-00001, *Design Criteria*, and is subject to the requirements of *Quality Management Directive* (QMD) QA-DIR-10 (BSC 2007 [DIRS 180474]).

1.6 Safety Classifications

Safety classifications for SSCs are documented in the 000-3DR-MGR0-00300-000-001, *Basis of Design for the TAD Canister-Based Repository Design Concept* (BOD) (BSC 2007 [DIRS 182131]). The BOD classifications will not be repeated or referenced in this document.

1.7 Units of Measure

Units of measure to be used in the design, fabrication, construction, testing, and operation of the procured items for the repository shall be in English units in accordance with IEEE Std 260.1-2004, *IEEE Standard Letter Symbols for Units of Measurement (SI units, Customary Inch-Pound Units, and Certain Other Units)* [DIRS 176341]. This includes surface facilities, subsurface facilities, waste packages, and other SSCs. Units of measurement that are currently stated in this document as metric units may remain as such, and converted to English units, as necessary. All conversions of metric units to English units shall utilize Annexes A and B of IEEE/ASTM SI-10-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System* [DIRS 177651], (factors and rules, respectively). Supporting calculations or analyses, such as those for waste packages, may be performed in SI units but the design output must be performed in English units.

Values should be rounded to an equal or greater number of significant figures as the value to be converted using standard procedures. Therefore, conversion factors are not the limit on accuracy in the calculation. Converted values should be rounded to the same number of significant figures as the original quoted value. In the cases where only two significant figures are given in the source, only two significant figures should be provided. In such a case, it may appear as though there is a significant arithmetic error in the conversion. However, if only two significant figures are given in the source, one must assume that is the extent of known or desired accuracy. The authors have no license or reason to expand the number of significant figures to something greater than that given in the source.

Although standards identified don't explicitly state so, they address the English Units. English units consist of both the U.S. Customary Units and the Imperial Units. Differences are included for some weight, fluid, and distance measures. Although both sets are acceptable, U. S. Customary Units should be utilized.

[MGR-RD (DOE 2006 [DIRS 177491] Requirement 3.1.1.AC references the Policy Statement, Lake H. Barrett, September 13, 2001, "Units of Measure to be Used in Design, Fabrication, Construction, Component Testing, and Operation of Procured Items for a Repository", (Barrett 2001 [DIRS 156051]). IEEE Std 260.1-2004 , provides information from the industry. Condition Report (CR) 6557 prompted addition of the conversion factors and rules of IEEE/ASTM SI-10-2002, as they do not exist in IEEE Std 260.1-2004. Waste Acceptance System Requirements Document (WASRD), DOE/RW-0351 (DOE 2007 [DIRS 169992]), Appendix E provides the guidance on limiting conversion values to the same number of significant digits. The "Contracting Officer Guidance for Implementation of Policy Statement; Contract No. DE-AC08-01RW12101; Letter No. 02-046", (Hamilton-Ray 2002 [DIRS 160836]) provided the clarification for supporting documents. CBCN004 to Rev 6 provided most of the changes to the text.]

INTENTIONALLY LEFT BLANK

2 Acronyms And Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AAR	Association of American Railroads
AC	alternating current
ACGIH	American Conference of Governmental Industrial Hygienists
ACI	American Concrete Institute
AIChE	American Institute of Chemical Engineers
AISC	American Institute of Steel Construction
ALARA	as low as is reasonably achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
ARI	Air Conditioning and Refrigeration Institute
ARM	area radiation monitor
ASCE	American Society of Civil Engineers
ASD	allowable stress design
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATHENEA	a technique for human event analysis
AWG	American Wire Gauge
AWS	American Welding Society
BDBGM	beyond design basis ground motion
BEI	biological exposure indices
BHEP	basic human error probability
BOD	*Basis of Design for the TAD Canister-Based Repository Design Concept*
BOP	Balance of Plant
BSC	Bechtel SAIC Company, LLC
BTU	British thermal unit
CAM	continuous air monitor
CAS	central alarm station
CCC	central control center
CCCF	Central Control Center Facility
CCF	common cause failure
CCTV	closed circuit television
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CMAA	Crane Manufacturers Association of America
CRCF	Canister Receipt and Closure Facility
CRD	Civilian Radioactive Waste Management System Requirements Document
CSNF	commercial spent nuclear fuel
CTM	canister transfer machine
DBGM	design basis ground motion
DC	direct current
DCMIS	digital control and management information system
DIRS	Document Input Reference System
DOE	U.S. Department of Energy
DPM	disintegrations per minute
DTN	data tracking number
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EOC	Emergency Operations Center
EOF	Emergency Operations Facility
EPA	U.S. Environmental Protection Agency
ERF	Emergency Response Facility
ES&H	Environmental, Safety and Health

FAA	Federal Aviation Administration
FEP	features, event, and processes
FNMC	fundamental nuclear material control
FTA	fault tree analysis
GROA	Geologic Repository Operations Area
HEPA	high-efficiency particulate air
HFE	human failure event
HLW	high-level radioactive waste
HVAC	heating, ventilation, and air-conditioning
HRA	human reliability analysis
HMI	human-machine interface
I&C	instrumentation and control
IBC	International Building Code
ICA	Item Control Area
ICC	International Code Council
ICEA	Insulated Cable Engineers Association
IED	Information Exchange Document
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IHF	Initial Handling Facility
IICD	Integrated Interface Control Documents
ISFSI	independent spent fuel storage installation
ISA	Instrumentation, Systems, and Automation Society
ISG	Interim Staff Guidance
ITS	important to safety
ITWI	important to waste isolation
LA	license application
LAN	local area network
LEED	Leadership in Energy and Environmental Design (U.S. Green Building Council)
LLW	low-level radioactive waste
LPS	lightning protection system
LRFD	load-resistance factor design
LWR	light water reactor
M&O	Management and Operating Contractor
MGR-RD	Monitored Geologic Repository System Requirements Document
MPEG	Motion Picture Experts Group
MSHA	Federal Mine Safety and Health Administration
NAC	Nevada Administrative Code
NDL	nuclear data link
NDOT	Nevada Department of Transportation
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NOG	nuclear overhead gantry
NPH	Natural Phenomena Hazard
NSF	National Sanitation Foundation
NRC	U.S. Nuclear Regulatory Commission
NUM	nuclear underhung monorail
NUREG	NRC technical report designation
OCRWM	Office of Civilian Radioactive Waste Management
ORD	Office of Repository Development
OSC	Operational Support Center

OSHA	Occupational Safety and Health Administration
PAA	project accumulation area
PAS	primary alarm station
PCSA	preclosure safety analysis
PDC	Project Design Criteria (Document)
PPE	personal protective equipment
PRA	probabilistic risk assessment
PSF	performance shaping factors
PVC	polyvinyl chloride
QA	quality assurance
QMD	Quality Management Directive
R	Reaffirmed
RCRA	Resource Conservation and Recovery Act
RF	Receipt Facility
RFI	radio frequency interference
RGA	Regulatory Guidance Agreement
RRM	radiation/radiological monitoring
RTD	resistance temperature detector
RWP	radiation work permit
SAA	satellite accumulation area
SAE	Society of Automotive Engineers
SAPHIRE	System Analysis Programs for Hands-on Integrated Reliability Evaluations
SAR	Safety Analysis Report
SAS	secondary alarm station
SFPO	Spent Fuel Project Office
SNF	spent nuclear fuel
SNL	Sandia National Labs
SNM	special nuclear material
SPDS	safety parameter display system
SONET	Synchronous Optical Network
SRP	standard review plans
SRSS	square root of the sum of the squares
SSCs	structures, systems, and components
SSE	safe shutdown earthquake
STC	sound transmission class
TAD	transportation, aging, and disposal
TEDE	total effective dose equivalent
TEV	transport and emplacement vehicle
THERP	technique for human error rate prediction
TLV	threshold limit value
TNT	trinitrotoluene
TSC	Technical Support Center
TSPA	Total System Performance Assessment
UL	Underwriters Laboratory (Inc)
UPS	uninterruptible power supply
VAC	volts of alternating current
VDC	volts of direct current
WHF	Wet Handling Facility
WP	waste package
WSMO	Weather Service Meteorological Observatory

YMP	Yucca Mountain Project
YMRP	Yucca Mountain Review Plan

3 Definitions

3.1 Design-Specifications, drawings, criteria, and performance requirements. Also, the results of deliberate planning (e.g., feasibility studies), analysis (e.g., hazard and risk assessment, performance assessment), mathematical manipulation (e.g., sensitivity studies), and design processes (e.g., independent design review).

3.2 Design Bases (10 CFR 63.2 *ENERGY: Disposal of High-Level Radioactive Waste in a Geologic Repository at Yucca Mountain, Nevada* [DIRS 180319])-Means that information that identifies specific functions to be performed by an SSC of a facility and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be constraints derived from generally accepted "state-of-the-art" practices for achieving functional goals or requirements derived from analysis (based on calculation or experiments) of the effects of a postulated event under which an SSC must meet its functional goals. The values for controlling parameters for external events include:

1. Estimates of severe natural events to be used for deriving design bases that will be based on consideration of historical data on the associated parameters, physical data, or analysis of upper limits of the physical processes involved; and
2. Estimates of severe external human-induced events to be used for deriving design bases that will be based on the analysis of human activity in the region, taking into account the site characteristics and risks associated with the event.

3.3 Design Criteria-Standards, codes, laws, regulations, general discipline design criteria, and derived criteria from analysis of event sequences and hazards that shall be used as a basis for acceptance of design for SSCs to satisfy requirements.

3.4 Design Input-The criteria, parameters, bases, or other design requirements upon which design output documents are based.

3.5 Design Output-Drawings, specifications, and other design documents prepared to present the design configuration(s) of SSCs that is supported by design inputs.

3.6 Design Requirement-Engineering technical requirements determined by design processes that define, for example, the functions, capabilities, capacities, physical size, configurations, dimensions, performance parameters, limits, and setpoints, and are developed and specified by the design authority for SSCs to satisfy the mission design input requirements. Detail design requirements are the result (often iterative) of the design processes.

3.7 Design Verification-Documented, traceable measures (e.g., design review, alternate calculation, and qualification testing) applied to a design package or technical output by qualified individuals or groups other than those who performed the original design work. These measures verify the technical validity, adequacy, and completeness of a design package or technical output in context with the total design, natural or engineered barrier system, or integrated technical work.

3.8 Geologic Repository Operations Area (GROA) (10 CFR 63.2 [DIRS 180319])-Means a high-level radioactive waste (HLW) facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

3.9 Important to Safety (10 CFR 63.2 [DIRS 180319])-With reference to SSCs, means those engineered features of the GROA whose function is:

(1) to provide reasonable assurance that high-level waste can be received, handled, packaged, stored, emplaced, and retrieved without exceeding the requirements of 10 CFR 63.111(b)(1) for Category 1 event sequences or

(2) to prevent or mitigate Category 2 event sequences that could result in radiological exposures exceeding the values specified at 10 CFR 63.111(b)(2) to any individual located on or beyond any point on the boundary of the site.

3.10 Important to Waste Isolation (10 CFR 63.2 [DIRS 180319])-With reference to design of the engineered barrier system and characterization of natural barriers, means those engineered and natural barriers whose function is to provide a reasonable expectation that high-level waste can be disposed without exceeding the requirements of 10 CFR 63.113(b) and (c).

3.11 Mission/Regulatory Requirements-Input design demands requested by the owner or client (or imposed by statute or regulation) that identify and define design requirements for performance; functional, operational, and maintenance characteristics; or parameters that the facility SSCs are to be designed to satisfy.

3.12 Postclosure-The period of time after permanent closure of the repository system.

3.13 Preclosure-The period of time prior to permanent closure of the repository system.

3.14 Preclosure Safety Analysis (PCSA) (10 CFR 63.2 [DIRS 180319])-Means a systematic examination of the site; the design; and the potential hazards, initiating events, and event sequences and their consequences (e.g., radiological exposures to workers and the public). The analysis identifies SSCs ITS.

4 Facility Design Criteria

4.1 General Design Criteria

4.1.1 Facilities Requiring Sanitation Services

All manned facilities requiring sanitation services shall be designed to meet the requirements of 29 CFR 1910.141, *Labor: Occupational Safety and Health Standards, Sanitation* [DIRS 177507]. Water supplies for potable water and non-potable water used for sanitary services, toilet facilities, lavatories, showers, change rooms, and clothes drying facilities shall be designed to meet the requirements of 29 CFR 1910.141.

[29 CFR 1910.141 [DIRS 177507].]

4.1.2 Potential Explosives Storage Facilities

If a decision is made to utilize any repository facilities for the storage of explosives, these facilities that provide for storage of explosives shall conform to the applicable portions of the DOE explosives safety design requirements of DOE M 440.1-1, *DOE Explosives Safety Manual* [DIRS 158761] Contractor Requirements Document (Attachment 2).

[DOE O 420.1A, Facility Safety [DIRS 159450], Contractor Requirement 4.1.2 referred to the manual (without a version) and 10 CFR 851.27(b)(10) [DIRS 182868] refer to DOE M 440.1-1A-2006. Although the repository facilities are not currently planned to handle explosives, the final locations or methods of storing explosives has not been determined. Although DOE O 420.1A, Section 4.1 also applies to ammunitions, the manual specifically does not apply to the storage of limited quantities of protective force ammunitions. Therefore, the security facilities for protective force personnel do not have to comply with the manual. Also see Criteria 4.2.10.3 for specific discipline criteria.]

4.1.3 Energy Conservation

4.1.3.1 Building Design Requirement

The repository building design shall meet the goal of minimizing energy consumption per gross square foot of facilities or gross square foot per unit for industrial and laboratory facilities. To meet the goals, the design shall comply with the applicable requirements of 10 CFR 433.4 and 10 CFR 433.5, Energy: *Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High Rise Residential Buildings* [DIRS 181833]. Compliance with this code shall be identified and justified in the implementing documents.

[Although this criterion previously referenced 10 CFR 434, it has been replaced by 10 CFR 433. 10 CFR 433 is being mandated for buildings to be designed and constructed after January 2007 and 10 CFR 434 is for buildings designed and constructed prior to January 2007. 10 CFR 434 is subsequently a general and historical citation and does not require reference, therefore, the DIRS and reference are removed from this document. This criterion also satisfies 64 FR 30851, Greening the Government Through Efficient Energy Management, Executive Order 13123 [DIRS 104026], Sections 202 and 203. Although the executive order provides specific reduction goals, nuclear safety takes precedence over energy conservation and is, therefore, not specifically applied. Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information.]

4.1.3.2 Energy Standards and Outdoor Design Conditions

Repository facilities shall be designed to comply with ANSI/ASHRAE/IESNA Std 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [DIRS 174321], including meeting the ambient (outdoor) exterior design conditions described in Section 4.9.2.3.1.

[Although this criterion previously referenced 10 CFR 434.301.1.1 (see historical statement in Criterion 4.1.3.1), it has been replaced by 10 CFR 433.4 (a)(1) [DIRS 181833], which directly imposes ANSI/ASHRAE/IESNA Std. 90.1-2004. Although errata are available for this standard, this is the latest version available. This comment will not be repeated throughout the PDC.]

4.1.3.3 Indoor Comfort Criteria

Repository facilities shall be designed to ANSI/ASHRAE Std 55-2004, *Thermal Environmental Conditions for Human Occupancy* [DIRS 174322], including allowing the heating, ventilation, and air-conditioning (HVAC) systems to be able to meet the applicable indoor comfort criteria, except that humidification and dehumidification are not required.

[Although no longer specifically mandated through the contract, criteria in 10 CFR 434.301.2 and 10 CFR 434.701 (10 CFR 434 is for buildings designed and constructed prior to January 2007) have been superceded by 10 CFR 433 [DIRS 181833] and no longer need to be referenced for the earlier versions of the indoor environmental conditions in the cited standard (R-2 of Table 701.1). See Section 4.9.2 for HVAC criteria. Although 10 CFR 433 does not contain this criteria, it should remain as criteria.]

4.1.3.4 Water Conservation Products

Repository facilities shall utilize products that comply with 10 CFR 430, Energy: *Energy Conservation Program for Consumer Products* [DIRS 181978], Subpart C, Sections 10 CFR 430.32 (n) - (r) and (u), and 66 FR 40571 (Executive Order 13221), *Energy Efficient Standby Power Devices* [DIRS 159949].

[Although 10 CFR 430 was previously referenced through 10 CFR 434 (10 CFR 434 is for buildings designed and constructed prior to January 2007), 10 CFR 434 is no longer applicable and has been removed from this document and its references. The only sections applicable to design are 10 CFR 430.32 (n) - (r) and (u). The other consumer products in the code are not expected in the repository design. Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information.]

4.1.3.5 Deleted

[10 CFR 433 replaces 10 CFR 434, therefore, this criterion is no longer applicable.]

4.1.3.6 Deleted

[10 CFR 433 replaces 10 CFR 434, therefore, this criterion is no longer applicable.]

4.1.3.7 Water Conservation

Through life-cycle cost-effective measures, agencies shall reduce water consumption and associated energy use in their facilities to reach the goals established by DOE. Where possible, water cost savings and associated energy cost savings shall be included in energy-savings performance contracts and other financing mechanisms.

[64 FR 30851, Greening the Government Through Efficient Energy Management, Executive Order 13123 [DIRS 104026], Section 207. Section 503(f) requires DOE to establish goals. Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information.]

4.1.4 Life Cycle Cost Criteria and Methodology

Facilities shall use the life cycle cost analyses and methodology in accordance with 10 CFR 436, Energy: *Federal Energy Management and Planning Programs* [DIRS 181963], Subpart A.

[The life cycle cost criteria are in accordance with 10 CFR 433.8 [DIRS 181833].]

4.1.5 Additional Sustainable Design Criteria

4.1.5.1 Application of Principles

The repository shall apply high performance sustainable design principles to new buildings and major building alterations. Compliance with 10 CFR 433, Energy: *Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High Rise Residential Buildings* [DIRS 181833]; is mandatory for federal buildings, from conceptual sitting, design, and construction through commissioning.

[DOE O 413.3A [DIRS 181834], Contractor Requirement 14 and DOE O 430.2A [DIRS 158913] Contractor Requirement 2 d.(5) specifically requires the use of these principles. As described in DOE O 450.1, [DIRS 176641] Attachment 3,"Green Buildings," this application is to optimize life cycle costs, reduce pollution, minimize energy consumption, conserve water, and enhance indoor air quality, worker safety, and productivity. Although an Administrative Change was made to DOE O 450.1, it has not been placed on contract. This also satisfies 64 FR 30851, Executive Order 13123 [DIRS 104026], Section 403(d). Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information. Although DOE O 430.2A calls for 10 CFR 434 (10 CFR 434 is for buildings designed and constructed prior to January 2007) for repository facilities based on the application date for starting detailed design, 10 CFR 433 has replaced it.]

4.1.5.2 Energy Star® Products

The repository shall select DOE/U.S. Environmental Protection Agency (EPA) Energy Star® products, including microcomputers and peripheral equipment where possible and reasonable, and insert them into guide specifications and acquisition systems. Where Energy Star® products are not available, select products that are in the upper 25 percent of energy efficiency.

[DOE O 430.2A [DIRS 158913] Contractor Requirement 2 d.(7) and 64 FR 30851, Executive Order 13123 [DIRS 104026], Sections 403.(b)(1 and 3) and 403.(d). Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information.]

4.1.5.3 Energy Star® Buildings

The repository shall strive to meet Energy Star® building criteria for energy performance and indoor environmental quality to the maximum extent practical. Energy-savings performance contracts, utility energy-efficiency service contracts, or other means may be used to conduct evaluations and make improvements to buildings in order to meet the criteria. Buildings that rank in the top 25 percent in energy efficiency relative to comparable commercial and federal buildings will receive the Energy Star® building label.

[64 FR 30851, Greening the Government Through Efficient Energy Management, Executive Order 13123 [DIRS 104026] Section 403.(c). It is expected that DOE will audit the facilities for this purpose. Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information.]

4.1.5.4 Petroleum-Based Fuels

The repository shall minimize the use of petroleum-based fuels in DOE-owned buildings and facilities by switching to a less greenhouse gas intensive, non-petroleum-based energy source such as natural gas or renewable energy source as measured at the end source when life cycle cost effective. For buildings and facilities that use petroleum-based fuel systems, provide dual-fuel capability where cost effective and practicable.

[DOE O 430.2A [DIRS 158913] Contractor Requirement 2 d.(10) and 64 FR 30851, Executive Order 13123 [DIRS 104026], Sections 205 and 206. Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information.]

4.1.5.5 Off-Grid Generation

The repository shall increase use of off-grid generation systems, including solar hot water and solar electric supporting the million solar roofs initiative, solar outdoor lighting, small wind turbines, fuel cells, and other technologies, when such systems are life cycle cost effective and offer other benefits.

[DOE O 430.2A [DIRS 158913] Contractor Requirement 2 d.(13) and 64 FR 30851, Executive Order 13123 [DIRS 104026], Sections 205 and 206. Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information.]

4.1.5.6 Certification

The repository shall design facilities with a goal to reduce energy and water consumption. The repository shall use the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED™) Green Building Rating System® for New Construction as the basis of demonstrating the application of sustainable building design criteria. All buildings and facilities shall apply sustainable building design criteria. Non-nuclear buildings and facilities shall be designed to achieve the LEED-NC Silver status.

[LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata (U.S. Green Building Council 2005 [DIRS 176803]). This rating system is an industry standard and is appropriate to apply to certain repository facilities.]

4.1.5.7 Greenhouse Gas Emissions

Facility design shall minimize greenhouse gas emissions attributed to facility energy use.

[64 FR 30851, Executive Order 13123 [DIRS 104026], Section 201. Although the executive order provides for numerical percentage reductions, DOE has not provided the specific criteria.]

4.1.5.8 Ozone-Depleting Substances

Facilities and systems shall reduce or eliminate the generation of waste, the release of pollutants to the environment, and NOT use Class I ozone-depleting substances such as chloroflourocarbon based refrigerants. Facilities shall accomplish this through source reduction, reuse, segregation, and recycling, and by procuring recycled content materials and environmentally preferable products and services.

[DOE O 450.1 Change 2 [DIRS 176641] Contractor Requirement 2.(c) specifically provides the requirement text.]

4.1.5.9 Erosion and Sediment Control

The repository shall reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust generation; create and implement an Erosion and Sedimentation Control Plan for all construction activities associated with the project. The Erosion and Sedimentation Control Plan shall conform to the erosion and sedimentation requirements of the 2003 EPA Construction General Permit or local erosion and sedimentation control standards and codes, whichever is more stringent. The Erosion and Sedimentation Control Plan shall describe the measures implemented to accomplish the following objectives:

- Prevent loss of soil during construction by storm water runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse
- Prevent sedimentation of storm sewer or receiving streams
- Prevent polluting the air with dust and particulate matter.

[LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata (U.S. Green Building Council 2005 [DIRS 176803]), Sustainable Sites Prerequisite 1, provides specific criteria selected for use in design.]

4.1.5.10 Eliminating Hazardous Substances

The repository shall substitute, reduce or eliminate toxic and hazardous substances in facilities, processes, and their surrounding environments.

[Good engineering practice dictates these criteria to establish and implement a hazard prevention and abatement process to ensure that all identified and potential hazards are prevented.]

4.1.5.11 Improve Indoor Air Quality

Repository facilities shall be designed in accordance with ANSI/ASHRAE 62.1-2004, *Ventilation for Acceptable Indoor Air Quality* [DIRS 174320], including establishing minimum indoor air quality performance criteria to enhance air quality in buildings, thus contributing to the comfort and well being of the occupants, meeting the minimum requirements of Sections 4 through 7. Mechanical ventilation systems shall be designed using the ventilation rate procedure in Section 6 or the applicable local code, whichever is more stringent. Naturally ventilated buildings shall comply with ASHRAE 62.1-2004, Paragraph 5.1.

[LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata (U.S. Green Building Council 2005 [DIRS 176803]), Indoor Environmental Quality Prerequisite 1 provides criteria for improving indoor air quality and interior and exterior environments leading to increased human productivity and performance, and better human health. Although a later version of ANSI/ASHRAE 62.1 is available, the responsible DEM has elected to utilize the referenced version.]

4.1.5.12 Using Recycled Materials

The repository shall increase the use of materials and products with recycled content and environmentally preferred products. This includes procurement of designated items composed of the highest percentage of recovered materials practicable, consistent with maintaining a satisfactory level of competition, considering such guidelines. Such items are not required if they are not reasonably available in a reasonable period of time, fail to meet reasonable performance standards, or are only available at an unreasonable price. Vehicular, construction, and transportation products are listed.

[40 CFR 247, Protection of Environment: Comprehensive Procurement Guideline for Products Containing Recovered Materials [DIRS 177839] Sections 2(d), 5(b) and 11 through 13.]

4.1.5.13 Energy Efficiency/Sustainable Design Report

An energy efficiency/sustainable design report prepared for each building at the end of each design phase of the project shall demonstrate that the design complies with the executive orders, federal regulations, and sustainable design principles for energy efficiency. A performance test report shall also be prepared during the operation phase of the facilities. New buildings where total energy consumption is expected to exceed 500 million BTUs per year or a building larger than 10,000 gross square feet shall have a certificate of compliance. A performance test during the operation phase shall demonstrate progress towards meeting energy costs and consumption goals and the greening of the government through efficient energy management.

[This criterion complies with DOE O 430.2A [DIRS 158913], Section 5.c(6)(e), which is the responsibility of DOE to produce the report and requires the design report be submitted at the end of Title II.]

4.1.5.14 Verification Review

The repository shall verify that the energy related systems of the buildings are installed and calibrated and perform to the owner's project requirements, basis of design, and construction documents. The following commissioning process activities shall be completed by the commissioning team in accordance with the *LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata* (U.S. Green Building Council 2005 [DIRS 176803]):

1) Designate an individual as the commissioning authority to lead, review, and oversee the completion of the commissioning process activities.
2) The Owner shall document the owner's project requirements. The design team shall develop the basis of design. The commissioning authority shall review these documents for clarity and completeness. The Owner and design team shall be responsible for updates to their respective documents.
3) Develop and incorporate commissioning requirements into the construction documents.
4) Develop and implement a commissioning plan.
5) Verify the installation and performance of the systems to be commissioned.
6) Complete a summary commissioning report.

[LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata, Energy and Atmosphere Prerequisite 1 provides appropriate criteria for repository facilities.]

4.1.5.15 Energy Efficiency Level

The repository shall establish a minimum level of energy efficiency for the proposed building and systems and design the buildings to comply with ANSI/ASHRAE/IESNA Std 90.1-2004 [DIRS 174321] including the mandatory provisions in Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4; the prescriptive requirements in Sections 5.5, 6.5, 7.5, and 9.5; and the performance requirements in Section 11. The repository shall also determine the energy consumption levels of the baseline building and the proposed building and use the performance rating in accordance with 10 CFR 433.5(a) [DIRS 181833].

[LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata (U.S. Green Building Council 2005 [DIRS 176803]), Energy and Atmosphere (EA) Prerequisite 2 provides appropriate criteria for repository facilities. 10 CFR 433.5(a) specifies the use of this version of Std 90.1-2004 and provides a change in the formula for calculating performance ratings.]

4.1.5.16 Collecting Recyclables

The repository facilities shall provide easily accessible areas that serve the entire building and is dedicated to the collection and storage of non-hazardous materials for recycling, including (at a minimum) paper, corrugated cardboard, glass, plastics, and metals.

[LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata (U.S. Green Building Council 2005 [DIRS 176803]), Materials and Resources Prerequisite 1. This criterion facilitates the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.]

4.1.5.17 Locating Smoking Areas

Minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke by either locating any exterior designated smoking area at least 25 ft away from entries, outdoor air intakes, and operable windows; or providing designated smoking areas within buildings that effectively contain, capture, and remove environmental tobacco smoke. Although measurements are programmatic, performance of smoking room differential air pressures shall be verified by conducting 15 minutes of measurement, with a minimum of one measurement every 10 seconds, of the differential pressure in the smoking room with respect to each adjacent area and in each adjacent vertical chase with the doors to the smoking room closed.

[LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata (U.S. Green Building Council 2005 [DIRS 176803]), Indoor Environmental Quality Prerequisite 2 provides appropriate criteria for repository facilities.]

4.1.6 Waste Prevention, Recycling, and Federal Acquisition

The repository facilities shall use the principles and concepts in the EPA Guidance on Acquisition of Environmentally Preferable Products and Services, in addition to the lessons from pilot and demonstration projects, to the maximum extent practicable in identifying and purchasing environmentally preferable products and services.

[63 FR 49643, Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition, Executive Order 13101 [DIRS 104024], Section 503.(c). Although the executive order was revoked, it is still on the contract and still provides useful information.]

4.1.7 American National Standard Institute Standards

Repository facilities and SSCs shall utilize the following standards for specifying safety signs:

- ANSI Z535.1, *American National Standard for Safety Color Code*,
- ANSI Z535.2, *American National Standard for Environmental and Facility Safety Signs*,
- ANSI Z535.3, *Criteria for Safety Symbols*,
- ANSI Z535.4, *American National Standard for Product Safety Signs and Labels*, and
- ANSI Z535.5, *American National Standard, Safety Tags and Barricade Tapes (for Temporary Hazards)*.

[These generally recognized industry standards are output constraints that may be utilized in the design and construction of repository facilities and do not constitute inputs to the design. Although 2002 versions were previously specified, [DIRS 176311], [DIRS 176312], [DIRS 158834], [DIRS 176313], and [DIRS 176314], respectively, they have subsequently been removed from the text and reference list of this document and added to Section 8.4. These standards are constraints and not inputs requiring referencing. The latest versions should be utilized.]

4.1.8 Environmental Protection

4.1.8.1 Hygiene Facilities

If solutions of 0.1 percent or greater (including splashes, spills, or improper work practices) of methylene chloride may come into contact with an employee's skin, then hygiene facilities shall be provided.

[29 CFR 1910.1052(i) [DIRS 177507]. Although it is not expected that the exposure will occur during repository operations, this standard is provided to cover potential changes in design and operations.]

4.1.8.2 Change Rooms

If employees are required to wear protective clothing or equipment due to exposure to acrylonitrile, formaldehyde, or methylenedianiline, then appropriate change rooms shall be provided.

[29 CFR 1910 [DIRS 177507] Sections 1045(m), 1048(i), and 1050(j), respectively. Although it is not expected that the exposure will occur during repository operations, this standard is provided to cover potential changes in design and operations.]

4.1.8.3 Pollution Prevention

The repository shall be designed with pollution prevention systems to control air emissions and effluents, minimize water use, and reduce or eliminate discharges to the environment.

[40 CFR 112.12, Oil Pollution Prevention [DIRS 181981], is mandated through the contract and allocated to engineering. All other solutions based on engineering judgment.]

4.1.8.4 Design Considerations

The repository shall consider the following in the design:

(1) Conformity of DOE-proposed actions with state implementation plans to attain and maintain national ambient air quality standards

(2) Implementation of a watershed approach for surface water protection
(3) Implementation of a site-wide approach for groundwater protection
(4) Protection of other natural resources, including biota
(5 Protection of site resources from wildland and operational fires
(6) Protection of cultural resources.

[DOE O 450.1 Change 2 [DIRS 176641], Contractors Requirement 2(a), specifically provides the requirements text.]

4.1.8.5 Environmental Landscaping

The repository shall incorporate, where appropriate, environmentally and economically beneficial landscape practices into all new landscaping programs, policies, and practices for facilities.

[DOE O 450.1 Change 2 [DIRS 176641] Attachment 2, Item 6, and Attachment 3 information provides the requirements text. See requirements placed on federal agencies in 65 FR 24595, Executive Order 13148 [DIRS 154538]. Although Executive Order 13123 was revoked, it is still on the BSC contract and still provides useful information. Some of the information includes utilizing EPA GreenScapes, environmentally beneficial landscaping methods to reduce waste and energy usage, conserve water, and reduce greenhouse gas emissions.]

4.1.8.6 Deleted

[The requirements for water use limit is addressed in the Basis of Design for the TAD Canister-Based Repository Design Concept (BOD) (BSC 2007 [DIRS 182131] Section 9.10.2.2.4 and 24.2.2.1.1) and is subsequently deleted here.]

4.1.8.7 Wastewater

Wastewater shall be controlled such that the repository operates as a zero discharge process, where no discharges of wastes shall be made to surface waters of the state of Nevada and, thereby, lowering the quality of those waters. In addition, high-level radioactive waste shall not be discharged into any waters of the state of Nevada. Wastewater is defined and segregated as two types, depending on the source: industrial and non-hazardous oily wastewater.

Industrial Wastewater -- Includes blowdown water from the cooling tower, regeneration water from the water softening system, water from the deionization system, public water system discharge water (chlorinated water and arsenic treatment system backflush water), and firewater runoff. Industrial wastewater is collected in evaporation basins or ponds. Evaporation ponds shall be lined with a material compatible with the wastewater that flows into the pond. Evaporation ponds are sized to accommodate all flows with zero discharge.

Note: Industrial wastewater that may be contaminated by a radiological source is to be treated as suspect waste and should be segregated from other waste until a determination has been made. After waste categorization, handle as appropriate for that waste type.

Oil-contaminated wastewater generated at the subsurface and surface facilities shall be collected and processed to prevent the pollution of water drainage systems and evaporation ponds. Following processing, the oil-contaminated wastewater shall be discharged to a designated oil-water evaporation pond. The pond shall be lined with rock and allow percolation. Additional design requirements for oil-contaminated wastewater ponds may be imposed after discussions with the state of Nevada. Surface basins will need to be permitted under the Underground Injection Control Permit or a National Pollutant Discharge Elimination System Permit for Zero Discharge.

[No discharges of waste (in the first paragraph) complies with, Water Controls, NRS 445A.565 1 and NRS 445A.575 [DIRS 176458]. Nevada underground injection control NAC 445A.810-925 and water pollution control regulations NAC 445A.070-348 [DIRS 104040] contain program or permitting criteria but not design criteria.]

4.1.8.8 Sanitary Wastewater

Sanitary sewage shall be disposed in appropriate systems at the North and South Portal pads or North Construction Portal, as required. The sanitary sewage system and infrastructure shall provide adequate storage for the collection of wastewater.

[NAC 444, Sanitation [DIRS 104039], NAC 445A.070-348, Water Controls and NAC 445A.810-925, Underground Injection Controls [DIRS 104040], provide a general reference to the State of Nevada regulations that regulate this sewage and water. They are programmatic in nature and do not contain the specific text of this criterion. This criterion is a functional statement derived from the need to provide for personnel waste.]

4.1.8.9 Air Emission

The repository facilities and systems shall be designed in accordance with 40 CFR 61, *National Emission Standards for Hazardous Air Pollutants* [DIRS 177522]; NAC 445B, *Air Controls* [DIRS 104041]; and NRS 445B, *Air Pollution* [DIRS 176373], such that hazardous air emissions are minimized and the release of criteria pollutants and fugitive dust are within their limits.

[Although performance limits from 40 CFR 61 are provided in the basis of design for the repository, these standards provide the design details to meet those requirements.]

4.1.8.10 Public Water System

The design and construction of a public water system shall comply with the provisions of NAC 445A, *Water Controls* [DIRS 104040].

[NAC 445A is allocated through the requirements management system.]

4.1.8.11 Hazardous Waste

Repository facility designs shall facilitate the management of hazardous waste generated as a byproduct of operations in accordance with NAC 459, *Hazardous Materials* [DIRS 104042].

[NAC 459 is allocated to Engineering through the requirements management system.]

4.1.8.12 Emissions Control Performance

Emissions monitoring systems and equipment shall be designed to measure for emissions control performance to meet the regulations of 40 CFR 64, *Compliance Assurance Monitoring* [DIRS 177835].

[40 CFR 64.3(a)-(d).]

4.1.9 Level of Design and Operational Information

The design of repository SSCs should be sufficiently detailed for License Application such that (1) general information on the design of facilities, SSCs, equipment, and process activities will support the PCSA; and (2) specific information about ITS SSCs that demonstrate the ability of the ITS SSCs to perform their intended safety function(s) is available utilizing the guidance in HLWRS-ISG-02, *Preclosure Safety Analysis - Level of Information and Reliability Estimation - Draft* [DIRS 181942] and HLWRS-ISG-01, *Review Methodology for Seismically Initiated Event Sequences* [DIRS 178130].

[RGA REG-CRW-RG-000413, Agreement for HLWRS-ISG-02, Draft September 2006, Preclosure Safety Analysis - Level of Information and Reliability Estimation - Draft (BSC 2007 [DIRS 181782]) provides agreement that guidance in HLWRS-ISG-02 is applicable. While most of the sources discusses PCSA, accepted engineering practice could include the application of: (1) appropriate codes and standards; (2) realistic parameters, operating conditions, and safety margins in design performance calculations; (3) redundancies and defense-in-depth considerations; and (4) administrative program controls that provide confidence in hardware performance and human reliability. RGA REG-CRW-RG-000412, Agreement for HLWRS-ISG-01, Rev 0, Review Methodology for Seismically Initiated Event Sequences (BSC 2007 [DIRS 182086]) provides agreement for the review of seismically initiated event sequences in the preclosure safety analysis per HLWRS-ISG-02.]

4.1.10 Defining Condition Classification of Spent Nuclear Fuel

For informational purposes in designing the repository, the definitions and terminology shown in SFPO-ISG-01, *Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation Based on Function* [DIRS 182880] for classifying spent nuclear fuel for interim storage and transportation based on function is only for activities to be conducted at the YMP site related to the identification and handling of degraded spent fuel. Transportation activities and activities at reactor sites are outside the purview of the project.

[RGA REG-CRW-RG-000414, Agreement for SFPO-ISG-01, Rev 2, Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation Based on Function (BSC 2007 [DIRS 181943]) provides agreement that this guidance is applicable for defining the classification of the condition of spent nuclear fuel for placement in the repository. SFPO-ISG-01 provides the NRC staff's position regarding the classification of spent nuclear fuel as either: 1) damaged, 2) undamaged, or 3) intact, before interim storage or transportation. This guide is not a requirement and can be modified, but contains information that the repository should use to classify fuel.]

4.1.11 Cleanliness Requirements

During the development of detailed design, the repository will consider and apply appropriate ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications* (BSC 2007 [DIRS 159544]) criteria from subparts 2.1, 2.2, 2.5, and 2.8 to the appropriate SSCs, beyond those currently listed in other criteria.

[QMD (BSC 2007 [DIRS 180474]), Appendix A.]

4.2 Civil/Structural/Architectural Design Criteria

4.2.1 Civil Site Development

4.2.1.1 Site Description

The repository at Yucca Mountain is located approximately 100 miles northwest of Las Vegas, Nevada. The repository surface facilities are located in distinct operational areas, namely:

- North Portal Operations Area
- South Portal Development Operations Area
- Ventilation Shafts Surface Operations Areas
- North Construction Portal.

[The Site Development Plan (DOE 2004 [DIRS 170191]) described the phased approach for construction of the repository facilities and infrastructure, for the development of supporting elements required to emplace the high-level waste, and spent nuclear fuel. The site development plan for the repository incorporates the necessary civil engineering features and arrangement required to support the surface repository facilities and systems for safe and efficient operations. The site layout is organized around the subsurface accesses and is configured considering owner and radiological exposure boundaries, flood/fault zones, topographic features, and meteorological patterns. In addition, it supports surface and subsurface operations and the required facility and transportation arrangements. The site layout is designed to maximize preclosure radiological safety and deter postclosure human disturbance of the repository. The site layout is also designed to limit impacts to the waste handling operations caused by worst-case environmental conditions. This item is descriptive in nature and does not contain design criteria.]

4.2.1.2 Surveys and Datum

Design documents shall provide for the following:

- Site boundaries
- Site grade
- Datum elevation
- Coordinates (NOTE: Coordinate data shall correspond to the Nevada State Plane Coordinate System, Central Zone (NAD 27) for horizontal and NGVD 29 for vertical)
- Coordinates and elevations of the four operational areas will be given in a revision
- Survey control points
- Grid north based on the Nevada State Plane Coordinate System
- An optional "Plant Grid" may be used for defining locations of improvements inside of building envelopes

[The information presented is required for site description by good engineering practice and shall conform to Nevada State Plane Coordinate System, Central Zone (NAD 27) for horizontal and NGVD 29 for vertical. The data have been used for all previous surveys.]

4.2.1.3 Subsurface Investigations

The surface facility design shall be based on the subsurface investigation for the repository compiled in the *Supplemental Soils Report* (BSC 2007 [DIRS 182582]).

[Information obtained for the subsurface investigations for the repository as compiled in these reports is appropriate for engineering work.]

4.2.1.4 Site Design Parameters

Repository facilities and SSCs shall be designed for:

- Soil Properties—The soil properties are defined in the *Supplemental Soils Report* (BSC 2007 [DIRS 182582]), Tables 2-1 and 2-2
- Soil Bearing Capacity—The soil bearing capacity is defined in *Soils Report for North Portal Area, Yucca Mountain Project* (BSC 2002 [DIRS 159262]) and *Supplemental Soils Report*
- Groundwater—The groundwater table is reported to be located at a typical depth of 1,270 ft below present ground surface and is over 1,000 ft below the top of bedrock in the North Portal area, *Soils Report for North Portal Area, Yucca Mountain Project, Section 6.4* (BSC 2002 [DIRS 159262]); *Supplemental Soils Report, Section 6.1.4.4* (BSC 2007 [DIRS 182582])
- Flood—Flooding and wave action consequences associated with flooding events shall be identified in *Yucca Mountain Project Drainage Report* (BSC 2007 [DIRS 183261])
- Frost depth penetration for foundation design, as defined in Section 6.1.8
- Wind load and tornado load design requirements, as defined in Sections 6.1.3 and 6.1.4
- Seismic—Seismic design load requirements, as defined in Section 6.1.10
- Environmental condition to withstand and operate in an extreme outside temperature environment, as defined in Section 6.1.6
- Design basis precipitation presented in Sections 6.1.1 and 6.1.2
- In accordance with Regulatory Guide 1.132, *Site Investigations for Foundations of Nuclear Power Plants* [DIRS 169347]

[The technical parameters described above are considered adequate for design and constitute the best available sources. RGA REG-CRW-RG-000110 (BSC 2007 [DIRS 181611]) provided guidance for Regulatory Guide 1.132.]

4.2.1.5 Clearances and Setbacks

Repository design shall comply with the physical protection requirements of 10 CFR 73, Energy: Physical Protection of Plants and Materials [DIRS 181969].

[For the 3 criteria below, security clearances are necessary to provide sufficient space in anticipation of security requirements derived from a site-specific vulnerability assessment. The assessment has not derived any security spacing requirements at this time. The 200-ft distances specified are roughly similar to what is seen at other facilities requiring security fences. Construction clearances allow sufficient space for personnel, supplies, and moving equipment is good construction and safety practice. Although specific distances are not specified, it is reasonable to have approximately 100 ft around aging pads for construction activities and equipment laydown areas and even more than 100 ft (~180 ft) around nuclear facilities. CBCN002 to Revision 6 provided change.]

4.2.1.5.1 Inside Security Perimeter Fence

A clear zone or setback of a minimum of 200 ft shall be provided from the inside security perimeter fence to either (a) a confinement feature of an operating nuclear facility or (b) the exterior wall of a facility housing the central control and communication systems.

4.2.1.5.2 Outside Security Perimeter Fence Entrances

A clear zone or setback of a minimum of 200 ft shall be provided from the entrances to the secured area through which vehicles and personnel normally pass for any structure outside the secured area.

4.2.1.5.3 Construction Zones

A clear zone shall be provided for construction heavy equipment travel and material lay down areas during construction between the closest active security fence and (a) confinement features being constructed as part of nuclear facilities and (b) Aging Facility pads being constructed.

4.2.1.6 Site Drainage

The configuration and grading of pads shall be designed to prevent the pooling of water. Site drainage shall:

- Protect the ramp, ramp portal, shaft, and shaft collar areas from water inflow as a result of the probable maximum flood,
- Contain and route stormwater from natural surface water drainage ways around surface facilities and provide water drainage for systems located on pads,
- Be designed for the runoff accumulated from the storms identified in Sections 6.1.1, 6.1.2, and 6.1.9.

[Good engineering practice dictates the protection of facilities from probable maximum flood and runoff accumulations.]

4.2.1.7 Site Slopes and Grades

The nominal grades within pad areas shall be as required to provide proper drainage. Fill slopes shall be designed with a slope value no steeper than two horizontal to one vertical.

[Good engineering practice dictates proper drainage as well as practical slope requirements.]

4.2.1.8 Site Barriers

The design shall provide secondary containment around all single-walled fuel storage tanks and petroleum, oil, lubricant, and hazardous material storage sites.

[Secondary containment of storage sites containing hazardous materials shall be provided. Security requirements for barriers have been deleted because they are addressed in the BOD (BSC 2007 [DIRS 182131]) Sections 9 and 23.]

4.2.1.9 Other Site Impacts

The site layout should be such that site impacts due to historical and archaeological features, endangered species, and the environment are considered in the design. The layout design shall not require the disturbance of any known archaeological resource unless the disturbance has been specifically permitted in accordance with the applicable programmatic agreement between the DOE and Advisory Council on Historic Preservation. The layout design shall not require the disturbance of any known active desert tortoise (Gopherus agassizii) burrow, pallet, den, watering depression, or cover unless the tortoise is relocated in accordance with the issued biological opinion.

[Conformance with federal requirements for historical and archaeological features is required, as is the protection of endangered species such as the desert tortoise. Williams, R. D. 2001 [DIRS 157529] conservation recommendation on page 30, specifically provides for tortoise habitat protection considerations.]

4.2.1.10 Pollution and Soil Erosion Control

Pollution and soil erosion controls shall be implemented during construction activities to mitigate impacts on air, water, and other environmental resources and ensure compliance with appropriate sections of NAC 445A, *Water Controls* [DIRS 104040] and NAC 445B, *Air Controls* [DIRS 104041]. When riprap is required for erosion control, the riprap shall be a sound, durable stone with an average bulk density not less than 125 lbs/cu ft. The stone shall be graded from 12 in. maximum size to 3 in. minimum, as placed vertically. The largest dimension of any riprap stone shall be no longer than three times the vertical dimension.

[Construction activities are required to be environmentally responsible and in accordance with NAC 445A and NAC 445B. Riprap is specified in accordance with good engineering practice and generally accepted industry methods of erosion control.]

4.2.1.11 Prevention of Discharges

Repository facilities and SSCs shall comply with 40 CFR 122, *The National Pollutant Discharge Elimination System* [DIRS 181982], relevant to Storm Water Pollution Prevention Plan (SWPPP) for construction and industrial phases.

[Compliance with the regulation should ensure that best efforts to eliminate discharges would remove objections from stakeholders.]

4.2.1.12 Corrosion Potential and Corrosion Control

When buried pipelines require cathodic protection, the systems shall be installed at the same time as the piping system. The interior of ferric water tanks shall be protected by the cathodic protection system.

[Soils Report for North Portal Area, Yucca Mountain Project (BSC 2002 [DIRS 159262]) and Supplemental Soils Report (BSC 2007 [DIRS 182582]) identify the soil aggressivity to be lightly corrosive to ferrous metals. Supplemental Soils Report Section 7.3.6 calls for additional field resistivity testing. Required cathodic protection is suggested by good engineering practice.]

4.2.2 Civil Earthwork

4.2.2.1 Area Clearing

The area within the repository boundary that is required for construction operations shall be cleared of all materials above or at the natural ground surface. Materials to be cleared shall include trees, brush, rubbish, vegetation, and obstructions. However, in certain specified areas, trees and brush may have to be retained and preserved.

[This provides a good engineering practice.]

4.2.2.2 Excavation and Backfill

Temporary and permanent earthwork slopes, excavations, and structural fill shall be in accordance with the requirements of *Soils Report for North Portal Area, Yucca Mountain Project* (BSC 2002 [DIRS 159262]) and *Supplemental Soils Report* (BSC 2007 [DIRS 182582]) Sections 7.1 and 7.2. As a minimum, the cut and fill slopes shall meet the requirements of 29 CFR 1926 [DIRS 177634].

[The soils reports cited were developed specifically to address these issues (and others) and are appropriate sources. 29 CFR 1926 [DIRS 177634] contains specific requirements to maintain worker safety.]

4.2.2.3 Borrow Materials

Borrow material may be obtained from a variety of areas, to be designated in the future, and used in accordance with *Soils Report for North Portal Area, Yucca Mountain Project* (BSC 2002 [DIRS 159262]) and *Supplemental Soils Report* (BSC 2007 [DIRS 182582]) Sections 6.3, 6.4, and 7.2.9.

[The soils reports cited were developed specifically identify the appropriate area for borrow material.]

4.2.3 Civil Roadways, Parking Areas, Walkways, and Open Areas

4.2.3.1 Road Classification

The YMP may include paved or unpaved parking areas, driveways, construction roads and controlled access thoroughfares.

[Layout of roadways, parking areas, walkways, and open areas are in accordance with good engineering practice.]

4.2.3.2 Design Parameters

Roadway design shall conform to *Standard Plans for Road and Bridge Construction* (NDOT 2007 [DIRS 182650]) and *Standard Specifications for Road and Bridge Construction* (Stephens 2001 [DIRS 178176]). Design parameters not covered in the Nevada Department of Transportation documents shall be based on *A Policy on Geometric Design of Highways and Streets* (AASHTO 2004 [DIRS 175834]), as applicable.

- Paved and unpaved sections of roads shall be designed to be capable of handling legal weight trucks with a safety factor for overweight vehicles.
- Roadways servicing facilities shall be designed to accommodate the anticipated repository vehicles or class of vehicles selected from vehicle templates in *A Policy on Geometric Design of Highways and Streets*.
- Roads for firefighting apparatus shall have a maximum grade of 10 percent, nominal, in accordance with the *2006 International Fire Code* (ICC 2006 [DIRS 176293], Section D.103.2).

[The documents cited provide accepted industry design standards that are considered acceptable for repository design. Design Basis Vehicles are specified in the BOD (BSC 2007 [DIRS 182131]).]

4.2.3.3 Parking Areas

Parking areas shall have a maximum slope of two percent, nominal. Parking areas shall be sized to accommodate the number of vehicles anticipated.

[Although the repository vehicle fleet size cannot be determined at this time, provisions should be made to address this function.]

4.2.3.4 Site Access

Access to the site shall be via access control points. Within the site, personnel shall walk to their respective work location of the facility.

[Considering that all repository facilities will be located within security-fenced areas, access through the security fence access controls is necessary. Consideration of vehicle and pedestrian flows is necessary to accomplish the design.]

4.2.3.5 Walkways

Walkways shall be provided for pedestrian traffic from designated parking lots to and around all permanent buildings.

[Walkways are required to protect pedestrian traffic from the vehicles to be utilized within the site and to safely direct the pedestrian traffic.]

4.2.3.6 Accessibility

Repository buildings and adjoining sites, including parking areas, will require handicap accessibility to the buildings in accordance with ICC/ANSI A117.1-2003, *Accessible and Usable Buildings and Facilities* [DIRS 176223]. Handicapped parking shall be provided at two percent of total available parking. Handicapped parking and curb ramps for the handicapped shall be marked and dimensioned accordingly. Repository facility accessibility shall also comply with 28 CFR 36, *Judicial Administration: Nondiscrimination on the Basis of Disability by Public Accommodations and in Commercial Facilities* [DIRS 177828] and 36 CFR 1191, *Parks, Forests, and Public Property: Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines* [DIRS 182890].

[10 CFR 1041.151 [DIRS 181979] requires making buildings accessible and useable by handicapped persons. ICC/ANSI A117.1-2003 is a recognized industry standard addressing this subject. Similar requirements that are applicable are in 28 CFR 36. These requirements and standards implement the Americans with Disabilities Act of 1990 [DIRS 162264].]

4.2.3.7 Open Areas

Open areas disturbed by construction of buildings shall be covered with a 3-in. layer of 1-1/2-in. to 2 in. nominal landscaping stone.

[Specifying ground cover is necessary to limit dust movement. Crushed surface course is standard industry practice.]

4.2.3.8 Signs and Markings

Signs and markings on pavements shall be provided, as necessary, in accordance with US Department of Transportation (DOT) 2005, *Manual on Uniform Traffic Control Devices for Streets and Highways* (DOT 2005 (R2003) [DIRS 175926]).

[This manual provides the industry standard for providing signs and markings. The State of Nevada adapted this version (R2003) in the NDOT 2007 [DIRS 182650].]

4.2.3.9 Overhead Power Line Caution Sign

Standard caution signs shall be placed on both sides of the road where electrical lines cross over roads. Signs shall state the actual clearance from the top of the road to the lowest wire or cable. The sign shall be visible at 100 ft away from the overhead lines. Minimum clearance of power lines over plant roads shall be in accordance with electrical design criteria for clearances.

[Power lines crossing roads creates potentially hazardous situations that warrant providing safety signs. The

distances and clearances are considered reasonable for the work environment.]

4.2.4 Civil Railroad Design

The requirements of this section apply to all components of surface rail design except as specifically noted. The boundary between surface and subsurface rail lines is at the portal of the entry tunnel.

4.2.4.1 Track Layout

Track layouts shall allow rail movement to be continuous from the interchange yard through the classification yard to the delivery tracks. Each interchange or receiving track shall be designed to accommodate the maximum single delivery. The average number of cars in each classification shall determine the length of classification tracks. The minimum radius for the surface rail, where only the emplacement transporters travel, shall be 200 ft. The minimum radius for the surface rail, where conventional engines and railcars travel, shall be 478 ft. (nominal) chord definition.

[These statement provide the concepts needed to develop the layout. The distances specified are generally accepted radii.]

4.2.4.2 Electrical Grounding

Grounding requirements for railroad equipment are presented in Section 4.3.1.4. Electrical grounding shall comply with NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982] and IEEE C2-2007, *National Electrical Safety Code* [DIRS 177944].

[The NEC provides the industry standard for accomplishing grounding. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.2.4.3 Railway Engineering

The bases for surface railroad facilities design shall be the criteria in *Manual for Railway Engineering* (AREMA 2007 [DIRS 182893]), heavy freight criteria E-80.

[AREMA 2007 provides the industry standards for railroad facilities and provides appropriate criteria for site railroads.]

4.2.4.4 Turnout Geometry

Turnout geometry shall be in accordance with the *Track Standard Drawings* (UPRR 2005 [DIRS 177094]).

[This is an acceptable industry standard appropriate for repository use.]

4.2.4.5 Grades

The maximum grade on access lines shall be determined by the tonnage handled in one train unit. An analysis shall be made to design grades below three percent. Grades shall not exceed three percent without approval by the cognizant DOE authority. The design shall be coordinated with the requirements of the serving railroad.

[Providing a maximum grade appears to be reasonable. Rail experience indicates that even 3% challenges the system performance and significantly degrades system functionality.]

4.2.5 Civil Heliport Design

4.2.5.1 FAA Advisory Criteria

Heliport design shall be in accordance with the FAA Advisory Circular 150/5390-2B *Heliport Design* (DOT 2004 [DIRS 175920]).

[This circular provides design guidance from the applicable control authority for heliports and is relevant to repository facilities.]

4.2.5.2 Heliport Location

The heliport shall not be located closer than one-half mile from the IHF, CRCF, Receipt Facility, WHF, the Aging Facility pads, and the railcar and truck staging areas.

[Frequency Analysis of Aircraft Hazards for License Application (BSC 2007 [DIRS 180112]), Assumption 3.1.3

and Sections 7.4 and 8, provide a location requirements for the separation of this non-ITS facility from the nuclear facilities and other areas where the waste stream is kept that are potentially accessible to aircraft. Although the FAA circular in Criterion 4.2.5.1 discusses flight path restrictions, this requirement goes beyond the stated criteria. CBCN001 to Revision 6 provided change.]

4.2.5.3 Fire and Rescue Heliports

Heliports utilized for fire and rescue operations shall comply with NFPA 418-2006, *Standard for Heliports* [DIRS 177977].

[Although the FAA circular in Criterion 4.2.5.1 is generic in nature, the NFPA standard is recognized industry standard for the additional fire and rescue responsibilities and is appropriate for this use. CBCN001 to Revision 6 provided reference to and earlier version of the code. Using the later version as specified here is appropriate.]

4.2.6 Civil Sanitary Sewer System

4.2.6.1 Operations and Maintenance

The sanitary sewer system shall be designed in accordance with *ESF Sanitary Sewer System Operation and Maintenance Manual* (CRWMS M&O 2000 [DIRS 167332]).

[Previous engineering work was identified as suitable criteria for operation of the repository systems in a fashion similar to how the Exploratory Studies Facility system is operated.]

4.2.6.2 Nevada Regulations

The wastewater, treatment and disposal system shall be designed in accordance with NAC 444, *Sanitation* [DIRS 104039], as applicable.

[NAC 444 is allocated to Engineering through the requirements management system and provides primary appropriate criteria for the system.]

4.2.6.3 EPA Design Manual

The wastewater collection, treatment and disposal system shall be designed in accordance with EPA/625/R-00/008, *Onsite Wastewater Treatment Systems Manual,* (EPA 2002 [DIRS 177934]), as applicable.

[The EPA manual provides acceptable industry standard guidance for design.]

4.2.6.4 ASCE Design Criteria

The wastewater collection system design shall be in accordance with American Society of Civil Engineers (ASCE) 1982, *Gravity Sanitary Sewer Design and Construction* [DIRS 169217], and ASCE 1991, *Design and Construction of Sanitary and Storm Sewers* [DIRS 132149].

[These manuals provide industry design guidance acceptable for repository use.]

4.2.6.5 Design Parameters

Quantity of Sanitary Sewage-The rate of sanitary flow shall be calculated by correlation with the historical water use data recorded for the Exploratory Site Facility.

[Utilizing existing facility experience and the projected staffing for the repository is acceptable to calculate system needs and capacities.]

4.2.6.6 System Layout

Gravity flow wastewater systems are preferred over pressurized systems. Sanitary sewer main line minimum diameters shall be 8 in. and lateral line minimum diameters shall be 6 in. Manholes shall be located at all junctions and changes of grade or size of mains. Spacing between manholes on the main lines shall not exceed 400 ft. Single cleanouts shall be located at dead ends of laterals. Double cleanouts shall be used where laterals make a horizontal change in direction. The maximum length of a sewer lateral shall be 100 ft without a cleanout.

[These parameters are specified to provide consistency in the system design across the repository.]

4.2.6.7 Existing Technology

The sanitary sewer system shall use the highest and best degree of waste treatment available under the existing technology, consistent with the best practice in the particular field under the conditions applicable, and reasonably consistent with the economic capability of the project or development.

[NRS 445A, Water Controls [DIRS 176458], Section 565 (2).]

4.2.7 Civil Storm Drainage System

4.2.7.1 Managing Runoff

All areas of the repository shall be designed for storm water runoff based on the functional requirements of each facility using a drainage system that exits to a detention pond. The storm drainage system shall be designed to handle the flow specified in Section 6.1.2 and facilitate firewater runoff. The maximum single-source discharge shall be based on average annual precipitation. There shall be no process liquid or sanitary sewer contributions to the storm system. Building and surface runoff shall be directed toward drainage structures and ditches by sloping the tributary surface area.

[Determining the system capacity by specifying multiple, concurrent inputs provides a suitable basis for the system capacity. The other statements on sloped runoff etc. are in accordance with general industry practices.]

4.2.7.2 Storm Drains, Culverts and Ditches

- The minimum culvert diameter shall be 18 in.
- Culverts and pipes shall be designed to accommodate the minimum H-20 loading for traffic loads; E-80 for rail loads; and 300,000 lbs. point load (airport) rating for heavy haul areas.
- The drainage ditches shall be trapezoidal in cross section with a minimum bottom width of 3 ft and with a minimum side slope of 2:1. Roadway ditches may be V-shaped.
- Site storm water shall be managed in a drainage system, which exists to a detention pond.
- Drainage discharge points shall have a riprap in a fan shape to disperse outfall stormwater flow.
- Drainage ditch slopes shall be based on channel velocity, calculated using the "Manning Formula."
- Drainage ditch slopes shall be set to create velocities, which neither promote precipitation nor accelerate scour.

[The H-20 and E-80 loads for these items are contained in Standard Specifications for Highway Bridges, with 2004 and 2005 Errata (AASHTO 2005 [DIRS 178018]) and Manual for Railway Engineering (AREMA 2007 [DIRS 182893]). The 300,000 lbs. point load (airport) rating for heavy haul areas is from US DOT FAA Advisory Circular No. 150/5320-6D: Airport Pavement Design and Evaluation (U.S. DOT; FAA 1995 [DIRS 183013]. The standards for their construction are contained in the Standard Specifications for Road and Bridge Construction (NDOT 2001 [DIRS 176558]) and the U.S. Department of Transportation (USDOT) 1996 Standard Specification for Construction of Roads and Bridges on Federal Highway Projects [DIRS 182707].]

4.2.7.3 Storm Drains

Storm drains shall be designed to convey storm water runoff away from collection points and convey the runoff to those controlled discharge points that will minimize erosion. Storm drains, at a minimum, shall be designed to the same load standards as culverts. Storm drains may be designed consistent with the recommendations contained in the following two references:

- *Design and Construction of Urban Stormwater Management Systems* (UWRRC/ASCE 1992 [DIRS 164302]) and
- *Design and Construction of Sanitary and Storm Sewers* (ASCE 1991 [DIRS 132149]).

Storm drains shall be hydrostatically tested according to the following schedule:

- Pipe and joints shall sustain a maximum limit of 0.016 gallons per hour per inch of pipe diameter per 100 feet of pipe using an exfiltration test. The hydrostatic head for the test shall exceed 72 inches above the inside top of the highest section of pipe in the test section. The length of pipe tested by exfiltration shall be limited so that the pressure on the invert of the lower end of the section being tested shall not exceed 16 feet of water column. The pipe section being tested may be filled 24 hours prior to time of exfiltration testing to permit normal absorption into the pipe walls to occur.
- Manholes shall be hydrostatically tested. The test shall consist of plugging all inlets and outlets of the manhole and then filling the manhole with water to the uppermost watertight portion of the manhole assembly.

Leakage (exfiltration) in each manhole shall not exceed 0.2 gallons per hour per foot of head above the invert. A manhole shall be filled with water 24 hours prior to time of exfiltration testing to permit normal absorption into the manhole wall to occur.

[These standards provide industry standard guidance applicable to storm sewers and are appropriate to the repository scope due to the size of the disturbed site areas.]

4.2.7.3.1 Manning Coefficient of Roughness

The Manning coefficient of roughness shall be:

- 0.013 for concrete-lined ditches
- 0.033 for riprap ditches
- 0.025 for gravel-lined ditches
- 0.009 for polyvinyl chloride (PVC) piping.

[These values for Manning Coefficient are generally accepted industry values found on line and in standard civil design texts. No reference is necessary.]

4.2.7.3.2 Quantity of Storm Flows

Quantity of storm flows shall use calculated surface runoff peak flow rates by the rational method as follows:

$Q = CIA$

Where,

Q = Peak discharge in cu. ft per second

C = Coefficient of runoff. The runoff factor, C, shall be:

0.90 for roofs and impervious pavements
0.50 for graveled areas
0.10 for all other open areas
The weighted average of coefficient of runoff factor, C, for sub-areas shall be used in the design.

I = Average rainfall intensity in inches per hour for a given frequency and for the duration equal to the time of concentration. Storm management systems for all areas shall be designed for rainfall per Section 6.1.2.

A = Drainage area in acres

- The minimum Tc shall be 5 minutes
- The Soil Conservation Service (SCS) Type II, 24-hour storm distribution, shall be used as appropriate.

[The stormwater drainage system is configured and designed according to good engineering practice using the rational method for surface runoff that is commonly known in the civil discipline (does not require a documented source), which is valid for drainage areas less than 200 acres. Although the repository is approximately 1,000 acres, using 200 acres sections and summing partial flows provides a higher value than using the value for 1,000 acres. The SCS is now the Natural Resources Conservation Service (NRCS).]

4.2.8 Not Used

4.2.9 Civil Utilities

4.2.9.1 Underground Piping

Anchor blocks or joint restraints shall be provided for pressure piping systems at all pipe fittings. All underground pipes shall be designed for soil loads and traffic loads. Concrete encasement (reinforced) or pipe casings shall be provided at road crossings or other locations as required by load conditions. Sewer or water main trench widths shall be minimized; however, excavations, trenching, and shoring shall comply with 29 CFR 1926 [DIRS 177634], Subpart P, Excavations, and the *Yucca Mountain Site Geotechnical Report* (CRWMS M&O 1997 [DIRS 111187]). Piping material for fire protection shall meet the requirements of NFPA 24-2006, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances* [DIRS 177972]. Separation and configuration of water mains and sewer lines are designed according to NAC 445A, *Water Controls* [DIRS 104040].

[Underground utility pipes are designed for pressure loads, soil loads, and traffic loads according to good engineering practice. Access mains for fire lines are configured according to good engineering practice.]

4.2.9.2 Buried PVC Sewer Pipe

At a minimum, buried Poly Vinyl Chloride (PVC) sewer pipe shall be SDR 26 for traffic/heavy loading and rail areas, and SDR 35, otherwise. At a minimum, sewer pipe and manhole testing shall meet or exceed the requirements presented in Section 4.2.7.3.

[PVC Pipe - Design and Installation (AWWA 2002 [DIRS 174317]) provide an acceptable industry design methodology for PVC pipe design. The following output in material specification are acceptable for use: ASTM D 1784, Standard Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds, and ASTM D 3034, Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings. Although the 2006 versions were previously specified ([DIRS 178106] and [DIRS 178107], respectively), the latest versions of these material specifications or constraints should be used. The specific date version and DIRS have been moved to Section 8.4.]

4.2.9.3 Not Used

4.2.9.4 Electrical Duct Bank

Electrical duct banks shall be designed as follows:

- Soil and traffic loads at road and railroad crossings shall include H-20 for traffic areas, E-80 for rail crossing and 300,000 lb point load for heavy haul areas.
- Located at a depth of a 3-ft minimum cover top of duct bank to finish grade surface. Exceptions to the depth requirement shall be permitted for short portions of 10 percent or less of the entire length of the duct bank run.
- Minimum horizontal clearance between adjacent duct banks shall be 1 ft face to face, except when another utility is a heat source and then the horizontal clearance will be 3 ft.

[The H-20 and E-80 loads for these items are contained in Standard Specifications for Highway Bridges, with 2004 and 2005 Errata (AASHTO 2005 [DIRS 178018]) and Manual for Railway Engineering (AREMA 2007 [DIRS 182893]). The 300,000 lbs. point load (airport) rating for heavy haul areas is from US DOT FAA Advisory Circular No. 150/5320-6D: Airport Pavement Design and Evaluation (U.S. DOT; FAA 1995 [DIRS 183013]. This criterion is used to facilitate interfaces between the duct bank routing and other underground utilities. This is a common practice in industry for a reliable power distribution system.]

4.2.9.5 Pipe Rack Utilities

Pipe rack utilities shall be designed based on the structural design criteria. Foundation design recommendations for isolated spread footings shall be in accordance with structural design criteria in *Soils Report for North Portal Area, Yucca Mountain Project* (BSC 2002 [DIRS 159262]) and *Supplemental Soils Report* (BSC 2007 [DIRS 182582])**.**

[Pipe rack utilities design is based on structural design criteria and soil loads as specified in the referenced documents and according to good engineering practice.]

4.2.9.6 Fencing

The repository restricted area perimeter shall be fenced to prevent intrusion into the area. Fencing shall be limited to that required for safety, physical security, and activity control.

- The overall fence height, including barbed wire topping, shall be 8 ft nominal and zero ground clearance.
- Fencing shall be topped with three strands of barbed wire on outriggers angled outward, away from the security area. Tension wires at top and bottom shall be used to secure the fence fabric.
- Perimeter fence shall meet the security requirements of the site. Posts, bracing, and other structural members shall be located on the inside of secured perimeters.
- All permanent fencing material shall be 9-gauge, galvanized steel fabric (ASTM A 392, *Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric,* is acceptable) with mesh openings not larger than 2 in.
- All posts shall be set in concrete. Concrete foundation shall be designed to withstand any strain or shocks ordinarily brought to bear on the fence.
- Gates shall be double swing, unless called out as roll and slide type.
- All permanent fencing, including around substations, fuel storage areas, and other hazardous areas, shall be electrically grounded in accordance with NFPA 70-2005 [DIRS 177982].

[Fencing configuration, material, and construction are required for security and good engineering practice.

Grounding is in accordance with NFPA 70. Although the 2003 version of ASTM A 392 [DIRS 174875] was previously identified here as an output material specification or constraint, the date version and DIRS 174875 have been removed. The latest version of the standard should be utilized. ASTM A 392 has been moved to Section 8.4. For example, at least a 2006 and 2007 versions have been issued since this constraint was selected. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.2.9.7 Deleted

[Appropriate Yard Fire Protection design criteria is presented in Section 4.9.1.11.]

4.2.9.8 Field-Erected Tanks

Water tanks (for purposes other than fire protection) shall be designed in accordance with:

- ANSI/AWWA D100-05, *Welded Carbon Steel Tanks for Water Storage* [DIRS 177866]
- ANSI/AWWA D103-97, *AWWA Standard for Factory-Coated Bolted Steel Tanks for Water Storage* [DIRS 178182]
- API Std 2000, *Venting Atmospheric and Low-Pressure Storage Tanks, Non-refrigerated and Refrigerated, with Errata* [DIRS 169966].

Tanks for fire water storage and/or water tanks used for dual purposes that include fire protection shall be designed to NFPA 22-2003, *Standard for Water Tanks for Private Fire Protection* [DIRS 165075].

Fuel oil, chemical tanks, or other process tanks shall be designed to:

- API Std 650, *Welded Steel Tanks for Oil Storage, with Addendum 3* [DIRS 171925]
- API Std 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks, with Addendum 1* [DIRS 176388]
- API Std 2000, *Venting Atmospheric and Low-Pressure Storage Tanks, Non-refrigerated and Refrigerated, with Errata* [DIRS 169966].

[These are industry standards that are appropriate for the specified use. Although a later version of API Std 650 is available, the responsible DEM has elected to utilize the referenced version.]

4.2.9.9 Tank Foundation Loading

Tanks shall be designed for the following loading and ambient conditions:

- Roof load (including snow load)
- Design wind velocity
- Seismic load
- Lowest 1-day mean ambient temperature
- Allowable soil pressure
- Ambient temperature range.

Minimum corrosion allowances for various tank elements shall be:

- Bottom, 1/8 in.
- Shell, 1/16 in.
- Roof plate, 1/16 in.
- Webs of roof support members, 1/16 in.

Tanks shall have the following components:

- Roofs, using tubular or pipe section columns to support cone roofs
- Ladders, fittings, and other appurtenances, as required, in accordance with NFPA 22-2003 [DIRS 165075], with ladders terminating 1 ft above finish grade
- Ladders, ladder safety cages, walkways, work platforms, and handrails in accordance with Occupational Safety and Health Administration (OSHA) requirements
- Overflow pipes, vents, nozzles, shell manholes, and roof hatches in accordance with industry standards.
- Liquid-level indicator, as required, in accordance with industry standards
- Supports and fasteners for the liquid-level indicator(s) in accordance with manufacturer recommendations
- Tank foundations in accordance with accepted design practices.
- 1/4 " minimum shell thickness

[Field erected tanks and tank foundations shall be designed for loadings specified in the structural design criteria. Configuration and appurtenances are based on good engineering practice.]

4.2.10 Additional Civil Design Criteria

4.2.10.1 International Building Code

Repository facilities shall be designed in accordance with the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), as modified by NAC 477.283, Sections 2.(c), 2.(f), 2.(g), 2.(i), 2.(j), and 2.(l) [DIRS 182445].

[This is the primary industry standard building code and is applicable to repository facilities and systems. Although 4 errata were issued in 2004 and another in 2005 and complete revisions were issued in 2003 and 2006, these versions have not been adopted by the project at this time. Repository design will, therefore comply with the version specified above. This comment will not be repeated in subsequent criteria. NAC 477.283 made modifications to sections of the IBC 2003 that are being applied to the same sections of the IBC 2000.]

4.2.10.2 Flooding Protection

Repository facilities and SSCs shall be protected from flooding utilizing the guidance in Regulatory Guide 1.102, *Flood Protection for Nuclear Power Plants* [DIRS 117499], and Regulatory Guide 1.59, *Design Basis Floods for Nuclear Power Plants* [DIRS 131488] as follows:

- Portions of the regulatory guide apply to specific geographic locations. Only those portions, which apply to the YMP site, will be adapted.
- Where the regulatory guide refers to "safety related" SSCs, the YMP will replace the term with SSCs ITS or ITWI.
- The term cold shutdown , as used in the regulatory guide, has no meaning at the YMP and will not be considered.

ANSI/ANS-2.8-1992, *American National Standard for Determining Design Basis Flooding at Power Reactor Sites* [DIRS 103071] shall also be utilized to protect the repository ITS SSCs.

[RGA REG-CRW-RG-000086, Agreement for Regulatory Guide 1.102, Rev.1 - Flood Protection for Nuclear Power Plants (BSC 2006 [DIRS 181691]) adopted RG 1.102 with the single clarification of safety-related. RGA REG-CRW-RG-000048, Agreement for Regulatory Guide 1.59, Rev. 2 - Design Basis Flood for Nuclear Power Plants (BSC 2006 [DIRS 181732]) adopted Regulatory Guide 1.59 with clarification of geographic locations and no cold shutdown. Although the repository is not a nuclear power plant, the same principles apply.]

4.2.10.3 Protection Against Accidental Explosions

If a decision is made to utilize any repository facilities for the storage of explosives, these facilities that provide for storage of explosives shall conform to facility structural design and construction that shall comply with the requirements of TM 5-1300, *Structures to Resist the Effects of Accidental Explosions* [DIRS 178041]. Blast-resistant design for personnel and facility protection shall be based on the TNT equivalency of the maximum quantity of explosives and propellants permitted. In accordance with TM 5-1300, the TNT equivalency shall be increased by 20 percent for design purposes.

[DOE O 420.1A [DIRS 159450] Contractor Requirement 4.1.2 provides the requirement text. Although the repository facilities are not currently planned to include facilities that will handle explosives, the final locations or methods of storing explosives has not been determined. Although DOE O 420.1A Section 4.1 also applies to ammunitions, the manual specifically does not apply to the storage of limited quantities of protective force ammunitions. Therefore, the security facilities for protective force personnel do not have to comply with this criterion. Although the order also refers to another manual, it is not applicable and therefore not identified. See Sections 4.1.2 and 4.9.2.1.2]

4.2.10.4 Injection Wells

Injection wells utilized for testing purposes, e.g., injecting dies and tracers, shall comply with NAC 445A, *Water Controls* [DIRS 104040], Section 908, Location and Construction of Wells.

[State regulations provide appropriate citing and design criteria for these wells. Injection wells are only used for testing purposes and not for injecting waste streams.]

4.2.10.5 Building Design and Passive Fire Resistance Features

Building layout (e.g., fire areas and zones), materials of construction, and building system design (e.g., electrical, HVAC, lighting, and communication systems) shall be designed to effectively prevent fires and provide appropriate level of protection in accordance with Regulatory Guide 1.189 [DIRS 155040] Sections C.4.1.1 through C.4.1.3.6 and C.4.2 through C.4.3.2.3.

[RGA REG-CRW-RG-000164, Agreement for Regulatory Guide 1.189, REV. 0 - Fire Protection for Nuclear Power Plants (BSC 2007 [DIRS 181799]) adopted this guidance. Other portions of the guidance are applied to specific systems. Although NUREG-1804, Yucca Mountain Review Plan (NRC 2003 [DIRS 163274]) included a reference to Regulatory Guide 1.120, Fire Protection Guidelines for Nuclear Power Plants [DIRS 178101], the NRC superseded this guide with Regulatory Guide 1.189 with clarification. Although Section 4.9.1 of this document also contains guidance from Regulatory Guide 1.189, this comment will not be reproduced each time it is used.]

4.2.11 Structural Surface Design Criteria

4.2.11.1 Structures Providing Protection

Repository structures shall provide protection in accordance with 10 CFR 73 [DIRS 181969].

[Portions of this document must be implemented by the structural design of SSCs.]

4.2.11.2 Structural Categorization of SSCs

The surface facilities in the repository handle large quantities of radioactive and hazardous materials. Natural phenomena hazards such as earthquakes, winds, and floods can result in the uncontrolled release of these materials. Consequently, it is necessary to ensure that facility structures shall be designed to withstand the effects of those natural phenomena events that are postulated to occur during the life of the facility. To ensure that an adequate level of protection is provided for facility workers, co-located workers, and the public from the potential consequences associated with natural phenomena hazards, a graded approach has been employed in the natural phenomena hazard design of the repository. Specific natural phenomena hazard design inputs (values) are addressed in Section 6.

4.2.11.2.1 Seismic Ground Motion for Surface ITS SSCs

Seismic analysis and design for ITS SSCs shall be assigned design basis ground motions (DBGMs) based on dose consequences of 10 CFR 63.111 [DIRS 180319], due to postulated Category 1 and Category 2 event sequences. For this purpose, three different levels of seismic ground motions are considered in terms of return periods:

- DBGM-1: Mean annual probability of exceedance of 1×10^{-3} (1,000-yr return period)
- DBGM-2: Mean annual probability of exceedance of 5×10^{-4} (2,000-yr return period)
- Beyond design basis ground motion (BDBGM): Mean annual probability of exceedance of 10^{-4} (10,000-yr return period)

Seismic designs of ITS SSCs assigned either DBGM-1 or DBGM-2 shall be prepared to meet the governing code allowable acceptance criteria. Some ITS SSCs are not required following a seismic initiating event and their seismic design is governed by other repository requirements.

In addition, SSCs ITS designed for DBGM-2 will be evaluated at BDBGM to demonstrate the capacity of the SSCs ITS to perform their intended safety functions consistent with the methods outlined in *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report* (DOE 2007 [DIRS 181572]).

The selection of damping values used in the analysis of ITS SSCs at Yucca Mountain is based on the industry values as provided in ASCE/SEI 43-05, *Seismic Design Criteria For Structures, Systems, and Components in Nuclear Facilities* [DIRS 173805], Section 3.4.3.

The site specific seismic hazard evaluation shall be performed in accordance with Regulatory Guide 1.165, *Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion* [DIRS 119139].

[The Seismic Topical Report (DOE 2007 [DIRS 181572]) provides an accepted methodology for the repository preclosure period. RGA REG-CRW-RG-000050 Rev 01, Agreement for Regulatory Guide 1.61, Rev. 1 - Damping Values for Seismic Design of Nuclear Power Plants (BSC 2007 [DIRS 182802]) indicated that ASCE/SEI 43-05 is

an acceptable alternative to Regulatory Guide 1.61, Rev 1 [DIRS 182003], which will not be used. RGA REG-CRW-RG-000140, Agreement for Regulatory Guide 1.165, Rev. 0, Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion (BSC 2007 [DIRS 181813]) provided agreement to use Regulatory Guide 1.165 with clarifications. The site-specific seismic hazard evaluation and development of the site-specific ground motion for seismic design and evaluation is contained in a variety of project-developed documents. The process followed, methodology and data utilized, and results obtained shall be considered appropriate for the YMP repository. The risk-informed performance-based process forms the basis for seismic design and evaluation of SSCs.]

4.2.11.2.2 Seismic Use and Importance Factors for Surface Non-ITS SSCs

Non-ITS SSCs shall be designed to the *International Building Code 2000, with Errata to the 2000 International Building Code* (IBC) (ICC 2003 [DIRS 173525]) as follows:

- Seismic Use Group I SSCs shall utilize an importance factor of 1.0 for designing conventional SSCs for standard occupancy
- Seismic Use Group II shall utilize an importance factor of 1.25 for designing SSCs that represent substantial hazards to human life (example: Heavy Equipment Maintenance Facility)
- Seismic Use Group III shall utilize an importance factor of 1.5 for designing essential or hazardous SSCs (example: Warehouse and Non-Nuclear Receipt Facility, Central Control Center Facility (CCCF), and the Administration Facility including the Emergency Operation Center (EOC)).

[The Seismic Use Groups and importance factors are in accordance with ICC 2003. RGA REG-CRW-RG-000455, Agreement for NUREG-0696, Functional Criteria for Emergency Response Facilities - Final Report (BSC 2007 [DIRS 181426]) Table 1, Sections 1.3.2 and 1.3.3 defines specific emergency management functions and communications requirements in NUREG-0696 (NRC 1981 [DIRS 104098]) that dictate defining the CCCF and EOC portion of the Administration Facility as Seismic Use Group III in accordance with the 4th bullet in IBC Table 1604.5. CBCN017 to Revision 6 provided change.]

4.2.11.2.3 Seismic Design for Surface ITS Facilities

Seismic design basis for surface ITS structures are defined in the *Basis of Design for the TAD Canister-Based Repository Design Concept* (BSC 2007 [DIRS 182131]).

[This criterion is considered appropriate for the facility types and functional requirements.]

4.2.11.2.4 Classification of Surface Non-ITS SSCs

The non-ITS switchgear and electrical facilities, WNNRF, CCCF, the Administration Facility including the EOC, and transportation cask staging/buffer areas shall be designed as Seismic Use Group III and as Seismic Design Category D SSCs. The Heavy Equipment Maintenance Facility shall be designed as Seismic Use Group II and Seismic Design Category D SSCs. The utility buildings and remaining balance of plant facilities shall be designed as Seismic Use Group I and Seismic Design Category D SSCs.

[Seismic Design Category D refers to the International Building Code 2000, with Errata to the 2000 International Building Code (ICC 2003 [DIRS 173525]) definition. RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]), Table 1, Sections 1.3.2 and 1.3.3, defines specific emergency management functions and communications requirements in NUREG-0696 (NRC 1981 [DIRS 104098]) that dictate defining the CCCF and EOC portion of the Administration Facility as Seismic Use Group III in accordance with the 4th bullet in IBC Table 1604.5 and Seismic Design Category D. CBCN017 to Revision 6 provided changes.]

4.2.11.2.5 Seismic Design for Surface SSCs

Seismic design and structure response for non-ITS SSCs shall be in accordance with *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]). Seismic analysis for ITS SSCs shall be in accordance with ASCE 4-98, *Seismic Analysis of Safety-Related Nuclear Structures and Commentary* [DIRS 159618]. The seismic response methodology for combination of modal responses and spatial components shall be in accordance with ASCE 4-98. Development of in-structure response spectra in seismic response and analysis will be performed in accordance with ASCE 4-98, Section 3.4, as further clarified in *Seismic Analysis and Design Approach Document* (BSC 2006 [DIRS 180531], Section 7.3.2.2).

[RGA REG-CRW-RG-000077, Agreement for Regulatory Guide 1.92, Rev. 1 - Combining Modal Responses and Spatial Components in Seismic Response Analysis (BSC 2007 [DIRS 182087]) has accepted ASCE 4-98 as an alternative to the guidance provided in Regulatory Guide 1.92 [DIRS 151403]. Although Rev. 2 of the Guide has

been issued, the repository has not adopted it. RGA REG-CRW-RG-000101, Agreement for Regulatory Guide 1.122, Rev.1 - Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components (BSC 2007 [DIRS 182781]) supports using ASCE 4-98 instead of the Guide [DIRS 151404].]

4.2.11.2.6 Seismic Design Margin

EPRI NP-6041-SL, *A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)* [DIRS 161330].

4.2.11.3 Structural Design Loads

SSCs shall be designed for the loads prescribed in this document and as supplemented by any additional criteria for the project.

4.2.11.3.1 Dead Load (D)

Dead loads shall be loads that remain permanently in place.

[Standard structural terminology. This is a commonly accepted definition. No source needed.]

4.2.11.3.2 Live Load (L and Lr)

Live loads (L) shall be those loads produced by the use and occupancy of a building or other structure. Live loads on a roof (L_r) are those loads produced (1) during maintenance by workers, equipment, and materials, and (2) during the life of the structure by movable objects such as temporary equipment. Also considered to be live loads are the dynamic effects of operating equipment such as cranes and pumps.

Live loads on floors shall be based on ASCE 7-98, *Minimum Design Loads for Buildings and Other Structures* [DIRS 149921], unless otherwise defined or computed for specific facilities. Live loads on roofs shall be as stipulated in the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]).

[Standard structural terminology. Using the IBC is good engineering practice. Uniform loads for specific areas are prevailing design loads for similar industrial facilities. A later version of ASCE 7 is available but is not adopted for the repository. The responsible DEM has elected to utilize the ASCE 7-98, since the current design were based on this version of the standard and the later version has not yet been evaluated for suitability.]

4.2.11.3.3 Snow Load (S_n)

All structures (both ITS and non-ITS) shall be designed to snow loads calculated per the methodology of the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), using the parameter values from Section 6.

[Using the IBC is good engineering practice.]

4.2.11.3.4 Ash Load (A)

The roof of the structure shall withstand a design basis volcanic ash fall (Live Load (L and L_r)).

[Monitored Geologic Repository External Events Hazards Screening Analysis (BSC 2005 [DIRS 174235]), Section 6.4.56 Evaluation Item 2 identifies ash fall roof loading. See specific criteria in Section 6.1.11.]

4.2.11.3.5 Lateral Earth Pressure (H)

Every foundation wall or other wall serving as a retaining structure shall be designed to resist (in addition to the vertical loads acting on it) the incident lateral earth pressures and surcharges. The minimum surcharge load shall be 300 lbs/ft^2 for normal vehicular traffic. Dynamic lateral earth pressures due to a design basis earthquake shall be computed for ITS structures from the soil-structure interaction analysis where appropriate. At rest, lateral earth pressure shall be used in the design of structures. Active lateral and passive earth pressures, as appropriate, shall be used in the stability evaluation of structures. Any hydrostatic pressure shall correspond to maximum probable groundwater level. Lateral earth pressure coefficients are summarized in Section 4.2.1.4.

[Surcharge load listed is in conformance with good engineering practice.]

4.2.11.3.6 Wind Load (W)

All structures (both ITS and non-ITS) shall be designed to wind loads calculated per the methodology and provisions of the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525] using the basic wind speed in Section 6.1.3.

[Using the IBC for wind loading is good engineering practice.]

4.2.11.3.7 Tornado Loads (W_t)

Repository ITS structures that are potentially vulnerable to design basis tornados as identified in event sequences shall be designed for tornado loads provided in Section 6.1.4. For conventional quality non-ITS structures, tornado loads are not applicable.

[NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, Draft Report for Comment (NRC 1996 [DIRS 177328]), Section 3.5.1.4. Although NUREG-0800 was revised after 1996 (draft in 2006 and issued in 2007), the project is not specifically adapting the NUREG. It does not specifically apply. The text in the version cited is good information and can be utilized here. RGA REG-CRW-RG-000098, Agreement for Regulatory Guide 1.117, Rev 1 - Tornado Design Classification [DIRS 181701] provides agreement that the repository will meet the intent of the Regulatory Guide 1.117 [DIRS 144751].]

4.2.11.3.8 Seismic Loads (E)

Seismic loads for conventional structures shall be based on seismic use groups listed in the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]. Seismic loads for ITS structures shall be based on the acceleration ground response spectra provided in Section 6.1.10.

[NUREG-0800 (NRC [1989] [DIRS 165110], [DIRS 165111], [DIRS 165112]), Sections 3.7.1, 3.7.2, and 3.7.3, respectively, provides guidance for ITS structures. See comment on NUREG-0800 in Criteria 4.2.11.3.7. Soil-structure interaction effects shall be considered. The IBC provides for conventional quality structures seismic response. Also see Section 6.1.10.]

4.2.11.3.9 Thermal Loads (T_o, T_a)

The design of structures shall include the effects of stresses resulting from variations in temperatures under Category 1 or Category 2 event sequences. Structures shall also be designed for movements resulting from the maximum seasonal temperature change. The design shall provide for the lags between air temperatures and interior temperatures of massive concrete members or structures. The ambient temperature profile provided in Section 6.1.6 shall be used in the determination of the thermal loads.

Operating Temperatures, T_o

Internal temperatures at various locations inside the facility structures during normal operating conditions shall be per the ventilation design criteria.

Accident Temperatures, T_a

Internal temperatures at various locations inside the facility structures during accident conditions shall be identified on a case-by-case basis.

Temperature Effects on Structural Elements

- The temperature effects for structural steel elements shall be in accordance with *Manual of Steel Construction, Allowable Stress Design* (AISC 1997 [DIRS 107063], Part 6).
- The temperature effects for structural concrete elements shall be in accordance with ACI 349-01/349R-01, *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01) and Commentary (ACI 349R-01)* [DIRS 181670], Appendix A.

[The cited standards provide acceptable industry design criteria for the design of structures. Although AISC issued a more recent version, it was combined with another method of design, making it more difficult to implement the allowable stress design methodology. The new AISC volume is not used. This comment will not be repeated in the PDC.]

4.2.11.3.10 Creep and Shrinkage Forces

Effects of creep and shrinkage shall be included with the dead load, as applicable.

[Standard engineering practice.]

4.2.11.3.11 Fluid Load, F

The design of structures shall include the effects of stresses resulting from fluid loads. Fluid loads include loads due to the weight and pressure of fluids with well-defined densities and controllable maximum heights. Fluid loads shall include the effects of horizontal sloshing in accordance with Section 3.5.4.3 of ASCE 4-98 [DIRS 159618].

[Sloshing shall be included in addition to normal fluid loads in accordance with the cited standard.]

4.2.11.3.12 Operating Pipe Reactions~~,~~ (R_o)

Operating pipe reactions shall be included during normal, operating, and shutdown conditions.

[Standard engineering practice.]

4.2.11.3.13 Precipitation Loads

Design basis precipitation (rainfall) shall be in accordance with Section 6.1.2.

[Standard engineering practice.]

4.2.11.3.14 Settlement

Buildings and structures shall be designed for the total and differential foundation settlements resulting from the combined static and dynamic loads. The dynamic settlement is due to dissipation of pore pressure or redistribution of soil stresses from the effects of a design basis earthquake.

[Standard engineering practice.]

4.2.11.3.15 Flood Load (F_a)

Flood loads shall be computed based on the maximum probable flood defined in Section 6.1.9.

[Standard engineering practice.]

4.2.11.3.16 Construction Loads on Steel Deck and Framing Supporting Concrete Slabs

Steel Deck-Steel deck supporting wet concrete shall be designed for the weight of concrete plus a 50-pounds per sq ft (psf) uniformly distributed load.

Structural Steel Framing-Steel framing supporting a steel deck shall be designed for the following load case: The weight of wet concrete plus a 50-psf uniformly distributed load. In addition, a 5,000 lb concentrated load shall be placed anywhere on the span to maximize moment and shear. The concentrated load is not cumulative and shall not be carried to columns.

[Construction loads are values used in good engineering practice.]

4.2.11.3.17 Drop Load

Postulated drop loads shall be evaluated for local damage (e.g., penetration, perforation, and spalling of a concrete slab) as well as for structural integrity. The acceptability of damage due to the dropped load shall be evaluated by the integrated safety management process (e.g., penetration may be acceptable, but perforation may not be acceptable due to loss of confinement). The drop load evaluation shall be based on *Design of Structures for Missile Impact, Topical Report* (Linderman et al. 1974 [DIRS 159274]) or other similar applicable reference guides.

[The Topical Report provides guidance that the nuclear power industry utilities on drop load evaluations and is considered acceptable for use at the repository.]

4.2.11.4 Structural Design Criteria for ITS SSCs

The following design criteria are applicable for ITS structures.

4.2.11.4.1 Reinforced Concrete Design For ITS SSCs

Reinforced concrete structures shall be designed in accordance with the strength design method of ACI 349-01/349R-01, *Code Requirements for Nuclear Safety Related Concrete Structure (ACI 349-01) and Commentary (ACI 349R-01)* [DIRS 181670] and in accordance with Regulatory Guide 1.142, *Safety-Related Concrete*

Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments) [DIRS 177654], Sections C.1 through C.3 and C.6 through C.15 for load combinations and acceptance criteria.

The reinforced concrete structures shall be evaluated for BDBGM seismic levels to ensure the defined seismic safety function(s) are maintained. This will be accomplished by the demonstration of the overall structural performance with limited inelastic behavior. The methodology shown in *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report* (DOE 2007 [DIRS 181572]) shall be utilized for the evaluation of reinforced concrete structures for BDBGM seismic levels.

The aging pad concrete slabs and embedment and cask anchorage steel shall be designed in accordance with ACI 349-01/349R-01.

[RGA REG-CRW-RG-000120, Agreement for Regulatory Guide 1.142, Rev. 2 - Safety Related Concrete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments) (BSC 2007 [DIRS 181746]) provided agreement on utilizing Regulatory Guide 1.142; C4 and C5 are not applicable to design and apply to construction. Although RG-1.142 specifies using one version of ACI 349, the RGA provides agreement to utilize the 2001 version. The methodology shown in the Topical Report is applicable for concrete structures evaluated for limited inelastic behavior at BDBGM seismic levels. Although RG-1.142 also refers to ACI 318, it is not adopted per the RGA; use ACI 349 instead. ACI 349-01/349R-01 is the code for safety-related concrete structures and is appropriate for concrete ITS SSCs. RGA REG-CRW-RG-000058, Agreement for Regulatory Guide 1.69, Rev. 0 - Concrete Radiation Shields for Nuclear Power Plants [DIRS 181671] provides agreement that ACI 349-01 is an acceptable alternative to the guide [DIRS 158959].]

4.2.11.4.2 Structural Steel Design For ITS SSCs

Steel structures shall be designed in accordance with ANSI/AISC N690-1994, *Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities* [DIRS 158835], for load combinations and acceptance criteria, along with Supplement 2 to ANSI/AISC N690-1994 [DIRS 177028]. Proportioning and detailing for seismic loads shall meet the additional requirements of ANSI/AISC 341-02, *Seismic Provisions for Structural Steel Buildings* [DIRS 171789], Part III. Steel structures shall be evaluated for a BDBGM seismic level in accordance with ANSI/AISC N690-1994 to assess the overall structural performance for demonstration that building safety is not impaired with limited inelastic behavior. The methodology shown in *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report* (DOE 2007 [DIRS 181572]) shall be utilized for the evaluation of steel structures for BDBGM seismic level.

[ANSI/AISC N690-1994 is the code for safety-related steel structures. Therefore, it will be used for steel ITS SSCs. ANSI/AISC 341-02 applies to all steel buildings. The methodology shown in the topical report was developed specifically to address project SSCs and is applicable for steel structures evaluated for limited inelastic behavior at BDBGM seismic levels.]

4.2.11.4.3 Masonry Design

Use of masonry shall not be permitted for ITS structures.

[Construction difficulties make it difficult to get the desired strength in masonry SSCs.]

4.2.11.4.4 Load Factors, Load Combinations, and Acceptance Criteria

Notations:
A = Ash load
D = Dead load
L = Live load
L_r = Roof live load
S_N = Snow load
E = Earthquake (seismic) load resulting from DBGM-1, DBGM-2, and BDBGM seismic level definition
H = Lateral earth pressure load
T_a = Thermal loads during accident condition
T_o = Thermal loads during normal operating conditions
F = Fluid load

F' = Buoyant force of design basis flood
R_o = Operating pipe reaction load
S = Allowable stress per allowable stress design (ASD) method
U = Required strength per strength design method
W = Wind load
W_t = Tornado load (This includes effects from tornado wind pressure, tornado-created differential pressure, and tornado-generated missiles.)
Y_m= Missile impact equivalent static load on structure generated by drop load and including appropriate dynamic load factor to account for the dynamic nature of the load. (In determining an appropriate static load for Y_m, elasto-plastic behavior may be assumed with appropriate ductility ratios, provided excessive deflection will not result in loss of function of any SSCs ITS.)

In the load combinations provided in this section, the following conditions shall be considered:

A. Where the structural effects of differential settlement, creep, or shrinkage may be significant, they shall be included with the dead load D in all the load combinations. Estimation of these effects shall be based on a realistic assessment of such effects occurring in service.

B. Where any load reduces the effect of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load shall be taken as zero.

C. In the load combinations that include Y_m, appropriate dynamic load factor should be used unless a time-history analysis is performed to justify otherwise.

D. In the load combinations that include W_t or Y_m, the corresponding acceptance limits (U, 1.6S, or 1.7S) should be satisfied first without a tornado missile load of W_t, or without Y_m. When considering these concentrated missile loads, local section strength capabilities may be exceeded provided there would be no loss of function of any SSCs ITS system.

[Definitions given are standard structural definitions. Conditions listed are to be used with load combinations are good engineering practice. Load combination are derived in part from ACI 349-01/349R-01 [DIRS 181670], E_{ss} of Section 9.2, and ANSI/AISC N690-1994 [DIRS 158835], E_{ss} of Table Q1.5.7.1, p.22. RGA REG-CDR-RG-000120 (BSC 2007 [DIRS 181746]) adopted RG-1.142 [DIRS 177654] that supports using ACI 349. The RGA specifies using the version listed.]

4.2.11.4.5 Reinforced Concrete Design Load Combinations

Load combinations for ITS SSCs reinforced concrete shall be based on ACI 349-01/349R-01, *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01) and Commentary (ACI 349R-01)* [DIRS 181670], Section 9.2, and NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*, *LWR Edition, Draft Report for Comment* (NRC 1996 [DIRS 177328], Paragraphs II.3.b(ii) and II.5.a of Section 3.8.4). The required ultimate strength (u) shall be the maximum of the following:

1. $U = 1.4D+1.7L+1.7(L_r \text{ or } A)+1.4F+1.7H+1.7R_o$
2. $U = 1.4D+1.7L+1.7S_N+1.4F+1.7H+1.7R_o$
3. $U = 1.4D+1.7L+1.7L_r+1.4F+1.7H+1.7R_o+1.7W$
4. $U = 1.4D+1.7L+1.7S_N+1.4F+1.7H+1.7R_o+1.7W$
5. $U = 1.05D+1.3L+1.3(L_r \text{ or } A)+1.05F+1.3H+1.05T_o+1.3R_o$
6. $U = 1.05D+1.3L+1.3S_N+1.05F+1.3H+1.05T_o+1.3R_o$
7. $U = 1.05D+1.3L+1.3L_r+1.05F+1.3H+1.3W+1.05T_o+1.3R_o$
8. $U = 1.05D+1.3L+1.3S_N+1.05F+1.3H+1.3W+1.05T_o+1.3R_o$
9. $U = D+L+L_r+F+H+T_o+R_o+E$
10. $U = D+L+L_r+F+H+T_o+R_o+W_t$
11. $U = D+L+S_N+F+H+T_o+R_o+E$
12. $U = D+L+L_r+F+H+T_a+R_o$
13. $U = D+L+S_N+F+H+T_a+R_o$
14. $U = D+L+L_r+F+H+T_a+R_o+E+Y_m$
15. $U = D+L+L_r+F+H+T_a+R_o+W_t$
16. $U = D+L+S_N+F+H+T_a+R_o+E+Y_m$
17. $U = D+L+S_N+F+H+T_a+R_o+W_t$

[Although ACI 349-01/349R-01 provided only eleven of the items above, NUREG-0800 provided the remaining items and added terms to those listed in ACI 349-01/349R-01. These are acceptable criteria for the ITS SSCs. RGA REG-CRW-RG-000120 (BSC 2007 [DIRS 181746] adopted Regulatory Guide 1.142 [DIRS 177654] that

supports using ACI 349. The RGA specifies the version to use. Although NUREG-0800 was revised in 2007, the version specified (1996) specifically contains this information while the 2007 version does not. The specified version is acceptable for use.]

4.2.11.4.6 Structural Steel Design Load Combinations

Load combinations for ITS SSCs structural steel shall be based on ANSI/AISC N690-1994 [DIRS 158835], Table Q1.5.7.1, along with Supplement 2 to ANSI/AISC N690-1994 [DIRS 177028], and NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, Draft Report for Comment* (NRC 1996 [DIRS 177328], Paragraphs II.3.c.i(a), II.3.c.ii(a), and II.5.b of Section 3.8.4):

1. $S = D+L+(L_r \text{ or } A)$
2. $S = D+L+S_N$
3. $S = D+L+(L_r \text{ or } A)+R_o+T_o$
4. $S = D+L+S_N+R_o+T_o$
5. $S = D+L+L_r+W$
6. $S = D+L+S_N+W$
7. $S = D+L+L_r+W+R_o+T_o$
8. $S = D+L+S_N+W+R_o+T_o$
9. $1.6\ S = D+L+L_r+R_o+T_o+E$
10. $1.6\ S = D+L+S_N+R_o+T_o+E$
11. $1.6\ S = D+L+L_r+R_o+T_o+W_t$
12. $1.6\ S = D+L+S_N+R_o+T_o+W_t$
13. $1.6\ S = D+L+L_r+T_a+R_o$
14. $1.6\ S = D+L+S_N+T_a+R_o$
15. $1.7\ S = D+L+L_r+T_a+R_o+E+Y_m$
16. $1.7\ S = D+L+S_N+T_a+R_o+E+Y_m$
17. $1.7\ S = D+L+L_r+T_a+R_o+W_t$
18. $1.7\ S = D+L+S_N+T_a+R_o+W_t$.

In load combinations 9 through 18, the stress limit in shear shall not exceed 1.4S in members and bolts.

[ANSI/AISC N690-1994, along with Supplement 2, and NUREG-0800 provide acceptable criteria. Although NUREG-0800 was revised in 2007, the version specified (1996) specifically contains this information while the 2007 version does not. The specified version is acceptable for use.]

4.2.11.4.7 Stability Criteria for ITS SSCs

ITS structures shall be evaluated to demonstrate that the buildings are adequately stable against sliding and overturning effects for the following load combinations:

1. $O/S = FS\ (D + H + W)$
2. $O/S = FS\ (D + H + E)$
3. $O/S = FS\ (D + H + W_t)$.

NOTE: O/S = overturning/sliding resistance; FS = factor of safety.

The stability against sliding and overturning shall be verified using the static evaluation approach comparing forces and moments versus resistance using a factor of safety of 1.5 for load combination No. 1 and 1.1 for load combinations No. 2 and 3. If static approach is not possible, the following approaches will be used:

- Stability against overturning due to seismic forces shall be evaluated by the energy approach (where the factor of safety against overturning shall be calculated as the ratio of potential energy required to cause overturning about one edge of the structure to the maximum kinetic energy in the structure due to the earthquake).
- The effect of building sliding due to seismic forces shall be evaluated by the use of energy or time-history approach to demonstrate that any potential building displacements are inconsequential to the structural integrity of the building. However, the commodities (piping and electrical cable) attached to the building shall be designed so that the commodities shall have an adequate factor of safety to withstand the results from the building displacements.

[The listed load combinations for evaluating sliding and overturning are from NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, Draft Report for Comment (NRC 1996 [DIRS 177328]), Section 3.8.5, Paragraph II.5. Resistance against overturning shall be evaluated by energy approach, and the effect of building sliding shall be evaluated by the use of energy or time history approaches.]

4.2.11.4.8 Deflection Limits

Deflections in ITS reinforced concrete members shall be computed based on cracked section properties and deflections controlled in accordance with ACI 349-01/349R-01, *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01) and Commentary (ACI 349R-01)* [DIRS 181670], Section 9.5.

Deflections in ITS structural steel members shall be in accordance with ANSI/AISC N690-1994, *American National Standard Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities* [DIRS 158835], Section Q1.13, and Comments CQ1.13, along with Supplement 2 to ANSI/AISC N690-1994 [DIRS 177028].

Deflections in crane runway support beams and monorails shall utilize the following:

- Maximum vertical deflection (loads without impact) = Lr/600,
- Maximum lateral deflection = Lr/400
- Steel deck - The live load deflection shall not exceed span/240.

[RGA REG-CRW-RG-000120 (BSC 2007 [DIRS 181746]) adopted RG-1.142 [DIRS 177654] that supports using ACI 349. The RGA specifies the version listed. ANSI/AISC N690-1994 and CMAA 70-2004 Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes [DIRS 176257] provide adequate industry standards for deflections and specifically provide for Lr/400 and Lr/600.]

4.2.11.4.9 Anchorage

Anchorage rods and concrete expansion anchors design for SSCs ITS shall be in accordance with ACI 349-01/349R-01, *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01) and Commentary (ACI 349R-01)* [DIRS 181670], Appendix B.

Allowable design capacities of concrete expansion anchors shall be based on manufacturer recommendations and shall include a minimum factor of safety of 4 of the mean ultimate capacity. Manufacturer test data shall be current and shall be approved and published by the International Conference of Building Officials.

[RGA REG-CRW-RG-000120 (BSC 2007 [DIRS 181746]) adopted RG-1.142 [DIRS 177654] that supports using ACI 349. The RGA specifies the version listed.]

4.2.11.4.10 Story Drift

Story drift for ITS structures shall be calculated from a dynamic, elastic analysis and include translational as well as torsional deflections. Calculated story drift shall not exceed 0.01 times the story height for structures with a contribution to distortion from shear and flexure. For structures in which shear distortion is the primary contributor to drift, the calculated story drift shall not exceed 0.004 times the story height.

[Story drift limitations for ITS structures conform to good engineering practice.]

4.2.11.4.11 Foundation Design

The foundation design for ITS structures shall meet the requirements of NUREG-0800 (NRC 1996 [DIRS 177328]), Section 3.8.5. For ITS structures, the foundation stability is addressed in Criterion 4.2.11.4.7 of this document.

[Although NUREG-0800 was revised in 2007, the version specified (1996) provides acceptable industry guidance and is consistent with other criteria that only existed in previous (specified) version.]

4.2.11.5 Structural Design Criteria for Non-ITS SSCs

4.2.11.5.1 Seismic Design of Non-ITS SSCs

Non-ITS SSCs shall be designed in accordance with the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]).

4.2.11.5.2 Reinforced Concrete Design

Non-ITS reinforced concrete structures shall be designed in accordance with ACI 318-02/318R-02, *Building Code Requirements for Structural Concrete (ACI 318-02) and Commentary (ACI 318R-02)* [DIRS 158832].

[ACI 318-02/318R-02 is the standard engineering code for reinforced concrete conventional structures. The responsible Discipline Engineering Manager has determined that ACI 318-02/318R-02 is appropriate for use in the design instead of the latter revision (ACI 318-05/318R-05).]

4.2.11.5.3 Structural Steel Design

Non-ITS steel structures shall be designed in accordance with the *Manual of Steel Construction, Allowable Stress Design* (AISC 1997 [DIRS 107063] and *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, June 1, 1989, with Commentary* (AISC 1989 [DIRS 159157]).

[The ASD methodology (AISC 1989) is widely accepted for structural steel design and detailing requirements as listed in the IBC. Although a more recent standard is available that includes the ASD methodology, it zippered the ASD with another methodology such that the use of the ASD was more difficult, making the newer document an undesirable standard to follow. CBCN011 to Revision 6 restored the reference to AISC 1989, which does not blend the ASD with alternative load factor methods.]

4.2.11.5.4 Masonry Design

Masonry shall be designed in accordance with the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]).

[Masonry is acceptable for conventional structures. Using the IBC is good engineering practice.]

4.2.11.5.5 Load Factors, Load Combinations, and Acceptance Criteria

Notations:
D = Dead Load
L = Live Load
L_r = Roof Live Load
S_N = Snow Load
E = Earthquake (Seismic) Load
H = Lateral Earth Pressure Load
T_a = Thermal Force
F = Fluid Load
S = Allowable Stress per ASD Method
U = Required Strength per Strength Design Method
W = Wind Load.

In the load combinations provided in Sections 4.2.11.5.6 , 4.2.11.5.7, and 4.2.11.5.8, the following load conditions shall be considered:
A. Where the structural effects of differential settlement, creep, or shrinkage may be significant, they shall be included with the dead load D in all the load combinations. Estimation of these effects shall be based on a realistic assessment of such effects occurring in service.
B. Where any load reduces the effect of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load shall be taken as zero.

[Definitions given are standard structural definitions. Conditions listed are to be used with load combinations, which are good engineering practice.]

4.2.11.5.6 Reinforced Concrete Design Load Combinations

Load combinations for non-ITS SSC reinforced concrete shall be based on ACI 318-02/318R-02 [DIRS 158832], Section 9.2, and the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525], Section 1605.2.1):

1. $U = 1.4(D+F)$
2. $U = 1.2(D+F+T)+1.6(L+H)+0.5(L_r \text{ or } S_N)$
3. $U = 1.2D+1.6(L_r \text{ or } S_N)+(1.0L \text{ or } 0.8W)$
4. $U = 1.2D+1.6W+1.0L+0.5(L_r \text{ or } S_N)$
5. $U = 1.2D+1.0E+1.0L+0.2S_N$
6. $U = 0.9D+1.6W+1.6H$
7. $U = 0.9D+1.0E+1.6H$

NOTES: 1. The load factor on L in load combinations 3, 4, and 5 above shall be permitted to be reduced to 0.5 except for garages, areas occupied as places of public assembly, and all areas where L is greater than 100 lbs/ft^2.

2. The load factor for H shall be zero in load combinations 6 and 7 if structural actions due to H counteract that due to W or E. Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in H but shall be included in the design resistance.

[The design load combinations listed for reinforced concrete are based on ACI 318-02/318R-02 and ICC 2003 which, are appropriate industry standards. These are to be used for conventional SSCs. The responsible Discipline Engineering Manager has determined that ACI 318-02/318R-02 is appropriate for use in the design instead of the latter revision (ACI 318-05/318R-05).]

4.2.11.5.7 Structural Steel Design Load Combinations

Load combinations for non-ITS SSC structural steel shall be based on the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525], Section 1605.3.2):

1. $S = D+L+L_r$
2. $S = D+L+S_N$
3. $S = 0.75(D+L+1.3W)$
4. $S = 0.75(D+L+S_N/2+1.3W)$
5. $S = 0.75(D+L+S_N+0.65W)$
6. $S = 0.75(D+L+S_N+E/1.4)$
7. $S = 0.75(0.9D+E/1.4)$.

Exception: Crane hook loads need not be combined with roof live load or with more than three-fourths of the snow load or one-half of the wind load.

NOTE: For anchorages against overturning, uplift, and sliding, where portions of resistance are provided by dead load, only 2/3 of the minimum dead load likely to be in place during the design wind event shall be used.

[The design load combinations listed for structural steel are based on the ICC 2003, Section 1605.3.2. These are to be used for conventional SSCs.]

4.2.11.5.8 Masonry Design Load Combinations

Load combinations and acceptance criteria for masonry design shall be in accordance with the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525], Chapter 21).

[This is good engineering practice.]

4.2.11.5.9 Stability Criteria for Conventional Structures

Conventional structures shall be evaluated to demonstrate that the buildings are adequately stable against sliding and overturning effects for the following load combinations:

Load Combination

1. $O/S = (FS)(D + H + W)$

$O/S = (FS)(D + H + E/1.4)$

O/S = overturning or sliding resistance

FS = factor of safety (FS = 1.5)

[The load combinations listed conform to good engineering practice.]

4.2.11.5.10 Deflection Limits

Control of deflections in non-ITS reinforced concrete members shall be in accordance with ACI 318-02/318R-02, *Building Code Requirements for Structural Concrete (ACI 318-02) and Commentary (ACI 318R-02)* [DIRS 158832], Section 9.5. Control of deflections for non-ITS structural steel members shall be in accordance with AISC 1997 [DIRS 107063], Section L3, and commentary Section L3.

Control of deflections in crane runway support beams and monorails for non-ITS SSCs is the same as for ITS SSCs. Allowable live load deflection of steel deck for non-ITS SSCs is the same as for ITS SSCs defined in Section 4.2.11.4.8.

[ACI 318-02/318R-02 and AISC 1997 are industry standards that are applicable to conventional structures. The use of the same deflection limits as for ITS SSCs provides additional margin in the design. The responsible Discipline Engineering Manager has determined that ACI 318-02/318R-02 is appropriate for use in the design

instead of the latter revision (ACI 318-05/318R-05).]

4.2.11.5.11 Anchorage

Anchorage design of conventional SSCs using anchor rods shall be in accordance with the ACI 318-02/318R-02, *Building Code Requirements for Structural Concrete (ACI 318-02) and Commentary (ACI 318R-02)* [DIRS 158832], Appendix D.

Allowable design capacities of concrete expansion anchors shall be based on manufacturer recommendations. Manufacturer test data shall be current and shall be approved by the International Conference of Building Officials.

Anchorage of conventional concrete and masonry walls shall be capable of resisting the largest of the horizontal forces specified in the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), Sections 1604.8.2 and 1620.2.0. Walls shall be designed to resist bending between anchors where the anchor spacing exceeds 4 ft. Anchors in masonry walls of hollow units or cavity walls shall be embedded in a reinforced grouted structural element of the wall.

[The American Concrete Institute formally adopted the Strength of Design of Anchorage to Concrete (Cook 1999 [DIRS 159359]) contents with some modifications to equations into ACI 318-02/ACI 318R-02. This negates the need to use Cook 1999. The responsible Discipline Engineering Manager has determined that ACI 318-02/318R-02 is appropriate for use in the design instead of the latter revision (ACI 318-05/318R-05). Anchorage of walls is based on the largest of forces specified in the ICC 2003, which was adopted by the project.]

4.2.11.5.12 Story Drift

Story drift for conventional structures shall be based on the provisions of the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525], Section 1617.3).

[The IBC provides an acceptable industry standard for story drift.]

4.2.11.5.13 Foundation Design

Foundation design for the conventional structures shall be in accordance with the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), Chapter 18.

[The IBC provides an acceptable industry standard for the foundation design.]

4.2.11.6 Materials

4.2.11.6.1 Structural Steel

Structural steel material designation shall be those material constraints identified in Table 4.2-1.

Table 4.2-1. Structural Steel Material Designation

Section(s)	ASTM Standard	F_y (ksi)	F_u (ksi)
W-shapes	A 992/A 992M	50	65
M-shapes	A 36/A 36M	36	58
S-shapes	A 36/A 36M	36	58
HP-shapes	A 36/A 36M	36	58
Channels	A 36/A 36M	36	58
Angles	A 36/A 36M	36	58
Structural plate	A 36/A 36M	36	58
Structural tees	(per source of split section)		
Steel pipe	A 53/A 53M	35	60
Round hollow structural shape	A 500-03a Grade B [DIRS 176418]	42	58
Square and rectangular hollow structural shape	A500-01a Grade B [DIRS 158930]	46	58
Anchor rods	F 1554	36/55	58/75

Welded studs	A 108	*	*
Steel deck (galvanized)	A 653/A 653M	33	*
Stainless steel plates	*	*	*

* To be added later.

[The structural steel material constraints identified conform to what is considered good engineering practice. Although specific date versions (with DIRS numbers) were specified, these material specifications are outputs and not source references and are now listed in Section 8.4 [DIRS 177898, 176249, 177894, 176429, 176403, and 177895]. The latest version of the standards may be utilized. ASTM A500 has two versions specified with different parameter values. These two are not to use latest versions, but those specified.]

4.2.11.6.2 Concrete and Reinforcing

Concrete - The 28-day compressive strength, f'_c, for the concrete shall be the choice of the design engineer for a given application. The design f'_c for the given application shall be indicated on the structural drawings. The following f'_c values are recommended for the design of surface facilities.

Structures ITS, f'c = 4,000 psi or 5,000 psi
Conventional Structures, f'c = 3,000 psi or 4,000 psi.

Reinforcing steel shall comply with ASTM A 706/A 706M-06a, *Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement* [DIRS 177896]. ASTM A 615/A 615M-06a, *Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement* [DIRS 177891], Grade 60 reinforcement shall be permitted if:

- The actual yield strength based on mill tests does not exceed the specified yield strength by more than 18,000 psi (retests shall not exceed this value by more than an additional 3,000 psi).
- The ratio of the actual ultimate tensile strength to the actual tensile yield strength is not less than 1.25.

Welded Wire Fabric: ASTM A 185/A 185M, *Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete*.

[Compressive strength specified is reasonable for the area of use. Either ASTM A 706/A 706M-06a or ASTM A 615/A 615M-06a may be used for reinforcing steel providing ASTM A 615/A 615M-06a meets the requirements stated for ductility.

Although a specific date version of ASTM A 185/A 185M [DIRS 177883] (with DIRS number) was specified, this material specification constraint is an output and not a source reference and has been moved to Section 8.4. The other two specifications require particular application to a specific use and the specified version shall be used. The latest version of this standard may be utilized.]

4.2.11.6.3 Masonry

All masonry shall be composed of grouted hollow concrete units and shall have a minimum compressive strength, f_m, of 1,500 psi. The minimum compressive strength shall be reduced by 50 % unless special inspection requirements are specified for the construction of masonry elements.

[Requirements given conform to good engineering practice.]

4.2.11.6.4 Structural Bolting Materials

Structural bolting shall be in accordance with ASTM A 325-06, *Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength* [DIRS 177892] or ASTM A 490-06, *Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength* [DIRS 177893].

Structural connections shall be bearing type connections except where slip critical connections are essential (such as load reversal). Sizes for structural bolting material should be limited to 7/8-in. diameter for all ASTM A 325-06 bolts or 1-1/8-in. diameter for ASTM A 490-06 bolts. Bolting of members that are not considered to be part of the main building structure (i.e., stair or platform connections) may utilize ASTM A 307, *Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength* bolts. The maximum size of ASTM A 307 bolts shall be 3/4-in. diameter.

[ASTM A 325-06 or ASTM A 490-06 bolts may be used for structural steel connections depending on the size of the forces being resisted. Limiting the size for each negates the possibility of using the wrong strength bolt in any

connection. ASTM A 307 bolts are sufficient for the application given. Although a specific date version of ASTM A 307-04 [DIRS 177889] (with DIRS number) is specified, this material specification constraint is an output and not a source reference and has been moved to Section 8.4. The other two specifications require specific structural/building application and the specified version shall be used. The latest version of ASTM A 307 may be utilized.]

4.2.11.6.5 Welding Material

Welding electrodes shall be E70XX in accordance with AWS D1.1/D1.1M, *Structural Welding Code-Steel (with Errata)*.

[The welding electrodes specified are commonly used in steel construction. Although a specific date version or revision (2006 [DIRS 176256]) is specified, this material specification is an output and not a source reference and has been moved to Section 8.4. The latest version of the standard may be utilized.]

4.2.11.6.6 Structural Analysis/Design Material Properties

The following values shall be used in an analysis of steel and concrete structures:

Steel: Modulus of Elasticity $E_s = 29 \times 10^6$ psi
Poisson's Ratio $\nu = 0.3$
Concrete: Modulus of Elasticity $E_c = 3.32 \times 10^6$ psi (for $f'_c = 3,000$ psi)
$E_c = 3.83 \times 10^6$ psi (for $f'_c = 4,000$ psi)
$E_c = 4.29 \times 10^6$ psi (for $f'_c = 5,000$ psi)
Poisson's Ratio $\nu = 0.17$

NOTE: The above value for E, the modulus of elasticity for concrete, is determined in accordance with ACI 318-02/318R-02 [DIRS 158832], Section 8.5, or ACI 349-01/349R-01 [DIRS 181670], Section 8.5, where:
$E_c = w_c^{1.5}\, 33\, (f'_c)^{1/2}$
where w_c is the unit weight for concrete in lb/ft^3.

For design calculations, the following unit weight (material density) values shall be used:
Concrete: 150 pcf
Steel: 490 pcf.

[The values given for steel and concrete are commonly used in good engineering practice. Although Poisson's Ratio for concrete is typically 0.20 to 0.21 for Portland concrete, the 0.17 specified should bound the analysis for the various mixtures intended or expected to be used. The unit weights are at the high end of the generally accepted ranges. The responsible Discipline Engineering Manager has determined that ACI 318-02/318R-02 is appropriate for use in the design instead of the latter revision (ACI 318-05/318R-05).]

4.2.11.6.7 Foundation Recommendations

Foundation design recommendations from the *Supplemental Soils Report* (BSC 2007 [DIRS 182582] include:

- Foundation pressures for square and continuous footings (Figures 7-2 and 7-3 of report)
- Estimated settlements of square and strip footings (Figures 7-4 through 7-6 of report)
- Estimated settlements for a mat foundation (Table B7-1 of report and Figures B7-6, B7-7, and B7-8)
- Recommended material properties (Table 2-1 of report)
- Recommended surface facilities foundation design parameters (Table 2-2 of report).

[The Supplemental Soils Report (BSC 2007 [DIRS 182582]) *provides adequate parameters for design.]*

4.2.11.7 Structural Life Safety Provisions

Structural design of the repository facilities shall be designed in accordance with the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]) including reference to NFPA 101-2006, *Life Safety Code, with Errata and Tentative Interim Amendments* [DIRS 177965], as modified by NAC 477.283, Sections 2.(c), 2.(f), 2.(g), 2.(i), 2.(j), and 2.(l).

[This provides the industry standard for protecting individuals working in facilities. NAC 477.283 made modifications to sections of the IBC 2003 that are being applied to the same sections of the IBC 2000.]

4.2.11.8 Electrical Support Structures

Repository structures shall support electrical and other equipment to reduce energy usage in accordance with IEEE Std 739-1995, *IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities* [DIRS 116978].

[This provides the industry standard for managing energy use and contains some guidance for civil, structural, and architectural designers, such as for insulating structures.]

4.2.11.9 Crane Support Structures

Repository structures that support ITS cranes shall meet the requirements of ASME NOG-1-2004, *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)* [DIRS 176239].

[ASME NOG-1 provides the industry standard for ITS cranes and structures.]

4.2.11.10 Not Used

4.2.11.11 Deleted

[Items previously included are all covered in other criteria.]

4.2.11.12 Additional Structural Codes and Standards

In addition to those codes and standards previously identified, the following shall apply to repository structural designs:

- ACI 201.2R-01, *Guide to Durable Concrete* [DIRS 158830]
- ACI 301-99, *Specifications for Structural Concrete* [DIRS 158831]
- ACI 530-02/ASCE 5-02/TMS 402-02, *Building Code Requirements for Masonry Structures* [DIRS 158925]
- AISC 303-05, *Code of Standard Practice for Steel Buildings and Bridges* [DIRS 176238]
- ANSI/ANS-57.7-1988 (Reaffirmed 1997), *American National Standard, Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)* [DIRS 177851]
- ANSI/ANS-57.9-1992 (Reaffirmed 2000), *Design Criteria for an Independent Spent Fuel Storage Installation* [DIRS 176945]
- ANSI/ANS-6.4.2-1985 (R1997, R2004), *Specification for Radiation Shielding Materials* [DIRS 177856]
- MIL-STD-1472F Notice 1, *Department of Defense Design Criteria Standard, Human Engineering* [DIRS 170418]
- 29 CFR 1910, Labor: Occupational Safety and Health Standards [DIRS 177507] (parts not already cited)
- DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities* [DIRS 159258]
- DOE-HDBK-1140-2001, *Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance* [DIRS 170491]

4.2.12 Architectural Design Criteria

4.2.12.1 Project Facilities

4.2.12.1.1 Surface Nuclear Facilities

The Canister Receipt and Closure Facilities (CRCF-1, 2, and 3), Receipt Facility, Initial Handling Facility, and Wet Handling Facility shall consist of a reinforced concrete foundation mat, floor slabs, a roof slab, and walls. The floor and roof slabs are supported from concrete walls and the steel floor support system. The vestibules and superstructure above the roof are constructed of steel structures.

The Aging Facility shall be constructed as a reinforced concrete foundation mat.

[The buildings in this area contain heavy industrial processes that require shielding and confinement. Furthermore, they have large seismic loads due to tall heights and large floor areas. These require the use of massive, non-combustible structures and systems. The selection of materials and systems in this area comply with

operational demands as well as applicable codes and standards.]

4.2.12.1.1.1 WHF Spent Fuel Pool

The WHF SSCs shall be designed to the guidance in ANSI/ANS 57.2-1983, *American National Standard Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants* [DIRS 111337] with additions, clarification, and exceptions provided in Regulatory Guide 1.13, *Spent Fuel Storage Facility Design Basis* [DIRS 183088]. The WHF SSCs shall also comply with regulatory positions C.2 and C.12 - C.14 of Regulatory Guide 1.13. The WHF SSCs shall also meet the intent of regulatory positions C.1 and C.4 - C.11 of Regulatory Guide 1.13.

Some of the exceptions to ANSI/ANS-57.2-1983 include:

- Pool water should be maintained below 140°F (60°C) for all heat load conditions
- Minimum pool depth for shielding should be 10 ft (3 m) above the top of the stored [racked] fuel assemblies.
- Either a high radiation level alarm should adjust the ventilation system to contain the radiation, or filter the air.

[RGA REG-CRW-RG-000011, Agreement for Regulatory Guide 1.13, Rev. 2 - Spent Fuel Storage Facility Design Basis (BSC 2007 [DIRS 183182]) provides agreement to utilize the guidance. Regulatory Guide 1.13 adopted ANSI/ANS-57.2-1983.]

4.2.12.1.2 General Balance of Plant (BOP) Facilities

The BOP buildings shall have non-combustible building systems of construction Types II or I as defined by the IBC and other applicable codes, ordinances, and regulations. The buildings shall have an appearance consistent with the character theme of this site. Generally, all buildings shall have at least R-30 insulation for roofs and R-19 insulation for walls, except for special cases such as those with evaporative cooling, which may be R-19 for roofs and R-11 for walls.

[The BOP buildings house ordinary office and light industrial usage, therefore, to comply with applicable codes and standards that require only conventional commercial-grade structures and systems, such as found in business offices and warehouses.]

4.2.12.1.3 Central Control Center Facility

The CCCF consists of a concrete structure with controlled access. The primary alarm station (PAS) shall have one HVAC system and electrical system. The Central Control Center (CCC) and central communications room share another HVAC system and electrical system. The CCC complex must be able to withstand the most adverse conditions reasonably expected during the design life of the plant as detailed in NUREG-0696, *Functional Criteria for Emergency Response Facilities - Final Report* (NRC 1981 [DIRS 104098]), Section 2.5. The detailed design of this facility shall be determined based on input from safeguards and security, functional, and operational requirements as they are developed.

[RGA REG-CRW-RG-000455, Agreement For NUREG-0696, Functional Criteria for Emergency Response Facilities - Final Report (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification. NUREG-0696, Section 2.5 defines specific requirements of the CCC structure. The selected configuration, materials, and systems efficiently and effectively provide for the needs of the building end users and occupants. As yet undefined, future requirements shall determine the configuration of this facility. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.1 CCC Location

The repository applicable functions of the Technical Support Center (TSC) will be performed in the CCC located in the CCCF. The CCC in the CCCF shall provide capability to transfer its functions to the backup Emergency Operations Facility (EOF)/TSC (Emergency Operations Center (EOC)), should conditions warrant such transfer.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696, Section 2.1 defines specific emergency management functions and communications requirements of the CCC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.2 CCC Functions

The CCC in CCCF will be located in an area where there is timely access to each facility's control areas. The time for access to and from the CCC will be less than 15 minutes. The CCC shall be fully functional within 30 minutes.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696, Sections 2.2 and 2.3 defines specific emergency management access and timing requirements of the CCC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.3 CCC Size

The CCC working space shall be sized for a minimum of 25 persons including five NRC personnel and an NRC conference room. This minimum size shall be increased to meet the maximum staffing level determined by the emergency plan requirements. The CCC shall be large enough to provide additional facilities detailed in NUREG-0696 (NRC 1981 [DIRS 104098]) Section 2.4.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification. NUREG-0696, Sections 2.4 and 2.7 defines specific space requirements of the CCC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.4 CCC Radiological Habitability

CCC personnel shall be protected from radiological hazards, including direct radiation and airborne radioactivity from in-plant sources under accident conditions, to the same degree as operations room personnel. If necessary, initial startup testing of operations room envelope integrity shall consider the guidance in Section C of Regulatory Guide 1.197, *Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors* [DIRS 165796].

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 2.6 defines specific radiological habitability requirements of the CCC. CBCN017 to Revision 6 provided this RGA REG-CRW-RG-000455. The agreement defining the applicability of General Design Criterion 19, Standard Review Plan 6.4, and NUREG-0737 referenced in NUREG-0696 Section 2.6, and the referenced Regulatory Guides included in them, associated with nuclear power plant control room habitability have not yet been approved. Therefore, the application of these guides to the habitability of the repository operations rooms and the CCC cannot be specified at this time. RGA REG-CRW-RG-000172, Agreement for Regulatory Guide 1.197, Rev. 0 - Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors (BSC 2007 [DIRS 181816]) provides agreement to utilize the guidance from RG-1.197.]

4.2.12.1.3.5 CCC HVAC

The CCC ventilation system shall function in a manner comparable to the control room ventilation system. The CCC ventilation system need not be seismically qualified, redundant, instrumented in the control room, or automatically activated to fulfill its role. A CCC ventilation system that includes high-efficiency particulate air (HEPA) and charcoal filters is needed, as a minimum.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 2.6 defines specific HVAC requirements of the CCC. The agreement defining the applicability of General Design Criterion 19, Standard Review Plan 6.4, and NUREG-0737 referenced in NUREG-0696 Section 2.6, and the referenced Regulatory Guides included in them, associated with nuclear power plant control room habitability have not yet been approved. Therefore, the application of these guides to the habitability of the repository operations rooms and the CCC cannot be specified at this time. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.6 CCC Radiation Monitoring

Radiation monitoring systems shall be provided in the CCC composed of installed monitors or portable monitoring equipment dedicated to the CCC. These systems shall continuously indicate radiation dose rates and airborne radioactivity concentrations inside the CCC while in use during an emergency. These monitoring systems shall include local alarms with trip levels set to provide early warning to CCC personnel of adverse conditions that may affect the habitability of the TSC. Detectors shall be able to distinguish the presence or absence of radioiodine at concentrations as low as 10^{-7} microcuries/cc.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 2.6 defines specific radiation monitoring requirements of the CCC. The agreement defining the applicability of General Design Criterion 19, Standard Review Plan 6.4, and NUREG-0737 referenced in NUREG-0696 Section 2.6, and the referenced Regulatory Guides included in them, associated with nuclear power plant control room habitability have not yet been approved. Therefore, the application of these guides to the habitability of the repository operations rooms and the CCC cannot be specified at this time. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.7 CCC Protective Equipment

Equipment that protects personnel shall be provided in the CCC for the staff who must travel between the CCC and the facility operations rooms or the Operational Support Center (OSC)/EOF under adverse radiological conditions. Protective equipment also shall be provided to allow CCC personnel to continue to function during the presence of low-level airborne radioactivity or radioactive surface contamination. Anti-contamination clothing and respiratory protective gear are examples of equipment that shall be provided. This equipment shall be properly maintained to assure availability during an emergency. If the CCC becomes uninhabitable, the CCC plant management function shall be transferred to the operations rooms, EOC, or the EOF.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 2.6 defines specific protective equipment and additional space requirements of the CCC. The agreement defining the applicability of General Design Criterion 19, Standard Review Plan 6.4, and NUREG-0737 referenced in NUREG-0696 Section 2.6, and the referenced Regulatory Guides included in them, associated with nuclear power plant control room habitability have not yet been approved. Therefore, the application of these guides to the habitability of the repository operations rooms and the CCC cannot be specified at this time. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.8 CCC Communications

The NRC conference room shall be provided with appropriate communications capabilities. The CCC will be the primary onsite communications center for the repository during an emergency. It shall have reliable voice communications to the Operations Centers, the OSC, the TSC/EOF (EOC) in the Administration Facility, the EOF located Summerlin office complex, and the NRC. The primary function of this voice communication system will be plant management communications and the immediate exchange of information on plant status and operations. Provisions for communications with State and local operations centers also shall be provided in the CCC to provide early notification and recommendations to offsite authorities prior to activation of the EOF.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 2.7 defines specific communications requirements of the CCC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.9 CCC Equipment

Instruments, data system equipment, and power supplies shall be provided to gather, store, and display data needed in the CCC to analyze plant conditions. The equipment shall be designed to meet all the requirements, except operational reliability, of NUREG-0696 (NRC 1981 [DIRS 104098]) Section 2.8.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification. NUREG-0696 Section 2.8 defines specific requirements for instrumentation, data system equipment, and power supplies requirements of the CCC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.10 CCC Technical Data and Data Systems

The CCC technical data system, which is part of the DCMIS, shall receive, store, process, and display information acquired from different areas of the plant as needed to perform the CCC function. The data system shall provide access to accurate and reliable information sufficient to determine plant steady-state operating conditions prior to the accident, transient conditions producing the initiating event, and plant systems dynamic behavior throughout the course of the accident. The CCC technical data system shall provide all functions described in NUREG-0696 (NRC 1981 [DIRS 104098]) Section 2.9, except the requirements of Regulatory Guide 1.97, *Criteria for Accident Monitor Instrumentation for Nuclear Power Plants* [DIRS 178008] do not apply.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification. NUREG-0696 Section 2.9 defines specific requirements of the technical data and data system of the CCC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.3.11 Additional PAS Requirements

The PAS exterior walls, windows, doors, and roof must be constructed of, or reinforced with, materials that have a bullet-penetration resistance equivalent to the Level 8 rating given in Underwriters Laboratories (UL) - 752, "Bullet-Resisting Equipment". PAS entryways must be fitted with doors equipped with locks that can be operated from within the alarm station.

[DOE M 470.4-2, Physical Protection [DIRS 178562] Chapter V. 2.b. UL-752 is a reference provided in the DOE

manual and an output code and not a reference, since a specific version was not specified, the latest version should be used.]

4.2.12.1.4 Warehouse and Non-Nuclear Receipt Facility

The Warehouse and Non-Nuclear Receipt Facility shall be constructed of a steel structure on a reinforced concrete foundation mat. The WNNRF shall have adequate space for an Operational Support Center (OSC).

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 3 called for an OSC. This facility contains heavy industrial processes that require the use of massive, non-combustible structures and systems. Furthermore, they have large seismic loads due to tall heights and large floor areas. The selection of materials and systems in this area comply with operational demands as well as applicable codes and standards. CBCN017 to Revision 6 provided the change.]

4.2.12.1.5 Administration Facility

This facility shall contain a food service facility, training auditorium, computer operation center, and emergency operations center. The building shall consist of a steel frame structure with tilt-up concrete panels or precast concrete panels for the exterior walls with steel structure roof of trusses and metal deck and single-ply membrane roofing. The Administration Facility shall have adequate space for an Emergency Operations Center.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 4.1 specified location of the OSC. The selected configuration, materials, and systems efficiently and effectively provide for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.]

4.2.12.1.5.1 Emergency Operations Center Size

The EOC Shall be sized to provide office space for 35 people and space for displays, data system equipment, communications equipment, and their maintenance activities as specified in NUREG-0696 (NRC 1981 [DIRS 104098]) Section 4.4.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification. NUREG-0696 Section 4.4 defines specific size requirements of the OSC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.5.2 EOC HVAC

The EOC ventilation system shall function in a manner comparable to the CCC. The EOC ventilation system need not be seismically qualified, redundant, instrumented in the control room, or automatically activated to fulfill its role. An EOC ventilation system that includes high-efficiency particulate air (HEPA) and no charcoal filters is needed.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 4.2 defines specific HVAC requirements of the CCC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.5.3 EOC Radiation Monitoring

Radiation monitoring systems shall be provided in the EOC composed of installed monitors or portable monitoring equipment dedicated to the EOC. These systems shall continuously indicate radiation dose rates and airborne radioactivity concentrations inside the EOC while it is in use during an emergency. These monitoring systems shall include local alarms with trip levels set to provide early warning to EOC personnel of adverse conditions that may affect the habitability of the OSC. Detectors shall be able to distinguish the presence or absence of radioiodine at concentrations as low as 10^{-7} microcuries/cc.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 4.5 defines specific radiation monitoring requirements of the EOC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.5.4 EOC Communications

The EOC shall have reliable voice communications facilities to the CCC, EOF, the operations rooms, NRC, and state and local emergency operations centers. The normal communication path between the EOC and the operations rooms will be through the CCC. The primary functions o f the EOC voice communications facilities will be as detailed in NUREG-0696 (NRC 1981 [DIRS 104098]) Section 4.6 except, mobile monitoring efforts will be directed through the CCC. The exact nature of communications facilities for the NRC will be provided after negotiating with the NRC.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification. NUREG-0696 Section 4.6 defines specific communications requirements of the EOC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.5.5 EOC Equipment

Instruments, data system equipment, and power supplies shall be provided to gather, store, and display data needed in the EOC to analyze plant conditions. The equipment shall be designed to meet all the requirements, except operational unavailability goal, of NUREG-0696 (NRC 1981 [DIRS 104098]) Section 4.7.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification. NUREG-0696 Section 4.7 defines specific requirements for instrumentation, data system equipment, and power supplies requirements of the EOC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.5.6 EOC Technical Data and Data Systems

The EOC technical data system,which is part of the DCMIS, shall receive, store, process, and display information acquired from different areas of the plant as needed to perform the EOC function. The data system shall provide access to accurate and reliable information sufficient to determine plant steady-state operating conditions prior to the accident, transient conditions producing the initiating event, and plant systems dynamic behavior throughout the course of the accident. The EOC technical data system shall provide all functions described in NUREG-0696 (NRC 1981 [DIRS 104098]) Section 4.8, except the requirements of Regulatory Guide 1.97 [DIRS 178008] do not apply.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification including exception to RG 1.97. NUREG-0696 Section 4.8 defines specific requirements of the technical data and data system of the EOC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.5.7 EOC Records Availability and Management

The EOC shall have ready access to up-to-date plant records, procedures, and emergency plans needed to exercise overall management of licensee emergency response resources. The records available in the EOC shall be as detailed in NUREG-0696 (NRC 1981 [DIRS 104098]) Section 4.9.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) adopted NUREG-0696 with clarification. NUREG-0696 Section 4.9 defines specific requirements of the records available in the EOC. CBCN017 to Revision 6 provided this criterion.]

4.2.12.1.6 Security Facilities

The BOP security facilities consist of a Perimeter Security Station, Central Security Station, Cask Receipt Security, and North and South Administration Security.

1. The North Perimeter Security Station, Area 30C, consists security and support functions and truck inspection canopy, and controls exiting from the protected area. The building construction consist of steel and concrete.
2. The Central Security Station, Area 30A, controls access to the GROA for primary plant employees and non-nuclear equipment. Other security stations will control supplemental access under special conditions. The Central Security Station construction consists of tilt-up or cast in place concrete exterior walls, a structure of steel trusses and steel beams with metal deck roof, and single-ply roofing.
3. Cask Receipt Security Station, Area 30B, receives various casks from sources off site. This information shall be supplied later.
4. The Administration Security Stations (South and North), Areas 65A and B, control access to the administrative support area for all personnel and non-nuclear equipment. These buildings consist of small, possibly pre-manufactured, kiosk-style guard stations.

[The selected configuration, materials, and systems efficiently and effectively provide for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.]

4.2.12.1.7 Utility Facilities

These facilities shall provide common infrastructure for the entire project such as electrical power and fire water.

1. Utilities Facility, Area 25A—The Utilities Facility provides hot and chilled water for the plant heating and cooling system; deionized water for the WHF pool make-up, cask wash down, and other miscellaneous analytical uses; a local control room; and minimal offices and locker spaces. Its construction consists of tilt-up or cast in

place exterior walls, a structure of steel trusses and steel beams with metal deck roof, and single-ply roofing.
2. Cooling Tower, Area 25B—This facility supports the requirements of the utilities. This facility occupies an open fenced area with small equipment enclosures where required. The cooling tower structure, fan, distribution system, louvers, and fill and drift eliminators are all of noncombustible materials.
3. Evaporation Pond, Area 25C—This facility holds surface runoff and cooling tower blowdown in an open basin.
4. Standby Diesel Generator Facility, Area 26B—This facility provides standby power and has cast-in-place concrete exterior walls, concrete roof structure, and single-ply roofing.
5. Emergency Diesel Generator Facility, Area 26D—This facility houses the emergency diesel generators and has cast-in-place concrete exterior walls, concrete roof structure, and single-ply roofing.
6. Switchyard (138 kV), Area 27A— This facility forms part of the electrical power supply and distribution system for the site. This facility occupies an open fenced area with small equipment enclosures where required.
7. 13.8 kV Switchgear Facility, Area 27B—This facility forms part of the electrical power supply and distribution system for the site. This facility has tilt-up or cast-in-place concrete exterior walls, steel column, truss and beam roof structure, with metal deck roof and single-ply roofing.
8. Fire Water Facilities, Areas 28A, 28B, and 28E—The fire water facilities provide water storage and pumping to supply water based fire sprinkler systems, standpipes, and fire hydrants to the various facilities associated with this site. Fire hydrant locations are provided in Criterion 4.9.1.11.9.

[The selected configuration, materials, and systems efficiently and effectively provide for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility. Cross-reference of hydrant locations is required for CR 10514 per CBCN016 to Revision 6.]

4.2.12.1.8 Emergency Response Facilities

The emergency response facilities shall house personnel and equipment needed in case of medical or other emergency. This facility includes a fire/rescue/medical facility and a helicopter pad.

[The selected configuration, materials, and systems efficiently and effectively provide for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.]

4.2.12.1.9 Materials and Consumables Facilities

These facilities include a warehouse, fuel depot, waste handling area, and a non-radioactive/non-hazardous material area.
1. Warehouse/Central Receiving, Area 68A—The central warehouse receives non-nuclear materials and consumables for the site, including maintenance materials and parts. Its construction is of tilt-up or cast in place exterior walls, structure of steel trusses and steel beams with metal deck roof, and single-ply roofing.
2. Fuel Depot, Area 700—The fuel depot provides a canopy space for vehicle refueling. Bulk storage of No. 2 diesel fuel will be provided in quantities to be determined later.
3. Low-Level Waste Handling (LLW), Area 160—This facility provides an area for collecting, staging, and handling LLW generated within the various facilities of the main North Portal area. The final configuration comes from the anticipated volume of waste generated for legal disposition off site.
4. Hazardous Materials Collection—This area sits adjacent to the Vehicle Maintenance and Motor Pool Facility and holds anticipated quantities of oil, batteries, and other hazardous materials identified as recyclable materials for the collection, staging, and legal disposition off site. Process water that collects in the tunnels during construction is pumped out of the subsurface facility. The location for the treatment of water will be developed later.
5. Non-radiological/non-hazardous materials areas—This area stores collected materials for legal disposition off site. The design derived from the probable quantities of materials and final configuration depends on the anticipated volume of waste generated for legal disposition off site.

[The selected configuration, materials, and systems efficiently and effectively provides for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.]

4.2.12.1.10 Maintenance and Repair Facilities

These facilities include craft shops, heavy equipment maintenance, and vehicle maintenance and motor pool.
1. Craft Shops, Area 71A - This information supplied later.
2. Heavy Equipment Maintenance Facility, Area 220 - This facility provides maintenance capability for the heavy load handling equipment used to transport waste packages to and from the surface facilities and the subsurface facility.
3. Vehicle Maintenance and Motor Pool, Area 690 - This facility provides space for a wash bay, five maintenance bays, material and equipment storage, and associated office space and rest rooms.

4. Equipment/Yard Storage, Area 71B - This area provides space for equipment parking and storage in an open area with small equipment enclosures as required.

[The selected configuration, materials, and systems efficiently and effectively provide for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility.]

4.2.12.1.11 Offsite Facilities

The offsite facilities could include the following five facilities: (1) Visitor Center (Area 610), (2) Offsite Training Facility (Area 980), (3) Gate 510 Facilities (Area 730), (4) Emergency Operations Center, Area 970, and (5) Emergency Operations Facility located in Las Vegas, Nevada, within the Summerlin office complex. Specific information may be provided later.

[The selected configuration, materials, and systems efficiently and effectively provide for the needs of the building end users and occupants. As yet undefined, future requirements will determine the configuration of this facility. RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 1.3.4 provides for this off-site EOF. The EOF located in Las Vegas, Nevada, within the Summerlin office complex is per Contracting Officer Letter (Peterson 2007 [DIRS 181224]). This facility is not within the repository design scope. CBCN017 to Revision 6 provided the change.]

4.2.12.2 Layout and Spacing

4.2.12.2.1 Building Separation

The distance between buildings, adjoining site areas, including access ways, egress drives, parking and building access, and heights shall comply with *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]) including reference to NFPA 101-2006 [DIRS 177965], as modified by NAC 477.283, Sections 2.(c), 2.(f), 2.(g), 2.(i), 2.(j), and 2.(l).

[This establishes a minimum separation for fire separation in industrial occupancies and a maximum allowable floor area and overall height. This ensures that personnel and vehicles have safe and accessible operating areas in and around buildings and structures. All facilities require accessibility. NAC 477.283 made modifications to sections of the IBC 2003 that are being applied to the same sections of the IBC 2000.]

4.2.12.2.2 Deleted

[Deleted Criterion. Already covered in Criteria 4.2.12.2.1 and 4.2.3.6.]

4.2.12.3 Design of Architectural Works

The design and construction of the repository surface facilities shall incorporate standard materials and practices appropriate for the specific building type and facilitate a 50-yr operational life. The design shall be defensible in terms of scope, cost, and appearance. A defensible design has good planning, effective function, simple form, cost-effectiveness, contractibility, adaptability, durability, cleanability, clean appearance, and maintainability.

[The architectural design philosophy represents good practice in the approach to architectural features for the types of buildings planned.]

4.2.12.3.1 General Considerations

The design of the facilities shall reflect design characteristics developed for the repository project complex and considers form, function, constructability, durability, cleanability, and cost effectiveness. All facilities have a 50-yr design life and incorporate neutral colors that blend with the visual or aesthetic impact on the surrounding environment. All structures include the following elements as appropriate to the specific consideration of the buildings magnitude and design:

A. Exterior materials shall include variations of material types such as precast concrete, reinforced cast-in-place concrete, concrete masonry units, or metal siding.

B. Interior finishes and wall types have durable, easily cleaned surfaces. Finish types and colors have a standardized appearance throughout the project facilities depending on specific area function. Determination of wall types depends on fire protection requirements, function, durability, shielding, and other factors.

C. Component features of exterior elements, including color, profile, design, and textures, look similar throughout the project complex.

D. Material products, product salient features, sizes, and manufacturers (where necessary) remain consistent for ease of procurement and maintenance. Items of particular importance include siding systems, roofing systems, interior finish materials, doors and hardware or keying, signage, elevators, platforms, handrails, and plumbing fixtures. Interior and exterior areas subject to equipment movements and operations of potential impact have durable materials.

[Architectural design philosophy represents general good practice in approaching architectural features for types of buildings planned on this site.]

4.2.12.3.2 Types of Occupancy and Construction

The repository facilities shall comply with occupancy classifications and construction types identified in the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), as modified by NAC 477.283, Sections 2.(c), 2.(f), 2.(g), 2.(i), 2.(j), and 2.(l). However, occupancy loads for determining life safety means of egress also comply with NFPA 101-2006 [DIRS 177965]. See Table 4.2-2 for Occupancy Classification.

Table 4.2-2 Occupancy Classifications

Building/Facility Name	Total Building Area Sq Ft (approx.)[a]	IBC Use and Occupancy Classification	IBC Type of Construction
North Portal Facilities			
Canister Receipt and Closure Facility (1, 2, and 3)	234,000	F-2 and B	I B
Warehouse and Non-Nuclear Receipt Facility	24,000	S-2 and B	II B
Initial Handling Facility	56,000	F-2	I B
Wet Handling Facility	117,000	F-2	I B
Receipt Facility	112,000	F-2	I B
BOP Facilities			
Administration Facility, including Emergency Operations Center	63,000	A-2	II B
Central Control Center Facility	13,700	B	I B
BOP Security Facilities			
Administration Security Station (North)	150	B	II B
Administration Security Station (South)	150	B	II B
Central Security Station	15,500	B and U	II B
Cask Receipt Security Station	9,000	B and U	II B
North Perimeter Security Station	2,600	B	II B
Utilities Facilities			
Utilities Facility	16,500	F-2	II B
Cooling Tower	Future	Future	Future
13.8 kV Switchgear Facility	3,800	F-2	II B
Emergency Diesel Generator Facility	17,000	F-1	II B
Diesel Generator Facility (Standby)	4,000	F-1	II B
Fire Water Facility	Future	F-2	II B
138 kV Switchyard	Future	Future	Future
Storm Water Retention Pond	Future	Future	Future
Evaporation Pond	Future	Future	Future
Emergency Response Facilities			
Fire, Rescue, and Medical Facility (Operations)	18,000	B	II B
Helicopter Pad Facilities (operations)	Future	Future	Future
Offsite Facilities			
Visitor Center	Future	A-2	II B
Offsite Training Facility	Future	Future	Future

Gate 510 Facilities	Future	Future	Future
Emergency Operation Facility (Summerlin Office Complex)	Future	Future	Future
Materials and Consumables Facilities			
Warehouse/Central Receiving	22,000	S-2	II B
Fuel Depot	8,500	M	II B
Diesel Fuel Oil Storage	Future	Future	Future
LLW Handling Facility	Future	Future	Future
Hazardous Materials Collection	Future	N/A	Future
Non-Radioactive/Non-Hazardous Materials	Future	N/A	Future
Maintenance and Repair Facilities			
Craft Shops	19,000	S-1, S-2, and B	II B
Heavy Equipment Maintenance Facility	24,500	S-1 and B	II B
Vehicle Maintenance and Motor Pool	19,000	S-1 and B	II B
Transportation Facilities			
Truck Staging Area	Future	Future	Future
Rail Car Staging Area	Future	Future	Future
Personnel Transportation (shuttle stop)	Future	Future	Future
Construction Support Facilities			
South Portal	Future	Future	Future
North Construction Portal	Future	Future	Future
Other Facilities	Future	Future	Future
Infrastructure (general)	Future	Future	Future

NOTE: [a] Areas represent an approximation of space requirements and are subject to review and revision based on the final space needs requirements developed at the time of final design.

[The IBC occupancy classification and construction type summary represents general good practice in approaching architectural features for types of buildings planned on this site. The information in Table 4.2-2 has been specified by the project. 29 CFR 1910.34, .35, .36, and .37 endorse NFPA 101 as sufficient to demonstrate compliance with exit route provisions.]

4.2.12.3.3 Means of Egress

Means of egress for all surface facilities shall be designed in accordance with the most restrictive requirements of *International Building Code 2000, with Errata to the 2000 International Building Code 2000* (ICC 2003 [DIRS 173525]) or NFPA 101-2006 [DIRS 177965] as modified by NAC 477.283, *State Fire Marshal* [DIRS 182445], Sections 2.(c), 2.(f), 2.(g), 2.(i), 2.(j), and 2.(l). As a minimum, the repository facilities shall provide a continuous recognizable path of travel from all areas to public way via approved exit access, exit enclosure, and exit discharge. Stairwells exceeding 55 feet in height shall be pressurized. This section does not pertain to subsurface facilities.

[Represents a standard of professional care consistent with the degree of skill readily exercised by members of the same profession currently practicing under similar circumstances. 29 CFR 1910.34, .35, .36, and .37 endorse NFPA 101 as sufficient to demonstrate compliance with exit route provisions. NAC 477.283 made modifications to sections of the IBC 2003 that are being applied to the same sections of the IBC 2000.]

4.2.12.3.4 Fire Protection

4.2.12.3.4.1 **Fire Barriers**

Building fire barriers shall comply with *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), NFPA 101-2006 [DIRS 177965] and NFPA 801-2003, *Standard for Fire Protection for Facilities Handling Radioactive Materials* [DIRS 165077]. At a minimum, fire barriers shall provide continuous separation of zones to the extent required for fire and life safety.

[The identified codes provide industry standards for fire barriers. Non-combustible or fire-resistive construction materials are described in the specific facility fire hazard analyses and in Section 4.9.1.]

4.2.12.3.4.2 **Exposed finish or facing materials**

Exposed interior wall and ceiling finish materials and any factory installed facing materials shall limit flame spread and smoke development to a code approved flame spread rating.

[Interior finishes and materials meet the most restrictive criteria specified in Section 4.9.1.9.3.]

4.2.12.3.5 Energy Conservation

All facilities shall comply with the energy conservation requirements set forth in ANSI/ASHRAE/IESNA Std 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [DIRS 174321]. Other energy conservation measures shall include the following items:

- Exterior windows in air-conditioned buildings shall meet shading coefficient requirements by means of tinted insulated glass.
- Personnel, equipment, and vehicular exterior access doors in air-conditioned buildings shall have insulation.
- Exterior openings shall have adequate weather stripping to minimize air infiltration and exfiltration.
- Exterior insulated metal siding walls shall have double caulking to minimize air leakage.
- All entrances of occupied buildings shall have vestibules to serve as airlocks and to maintain positive or negative air pressure, as appropriate. Allowable infiltration and exfiltration shall comply with ANSI/ASHRAE/IESNA Std 90.1-2004, except where building or process operations require more stringent provisions to maintain differential pressure.

[10 CFR 433 [DIRS 181833] endorses ANSI/ASHRAE/IESNA Std 90.1-2004 for energy efficiency. The design uses good engineering practice in addition to ANSI/ASHRAE/IESNA Std 90.1-2004 requirements to produce the maximum energy conservation.]

4.2.12.3.6 Building Envelope

Exterior walls shall consist of cast-in-place concrete, tilt-up concrete panels, precast concrete, or prefinished metal siding as described in the following list:

- Roofing systems shall consist of prefinished metal or single-ply roofing. All facility roofs have standard roof drains, overflow roof drains, and scuppers and downspouts with concrete splash blocks. Roof drainage systems are of an adequate size to accommodate rainfall criteria.
- Wall systems, including penetrations, flashing, accessories, doors, and windows, shall have air and water infiltration seals and fire rated penetration materials and constructions where required.
- Exterior walls shall have fire resistance and opening protection in accordance with the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525], including those given in Tables 601 and 602 and Section 704).
- Exterior wall, door, regulator assemblies, and exterior roof systems can withstand wind and wind-driven missile design loads as specified in the repository structural design criteria on a facility-by-facility basis.

[The building envelope configurations conforms to good architectural and structural practices for the operational life expectancy indicated in Section 4.2.12.3.1. They also comply with energy conservation and fire resistive standards and have the capability to withstand and resist high wind and wind-driven missiles.]

4.2.12.3.7 Decontamination and Decommissioning

4.2.12.3.7.1 **Interior Finishes and Coatings For Contamination Control**

Interior finishes in areas used for processing or storing radioactive materials and those areas having a possibility of radioactive contamination of wall, ceiling, or floor surfaces shall have non-porous surfaces for ease of decontamination per NFPA 801-2003 [DIRS 165077], Paragraph 5-8. Potentially contaminated areas not provided with stainless steel cladding, and areas requiring high durability, or liquid containment areas have special protective coatings. Levels II and III coatings and thickness can vary as determined through analysis on an area-by-area basis in accordance with Regulatory Guide 1.54, *Service Level I, II and III Protective Coatings Applied To Nuclear Power Plants* [DIRS 182350] and ASTM D 5144-00, *Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants* [DIRS 158844]. Level I coating will not be used. Protective coatings shall be qualified and capable of surviving an event sequence without adversely affecting SSCs needed for mitigation.

[Coating requirements in radioactive material processing areas or areas where radioactive material is stored have non-porous surfaces for ease of decontamination. RGA REG-CRW-RG-000045, Agreement for Regulatory Guide, 1.54 Rev. 1 - Service Level I, II and III Protective Coatings Applied To Nuclear Power Plants (BSC 2007 [DIRS 181682]) adopted Regulatory Guide 1.54 with clarification that provides clarification and guidance on

protective coating.]

4.2.12.3.7.2 Material Selection Facilitating Decontamination

The repository design shall comply with the objectives of permanent closure and decontamination or decontamination and dismantlement. The design meets this requirement if design includes, where feasible and economical, choices that support closure and decontamination or decontamination and dismantlement over competing alternatives. Examples of favorable design features include the following:

1. Selection of materials and processes to minimize waste production
2. Minimization of the mass of shielding materials subject to neutron activation
3. Use of modular design and inclusion of lifting points to facilitate removal and dismantlement
4. Selection of materials for compatibility with projected closure and decontamination, or decontamination and dismantlement, or waste processing procedures
5. Use of minimum surface roughness finishes on SSCs that have potential for contamination
6. Use of coatings that preclude penetration into porous materials by radioactive gas, condensate, deposited aerosols, or spills, to permit decontamination by surface treatment
7. Incorporation of features to contain leaks and spills
8. Incorporation of waste minimization techniques
9. Incorporation of features that would maintain occupational and public radiation doses as low as is reasonably achievable (ALARA) during decommissioning.

[The design complies with NUREG-1804, Yucca Mountain Review Plan, Final Report (NRC 2003 [DIRS 163274], Section 2.1.3.2, Review Method 1), and Regulatory Guide 8.8, Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations will be As Low As Is Reasonably Achievable [DIRS 103312], Sections C.1.d, C.2.d, and C.2.f. RGA REG-CRW-RG-000399, Agreement for NUREG-1804, Rev 2 Yucca Mountain Review Plan, Final Report (BSC 2007 [DIRS 182359]) adopted NUREG-1804 with clarification by mapping a crosswalk to the License Application. RGA REG-CRW-RG-000338, Agreement For Regulatory Guide 8.8, Revision 3 - Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be As Low As Is Reasonably Achievable (BSC2007 [DIRS 181778]) adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.2.12.3.8 Plumbing Fixtures

Restrooms, shower areas, and office areas shall have, at the least, minimum quantities of plumbing fixtures required by *2006 International Plumbing Code* (ICC 2006 [DIRS 176292]).

[The design complies with good engineering practice and the standards of ICC 2006 identify minimum quantities of plumbing fixtures.]

4.2.12.3.9 Security/Access Control

The design shall provide security access and control features. The detailed design phase of the project shall address specialty door hardware, windows, surveillance at the entrance of the building, and other architectural building features required for repository facility security.

[Security and access control requirements represent good architectural practices and comply with safeguard and security criteria as it develops.]

4.2.12.3.10 Electrical Penetrations and Seals

Penetrations and seals shall provide closure to the extent required by applicable codes standards and operational requirements. Electrical penetrations shall be designed in accordance with IEEE Std 317-1983 (R2003), *IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations* [DIRS 178086] related to fire barriers. The external circuit protection of electric penetration assemblies should meet the provisions of Section 5.4 of IEEE Std 741-1977 (R2002), *IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations* [DIRS 166689]. The electrical penetrations and seals required for fire barriers shall also be applicable to a ventilation or confinement barrier.

[Architectural material requirements represent good architectural practices in architectural design. RGA REG-CRW-RG-000052, Agreement for Regulatory Guide 1.63, Rev. 3 - Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants (BSC 2007 [DIRS 181949]) provided agreement with Regulatory Guide 1.63,

Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants [DIRS 177558] that endorsed IEEE Std 317-1983 and Section 5.4 of IEEE 741-1997 (R2002). Although the RGA is silent on the year and RG 1.63 specifies 1986, the latest IEEE 741-1997 (R2002) is selected for the repository.]

4.2.12.4 Architectural Material Requirements

The building exterior system and penetrations, copings, covers, louvers, and trim pieces shall produce weather tight durable enclosures.

[Architectural material requirements represent good architectural practices for the operational life expectancy.]

4.2.12.4.1 Exterior Wall and Roof System Assemblies

Exterior wall and roof system assemblies shall consist of compatible components of the same manufacturer, where possible. Exterior windows, glass, and glazing shall consist of manufacturer standard fabrication and sizes. Exterior metal louver size and construction shall meet airflow requirements determined by HVAC and other criteria identified within this document.

[Architectural material requirements represent good architectural practices for the operational life expectancy.]

4.2.12.4.2 Concrete Masonry Units

Concrete masonry unit exterior wall construction consists of medium-weight standard block.

[Architectural material requirements represent good architectural practices for the operational life expectancy.]

4.2.12.4.3 Composite Metal Wall System

Field-assembled composite metal wall panel system shall consist of a field-assembled composite metal liner panel and an exterior metal panel on metal purlins or girts with fiberglass or polystyrene insulation in the cavity. Other related system components include flashing, sealant, clips, coping, subgirts, fasteners, panel closure, and gaskets. R-value for composite wall system has R-19 or greater thermal resistance.

Exterior panels shall consist of factory finished, galvanized metal. Interior liner panels shall consist of factory finished, galvanized metal, flat profile panels with 1-1/2 in. "z" shape subgirts or channels. Metal louvers shall consist of factory finished galvanized metal, 45-degree blades with center baffles, and return bend for weather protection and bird screen.

[Architectural material requirements represent good architectural practices for the operational life expectancy.]

4.2.12.4.4 Metal Sandwich Wall System

The factory-assembled metal sandwich panel system shall consist of a factory-assembled metal sandwich panel system that resembles the components in the composite metal wall system. The R-value for exterior wall system has R-21 or greater thermal resistance. Exterior panels shall consist of factory-finished sheet metal of at least 24-gauge galvanized steel. Metal louvers used with this system shall match toe system finish and consist of factory-finished galvanized sheet metal with 45-degree blades, center baffles, and return bend for weather protection and bird screen.

[Architectural material requirements represent good architectural practices for the operational life expectancy.]

4.2.12.4.5 Entrance doors, glass, glazing, and exterior windows entry doors

Entrance doors, glass, glazing, and exterior windows shall have insulated glazing and tempered glazing where required. Window frames shall have thermal breaks fixed. Glazing shall consist of two panes separated by ½-inch hermetically sealed dehydrated air space and consist of ¼-inch clear glass interior, and 1/4 inch tinted "low E" glass on the exterior side similar to Pittsburgh Plate Glass "Graylite." Main entry doors to facilities that are accessible to the public shall consist of storefront type aluminum frames with clear anodized finish.

[Architectural material requirements represent good architectural practices for the operational life expectancy.]

4.2.12.4.6 Exterior Windows

Exterior windows shall consist of aluminum frames with anodized finish. Main entry doors shall have a storefront type aluminum frame with clear anodized finish. Window glazing shall have an exterior side with a tint similar to Pittsburgh Plate Glass "Graylite."

[Architectural material requirements represent good architectural practices for the operational life expectancy.]

4.2.12.4.7 Not Used

4.2.12.4.8 Precast Concrete Walls

Information to be provided later.

4.2.12.4.9 Cast-in-Place Concrete Walls

Information to be provided later.

4.2.12.4.10 Tilt-up Concrete Panels

Information to be provided later.

4.2.12.4.11 Roof Assemblies

Roof assemblies shall comply with:

- Class B standards in ASTM E 108-05, *Standard Test Methods for Fire Tests of Roof Coverings* [DIRS 176426];
- NFPA 256-2003, *Standard Methods of Fire Tests of Roof Coverings* [DIRS 173417]; and
- UL 790-2004 , *Standard Test Methods for Fire Tests of Roof Coverings* [DIRS 173419], or
- Class I standards in FM 4471-1995, *Approval Standard for Class I Panel Roofs* [DIRS 173418].

Roof systems use commercial grade materials and consist of compatible components as recommended by the roofing manufacturer. Roof application complies with the guidelines indicated in the manual, which have been identified and are being procured. Roof insulation for all repository facilities shall have a minimum resistance value of R-30. Metal roofing complies with Factory Mutual Class I or UL Class B requirements. All process building main roofs and other roofs with mechanical equipment have roof access by means of ladders, hatches, or stairs complying with OSHA standards. Roofs requiring access to roof mounted mechanical equipment shall have walkways. Walkways within 10 ft of roof edges have fall protection by means of guardrails or safety harness.

Roofing systems may comply with one or more of the following systems:
A. **Standing Seam Metal Roof System—**The system includes panels, polyisocyanurate rigid insulation, structural deck sub-purlins, clips, flashing, roof drain pans, sealant, and accessories that provide for a complete system with at least 1/4 in. per ft slope. Roofs have a manufacturer's standard color.
B. **Single Ply Roof System—**This system includes membrane, insulation, vapor barrier, flashing, expansion joints, pedestals and curbs, mechanical equipment curbs, sealant, roof drains and overflow roof drains, drainage scuppers or gutters, downspouts, roof drain leaders, and accessories and appurtenances necessary to provide a complete system meeting the industry standards for roofing applications and the requirements of this architectural criterion. The single ply roof system consists of roof membrane fully adhered to rigid board insulation fully adhered or mechanically fastened to metal decking with at least 1/4 in. per ft slope. Roofs have a manufacturer's standard color.

[The roof systems described represent good architectural practices for the operational life expectancy.]

4.2.12.4.12 Doors and Hardware

The doors and frames systems described represent good architectural practices for the operational life expectancy.

4.2.12.4.12.1 Exterior and Interior Door Criteria

Exterior and interior personnel doors, service doors, and vehicle doors shall have frames, hardware, and fittings suitable for the purpose intended. Descriptions and requirements for shielding and special doors for operations appear elsewhere in this document. Exterior door assemblies and roll-up doors, including the frame, shall have the capability to withstand wind loads as required in Section 4.2.11.3.6. Doors and frames for openings in fire-rated barriers shall bear UL or Factory Mutual labels appropriate for each fire-rated wall opening. Design and installation of fire doors shall meet NFPA standards identified in Section 4.9.1. Doors at ventilation zone boundaries shall have appropriate seals; doors in areas where adverse ventilation conditions may impair normal egress shall have pressure equalization devices and hardware that do not restrict exiting.

[Architectural material requirements represent good architectural practices for the operational life expectancy.]

4.2.12.4.12.2 **Exterior Personnel Openings**

Exterior personnel openings shall have 1-3/4 in. insulated hollow metal doors, flush face, at least 16-gauge material. Exterior door frames shall have hollow metal steel, at least 14-gauge material. Doors shall have lockable entrance hardware, exit or panic hardware where required, weather-stripping, door sweep, threshold, closer, and other associated hardware. These doors have an R-value of not less than 2.

[The doors and frames systems described represent good architectural practices for the operational life expectancy.]

4.2.12.4.12.3 **Interior Personnel Openings**

Interior personnel openings in operational areas shall have flush face, 1-3/4-in. hollow metal doors, and at least 18-gauge material. Doors in office or similar support areas may consist of solid core wood with wood or laminate veneer. Where required for visibility, doors shall have wired glass vision panels. Door frames shall be hollow metal steel, at least 16-gauge material. Doors shall have appropriate hardware.

[The doors and frames systems described represent good architectural practices for the operational life expectancy.]

4.2.12.4.12.4 **Interior Overhead Coiling Service Doors**

Interior overhead coiling service doors shall have interlocking slat roll-up type, top coiling with dust hood, and manual operation. Overhead coiling doors over 100 sq ft in area shall have motor operators. Other overhead coiling service doors and vehicular doors shall have insulation and weather stripping.

[The doors and frames systems described represent good architectural practices for the operational life expectancy.]

4.2.12.4.12.5 **Sliding, Overhead Sectional, Vertical Lift, and Overhead Coiling Doors**

Sliding, overhead sectional, vertical lift, and overhead coiling doors shall have motorized operators and have the capability to withstand specific building seismic and wind requirements.

[The doors and frames systems described represent good architectural practices for the operational life expectancy.]

4.2.12.4.12.6 **Door Hardware**

Door hardware shall meet the requirements for the door function, code, and underwriters fire label requirements. Door hardware shall meet the appropriate ANSI standards. All hardware finishes shall be brushed chrome finish. Locksets and latch sets for all doors except special doors specified by other disciplines, shall have lever handles meeting accessibility requirements. Locksets shall consist of the mortise type with interchangeable cores and six pin tumbler cylinders with Corbin 59C2-6 keyway for each lockset, unless otherwise indicated. All lock keying shall match the project master and grand master keying system. Hardware shall have the UL listing for fire-rated doors.

[The doors and frames systems described represent good architectural practices for the operational life expectancy.]

4.2.12.4.13 Interior Partitions

Interior partitions include non-bearing walls consisting of reinforced concrete, reinforced concrete masonry units, and metal stud and gypsum board construction. Steel studs shall have a C-shaped section and punched webs. Walls required for fire barrier assemblies shall meet UL rated fire-resistive standards including penetration protection as required. Partition construction shall consist of reinforced concrete construction, reinforced grout filled concrete masonry units, or gypsum board on metal studs. Where required to shield areas of liquids or bulk materials, or for operational durability, concrete construction will be used.

Gypsum board walls shall have metal studs with 5/8-in. type X gypsum board on each side, layered as required for fire rating. Gypsum board walls along corridors within process areas shall have an impervious smooth surface wainscot to a height of at least 6 ft above the finished floor or as needed for moveable equipment protection. Bulk materials storage areas and areas that need operational durability will use reinforced concrete masonry unit construction. Computer rooms, reproduction rooms, and high noise-level areas separated from occupied areas shall have full height partitions with sound insulation.

Sound transmission class (STC) ratings refer to measurements of specific partition construction for reducing airborne sound. Minimum sound isolation requirements for separation of source room from adjacent receiver room are as follows:

- Offices, conference rooms, computer rooms, and restrooms—STC 50
- Mechanical room near occupied areas—STC 65.

The design and materials of the beams, floors, roofs, columns, walls, and partitions shall comply with *Fire Resistance Directory 2006* (UL 2006 [DIRS 178042]).

Interior partitions shall be designed for the ventilation differential pressure load, in addition to the dead and seismic loads. The Surface HVAC group shall provide maximum ventilation differential pressure.

[The interior partitions comply with good engineering practice for the operational life expectancy indicated in Section 4.2.12.3.1.]

4.2.12.4.14 Flooring

Flooring systems shall include stainless steel liners, special protective coatings, vinyl composition tile, sheet vinyl, ceramic tile, carpet, raised access flooring, and sealed concrete:

- Where the potential threat of water or liquid damage is possible, floors slope to a sump or drain.
- Process and service floors involving radioactive materials, including ventilation areas that have contamination classifications, have special protective coatings to facilitate decontamination. These special coatings extend up the walls to form a 6 in. tall base.
- Lunchrooms, offices, corridors, and other similar spaces where contamination classification is not required to have vinyl composition tile.
- Non-contaminated change room areas have sheet vinyl with a 6-in. covered vinyl base. Restroom and shower areas have ceramic tile floors, 4ft of wall wainscoting, bull nose on top, and curb on the floor.
- Laboratory areas have chemical-resistant floor systems. Computer areas have raised access floor systems consisting of 24-in. square steel panel modules. The panel finish is carpet tile.
- Non-radioactive materials usage areas of exposed construction requiring heavy equipment usage, such as shops and mechanical and electrical equipment rooms, have concrete floors with hardener and sealer finish.
- Floor finishes have Class I rating when tested in accordance with *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525] and have a critical radiant flux of 0.45 W/sq cm minimum.
- Floor surfaces have a minimum slip resistance rating of 0.5 in accordance with the ASTM standard for the type of flooring selected.
- The Administration Building shall have carpet with rubber base throughout offices and similar areas. Lobbies may employ high traffic coatings (i.e., ceramic or porcelain paver tile with appropriate base material). Lunchrooms, workrooms, janitor closets, and similar spaces shall have sheet vinyl flooring with rubber base. Restrooms shall have ceramic tile with ceramic tile wainscot.

[The flooring systems described represent good architectural practices for the operational life expectancy.]

4.2.12.4.15 Ceilings

Non-contaminated areas of occupied facilities, including offices, conference rooms, computer rooms, change space rooms, restrooms, and associated lobbies and corridors, shall have suspended acoustical lay-in panel system ceilings with a 2- by 4-ft tee-bar grid. Shower areas and janitor closets shall have painted suspended gypsum board ceilings. Ceiling systems shall have integrated lighting, partitions, water sprinklers, HVAC, and related building systems.

Occupied or unoccupied areas without ceilings shall have exposed construction finished with coatings as described in Sections 4.2.12.3.7.1 and 4.2.12.4.16. These areas include subchange rooms, storage areas, shops, mechanical and electrical areas, janitor rooms, and similar spaces.

[The ceiling systems described represent good architectural practices for the operational life expectancy.]

4.2.12.4.16 Architectural Finishes

Finishes used throughout the repository facilities shall meet fire-resistive requirements. Areas within the facilities that contain radioactive materials and processes or have potential of radioactive contamination shall receive special protective coatings selected for the specific area environment. Areas that require radiation tolerance, chemical resistance (e.g., decontamination process), temperature resistance, resistance to flame spread and smoke generation, fire resistance (fireproofing), interior finish (specifically excluding equipment and piping), and potential mechanical abuse may need special protective coatings. Protective coatings shall be qualified and capable of surviving an event sequence without adversely affecting safety-related SSCs needed to mitigate the accident. These coatings shall facilitate decontamination and decommissioning. Levels II and III coatings and thickness can vary as determined through analysis on an area-by-area basis in accordance with Regulatory Guide 1.54, *Service Level I, II and III Protective Coatings Applied To Nuclear Power Plants* [DIRS 182350] and ASTM D 5144-00, *Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants* [DIRS 158844]. Level I coating will not be used.

Industrial areas without radioactive materials and processes shall have conventional coatings to maintain cleanliness and adequate illumination levels for safety and work efficiency. Offices, conference rooms, corridors, computer rooms, restrooms, and similar spaces shall receive semi-gloss paint finishes or other paint finish, where applicable.

[The architectural finishes described represent good architectural practices for the operational life expectancy. RGA REG-CRW-RG-000045 (BSC 2007 [DIRS 181682]) has adopted Regulatory Guide 1.54 [DIRS 182350] that provides clarification and guidance on protective coating.]

4.2.12.4.17 Architectural Specialty Criteria

Minimum specialties used in repository facilities shall include visual display boards, projection screens, metal toilet partitions, shower compartments, corner guards, identifying devices, lockers, fire extinguisher cabinets, cubicle curtains, and toilet and bath accessories. Other architectural accessories will be identified during design. The design shall comply with the applicable provisions of NAC 477 [DIRS 182445].

The following standards will apply throughout unless noted otherwise:

- Lunchrooms, conference rooms, and other rooms used for meetings shall have visual display boards. Display boards shall be white dry-erase writing surfaces or electronic that can be controlled from a central location.
- Main conference rooms shall have projection screens. Screens shall be a matte white or glass bead surface with a 60-in. square screen or screen size appropriate to the room size.
- Each water closet shall have a metal toilet compartment, and each urinal shall have a metal visual screen. Toilet compartments shall have a baked enamel finish on steel, be floor attached, and have overhead bracing complete with chrome steel hardware and accessories. Urinal screens shall have a baked enamel finish on steel, and be wall supported, with concealed wall supports and hardware.
- Each showerhead shall have a separate shower compartment. The compartments shall include shower and dressing areas and have a baked enamel finish on steel, floor attached, and have overhead bracings with an integral bench, a curtain rod with snap hooks, and a heavy plastic curtain. Showers may have a ceramic tile surround, substituted for metal compartment, with a metal dressing area compartment.
- Corridor corners shall have corner guards where operations use moveable carts or equipment or in heavy traffic areas. Corridors within office-type areas do not require corner guards. Guards shall resist impacts of a minimum 25.4 ft-lb/in.^{2}, Izod test, per standard. Standard tile and number are to be added later.
- Identifying devices throughout the repository complex facilities shall comply with *Americans with Disabilities Act of 1990* [DIRS 162264]. Signage includes main entry signs, emergency exit signs, area identification signs, room signs, emergency exit signs, and main directory sign.
- Change rooms shall have metal lockers 12-in. wide by 15-in. deep of single tier with sloping top. Benches shall be 12 in. wide.
- The repository facilities shall have fire extinguishers with cabinets in quantities and locations required by NFPA 10-2006, *Standard for Portable Fire Extinguishers* [DIRS 177964].
- Personnel decontamination rooms shall have cubicle curtains for personnel privacy. Curtain assemblies shall consist of a surface mounted aluminum cubicle track, metal bead chain and hook assembly with nylon axle, and 5-1/2 oz/sq yd fire retardant cotton cloth curtain that complies with flame spread/smoke index rating for this project.
- Restrooms, shower rooms, and janitor closets shall have toilet and bath accessories.

● Accessories shall have a satin chrome steel finish and include paper towel dispensers, lavatory mirrors, liquid soap dispensers, sanitary napkin dispenser, toilet seat cover dispensers, sanitary napkin disposals, robe hooks, and mop holders.

[The architectural specialties described represent good architectural practices for the operational life expectancy.]

4.2.12.4.18 Fixed Equipment

Fixed equipment shall include general casework and countertops, laboratory casework and worktops, laboratory storage casework, work clothes storage bins, main entry mats, and exterior window blinds. The following apply unless noted otherwise:

● Lunchrooms, workrooms, health physics rooms, and other similar spaces shall have general casework including lower and upper cabinetry, countertops, and splashes.
Casework shall have plastic laminate faces mounted on high-density particleboard with a splash.

● Laboratories shall have laboratory casework and storage units. Casework shall include lower and upper cabinetry and chemical resistant laboratory worktops with an integral splash.

● Main and subchange rooms and laundry storage rooms for the storage of clean work clothing shall have work clothes storage bins. Bins shall have plastic laminate faces mounted on high-density particleboard.

● Main entrances shall have fixed recessed entry mats with an aluminum frame.

● Fixed exterior windows in offices and lunchrooms shall have window blinds. Blinds shall be 1-in. horizontal aluminum louvers with full tilt and lift controls.

[The fixed equipment described represents good architectural practices.]

4.2.12.4.19 Architectural Aspects of Ventilation Hoods

Architectural aspects of design of ventilation enclosures or hoods used for abrasive blasting, grinding, buffing, polishing, or spraying shall meet the applicable requirements of 29 CFR 1910.94, Ventilation [DIRS 177507].

[29 CFR 1910.94 (c)(3)(ii), (c)(4) and (c)(4)(ii)]

4.2.12.4.20 Conveying Equipment

Conveying equipment shall include personnel elevators, freight elevators, and dumb waiters. Size of conveying equipment depends on need and function, including dimensions and load requirements.

[Conveying equipment depends on the specific needs of each facility.]

4.2.12.4.21 Plumbing Fixtures

Plumbing fixtures shall include water closets, urinals, restroom lavatories, showers, service sinks, lunchroom sinks, health physics lavatories, electric water coolers, and emergency eyewash and shower stations.
The following standards will apply throughout unless noted otherwise:

● Water closets consist of wall-hung type with elongated vitreous china bowl, molded composition split seat, water closet support carrier, and automatic flush valves operation (1.6 gal per flush maximum). Pipe chase sizes provide for the installation of piping, carriers, and insulation material, if required.

● Urinals consist of wall-hung type with vitreous china bowl with support carrier and automatic operated flush valve (1 gallon per flush maximum).

● Restroom lavatories consist of wall-hung type or counter-mounted type and vitreous china bowl with splash lips and front overflow, complete with anti-scald faucet (2.2 gal/min maximum) and provisions for soap dispenser.

● Showers consist of single occupancy floor receptor with concealed water supply, drainage, and vent piping. Showers have single lever type shower valves (2.5 gal per minute maximum) with anti-scald mixer and vandal-proof showerheads.

● Service sinks consist of wall-hung type acid-resisting enameled cast iron bowl with wall hanger.

● Faucets in janitor closets consist of service-type with integral bucket hook and hose connection.

● Each lunchroom has a double bowl sink with appropriate fixtures.

● Faucets have a 2.2 gal per minute maximum flow.

● Each personnel decontamination room has a single bowl stainless steel lavatory with an associated trim (2.2 gal per minute maximum) and shower consisting of single occupancy floor receptor with concealed water supply, drainage, and vent piping.

● Water coolers consist of wall mounted metal electrically refrigerated units with adjustable stream regulator.

- Emergency eyewash and shower comply with ANSI Z358.1-2004, *American National Standard for Emergency Eyewash and Shower Equipment* [DIRS 173120].
- All plumbing fixtures and trim comply with ICC/ANSI A117.1-2003, *Accessible and Useable Building and Facilities* [DIRS 176223].

[The plumbing fixtures described represent good architectural practices for the operational life expectancy.]

4.2.12.4.22 Lighting

Lighting criteria is addressed in Section 4.3.1.2.

4.2.12.4.23 Floor Drains, Curbs, Ramps, and Sills

Floor drains, curbs, ramps, or sills shall be sized to accommodate anticipated fire fighting water without flooding ITS SSCs in all areas where automatic or manual water fire suppression systems are installed. Floor drains from different confinement zones shall not be interconnected. Facility design shall also ensure that fire water discharge in one area does not affect ITS SSCs in adjacent areas. The size and method of collection for fire suppression water shall be determined in a manner consistent with NFPA 801-2003 [DIRS 165077].

[This criterion is necessary to specify protection from the accumulation of fire water system discharge at an acceptable level to limit damage from fire water flooding. Specification of protection from fire water flooding limits potential fire damage to ITS SSCs and increases the likelihood that necessary or inadvertent fire system discharges do not result in degraded SSC performance. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.5; and NFPA 801-2003, Section 5.10, which specify the criterion for the protection of ITS SSCs for inadvertent effects of fire water system discharge. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.2.12.5 Building Materials Fire Protection

Building materials shall be fire tested in accordance with ASTM E 84-07, *Standard Test Method for Surface Burning Characteristics of Building Materials* [DIRS 182857]. Walls shall be designed in accordance with NFPA 221-2005, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls* [DIRS 177544].

[These are acceptable industry standards for wall design to protect against the spread of fires.]

4.2.13 Subsurface Structural Design Criteria

4.2.13.1 Site Information

4.2.13.1.1 Rock Properties

For rock properties, see *Subsurface Geotechnical Parameters Report* (BSC 2007 [DIRS 178693]).

4.2.13.1.2 Seismology

Yucca Mountain site-specific acceleration time histories and associated acceleration response spectra at the repository elevation and rock surface above repository elevation shall be those referenced in Section 6.1.10. The site specific seismic hazard evaluation shall be performed in accordance with Regulatory Guide 1.165, *Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion* [DIRS 119139] as clarified in RGA REG-CRW-RG-000140, *Agreement for Regulatory Guide 1.165, Rev. 0, Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion* [DIRS 181813].

[The YMP is committed to using site-specific ground motion. RGA REG-CRW-RG-000140 has provided guidance for Regulatory Guide 1.165.]

4.2.13.1.3 Groundwater

The water table is estimated to be over 1,000 ft below the North Portal and repository horizon. Although local and perched water may be encountered, environmental design conditions for the drifts and shafts shall be maintained dry.

[The water table is determined based on site investigations per Postclosure Modeling and Analyses Design Parameters (BSC 2007 [DIRS 179342]), Table 1, item # 01-04.]

4.2.13.2 Seismic Categorization of SSCs

4.2.13.2.1 Subsurface Seismic

All SSCs located underground shall be designed for seismic conditions in accordance with the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525] as described in Section 6.1.10.2.2.

[There are no SSCs in the Subsurface Facility that are ITS. The seismic categorization in accordance with site-specific seismic ground motion is not applicable.]

4.2.13.2.2 Seismic Use and Importance Factors for Subsurface Non-ITS SSCs

Non-ITS SSCs shall be designed based on the nature of occupancy and importance, and grouped as follows:

- Seismic Use Group I SSCs shall utilize an Importance Factor of 1.0 for designing conventional SSCs for standard occupancy.
- Seismic Use Group II shall utilize an Importance Factor of 1.25 for designing SSCs that represent substantial hazard to human life (example: Heavy Equipment Maintenance Facility).
- Seismic Use Group III shall utilize an Importance Factor of 1.5 for designing essential or hazardous SSCs (example: Warehouse and Non-Nuclear Receipt Facility).

[The use groups and importance factors are in accordance with the International Building Code 2000, with Errata to the 2000 International Building Code (ICC 2003 [DIRS 173525]).]

4.2.13.2.3 Reinforced Concrete Design For Subsurface Non-ITS SSCs

Non-ITS reinforced concrete structures shall be designed in accordance with ACI 318-02/318R-02, *Building Code Requirements for Structural Concrete (ACI 318-02) and Commentary (ACI 318R-02)* [DIRS 158832].

[ACI 318-02/318R-02 is the standard engineering code for reinforced concrete conventional structures. The responsible Discipline Engineering Manager has determined that ACI 318-02/318R-02 is appropriate for use in the design instead of the latter revision (ACI 318-05/318R-05).]

4.2.13.2.4 Structural Steel Design For Subsurface Non-ITS SSCs

Non-ITS steel structures shall be designed in accordance with *Manual of Steel Construction, Allowable Stress Design* (AISC 1997 [DIRS 107063]) and *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, June 1, 1989, with Commentary* (AISC 1989 [DIRS 159157]). Proportioning and detailing for seismic loads shall meet the additional requirements of ANSI/AISC 341-02-2002, *Seismic Provisions for Structural Steel Buildings*, Part III [DIRS 171789].

[The ASD method in AISC 1989 is widely accepted for structural steel design and detailing requirements as listed in the IBC. Although a more recent standard is available that includes the ASD methodology such that the use of the ASD was more difficult, making the newer document an undesirable standard to follow. CBCN011 to Revision 6 restored the reference to AISC 1989, which does not blend the ASD with alternative load factor methods.]

4.2.13.3 Materials

In addition to the criteria below, material restrictions in the Subsurface Facility are identified in the interface exchange documents listed in the BOD (BSC 2007 [DIRS 182131]).

4.2.13.3.1 Structural Steel

Structural steel for the invert structure in emplacement drifts shall conform to ASTM A 588/A 588M-05, *Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance* [DIRS 176255], corrosion resistant, high-strength, low-alloy steel.

All other applications including platforms, bulkhead plates, stiffeners, and miscellaneous steel shall conform to ASTM A 36/A 36M, *Standard Specification for Carbon Structural Steel*; ASTM A 992/A 992M, *Standard Specification for Structural Steel Shapes;* or ASTM A 500-03a , *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes* [DIRS 176418] carbon steel, with a minimum yield stress of 36 ksi. Higher strength and/or corrosion resistant materials may be used if required by the design.

Structural bolts shall conform to ASTM A 325-06 [DIRS 177892] or ASTM A 490-06 [DIRS 177893]. Bolts for the platform and stairs may conform to ASTM A 307. Structural connections shall be bearing type connections, except where slip critical connections are essential. Anchor bolts shall conform as a minimum to ASTM A 307 with a minimum yield of 36 ksi. Welding electrodes shall conform to Table 3.1 of the AWS D1.1/D1.1M.

[Structural steel in emplacement drifts is subjected to a corrosive environment; therefore, corrosion resistant material is recommended. Outside emplacement drifts industry standard materials are used. Although date revisions were previously specified for ASTM A 36/A 36M-05 [DIRS 176249], ASTM A 992/A 992M -06a [DIRS 177898], ASTM A 307-04 [DIRS 177889] and AWS D1.1/D1.1M-2006 [DIRS 176256], they have subsequently been removed from the text and reference list of this document. The standards are material constraints for which the latest year should be used. The previously cited versions have been identified in Section 8.4.]

4.2.13.3.2 Concrete and Reinforcing Steel

Reinforced concrete structures are not used in the emplacement drifts. Concrete structures used in nonemplacement areas shall conform to the following material properties:

- Concrete compressive strength (f'_c), based on 28 days strength, shall be 4,000 psi minimum.
- Reinforcing steel shall be deformed bars conforming to ASTM A 615/A 615M-06a [DIRS 177891] or ASTM A 706/A 706M-06a [DIRS 177896], Grade 60, with a minimum yield stress of 60,000 psi.
- Welded wire fabric shall conform to ASTM A 185/A 185M.

[Concrete and reinforcing materials are selected to conform with industry standards. Although date revisions were previously specified for ASTM A 185/A 185M-06 [DIRS 177883], they have subsequently been removed from the text and reference list of this document. This standard is a material constraint for which the latest year should be used. The previously cited versions have been identified in Section 8.4 .]

4.2.13.3.3 Nonshrink Grout

Nonshrink grout, where used, shall be based on type K Portland cement in accordance with the following:

- ASTM C 150-05, *Standard Specification for Portland Cement* [DIRS 176252]
- ASTM C 1240-05, *Standard Specification for Silica Fume Used in Cementitious Mixtures* [DIRS 176253]
- super plasticizer (no standard listed);
- ASTM C 494/C 494M-05a, *Standard Specification for Chemical Admixtures for Concrete* [DIRS 177900].

[Grout mix is selected to minimize the affects of shrinkage and to improve flowability.]

4.2.13.3.4 Ballast

Crushed tuff generated from the tunnel boring machine excavations shall be evaluated for its suitability for use as ballast material for the emplacement drift invert. Technical specification shall then be developed that describes the requirements for the ballast material, placement, and compaction.

[Ballast material will be selected based on its suitability for use in the tunnel.]

4.2.13.4 Environment and Corrosion Effects

The emplacement and nonemplacement areas of the subsurface facility are subject to the normal air temperature ranges listed in Section 4.2.13.5.7 and to the following operating environment during the preclosure period:

- Relative Humidity - Low 3%, High 10%
- Ionizing Radiation - Low levels of beta particles, neutron, and high and low energy photons (gamma and x-rays)
- Biological - Minimal effects.

The emplacement drifts and downstream airway openings and structures are also subject to off-normal peak temperatures not to be exceeded for a predetermined duration, as listed in Section 4.2.13.5.7.

[High temperatures in the emplacement drifts and downstream airway openings are caused by heat output generated by the waste packages. Continuous ventilation during the preclosure period will moderate the relative humidity. The relative humidity in the emplacement drifts is based on ANSYS Calculations in Support of Natural Ventilation Parametric Study for SR (BSC 2001 [DIRS 155246]), Figure 6-5, page 62. In the repository environment, many different microbes could grow and provide potential chemical processes that may affect bulk chemistry within the emplacement drift construction materials. However, during the preclosure period, the emplacement drifts are expected to be dry and low in relative humidity (about 10% or lower). The potential

microbiological affects on steel material will be insignificant under this environment. Further verification of the relative humidity range of 3% to 10% is required to verify if the range is applicable to the entire emplacement and nonemplacment area.]

4.2.13.4.1 Environmental Effects

Materials used in the emplacement drifts shall be evaluated with regards to the expected operating environment.

[Materials used in the design must meet design requirements in the expected operating environment.]

4.2.13.4.2 Corrosion Effects

A corrosion allowance for structural steel members shall be determined to allow for material degradation due to potential corrosion during the preclosure period in the subsurface facility.

[Factors that have a potential to effect corrosion in emplacement drifts are identified in Corrosion Evaluation of Steel Ground Support Components (BSC 2003 [DIRS 162448]); hence, a corrosion allowance is provided.]

4.2.13.5 Design Loads

SSCs shall be designed for the following loads.

4.2.13.5.1 Dead Loads (D)

Dead loads shall be those loads that remain permanently in place and include the weight of framing, permanent equipment, and all attachments.

[Industry standard practice.]

4.2.13.5.2 Live Loads (L and Lo)

Live loads (L) shall be those loads that are superimposed by the use and occupancy of the building or structure. Minimum live loads used for the design shall not be less than the following:

- Platforms, walkways, and stairs
- Uniform live load, 100 psf
- Concentrated load, 1,000 lbs.

These loads are concurrent. Concentrated load shall be applied to maximize moment and shear.

(Live load (L_o) is defined as the live load expected to be present during an earthquake event. L_o equal to 25% of the minimum uniform design live loads, as specified previously, may be used.)

Construction loads for the steel invert structure	500 psf
Minimum traffic load near shafts	H20 truck loading
Minimum surcharge load	300 psf
Minimum laydown load near shafts	250 psf.

[Recommended live loads and construction loads are based on the industry standard and construction experiences. H20 truck loading is from Standard Specifications for Highway Bridges, with 2004 and 2005 Errata (AASHTO 2005 [DIRS 178018]).]

4.2.13.5.3 Transport and Emplacement Vehicle (TEV) Loads

Transport and Emplacement Vehicle (TEV) supplier's information shall be used for the vehicle weight, wheel loads, and lifted loads for the final design of crane rails and supporting structural steel beams. The design allowances shall be in accordance-with ASME NOG-1-2004 [DIRS 176239].

[Project personnel determined that the TEV should be designed as a heavy lift device as opposed to a rail movement device. This allows for addressing the inherent safety risks associated with lifting and moving the waste packages. ASME NOG -1 suits this purpose.]

4.2.13.5.4 Waste Package Loads (WP)

For steel invert design, the maximum weight of the waste packages and pallets shall be used.

[The maximum dead load weights are necessary to develop the SSCs. Waste package components are just a portion of these loads.]

4.2.13.5.5 Drip Shield Loads (DS)

Drip shields in the emplacement drifts are planned to protect the waste packages from the rockfall and water intrusion during the postclosure period (including the regulatory period of 10,000 years). Drip shields shall be installed after the completion of the emplacement of all waste packages and prior to closure. No backfill is anticipated for the postclosure period. However, the backfill option shall not be precluded.

[The maximum dead load weights are necessary to develop the SSCs. Drip shield components are just a portion of these loads.]

4.2.13.5.6 Ventilation Pressure Loads (P)

Isolation barriers, steel bulkheads, and ventilation doors shall be designed for the ventilation differential pressure load, in addition to the dead and seismic loads. Maximum ventilation differential pressure shall be equivalent to the potential maximum primary fan pressure transmitted when the barrier and turnout bulkheads are closed. Intake and exhaust shaft collar and ventilation sweep shall be designed for the maximum internal air pressure.

[Maximum ventilation differential pressure is needed to design the barriers, bulkheads, and doors and shall be provided by the Subsurface Ventilation group. Maximum internal air pressure needed to design shaft collars and vent sweeps is provided by the Subsurface Ventilation group.]

4.2.13.5.7 Temperature Loads (T)

The design of SSCs shall include the effects of variations in temperatures. Air temperatures in emplacement and nonemplacement areas of the subsurface facility are not expected to fall outside the normal air temperature ranges listed in Table 4.2-3. Design temperatures for structural components shall consider these normal air temperature ranges in addition to deviations (temperature spikes for a given duration) that might occur during off-normal events affecting subsurface ventilation mechanical equipment or ventilation underground airways.

Table 4.2-3 Normal Range of Area Air Temperatures

Subsurface Facility Areas	Normal Air Temperature Range, °C	Comment
Access Mains and Turnouts[c]	7 - 31 (average inlet air temperature range)	Habitable conditions
Fully loaded emplacement drifts[a] (Uninhabitable)	23 - 74	In-drift air temperatures vary per these parameters: location in drift (low values near drift entrance); emplacement drift length; and years of ventilation. NOTES: (1)23°C is the emplacement drift inlet design temperature; (2) in-drift air temperatures are maintained below 50°C when emplacement equipment is operating.
Exhaust mains, shaft access drifts, and shafts[a] (Uninhabitable)	42 - 74	Temperatures in these areas vary with extent of emplacement in a given area or panel, and years of ventilation.
Exhaust fans[b]	32 - 64	These temperatures reflect a 10-degree cooling for the vertical ascent.

Sources: [a] DTN: MO0307MWDAC8MV.000 [DIRS 165395]
[b] *Mine Ventilation and Air Conditioning* (Hartman et al. 1997 [DIRS 101877]), Equation 16.2
[c] DTN: GS030808312231.004 [DIRS 166735], SEP Table S0332701

[Design peak wall temperatures in emplacement drifts and downstream airway openings are based on temperature limits that will preserve structural integrity of ground support and structural components for off-normal event conditions not to exceed a predetermined duration. DTNs MO0307MWDAC8MV.000, Analytical-LA-Coarse-800M Ventilation [DIRS 165395] and GS030808312231.004, Moisture Monitoring in the Exploratory Studies Facility (ESF) from August 2000 to July 2002 [DIRS 166735], referenced as sources in Table 4.2-3 are included in IED Emplacement Drift Configuration and Environment (BSC 2007 [DIRS 180412]). Although CBCN008 to Revision 6 provided the DTNs, the IED has since been revised and updated here.]

4.2.13.6 Load Combinations and Allowable Stresses

Notations:

CL = Gantry crane load
D = Dead loads
L = Live loads (L and L_o)
E = Seismic loads
TEV = Transport and Emplacement Vehicle Loads
WP = Waste package load plus emplacement pallet load
DS = Drip shield loads
P = Ventilation pressure differential loads
T = Temperature loads.

4.2.13.6.1 Steel Structures

Invert steel structures in the emplacement drifts are designated as non-ITS SSCs and shall be designed in accordance with the following load combinations, as applicable:

S = D + CL + L + P
S = D + CL + L + P + T
S = D + WP + DS + L + P
S = D + WP + DS + L + P + T
S = D + CL + L + P + E
S = D + CL + L + P + T + E
S = D + WP + DS + L + P + E
S = D + WP + DS + L + P + T + E
S = Allowable stress as permitted by the AISC ASD method (AISC 1997 [DIRS 107063]).

NOTE: Allowable stresses may be increased by 33% when seismic load is present in the above load combinations. Other steel structures and components that are in the subsurface area and designated as non-ITS SSCs shall be designed in accordance with the following (alternative) load combinations of *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525], Section 1605.3.2) and conform to the requirements of the AISC ASD method AISC 1997:

S = D + L
S = D + L + P + T
S = D + L + 0.7E
S = D + L + P + T + 0.7E
S = 0.9D + 0.7E
S = Allowable stress as permitted by the AISC ASD method.

[Steel structures that are designated as non-ITS SSCs are based on the AISC ASD method and in conformance with the industry practice.]

4.2.13.6.2 Concrete Structures

Concrete structures are not expected to be used in the emplacement drifts. Concrete structures where used in the nonemplacement areas are designated as non-ITS SSCs and shall be designed in accordance with the following load combinations, conforming to the requirements of the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]):

U = 1.4D
U = 1.2D + 1.6L
U = 1.2D + 1.2T + 1.6L
U = 1.2D + 1.0L + 1.0E
U = 1.2D + 1.2T + 1.0L + 1.0E
U = 0.9D + 1.0E
U = Required strength per the IBC.

NOTE: Above load combinations are not applicable to concrete shaft collar design.

[The design load combinations listed for the concrete structures that may be used in the nonemplacement area are based on the IBC. These structures are classified as non-ITS SSCs, and it is an industry practice to design them in accordance with IBC.

4.2.13.6.3 Foundation Design

Foundation design for the non-ITS SSCs shall be in accordance with the requirements of the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525], Chapter 18).

[Foundations are addressed with in the IBC.]

4.2.13.6.4 Surface Structures that are Part of Subsurface Facilities

Surface structures that are part of subsurface facilities and categorized as non-ITS SSCs shall be designed in accordance with applicable sections of Section 4.2.11.5.

[Required design criteria for conventional structures located at the surface level are provided in Section 4.2.11.5]

4.2.13.7 Anchors

4.2.13.7.1 Rock Anchors

Rock anchors to be used for securing invert structures and ventilation bulkhead doors shall conform to applicable criteria in Section 4.5, and are specifically designed to accommodate applications to both lithophysal and nonlithopysal rocks with adequate shear resisting capacity.

[Section 4.5 is developed by the Subsurface Geotechnical group for designing ground support systems including rockbolts. The rock anchors discussed in this section are to be used for securing invert structures and ventilation bulkhead doors in place and have different functional requirements from those for typical rockbolts. Although rockbolts and rock anchors will be of similar materials, specific design and installation requirements must be considered for their specific purposes. The criteria to conform to the rock bolts specified in Section 4.5 are to emphasize rock anchor design responsibility placed on the Subsurface Geotechnical group, provide for design consistency between PDC sections 4.2 and 4.5, and ensure uniformity of materials, installation, and testing. It is noted that shear resisting capability must be made adequate to meet the functional requirements for rock anchors.]

4.2.13.7.2 Concrete Expansion Anchors

Concrete expansion anchors shall be designed and installed in accordance with manufacturer recommendations.

[It is industry practice to design and install expansion anchors in accordance with manufacturer recommendations.]

4.2.13.8 Permanent Subsurface Design

4.2.13.8.1 Vertical Separation

The vertical separation between crossing drifts shall be a minimum of 33 ft (10m) from the crown of the lower opening to the invert of the upper opening.

[This is to ensure stable openings when drifts cross at different elevations. Ground Control for Non - Emplacement Drifts for LA (BSC 2007 [DIRS 183406], Section 7.2) provides this criterion.]

4.2.13.8.2 Minimum Spacing

The minimum spacing (centerline-to-centerline) for nonemplacement drifts, running parallel, shall be three diameters, based upon the diameter of the larger drift.

[This is to provide for stable openings. This criterion was selected off Rock Mechanics and the Design of Structures in Rock (Obert and Duvall 1967 [DIRS 173469], Figure 16.2.2, page 497). The specific point off the curve is based on judgment.]

4.2.13.8.3 Diameter Dimensions for Access Mains

The access mains and ramps shall be a nominal 25 ft (7.62 m) in diameter.

[This criterion establishes a nominal opening for use in designing mobile equipment that is intended to use these openings. This diameter is the same as the excavated diameter of the existing Exploratory Studies Facility. Underground Layout Configuration (BSC 2003 [DIRS 165572], Tables 4, 5, and 6) provides this criterion.]

4.2.13.8.4 Deleted

[This criterion was deleted and consolidated in the BOD (BSC 2007 [DIRS 182131]), Criterion 8.2.1.8 Emplacement Drift Configuration. CR 10700.]

4.2.13.8.5 Subsurface Flood Protection

Portal and shaft or raise collar openings shall be protected from the probable maximum flood by making the surface gradient at the portal openings and shaft collars down gradient and away from the openings.

[This will prevent surface waters/surface runoff from rain or spills from entering the emplacement drifts and shaft openings during times of flooding. Underground Layout Configuration (BSC 2003 [DIRS 165572], Sections 7.2.3 and 7.2.4) provides this criterion.]

4.2.13.8.6 Opening Stability

The emplacement drifts shall be oriented at least 30 degrees from the dominant joint set.

[This provides for stable emplacement drift openings. The emplacement drifts are presently located along an azimuth of 252 degrees or alternately an azimuth of 72 degrees (180 degrees from 252 degrees) (BSC 2003 [DIRS 165572], Section 5.1.4). TBV-361 Resolution Analysis: Emplacement Drift Orientation (CRWMS M&O 1999 [DIRS 115042], Section 8.2, p. 26) provides this criterion. This criterion was moved from Section 4.12.2 per CBCN016 to Revision 6.]

4.3 Electrical Design Criteria

4.3.1 General Electrical Design Criteria

4.3.1.1 System Design

4.3.1.1.1 Electrical Codes

Electrical system design shall comply with NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982] and NFPA 70E-2004, *Standard for Electrical Safety in the Workplace* [DIRS 178067].

[DOE O 440.1A Worker Protection Management for DOE Federal and Contractor Employees [DIRS 102288] Section 12.k, Contractor Requirement mandates the use of the National Electric Code. 10 CFR 851.27(b) Worker Safety and Health Program [DIRS 182868] mandates the use of both NFPA 70 and NFPA 70E-2004. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.1.2 Power and Lighting

Electrical power and lighting systems, other than those systems or portions thereof required for emergency use only, shall comply with ANSI/ASHRAE/IESNA Std 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [DIRS 174321], Sections 8 and 9.

[Although this criterion previously referenced 10 CFR 434, it has been replaced by 10 CFR 433 [DIRS 181833], which directly imposes ANSI/ASHRAE/IESNA 90.1-2004.]

4.3.1.1.3 Safety Design

4.3.1.1.3.1 **Life Safety**

Electric power system design shall provide for the safe distribution of power and comply with NFPA 101-2006 *Life Safety Code, with Errata and Tentative Interim Amendments* [DIRS 177965].

[Industry standard code.]

4.3.1.1.3.2 **Electrical Safety Design**

Electrical design of power generation, transmission, and distribution shall comply with the applicable requirements of 29 CFR 1910 *Labor: Occupational Safety and Health Standards* Section *269, Electrical Power Generation, Transmission and Distribution* [DIRS 177507]. This includes, as part of the energy control program, that energy isolating devices for machines or equipment shall be designed to accept a lockout device. The appropriate components shall be substantial enough to prevent removal without the use of excessive force and provide for a safe or off position.

[29 CFR 1910.269(d)(2)(ii)(C), (3)(i)(C), (6)(iv)(A), and 29 CFR 1910.269(t)(1).]

4.3.1.1.3.3 **Storage Near Electrical Equipment**

Facilities may not provide for material or equipment storage (in areas not restricted to qualified persons only) closer than 10 ft for lines and equipment energized at 50 kV or less and 10 ft plus 4 in. for every 10 kV over 50 kV. The design shall provide additional distance to energized lines or exposed energized parts of equipment for the maximum sag and side swing of all conductors and providing for the height and movement of material handling equipment. In areas restricted to qualified employees, material may not be stored within the working space (size contained in 29 CFR 1910 *Labor: Occupational Safety and Health Standards* [DIRS 177507] Section 269(u)(1) and (v)(3)) about energized lines or equipment0.

[29 CFR 1910.269(k)(2)(i)(A and B) and (ii).]

4.3.1.1.3.4 **Electrical Components for Ventilation Hoods**

Electrical components for ventilation enclosures or hoods used for abrasive blasting, grinding, buffing, polishing, or spraying shall meet the applicable requirements of 29 CFR 1910.94 *Labor: Occupational Safety and Health Standards*, *Ventilation* [DIRS 177507].

[29 CFR 1910.94(a)(2)(iii) and (c)(3)(i)(a).]

4.3.1.1.3.5 **Fire Protection Design**

Electric power system design shall provide for fire protection requirements by complying with NFPA 1-2005, *Uniform Fire Code* [DIRS 175765] and NFPA 801-2003, *Standard for Fire Protection for Facilities Handling Radioactive Materials* [DIRS 165077].

[Industry codes addressing the subject.]

4.3.1.1.3.6 **Hazardous Locations**

Engineering shall address the applicable requirements of 29 CFR 1910 *Labor: Occupational Safety and Health Standards* [DIRS 177507], Section 307, *Hazardous (classified) Locations,* and NFPA 70.2005 [DIRS 177982], Article 500, Hazardous (Classified) Locations, Classes I, II, and III, Divisions 1 and 2 for the placement of electrical equipment and wiring in classified locations of the YMP.

[29 CFR 1910.307 provides acceptable criteria. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.1.3.7 **Fire Protection Capability**

Fire barriers or automatic suppression, or both, shall be installed as necessary to protect systems or components necessary to prevent or mitigate and event sequence in accordance with Regulatory Guide 1.189, *Fire Protection for Operating Nuclear Power Plants* [DIRS 155040] Sections C.5, C.5.5.1 through C.5.5.7 (Except Section C.5.5.3 and C.5.5.4).

[RGA REG-CRW-RG-000164, Agreement for Regulatory Guide 1.189, Rev. 0 - Fire Protection for Operating Nuclear Power Plants (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.3.1.1.4 Future Load Growth

The system design shall provide a design margin to accommodate future load growth for electrical equipment like transformers, switchgear, load centers, motor control centers, raceway, cables, etc.

[This criterion is needed to ensure that the electrical system is designed with sufficient margin for the future. The design margin is applied in addition to the system loads defined during the final design.]

4.3.1.1.5 Voltage Regulation

Voltage regulation shall be based on ANSI C84.1-19915, *Electric Power Systems and Equipment- Voltage Ratings (60 Hz)* [DIRS 126007] as follows:

• The voltages on the 13.8 kV, 4.16 kV, and 480 V buses during normal operation is within +5%, and -10%

• The maximum momentary bus voltage dip on the 4.16 kV buses during the starting of a 4 kV motor is -20%

• The maximum momentary bus voltage dip on the 480 V buses during the starting of a 460 V motor is -20%

• Motor terminal voltage range under steady-state operating condition is ±10% of the motor-rated terminal voltage

• Minimum motor terminal voltage is 80% of the motor-rated terminal voltage when starting with all other motors running

• The voltage drop in feeder circuits (between Motor Control Center and panelboard) and branch circuits (between panelboard and load) combined should not exceed -5%

[This criteria is needed to define the design voltage regulation. For voltages of 600 volts and below, NFPA 70, National Electrical Code, with Tentative Interim Amendment, 2005 Edition [DIRS 177982] describes that the voltage drop in feeder circuits (between Motor Control Center and panelboard) and branch circuits (between panelboard and load) combined should not exceed -5%. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.1.6 Division of Power Systems

Electric power systems shall be divided into normal, standby, and emergency power systems. The uninterruptible and direct current (DC) power sources shall be included for uninterruptible power as well as protective relaying and control functions. Distribution shall be in accordance with:

- IEEE Std 141-1993, *IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants* [DIRS 122242]
- IEEE Std 241-1990 (Reaffirmed 1997), *IEEE Recommended Practice for Electric Power Systems in Commercial Buildings* [DIRS 169314]
- IEEE Std 399-1997, *IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis* [DIRS 122246]
- IEEE Std 336-2005, *IEEE Guide for Installation, Inspection, and Testing for Class 1E Power, Instrumentation, and Control Equipment at Nuclear Facilities* [DIRS 177587]
- IEEE Std 112-2004, *IEEE Standard Test Procedure for Polyphase Induction Motors and Generators* [DIRS 177608]
- IEEE Std 739-1995, *IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities* [DIRS 116978].

[These industry standards provide for requirements for defining power distribution systems.]

4.3.1.1.7 Normal Power Supply Voltages

The facility normal power supply voltages shall be in accordance with the following per IEEE Std 141-1993 [DIRS 122242]:

- 13.8 kV, 60 Hz, 3-phase, 3-wire, resistance grounded neutral
- 4.16 kV, 60 Hz, 3-phase, 3-wire, resistance grounded neutral
- 480V, 60 Hz, 3-phase, 3-wire, solidly grounded neutral
- 480/277 V, 60 Hz, 3-phase, 4-wire, solidly grounded neutral
- 208/120 V, 60 Hz, 3-phase, 4-wire, solidly grounded neutral
- 240/120 V, 60 Hz, 1-phase, 3-wire, solidly grounded neutral.

The DC battery system voltage shall be 125 V.

[This criterion is required to define the facility application voltages in compliance with IEEE Std 141-1993. These voltages are most commonly used in the industry in the United States for medium- and low-voltage systems. The electrical equipment is most readily available in these voltages. Their performances have long been proven.]

4.3.1.1.8 DC Power System

The DC power system shall be used for protective relaying and medium-voltage switchgear control, as needed, in accordance with IEEE Std 946-2004, *IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations* [DIRS 177610].

[This criterion is required to define the facility medium-voltage switchgear control voltage for the service

continuity capability. The DC power will be available even in facility blackout. Therefore, the critical circuit breaker control capability is secured.]

4.3.1.1.9 Electrical Load Distributation

Nuclear facility electrical loads shall be divided into two groups (trains) as either group A or B. The loads shall be evenly distributed as much as possible to achieve balance between the two groups (trains).

[This criterion is required to define the power distribution system structure. This can simplify the system design, system control, avoid a common mode failure, or minimize the effects of failure of one load group. Division of the loads can also facilitate maintenance and increase availability of the facility loads.]

4.3.1.1.10 Panelboards

Panelboards shall be designed, manufactured and tested in accordance with UL 67-2006, *Panelboards* [DIRS 178046], UL 50-2007, NEMA PB1-2006 *Panelboards,* [DIRS 177613] and NFPA 70-2005 [DIRS 177982]. They shall be sized to accommodate a minimum twenty-five percent load growth and have the space capacity to add a minimum twenty-five percent additional circuit breakers based on the number of circuit breakers at the time of procurement.

[This criterion is required to conform to national standards for panelboards. The spare capacity is provided to allow sufficient margin for future load growth. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.1.11 Transformers

Transformers shall be liquid-filled or dry-type for outdoor service and dry-type for indoor and subsurface service with a minimum twenty-five percent spare capacity based on the forced-air cooling rating of the transformer, at time of procurement. If the transformer does not have forced-air cooling, then the spare capacity will be based on the normal ONAN or AA rating. For dual source line-up, the 25% spare capacity does not apply during conditions when the tie circuit breaker is closed and one transformer is supplying power to the loads. The transformers shall be manufactured in accordance with IEEE Std C57.12.00-2006. *IEEE Standard for Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers* [DIRS 180653] and IEEE Std C57.12.01-2005. *IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin-Encapsulated Windings* [DIRS 180651].

[This criterion is required for increasing the outdoor transformer efficiency and minimizing the potential fire hazards, which can be caused by indoor transformers. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.1.12 Transformer Voltages

The transformers for outdoor installation shall be 13.8 kV to 4.16 kV, 13.8 kV to 480/277 V, 4.16 kV to 480/277 V, 480 V to 480/277 V and 480 V to 208/120 V, 3-phase, 60 Hz, with taps provided for voltage regulation. The primary side shall be delta connected; the secondary side shall be wye connected; with the neutral resistance-grounded for 4.16 kV secondary and solid-grounded for 480/277 V or 208/120 V secondary.

[This criterion is required to standardize design for reliable operation. The transformers with these voltages are most commonly used in the industry. The neutral resistance grounding in the medium-voltage system will minimize the fault current for human safety. The solid neutral grounding for the low-voltage system will facilitate quick clearing of the fault. The delta-wye connection will minimize grounding fault effects and minimize harmonics in the system.]

4.3.1.1.13 Medium-Voltage Switchgear

The medium-voltage switchgear~~s~~ shall be rated at 13.8 kV or 4.16 kV, 3-phase, 60 Hz. The switchgear~~s~~ shall be rated to withstand the maximum short-circuit current available in the system. The medium-voltage switchgear bus shall be sized to accommodate a minimum twenty-five percent load growth and have the space capacity to add twenty-five percent (minimum) additional circuit breakers based on the number of circuit breakers at the time of procurement

[This criterion is required to define the system operation voltages and to standardize design. The maximum short-circuit current withstanding capability is required to prevent failures that result in unnecessary damage, power

interruptions, personnel injury and production shutdowns. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.1.14 Lighting and Instrumentation Transformers

Lighting and instrumentation transformers shall be a dry type with a minimum twenty-five percent spare capacity at the time of procurement. The primary shall be delta connected, and the secondary shall be wye connected and solidly grounded (480/277 V or 208/120 V). The single phase lighting transformer of 480 - 240/120 V can also be used as required.

[This criterion is required to standardize design for a reliable and safe operation. It will minimize fire hazards by not using an oil-filled transformer for indoor application and minimize harmonics in the system. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.1.15 Load Center

The 480 V load center (switchgear) shall be used to provide power to the downstream motor control centers and motors larger than 150 hp up to 250 hp and static loads up to 400 kW. The load center bus shall be sized to accommodate a minimum twenty-five percent load growth and have the space capacity to add a minimum twenty-five percent additional circuit breakers based on the number of circuit breakers at the time of procurement.

[This criterion is required to define the role of the 480 V load center and ensure safe operation of medium size 480V motors and other static loads. This is the commonly accepted industry practice. This practice will minimize the stress in electrical equipment. This will enable long-term equipment operation. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.1.16 Motor Control Center

The 480 V motor control center shall be used to provide alternating current (AC) power to induction motors rated 150 hp or below, but above 1/3 hp, miscellaneous branch circuits, and static loads up to 240 kW. The motor control center bus shall be sized to accommodate a minimum twenty-five percent load growth and have the space capacity to add a minimum twenty-five percent additional circuit breakers based on the number of circuit breakers at the time of procurement.

[This criterion is required to define the role of the 480 V motor control center and for reliable and safe operation of low integral or fractional size motors and other static loads. This is the commonly accepted industry practice. This practice will facilitate easy installation and easy replacement of motors or static loads. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.1.17 Circuit Breakers

Circuit breaker trip units shall be connected in series with each ungrounded conductor. Units shall be sized in accordance with circuit ampacity and rated to withstand available short-circuit current

[Common Industry Practice]

4.3.1.1.18 Alternating Current Motors

In general, AC motors shall be squirrel-cage, induction type, and suitable for operation in accordance with IEEE Std 141-1993, *IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants* [DIRS 122242] and ANSI C84.1-2006, *Electric Power Systems and Equipment - Voltage Ratings (60 Hz)* [DIRS 182858]. System supplies shall be as listed in Table 4.3.1-1.

[This criterion is required to define the motor application voltages for reliable and safe operation. This is a commonly accepted industry practice.]

Table 4.3.1-1. AC Motor Supplies

Motor Size	Utilization Voltage	System Supply
1/3 hp and smaller	115 V	120 V, 1-phase, 60 Hz
1/2 hp to 250 hp	460 V	480 V, 3-phase, 60 Hz
251 hp to 4,000 hp	4 kV	4.16 kV, 3-phase, 60 Hz
Adjustable speed, reversing and two-speed motors	460 V	480 V, 3-phase, 60 Hz

4.3.1.1.19 Outdoor Motors

The motors used for outdoor installation or in areas where moisture, chemical fumes or other harmful ingredients are present in the surrounding environment shall be either totally enclosed fan-cooled, totally enclosed non-ventilated, or weather-protected and Type II.

[This criterion is required to ensure that the motor is protected from weather or chemical hazards.]

4.3.1.1.20 4 kV motors

The 4 kV motors shall be designed to accelerate the load with 80% rated voltage at the motor terminals during the motor starting period.

[This criterion is required to ensure that the motor is able to start and accelerate its load, even at a point that the electric power supply system is at its designed minimum value.]

4.3.1.1.21 Motor Space Heaters

Motors shall be provided with single phase or three phase space heaters to keep the motor winding and internal parts dry when the motor is not running.

[This is a commonly accepted industry practice to keep moisture from degrading or damaging the motor winding and internal parts.]

4.3.1.1.22 Voltage Rating of Motor Space Heaters

The voltage rating of the motor space heaters shall be rated 240 volts of alternating current (VAC) for heaters to be powered from the 120 VAC, single phase source, and 575 VAC for heaters to be powered from the 480 VAC, single phase or three phase. The space heaters for motors shall be energized automatically when the motor is idle.

[This is a commonly accepted industry practice that provides the space heater extended service life and still does its intended function.]

4.3.1.1.23 Adjustable Speed Drives

Adjustable speed drives shall be used where it is required to control the speed of the driven mechanical equipment. Adjustable speed motors should be qualified for inverter duty per NEMA MG 1-1998, Rev. 1. 2000. *Motors and Generators*, Part 31 [DIRS 177612].

[This criterion is required because some mechanical equipment require adjustable speeds for operation or require large torque to start rotation.]

4.3.1.1.24 Battery Systems

The battery systems for switchgear circuit breaker control shall be 125 V of direct current (VDC) nominal voltage. The battery systems shall be designed for a long life and with low maintenance requirements per NFPA 70 [DIRS 177982]. The batteries shall be designed in accordance with IEEE Std 485-1997 (R2003), *IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications* [DIRS 172090], qualified in accordance with IEEE Std 535-1986, *IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations* [DIRS 145717], and maintained and tested in accordance with IEEE Std 450-2002, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications* [DIRS 171696]. The batteries shall be sized with an additional (minimum) twenty-five percent capacity at time of commissioning.

[This criterion is required to define the DC system voltage. The voltage is most commonly used in the industry. RGA REG-CRW-RG-000134, Agreement for Regulatory Guide 1.158, Rev. 0 - Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants (BSC 2007 [DIRS 181773]) provided agreement on Regulatory Guide 1.158, Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants [DIRS 165779] to use IEEE Std 535-1986. RGA REG-CRW-RG-000107, Agreement for Regulatory Guide 1.129, Rev. 1 - Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants (BSC 2007 [DIRS 181743]) provided agreement on Regulatory Guide 1.129,Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants [DIRS 145515] except that IEEE Std 450-2002 is adopted instead of the 1975 version.
NOTE: IEEE Std 484, IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications [DIRS 169128], and Regulatory Guides 1.128, Installation Design and

Installation of Large Lead Storage Batteries for Nuclear Power Plants [DIRS 145510] moved to section 4.3.1.1.33.
The requirements for UPS batteries is provided in 4.3.1.1.27. The additional spare capacity is provided to allow sufficient margin for future load growth. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.1.25 125 VDC Equipment

The 125 VDC equipment shall be designed to operate between 140 VDC and 105 VDC range in accordance with IEEE Std 946-2004, *IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations* [DIRS 177610].

[The standard battery and battery charger system voltages range from 140 VDC when the battery is being charged to a minimum of 105 VDC. This is a commonly accepted industry requirement.]

4.3.1.1.26 125 VDC System Grounding and Alarms

The 125 VDC systems shall be ungrounded with a ground detection system on the positive and negative legs. Other alarms shall include battery breaker position open alarm, battery charger output breaker position open alarm, battery charger AC undervoltage alarm, battery charger DC overvoltage alarm, and battery charger DC undervoltage alarm.

[This is a commonly accepted industry practice to enable the DC systems to satisfy the reliability and availability of the requirements expected of the system.]

4.3.1.1.27 Uninterruptible Power Supplies

Uninterruptible power supplies (UPS) shall have a minimum twenty-five percent spare capacity at the time of procurement and be designed in accordance with:

- IEEE Std 446-1995, *IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial* A*pplications* [DIRS 125763]
- ANSI/IEEE Std 944-1986, *IEEE Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations* [DIRS 166684] for ITS applications
- IEEE Std 1184-1994 (R1995), *IEEE Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems* [DIRS 164267] for ITS applications
- IEEE Std 650-2006, *IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations* [DIRS 177954] for maintenance and surveillance program of ITS components.

UPS power of acceptable quality shall be provided, without delay or transient during a power interruption, to important monitoring and control loads that cannot tolerate a power interruption. Important computer systems shall also be supplied with UPS. Furthermore, the waste package closure system will also be supplied by an UPS so that a controlled shutdown of the welding process can be performed upon loss of power.

[This criterion is required for operational continuity. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.1.27.1 **Deleted**

[This criterion for normal power supplying a UPS has been combined with other seismic monitoring subsystem criteria in Section 4.6.3.4. CBCN014 to Revision 6 provided for this change.]

4.3.1.1.28 Control and Instrumentation

UPS battery banks shall be designed in accordance with IEEE Std 1184-1994 (R1995) [DIRS 164267]. The UPS systems for facility control and instrumentation applications shall be supplied by 480 VAC power and the output shall be 208/120 V, 3-phase, 60 Hz. These UPS systems shall have a minimum twenty-five percent spare capacity at the time of procurement. UPS battery banks shall be sized to provide UPS power for the duty cycle required by the load it feeds, with a minimum of 15 minutes.

[This criterion is required to define the UPS system voltage. The selected voltage is most commonly used in the industry. The performance and reliability are superior. The minimum continuous UPS operating time is an industry standard and allows adequate time for the diesel generators to supply power to UPS backed equipment. The requirement of providing uninterruptible power is also indicated in NFPA 70, *National Electrical Code, with*

Tentative Interim Amendment, 2005 Edition [DIRS 177982]. *Although a later version of* NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version. The spare capacity is provided to allow sufficient margin for future load growth.*

4.3.1.1.29 Diesel Generators

The standby diesel generators, the emergency diesel generators, and security diesel generators shall be rated 13.8 kV, 4.16 kV, or 480v, as appropriate, 3-phase, and 60 Hz, wye connected. Upon loss of voltage on its associated bus, the diesel generator shall be automatically started. Each diesel generator shall have a minimum fifteen percent spare capacity at the time of procurement. The electrical system shall be designed to accommodate additional paralleled diesel generators (except for CCCF).

[This criterion is required for the optimum system design. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.1.30 Batteries

Batteries shall be designed in accordance with:

- IEEE Std 485-1997 (R2003) [DIRS 172090]
- IEEE Std 650-2006 [DIRS 177954]
- IEEE Std 1115-2000 (R2005), *IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications* [DIRS 177947]
- IEEE Std 1184-1994 (R1995) [DIRS 164267]
- IEEE Std 1188-2005, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications* [DIRS 177609]
- IEEE Std 1189-1996, *IEEE Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications* [DIRS 166681].

[These provide the industry standards.]

4.3.1.1.31 Harmonic Control

Electric power systems shall be designed to minimize harmonics in accordance with IEEE Std 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems* [DIRS 164198].

[Industry standard.]

4.3.1.1.32 Enclosures

Electrical enclosures shall be designed in accordance with NEMA 250, *Enclosures for Electrical Equipment (1000 Volts Maximum)*.

[Industry standard for application.]

4.3.1.1.33 Lead Storage Battery Installation Design

Lead storage battery installation design and installation shall be in accordance with IEEE Std 484-2002, *IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications* [DIRS 169128].

[RGA REG-CRW-RG-000106, Agreement for Regulatory Guide 1.128, Rev. 1 - Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants (BSC 2007 [DIRS 181711]) adopted Regulatory Guide 1.128,Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants [DIRS 145510] with clarification that IEEE Std 484-2002 will be used instead of IEEE Std 484-1975.]

4.3.1.1.34 Electrical and Control Equipment Room Layouts

The location and layout of the electrical, controls, and communications rooms shall be designed to aid in fire protection, mitigation and suppression in accordance with Regulatory Guide 1.189 *Fire Protection for Operating Nuclear Power Plants* [DIRS 155040] Sections C.6.1.2 through C.6.1.9, and C.7.3.

[RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.3.1.2 Lighting System

Normal, essential, and emergency lighting systems (including illumination levels) shall be designed in accordance with:

- *IESNA Lighting Handbook, Reference and Application*, *with Errata* (Rea 2005 [DIRS 176384])
- ANSI/IESNA RP-22-05, *IESNA Recommended Practice for Tunnel Lighting* [DIRS 177606]
- ANSI/IESNA RP-1-04, *American National Standard Practice for Office Lighting* [DIRS 174537]
- ANSI/IESNA-RP 7-01, *Recommended Practice for Industrial Lighting, with Errata* [DIRS 176343]
- ANSI/IESNA RP-8-00, *Standard Practice for Roadway Lighting, with Errata* [DIRS 173093]
- NFPA 70, *National Electrical Code, with Tentative Interim Amendment*, 2005 Edition [DIRS 177982]
- NFPA 101-2006 [DIRS 177965].

Normal lighting shall be provided in areas where sudden loss of light does not affect safety or production. Essential lighting shall be provided in areas where sudden loss of light does have an affect on production and safety to personnel. Emergency lighting shall be provided in areas where manual operations, sustained system operations, and exits from the facilities are required during postulated emergencies. Emergency lighting shall include egress, safeguard, and security lighting.

[This criterion is required to ensure adequate illumination for all areas in the facility and operations during all modes of facilities operations. The documents identified are accepted industry standards. 29 CFR 1910.34, .35, .36, and .37 endorse NFPA 101 as sufficient to demonstrate compliance with exit route provisions. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.3 Cable

4.3.1.3.1 Distribution Cable

Power system cables shall be designed in accordance with IEEE Std 525-1992, *IEEE Guide for the Design and Installation of Cable Systems in Substations* [DIRS 169318]. The 15 kV and 5 kV power cables shall be shielded and shall be either a single conductor or a triplexed Class B stranded copper conductor, with a 133% insulation level, rated for continuous operation at 90°C, 130°C for emergency overload operation, and 250°C for short circuit conditions in accordance with applicable Insulated Cable Engineers Association (ICEA) standards:

- NEWA WC 8-1988, *Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy* [DIRS 158601]
- NEMA WC 58-1997 (R2005), *Portable and Power Feeder Cables for Use in Mines and Similar Application* [DIRS 177963]
- NEMA WC 70/ICEA S-95-658-1999, *Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy* [DIRS 173603]
- NEMA WC 71-1999, *Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy* [DIRS 173604]
- NEMA WC 72-1999 (R2004), *Continuity of Coating Testing for Electrical Conductors* [DIRS 178298]
- NEMA WC 50-1976 (R1999),ICEA P-53-426 (Second Edition), *Ampacities Including Effect of Shield Losses for Single-Conductor Solid-Dielectric Power Cable, 15kV through 69kV (Copper and Aluminum Conductors)* [DIRS 177962]
- NEMA WC 51-2003, *Ampacities of Cables Installed in Cable Trays* [DIRS 173601]
- NEMA WC 74-2006 (R2007), *5-46kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy* [DIRS 182861].

[This criterion is required to ensure the quality of cables is satisfactory for normal and emergency applications. The cited codes are industry standards.]

4.3.1.3.2 Utilization Cable

The 480 V power, 277 or 208/120 V lighting, 480 V motor feeder and 120 V control cables shall be single conductors, copper, rated 600 V, and 75°C. The conductor shall be hard-drawn or solid or stranded copper. All power and control wiring shall be solid or stranded copper flame-retardant moisture and heat-resistant or heat-resistant thermoplastic insulated 75°C.

[This criterion is required to ensure the quality of cables for YMP application. These are the most common and reliable cables that satisfy ICEA standards.]

4.3.1.3.3 Cable Conductors

Transmission conductors shall be designed in accordance with IEEE Std 524-2003 *IEEE Guide to the Installation of Overhead Transmission Line Conductors* [DIRS 169316]. Power cables shall be single conductor or triplexed. Wiring for lighting circuits shall be single conductor, solid copper. Wiring insulation and jacket material shall be resistant to heat, moisture, impact, radiation (where required), and ozone.

[This criterion is required to ensure the quality of cables for YMP application. These are the most common and reliable cables that satisfy ICEA standards. Cables installed near radiation need to be protected for long-term performance.]

4.3.1.3.4 Lighting and Panel Branch Circuits

All lighting and receptacle panel branch circuits shall have a maximum of three circuits sharing a common neutral for single-phase loads. Where non-linear loads have been identified, each circuit shall have an individual neutral.

[This criterion is required to limit the ground fault current passing a neutral conductor, for protection of integrity of the circuit. This is in accordance with NFPA 70, National Electrical Code, with Tentative Interim Amendment, 2005 Edition [DIRS 177982]. Although a later version of NFPA 70 is available, the responsible DEM has elected to utilize the referenced version.]

4.3.1.3.5 Instrument Cable

Instrument cables shall be single-pair, triad-twisted and shielded, or multi-pair with shielded pair and overall shield and drain wire, unless supplied by the instrument vendor. For multi-conductor cables, twenty five percent additional conductors shall be provided.

[Shielding is required to shield the transmitted signal from external noise. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.3.6 Instrument Cable Protection

All instrument cable shall be fire-resistant per IEEE Std 1202-2006, *IEEE Standard for Flame -Propagation Testing of Wire and Cable* [DIRS 177949]; and UL 1581, *Reference Standard for Electrical Wires, Cables, and Flexible Cords*. All instrument wiring shall be stranded. Fiber optic cable and field bus shall be used for most data network, voice, and video communication. For cable with requirements for use in radiation environments, such as transfer cells, the aging effect of cables shall be evaluated in accordance with IEEE Std 1205-2000 (R 2007)/Cor 1-2006, *IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations, Corrigendum 1: Thermal Aging Model Corrections* [DIRS 182870].

[This criterion is required to ensure the satisfactory performance of cables with the state-of-the-art technologies. This will ensure integrity of instrumentation system function. UL 1581 has been removed from the reference list (Section 8.2, Codes, Standards and Regulations) and move to Section 8.4 (Output Constraint) of this document.]

4.3.1.3.7 Bulk Cable

Bulk cable insulation and jacket material shall be the low flammable type.

[This criterion is required to protect cables from failure due to fire or heat.]

4.3.1.3.8 Control Cables

Control cables shall be single or multi-conductor and color coded in accordance with the ICEA standard method. For multi-conductor cables, twenty five percent additional conductors shall be provided.

[This criterion is required to comply with ICEA standards. The spare capacity is provided to allow sufficient margin for future load growth]

4.3.1.3.9 Additional Cabling Codes and Standards

The cables classified as ITS and located in harsh environments shall be qualified in accordance with IEEE Std 383-2003, *Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations* [DIRS 171695] and Regulatory Guide 1.131, *Qualification Tests of Electric Cables, Field Splices, and Connections for Light Water Cooled Nuclear Power Plants* [DIRS 169346].

The environmental qualification of quick-disconnect connection assemblies and environmental seals in combination with cables or wires shall be performed in accordance with IEEE Std 572-2006, *IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations* [DIRS 182871] and in accordance with IEEE Std 323-2003, *IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations* [DIRS 166907].

[RGA REG-CRW-RG-000109 (BSC 2007 [DIRS 181809]) has provided guidance for Regulatory Guide 1.131 [DIRS 169346] to endorse IEEE Std 323-2003. RGA REG-CRW-RG-000132, Agreement for Regulatory Guide 1.156, Rev. 0 - Environmental Qualification of Connection Assemblies for Nuclear Power Plants (BSC 2007 [DIRS 181811]) has adopted Paragraph C of Regulatory Guide 1.156, Environmental Qualification of Connection Assemblies for Nuclear Power Plants [DIRS 165773] in full that described IEEE Standard 572-1985 (R2004) [DIRS 178095] pertaining to the environmental qualification of quick-disconnect connection assemblies and environmental seals in combination with cables or wires as assemblies to ensure that the connection assemblies can perform their safety function. RGA REG-CRW-RG-000074, Agreement for Regulatory Guide 1.89, Rev. 1 - Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants (BSC 2007 [DIRS 181952]) has adopted Regulatory Guide 1.89, Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants [DIRS 102609] with clarification that IEEE Std 323-2003 be used instead of IEEE Std 1974.]

4.3.1.3.10 Testing and Qualification of Electrical Raceway Fire Barrier Systems

Testing and Qualification of Electrical Raceway Fire Barrier Systems shall be performed in accordance with Regulatory Guide 1.189, *Fire Protection for Operating Nuclear Power Plants* [DIRS 155040] Sections C.4.3 through C.4.3.5.

[RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.3.1.3.11 Cable Sizing

Cables shall be sized in accordance with IEEE Std 835-1994 (R 2006), *IEEE Standard Power Cable Ampacity Tables* [DIRS 177956].

[Industry Recognized standard for sizing cables.]

4.3.1.4 Grounding

4.3.1.4.1 Ground Fault Detection

The system shall provide ground-fault detection and relaying to automatically de-energize any medium-voltage system component that has developed a ground fault for circuits that are 1,000 volts or higher.

[This criterion is needed to address ground fault relaying and circuit de-energization. This criterion supports 29 CFR 1910.304(f)(7)(ii)(C) [DIRS 177507] and 29 CFR 1926.404(f)(11)(ii)(C), Labor: Safety and Health Regulations for Construction [DIRS 177634].]

4.3.1.4.2 Grounding System

A grounding system shall be furnished in the facility area to provide for personnel safety and to facilitate systems, structures, and equipment grounding in compliance with IEEE Std 80-2000, *IEEE Guide for Safety in AC Substation Grounding* [DIRS 164256]; and IEEE Std 142-1991, *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (with Erratum)* [DIRS 176545].

[This criterion is required to protect the safety of site and general public personnel in the area during a system fault (short circuit), lightning strike, or system voltage surge. It will also prevent equipment failure and mitigate damages to SSCs.]

4.3.1.4.3 Ground Grid Design

The ground grid shall be designed per the requirements of IEEE Std 80-2000, *IEEE Guide for Safety in AC Substation Grounding* [DIRS 164256] to limit touch and step potentials to safe values under the calculated ground fault conditions. The ground soil resistivity shall be measured per the requirements of IEEE Std 81-1983, *IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System* [DIRS 102325]. Neutral grounding is designed in accordance with IEEE Std 665-1995 (R2001), *IEEE Guide for Generating Station Grounding* [DIRS 173591].

[This criterion is required for the safe and adequate design of the station grounding grid to protect the safety of site and general public personnel, systems, structures, buildings, and components during a system fault (short circuit), lightning strike, or system voltage surge.]

4.3.1.4.4 Ground Grid Construction

The main ground grid shall be made of bare copper no smaller than No. 4/0 American Wire Gauge (AWG), buried below the earth surface at no less than 2-1/2 ft deep in accordance with IEEE Std 80-2000, *IEEE Guide for Safety in AC Substation Grounding* [DIRS 164256]. The grounding rods shall be made of steel with copper clad and 3/4 in. diameter.

[This criterion ensures that No. 4/0 AWG grounding conductor is adequate to carry the maximum available ground fault current safely and allow ground rods to be driven through the hard soil without damage.]

4.3.1.4.5 Grounded Equipment

Electrical equipment and steel, structures, and metal components in the building likely to become energized under abnormal conditions shall be effectively grounded to the site-grounding grid that connects to the main ground grid in accordance with IEEE Std 142-1991, *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (with Erratum)* [DIRS 176545] and requirements of NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982]. Ground plates shall be located for multiple grounding runs from a single location. Columns and beams shall be connected to the site-grounding grid.

[This criterion is required for the personnel safety and equipment protection. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.4.6 Low Voltage Grounding

The grounding conductor for the instrument, digital systems, communication systems, and computer systems shall be kept separate and insulated until it connects to the main ground grid at one specific point (single point) in accordance with the recommendations of IEEE Std 1050-1996 *(*1999), *Corrections to IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations* [DIRS 169773].

[The single point ground system is used to eliminate circulation of ground current that causes common mode noise. The purpose of this criterion is to prevent instrument malfunctions due to noise on the line. This is the most commonly used system in an industrial environment. Although a later version of the IEEE Std 1050 (2005) is available, BSC has elected to utilize the 1999 version.]

4.3.1.4.7 Grounding Criteria

Facility power system grounding shall be based on the following criteria:

- 13.8 kV system - This system shall be grounded through a neutral resistor to limit damaging ground fault current to a value adequate for relay operation (low resistance grounding).
- 4.16 kV system - This system shall be grounded through a neutral resistor to limit damaging ground fault current to a value adequate for relay operation (low resistance grounding).
- 480 V system - The neutral point for the system shall be solidly grounded to the ground grid.
- 480Y/277 V system - The neutral point for the system shall be solidly grounded to the ground grid.
- 240Y/120 V - The system neutral point shall be solidly grounded to the ground grid.
- 208Y/120 V - The system neutral point shall be solidly grounded to the ground grid.
- 125 V DC - Ungrounded.

[This criterion is required for personnel safety and equipment protection. This rationale is based on IEEE Std 142-1991, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (with

Erratum) [DIRS 176545] and NFPA 70, National Electrical Code, with Tentative Interim Amendment, 2005 Edition [DIRS 17982]. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.4.8 Underground Connections

All underground connections shall be made by a thermo-welding process or UL 467-2004, *UL Standard for Safety for Grounding and Bonding Equipment* [DIRS 176348] listed compression type connection approved for this application. Exposed connections and taps shall be made with pressure type connectors.

[This criterion is required because the thermo-weld connection underground is a better selection for prevention of corrosion. For exposed application, pressure type connection costs less and is easier to install or replace.]

4.3.1.4.9 Cable Support

Cable trays, supports, hangers, conduits, and fittings shall be effectively connected to the system ground network. Cable trays shall be grounded at both ends and individual tray sections shall be connected together for ground circuit continuity.

[This criterion is required to protect personnel and electrical equipment from fault current. This criterion is also required to assure that at least one ground return path will be available for the ground fault current in case the ground return path is open at the other end.]

4.3.1.4.10 Motors

All motors shall be grounded through the grounding conductor enclosed in the power cable, or a ground wire run with the power circuit in conduit, to the ground bus in the motor control center and/or switchgear.

[This criterion is required for personnel safety and equipment protection based on the procedures and recommendations of IEEE Std 142-1991 [DIRS 176545] and requirements of NFPA 70, National Electrical Code, with Tentative Interim Amendment, 2005 Edition [DIRS 177982]. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.4.11 Power Lines

Power lines shall be grounded in accordance with IEEE Std 1048-2003, *IEEE Guide for Protective Grounding of Power Lines* [DIRS 169311].

[Industry standard.]

4.3.1.5 Lightning Protection

4.3.1.5.1 Protected Structures

All buildings and outdoor elevated structures shall have lightning protection. Electrical equipment and power lines shall be protected with surge arrestors.

[This criterion is required to provide a designated path for the lightning current to dissipate to the ground and, thereby, protect life, equipment, buildings, and elevated outdoor structures against damages caused by lightning strikes.]

4.3.1.5.2 Lightning Protection System Installation

The lightning protection system shall be installed for all buildings and outdoor elevated structures in accordance with NFPA 780-2004, *Standard for the Installation of Lightning Protection Systems* [DIRS 173517], and UL 96A, *Installation Requirements for Lightning Protection Systems* standards and in accordance with Regulatory Guide 1.204, *Guidelines for Lightning Protection of Nuclear Power Plants* [DIRS 177603]. The protection system shall consist of air terminals bussed together and connected by at least two down conductors to the site grounding system. The surge protection circuit, to avoid equipment damage due to lightning discharge, is designed in accordance with IEEE Std C62.23-1995 (R2001), *IEEE Application Guide for Surge Protection of Electric Generating Plants* [DIRS 173593].

[This criterion is required for personnel safety and equipment protection based on the procedures and

recommendations of NFPA 780-2004 and UL 96A. 2005 [DIRS 178048]. UL 96A is a constraint and not input requiring referencing. The latest version should be utilized. RGA REG-CRW-RG-000179,Agreement for Regulatory Guide 1.204, Rev 0 - Guidelines for Lightning Protection of Nuclear Power Plants (BSC 2007 [DIRS 181994]) has adopted Regulatory Guide 1.204. UL 96A has been removed from the reference list (Section 8.2, Codes, Standards and Regulations) and move to Section 8.4 (Output Constraint) of this document.]

4.3.1.6 Cathodic Protection

The cathodic protection system shall be designed per the requirements of applicable NACE Standards, including NACE Standard RP0169-2002, *Standard Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems* [DIRS 165132]; and NACE Standard RP0572-2001, *Standard Recommended Practice, Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds* [DIRS 173097], for underground metallic piping systems and water/fuel oil tanks in contact with soil.

[The cathodic protection system is provided per the requirements of NACE Standard RP0169-2002 to mitigate underground metal corrosion and, thereby, increase the useful life of the existing underground metallic piping systems and water/fuel oil tanks in contact with the soil. This criterion is also required to prevent premature failures of underground metallic piping systems and water or fuel oil tanks in contact with the soil due to corrosion.]

4.3.1.7 Heat Tracing

4.3.1.7.1 Protected Equipment

Electrical heat tracing (freeze protection) shall be provided for liquid filled piping and instrument sensing lines that are subject to freezing per the requirements of the IEEE Std 515-2004, *IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications* [DIRS 169803]. The system shall be designed for the outdoor temperature range as defined in Section 6. The turn on and turn off temperature settings of the heat tracing system shall be based on the fluid properties and characteristics of the pipe insulation.

[This criterion is required for the safe design of the heat tracing system and continuous facility normal operation of the liquid-filled piping and instrumentation sensing lines, especially in the freezing weather.]

4.3.1.7.2 Heat Tracing Voltage

The heat tracing cable supply voltage shall be 120 VAC or 240 VAC, 60 Hz. The incoming power shall be 480 VAC, 3-phase, 60 Hz at the primary side of the heat tracing power distribution transformer.

[The 120 VAC and 240 VAC are the most commonly accepted input voltage levels for the heat tracing system in the industry.]

4.3.1.7.3 Heat Tracing Supply

The normal power shall be used to supply the heat tracing system. Backup onsite diesel generator power sources shall not be used to supply the heat tracing system unless it is required for some specific process to support important operations in the freezing weather.

[This criterion will reduce load on the diesel generators during power outages and emergencies because loss of power to the heat tracing system generally will not affect operations or safety.]

4.3.1.7.4 Ground Leakage Protection

In the heat tracing circuit, ground leakage protection shall be employed and configured to provide local and remote indication of a ground fault.

[This criterion is required for the safe operation of the system by detecting ground leaks early. The detection will enable prevention of larger faults. This rationale is based on common industry practice.]

4.3.1.7.5 Heat Tracing Cable

The heating cable shall be fire retardant, rated for continuous operation, and insulated to be capable of resisting the chemical operating environment.

[This criterion is required for the design and operation of the heat tracing system.]

4.3.1.8 Raceway System

4.3.1.8.1 Raceway Separation

For redundant loads that may be determined in detailed design, the cables and raceways shall be separated and routed from separate power systems via separate fire areas in accordance with the principles defined in NFPA 70 [DIRS 177982].

[For the selected emergency redundant loads, physical separation of emergency power cables are required to prevent simultaneous loss of selected emergency loads due to a fire in the same fire zone or other hazards such as flooding, icing, and vandalism. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.8.2 Raceway Division

Raceways are divided into two major classes: exposed and embedded systems. Exposed systems shall utilize cable trays or conduit arranged in a main distribution pattern branching out to serve individual equipment or devices. Embedded systems shall consist of conduit embedded in building floors (including trench), walls, and underground duct banks. The cable raceway for 600 V nominal or less shall be designed per the requirements of NFPA 70 [DIRS 177982, Chapter 3, and this document. The cable raceway for medium-voltage systems shall be designed by using applicable industry standards and this document.

[This criterion is required for the mechanical protection of cables. This is common practice in industry. In-floor trenches and cable pits can be used as required as special cases. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.8.3 Cable Routing

Cables shall be routed in conduit or cable trays to the individual equipment and devices. Underground duct banks shall be used between facilities and outlying structures.

[This is common practice in industry for the physical support and protection of cables. The duct bank prevents exposure of cable routing in the open areas of the surface facility.]

4.3.1.8.4 Overhead Lines

Power cable connections to loads in remote areas through a rough mountainous surface shall be by overhead lines per IEEE Std 751-1991, *IEEE Trial-Use Design Guide for Wood Transmission Structures* [DIRS 170498]; IEEE Std 524-2003, *IEEE Guide to the Installation of Overhead Transmission Line Conductors* [DIRS 169316]; and NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982], Section 230.24. Overhead lines clearances shall be in accordance with IEEE C2-2007, *National Electrical Safety Code* [DIRS 177944], Section 23.

[This criterion is required for a cost effective and practical way to route cables to remote areas. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.8.5 Cable Separation

A raceway designated for a single class of cables shall contain only cables of the same class. Cable trays containing low-voltage instrumentation cables with very low current control signals shall provide protection against spurious signal sources.

[This criterion is required to prevent interference between different classes of cables. This is common practice in industry. Protection of instrumentation cables is for prevention of equipment malfunctions due to noises mixed with a normal signal.]

4.3.1.8.6 Cable Trays

Unless otherwise specified, only hot-dipped galvanized steel cable trays shall be used. Standard tray lengths and widths shall be specified, as necessary, to fit the design situation. Cable trays shall be provided with a minimum twenty-five percent spare space capacity at time of procurement

[This criterion is required to standardize cable tray types. The hot-dipped galvanized steel cable tray will serve as

the partial ground fault return path for protection of personnel and equipment. This is common practice in industry. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.8.7 Cable Classification

In general, for areas using stacked trays, the highest voltage cables shall occupy the highest position in the stack. Low-voltage power cables trays shall be located below medium-voltage power cables. Control cables shall be located below low-voltage power trays, and low-voltage analog and digital communication cables and fiber optic cables shall be located below control cable trays.

- 15 kV cables
- 5 kV cables
- Low-voltage power AC and DC 600 V cables
- High-level control signal or discrete on/off control cables (120 VAC, 125 VDC)
- Cables for general instrumentation (i.e., low-level analog and digital signals and data communication).

[This criterion is required because higher voltage cables are more prone to starting fires. In case of fire, generated heat will flow upward. This practice prevents damaging lower voltage cables in case of fire generated in higher voltage cable trays. This is common practice in industry.]

4.3.1.8.8 300 V Cable

Cable rated at 300 V may be routed in the same raceway as 600 V cable and share the same enclosures (boxes), provided the maximum applied voltage of the 600 V cable does not exceed 300 V.

[This criterion is required to prevent the mixing of 120 V low power or control circuit cables with 600 V class power cables. Very low-voltage power cables and control circuit cables are rated 300 V or below. This is common practice in industry. (Although 300 V and 600 V cables belong to the low-voltage class, 600 V cables normally carry a higher amount of power.)]

4.3.1.8.9 Cable Conduit

Conduit for power and instrumentation shall be rigid, galvanized steel. Lighting and receptacle conduit, which is exposed to the weather, shall be rigid galvanized steel with weatherproof fittings. Lighting and receptacle conduits in buildings and vaults may be electrical metallic tubing with compression fittings. The lighting system may use electrical metal tubing for concealed work in non-hazardous areas, such as offices and control rooms. Generally, PVC conduit shall be used for underground duct banks.

[This is common practice in industry for a reliable and long lasting raceway installation.]

4.3.1.8.10 Cable Raceway Design

All cable raceway that support functions of the emergency power subsystem, as a minimum, shall be designed and installed in accordance with NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982].

[This is common practice in industry. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.1.8.11 Cable Raceway Seismic Qualification

All cable raceway that support functions of the emergency power subsystem and supports the function of ITS circuit cables shall be designed for DBGM-2 seismic loads, with sufficient margin for BDBGM. These raceway supports shall be qualified in accordance with IEEE Std 344-2004, *IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations* [DIRS 176259].

[This design criterion is based on the requirements of IEEE Std 344-2004. The design for DBGM-2 seismic load is in accordance with BOD (BSC 2007 [DIRS 182131]), Section 17.2.3.3.]

4.3.1.9 Duct Banks and Manholes

4.3.1.9.1 Underground Installation

For underground installation, concrete encased underground duct banks and manhole systems shall be installed throughout the site for the pulling and protection of power, control, instrumentation and telecommunications cables. Twenty five percent conduit spare capacity (minimum one) shall be provided for underground duct banks at the time of final duct bank design.

[This criterion is used to facilitate the cable routing between buildings or facilities. This is a common practice in industry for a reliable power distribution system. The spare capacity is provided to allow sufficient margin for future load growth.]

4.3.1.9.2 Manholes and Pull-Points

Manholes and pull points shall be used as required to facilitate cable pulling and inspection. Their sizes and locations shall depend on associated duct banks. The type and sizes of the cables to be installed shall be shown on the layout drawings. Manholes and pull points shall be provided with appropriate drainage. A copper grounding pad shall be provided in each manhole. The pad shall be connected back to the main ground grid by a 4/0 AWG copper cable.

[This criterion is required to facilitate cable pulling activities. Grounding provision is for the protection of personnel and equipment. This is common practice in industry for a reliable manhole installation.]

4.3.1.9.3 Duct Bank Design

- All electrical duct banks shall be designed for soil and traffic loads at road and railroad crossings. Traffic loading includes normal AASHTO (American Association of State Highway and Transportation Officials) HS-20 truck loading and heavy transporter loading where applicable.
- Electrical duct banks shall be located at a depth of a 3-ft minimum cover top of duct bank to finish grade surface. Exceptions to the depth requirement shall be permitted for short portions of 10% or less of the entire length of the duct bank run.
- The minimum horizontal clearance between adjacent duct banks shall be 1 ft., face-to- face, except when another utility is a heat source and then the horizontal clearance will be 3 ft.

[This criterion is used to facilitate interfaces between the duct bank routing and other underground utilities. This is a common practice in industry for a reliable power distribution system.]

4.3.1.10 Electronic Equipment Power

Electronic equipment shall be powered and grounded in accordance with IEEE Std 1100-2005, *IEEE Recommended Practice for Powering and Grounding Electronic Equipment* [DIRS 177597].

[Industry standard.]

4.3.1.11 Additional Electric Design Codes and Standards

- IEEE Std 317-1983 (R2003), *IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations* [DIRS 178086],
- IEEE 334-1994, *Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations* [DIRS 178264],
- IEEE 382-1996 (R 2004), *IEEE Standard for Qualification of Actuators for Power-Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants* [DIRS 177616]
- IEEE Std 666-1991 (R1993), *IEEE Design Guide for Electrical Power Service Systems for Generating Stations* [DIRS 178263],
- NEMA ICS 7-2006, *Industrial Control and Systems: Adjustable-Speed Drives* [DIRS 177611],
- NEMA MG 1-2006, *Motors and Generators* [DIRS 177612],
- NEMA MG 10-2001 (R 2007), *Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel - Cage Polyphase Induction Motors* [DIRS 182862],
- NEMA MG 11-1977 (R 1997, R 2001), *Energy Management Guide for Selection and Use of Single-Phase Motors* [DIRS 164202]
- NEMA PB 2-2006, *Deadfront Distribution Switchboards* [DIRS 177614]**,**
- NEMA PE 1-2003, *Uninterruptible Power Systems (UPS) - Specification and Performance Verification* [DIRS 169799],
- NEMA SG 5-1995, *Power Switchgear Assemblies* [DIRS 169323],
- NEMA SG 6-2000, *Power Switching Equipment* [DIRS 169324],
- NEMA TR 1-1993 (R 2000), *Transformers, Regulators and Reactors* [DIRS 164297],
- UL 508-2005, *Industrial Control Equipment* [DIRS 178044]

[The codes and standards listed above are commonly used in the industry. Although later versions may be available, BSC has elected to utilize the stated version.]

4.3.2 Emergency Electrical Power Design Criteria

The following criteria apply to the emergency power system in addition to the criteria listed in Section 4.3.1.

4.3.2.1 Emergency Power Supply Voltages

The facility emergency power supply voltages shall be in compliance with IEEE Std 141-1993 [DIRS 122242]. Supply voltages shall be 13.8 kV, 4.16 kV, 480/277 V, and 208/120 V, 3-phase, 60 Hz for AC system. The DC battery system voltage shall be 125 V.

[This criterion is required to define the facility application voltages. These voltages are commonly used in industry in the United States for medium- and low-voltage systems. Electrical equipment is most readily available in these voltages. Their performances have long been proven.]

4.3.2.2 Emergency Power Equipment

All equipment in the emergency power subsystem, including the emergency diesel generators, shall be designed to DBGM-1 seismic event. The ITS portions of the electrical power and electrical support systems are subject to programs including, but not limited to, design control, quality control, equipment qualification, installation, maintenance, periodic testing, and surveillance. Equipment qualification shall be in accordance with IEEE Std 344-2004 [DIRS 176259], Section 9, and IEEE Std 323-2003 [DIRS 166907] and conformance with the guidelines in Regulatory Guide 1.9, *Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants* [DIRS 146732] and in IEEE Std 387-1995 (REAF 2001), *Standard Criteria for Diesel-Generator Units Applied as Standby Power Generating Stations* [DIRS 178084].

[This criterion is to ensure that the emergency power subsystem is available after a seismic event to provide power to loads such as post-event monitoring systems, communications, egress lighting in defined areas, select HVAC units, and worker industrial and life safety systems. RGA REG-CRW-RG-000008, Agreement for Regulatory Guide 1.9, Rev. 3 - Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants (BSC 2007 [DIRS 181947]) provided agreement on Regulatory Guide 1.9 and the use of IEEE Std-387-1995. RGA REG-CRW-RG-000074, Agreement for Regulatory Guide 1.89, Rev. 1 - Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants (BSC 2007 [DIRS 181952]) has adopted Regulatory Guide 1.89, Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants [DIRS 102609] with clarification that IEEE Std 323-2003 be used instead of IEEE Std 1974.]

4.3.2.3 Emergency Power Switchgear Buses

The emergency power subsystem shall be designed with redundant 13.8 kV emergency switchgear buses. Each bus shall be designed such that electrical isolation and physical separation methods are applied to ensure that failures in one redundant load group will not cause failures to the other redundant load group or non-ITS equipment failures will not cause failures in ITS equipment. The implementation of these design enhancements for the ITS portion of the electrical power system shall be measured against applicable requirements in IEEE Std 384-1992 (REAF 1998), *Standard Criteria for Independence of Class 1E Equipment and Circuits* [DIRS 177952] and IEEE Std 308-2001, *IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations* [DIRS 158851] except, emergency power, including the DC Power, shall not be shared between the facilities. The system shall be tested on a 24-month frequency in accordance with Regulatory Guide 1.75, *Criteria for Independence of Electrical Safety Systems* [DIRS 176330]. Each emergency switchgear bus shall be connected to an emergency diesel generator that will supply loads such as post-event monitoring systems, communications, egress lighting in defined areas, select HVAC units, and worker industrial and life safety systems.

[This criterion is to provide reliability and to ensure that the emergency power subsystem is available to provide power to redundant system loads. RGA REG-CRW-RG-000063, Agreement for Regulatory Guide 1.75, Rev. 3 - Criteria for Independence of Electrical Safety Systems (BSC 2007 [DIRS 181996]) has adopted Regulatory Guide 1.75, with clarification that the results of analysis performed to meet the requirements of IEEE Std 384-1992, Sections 5.5.2, 5.6, 6.1, etc. (Regulatory Guide 1.75 paragraph C.2) may not be available at time of License Application. Results would then be available at a future agreed upon date. RGA REG-CRW-RG-000026, Agreement for Regulatory Guide 1.32, Rev. 3 - Criteria for Power Systems for Nuclear Power Plants (BSC 2007

[DIRS 181639]) endorses Regulatory Guide 1.32, Criteria for Power Systems for Nuclear Power Plants [DIRS 172087], with clarification that the emergency power systems are not shared between facilities.]

4.3.2.4 Emergency Power Single Failure Protection

The emergency power subsystem shall be designed in accordance with IEEE Std 446-1995 [DIRS 125763] and NFPA 110-2005, *Standard for Emergency and Standby Power Systems* [DIRS 173511], including a 13.8 kV emergency bus, 480 V emergency system, 125 VDC system, and 120 VAC UPS system. Redundant buses satisfying the single-failure criterion to ensure the availability of emergency power will be based on IEEE Std 379-2000, *IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems* [DIRS 166688].

[This criterion defines the requirements for the emergency power subsystem and ensures power is available to ITS loads, the safety functions of which will be needed after a Category 1 event sequence. Single failure criteria is satisfied by RGA REG-CRW-RG-000044,Agreement for Regulatory Guide 1.53, Rev. 2 - Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems (BSC 2007 [DIRS 181680]), which endorses Regulatory Guide 1.53, Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems [DIRS 171817] and IEEE Std 379-2000.]

4.3.2.5 Emergency Power Equipment Protection

Electric power equipment shall be protected in accordance with IEEE Std 741-1997 (R 2002), *IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations* [DIRS 166689].

[Industry standard.]

4.3.2.6 Emergency Power for Safety Systems

Emergency power for safety systems shall be designed in accordance with IEEE Std 603-1998, *IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations* [DIRS 125916] endorsed by Regulatory Guide 1.153, *Criteria for Safety Systems* [DIRS 103165].

[Industry standard for this purpose. RGA REG-CRW-RG-000129, Agreement for Regulatory Guide 1.153, Rev. 1 - Criteria for Safety Systems (BSC 2007 [DIRS 181771]) has provided guidance for Regulatory Guide 1.153.]

4.3.2.7 Emergency Power Subsystem Independence

The onsite (emergency diesel generator) power subsystem and the associated distribution system shall be designed in accordance with the guidance provided in Regulatory Guide 1.6, *Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems (Safety Guide 6)* [DIRS 110807] to provide sufficient independence to perform their safety function assuming failure. The design shall be such that the safety loads are separated into redundant/independent load groups, each redundant load group is connected to offsite and onsite power sources, each DC load group energized by a battery and battery charger with no automatic connection to any other redundant load group, and the onsite power source (emergency diesel generator) is driven by a single prime mover.

[RGA REG-CRW-RG-000005,Agreement for Regulatory Guide 1.6, Rev. 0 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems (Safety Guide 6) (BSC 2007 [DIRS 181632]) has adopted Regulatory Guide 1.6 with clarification.]

4.3.2.8 Emergency Power Subsystem Testing

As part of the initial preoperational testing program, and also after major modifications or repairs to a facility, the on-site electric (emergency diesel generator) power subsystem shall be tested to verify the existence of independence among redundant on-site power sources and their load groups in accordance with the guidance provided in Regulatory Guide 1.41, *Preoperational Testing of Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments* [DIRS 144748].

[RGA REG-CRW-RG-000036, Agreement for Regulatory Guide 1.41, Rev. 0 - Preoperational Testing of

Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments (BSC 2007 [DIRS 181839]) has adopted Regulatory Guide 1.41 with clarification.]

4.3.2.9 Station Blackout

The repository shall be analyzed and designed to meet the station blackout requirements of Regulatory Guide 1.155, *Station Blackout* [DIRS 144753].

[RGA REG-CRW-RG-000131, Agreement for Regulatory Guide 1.155, Rev. 0 - Station Blackout (BSC 2007 [DIRS 181768]) has adopted Regulatory guide 1.155 with clarification that only sections C.1.1. C.1.2, C.1.3, C.2, C.3, C.3.1, C.3.2, C.3.4, and C.3.5 of Regulatory Guide 1.155 are either fully or partially applicable.]

4.3.3 Switchyard and Transmission Design Criteria

The following criteria will apply to the switchyard and transmission subsystem in addition to the criteria listed in Section 4.3.1.

4.3.3.1 Switchyard Location

The switchyard located at the southwest corner of the North Portal facility area shall be used to receive power via 138 kV overhead transmission lines from the utility power company.

[This criterion is required to define the entry point of utility power transmission lines. CBCN009 to Revision 6 provided an editorial correction to voltage designation.]

4.3.3.2 Switchyard Access

The switchyard shall be in accordance with IEEE C2-2007, *National Electrical Safety Code* [DIRS 177944]. The switchyard shall be fenced with an access gate that can be locked to limit the access to only qualified workers. Coarse granite crushed rock shall be provided to increase the ground resistance to the grounding grid and mitigate shock hazards.

[This criterion is required to protect the safety of non-job-related personnel. This is also a safeguard and security requirement.]

4.3.3.3 Switchyard Voltages

The 138 kV power at switchyards shall be stepped down to 13.8 kV by means of step-down transformers located in the switchyard.

[This criterion is required to define the application voltage of the facility. Industry practice.]

4.3.3.4 Switchyard Transformers

Four 138 - 13.8 kV step-down transformers shall supply all facility loads normally. The fifth 138 - 13.8 kV step-down transformer shall supply affected facility loads when one of the other transformers is not available.

[This criterion is required to define the roles of five main step-down transformers. Industry practice.]

4.3.3.5 Switchyard Distribution

The 13.8 kV power output from the main transformer shall be connected to the 13.8 kV main switchgears in the switchyard switchgear building via underground duct banks or the overhead non-segregated phase bus.

[This criterion is required to define the method of power line connection. Industry practice.]

4.3.3.6 Switchyard Clearance

All clearances between live conductors and for clearances between live conductors and equipment shall be in accordance with IEEE C2-2007, *National Electrical Safety Code* [DIRS 177944], Section 23.

[This criterion is required to define the clearances for live parts.]

4.3.3.7 Voltage Monitoring

The 138 kV voltage, current, megawatts, megavars, and frequency of the incoming power shall be monitored and recorded to establish historical performance of the offsite power source.

[This criterion is required to ensure adequate reliability is maintained by the offsite power source to supply the facility power distribution system as required by Categorization of Event Sequences for License Application (BSC 2005, Section 6.2.4.4 [DIRS 174467]).]

4.3.3.8 Wood Transmission Structures

Wood transmission structures shall be in accordance with IEEE Std 751-1991, *IEEE Trial-Use Design Guide for Wood Transmission Structures* [DIRS 170498].

4.3.3.9 Deleted

4.3.4 Normal Electrical Power Design Criteria

A normal electric power system shall be designed in accordance with the codes and standards listed in Section 4.3.1. No additional standards are required.

4.3.5 Safeguards and Security Design Criteria

4.3.5.1 Material Surveillance

Building surveillance systems and cameras, intrusion detection devices, intrusion alarms, access control systems, hazardous material tracking systems, and radiological safety and control systems shall be provided to assist in protecting licensed material that is in a controlled or unrestricted area and not in storage.

[10 CFR 20.1802, Energy: Standards for Protection Against Radiation [DIRS 181962] provides for monitoring equipment. 10 CFR 73, Energy: Physical Protection of Plants and Materials [DIRS 181969] provides for physical protection of plants and materials.]

4.3.5.2 Building Access

Access to the buildings that make up the YMP facility shall be via automatic turnstiles actuated by individual passes under the supervision of a single site access control system. The access control system shall have the capability of granting or denying access at all points on an individual basis. The system shall record locations of personnel for the purposes of roll call following an incident. Access to this information shall be provided at the relevant security points.

[This criterion is required to define the access control equipment. 10 CFR 73 [DIRS 181969].]

4.3.5.3 Safeguards and Security Regulatory Guidance

The Safeguards and Security regulatory guidance shall conform to NUREG-1065, *Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Facilities* (Joy 1995 [DIRS 169589]), and NUREG-1280, *Standard Format and Content Acceptance Criteria for the Material Control and Accounting (MC and A) Reform Amendment* (NRC 1995 [DIRS 159029])

[NUREG-1065 and NUREG-1280. RGA REG-CRW-RG-000443, Agreement for NUREG-1065 and RGA REG-CRW-RG-000444, Agreement for NUREG-1280 are allocated to the Safeguards and Security Group and needs to be revised to include Engineering as an impacted organization.]

4.3.5.4 Locks in the Protection and Control of Facilities and Special Nuclear Materials

Locks for protecting facilities and SNM shall comply with the NRC Regulatory Guide 5.12, *General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials* [DIRS 158856], Sections C.1-C.8. This guide also specifies application of the following:

- UL 768, *Combination Locks*,
- Federal Specification FF-P-110F, *Padlock, Changeable Combination (Resistant to Opening by Manipulation and Surreptitious Attack*),
- UL 437, *Key Locks*, and
- Interim Federal Specification *FF-P-001480 (GSA FSS), Padlock, Key Operated (Resistant to Opening by Force, Pick, and Bypass Techniques*).

[RGA REG-CRW-RG-000268, Agreement for Regulatory Guide 5.12 Rev 0, General Use of Locks in the

Protection and Control of Facilities and Special Nuclear Materials (BSC 2007 [DIRS 181728]) provided agreement on this guide. The standards listed are citations in Regulatory Guide *5.12; the NRC has not specified a date version to use thus allowing the latest version to be used. Although date versions were previously specified for UL 768-2006 and UL 437-2004, they have subsequently been removed from the reference list (Section 8.2, Codes, Standards and Regulations) and move to Section 8.4 (Output Constraint) of this document. These standards are outputs and not inputs requiring referencing.]*

4.3.5.5 Safeguards and Security Lighting

Safeguards and security lighting shall be in accordance with *IESNA Lighting Handbook, Reference & Application, with Errata* (Rea 2005 [DIRS 176384]) and safeguards and security requirements that will be identified later.

[Industry lighting standard is appropriate for the specified use.]

4.3.5.6 Safeguards and Security Alarm Management

The Safeguards and Security System shall be designed such that:

- Acknowledgment of alarms is a simple and non-complex process and easily performed.
- When closed-circuit television (CCTV) systems are used, the alarm control system must be able to call the operators' attention to an alarm-associated video recorder/monitor. The picture quality must allow the operator to recognize and discriminate between human and animal presence in the camera field of view.
- Video recorders, when used, must be actuated by alarm signals and operate automatically. The response to activation must be capable of recording the actual intrusion.
- When used as the primary means of alarm assessment and to determine response level, CCTV systems must annunciate when the video signal from the camera is lost or disrupted.
- Alarm stations must indicate the status of the systems and annunciate a status change. The system must indicate the type and location of the alarm.
- Records must be kept of each alarm received in the alarm station and of any maintenance activities conducted on the alarm system or any of the related components.

[DOE M 470.4-2, Physical Protection [DIRS 178562] *Chapter V. 1.a.(4 through 9)]*

4.3.5.7 Design of Item Control Areas

The repository shall be designed such that item accounting will be relied upon to account for and control all nuclear material. Designation or selection of Item Control Areas (ICAs) should consider the following:

- Physical boundaries of ICAs must be established so that items moving into or out of an area can be controlled by identity, count, and a previously measured valid special nuclear material content, such that material assigned to a given area is kept separate from material assigned to any other area.
- The number of ICAs established in a specific plant should be based on considerations of the physical and functional aspects of the plant and material that would assist in identifying and localizing material losses or thefts. Functional areas such as receiving and shipping areas, and warehouses or storage vaults should be separate ICAs. Receiving and shipping areas may be established as ICAs provided the material is not processed or subdivided and is identifiable by item and in a sealed, tamper-safe condition. Warehouses and storage vaults should be considered ICAs since all material in storage should be identifiable by item and in a sealed, tamper-safe condition.
- Areas designated as ICAs should contain only items that are identified to differentiate them from other similar items and are in a sealed tamper-safe condition that ensures the integrity of prior measurements. Such items as loose fuel pellets or unsealed, unlabeled containers of SNM do not have identities that will differentiate them from other similar items and are therefore not acceptable for control in ICAs.

[RGA REG-CRW-RG-000278, Agreement for Regulatory Guide 5.26, Rev 1, Selection of Material Balance Areas (MBAs) and Item Control Areas (ICAs) (BSC 2007 [DIRS 181750]) provided agreement that the repository should conform to the above text from Regulatory Guide 5.26, Selection of Material Balance Areas (MBAs) and Item Control Areas (ICAs) [DIRS 103532], with the exception that nuclear material will not be subject to measurement. Material balance areas will not be utilized at the repository in accordance with RGA REG-CRW-RG-000279, Agreement for Regulatory Guide 5.27 Rev 0, Special Nuclear Material Doorway Monitors (BSC 2007 [DIRS 181752]). Detection capability criterion in Regulatory Guide 5.27 Special Nuclear Material Doorway Monitors [DIRS 165827] only apply to MBAs and are not applicable to the repository. Laboratories are also not applicable.]

4.3.5.8 Doorway Monitors for Item Control Areas

Special nuclear material doorway monitors (including electrical and instrumentation wiring, and sensors) for ICAs shall conform to the guidance provided in Regulatory Guide 5.27, *Special Nuclear Material Doorway Monitors* [DIRS 165827]

[RGA REG-CRW-RG-000279 (BSC 2007 [DIRS 181752]) provides agreement that the guidance will be followed.]

4.3.5.9 Perimeter Intrusion Alarm Systems

Perimeter intrusion alarm systems (including facilities, utilities, and services to house and operate equipment (e.g., electrical and instrumentation wiring, and sensors) shall be designed to conform to the guidance in Regulatory Guide 5.44, *Perimeter Intrusion Alarm Systems* [DIRS 158857].

[RGA REG-CRW-RG-000291, Agreement for Regulatory Guide 5.44 Rev 3, Perimeter Intrusion Alarm Systems (BSC 2007 [DIRS 181753]) provided agreement that the repository will conform to the guidance.]

4.3.5.10 SNM Material Transfers

The safeguards and security system shall provide for electronic material tickets in accordance with Regulatory Guide 5.49, *Internal Transfers of Special Nuclear Materials* [DIRS 165832], Sections B, C.1, and C.2.

[RGA REG-CRW-RG-000293, Agreement for Regulatory Guide 5.49 Rev 0, Internal Transfers of Special Nuclear Material(BSC 2007 [DIRS 181754]) provided agreement that paper tickets will not be utilized for MC and A but that the electronic system shall be utilized.]

4.3.5.11 Support Licensee Physical Protection Plan

The repository SSCs and safeguards and security system components shall support the Licensee Physical Protection Program in accordance with Regulatory Guide 5.52, *Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material at Fixed Sites (Other than Nuclear Power Plants)* [DIRS 167366], Sections C.5 through C.9.

[RGA REG-CRW-RG-000295, Agreement for Regulatory Guide 5.52 Rev 3, Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material at Fixed Sites (Other than Nuclear Power Plants) (BSC 2007 [DIRS 181803]) provides guidance on complying with Regulatory Guide 5.52. Although this guidance applies to completing a plan that does not constitute design requirements, this criterion assists in writing that plan.]

4.3.5.12 Physical Protection Upgrade Rule Implementation

The repository facilities, utilities, and services shall be designed to house and operate the safeguards and security system equipment (e.g., electrical and instrumentation wiring and sensors) in accordance with the guidance:

- Regulatory Guide 5.61, *Intent and Scope of the Physical Protection Upgrade Rule Requirements for Fixed Sites* [DIRS 165838],
- Regulatory Guide 5.65, *Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls* [DIRS 158858]

[RGA REG-CRW-RG-000304, Agreement for Regulatory Guide 5.61 Rev 0, Intent and Scope of the Physical Protection Upgrade Rule Requirements for Fixed Sites (BSC 2007 [DIRS 181804]) provides agreement to utilize the Regulatory Guide 5.61 in the design. RGA REG-CRW-RG-000307, Agreement for Regulatory Guide 5.65 Rev 0, Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls (BSC 2007 [DIRS 181805]) provides agreement to utilize Regulatory Guide 5.65 in the design.]

4.3.5.13 Vehicle Barrier Systems

Safeguards and Security System vehicle barrier systems shall be design in accordance with Regulatory Guide 5.68, *Protection Against Malevolent Use of Vehicles at Nuclear Power Plants* [DIRS 167365].

[RGA REG-CRW-RG-000310, Agreement for Regulatory Guide 5.68 Rev 0, Protection Against Malevolent Use of Vehicles at Nuclear Power Plants (BSC 2007 [DIRS 181806]) provides agreement to utilize the guidance in the design.]

4.3.5.14 Entry/Exit Control for Protected and Vital Areas

The repository should provide facilities, utilities, and services to house and operate access control equipment (e.g., electrical and instrumentation wiring and sensors) that conforms to Regulatory Guide 5.7, *Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas* [DIRS 103534].

- Entry to Protected Areas:
  - may utilize remotely viewed CCTV systems that compare facial images to authorized picture badges prior to allowing entry into the area for entry identification and authorization,
  - should use of both a firearms detector and an explosives detector to search entering personnel for firearms, explosives, or incendiary devices,
  - should provide for a separate search room,
  - the opening to the last barrier to the PA should be controlled by an individual isolated within a bullet-resisting structure (e.g., a bullet-resisting booth meeting UL Level IV standards) or to have this opening controlled remotely by the CAS or SAS operator or both,
  - should use vehicle sally ports (secure access passageways) to facilitate identification, control, and search functions,
  - should interlock the first and second openings in the sally port so they cannot be opened simultaneously and by providing observation of entry to prevent "piggybacking",
  - should annunciate metal and explosives detection both aural and visual, and
  - should be provided with one or more duress alarms that annunciate in both the CAS and SAS, placed in a concealed location that can generally be reached by attendant security personnel, and activated in an unobtrusive manner.
- Entry and exit traffic to Protected Areas should be separated by physical barriers, and
- Entry to vital areas may utilize remotely viewed CCTV systems that compare facial images to authorized picture badges prior to allowing entry into the area.

[RGA REG-CRW-RG-000263, Agreement for Regulatory Guide 5.7, Rev. 1 - Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas (BSC 2007 [DIRS 181785]) provided agreement to adopt Regulatory Guide 5.7 with clarification not to use Section C.2, Material Access Areas, which is not applicable because the GROA design will utilize item control areas rather than material access areas.]

4.3.6 Electrical Support Design Criteria

The electric support system shall be designed in accordance with the codes and standards listed in Section 4.3.1.

4.3.7 Communication Design Criteria

4.3.7.1 Not Used

4.3.7.2 SONET Backbone

All repository communications shall be transported on a common SONET communications backbone in accordance with T1.105-2001, *Synchronous Optical Network (SONET) -- Basic Description Including Multiplex Structure, Rates, and Formats Including Supplement T1.105a-2002* [DIRS 164162].

[SONET is an extremely robust industry standard for data transport with protection against single point failures. SONET also affords a high degree of management and repair assistance.]

4.3.7.3 Network Communications

The operations, safeguards and security, administrative, Environmental, Safety, and Health (ES&H), utility, and telephone networks shall comply with the internet protocols as required by RFC 791, *Internet Protocol, DARPA Internet Program Protocol Specification* (Postel 1981 [DIRS 167059]), and RFC 793, *Transmission Control Protocol, DARPA Internet Program Protocol Specification* (Postel 1981 [DIRS 167060]).

[All network communications shall be compliant with the Internet to ensure expandability and interoperability while avoiding obsolescence.]

4.3.7.4 Network Routing

Network routers shall be utilized on the communications networks to manage and route data in accordance with RFC 1541, *Dynamic Host Configuration Protocol* (Droms 1993 [DIRS 164144]); RFC 1583, *OSPF Version 2* (Moy 1994 [DIRS 164146]); RFC 1812, *Requirements for IP Version 4 Routers* (Baker 1995 [DIRS 164147]); RFC 1918, *Address Allocation for Private Internets* (Rekhter et al. 1996 [DIRS 164148]); RFC 2460, *Internet*

Protocol, Version 6 (IPv6) Specification (Deering and Hinden 1998 [DIRS 166818]); and RFC 3376, *Internet Group Management Protocol, Version 3* (Cain et al. 2002 [DIRS 164489]).

[Network routing is necessary for all network communications to be interoperable, allow for rapid recovery in the event of failure, and allow for the central management of the communications networks.]

4.3.7.5 Local Area Networking

The communications system shall provide local area network (LAN) components to connect interfacing devices to the communications system networks in accordance with IEEE Std 802.3ah-2004, *IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan-Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications. Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks* [DIRS 172990].

[Provisions must be provided to interface with the communications system LANs.]

4.3.7.6 Virtual Local Area Networks

Sub-networks shall be created as virtual LANs out of specific communications networks in accordance with IEEE 802.1Q-2005, *IEEE Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks* [DIRS 177607].

[Sub-networks integrated within larger networks are commonly used in industry as an economical alternative to creating additional communications networks.]

4.3.7.7 Network Management

Networks and network services shall be centrally managed from a network operations center in accordance with RFC 1155, *Structure and Identification of Management Information for TCP/IP- Based Internets* (Rose and McCloghrie 1990 [DIRS 166838]).

[Network management is required to provide a smooth operation and efficient maintenance of the communications system networks.]

4.3.7.8 Communications Security

All traffic on the operations network, safeguards and security networks, all connections between the onsite administrative network, and the offsite BSC Las Vegas Intranet shall be secured with Internet Protocol Security in accordance with RFC 2401, *Security Architecture for the Internet Protocol* (Kent and Atkinson 1998 [DIRS 166819]).

[Secure connections at the network layer are required for protection against malicious intrusions, interception, viruses, and spoofing.]

4.3.7.9 Firewalls

Firewalls shall be provided for the communications networks in accordance with RFC 2979, *Behavior of and Requirements for Internet Firewalls* (Freed 2000 [DIRS 166830]).

[Firewalls provide protection against unauthorized access to the communications networks.]

4.3.7.10 Encryption

The communications networks and satellite links shall be encrypted in accordance with *Guideline for Implementing Cryptography in the Federal Government* (Lee 1999 [DIRS 166847]).

[Encryption is required to enhance protection against malicious intrusions, interception, spoofing, and unauthorized access to the communications networks.]

4.3.7.11 Emergency Communications

Onsite and offsite communications shall be provided to coordinate and assess the emergency response activities.

[Emergency communications is required to provide onsite emergency response capabilities and alert offsite organizations of repository emergencies.]

4.3.7.11.1 Operational Support Center

The WNNRF shall provide a location for the OSC from where plant logistic support can be coordinated during an emergency. This location shall be supported by communications capability.

[RGA REG-CRW-RG-000455, Agreement for NUREG-0696, Functional Criteria for Emergency Response Facilities - Final Report (BSC 2007 [DIRS 181426]) has adopted NUREG-0696, Functional Criteria for Emergency Response Facilities - Final Report [DIRS 104098] with clarification Section 3.1. CBCN017 to Revision 6 provided this criterion. Although the CBCN identified criterion location 4.9.2.3.13, this location is more appropriate.]

4.3.7.11.2 OSC Communications

The OSC shall have direct communications with the operations rooms and with the CCC. The OSC communications system shall consist of one dedicated telephone extension to the operations rooms, one dedicated telephone extension to the CCC, and one dial telephone capable of reaching onsite and offsite locations, as a minimum. Direct voice intercommunications and/or reliable direct radio communications may be used to supplement these telephone communication links.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 [DIRS 104098] with clarification Section 3.1. CBCN017 to Revision 6 provided this criterion. Although the CBCN identified criterion location 4.9.2.3.13.1, this location is more appropriate.]

4.3.7.12 Public Address System

Live voice or prerecorded messages shall be transported from the Emergency Operations Center, CCC and alarm center over a public address system. Public address voice traffic shall be transported using dual-tone multiple frequencies and in accordance with ITU-T Rec. G.711, *General Aspects of Digital Transmission Systems, Terminal Equipments, Pulse Code Modulation (PCM) of Voice Frequencies* [DIRS 166880]. Subsurface public address systems shall be hard wired voice communications.

[A public address system is required to provide audible and clear spoken messages to all normally occupied areas of the surface and subsurface facilities during normal and off-normal conditions.]

4.3.7.13 Audible Alarm

Audible alarm notification appliances shall be provided and sound a distinctive sound that is not to be used for any purpose other than that of a fire alarm. The audible alarm notification appliances shall provide a sound pressure level of 15 decibels (dBA) above the average ambient sound level or 5 dBA above the maximum sound level having a duration of at least 60 seconds, whichever is greater, in every occupied space within the building. The minimum sound pressure levels shall be 80 dBA in all areas within the protected property. The maximum sound pressure level for audible alarm notification appliances shall be 120 dBA at the minimum hearing distance from the audible appliance. In addition, the audible alarm devices should include visual notification. Where the average ambient noise is greater than 105 dBA, visible alarm notification appliances shall be provided in accordance with NFPA 72-2006, *National Fire Alarm Code* [DIRS 177984] and audible alarm notification appliances shall not be required. The alarm signal shall be capable of being perceived above ambient noise or light levels by all employees in the affected portions of the workplace. Tactile devices may be used to alert those employees who would not otherwise be able to recognize the audible or visual alarm.

[The 2006 International Fire Code [DIRS 176293]) Section 907.10.2 and 29 CFR 1910 [DIRS 177507], Subpart L, Fire Protection, Subsection 165 (b)(2) requires specific sound levels for alarms. NAC 477.283, State Fire Marshal [DIRS 182445], Section 2.(d) modifies the International Fire Code to require higher alarm sound levels. Alarms are required within the immediate area and throughout the repository to make personnel aware that potential hazards exist. Sections 2.(c) and 2.(i) modify the IBC 2000 to revise the criteria for high-rise buildings.]

4.3.7.14 High Resolution Video

High resolution video shall be provided to monitor commercial spent nuclear fuel (CSNF)/HLW waste package transport, transfer, processing, and aging operations in accordance with the MPEG-2 standard per ISO/IEC 13818-1:2003(E), *Information Technology - Generic Coding of Moving Pictures and Associated Audio Information: Systems* [DIRS 182892]; ISO/IEC 13818-2:2000(E), *Information Technology - Generic Coding of Moving Pictures and Associated Audio Information: Video* [DIRS 166813]; and ISO/IEC 13818-3:1998(E), *Information Technology - Generic Coding of Moving Pictures and Associated Audio Information - Part 3: Audio* [DIRS

166814].

[High resolution video is required to provide the digital control and management information system (DCMIS) the capability to monitor the various processing areas within the repository, including welding and closure cells and the waste package transportation and emplacement equipment.]

4.3.7.15 Medium Resolution Video

Medium resolution video shall be provided to transfer images from portable cameras to the fire control center and the Emergency Operations Center in accordance with the MPEG-1 standard per ISO/IEC 11172-1:1993/Cor.2:1999 (E), *Information Technology - Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to About 1,5 Mbit/s - Part 1: Systems* [DIRS 166931]; ISO/IEC 11172-2:1993/Cor.4:2006(E), *Information Technology - Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to about 1,5 Mbit/s - Part 2: Video, Technical Corrigendum 4* [DIRS 177958]; and ISO/IEC 11172-3:1993/Cor.1:1996(E), *Information Technology - Coding of Moving Pictures and Associated Audio for Digital Storage Media at Up to About 1,5 Mbit/s - Part 3: Audio* [DIRS 167696].

[Medium resolution video is required to provide near-real-time portable video communications for firefighter and ES&H personnel from on-scene locations to the control centers.]

4.3.7.16 Closed Circuit Television

The video communications network shall be capable of interfacing with analog closed circuit television (CCTV) cameras in accordance with SMPTE 170M-2004, *SMPTE Standard for Television-Composite Analog Video Signal-NTSC for Studio Applications* [DIRS 178040].

[The capability to interface with analog CCTV cameras is required because many of the CCTV cameras placed throughout the repository will only be capable of providing analog video signals.]

4.3.7.17 Telephone Communications

The repository shall be provided with wired and mobile and wireless telephone services via a telephone network. Mobile and wireless telephone services shall only be available in the subsurface. Wired and mobile and wireless telephone services shall be implemented in accordance with IEEE Std 802.11b-1999, *Supplement to IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan Area Networks-Specific Requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band* [DIRS 164133]; RFC 2474, *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers* (Nichols et al. 1998 [DIRS 166885]); RFC 3260, *New Terminology and Clarifications for Diffserv* (Grossman 2002 [DIRS 166886]); RFC 3261, *SIP: Session Initiation Protocol* (Rosenberg et al. 2002 [DIRS 166815]); and RFC 3344, *IP Mobility Support for IPv4* (Perkins 2002 [DIRS 166817]).

[Telephone communications is required to provide voice communication services for surface and subsurface facilities, including access to the public switched telephone network, during normal and off-normal (emergency) operations.]

4.3.7.18 Voice Coder Decoder

Each voice channel on the telephone network shall consume 8 kilobits per second of bandwidth in accordance with ITU-T Rec. G.729, *General Aspects of Digital Transmission Systems, Coding of Speech at 8 kbit/s Using Conjugate - Structure Algebraic-Code-Excited Linear-Prediction (CS-ACELP)* [DIRS 166882].

[Voice conversations can be carried efficiently and reliably at 8 kilobits per second without significantly reducing voice quality or clarity.]

4.3.7.19 Telephone Trunk Lines

The site telephone network shall connect to the public switched telephone network via conventional T-1 telephone trunk lines in accordance with ITU-T Recommendation. G.703 (11/2001), *Physical/Electrical Characteristics of Hierarchical Digital Interfaces - Series G: Transmission Systems and Media, Digital Systems and Networks Digital Terminal Equipments -General, with Errata* [DIRS 177959].

[T-1 telephone trunk lines are one of the most common interfaces to the public switched telephone network.]

4.3.7.20 Mobile Radio Communications

Mobile radio communications shall be provided for firefighter, ES&H, and construction personnel in accordance with *Project 25-The TIA-Published 102-Series Documents* (TIA 2003 [DIRS 166835]).

[Mobile radios used by firefighter, ES&H, and construction personnel must be non-interfering and interoperable.]

4.3.7.21 Wireless Communications

Wireless communications shall be provided between the CCCF and waste package transportation and emplacement equipment in accordance with IEEE Std 802.11j-2004, *IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan Area Networks-Specific Requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, Amendment 7: 4.9 GHz-5 GHz Operation in Japan* [DIRS 172992].

[Wireless communications is the most practical method for communicating with a moving vehicle, as justified in the analyses performed in Subsurface Waste Package Handling-Remote Control and Data Communication Analysis (CRWMS M&O 1997 [DIRS 100252]) and Backbone Telecommunications Report (BSC 2007 [DIRS 182576]).]

4.3.7.22 Electromagnetic and Radio Frequency Interference

All wireless communications shall meet conventional electromagnetic compatibility (EMC) standards to prevent interference with radio frequency communications within and external to the communications system.

[Design and installation practices must mitigate and minimize the effects of electromagnetic interference (EMI) and radio frequency interference (RFI) in accordance with 47 CFR 15, Telecommunication: Radio Frequency Devices [DIRS 181973].]

4.3.7.23 Offsite Information Transfer

Selected video, voice, and data information shall be transported to predesignated offsite DOE and Management and Operating Contractor (M&O) locations in a secure manner.

[Offsite information transfer is required to provide near-real-time monitoring, but not control, of nuclear waste transfer, processing, transportation, and emplacement operations in the repository.]

4.3.7.24 Design and Installation of Communications Structures, Systems, and Components

All design, installation, and wiring of communications SSCs shall be in accordance with applicable sections of the latest versions of the following codes and standards:

- NFPA 70.2005 [DIRS 177982]
- NFPA 75-2003 [DIRS 177985].

[The codes and standards listed above directly apply to communications SSCs to be implemented at the repository. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.3.7.25 Telecommunications Building Wiring

Telecommunications wiring for each particular building shall be in accordance with ANSI/TIA-568-B.1-7-2006. *Commercial Building Telecommunications Cabling Standard - Part 1: General Requirements - Addendum 7 - Guidelines for Maintaining Polarity Using Array Connectors* [DIRS 169804]; ANSI/TIA-568-B.2-11-2005, *Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling Components, Addendum 11-Specification of 4-Pair UTP and SCTP Cabling* [DIRS 170590]; and ANSI/TIA/EIA-568 B.3-1-2002, *Optical Fiber Cabling Components Standard, Addendum 1-Additional Transmission Performance Specifications for 50/125 um Optical Fiber Cable*s [DIRS 170591].

[Buildings must be wired appropriately to support their particular telecommunications requirements.]

4.3.7.26 Telecommunications

Engineering shall address the applicable requirements of 29 CFR 1910.268 [DIRS 177507], for the design of telecommunications related systems/facilities associated with the YMP facilities.

[29 CFR 1910.268]

4.3.7.27 Post-Fire Safety

Emergency lighting and communication systems shall be provided to facilitate post-fire safe shutdown and emergency egress in accordance with Regulatory Guide 1.189 [DIRS 155040], Sections C.4.1.6 and C.4.1.7.

[Regulatory guidance Analysis REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.3.8 Important to Safety Electrical

Electrical power and support system classified as ITS shall be designed to the criteria listed in Sections 4.3.1 through 4.3.7. For information:

Equipment Qualifications - The primary objective of qualification is to demonstrate with reasonable assurance that electrical power system equipment can perform the safety function(s) without experiencing failures before, during, and after a design basis event. ITS portions of the electrical power system are subject to programs including, but not limited to, design control, quality control, equipment qualification, installation, maintenance, periodic testing, and surveillance. A maintenance and surveillance program based on vendor recommendations, which may be supplemented with operational experience, is provided to ensure that ITS equipment meets specified requirements. This program will follow the guidelines of IEEE Std 323-2003, *IEEE Standard Qualifying Class 1E Equipment for Nuclear Power Generating Stations* [DIRS 166907], and guidance provided in Regulatory Guide 1.89, *Environmental Qualification Of Certain Electric Equipment Important To Safety For Nuclear Power Plants* [DIRS 102609].

Qualifications for the electrical cables for the ITS portion of the electrical power system that will be located in harsh environments are discussed in Section 4.3.1.3.9.

[RGA REG-CRW-RG-000074 [DIRS 181952] has adopted Regulatory Guide 1.89, with clarification that IEEE Std 323-2003 be used instead of IEEE Std 1974.]

4.3.8.1 Electrical Systems

Facility ITS electrical systems shall be designed to the basic approach outlined in DOE G 420.1-1, *Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide for Use with DOE O 420.1, Facility Safety* [DIRS 159667], Section 5.2.3.

[DOE O 420.1A , Facility Safety [DIRS 159450], Section 4.1.1.2 last paragraph includes this specific criteria.]

4.4 Not Used

4.5 Geotechnical Design Criteria

4.5.1 Applicable Codes and Standards

- ACI 318-02/318R-02, *Building Code Requirements for Structural Concrete* [DIRS 158832],
- ACI 506.2-95, *Specification for Shotcrete* [DIRS 118373],
- ACI 506R-05, *Guide to Shotcrete* [DIRS 176319],
- AISC 1997, *Manual of Steel Construction, Allowable Stress Design* [DIRS 107063],
- DOE-HDBK-1140-2001, *Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance* [DIRS 170491],
- *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]),
- 29 CFR 1910, *Labor: Occupational Safety and Health Standards* [DIRS 177507],
- Regulatory Guide 1.199, *Anchoring Components and Structural Supports in Concrete* [DIRS 170602],
- ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications* [DIRS 159544],

Subpart 2.5.

[RGA REG-CRW-RG-000174 (BSC 2007 [DIRS 181775]) has provided guidance for Regulatory Guide 1.199 [DIRS 170602] to use Sections C1-1.5,1.7, and C.4-C.7 of the guide. The responsible Discipline Engineering Manager has determined that ACI 318-02/318R-02 is appropriate for use in the design instead of the latter revision (ACI 318-05/318R-05).]

4.5.2 Ground Support Design Criteria

4.5.2.1 Load Design

The ground support shall be designed to account for the appropriate worst possible case in terms of combinations of in situ, thermal, seismic, construction, and operation loads.

In Situ Load - In situ loads are the stresses existing prior to the excavation of underground openings. Lower and upper bounds of horizontal-to-vertical stress ratios shall be used, together with the maximum vertical stress at the repository host horizon.

Thermal Load - Thermal loads come from the elevated temperature caused by the heat released from emplaced waste packages. Since the rock mass surrounding underground openings and ground support components are subject to confinement from the cooler rock mass farther away and cannot expand freely, the constrained thermal expansion induces thermal stress in the rock mass and ground support components. The higher the temperature, the higher the induced stress. The maximum normal operational temperature (at the emplacement drift wall) shall be accounted for in ground support design, together with design consideration of the maximum off-normal temperature limits specified in Section 6.2.

Seismic Load - Analyzing the behaviors of unsupported underground openings subjected to vibratory ground motions caused by potential design basis earthquakes is an essential step towards designing an adequate ground support system and supporting the PCSA with needed information on maximum credible rockfalls. For supported underground openings, the seismic load shall be designed for a DBGM-2 seismic event. Ground support for emplacement drifts shall also be analyzed under a seismic load corresponding to a BDBGM seismic event for assessment of design sensitivity and in consistency with drift degradation analyses that support the Total System Performance Assessment (TSPA). Both levels of vibratory ground motion correspond to a subsurface location at Point B shown in Figure 6.1.3-1.

Construction Load - Construction loads such as tunnel boring machine weight and installation loads shall be considered only if they affect ground support.

Operation Load - Operation loads such as waste package weights, including the weight of site transporter, shall be considered only if they affect ground support.

[System safety requires that all the underground openings be designed to minimize the potential for harmful rock movement or fracturing so that operations can be carried out safely. This criterion is provided to ensure the adequacy of the ground support system by accounting for the worst-case loads and load combinations.]

4.5.2.2 Rockfall Prevention

The ground support shall be designed to prevent rockfalls that could result in personnel injury.

[Personnel safety requires that underground openings be designed to minimize the potential for harmful rock movement or fracturing so that underground operations can be carried out safely. To provide for safe operations, this criterion ensures a ground support system design that minimizes the potential of immediate or progressive failure (due to gradual deterioration) of the surrounding rock mass and harmful rock movement that could result in unsafe subsurface conditions.]

4.5.2.3 Design Safety Margin

The ground support system for emplacement drifts shall be designed with an adequate safety margin.

[The safe in-drift operation under the condition of none-to-limited ground support maintenance in emplacement drifts is an important consideration in repository design. This criterion will ensure that the design will provide conditions for safety and help minimize maintenance of the ground support in emplacement drifts.]

4.5.2.4 Accessible Nonemplacement Openings

The ground support system for accessible nonemplacement openings shall be designed for safety factors compatible with maintenance plans.

[The safe maintenance of the ground support in the accessible nonemplacement openings is an important consideration in repository operations. This criterion will ensure that the design will permit the safe maintenance of the ground support.]

4.5.2.5 Inspection Plan

The inspection plan and maintenance strategy shall be an integral part of the ground support design.

[The design of the ground support system should facilitate the planned inspection and maintenance of the ground support. This criterion will assist in ensuring that the design will be compatible with conducting planned inspections and maintenance during repository operations.]

4.5.2.6 Geotechnical Instrumentation

The geotechnical instrumentation program shall be designed to facilitate and support the performance confirmation program and confirm geotechnical data and design parameters, including thermomechanical responses and strength degradation geotechnical instrumentation of the rock mass.

[10 CFR 63.111(d) [DIRS 180319*] requires that a performance confirmation program be implemented within the GROA through permanent closure. 10 CFR 63.132(a) states that a specific requirement of this performance confirmation program is to provide a continuing program of surveillance, measurement, testing, and geologic mapping during repository construction and operation to confirm geotechnical and design parameters, including the thermomechanical responses and strength degradation of the rock mass. This criterion will ensure that the geotechnical instrumentation system will provide the necessary monitoring data for the confirmation of these parameters.]*

4.5.2.7 Site-Specific Geotechnical Data

The ground support shall be based on the site-specific geotechnical data that (1) are obtained from the laboratory and field investigations of the rock from or at Yucca Mountain, (2) comply with requirements for traceability and transparency, (3) account for spatial variability of rock strata, and (4) provide a representative geotechnical characterization of the rock mass and in situ environment.

- **Geotechnical Data** - Data that include intact rock and rock mass strength parameters, elastic modulus, Poisson's ratio, porosity, density, thermomechanical properties (specific heat, thermal conductivity, and coefficient of linear thermal expansion), and their dependence on time and temperature.
- **Data Traceability** - The ability to trace the history, original testing conditions, application, qualification status, and location of data and parameters using recorded documentation.
- **Data Transparency** - A data process that is sufficiently detailed as to purpose, data gathering, analysis and interpretation methodology, data quality appraisal, storage, and record keeping so that a person technically qualified in the subject can understand the process and the supporting documentation and verify their adequacy without recourse to the originator or the originating organization.
- **Spatial Variability** - A data attribute that must be taken into account to ensure data representativeness for engineering application to the design of the repository openings.
- **Representativeness** - A quality measure of the adequacy of data for their engineering application.

The laboratory testing methods shall be in accordance with Regulatory Guide 1.138, *Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants* [DIRS 174382] to establish geological and geotechnical characteristics of soils and rock based on site samples obtained following the guidance of Regulatory Guide 1.132, [DIRS 169347].

[Repository safety and operability requires that all underground openings are designed to minimize the potential for harmful rock movement or fracturing. Natural variability of rock strata requires that information obtained from underground excavations and field and laboratory testing is properly gathered, analyzed, preserved, and used as input to confirm and improve the adequacy of the design. These data provide a reliable basis for periodically evaluating and appraising ground control measures such that stability and safety of underground excavations is maintained. This criterion is provided to ensure that adequate and representative rock and rock mass geotechnical rock property data are used to design and evaluate the performance of the excavations and the associated ground support systems.

- ***Geotechnical Data*** *- These data are used to characterize and quantify the behavior and response of rock to the particular combination of loads imposed during the test or encountered in the field in response to excavation, method of ground support, and natural and operational factors.*
- ***Data Traceability*** *- By establishing traceability, the accuracy and applicability of data can be audited and*

verified by a person technically qualified in the subject. Such a requirement is described in the QMD QA-DIR-10, Rev 001 (BSC 2007 [DIRS 180474]).

- ***Data Transparency*** *- A data transparency requirement is described in the QMD. With clear transparency, data used in the design can be independently obtained from the database and verified. Data transparency provides assurance that the data integrity and traceability of design are preserved at any stage of the project.*
- ***Spatial Variability*** *- The underlying Yucca Mountain geology shows considerable variation in rock properties with depth, particularly porosity, and an effort is made to model this variability using refined models (lithostratigraphic zones) of the rock as well as more detailed vertical variations within some sub-zones where they can be identified. The geologic heterogeneity present in Yucca Mountain rock, especially in the lithophysal rock, means that even a nearby sample of rock can have different properties. As a consequence, any effort to determine the imprecision of rock measurements (random error or statistical variation) is compromised by the spatial variation of rock properties. In geology and geomechanics, professional judgment is implicit in the process of determining uncertainties and variability, and it is used in geotechnical data interpretation. The development of the repository will reveal the true nature of rock mass variability, and its documentation and effect on design will require periodic evaluations of geotechnical rock property data in the context of underground excavation and surrounding rock mass performance and the adequacy of the corresponding ground support design.*
- ***Representativeness*** *- The current knowledge of rock properties is derived from the portion of the repository host rock horizon penetrated by exploratory drillings and underground excavations (i.e., Exploratory Studies Facility, Enhanced Characterization of the Repository Block Cross Drift, and a number of alcoves). Questions remain on how representative these rock property data are with respect to the entire area of the repository. In the event of major deviation, the new properties will be incorporated into the design. During repository development, each new excavation will be a source of new rock property data, thus enriching the existing rock property database. Periodical evaluation of the new information and existing data will be required to ensure that opening stability is preserved and ground support design is appropriate for the conditions encountered at various repository locations.*

[RGA REG-CRW-RG-000116, Agreement for Regulatory Guide 1.138, Rev. 2 - Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants [DIRS 181810] has adopted Regulatory Guide 1.138 with clarification. RGA REG-CRW-RG-000110, Agreement for Regulatory Guide 1.132, Rev. 2 - Site Investigations for Foundations of Nuclear Power Plants [DIRS 181611] has adopted Regulatory Guide 1.132 with clarification.]

4.5.2.8 Drift Wall Temperature

The maximum emplacement drift wall temperature during preclosure shall be consistent with those identified in Section 6.2.

[The maximum emplacement drift wall temperature is one of the key factors impacting the performance of the supported drift.]

4.5.2.9 Relative Humidity

The maximum in-drift relative humidity and the maximum relative humidity inside the boreholes drilled for installing rock bolts shall be considered in addressing the longevity of ground support components.

[The relative humidity and chemical compositions of site-specific groundwater are important to corrosion assessment for steel ground support components. Specific humidity values are provided in Section 6.]

4.5.2.10 Groundwater

Chemical compositions of site-specific groundwater shall be considered in evaluating the longevity of ground support components.

[The relative humidity values inside emplacement drifts and inside the boreholes drilled for installing rock bolts are based on Longevity of Emplacement Drift Ground Support Materials for LA (BSC 2003 [DIRS 165425], Section 7).]

4.5.2.11 Ground Support/Subsurface/Emplacement Drift

The ground support design shall interface with the subsurface development and emplacement drift subsystems (subsystems of the subsurface facility) to accommodate opening orientation, configuration, and excavated opening sizes.

[The underground opening size, drift configuration, and drift orientation have a significant affect on ground support design. This criterion ensures that ground support design interfaces with the subsurface development and emplacement drift subsystems with respect to these parameters.]

4.5.2.12 Ground Support for TSPA

The ground support system shall interface with the TSPA (i.e., natural and engineered barrier systems) to ensure general acceptance of committed ground support materials.

[To comply with the postclosure performance requirements of 10 CFR 63.113(b) [DIRS 180319*], the interface between the ground support system and TSPA has to ensure that ground support materials are compatible with long-term waste isolation objectives. The ground support material used in the emplacement drifts will remain there during the postclosure period. Therefore, this criterion ensures a ground support system design that does not impede the long-term performance of the natural and engineered barrier systems.]*

4.5.2.13 Minimized Maintenance Design

The ground support for emplacement drifts and nonaccessible nonemplacement areas shall be designed to function without planned maintenance during the operational life, while providing for the ability to perform unplanned maintenance in the emplacement drifts and non-accessible nonemplacement areas on an as-needed basis.

[After waste emplacement, the environmental conditions in the emplacement drifts and non-accessible nonemplacement drifts will be too harsh for human entry. Therefore, planned ground support repairs, which would require retrieving waste packages, should be avoided or at least minimized. This criterion ensures that the ground support system is designed to function during the preclosure period without planned maintenance. Due to the length of service life and the number of unknown factors that can affect ground support (e.g., amount of convergence, ground relaxation, seismic conditions), design has to account for the inherent uncertainties. Therefore, ground support design will not prevent the ability to perform unplanned maintenance, if required.]

4.5.2.14 Maintenance Accommodation

The ground support shall accommodate the maintenance of accessible nonemplacement openings.

[Due to the possibly long operational life of the ground support system, this criterion is provided to allow or accommodate either planned or unplanned maintenance of the ground support in the accessible nonemplacement openings. This will ensure the safe accessibility of the subsurface openings over the operational life of the repository.]

4.6 Instrument And Control Design Criteria

4.6.1 Digital Control and Management Information and Non-ITS Process Control System Design Criteria

4.6.1.1 Monitoring and Control

The system shall provide real time monitoring, control, and data acquisition for the facility. Operator graphics from which control and monitoring are done shall be designed in accordance with guidelines contained in IEEE Std 1289-1998 (R2004), *IEEE Guide for the Application of Human Factors Engineering in the Design of Computer-Based Monitoring and Control Displays for Nuclear Power Generating Stations* [DIRS 177589]; ISA-S5.5-1985, *Graphic Symbols for Process Displays* [DIRS 164283]; IEEE Std 260.1-2004, *IEEE Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units)* [DIRS 176341]; IEEE Std 497-2002, *IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations* [DIRS 178088]; and applicable sections of NUREG-0700, *Human-System Interface Design Review Guidelines* [DIRS 170780].

[This criterion is required to ensure there is a means to control and monitor facility operations at all times. RGA REG-CRW-RG-000081, Agreement for Regulatory Guide 1.97, Rev. 4 - Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants (BSC 2007 [DIRS 181836]) has provided guidance for Regulatory Guide 1.97, Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants [DIRS 178008] to use IEEE 497-2002 [DIRS 178088]. RGA REG-CRW-RG-000442, Agreement For NUREG-0700, May 2002, Human-System Interface Design Review Guidelines [DIRS 182847] allows NUREG-0700 to be used as a reference.]

4.6.1.2 Alarms, Operator Messages, and Status Indications

The system shall provide alarms, operator messages, and status indications. The design of the presentation of alarms, messages, and indications shall be in accordance with guidelines contained in IEEE Std 1289-1998 (R2004) [DIRS 177589]; ISA-18.1-1979 (R2004), *Annunciator Sequences and Specifications* [DIRS 171932], Appendix A.5; applicable sections of NUREG-0700 [DIRS 170780], and IEEE Std 603-1998, *IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations* [DIRS 125916], Section 5.8.3.

[This criterion is required to provide a facility wide capability to detect abnormalities or off-normal events. RGA REG-CRW-RG-000040, Agreement for Regulatory Guide 1.47, Rev 0 - Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems (BSC 2007 [DIRS 181948]) provided agreement with Regulatory Guide 1.47 [DIRS 165716] to use IEEE STD 603-1998. RGA REG-CRW-RG-000442 [DIRS 182847] allows NUREG-0700 to be used as a reference.]

4.6.1.3 Data Logging and Trending

The system shall provide data logging and trending. The design of trends and reports shall be in accordance with guidelines contained in IEEE Std 1289-1998 (R2004) [DIRS 177589].

[This criterion is required to collect and provide backup storage for operational data and support of performance confirmation.]

4.6.1.4 CCTV

A CCTV system shall be provided for remote viewing of equipment and operations. The video from the cameras shall be displayed on the human-machine interface (HMI) consoles.

[The requirement for CCTV is based on good engineering practice and the design of other similar facilities and is required to provide the operator with a means to view operations being conducted in areas where radiation levels prohibit human occupation.]

4.6.1.5 Configuration Changes

The system shall provide the ability to make configuration changes. Engineering configuration work shall be performed in accordance with ANSI/ISA-5.1-1984 (R1992), *Instrumentation Symbols and Identification* [DIRS 166742]; ANSI/ISA-S5.2-1976 (R1992), *Binary Logic Diagrams for Process Operations* [DIRS 164286]; and ISA-5.3-1983, *Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems* [DIRS 164263].

[This criterion is required to facilitate a periodic adjustment and/or reconfiguration of the system or part of the system in order to accommodate future upgrades or refurbishment.]

4.6.1.6 Data Point Tagnames

Each data point from field devices shall be assigned a unique tagname. The DCMIS tagnames shall be derived from the field device tag. Tagnames for field devices shall be created in accordance with ANSI/ISA-5.1-1984 (R1992) [DIRS 166742].

[This criterion is required to provide a means to uniquely identify data in the system.]

4.6.1.7 Redundancy of Components

System components that could be a single point of failure shall be redundant. The requirement for redundancy possibly includes, but not limited to, processors, power supplies, network cables, and network interface devices. Use of redundant system components shall be evaluated on a case-by-case basis.

[The requirement for redundancy is based on good engineering practice and standard industry practice and is required to ensure system reliability.]

4.6.1.8 Spare Installed Capacity

The system shall have a minimum ten percent spare installed capacity at time of procurement for input/output modules and terminations, and twenty percent spare user availability capacity for all system memories.

[This criterion is required to accommodate immediate future growth.]

4.6.1.9 Future Growth

The system shall have space for a minimum twenty percent future growth at time of procurement. This shall include input and output space and allowance for additional nodes.

[This criterion is required to accommodate long-term future growth capacity.]

4.6.1.10 Fully Modular Components

The system shall be comprised of fully modular components to the maximum extent possible.

[This criterion is required to allow provisions for future upgrades or refurbishment to the maximum extent possible.]

4.6.1.11 Online Replacement and Installation of Components

The system components shall be removable and installable under the maximum power.

[This criterion is required to enable the online replacement and maintenance of components. This will reduce or eliminate down time to the maximum extent possible.]

4.6.1.12 Installation in Radiation Environments

The system components shall function normally if installed in radiation environments.

[This criterion is required so that components susceptible to radiation can withstand and operate in their radiation environment.]

4.6.1.13 Regulatory Guidance

Digital Control and Management Information and Non-ITS Process Control Systems shall be designed to the following:

- Regulatory Guide 1.21, *Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants* [DIRS 105991],
- Regulatory Guide 1.97 [DIRS 178008], and
- Regulatory Guide 8.8 [DIRS 103312].

Although Regulatory Guide 1.97 was adopted with clarification, the necessary accident monitoring instrumentation will be determined. As a minimum this determination should consider meteorological monitoring (Criterion 4.6.3.3.8), exhaust monitoring, radiation monitoring, status of ITS equipment (such as fans, damper positions, and diesels), WHF pool level, and WHF pool temperature. For those instruments determined to be needed, they shall comply with IEEE STD 497-2002 [DIRS 178088].

[These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides. Incorporation of RGA REG-CW-RG-000010 ,Agreement for Regulatory Guide 1.12, Rev. 2 - Nuclear Power Plant Instrumentation for Earthquakes (BSC 2007 [DIRS 181769]) allows removal of Regulatory Guide 1.12 [DIRS 103170] from this list as it is now covered in Criteria 4.6.3.4.1 through 4.6.3.4.9. CBCN014 to Revision 6 removed this guide. RGA REG-CRW-RG-000081 (BSC 2007 [DIRS 181836]) provided guidance for Regulatory Guide 1.97 to endorse IEEE 497-2002. RGA REG-CRW-RG-000338, Agreement for Regulatory Guide 8.8, Revision 3 - Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable (BSC 2007 [DIRS 181778]) adopted Regulatory Guide 8.8 [DIRS 103312]. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria. Regulatory Guide 1.23, Meteorological Monitoring Programs for Nuclear Power Plants [DIRS 181945] is moved to Criterion 4.6.3.3. RGA REG-CRW-RG-000015, Agreement for Regulatory Guide 1.21, Rev. 1 - Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants (BSC 2007 [DIRS 182077]) has adopted Regulatory Guide 1.21 with clarification.]

4.6.1.14 Control Areas

4.6.1.14.1 Central Control Center

A CCC shall be provided for in the CCCF. The design and layout of the CCC shall be in accordance with guidelines contained in IEEE Std 1023-2004, *IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and other Nuclear Facilities* [DIRS 177592], and applicable sections of NUREG-0700 [DIRS 170780].

[This criterion is required to provide a central area from which facility operations can be monitored and for which control can be exercised where required. Guidance is provided in Regulatory Guide 1.78, Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release [DIRS 161986]. RGA REG-CRW-RG-000066, Agreement for Regulatory Guide 1.78, Rev. 1 - Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release (BSC 2007 [DIRS 181950]) provides agreement to utilize Regulatory Guide 1.78 . Protection measures are contingent on the outcome of the evaluation. RGA REG-CRW-RG-000442 [DIRS 182847] allows NUREG-0700 to be used as a reference.]

4.6.1.14.2 Facility Operations Room

An operations room shall be provided in the waste handling facilities. The design and layout of the facility operations room shall be in accordance with guidelines contained in IEEE Std 1023-2004, *IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and other Nuclear Facilities* [DIRS 177592], and applicable sections of NUREG-0700 [DIRS 170780].

[Due to the nature of some operations in the facility, it is recommended that control capabilities be provided locally within the separate facilities. RGA REG-CRW-RG-000442 [DIRS 182847] allows NUREG-0700 to be used as a reference.]

4.6.1.14.3 Human Machine Interface Consoles

Human-machine interface (HMI) consoles shall be located in the CCC and in various facility operation rooms. Selected process support and utility operations are controlled and monitored from the HMI consoles in the CCC. Control and monitoring of the various nuclear facility operations shall be from the HMI consoles located in the respective facility operations room. The CCC HMI consoles shall have the ability to monitor operations within the various nuclear facilities. HMI consoles shall be designed in accordance with guidelines contained in IEEE Std 1023-2004 [DIRS 177592], IEEE Std 1289-1998 (R2004) [DIRS 177589], NEMA ICS 6-1993 (R 2001), *Industrial Control and Systems Enclosures* [DIRS 164222], applicable sections of NUREG-0700 [DIRS 170780], and in consideration of OSHA ergonomic factors guidelines.

[Human machine interface consoles are required to ensure that various operators have access to required operations for the facility simultaneously. Human machine interfaces provide the current technology for providing access and monitoring capability for facility operations. RGA REG-CRW-RG-000442 [DIRS 182847] allows NUREG-0700 to be used as a reference.]

4.6.1.14.4 Video and Operator Controls

Video and operator controls shall be provided at the HMI consoles in the facility operations rooms and at other areas where required. Video displays of nuclear facility operations shall be available in the CCC for monitoring purposes. Control features such as pan, tilt, and zoom shall be selectable at any location where an operator requires a variable view to assist in operations.

[The requirement for video is based on good engineering practice and the design of other similar facilities. A video system is required for remote viewing of equipment and operations within areas where the radiation levels are too high for personnel access and onboard the transporter.]

4.6.1.14.5 Password

A multi-level user password or similar system shall be provided to control access to specific control functions.

[The requirement for system password or similar security is based on good engineering practice and standard industry practice and provides the operator with a secure means by which to interface the facility.]

4.6.1.14.6 Engineering Configuration Room

An engineering configuration room shall be provided separate from the CCC to provide a separate engineers console to perform on- and off-line functions such as configuration of new control and monitor points, changes or additions to graphic displays, and calibration changes/updates to control and monitor instrumentation. The engineering configuration room is not intended to be a separate control room. It is intended to perform activities not related to operations.

[The requirement for an engineering configuration room is based on NUREG-0700 [DIRS 170780] and is intended to comply with the requirement to limit access and movement of nonessential, but authorized, personnel to prescribed areas within the CCCF. The engineering configuration room will be used to perform tasks not related to daily operations of waste emplacement but rather to update the configuration of the repository as the surface and subsurface areas continue to be developed over the phased construction and emplacement period. RGA REG-CRW-RG-000442 [DIRS 182847] allows the NUREG-0700 to be used as a reference.]

4.6.1.14.7 Environmental Considerations

Environmental considerations in the CCC, engineering configuration room, and facility operations rooms shall be in accordance with guidelines contained in IEEE Std 1023-2004 [DIRS 177592] and applicable sections of NUREG-0700 [DIRS 170780].

[This criterion is required to ensure that temperature, airflow, humidity, illumination, and acoustics are controlled within a comfort zone preferred by personnel. When conditions are outside the comfort zone, it can be a detriment to human performance. RGA REG-CRW-RG-000442 [DIRS 182847] allows NUREG-0700 to be used as a reference.]

4.6.1.14.8 System Printers

System printers shall be provided in the CCC and facility operations rooms to print shift reports, alarm messages, and other administrative reports relating to the system operation. An engineering printer may be provided in the engineering configuration room to record configuration changes, produce engineering reports and calibration records, and perform similar engineering related activities.

[The requirement for report and configuration printers for generating hard copy reports and providing configuration documentation is based on applicable sections of NUREG-0700 [DIRS 170780] and standard industry practice and ensures adequate means to provide hard copy reports from the system. RGA REG-CRW-RG-000442 [DIRS 182847] allows NUREG-0700 to be used as a reference.]

4.6.1.15 UPS Power

The system shall receive UPS power in accordance with IEEE Std 1100-2005, *Recommended Practice for Powering and Grounding Electronic Equipment* [DIRS 177597]. The DCMIS shall be available during loss of offsite power.

[The requirement for UPS power is a standard industry practice. This criterion is required for surface and subsurface repository operations.]

4.6.1.16 System Interfaces

The system shall interface with other repository systems. The interface to these systems shall be via an opened, non-proprietary network protocol. These interfaces shall be designed to the specifications of NEMA ICS 1-2000 (R2005), *General Standards for Industrial Control and Systems* [DIRS 177594], and IEEE Std 802.3ah-2004, *IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan-Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications. Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks*, [DIRS 172990]. The system shall be able to interface with various offsite locations.

[This criterion is required to monitor, control, and provide the necessary data exchange between systems within the facility and to offsite locations.]

4.6.1.17 Post Event Monitoring and Control Controls

Portions of the DCMIS and non-ITS process control systems that are required to operate after an earthquake shall be designed per the criteria in Sections 4.2.11.2.2 and 4.2.11.2.4. The acceptability of passive equipment, such as cabinets and enclosures, shall be verified by analysis. Acceptability, including operability after an earthquake, for active equipment such as HMI consoles, controllers, and input/output modules shall be verified in accordance with IEEE Std 344-2004, *IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations* [DIRS 176259], Section 9.

[System equipment associated with important functions, such as post-event monitoring, including transfer of information to the emergency operations center, controls necessary for plant stabilization after an off-normal event, controls necessary for emergency lighting, control of selected HVAC units, and monitoring and controls for worker industrial and life safety, should be designed to operate after an earthquake.]

4.6.1.18 Safety Parameter Display System

The repository shall use DCMIS instead of the safety parameter display system (SPDS) specified in NUREG-0696, *Functional Criteria for Emergency Response Facilities, Final Report* [DIRS 104098]. The DCMIS shall provide a subset of plant parameters from which the safety status of operations may be assessed. These DCMIS subsets displays shall be duplicated in the CCC, EOC, EOF, and each control facility (operations center). The size, location, display considerations and the design criteria shall be as detailed in NUREG-0696 Section 5 except, the requirements of Regulatory Guide 1.97 [DIRS 178008] do not apply. The DCMIS shall be operated during normal operations and emergencies. Future capability to include operator interaction and diagnostic analysis shall be provided.

[RGA REG-CRW-RG-000455, Agreement for NUREG-0696, Functional Criteria for Emergency Response Facilities - Final Report (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 [DIRS 104098] with clarification. NUREG-0696 Sections 1.3.4 and 5 provide for the function, location, size, staffing, display considerations and the design criteria for the DCMIS. CBCN017 to Revision 6 provided this criterion. Although RGA REG-CRW-RG-000081, [DIRS 181836] adopted Regulatory Guide 1.97 (with clarification to use IEEE 497-2002), it does not apply to the SPDS per REG-CRW-RG-000455.]

4.6.1.19 Nuclear Data Link

The DCMIS shall be designed to send a set of variables from the repository to the NRC operations center via the Nuclear Data Link (NDL), which will aid the NRC in its role to advise the repository, state and local authorities, and federal officials. The exact scope of the data communication to the NRC facilities will be negotiated with the NRC staff.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 [DIRS 104098] with clarification. NUREG-0696 Sections 1.3.5 and 6 provide for the function, description, interface, and environment for the NDL. CBCN017 to Revision 6 provided this criterion.]

4.6.1.20 Data Acquisition System

Appropriate data acquisition systems shall be provided to ensure that personnel in the CCC, backup EOF/TSC (EOC) and the EOF have any required information. The requirements related to the specific parameters in Regulatory Guide 1.97 [DIRS 178008] that are unique to nuclear power plants are not applicable. Data acquisition system design shall be such that all required data can be accessed and communicated in a manner appropriate to support Emergency Response Facilities (ERFs) activities following an event.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 [DIRS 104098] with clarification. NUREG-0696 Section 7 provides requirements of the DAS and its requirements. CBCN017 to Revision 6 provided this criterion. Although RGA REG-CRW-RG-000081 (BSC 2007 [DIRS 181836]) adopted Regulatory Guide 1.97 (with clarification to use IEEE 497-2002), it does not apply to the SPDS per REG-CRW-RG-000455.]

4.6.1.21 Emergency Response Facilities

The ERFs include the CCC, OSC, EOC, EOF, SPDS, NDL, and the facility operations rooms. The ERFs shall be designed to provide coordinated support to the facility operations rooms during emergency operating conditions. The systems design shall comply with section 8 of NUREG-0696 [DIRS 104098] except the provisions of Regulatory Guide 1.97 [DIRS 178008] applicable to only nuclear power plants do not apply.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 with clarification. NUREG-0696 Section 8 provides requirements of the ERFs. CBCN017 to Revision 6 provided this criterion.]

4.6.1.22 Emergency Management Interface Design Criteria

Although not part of the repository design work scope, an off-site EOF (located in Summerlin) must interface with the DCMIS system providing facility information and with the CCC (as a TSC) and the EOC in the Administration Facility (as an alternate TSC or as an EOF) for the transfer of emergency management functions as defined in the site emergency plan.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 [DIRS 104098] with clarification. NUREG-0696 Section 4.1 provides for the functions being performed by the facilities and systems. CBCN017 to Revision 6 provided this criterion. Although the CBCN identified criterion location 4.11.3, this location for DCMIS is more appropriate.]

4.6.2 Radiation/Radiological Monitoring Design Criteria

4.6.2.1 Monitoring Program

Radioactivity monitoring programs shall comply with 10 CFR 20, *Energy: Standards for Protection Against Radiation* [DIRS 181962].

[The project is required to meet the regulations and the guidance is appropriate.]

4.6.2.2 Equipment Codes and Standards

Seismic qualification of the necessary RRMS equipment shall be in accordance with IEEE Std 344-2004 [DIRS 176259]. Equipment will be grounded in accordance with IEEE Std 1050-1996 (1999), *Corrections to IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations* [DIRS 169773].

[Applicable sections of these documents will be determined during the design process and in the development of design products.]

4.6.2.3 Area Radiation Monitors

4.6.2.3.1 Location of Area Radiation Monitors

Area radiation monitors (ARMs) shall be provided where required throughout the surface facilities in areas that require entry or exit or both, which are normally accessible as required by ANSI/ANS-HPSSC-6.8.1-1981, *Location and Design Criteria for Area Radiation Monitoring Systems for Light Water Nuclear Reactors* [DIRS 159434].

[This criterion is required to ensure adequate coverage of areas where there is potential for significant personnel radiation dose. Area radiation monitors are not required for subsurface facilities as adequate administrative controls will be imposed where entry to high radiation areas is required.]

4.6.2.3.2 Indicators and Alarms

Each monitor shall have local exposure rate indication as well as audible and visual alarms as stated in ANSI/ANS-HPSSC-6.8.1-1981 [DIRS 159434].

[This criterion is required to alert individuals in the vicinity of the monitor that immediate action is necessary to minimize exposure to gamma radiation and neutron radiation, if applicable.]

4.6.2.3.3 Change in Radiation Fields

The ARMs shall be located where there is the potential for a sudden and significant change in radiation fields as stated in ANSI/ANS-HPSSC-6.8.1-1981 [DIRS 159434].

[This criterion is required to provide workers with an indication that the working conditions have changed so they are able to react to the change appropriately.]

4.6.2.3.4 Output Signals and Fault Alarms

The monitors shall provide output signals representing radiation levels along with high-level and instrument fault alarms.

[This criterion is required to provide input to the DCMIS for indication that an abnormality or off-normal event has occurred in a specific or general area of the radiation/radiological monitoring (RRM) system.]

4.6.2.3.5 Data Transfer

Signals from each emergency radiological monitor shall be sent to a remote location per ANSI N320-1979 (Reaffirmed 1993), *Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation* [DIRS 166977].

[This criterion is required to provide information to the DCMIS to characterize the type of release and initiate actions for evacuation and re-entry, if required. These data will also provide data for backup storage, trending, and performance confirmation.]

4.6.2.4 Continuous Air Monitors

4.6.2.4.1 Location of Continuous Air Monitors

The continuous air monitors (CAMs) shall be located where there is a potential for intake of airborne radioactive materials by personnel as required by ANSI N42.17B-1989 (Reaffirmed 2005), *American National Standard Performance Specifications for Health Physics Instrumentation - Occupational Airborne Radioactivity Monitoring Instrumentation* [DIRS 177595].

[This criterion ensures adequate coverage of areas where personnel exposure to airborne radioactivity is possible. This criterion also ensures that monitoring is performed for process systems that may contribute to radioactive effluent pathways or process systems that may be a precursor to an effluent pathway.]

4.6.2.4.2 Local Audible Alarms

Each monitor shall have local audible alarms with at least 75 dB in a frequency range of 500 to 3,000 Hz at a distance of 15 cm (6 in.) and flashing or steady state visual alarms as required by ANSI N42.17B-1989 (Reaffirmed 2005) [DIRS 177595]. Any alarming monitor should have a dB frequency range that considers the background noise in the working environment and be about 15 dB above the background, not to exceed 115 dB. The alarm should be distinctive and identifiable from other alarms used in the system.

[This criterion is required to alert individuals in the vicinity of the monitor that immediate action is necessary to minimize exposure to airborne radioactivity.]

4.6.2.4.3 Output Signals and Fault Alarms

The monitors shall provide output signals representing airborne radioactivity levels along with high-level and instrument fault alarms as stated in ANSI N42.17B-1989 (Reaffirmed 2005) [DIRS 177595].

[This criterion is required to provide input to the DCMIS for indication that an abnormality or off-normal event has occurred in a specific or general area of the RRM CAM system, which may indicate a release of radioactivity to an effluent pathway.]

4.6.2.4.4 Data Transfer

Signals from each monitor shall be sent to remote locations per ANSI N320-1979 (Reaffirmed 1993) [DIRS 166977].

[This criterion is required to provide the information to the DCMIS to characterize the type of release and alert operators of the release. These data will also provide data for backup storage, trending, and performance confirmation.]

4.6.2.4.5 Compensation

CAMs shall compensate between background radioactivity and facility-generated airborne radioactive material.

[This criterion is required to ensure that the monitoring results reflect radioactivity from licensed material and not from background radiation per 10 CFR 20 [DIRS 181962].]

4.6.2.4.6 NRC Guidance on Air Sampling

Continuous air monitors in the workspaces sampling for airborne radioactive particulate matter are required by 10 CFR 20.1703(c) [DIRS 181962] and shall comply with the design guidance in Regulatory Guide 8.25, *Air Sampling in the Workplace* [DIRS 106172].

[RGA REG-CRW-RG-000351,Agreement for Regulatory Guide 8.25, Revision 1 - Air Sampling in the Workplace (BSC 2007 [DIRS 181807]) provides agreement to utilize Regulatory Guide 8.25 for use in the YMP. Although the guide was previously applied to exhaust monitoring, Condition Report 10376 identified that it is scope limited to work space monitoring. CBCN012 to Revision 6 applied it to the continuous air monitors.]

4.6.2.5 Slave Alarm Units/Door Warning Signs

Alarm units shall be provided to warn against the continued occupancy of radiologically controlled area due to high airborne radioactivity. Alarm driver units from one or more CAMs shall activate the slave alarm units, as required. Alarm driver units allow the interconnection of a number of CAMs and slave alarm units.

Door warning signs shall be a standard design and include separate annunciation of airborne radioactivity and high radiation. The door warning signs shall be activated from one or more CAM or ARM, as required, and includes key-switch reset located in readily accessible locations. The warning shall not automatically reset when the off-normal situation-initiating monitor returns to normal. The door warning signs, alarm units, CAMS, and ARMS shall be powered from an UPS.

[Alarms and warning signs warn of potential radiation exposures and help minimize the exposures.]

4.6.2.6 Airborne Radioactivity Effluent Monitors

4.6.2.6.1 Monitoring of Airborne Radioactivity

Continuous airborne radioactivity effluent monitors shall be provided on effluent pathways having significant expected airborne radioactivity due to normal operations and Category 1 event sequences. Grab sample capability shall be provided on those monitors. Continuous sampling shall be provided on radioactivity effluent pathways not required to be monitored continuously. Airborne radioactivity effluent monitoring shall compensate between background radiation and facility-generated effluents.

[This criterion is required to ensure that continuous monitoring is provided for areas where airborne radioactivity is expected: grab samples are needed to quantify specific effluent release limits. Radioactivity release from the subsurface is not expected, and therefore, only continuous sampling is provided, for prudence.]

4.6.2.6.2 Exhaust Air Sampling

The system shall sample the exhaust air for airborne radioactive particulate matter as required by Regulatory Guide 1.21, *Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants* [DIRS 105991] positions C.2, C.4, and C.5. Sampling shall be in accordance with applicable sections of ANSI/HPS N13.1-1999, *American National Standard Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities* [DIRS 152380].

[This criterion is required to ensure proper monitoring of radioactive air effluents and to meet performance and regulatory requirements. RGA REG-CRW-RG-000015, Agreement for Regulatory Guide 1.21, Rev. 1 - Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants (BSC 2007 [DIRS 182077]) has adopted Regulatory Guide 1.21 with clarification. Although Regulatory Guide 8.25 [DIRS 106172] was previously applied to the exhaust monitoring, Condition Report 10376 identified that it is limited in scope to work space monitoring. A new criterion 4.6.2.4.6 now applies this design guidance. CBCN012 to Revision 6 removed regulatory Guide 8.25.]

4.6.2.6.3 Alarms

The continuous airborne effluent monitors shall have the capability to alarm at a preset level and on an instrument fault per ANSI N42.18-2004, *Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents* [DIRS 177596].

[This criterion is required to provide input to the DCMIS for indication that an abnormality or off-normal event has occurred in a specific or general area of the continuous airborne effluent monitors.]

4.6.2.6.4 Input Signals

Signals representing the airborne radioactivity level and status shall be input to the DCMIS to allow continuous airborne effluent monitor status to be remotely monitored per ANSI N42.18-2004 [DIRS 177596].

[This criterion is required to collect and provide data to the DCMIS for backup storage, trending, and performance confirmation.]

4.6.2.6.5 Data Transfer

Signals from individual radiation monitors shall be sent to a remote location per ANSI N42.18-2004 [DIRS 177596].

[This criterion is required to provide the information to the DCMIS to characterize the type of release so adequate safety and administrative procedures can be followed.]

4.6.2.7 Deleted

[Criticality Detection and Alarm Systems criteria was deleted. Technical Management Review Board decision TMRB-2004-073 (BSC 2004 [DIRS 177194) imposed requirements on the criticality detection and alarm system for the surface process facilities as a defense-in-depth measure and is currently specified in BOD (BSC 2007 [DIRS 182131]), Section 28.2.1.3. TMRB-2007-053, TMRB Decision Proposal - Criticality Accident Alarm System [DIRS 183263] removes the criticality monitors and alarm subsystem. The existing requirement in BOD Section 28.2.1.3 will be removed in the next revision of the document.]

4.6.2.8 Annunciation

4.6.2.8.1 Alarm Annunciation

Annunciation shall be provided to indicate the status of, and locate problems with instruments within, the RRM system of the facility as required by ANSI N42.17B-1989 (R2005) [DIRS 177595], ANSI N42.18-2004 [DIRS 177596], and ANSI/ANS 8.3-1997 (R2003) [DIRS 176884].

[This criterion is required to ensure the proper system operation and maintenance.]

4.6.2.8.2 CCC and Local Capability

Annunciation shall be provided locally and in the CCC with the capability to monitor instrument parameters and provide alarm information for the following items per ANSI N320-1979 (R1993) [DIRS 166977]:

- ARMs
- CAMs
- Airborne Radioactivity Effluent Monitors

[This criterion is required to alert the CCC operator that immediate action is necessary to minimize personnel exposure and to meet performance requirements. Technical Management Review Board decision TMRB-2004-073 (BSC 2004 [DIRS 177194]) imposed these requirements on the surface process facilities as a defense-in-depth measure and is currently specified in BOD (BSC 2007 [DIRS 182131]), Section 28.2.1.3. TMRB-2007-053, TMRB Decision Proposal - Criticality Accident Alarm System [DIRS 183263] removes the criticality monitors and alarm subsystem.]

4.6.2.9 System Hardware

4.6.2.9.1 Provisions for Upgrades

The RRM system hardware shall include provisions for upgrades.

[This criterion is required to increase the operational life of the system and support closure deferral, and it is a general engineering practice.]

4.6.2.9.2 Self-Test Capabilities and Performance Diagnostics

The RRM system components shall provide self-test capabilities and performance diagnostics to verify the integrity and accuracy of the RRM data as required by ANSI N42.17B-1989 (R2005) [DIRS 177595], ANSI N42.18-2004 [DIRS 177596], and ANSI/ANS 8.3-1997 (R2003) [DIRS 176884].

[This criterion is required to perform system maintenance and troubleshooting without affecting the performance of the system.]

4.6.2.9.3 Radiation Environment

The system components shall function normally if installed in radiation environments as required by ANSI N42.17B-1989 (R2005) [DIRS 177595] and ANSI/ANS 8.3-1997 (R2003) [DIRS 176884].

[This criterion is required so that components susceptible to radiation can withstand and operate in their radiation environment.]

4.6.2.9.4 Testing and Calibration

The monitors shall be periodically tested and calibrated in accordance with ANSI/ANS-HPSSC-6.8.1-1981 [DIRS 159434], ANSI N42.17B-1989 (R2005) [DIRS 177595], and ANSI N42.18-2004 [DIRS 177596].

[This criterion is to ensure the proper functioning of the equipment.]

4.6.2.9.5 Adequate Workspace

The radiation monitoring equipment shall be installed to ensure adequate workspace to allow for servicing and maintenance per NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982].

[This criterion is to permit ready and safe operation and maintenance. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.6.2.9.6 Minimized Exposure

The system components shall be located, shielded, or located and shielded to minimize exposure except for required radiation measuring components. This is in accordance with Regulatory Guide 8.8 [DIRS 103312].

[This criterion is required to ensure that personnel exposure is minimized to meet ALARA principles. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.6.2.9.7 Minimized Interference

The system shall be designed and installed such that the effects of EMI and RFI will be minimized. This is in accordance with Regulatory Guide 1.180, *Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems* [DIRS 171818].

[This criterion is required to ensure that instrumentation associated with this system will be protected from the effects of EMI and RFI. RGA REG-CRW-RG-000155, Agreement for Regulatory Guide 1.180, Rev. 1 - Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems (BSC 2007 [DIRS 181951]) has adopted Regulatory Guide 1.180, Sections C.1, C.2 with clarification that the term Important to Safety will be used instead of Safety Related].

4.6.2.10 System UPS Power

The RRM system shall receive UPS power in accordance with ANSI N320-1979 (Reaffirmed 1993), *Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation* [DIRS 166977]. The RRM system shall be capable of performing its intended functions during loss of offsite power.

[The requirement for UPS power is a standard industry practice. This criterion is required so that the system is capable of performing its intended function during a loss of normal power or after the occurrence of Category 1 and Category 2 event sequences.]

4.6.3 Environmental/Meteorological Design Criteria

4.6.3.1 Equipment Codes and Standards

Seismic qualification of seismic monitoring equipment shall be in accordance with IEEE Std 344-2004 [DIRS 176259]. Equipment will be grounded in accordance with IEEE Std 1050-1996 (1999), *Corrections to IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations* [DIRS 169773].

[Applicable sections of these documents will be determined during the design process and in the development of design products.]

4.6.3.2 Environmental/Meteorological General

4.6.3.2.1 Alarms, Operator Messages, Status Indications, and Trending

The system shall provide alarms, operator messages, status indications, and trending through interface with the DCMIS. This is standard industry practice.

[This criterion is required to provide operators in the CCC with information that will inform them of system abnormalities or off-normal conditions.]

4.6.3.2.2 Environmental Conditions

Equipment installed outdoors shall be designed for the expected environmental conditions. This is standard engineering practice.

[This criterion is required to ensure that the equipment installed outdoors is designed to perform its intended functions in the expected environmental conditions.]

4.6.3.2.3 Enclosures

Removable or hinged parts of enclosures, such as doors and covers, shall be provided with a means for firmly securing them in place. This is in accordance with NEMA ICS 6-1993 (R 2001), *Industrial Control and Systems: Enclosures* [DIRS 164222].

[This criterion is required to ensure that doors or covers are not inadvertently opened or removed; hence, exposing the electronics to any adverse weather conditions.]

4.6.3.2.4 Ergonomic Considerations

Ergonomic considerations shall be included in the design and installation of the system. This is in accordance with IEEE Std 1289-1998 (R2004), [DIRS 177589], Sections 5 and 6.

[This criterion is required to facilitate ease of maintenance, reduce errors, and minimize health and safety risks.]

4.6.3.2.5 Minimized Exposure

The system components shall be located, shielded, or located and shielded to minimize exposure. This is in accordance with Regulatory Guide 8.8 [DIRS 103312] and 10 CFR 20 [DIRS 181962].

[This criterion is required to ensure that personnel exposure is minimized to meet ALARA principles. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.6.3.2.6 Adequate Workspace

The environmental and meteorological monitoring equipment shall be installed to ensure that the workspace will be of sufficient size to allow for servicing and maintenance per NFPA 70.2005 [DIRS 177982].

[This criterion is to permit safe operation and maintenance. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.6.3.3 Meteorological Monitoring

The meteorological monitoring equipment shall be designed utilizing the guidance in Regulatory Guide 1.23 [DIRS 181945], except that in Section 2.3 ambient temperature measurements should be made 2 m above ground level (instead of 10 m). Additional guidance is adopted from:

- ANSI/ANS-3.11-2005, *American National Standard for Determining Meteorological Information at*

Nuclear Facilities [DIRS 177557] and

- EPA-454/R-99-005, *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA 2000 [DIRS 161842]).

RGA REG-CRW-RG-000017, Agreement for Regulatory Guide 1.23, Revision 1, Meteorological Monitoring Programs for Nuclear Power Plants (BSC 2007 [DIRS 181944]) provides agreement to utilize Regulatory Guide 1.23 and adopted ANSI/ANS-3.11-2005, which contains most of the preceding criterion.]

4.6.3.3.1 Data Logging and Storage

The meteorological monitoring system shall provide data logging and storage of instantaneous values and 10-minute or 15-minute averages. These data shall be displayed continuously and in real time.

[This criterion is required to collect and provide data to users for real time and historical analysis using an atmospheric dispersion model.]

4.6.3.3.2 Local Downloading and Uploading

The meteorological monitoring system shall provide data logging and storage locally that can be downloaded and uploaded to an appropriate computer for analysis.

[This criterion is required so that if the data are not available from the DCMIS or meteorological server, they can be downloaded from local equipment.]

4.6.3.3.3 System Power

Power for the system shall be provided from a UPS and solar cells with batteries for the remote equipment.

[This criterion is required to maintain continuous operation and avoid extended data losses]

4.6.3.3.4 Post Event Functional Checks

Functional checks of instrumentation shall be performed after exposure to extreme meteorological conditions or other events.

[This criterion is required to ensure that the system integrity is not compromised.]

4.6.3.3.5 System and Component Accuracies

Minimum system and component accuracies shall be used from ANSI/ANS-3.11-2005 [DIRS 177557] and *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]).

[This criterion is required because the reference documents provide guidance regarding acceptable system and component accuracies.]

4.6.3.3.6 Data Sampling

The datalogger shall be capable of sampling data at a rate of at least 30 samples within 60 seconds spaced equally over not less than 10 minutes.

[This criterion is from ANSI/ANS-3.11-2005 [DIRS 177557].]

4.6.3.3.7 Transceiver Operation

The radio transceiver shall operate within the specified frequency range without interference.

[This criterion is required to ensure that reliable data are transmitted to the meteorological server.]

4.6.3.3.8 Sensors

Sensors shall be installed to measure wind speed, wind direction, pressure, relative humidity, temperature, solar radiation, and precipitation within site boundaries.

[This criterion is required to monitor meteorological conditions, which will be used as an aid in the evaluation of radiological releases. This criterion was moved from 4.6.3.5.1 to be located with the rest of the meteorological criterion.]

4.6.3.4 Seismic Monitoring

Suitable instrumentation must be provided so that the seismic response of YMP features that are ITS can be evaluated promptly after an earthquake.

[RGA REG-CRW-RG-000010, Agreement for Regulatory Guide 1.12, Rev. 2 - Nuclear Power Plant Instrumentation for Earthquakes (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170], Paragraph C, with clarification as noted in Table 1 of the RGA. CBCN014 to Revision 6.]

4.6.3.4.1 Digital Instruments

Solid-state digital instrumentation that will enable the processing of data at the plant site within 4 hours of the seismic event shall be used. The data recording and analysis equipment shall be located in a facility required to be designed to the DBGM-2 seismic response spectra and installed/mounted to withstand the DBGM-2 earthquake.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170],Paragraph C.1.1, with clarification as noted in Table 1 of the RGA. CBCN014 to Revision 6.]

4.6.3.4.2 Accelerograph Locations

Triaxial time-history accelerographs shall be provided as follows:

1. Free-field;
2. Foundations of IHF, CRCF-1, and WHF;
3. One elevation (excluding the foundation) in each of IHF, CRCF-1, and WHF;
4. Foundations of Receipt Facility, Emergency Diesel Generator Facility, CRCF-2, and CRCF-3, unless the responses
of those facilities have been shown to be essentially the same as another monitored facility;
5. One elevation (excluding the foundation) of Receipt Facility, Emergency Diesel Generator Facility, CRCF-2, and
CRCF-3, unless the responses of those facilities have been shown to be essentially the same as another monitored facility;
6. If seismic isolators are used, instrumentation should be placed on both the rigid and isolated
portions of the same or an adjacent structure, as appropriate, at approximately the same elevations;
7. Subsurface location(s) as needed to measure subsurface responses.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170], Paragraph C.1.2, with clarification as noted in Table 1 of the RGA. Considerations because of phased construction / operations: When the IHF, WHF, and CRCF-1 are placed in operation (first operational phase), those facilities must have the capability to monitor for DBGM-2 responses. Accelerographs for those facilities and for the operational drift(s) in the subsurface are required to be operational at that time, as is the recording and analysis equipment. As the surface facilities and additional subsurface drifts are placed into operation, accelerographs shall be installed and placed into operation as required above. Those accelerographs shall input to the operational recording and analysis equipment. CBCN014 to Revision 6.]

4.6.3.4.3 Continuous Operation

The seismic monitoring system instrumentation shall be designed for continuous operation, with high reliability and low mean-time-to-repair times.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170], Paragraph C.3 with clarification as noted in Table 1 of the RGA. CBCN014 to Revision 6.]

4.6.3.4.4 System Power UPS

The electrical power system shall supply the Seismic Monitoring Subsystem UPS from a UPS. The seismic monitoring system UPS shall be sufficient to power the system to sense and record a minimum of 25 minutes at any time over a 24-hour period without recharging.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170] with clarification as noted in Table 1 of the RGA. This criteria replaces Criterion 4.3.1.1.27.1. CBCN014 to Revision 6.]

4.6.3.4.5 Instrumentation

The seismic monitoring instrumentation shall comply with Sections C.1.3.1 through C.1.3.5 and Sections C.4.1 through C.4.5 of Regulatory Guide 1.12 [DIRS 103170]. As an enhancement of Section C.4.4, a minimum of 30 seconds of low-amplitude motion prior to seismic trigger actuation shall be recorded. The instrumentation should be (a) designed and installed such that the mounting is rigid, (b) oriented so that the horizontal components are parallel to the orthogonal horizontal axes assumed in the seismic analyses, and (c) protected against accidental impact.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170] with clarification as noted in Table 1 of the RGA. CBCN014 to Revision 6.]

4.6.3.4.6 Recorder

The seismic monitoring recorder shall be capable of sampling data at a rate of at least 200 samples per second in each of the three directions. The bandwidth should be at least from 0.20 Hz to 50 Hz. The dynamic range shall be 1000:1 or greater, and the instrumentation shall be able to record at least 1.0g zero to peak. The seismic trigger actuating level shall be adjustable and within the range of 0.001g to 0.02g.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170] with clarification as noted in Table 1 of the RGA, for Sections C.4.8 and C.4.9. CBCN014 to Revision 6.]

4.6.3.4.7 Annunciation

Annunciation shall be provided in each waste handling facility operations room (IHF, CRCFs, Receipt Facility, and WHF) and in the CCC facility. Triggering of the free-field or any foundation-level time-history accelerograph shall be annunciated in each location.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted with Regulatory Guide 1.12 [DIRS 103170] with clarification as noted in Table 1 of the RGA for Sections C.2. and C.7. CBCN014 to Revision 6.]

4.6.3.4.8 Recording Actuation and Seismic Triggers

Seismic sensors and recording devices shall ensure all significant ground motion associated with an earthquake is recorded. Both vertical and horizontal input vibratory ground motion should actuate the same time-history accelerograph. One or more seismic triggers may be used to accomplish this. Spurious triggers should be avoided. The seismic trigger mechanisms of the time-history accelerograph should be set for a threshold ground acceleration of not more than 0.02g.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170] with clarification as noted in Table 1 of the RGA, for Section C.6. CBCN014 to Revision 6.]

4.6.3.4.9 Peak Acceleration Measurements

Seismic acceleration sensors shall measure vertical and horizontal peak acceleration. The dynamic range shall be 1000:1 zero to peak or greater, with a minimum of 0.001g to 1.0g. The actual range shall be determined for each accelerometer location and shall be sufficient to measure 1.2 times the DBGM-2 acceleration or 1.0g, whichever is higher. The frequency range should be 0.2 to 50 Hz or an equivalent demonstrated to be adequate by computational techniques applied to the resultant accelerogram.

[RGA REG-CRW-RG-000010 (BSC 2007 [DIRS 181769]) has adopted Regulatory Guide 1.12 [DIRS 103170] with clarification as noted in Table 1 of the RGA, for Sections C.4.7.1. and C.4.7.2. CBCN014 to Revision 6.]

4.6.3.5 Deleted

4.6.3.5.1 Deleted

[Criterion deleted to 4.6.3.3.8.]

4.6.3.5.2 Deleted

[Criterion deleted to 4.6.3.4.8.]

4.6.3.5.3 Deleted

[Criterion deleted to 4.6.3.4.9.]

4.6.4 General Instrumentation Design Criteria

4.6.4.1 Instrumentation Location

Instrumentation locations shall be selected to minimize radiological exposures for operations and maintenance of the equipment, and minimize the effects of radiation on the instrumentation.

[RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.6.4.2 General

4.6.4.2.1 Not Used

4.6.4.2.2 Units of Measurement

All transmitters, gauges, and other readouts for this facility shall be the United States customary units shown in Table 4.6.4-1.

Table 4.6.4-1. Units of Measurement

Parameter	Preferred Units[a]
Mass	lb, ton (defined as a short ton of 2,000 lbs)
Length	ft, in
Volume (volume, liquid)	ft^3 (gal)
Positive gauge pressure	psig
Vacuum	bars absolute, torr
Absolute pressure	in H_2O or psia
Differential pressure	in H_2O, mm Hg, or psid
Temperature	°F, °C
Flow (solids)	tons/hr, lb/hr
Flow (liquids)	gpm
Flow (gas)	cfm, scfm
Flow (steam or slurries)	lb/hr
Level	in, ft, or % (for tank levels)
Density	lb/ft^3
Velocity	fps
Composition	% wt, % vol, or ppm
Radiation	rad/hr, rem/hr
Activity	Ci
Electrical current	ampere
Electrical potential	volt
Resistance	ohm
Power	hp, BTU/hr
Viscosity	cP
Conductivity	siemens

NOTE: [a] Where appropriate, the above may be modified by the following prefixes:

Multiplication Factor	Prefix	Symbol
10^6	mega	M
10^3	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ

[See Section 1.7.]

4.6.4.2.3 Standardized Components

Cabinets, racks, and systems that utilize identical components shall be standardized to reduce maintenance and warehousing activities. Components performing similar duties shall be standardized, as far as possible, so that one particular make, model, and size can be used in all similar applications. Where possible, commercially available items without modification shall be selected from the manufacturer's standard range.

[The goals of this effort are to reduce procurement costs, spare holdings, and design effort, while fostering increased operability and maintainability.]

4.6.4.2.4 CCTV System

A process and mechanical handling monitoring CCTV system, which is a subsystem of the communications system, shall be provided. The CCTV video is integrated with the DCMIS. Areas are classified according to their respective hazard, with electrical and instrumentation and control equipment, specification, design, and installation engineered appropriately in accordance with the guidelines of NFPA 497-2004, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas* [DIRS 173514], and IEEE Std 208-1995 (R2005), *IEEE Standard on Video Techniques: Measurement of Resolution of Camera Systems, 1993 Techniques* [DIRS 177588].

[A CCTV system is required for the remote viewing of equipment and operations in areas where the radiation levels are too high for personnel access.]

4.6.4.2.5 Signal Levels

Continuous analog current signals transmitted to and from the field, which shall be 4 to 20 mA in accordance with ANSI/ISA-50.00.01-1975 (R2002), *Compatibility of Analog Signals for Electrical Industrial Process Instruments* [DIRS 164191]. Digital pulses or optic transmissions are acceptable where appropriate. Signal levels within vendor instrument systems shall be as specified by the vendor and approved by BSC.

[The output signal of 4-20 mA for instrumentation transmitters is from Section 3.0 of the industry standard.]

4.6.4.2.6 Instrument Ranges

Instrument ranges shall be selected to preclude damage during startup or expected abnormal operating conditions per ANSI/ISA-50.00.01-1975 (R2002) [DIRS 164191], Section 2.0.

[Establishment of the appropriate operating conditions will ensure proper sizing and selection of instruments.]

4.6.4.2.7 Valve Manifolds

Pressure and flow transmitters shall be supplied with valve manifolds.

[Manifolds are normally used for ease of operation, maintenance, and calibration of the instrument and are standard for industry.]

4.6.4.2.8 Instrument Enclosures

Instrument enclosures shall be per NEMA ICS 6-1993 (R2001) [DIRS 164222]. The minimum acceptable standard of protection against liquids and solids ingress for indoor and outdoor mounted equipment shall be NEMA 4 or 4X, as appropriate. Indoor service enclosures not subject to potential liquid or solids ingress shall be NEMA 12. NEMA 1 enclosures are acceptable for equipment located in rooms with HVAC.

[Proper enclosure selection for instruments protects them from corrosive environments and hostile weather conditions.]

4.6.4.2.9 Winterization/Air-Conditioning

Instrumentation requiring winterization for protection against the cold shall be installed within thermally insulated enclosures provided with a heater and thermostat. When temperature upper limits are expected to be exceeded due to heat, air-conditioning shall be provided.

[Winterization or trace heating and air-conditioning are the industry standard means of weather protection used for instruments that may become inoperable due to freezing or crystal precipitation and overheat, respectively.]

4.6.4.2.10 Instrument Air

Instrument grade air, if utilized, shall be in accordance with ANSI/ISA-S7.0.01-1996, *Quality Standard for Instrument Air* (ANSI 1996 [DIRS 164287]) and tested in accordance with Regulatory Guide 1.68.3, *Preoperational Testing of Instrument and Control Air Systems* [DIRS 181664]. Air shall be provided that is oil free, dry, and filtered at a minimum of 100 psig.

[RGA REG-CRW-RG-000057, Agreement for Regulatory Guide 1.68.3, Rev. 0 - Preoperational Testing of Instrument and Control Air Systems (BSC 2007 [DIRS 181665]) adopted this guidance for Regulatory Guide 1.68.3. Standard air supply pressure and operating ranges for pneumatic devices provide limits for moisture and oil content and entrained particle size in instrument quality air.]

4.6.4.2.11 Instrument Accessibility

All field mounted controllers, control valves, and transmitters (except for line mounted flow transmitters) shall be easily accessible from grade or platform. Local indicators, such as pressure gauges, flow indicators, and gauge glasses shall be accessible and readable from the grade or operating level and, if used for manual control, shall be readable at the control device.

[Consideration of instrument accessibility in design would ease the control, operation, and maintenance of any system.]

4.6.4.2.12 Design, Installation, and Wiring of Instrument Systems

All design, installation, and wiring of instrument systems shall be in accordance with the applicable sections of the following codes and standards:

- ANSI/ANS 57.9-1992 (R2000), *American National Standard, Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)* [DIRS 176945]
- NFPA 70, *National Electrical Code, with Tentative Interim Amendment*, 2005 Edition [DIRS 177982]
- NFPA 75-2003, *Standard for the Protection of Information Technology Equipment, with Errata* [DIRS 177985]
- ANSI/ISA-5.1-1984 (R1992) [DIRS 166742].

[The codes and standards cited are commonly used in industry. These codes and standards are not meant to be all-inclusive; other codes and standards may apply. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.6.4.2.13 Instrument Sensing Lines

Sensing lines for instruments that are ITS/ITWI shall be designed and installed per ANSl/lSA-S67.02.01-1999, *Nuclear Safety-Related Instrument-Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants* [DIRS 169626].

[RGA REG-CRW-RG-000127, Agreement for Regulatory Guide 1.151, Rev. 0 - Instrument Sensing Lines (BSC 2007 [DIRS 181767]) has adopted Regulatory Guide 1.151, Instrument Sensing Lines [DIRS 165761] with clarification that ANSl/lSA-S67.02.01-1999 will be used in place of ANSl/lSA-S67.02.

4.6.4.3 Temperature Measurement

4.6.4.3.1 Remote Temperature Measurement Devices

Remote temperature measurement shall be primarily made by the use of either resistance temperature detectors (RTDs) or thermocouples. Temperature transmitters may be provided with RTDs and thermocouples. Wherever possible, these devices shall be used with head mounted 4-20 mA output, smart transmitters.

[Use of RTDs and thermocouples is common throughout the industry.]

4.6.4.3.2 Dual Devices

Dual RTDs or thermocouple elements shall be provided.

[This criterion provides a backup element in the event of an instrument failure, thereby reducing downtime. It also provides a second element that is available for troubleshooting and testing.]

4.6.4.3.3 RTDs

RTDs shall use duplex element, 3 wire, 100 Ω platinum with DIN (Deutsches Institut für Normung) type and α coefficient 0.00392 Ω/Ω-F. Each element head shall have two cable entries (one plugged). The RTDs shall be of spring-loaded, tip-sensitive construction.

[100Ω platinum 3 wire elements have become an increasingly popular standard for use in industrial applications because of their increased accuracy. They are widely used in HVAC, electric motors, process control, and electronic circuits.]

4.6.4.3.4 Thermocouples

Thermocouples shall be selected to meet the requirements of the application in accordance with ISA-MC96.1-1982, *Temperature Measurement Thermocouples* [DIRS 164231]. Type J (-346 to 1,400ºF) and type K (-454 to 2,502ºF) calibration thermocouples shall be used as standard.

[Thermocouples are the most commonly used method of industrial temperature measurement in the United States. They are characterized by their low cost and wide rangeability.]

4.6.4.3.5 Temperature Controllers

Where local temperature control is required, liquid- or gas-filled type indicating transmitters may be used. Combined transmitter/controllers may be used for simple services such as tank heating. Transmitter element shall be of the bulb type.

[Local temperature controllers are still considered the traditional and most economical choice in projects where sensitive electronics are not required.]

4.6.4.3.6 Temperature Gauges

Bimetallic thermometers shall be used for temperature gauges. Temperature elements shall be installed in thermowells. Filled-system (liquid or gas) type indicating thermometers shall be considered as appropriate.

[The use of a bimetal, gas, or vapor-actuated thermometer in the industry is common practice where the need arises to make temperature measurements that can be observed on the spot or locally and where errors in excess of one percent of span are acceptable.]

4.6.4.3.7 Thermowells

A thermowell shall be provided for temperature sensing elements. Thermowells shall be assessed for resonance effects. Where thermowells are installed in lines subject to high fluid velocities, combined stress and frequency calculations shall be carried out to a proven method. The vortex frequency, where calculated, shall comply with ASME PTC 19.3-1974 Reaffirmed 2004, Part 3, *Temperature Measurement, Instruments and Apparatus, Supplement to ASME Performance Test Codes* [DIRS 176400].

[Thermowells are provided for protection of the temperature elements and are commonly used throughout the industry.]

4.6.4.4 Flow Measurement

4.6.4.4.1 Flow Measuring Devices

The appropriate flow measurement shall generally be made by one of the following devices: differential pressure flowmeters, positive displacement flowmeters, turbine flowmeters, variable area flowmeters, or open channel flowmeters.

[Each type of flowmeter has its own specific advantages and limitations, and all features are accepted in the industry as best for the particular application.]

4.6.4.4.2 Other Flow Measurement Methods

Other flow measurement methods such as magnetic flowmeters, mass flowmeters (coriolis), oscillatory flowmeters, target flowmeters, and ultrasonic flowmeters shall be considered.

[Such instruments shall be used where the benefits of increased accuracy or simplicity of installation justify the

higher cost.]

4.6.4.4.3 Differential Pressure Transmitters

Differential pressure transmitters measure the differential pressure and provide the signal that is converted to the actual flow value per ASME MFC-8M-2001, *Fluid Flow in Closed Conduits: Connections for Pressure Signal Transmissions Between Primary and Secondary Devices* (ASME MFC-8M-2001 [DIRS 167093]). Primary elements in differential pressure flowmeters shall be selected from the following types: orifice plate, venturi, flow nozzle, flow tube, pitot tube, wedge, v-cone, elbow, and laminar.

[The most frequently used primary element in differential pressure type flowmeters is the orifice plate. The orifice plate is the most economical and is simply a flat piece of metal with a specific-sized hole bored in it. This is commonly specified in industry standards and used by engineering, procurement, and construction companies.]

4.6.4.4.4 Orifice Plates

Orifice plates shall normally be installed between line-sized orifice flanges equipped with flange taps. The beta ratio should normally be between 0.2 and 0.6 per ASME MFC-3M-2004, *Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi* [DIRS 176398], Section 2.4.

[The beta ratio of 0.2 to 0.6 is a commonly used standard for a differential orifice plate measurement. Ratios below 0.2 are not recommended because of pressure loss. Ratios above 0.6 are not recommended because of the reduction in differential pressure.]

4.6.4.4.5 Orifice Plate Identification

Orifice plates shall be thin, square edged, paddle type, faced, and recessed and, unless otherwise specified, shall be fabricated of Type 316 stainless steel as a minimum per ASME MFC-3M-2004 [DIRS 176398]. The following data shall be stamped on the upstream side of the tab projecting beyond the orifice flanges: upstream, instrument tag number, plate material, orifice diameter, and pipe inside diameter.

[This practice in the industry makes the identification and replacement of existing orifices easier.]

4.6.4.4.6 Meter Runs

Meter runs shall be based on a beta ratio of 0.6. The minimum meter run diameter shall be 2 in. Where it is impossible to provide the required meter run lengths, straightening vanes may be used per ASME MFC-3M-2004 [DIRS 176398].

[The intent of this specification is to allow a fluid velocity profile to fully develop before it is metered.]

4.6.4.4.7 Meter Ranges

Differential type flow transmitters shall normally be used for cases where remote flow control is desired. The range specified shall normally be 100 in. of water column, although higher or lower ranges shall be used to obtain a beta ratio within the specified limits of 0.2 and 0.6.

[Flow transmitters with 100 in. of water column are routinely used for good rangeability because it gives room for adjustment to a lower or increased water maximum pressure differential when a change in process condition warrants a corresponding change in transmitter range.]

4.6.4.4.8 Sizing and Ranging Requirements

Flow calculations shall use 20 percent above the maximum design flowrate as the meter maximum. All transmitters may be used to the manufacturers' maximum recommended turndown to a ratio not exceeding 40:1. Flow rate turndown for an orifice plate with a transmitter shall not be greater than 3:1; those fitted with two transmitters shall not be greater than 10:1.

[These ranges have been found to be the ideal limits to use in the industry and still remain within the normally required accuracy for the flow instruments. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.]

4.6.4.4.9 Variable Area Flowmeters

Rotameters shall be an armored type with a magnetic pick-up. Mechanically protected glass tube meters may be used on non-hazardous fluid services. Rotameters shall be per the following standards:

- ISA-RP16.1, 2, 3-1959, *Terminology, Dimensions and Safety Practices for Indicating Variable Area*

Meters (Rotameters)-RP16.2 Glass Tube, RP16.2 Metal Tube, RP16.3 Extension-Type Glass Tube [DIRS 167089]
- ISA-RP16.5-1961, *Installation, Operation, and Maintenance Instructions for Glass Tube Variable Area Meters (Rotameters)* [DIRS 167088]
- ISA-RP16.6-1961, *Methods and Equipment for Calibration of Variable Area Meters (Rotameters)* [DIRS 167087].

[Where process fluid conditions prohibit the use of orifice plates, rotameters may be used in lines 1/2 to 3 in. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.]

4.6.4.4.10 Turbine Meters and Positive Displacement Meters

Turbine meters and positive displacement meters shall have a properly sized strainer installed upstream of the meter and shall have provisions to ensure elimination of vapors from and prevent formation of vapors in the meter body. Block and vent valve or bypass arrangements shall be provided to eliminate vapors per ISA-RP31.1-1977, *Specification, Installation, and Calibration of Turbine Flowmeters* [DIRS 169812].

[Turbine and positive displacement meters shall be used where a higher accuracy of flow measurement is required.]

4.6.4.5 Level Measurement

4.6.4.5.1 General

The appropriate level measurement shall generally be made by one of the following techniques: float type (displacer, ball), radar, hydrostatic head (static, bubbler system, differential pressure), capacitance, conductivity, sonic, and ultrasonic.

[The indication of level serves as a measure of the inventory in the vessel. The approach to level measurement is to determine whether a float, a displacer, or some equivalently simple technology may be applicable. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.]

4.6.4.5.2 Gauge Glass

The visibility of the level glass shall be specified such that the glass covers the operating range of the level instrument. In alarm and shutdown service, the visibility shall normally cover the range of all instruments, including the shutdown set points. All gauge glass shall have a rating equal to or higher than the vessel/equipment design pressure and temperature. Gauge glasses shall be reflex type for all services except the following where transparent type, with illuminators, shall be used: (1) interface between liquids, (2) dirty or dark-colored liquids, and (3) liquids requiring protecting shields, such as steam condensate above 300 psig or caustic above 15 percent. Frost shields shall be used if the operating temperature is below -7ºC (20ºF). This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

[The gauge glass criteria stated above is a typical industry standard for checking the accuracy and operational condition of level instruments.]

4.6.4.5.3 Magnetic Level Gauge

Magnetic type level gauges shall be used where glass breakage would be a hazard or when measuring dangerous or toxic fluids. Magnetic type level gauges shall be used only in areas that are free of the physical forces and materials that would adversely affect the magnetic operation of the system.

[Magnetic type gauges are used for services in which gauge glasses are not suitable for the application.]

4.6.4.6 Pressure Measurement

4.6.4.6.1 General

Pressure measurement shall normally be made by the use of electronic pressure and differential pressure transmitters. Where necessary, drain valves shall be installed at the lowest point in each gas-containing line to facilitate moisture removal. A block and bleed instrument valve (manifold) shall be provided between the primary valve and pressure instrument. Process wetted transmitters, such as pressure transmitters, shall be located in shielded locations. For low activity waste, the requirement for pressure transmitters to be housed within shielded enclosures shall be evaluated based on ALARA principles.

[Transmitters used in radioactive service are designed for radiation tolerance. ALARA principles are in 10 CFR 20 [DIRS 181962].]

4.6.4.6.2 Pressure Instruments and Accessories

Pressure elements shall be Type 316 stainless steel as a minimum unless process conditions require a different material. Pulsation dampeners shall be furnished on all pressure instruments in vibrating or pulsating services. Pressure instruments in steam or other high temperature vapor service shall be protected by a liquid seal. Pressure instruments in services that are corrosive to available pressure elements or where plugging may occur shall be furnished with clean-out type filled diaphragm seals.

[These available accessories may be used in conjunction with pressure instruments to improve their ability to withstand adverse environmental conditions and to broaden their usefulness.]

4.6.4.6.3 Pressure Gauges

Accuracy of direct connected gauges in process service shall be at least 0.5 percent of maximum scale reading over the entire scale. Maximum operating temperature and pressure shall be less than the rating of the gauge. The range shall be specified so that the gauge operates in the middle third of the scale. Normally, the maximum operating pressure should not exceed 75 percent of the full-scale range. Over pressure protection shall be 1.3 times the maximum rating to prevent set or loss of calibration from continuous over pressures. Dials shall normally be 4-1/2 in. in diameter with a white face and black markings. Pressure gauges in pulsating services shall be equipped with an integrally mounted dampening mechanism and shall have filled cases. Siphons shall be used to prevent steam or other condensable vapors from entering the pressure gauge.

[The criteria listed above are an accepted industry standard for good practice in specifying pressure gauges.]

4.6.4.7 Density Measurement

Density measurement shall generally be made by one of the following methods: hydraulic head (bubbler), coriolis, refractometer, radiation (gamma ray densitometer), gravitometer, buoyancy, or fixed volume weighing.

[The bubbler system and coriolis are the two most widely used methods for density measurement. The bubbler system is for mounting directly in the vessel and is considered the simplest, most inexpensive, and relatively fast method, whereas the coriolis is used for in-line density measurement of almost any type of fluid streams. The criteria listed above are an accepted industry standard for good practice in specifying density instruments.]

4.6.4.8 Control Valves

4.6.4.8.1 Valve Styles and Characteristics

Control valves shall generally be globe type. Where tight shutoff is required, single seated globe or cage trim valves shall be used. V-ball may be used for larger turndown, large capacities, tight shutoff, and dirty service. Butterfly valves may be used for high capacity and low-pressure drop service.

[Consideration of cost, flow capacity, size, reliability, accuracy, and turndown (minimum controllable Cv) in selecting the best control valve for a given application will contribute to a good system performance.]

4.6.4.8.2 Sizing

Generally, valves shall be selected to have 1.4 times the Cv required for the normal design flow or 1.1 times the Cv required for the maximum design flow, whichever is greater. Necessary modification of these general sizing criteria due to other design considerations shall be approved by design authority. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

[This specified method in assigning the required control valve Cv for use in process design, piping system, and control valve sizing calculations ensures that every control valve is specified with the minimum design pressure drop required for energy conservation but still high enough for adequate control of the process. Experience indicates that a chronic contributor to loop instability is the selection of the wrong size valve.]

4.6.4.8.3 Components

Valve components and materials shall be suitable for the specified environmental and service conditions.

[Particular attention is given to ideal valve component specifications in order to achieve long-term service of the control valve subjected to any given conditions.]

4.6.4.8.4 Construction

Valve design, body pressure, temperature rating, and minimum wall thickness shall comply with ASME B16.34-2004, *Valves-Flanged Threaded, and Welding End* [DIRS 176394]. The minimum body and flange pressure rating for control valves, up to and including 6 in., shall be 300 ANSI. Above 6 in., butterfly valves shall have the line rating; rotary valves may be flangeless; and globe valves, including angle globe bodies, shall have a minimum rating of 300 ANSI. All flanged valves shall have flanges integral with the body. Slip-on flanges are not acceptable.

[Proper consideration of control valve construction during the selection process helps prolong valve life.]

4.6.4.8.5 Fail-Safe Considerations

Fail-safe considerations shall be applied to each control valve application. Special accessories, such as air tanks and lock-up valves, shall be provided as required. This criterion is commonly specified in industry standards and used by engineering, procurement, and construction companies.

[These are special elements added to the control valve to ensure that it achieves the desired optimum performance during off-normal occurrences.]

4.6.4.8.6 Actuators

Spring-diaphragm type actuators shall be used for throttling service unless use of piston type is justified by high torque requirements. Actuators shall be sized to provide sufficient power to stroke the valve through its full travel at 1.25 times the maximum pressure drop condition specified for the particular valve.

[Proper selection of actuator for the valve will help improve valve stroking speed and valve stability.]

4.6.4.8.7 Maximum Noise Level

The permitted maximum noise level measured at 3 ft from the control valve body shall be 85 dBA in accordance with *TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* (ACGIH 2006 [DIRS 180457]).

[The referenced document is required by DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees [DIRS 102288]. Conformance ensures the occupational noise levels of 29 CFR 1910.95 [DIRS 177507] are achieved.]

4.6.4.9 Relief Valves

The following general guidelines shall be used for the selection and specification of relief valves.

[For each of the subitems below, these specifications are applicable to relieving devices operating on equipment where the pressure is in excess of 15 psig.]

4.6.4.9.1 Types

The different types of relief valves to use depending on the service are as follows:

- Conventional spring opposed relief valves
- Pressure balanced relief valves
- Thermal expansion relief valves
- Screwed type relief valves.

4.6.4.9.2 Sizing

The rated capacity of the relief valves for inclusion in a datasheet shall be calculated in accordance with *2004 ASME Boiler and Pressure Vessel Code* (ASME 2004 [DIRS 171846], Section I, Paragraph PG-70, Section VIII, Paragraph UG-131). The allowable overpressure taken for this calculation shall be based on the allowable overpressure stated in the datasheet for the following applicable codes:

- ASME 2004, Section I, Power Boilers

- ASME 2004, Section VIII, Unfired Pressure Vessels
- ASME B31.1-2004, *Power Piping* [DIRS 177876]
- ASME B31.3-2004 (R2005), *Process Piping* [DIRS 176242].

[Although a later versions of ASME B31.3 and ASME 2004 are available, the responsible DEM has elected to utilize the referenced versions.]

4.6.4.9.3 Settings and Ratings

Relief valve blowdown shall be less than 2 psig for valves with a set pressure of 100 psig. The minimum blowdown setting for higher set pressures shall not be less than 2 percent of the valve set pressure. Pressure-Temperature ratings shall be per API Std 526, *American Petroleum Institute, Flanged Steel Safety Relief Valves* [DIRS 164268].

4.6.4.9.4 Components

Materials for relief valve bodies shall be per API Std 526 [DIRS 164268], Table 2-15. Bonnets shall use the same material as the body of the valve. Bolted bonnet for flanged relief valves are required. Closed bonnet (i.e., no vent anywhere in the bonnet) construction is required for all services except for power boilers service per ASME 2004 [DIRS 171846], Section I. The conventional type valve shall have a bonnet vent plugged with a National Standard Pipe Taper plug. A bellows type relief valve shall have open bonnet vent with a bug screen or piped to a safe location.

Relief valves in accordance with ASME 2004, Section I shall use lifting levers. Relief valves in accordance with ASME 2004, Section VIII shall use lifting levers for valves used in steam, hot water over 140°F, or air service unless specified otherwise.

Screwed caps shall be used for all valves without lifting levers. Valves with plain lifting levers shall use plain caps secured with setscrews. Valves with packed levers shall use bolted caps and provide the valve with a means of inserting a sealing wire to prevent the removal of cap.

The O-Ring (Soft) Seats shall be compatible with the process fluid and temperature requirements.

4.6.5 Deleted

[This section has been deleted in accordance with Technical Management Review Board Decision Proposal TMRB-2007-024 (BSC 2007 [DIRS 183085]).]

4.7 Not Used

4.8 Mechanical Handling

4.8.1 Mechanical Handling Design Criteria

4.8.1.1 Mechanical Handling Codes and Standards

- ACI 349-01/349R-01, *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01) and Commentary (ACI 349R-01)* [DIRS 181670],
- AISC 1997, *Manual of Steel Construction, Allowable Stress* [DIRS 107063]),
- ANSI/AISC N690-1994, *Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities* [DIRS 158835],
- ANSI/ANS-6.1.1-1991, *American National Standard for Neutron and Gamma-Ray Fluence-to-Dose Factors* [DIRS 107719],
- ANSI/ANS-6.4-1997 (REAF 2004), *Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants* [DIRS 177855],
- ANSI/ANS-6.4.2-1985, *Specification for Radiation Shielding Materials* [DIRS 117482],
- ANSI/ANS-57.1-1992 (R 2005), *Design Requirements for Light Water Reactor Fuel Handling Systems* [DIRS 177850],
- ANSI/ANS-57.2-1983, *Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants* [DIRS 111337],
- ANSI/ANS-57.7-1988 (R1997), *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)* [DIRS 177851],

- ANSI/ANS-57.9-1992, *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)* [DIRS 176945],
- ANSI/ITSDF B56.8-2006, *Safety Standard for Personnel and Burden Carriers* [DIRS 183402],
- ANSI/ITSDF B56.9-2006, *Safety Standard for Operator Controlled Industrial Tow Tractors* [DIRS 183403],
- ANSI N14.30-1992, *Semi-Trailers Employed in the Highway Transport of Weight-Concentrated Radioactive Loads - Design, Fabrication, and Maintenance* [DIRS 161196],
- ASCE 4-98, *Seismic Analysis of Safety-Related Nuclear Structures and Commentary* [DIRS 159618],
- ASCE/SEI 43-05, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities* [DIRS 173805],
- *2004 ASME Boiler and Pressure Vessel Code* (ASME 2004 [DIRS 171846]), Section III, Division I, Subsection NC,
- *2004 ASME Boiler and Pressure Vessel Code* (ASME 2004 [DIRS 176963]), Section III, Division I, Subsection NF,
- ASME B30.20-2003, *Below-the-Hook Lifting Devices* [DIRS 171688],
- ASME B30.5-2004, *Mobile and Locomotive Cranes* [DIRS 176396],
- ASME B30.9-2003, *Slings* [DIRS 171686],
- ASME NOG-1-2004, *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)* [DIRS 176239],
- ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications* [DIRS 159544], Subparts 2.2, 2.8 and 2.15,
- ASTM C 992-06, *Standard Specification for Boron-Based Neutron Absorbing Material Systems for Use in Nuclear Spent Fuel Storage Racks* [DIRS 177901],
- ASTM C 1572-04, *Standard Guide for Dry Lead Glass and Oil-Filled Lead Glass Radiation Shielding Window Components for Remotely Operated Facilities* [DIRS 173069],
- CMAA-70-2004, *Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes* [DIRS 176257],
- CMAA-74-2004, *Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist* [DIRS 176258],
- NUREG-0700, *Human-System Interface Design Review Guidelines,* (O’Hara et al. 2002 [DIRS 170780]),
- 10 CFR 71, Energy: Packaging and Transportation of Radioactive Material [DIRS 181967],
- 29 CFR 1910, Labor: Occupational Safety and Health Standards [DIRS 177507],
- DOE-HDBK-1140-2001, *Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance* [DIRS 170491],
- DOE-STD-1090-2004, *Hoisting and Rigging (Formerly Hoisting and Rigging Manual)* [DIRS 176661],
- MIL-STD-1472F, Notice 1, 2003, *Department of Defense Design Criteria Standard, Human Engineering* [DIRS 170418],
- Regulatory Guide 1.13, Rev. 2. 2007, *Spent Fuel Storage Facility Design Basis* [DIRS 183088],
- Regulatory Guide 1.84, *Design, Fabrication, and Materials Code Case Acceptability, ASME Section III,* (NRC [DIRS 177621]),
- Regulatory Guide 1.100, *Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants* [DIRS 110810],
- Regulatory Guide 1.193, *ASME Code Cases Not Approved for Use* (NRC [DIRS 177622]).

[Applicable sections of the above codes and standards, DOE directives and handbook, and level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products.

RGA REG-CRW-RG-000011, Agreeement for Regulatory Guide 1.13, Rev. 2 - Spent Fuel Storage Facility Design Basis (BSC 2007 [DIRS 183182]).
RGA REG-CRW-RG-000071, Agreement for Regulatory Guide 1.84, Rev. 33 - Design, Fabrication, and Materials Code Case Acceptability, ASME Section III (BSC 2006 [DIRS 181679]) has adopted Regulatory Guide 1.84 [DIRS 177621], to allow the option of using NRC approved ASME Section III code cases.
RGA REG-CRW-RG-000084, Agreement for Regulatory Guide 1.100, Rev. 2 - Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants (BSC 2007 [DIRS 181689]) has provided guidance for Regulatory Guide 1.100. This regulatory guide describes a methodology acceptable to the NRC staff for satisfying NRC regulations pertaining to the seismic qualification of electrical and mechanical equipment.
RGA REG-CRW-RG-000168, Agreement for Regulatory Guide 1.193, Rev. 1 - ASME Code Cases Not Approved

for Use (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 [DIRS 177622]. The Code Cases listed therein shall not be used.
RGA REG-CRW-RG-000442 [DIRS 182847] allows NUREG-0700 to be used as a reference. Although a 2007 version of ASME 2004, 2006 version of ANSI/ANS-6.4, and 2004 version of ANSI/ANS 6.4.2 is available, the responsible DEM has elected to utilize the versions cited in the criterion.
RGA REG-CRW-RG-000033, Agreement for Regulatory Guide 1.38, Rev. 2 - Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants (BSC 2007 [DIRS 182071]) provides agreement that ASME NQA-1-2000, Quality Assurance Requirements for Nuclear Facility Applications [DIRS 159544], Subpart 2.2 is an acceptable alternate to Regulatory Guide 1.38 Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants. Although a later version of the ASME NQA-1 is available (2004), BSC has elected to utilize the 2000 version.]

4.8.1.2 General Mechanical Handling Design Criteria

4.8.1.2.1 Operational Life

Mechanical handling systems shall have an operational life of 50 years. Mechanical handling equipment shall satisfy this criterion directly or be maintainable or easily replaced over the system lifetime.

[This is a derived engineering requirement to ensure the system will support the entire emplacement period. The repository has a 25-year receipt period and a 50-year emplacement period.]

4.8.1.2.2 Mechanical Equipment Fire Safety

The repository mechanical handling equipment shall follow NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982].

[DOE O 440.1A. [DIRS 102288] Contractor Requirement 12.k requires the use of NFPA 70. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.8.1.2.3 Deleted

[This criterion for waste package damage has been deleted. It is addressed in the BOD Section 13.2.3.1.35, Handling of Waste Forms and Waste Packages and BOD Section 13.2.3.1.37, Waste Package Surface Defects.]

4.8.1.2.4 ITS Cranes to Prevent Load Drop

ITS cranes and canister transfer machines whose safety function is to prevent the drop of a waste form or prevent a load drop onto a waste form shall be designed and constructed per ASME NOG-1-2004, *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)* [DIRS 176239], Type I or ASME NUM-1-2004, *Rules for Construction of Cranes, Monorails, and Hoists (with Bridge or Trolley or Hoist of the Underhung Type)* [DIRS 180437], Type I as applicable.

[ASME NOG-1-2004 is an industry standard for cranes. CBCN013 to PDC Revision 6 added ASME NUM-1-2004.]

4.8.1.2.5 Hoisting Equipment Rerating

Rerated lifting equipment shall be given a dynamic load test over the full range of the lift using a test weight at least equal to 110% of the lift weight.

[ASME NQA-1-2000, Quality Assurance Requirements for Nuclear Facility Applications [DIRS 159544], Subpart 2.15]

4.8.1.2.6 Protective Coating

Protective coatings shall be qualified and capable of surviving an event sequence without adversely affecting safety-related SSCs needed to mitigate the accident. Service Level II and II protective coatings shall be in accordance with Regulatory Guide 1.54, *Service Level I, II and III Protective Coatings Applied To Nuclear Power Plants* [DIRS 182350]. The following standards should be utilized as appropriate:

- ASTM D 5144-00, *Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants* [DIRS 158844]
- ASTM D 3843-00, *Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities* [DIRS 169620]

- ASTM D 5139-90 (Reapproved 1996), *Standard Specification for Sample Preparation for Qualification Testing of Coatings to be Used in Nuclear Power Plants* [DIRS 183058]
- ASTM D 3911-95, *Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions* [DIRS 183066]
- ASTM D 4082-95, *Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Light-Water Nuclear Power Plants* [DIRS 183067]
- ASTM D 4286-90 (Reapproved 1999), *Standard Practice for Determining Coating Contractor Qualifications for Nuclear Powered Electric Generation Facilities* [DIRS 183449]

[RGA REG-CRW-RG-000045, Agreement for Regulatory Guide 1.54, Rev. 1 - Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants (BSC 2007 [DIRS 181682]) has adopted Regulatory Guide 1.54 with clarification that provides clarification and guidance on protective coating. Although the NRC document has specified date versions, the latest version should be used. Although date versions are specified, they have subsequently been removed from this document. Not all included reference standards are included here; most of the rest dealt with terminology, training, and procedures and are not relevant to design activities.]

4.8.1.2.7 Control of Heavy Loads

Control of heavy loads, (e.g., design of lifting devices and safe load paths for routine operations), shall be in accordance with NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants* [DIRS 104939], Sections 5.1, 5.1.1, 5.1.2, 5.1.5, and 5.1.6.

[RGA REG-CRW-RG-000383, Agreement for NUREG-0612, January 1980 - Control of Heavy Loads at Nuclear Power Plants - Resolution of Generic Technical Activity A-36 (BSC 2007 [DIRS 181781]) endorses NUREG-0612 for control of heavy loads. Heavy loads will be routinely handled at repository as part of operation, maintenance, and waste/SNF packaging activities. Since drops of these loads could result in radiological consequences similar to those described in NUREG-0612, YMP is adopting the guidance of NUREG-0612 as applicable.]

4.8.1.2.8 Cranes to Withstand Seismic Events

ITS or non-ITS cranes whose safety function is to avoid collapse during a seismic event (but which are not required to retain their load) shall be designed and constructed per ASME NOG-1-2004 [DIRS 176239] Type II or ASME NUM-1-2004, *Rules for Construction of Cranes, Monorails, and Hoists (with Bridge or Trolley or Hoist of the Underhung Type)* [DIRS 180437], Type II as applicable.

[ASME NOG-1-2004 is an industry standard for cranes. CBCN013 to PDC Revision 6 added ASME NUM-1-2004.]

4.8.1.2.9 ITS Special Lifting Devices

ITS special lifting devices whose safety function is to prevent the drop of a waste form or prevent a load drop onto a waste form shall be designed and constructed per ANSI N14.6-1993, *American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More* [DIRS 102016], using design criteria for devices handling critical loads. Exceptions to this requirement are grapples such as those for fuel assemblies and DOE waste canisters that have been previously designed for other facilities and are being adopted for use at Yucca Mountain.

[ANSI N14.6-1993 is an industry standard for cranes with lifting devices.]

4.8.1.3 Mechanical Handling Equipment-Specific Criteria

The following design criteria represent good engineering practice to achieve worker safety, including ALARA goals, and improve mechanical handling system reliability, maintainability, and availability.

4.8.1.3.1 Safe Shutoff

Equipment that handles waste forms shall have features for safe shutoff of the power supply in an off-normal situation.

4.8.1.3.2 Operator Visibility

The operating areas shall provide shield windows and/or remote viewing systems (CCTV) to assist operators in performing required operations and recovery from off-normal events.

4.8.1.3.3 Grapples and Tools

Grapples and tools shall be designed for ease of decontamination, nondestructive testing, maintenance, handling, and storage.

4.8.1.3.4 Remote Handling Features

Fixtures, temporary storage locations, fuel unit container, and similar devices shall be designed with appropriate lead-ins and chamfers to facilitate and guide insertion and removal for remote assembly and disassembly operations.

4.8.1.3.5 Operator Design Constraints

The site transporter shall be constructed to allow the operator clear visibility while operating in the travel direction and not expose the operator to elevated radiation levels, noise, dust, or other constituents above the threshold limits.

4.8.1.3.6 Movement Alarm

The site transporter shall, when operating in reverse, have a movement alarm system.

4.8.1.3.7 Wheels

The transporter tracks/wheels shall not damage concrete floors.

4.9 Mechanical Design Criteria

4.9.1 Fire Protection Design Criteria

4.9.1.1 General Criteria

4.9.1.1.1 Hazards - Control and Suppress Fire Events

Facilities at the repository shall handle large quantities of radioactive and hazardous materials. Consequently, it is necessary to ensure that facilities are designed to control, suppress, and contain the effects of fire events that are postulated to occur during the life of the facility.

[To ensure that adequate levels of fire protection are provided, a graded approach is used in the design of facilities and areas.]

4.9.1.1.2 Primary Fire Protection Codes and Standards

Repository facilities and systems shall be designed to meet the following fire protection codes and standards:

- *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), as modified by NAC 477.283, Sections 2.(c), 2.(f), 2.(g), 2.(i), 2.(j), and 2.(l).
- *2006 International Fire Code (*ICC 2006 [DIRS 176293])
- NFPA 1-2005, *Uniform Fire Code* [DIRS 175765]
- NFPA 101-2006, *Life Safety Code, with Errata and Tentative Interim Amendments* [DIRS 177965]
- Other NFPA codes and standards, as referenced in the following sections

[NAC 477, State Fire Marshal [DIRS 182445] modified some of the Life Safety Code, such as shortening the egress distances within facilities. NAC 477.283 made modifications to sections of the IBC 2003 that are being applied to the same sections of the IBC 2000. Although NAC 477.281.1(a) provides for Nevada's adoption of the 2003 version of the International Fire Code, the project has adopted the 2006 version. NAC 477.281.1(b) also adopts the IBC 2003, while the project adopted the 2000 version with Errata to the 2000 International Building Code. Meeting applicable building and NFPA codes is mandated by DOE O 420.1A, Facility Safety [DIRS 159450] Section 4.2(5).]

4.9.1.1.3 OSHA Fire Protection

The fire protection systems shall be designed to the applicable requirements of 29 CFR 1910, Labor: Occupational Safety and Health Standard [DIRS 177507], Subpart L, Fire Protection, Appendix A to Subpart L, and the national consensus standards listed in Appendix B to Subpart L.

[29 CFR 1910.159-.165, Appendix A, and Appendix B. Some requirements of 29 CFR 1910 Subpart L (1910.155,

1910.156, 1910.157, 1910.158, Appendix A to Subpart L, Appendix B to Subpart L, and Appendix E to Subpart L) are operationally related or informational and not applicable to engineering design.]

4.9.1.1.4 DOE Facility Safety Fire Protection

All facilities shall comply with the fire protection requirements contained in DOE O 420.1A, *Facility Safety* [DIRS 159450], Section 4.2.2.

[Required by contract.]

4.9.1.1.5 Equipment Qualification or Listing

All devices or components of any fire system shall be approved, labeled, or listed by Underwriters Laboratories Inc., Underwriters' Laboratories of Canada, FM Global Technologies, LLC, or any other testing laboratory approved by the State Fire Marshal as being qualified to test such systems or devices.

[NAC 477.350.1 [DIRS 182445] specifically provides this requirement.]

4.9.1.1.6 SSC Design and Selection

The design and selection of fire protection SSCs shall be in accordance with the *Fire Resistance Directory 2006* (UL 2006 [DIRS 178042]), and the *Fire Protection Equipment Directory 2006* (UL 2006 [DIRS 178051]). Protective coatings used in the facilities shall be in accordance with ASTM D 5144-2000, *Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants* [DIRS 158844] and not contribute to the flammability or fire loading of the facilities and SSCs. Protective coatings shall be qualified and capable of surviving an event sequence without adversely affecting safety-related SSCs needed to mitigate the accident.

[To satisfy NAC 477.350.1 [DIRS 182445], SSCs should be designed to these directories as industry guidance. RGA REG-CRW-RG-000045 (BSC 2007 [DIRS 181682]) has adopted Regulatory Guide 1.54, Service Level I, II, AND III Protective Coatings Applied To Nuclear Power Plants [DIRS 182350] that provides clarification and guidance on protective coating.]

4.9.1.1.7 DOE Design Guidance

The fire protection system shall incorporate appropriate design guidance from DOE G 440.1-5, *Implementation Guide for Use with DOE Orders 420.1 and 440.1 Fire Safety Program* [DIRS 144423], and DOE-STD-1066-99, *Fire Protection Design Criteria* [DIRS 154954].

[Although not mandated through the contract, DOE G 440.1-5 is considered appropriate to obtain design guidance for repository facilities. Previous YMP documents have cited Sections 3.2, 3.3, 3.4, and 5.3. The DOE standard is also considered appropriate guidance.]

4.9.1.1.8 Fire Protection ALARA

The fire protection system shall be designed in accordance with Regulatory Guide 8.8, *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will be as Low as is Reasonably Achievable* [DIRS 103312] and 10 CFR 20, Energy: Standards for Protection Against Radiation [DIRS 181962] such that the equipment can operate in the radiation and contamination environments expected, and the equipment can be maintained while limiting personnel exposures.

[Engineering judgment dictates protection of the individuals and equipment. Specific ALARA criteria are included in Section 4.10. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.9.1.1.9 NRC Regulatory Guidance

The fire protection system design shall utilize NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants* [DIRS 165112], Section 3.73 (Revision 2), Seismic Subsystem Analysis, and Regulatory Guide 1.189, *Fire Protection for Operating Nuclear Power Plants* [DIRS 155040] for design guidance.

[Applicable sections of the codes, standards, and industry guides will be determined during the design process and in the development of the design products. This regulatory guide have been determined to be applicable to the

design of the fire protection system. The level of conformance with the regulatory position will be determined during the design process and in the development of the design products. RGA REG-CRW-RG-000164, Agreement for Regulatory Guide 1.189, Rev. 0 - Fire Protection for Operating Nuclear Power Plants (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189. Regulatory Guide 1.120, Rev. 1, 1977, Fire Protection Guidelines for Nuclear Power Plants [DIRS 178101] was superceded by Regulatory Guide 1.189 in 2001 by NRC.]

4.9.1.1.10 Fire Protection and Security

The fire protection system shall be designed such that the placement of equipment and emergency response personnel do not compromise the security of the facilities and SSCs.

[Consideration of 10 CFR 73, Energy: Physical Protection of Plants and Materials [DIRS 181969] dictates this design consideration.]

4.9.1.1.11 Fire Protection Analyses and Evaluations

Fire hazards analyses and safety evaluations shall be performed in accordance with Regulatory Guide 1.189 [DIRS 155040] Sections C.1.2, C.1.4, C.1.5, C.1.8 through C.1.8.5, C.1.8.7 and DOE G 440.1-5 [DIRS 144423] Section 4.

[RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189 and DOE G 440.1-5.]

4.9.1.1.12 Fire Prevention, Detection, and Suppression

Fire prevention, detection, and suppression shall be accomplished in accordance with Regulatory Guide 1.189 [DIRS 155040] Sections C.2.1, C.2.1.1, C.2.1.2, C.2.1.4, C.3 through C.3.4.4 (except C.3.2), C.3.4 through C.3.4.4, and C.3.5.2.1.

[RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189 [DIRS 155040].]

4.9.1.2 Site Criteria

4.9.1.2.1 Minimum Access Width or Building to Building Spacing

The minimum access width, building to building spacing, for fire fighting apparatus shall be not less than 26 ft where fire hydrants are provided and shall not be less than 20 ft in width where there are no hydrants. Access pathways shall not exceed 150 ft in length unless a suitable turnaround is provided.

[This criterion provides for acceptable width for the access and operation of fire fighting apparatus per the 2006 International Fire Code (ICC 2006 [DIRS 176293]), Sections 503.2.5, D103.1, and D103.4.]

4.9.1.2.2 Roads Grading

Roads that are used by fire fighting apparatus shall not exceed 10 percent in grade.

[This criterion provides for acceptable slope for the response of fire fighting apparatus per the 2006 International Fire Code (ICC 2006 [DIRS 176293]), Section D.103.2.]

4.9.1.2.3 Exposure From Natural Terrain

Exposures to buildings and significant equipment from the natural terrain shall be assessed and mitigated per NFPA 1144-2002, *Standard for Protection of Life and Property from Wildfire* [DIRS 160936].

[This criterion assists in the identification, assessment of risk, and specification of mitigating features in order to protect buildings and equipment from external fire threats due to the isolated location in an area that could be threatened by wild land fires.]

4.9.1.2.4 Exterior Fire Exposures

Exterior exposures to buildings or equipment created by other buildings or equipment shall be evaluated and mitigated in accordance with NFPA 80A-2006, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures* [DIRS 177989].

[This criterion assists in the identification, assessment of risk, and specification of mitigating features in order to protect buildings and equipment from fires in adjacent buildings or equipment.]

4.9.1.2.5 Flammable and Combustible Liquid Tanks

The location, spacing, and protection criteria for flammable and combustible liquid tanks shall be identified, evaluated, and mitigated per NFPA 30-2006, *Flammable and Combustible Liquids Code* [DIRS 177974]. Flammable gas tanks and diesel fuel oil storage tanks areas shall be designed to aid in fire protection, mitigation and suppression in accordance with Regulatory Guide 1.189 [DIRS 155040] Sections C7.4, and C.7.5.

[This criterion assists in the identification, assessment of risk, and specification of mitigating features to protect flammable and combustible tanks from adversely affecting other buildings and equipment from fire. Regulatory guidance Analysis REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.2.6 Water Tanks, Spent Fuel and Radwaste Storage Areas

The location and layout of the spent fuel, radwaste storage, and water storage tanks areas shall be designed to aid in fire protection, mitigation and suppression in accordance with Regulatory Guide 1.189 [DIRS 155040] Sections C.6.2.2, C.6.2.3, and C.6.2.5.

[RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189 [DIRS 155040].]

4.9.1.3 Nuclear Surface Facilities

4.9.1.3.1 Noncombustible and Heat Resistant Building Materials

Noncombustible and heat resistant building materials shall be used wherever practical.

[This criterion is necessary to limit the quantities of materials available to support combustion in a hazard area. Fire propagation is limited by restricting building materials to the use of noncombustible and heat resistant materials that will not support combustion. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B, GDC 3, which specifies the use of noncombustible and heat resistant materials. Although RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189, Section B is not included in the agreement.]

4.9.1.3.2 Minimize Fire Effects on ITS SSCs

Required fire detection and suppression systems of appropriate capacity and capability shall be designed to minimize the adverse effects of fires on ITS SSCs.

[This criterion is necessary to specify that the system design will be sufficiently comprehensive and adequate to limit damage from a fire and protect against an inadvertent release to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B, GDC 3, which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard. Although RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189, Section B is not included in the agreement.]

4.9.1.3.3 Minimize Adverse Effects of Fire System on ITS SSCs

Fire fighting systems shall be designed to ensure that their failure, rupture, or inadvertent operation does not significantly impair the capability of ITS SSCs to perform their intended function.

[This criterion is necessary to specify that the system design will be sufficiently comprehensive and adequate to limit damage from a fire and protect against an inadvertent release to affected SSCs in the hazard area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B, GDC 3, which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard. Although RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189, Section B is not included in the agreement.]

4.9.1.3.4 Backup Fire Suppression System

All nuclear facilities shall be provided with backup manual fire suppression in the form of a Class III standpipe installation in accordance with NFPA 14-2006, *Standard for the Installation of Standpipe and Hose Systems* [DIRS 177969]. The system shall be able to reach any location that contains or could present an exposure fire hazard to ITS SSCs with at least one effective hose stream. Additional standpipe and hose installations shall be provided in an area if the fire hazard could block access to a single hose station serving that area. All hose nozzles shall have shutoff capability. Standpipe systems shall comply with NAC 477.810-840.

[This criterion is necessary to specify a minimum threshold level for backup fire system protection that is acceptable in order to limit damage from a fire. Specification of backup suppression protection limits potential fire damage to ITS SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.4, which specifies this criterion for manual suppression systems. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189].

4.9.1.3.5 Design Interface, Control, and Usage

Repository building ventilation and exhaust systems shall be designed such that their interface, control, and usage shall be accomplished in a manner consistent with NFPA 801-2003, *Standard for Fire Protection for Facilities Handling Radioactive Materials* [DIRS 165077]. Fire and smoke damper specifications shall conform to the requirements or recommendation of NFPA 90A-2005, *Standard for the Installation of Air-Conditioning and Ventilating Systems, with Errata* [DIRS 176267], and shall include parameters to ensure satisfactory closure performance that addresses the total worst-case differential pressures at the damper under airflow conditions.

[This criterion is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. The specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.2.1.3, which specifies the criteria for ventilation system fire dampers. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.4 Non-Nuclear Surface Facilities

A building that is more than two stories in height, including any height added by usable floor space, shall have automatic sprinkler systems installed throughout.

[NAC 477.283.1.(h) [DIRS 182445] specifies a modification to the 2006 International Fire Code (ICC 2006 [DIRS 176293], Section 903.2.10). NAC 477.283, Sections 2.(c) and 2.(i) modify the IBC 2000 to revise the criteria for high-rise buildings.]

4.9.1.5 Subsurface Fire Protection Zoning Compatibility

The zoning of fire detection, alarm, and suppression systems shall be compatible with the layout of the subsurface ventilation system. The zoning of the fire protection systems shall permit the operational control of the subsurface ventilation system on a selective fan basis.

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Fire hazards with adequate fire protection system performance and capability, together with specific egress features, will aid in providing life safety for occupants to meet DOE criteria for occupant protection. This criterion is based on DOE O 420.1A [DIRS 159450], Section 4.2, which specifies the criteria for minimum level of life safety performance to demonstrate that occupants are adequately and appropriately protected from fire hazards.]

4.9.1.6 Separation of Construction From Emplacement

The subsurface development area or construction phase shall be separated from the subsurface emplacement area or repository phase by fire rated barriers in accordance with NFPA 221-2005, *Standard for High Challenge Fire Walls, Fire Walls and Fire Barrier Walls* [DIRS 177544]. The fire barriers shall have performance ratings as determined by fire hazards analysis. The fire barriers may be coincident with a ventilation barrier.

[This criterion is necessary to specify a level of fire barrier performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and associated fire hazards. The specification of fire barrier parameters increases the likelihood that a fire is contained within the subsurface development area and not extended to the subsurface emplacement area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.2.1.4, which specifies the criteria for fire area compartmentation. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189].

4.9.1.7 Protection of Mobile Equipment

4.9.1.7.1 Mobile Equipment Automatic Fire Detection and Suppression

Automatic fire detection and suppression of appropriate capacity and capability shall be installed as determined by the fire hazards analysis and as necessary to protect SSCs. The fire hazards analysis shall consider the worst-case location and exposure impact to SSCs in determining the protection required. The agent used for automatic suppression shall be based on the fire hazards analysis and any potential ITS concerns.

[This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. The specification of mobile equipment automatic suppression limits potential fire damage to SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.3, which specifies the criteria for the protection of SSCs ITS. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189].

4.9.1.7.2 Mobile Equipment Fire Detection and Suppression

The required mobile equipment fire detection and suppression system shall be designed to transmit signal(s) to the site fire alarm system to annunciate the equipment location and status whether within or exterior to any building, structure, or exterior area where the equipment is expected to operate. The manner in which this signal(s) is transmitted and received shall minimize adverse effects to ITS SSCs.

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to promptly control and extinguish a fire, and also protect against the inadvertent release to affected SSCs caused by undesirable plant systems interaction. Fire protection systems of sufficient capacity and capability, with normal and abnormal system status indications, will enable fires to be controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B, GDC 3, which specifies the use of fire protection systems of appropriate capacity and capability to be provided for the protected hazard. Although RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189, Section B is not included in the agreement.]

4.9.1.8 Redundant Fire Protection Systems

Redundant fire protection systems shall be provided in areas containing ITS SSCs where the resulting protection would not otherwise ensure that the fire would be successfully controlled until such time that the emergency fire fighting forces are expected to arrive to complete fire extinguishment. Redundant fire protection could consist of duplicate localized hazard protection or installation of a local hazard fire suppression system together with an appropriately designed area fire suppression system that would protect the entire fire area or hazard space.

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage, from a fire or an inadvertent release, to affected SSCs in a hazard area. Fire protection systems of sufficient capacity and capability, with normal and abnormal system status indications, will enable fires to be controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section B, GDC 3, which specifies the use of fire protection systems of appropriate capacity and capability, and DOE G 440.1-5 [DIRS 144423], Section IV, 9.6, which specifies additional protection when the manual fire fighting force is delayed in effecting extinguishment. Although RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189, Section B is not included in the agreement.]

4.9.1.9 Surface Facilities Life Safety

4.9.1.9.1 Life Safety Provisions

Acceptable life safety provisions shall be provided for all facilities in compliance with NFPA 101-2006, *Life Safety Code*, *with Errata and Tentative Interim Amendments* [DIRS 177965], as modified by NAC 477, *State Fire Marshal* [DIRS 182445]. DOE-STD-1066-99 [DIRS 154954] shall be used to provide additional design guidance.

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Facilities with adequate fire protection system of sufficient capacity and capability, together with personnel specific egress features, will provide acceptable life safety for facility occupants to meet DOE criteria for occupant protection. This criterion is based on DOE O 420.1A [DIRS 159450], Section 4.2, and DOE-STD-1066-99, Section 10, which specify the criteria for minimum level of life safety performance to demonstrate that facility occupants are adequately and appropriately protected from fire hazards. NAC 477.283, Sections 2.(c), 2.(f), 2.(g), 2.(i), 2.(j), and 2.(l) modified the IBC 2000.]

4.9.1.9.2 Explosion Potential From Hazardous Processes

Where hazardous processes are of a sufficient character as to introduce an explosion potential in a building compartment, personnel life safety protection features, per NFPA 101-2006 [DIRS 177965], shall be provided that may be additional to that specified below in Section 4.9.1.15.

Facility structural design and construction shall comply with the requirements of TM 5-1300, *Structures to Resist the Effects of Accidental Explosions* [DIRS 178041]. Blast-resistant design for personnel and facility protection shall be based on the trinitroluene equivalency of the maximum quantity of explosives and propellants permitted. In accordance with TM 5-1300, the TNT equivalency shall be increased by 20 percent for design purposes.

[This criterion is based on DOE O 420.1A [DIRS 159450]. It is necessary to specify that system design will be sufficiently comprehensive and adequate to provide adequate levels of life safety in areas where an explosion potential exists. This criterion is based on NFPA 101-2006, Sections 8.7.1.1 and 8.7.2, which specify the criteria for a minimum level of life safety performance to demonstrate that facility occupants are adequately and appropriately protected. Although the order refers to another manual, it is not applicable and therefore not identified (See Sections 4.1.2 and 4.2.10.3)]

4.9.1.9.3 Interior Finishes

Exposed interior wall and ceiling finish materials and any factory installed facing materials shall have a UL-listed or Factory Mutual-approved flame spread rating of 25 or less and smoke developed rating of 50 or less. Interior finishes in areas processing or storing radioactive materials shall have limited combustible rating.

[This criterion is necessary to specify that system design will be sufficiently comprehensive to provide an adequate level of life safety. This criterion is based on DOE-STD-1066-99 [DIRS 154954], Section 9.3.1; International Building Code 2000, with Errata to the 2000 International Building Code (ICC 2003 [DIRS 173525]), Section 803; NFPA 101-2006 [DIRS 177965], Section 10.2.3; and NFPA 801-2003 [DIRS 165077], Section 5.8. These specify the criteria for the minimum levels of passive fire protection performance to demonstrate that facility occupants and property are adequately protected from fire hazards.]

4.9.1.10 Subsurface Facility Life Safety

4.9.1.10.1 Fire Command Center

A fire command center shall be provided on the surface for the use of fire fighting forces during an emergency in the subsurface. This may be co-located with other surface or subsurface control equipment but shall meet the space and survivability criteria of NFPA 72-2006, *National Fire Alarm Code* [DIRS 177984], Section 6.9.6. The fire command center shall have displays for the status of all detection, alarm, and communication systems in the subsurface. This shall be the principal location for managing a subsurface emergency and from where subsurface systems credited for fire and worker protection can be manually controlled. Status, display, and command override functions shall be provided for all credited subsurface ventilation system dampers and fan controls. All required status, display, communications, and functional controls shall be monitored for integrity. The fire command center shall also comply with the applicable provisions of NAC 477 [DIRS 182445], including specifics in Section 283 2.(e)(1) and (2).

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Facilities with an adequate fire protection system of sufficient capacity and capability, together with personnel specific egress features, will provide acceptable life safety for facility occupants to meet DOE criteria for occupant protection. This criterion is based on DOE O 420.1A [DIRS 159450], Section 4.2, which specifies the criteria for a minimum level of life safety performance to demonstrate that facility occupants are adequately and appropriately protected from fire hazards. NAC 477.281.2 documents that the State of Nevada has adopted NFPA 72-2006.]

4.9.1.10.2 Preclude or Minimize Smoke to the Subsurface From Surface Fire

Provisions shall be provided to preclude or minimize the entrainment of smoke from the surface to the subsurface due to an surface fire near subsurface air intake structures or vent lines. These provisions shall be adaptable to the needs of the subsurface as emplacement and development activities continue to evolve.

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Protection from external fire hazards, together with personnel egress and

refuge features, will provide acceptable capacity life safety for occupants to meet DOE criteria for occupant protection. This criterion is compatible with DOE O 420.1A [DIRS 159450], Section 4.2, which specifies the criteria for minimum level of life safety performance to demonstrate that facility occupants are adequately protected from fire hazards internal and external to the facility.]

4.9.1.10.3 Subsurface Egress

Egress shall be provided from the subsurface areas in accordance with the subsurface life safety performance criteria.

[Egress requirements from the subsurface shall be developed to provide an acceptable level of risk to personnel in the subsurface areas.]

4.9.1.11 Fire Water System

4.9.1.11.1 Fire Water Supply

The fire water supply for nuclear facilities shall be calculated on the basis of the largest expected flow rate for a period of two hours, but not less than 300,000 gal. This flow rate shall be conservatively based on 500 gpm for manual hose streams, plus the largest design demand of any sprinkler or deluge system as determined by hydraulic calculation. Fire water service to non-nuclear buildings, except the subsurface zone, shall be serviced by the fire water system as permitted in the fire water system criteria.

[This criterion is necessary in order to specify a system design that will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, with allowance for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.2.1.b, which specifies that the use of fire protection systems of appropriate capacity and capability be provided for the protected hazard. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.11.2 Fire Water Tanks

At least two 100-percent system capacity dedicated fire water supply tanks shall be installed. The non-potable water supply capacity shall be capable of totally refilling each tank in eight continuous hours or less.

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.3.2.1.a and c, which specify the use of fire protection systems of appropriate capacity and capability for the protected hazard. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.11.3 Fire Pumps

Sufficient number of pumps shall be provided to ensure that 100 percent capacity will be available assuming failure of the largest pump or loss of offsite power (e.g., three 50-percent pumps or two 100-percent pumps). This may be accomplished by providing a combination of electric motor-driven and diesel-driven fire pumps.

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.2.2, which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.11.4 Fire Pump to Main Loop Connection

Individual fire pump connections to the yard fire main loop shall be separated with appropriate sectionalizing valves between connections. Diesel-driven fire pumps, together with the pump driver and controls, shall be located in a room separated from the remaining fire pumps by a firewall with a minimum fire rating of three hours. Fire pump trouble, supervisory and alarm signals shall report through the site fire alarm system to annunciate pump running, driver availability, failure to start, and low fire-main pressure.

[This criterion is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.3.2.2.b and c, which specify the use of fire protection systems of appropriate capacity and capability for the protected hazard. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.11.5 Isolation Control Valves

Control valves shall also be provided to isolate portions of the fire water system serving SSCs, which are or contain ITS SSCs from portions of the fire water system serving SSCs that are not or do not contain ITS SSCs, without simultaneously shutting off the fire water supply to areas containing ITS SSCs. The fire water distribution piping shall be capable of delivering this design demand over the longest piping route to the protected hazard. The distribution piping shall be capable of meeting the calculated design demand at a residual pressure not less than 20 psig at ground elevation.

[This criterion is necessary to specify a maximum level of fire system inoperability that is acceptable in order to limit damage to ITS SSCs in the event of a fire. The specification of isolation valves to prevent the simultaneous unavailability of primary and backup suppression systems from any impairment increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.3.2.3.g and h and GDC 5, and DOE-STD-1066-99 [DIRS 154954], Section 6.1.1, which specify the criterion for the arrangement of the fire water distribution system in regard to impairment of the primary and backup fire suppression system. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.11.6 Controlling and Sectionalizing Valves

Control and sectionalizing valves in fire mains and water-based fire suppression systems shall be electrically supervised. Status of control and sectional valves shall report through the site fire alarm system. Control and sectional valves shall be the visually-indicating type valves.

[This criterion is necessary to specify a level of fire system status indication that is acceptable in order to limit damage from a fire and to alert personnel to a valve being misaligned . Specification of a valve type and its position supervision when out of service increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.2.3.d, which specifies the criteria for the valve supervision of the fire water distribution system. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.11.7 Main Loop Feeds Systems

Sprinkler systems and backup standpipe and hose stations shall be provided with connections to the fire water distribution system so that a single active failure or line break will not simultaneously impair the primary and backup fire suppression systems. Alternatively, fire water headers fed from two ends are permitted inside buildings to supply sprinkler and standpipe systems. Such headers shall be considered an extension of the fire water distribution system. Each sprinkler and standpipe system shall be separately equipped with a means to detect water flow and transmit a water flow condition to a remote location. The design shall comply with the applicable provisions of NAC 477 [DIRS 182445].

[This criterion is necessary to specify a maximum level of fire system inoperability that is acceptable in order to limit damage from a fire. The specification of configuration limits the simultaneous impairment of primary and backup suppression systems, which increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.2.3.i, which specifies the criterion for the arrangement of the fire water distribution system. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.11.8 Fire Hydrant Flow Rates

Fire hydrants shall be capable of providing the water flow rates established in the *2006 International Fire Code* (ICC 2006 [DIRS 176293]), based on the most severe facility fire risk on site, as modified by NAC 477.283.1.(d). This rate shall be reduced by a maximum of 50 percent, in accordance with DOE-STD-1066-99 [DIRS 154954], for automatic sprinkler protected facilities. Fire hydrants shall each be capable of flowing a minimum of 1,500 gpm at 20-psig residual pressure.

[This criterion is necessary to specify a defense-in-depth design that will be sufficiently comprehensive and adequate to limit damage from a fire should one of the systems not be able to perform as intended to control a fire in the hazard area. The establishment of fire hydrant minimum waterflow rates will ensure that a sufficient capacity is available for manual fire fighting, which will increase the likelihood that fires are promptly controlled and extinguished. This fire hydrant criteria is based on the 2006 International Fire Code, Sections B102.1 and B105.2 and Table B105.1), and DOE-STD-1066-99, Section 6.1.2.]

4.9.1.11.9 Fire Hydrant Locations

Fire hydrants shall be located so that a sufficient and effective hose stream can be provided to any onsite location where fixed or transient combustibles could jeopardize ITS and non-ITS facility SSCs. Hydrants shall be installed approximately every 250 ft on the fire water distribution system. Valves shall be installed to permit isolation of fire hydrants from other portions of the fire water distribution system for maintenance or repair without interrupting the water supply to other portions of the distribution system. Hose threads compatible with those used by local fire departments shall be provided on all hydrants, hose couplings, and standpipe risers consistent with NFPA 1963-2003, *Standard for Fire Hose Connections* [DIRS 166981]. Hydrant locations shall be in accordance with the *2006 International Fire Code* (ICC 2006 [DIRS 176293], Section 508), as modified by NAC 477.283.1.(e).

[This criterion is necessary to specify a maximum level of fire system inoperability that is acceptable to the NRC in order to limit damage from a fire. Specification of a system configuration, which limits the simultaneous impairment of primary and backup suppression systems, which increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.3.2.3.h and C.3.4.2, which specify the criteria for the arrangement of the fire water distribution system. Also see Criterion 4.2.12.1.7, Utility Facilities. CBCN016 to PDC Revision 6 provided change. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.12 Fire Detection System

4.9.1.12.1 Fire Detection Systems

Fire detection systems shall be provided in all areas that contain or present a fire exposure to ITS SSCs. Fire detection systems shall comply with the criteria for Class A systems in accordance with NFPA 72-2006, *National Fire Alarm Code* [DIRS 177984], and Class I circuits in accordance with NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982].

[This criterion is necessary to specify a minimum threshold level for automatic fire detection system performance that is acceptable to limit damage from a fire. The specification of automatic detection performance limits potential fire damage to ITS SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.3.1, C.3.1.1.b, d, e, and i, which specify the criteria for the protection of ITS SSCs. NAC 477.281.2 [DIRS 182445] documents that the State of Nevada has adopted NFPA 72. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.9.1.12.2 Offsite Power

Fire detection systems shall be capable of operating with or without offsite power.

[This criterion is necessary to specify a level of fire detection system performance that is acceptable to limit damage from a fire. The specification of the capability for the fire detection system to detect fires when offsite power is available or unavailable increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.1, which specifies the criteria for fire detection performance during normal and off-normal conditions. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.12.3 Fire Detection

Fire detection shall be provided for all other buildings and areas where fire damage is postulated to occur per a fire hazards analysis and no other fire protection system is provided.

[This criterion is necessary to specify performance for fire detection systems in buildings and areas that would

otherwise not be provided with fire suppression. The specification of a fire detection system will increase the likelihood that fires are promptly controlled and extinguished. This criterion implements DOE O 420.1A [DIRS 159450], Section 4.2.2.6, and DOE G 440.1-5 [DIRS 144423], Section III, 2.0 and 6.6, and Section IV, 9.6, which specify the criteria for fire protection when other fire suppression is not otherwise installed.]

4.9.1.13 Fire Suppression System

4.9.1.13.1 Automatic Fire Suppression

Automatic fire suppression shall be installed as determined by the fire hazards analysis and, as necessary, to protect ITS SSCs. The type of automatic suppression chosen for protection shall be based on the fire hazards analysis and any potential ITS concerns.

[This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to ITS SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.3, which specifies the criteria for the protection of ITS SSCs. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.13.1.1 Remote Buildings

An automatic fire suppression system shall be provided for remote buildings (a) that have more than 5,000 square feet of floor space, (b) are not served by a water system or utility and cannot produce the required fire flow, (c) the fire department cannot respond to the report of an alarm at the building within 10 minutes, or (d) is not served by an all-weather access road.

[NAC 477.920 [DIRS 182445]]

4.9.1.13.2 Protection of ITS SSCs From Water

ITS SSCs that do not otherwise require protection by water-based suppression systems, but are subject to unacceptable damage if wetted by water suppression discharge, shall be appropriately protected by water shields or baffles.

[This criterion is necessary to specify protection feature levels for automatic fire system protection to limit damage from unintended system discharge effects to SSCs. Specification of water shields or baffles where automatic suppression systems are located limits potential unintended damage to ITS SSCs. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.3.1, which specifies the criterion for the protection of ITS SSCs. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.13.3 Water Mist Suppression Systems

Water mist suppression systems shall be considered for use in specialized situations where the application of water needs to be restricted. The basis for selection of a water mist system for hazard protection shall be documented in the fire hazards analysis.

[This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to ITS SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.3.3.1 and C.3.3.1.2, which specify the criteria for the protection of ITS SSCs. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.13.4 Hydraulic Design Requirement

Hydraulically designed automatic and manual suppression systems shall be designed for a supply pressure of at least 10 percent but not less than 10 psig below the supply curve.

[This criterion is necessary to specify a margin of safety in system design that will be sufficiently comprehensive and adequate to limit damage from a fire should one of the systems not be able to perform as intended to control a fire in the hazard area. The intent of the 10% / 10 psi "margin" is to ensure that a sufficient allowance / safety factor is built into hydraulically designed sprinkler systems. This criterion implements DOE O 420.1A [DIRS 159450] and DOE-STD-1066-99 [DIRS 154954], Section 7.2, which specify the criterion for hydraulic design of suppression systems in DOE facilities.]

4.9.1.13.5 Fire Protection for High Efficiency Particulate Air Filters

Fire protection for high-efficiency particulate air (HEPA) filter combustion shall protect against the potential of fire spreading to other facility areas. A fire hazards analysis shall determine the need for and the type of fire detection and suppression for the HEPA filters and their exposure to ITS SSCs.

[This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable to limit damage from a fire. The specification of automatic suppression protection limits potential fire damage to ITS SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.4, and DOE-STD-1066-99 [DIRS 154954], Section 14, which specify the criteria for the protection of ITS SSCs. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.13.6 Foam Water Systems

Foam water systems fire suppression protection shall be considered where significant flammable and combustible liquid fire hazards are present. This shall be documented in the fire hazards analysis.

[The specification of an appropriate and comprehensive fire protection system of sufficient capacity and capability will increase the likelihood that fires are promptly controlled and extinguished before unacceptable fire losses are incurred. This criterion implements DOE O 420.1A [DIRS 159450] and DOE-STD-1066-99 [DIRS 154954], Sections 5.3.1 and 5.3.2, which specify the criteria for fire protection when the maximum possible fire loss exceeds $1 Million.]

4.9.1.13.7 Preclusion of Water Sprinklers Due to Criticality

When the use of water sprinklers is precluded because of nuclear criticality concerns, non-aqueous fire extinguishing subsystems could be used. Confirmation that the extinguishing subsystems selected do not pose a criticality concern shall be demonstrated with an appropriate nuclear criticality analysis.

[This criterion is necessary to specify fire protection means when a water-based fire suppression system discharge could produce an undesired criticality event. Specification of alternative fire protection agents will limit potential fire damage to ITS SSCs, increasing the likelihood that fire may still be controlled and extinguished, as well as the prevention of a criticality event during discharge of the fire system agent. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.3.3.1 and C.3.3.2, which specify the criteria for protection using automatic suppression systems. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.13.8 Halon or Clean Agent Systems

Alternative halon or clean agent fire-extinguishing systems shall only use listed or approved agents. Provisions for locally disarming automatic systems shall be key-locked. The basis for selection of given clean agent systems for hazard protection shall be documented in the fire hazards analysis.

[This criterion is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. The specification of automatic suppression protection limits potential fire damage to ITS SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.1.2, C.3.3.2, and C.3.3.2.3, which specify the criterion for the protection of ITS SSCs. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.13.9 Confinement System Barrier Protection

The introduction of the fire-extinguishing agent into a compartment shall not result in over-pressurization and failure of the ventilation confinement system barrier.

[This criterion is necessary to specify limits to fire protection agent discharge that could otherwise produce a loss of confinement. The specification of a limit on the pressure effects from alternative fire protection agent discharge will allow a fire to be controlled and extinguished, as well as prevent potential loss of ventilation system confinement. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3.3.2, which specifies the criterion for protection using gaseous fire suppression systems. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189]

4.9.1.14 Fire Alarm System

4.9.1.14.1 Site Fire Alarm System

The site fire alarm system shall be designed to comply with the applicable provisions of NAC 477.365 [DIRS 182445] to minimize the adverse effects of fires on ITS SSCs. The site fire alarm system shall be a proprietary type system and installed in all site buildings and areas to connect all active fire protection systems with the main fire alarm monitoring console and other required system interfaces. The fire alarm system shall be capable of operating with or without offsite power.

[This criterion is necessary to specify a level of fire alarm system performance that is acceptable in order to limit damage from a fire. The specification of the capability for the fire alarm system to transmit fire related signals when offsite power is available and unavailable increases the likelihood that fires are promptly controlled and extinguished before unacceptable fire losses are incurred. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.3.1, C.3.1.1.a, and f, which specify the criteria for fire alarm performance during normal and off-normal conditions. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.14.2 Signaling Line Circuits

Signaling line circuits serving the subsurface shall be separate from those serving surface facilities, except ventilation shaft fan houses.

[This criterion is necessary to specify a level of fire alarm system performance that is acceptable in order to limit damage from a fire. The specification of the separate signaling line circuits for the surface and subsurface reduces the probability that faults on the surface will not affect subsurface fire alarm capability and vice versa. This increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.3, which specifies the criteria for fire alarm performance. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189]

4.9.1.15 Explosion Protection System

4.9.1.15.1 In Situ Explosion Hazards

In situ explosion hazards shall be identified and suitable protection provided. Transient explosion hazards that cannot be eliminated shall be controlled and suitable protection provided. Explosion hazards and their specific means of protection shall be discussed in the fire hazards analysis. NFPA 68-2006, *Standard on Explosion Protection by Deflagration Venting* [DIRS 182845], and NFPA 69-2002, *Standard on Explosion Prevention Systems* [DIRS 160953], shall be used for the identification, evaluation, and mitigation of explosive hazards.

[This criterion is necessary to specify a level of explosion protection system performance that is acceptable in order to limit damage from an explosion. The specification of the capability for the explosion protection system increases the likelihood that an explosion is controlled and mitigated. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.8, which specifies the criteria for explosion protection system performance. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189]

4.9.1.15.2 Storage and Piping for Flammable or Combustible Liquids or Gases

Miscellaneous storage and piping for flammable or combustible liquids or gases shall not create a potential exposure hazard to ITS SSCs or to the fire protection systems that serve those areas of concern. Processes that may involve hydrogen or explosive gases shall be designed to prevent development of explosive mixtures by limiting the concentration of explosive gases and vapors within enclosures to less than 50 percent of their lower explosive limit.

[This criterion is necessary to specify a level of explosion protection system performance that is acceptable in order to limit damage from an explosion. The specification of the capability for the explosion protection system increases the likelihood that an explosion is controlled and mitigated before unacceptable damage occurs to SSCs. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.8, which specifies the criteria for explosion protection system performance. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.15.3 Potential for Explosive Mixture of Hydrogen or Oxygen

If the potential for an explosive mixture of hydrogen and oxygen exists in off-gas systems, the systems shall either be designed to withstand the effects of a hydrogen explosion or be provided with dual automatic control functions to preclude the formation or buildup of explosive mixtures.

[This criterion is necessary to specify a level of explosion protection system performance that is acceptable in order to limit damage from an explosion. The specification of the capability for the explosion protection system increases the likelihood that an explosion is controlled and mitigated before unacceptable losses are incurred. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.8, which specifies the criteria for explosion protection system performance. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.16 Fire Barrier System

4.9.1.16.1 New Structure

New permanent structures in excess of a 5,000 sq ft floor area shall be of noncombustible or fire resistive construction.

[This criterion is necessary to specify performance for building construction types that would otherwise not meet the improved risk criteria, that is acceptable to the DOE and will limit damage from fires. Specification of a building construction type will increase the likelihood that fire hazards are limited and controlled. This criterion implements DOE O 420.1A [DIRS 159450] and DOE-STD-1066-99 [DIRS 154954], Section 5.2.1, which specify the criteria for building construction type when other criteria are not otherwise specified.]

4.9.1.16.2 Fire Barriers

Fire areas shall be separated from other portions of a building or facility (other fire areas) by suitable fire barriers, including suitably rated components of construction such as beams, joists, columns, penetration seals or closures, fire doors, and fire dampers. Fire barriers in buildings containing SSCs ITS shall define a fire area boundary and have a minimum fire resistance rating of three hours. Exterior walls forming a portion of a fire area boundary may be unrated if there is no fire exposure or other over-riding requirement to the wall that would otherwise require the wall to be rated. The construction and performance of fire barrier walls and firewalls shall comply with NFPA 221-2005, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls* [DIRS 177544].

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between adjacent fire areas and their associated hazards. The specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and does not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.2, which specifies the criteria for fire area construction and compartmentation. NOTE: Fire zones (fire area subdivisions) may be used to establish zones within fire areas where subdivision into other fire areas is not practical; fire zones shall be based on fire hazard analyses. Fire zone boundaries are usually not sufficient to protect from exposure fires within the same fire area. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.16.3 Fire Hazards Analysis

Fire areas shall be established in the fire hazards analysis. Fire areas shall be defined to separate ITS SSCs from potential fires in other areas containing non-ITS SSCs that could affect the ability of ITS SSCs to perform their safety function.

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between adjacent fire areas and their associated hazards. The specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.2, which specifies the criteria for fire area construction and compartmentation. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.16.4 Isolate Fire Hazards From ITS SSCs

Fire areas shall be defined to the extent feasible to isolate fire hazards from ITS SSCs in order to limit damage from a single fire. Separate fire areas shall be employed to limit the spread of fires between similar SSC components, including those configurations where high concentrations of cables serve other components of the same respective SSC.

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between different components of the same SSC from a given fire hazard. The specification of fire area parameters

increases the likelihood that a fire is contained within the same fire area and will limit the scope of damage to a given SSC, and will not extend to involve additional components of the same SSC. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.2, which specifies the criteria for fire area construction and compartmentation. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.16.5 Assess Fire Area Boundary

Where fire area boundaries are not three-hour rated or not continuous from boundary to boundary with all penetrations sealed equal to the required fire rating of the boundary, an evaluation shall be performed to assess the adequacy of the fire area boundary. This evaluation shall determine whether the fire area boundaries are adequate to withstand the hazards associated with the area and, as necessary, protect ITS SSCs in the area from a fire originating outside the area. Said evaluation shall be referenced or made part of the fire hazards analysis for the area of concern. Unsealed openings shall be identified and considered when evaluating the overall effectiveness of the barrier. If a fire area boundary contains major unprotected openings, such as hatchways or stairways, locations on either side of such a boundary shall be considered as part of a single fire area.

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between adjacent fire areas and their associated hazards. The specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.1.8.7 and C.4.1.2.1, which specify the criteria for fire area construction and compartmentation. The design shall comply with the applicable provisions of NAC 477 [DIRS 182445]. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189]

4.9.1.16.6 Exterior Walls Qualified as Rated Fire Barriers

Exterior walls, including any penetrations, shall be qualified as rated fire barriers if they are required to protect ITS SSCs on the interior of the facility from in situ hazards located in the vicinity of the exterior wall. The exterior yard area (without fire barriers) shall be considered as one fire area, though it may consist of several fire zones. The surrounding native terrain and vegetation, considering the degree of spatial separation, shall also be evaluated for fire hazards to site SSCs.

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between onsite fire areas and any offsite fire hazard exposure. The specification of this fire area parameter increases the likelihood that an exterior exposure fire is prevented from breaching the exterior fire area boundaries and will not extend to involve SSCs within the building. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.2.1, which specifies the criteria for fire area construction and exposure to fire area boundaries. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.16.7 Protection of Openings Through Fire Barriers

Building design shall ensure that openings through fire barriers are properly protected. Openings and penetrations through fire barriers that serve as fire area boundaries shall be appropriately sealed or protected to provide a minimum fire resistance rating equal to that required of the barrier. The construction and installation techniques for rated penetrations and openings through fire barriers shall be qualified by fire endurance tests conducted by nationally recognized laboratories. Structural steel whose sole purpose is to carry dynamic loads from a seismic event need not be protected solely to meet fire barrier criteria, unless the failure of any structural steel member owing to a fire could result in significant degradation of the fire barrier.

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between adjacent fire areas and their associated hazards. The specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Sections C.2.1.4, C.4.1.2.1, C.4.1.2.2, C.4.2.1, C.4.2.1.4, and C.4.2.2, and Appendix A and A-2, which specify the criteria for fire area construction and compartmentation. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.16.8 Fire Barrier Performance

Fire barrier walls that also act as part of a radioactive material confinement structure shall be able to withstand the worst case fire condition assuming a loss of any active fire suppression systems within the fire area. The fire resistance of these fire areas and confinement barrier enclosures shall be attained by the use of monolithic concrete construction. Fire walls rated two hours or one hour shall be provided where required by ICC 2003, *International*

Building Code 2000, with Errata to the 2000 International Building Code (ICC 2003 [DIRS 173525]), and NFPA 101-2006, *Life Safety Code, with Errata and Tentative Interim Amendments* [DIRS 177965] (as modified by NAC 477, *State Fire Marshal* [DIRS 182445]). These areas include stairwells and egress corridors. For subsurface area barriers, see Section 4.9.1.6.

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit fire damage and maintain confinement during a worst-case fire exposure condition. The specification of this fire barrier performance increases the likelihood that a fire is prevented from breaching the fire area boundary and will not result in the loss of confinement for the structure. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.1.2.1, which specifies the criteria for fire area construction. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.16.9 Ventilation Fire Dampers

Ventilation fire dampers shall be installed in ducts at fire barrier penetrations in accordance with the requirement of NFPA 90A-2005, *Standard for the Installation of Air-Conditioning and Ventilating Systems, with Errata* [DIRS 176267] (e.g., three hour rated barrier requires three hour fire dampers). Fire damper specifications shall include parameters to ensure satisfactory closure performance that addresses the total worst-case differential pressures at the damper under airflow conditions.

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between adjacent fire areas and their associated hazards. The specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.2.1.3, which specifies the criteria for fire dampers used to maintain compartmentation. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.1.16.10 Fire Barrier Penetration Integrity

Fire barrier penetrations that also function as environmental isolation, pressure differential, or airborne radioactivity barriers shall be qualified by test to maintain barrier integrity under such conditions.

[This criterion is necessary to specify a level of fire area performance that is acceptable in order to limit damage between adjacent fire areas and their associated hazards. The specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189 [DIRS 155040], Section C.4.2.1.4, which specifies the criteria for fire area construction and compartmentation. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189]

4.9.1.16.11 Fire Barriers Rating

Fire barriers in non-nuclear buildings and areas shall comply with the criteria as stated for nuclear buildings, except that fire area boundaries shall have a minimum fire rating of two hours. In addition, separate evaluations are not required to justify exceptions to stated criteria; exceptions may be directly cited and justified in the fire hazards analysis for the area of concern.

[This criterion is necessary to specify that the system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety and property protection. Passive fire protection features with adequate fire protection system performance will provide acceptable life safety for facility occupants and property protection to meet DOE criteria. This criterion is based on DOE O 420.1A [DIRS 159450], Section 4.2; DOE G 440.1-5 [DIRS 144423], Section IV, Paragraph 4.0; and DOE-STD-1066-99 [DIRS 154954], Section 9, which specify the criteria for the minimum level of passive fire protection system performance to demonstrate that facility occupants and property are adequately and appropriately protected from fire hazards.]

4.9.1.17 Additional NFPA Codes and Standards

The repository shall be designed in accordance with the following fire protection codes, as appropriate:

- NFPA 10, *Standard for Portable Fire Extinguishers* [DIRS 177964],
- NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam, with Tentative Interim Amendment* [DIRS 177966],
- NFPA 110, *Standard for Emergency and Standby Power Systems* [DIRS 173511],
- NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems* [DIRS 177967],
- NFPA 13, *Standard for the Installation of Sprinkler Systems* [DIRS 177968],

- NFPA 14, *Standard for the Installation of Standpipe and Hose Systems* [DIRS 177969],
- NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection* [DIRS 177970],
- NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems* [DIRS 183087],
- NFPA 17, *Standard for Dry Chemical Extinguishing Systems* [DIRS 160951],
- NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection* [DIRS 177971],
- NFPA 2001, *Standard for Clean Agent Fire Extinguishing Systems* [DIRS 183091],
- NFPA 22, *Standard for Water Tanks for Private Fire Protection* [DIRS 165075],
- NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances* [DIRS 177972],
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* [DIRS 160952],
- NFPA 30, *Flammable and Combustible Liquids Code, with Errata* [DIRS 177974],
- NFPA 385, *Standard for Tank Vehicles for Flammable and Combustible Liquids* [DIRS 183094],
- NFPA 502, *Standard for Road Tunnels, Bridges and Other Limited Access Highways, with Errata* [DIRS 177978],
- NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work* [DIRS 166980],
- NFPA 52, *Vehicular Fuel Systems Code, with Errat*a [DIRS 177979],
- NFPA 70, *National Electrical Code, with Tentative Interim Amendment*, 2005 Edition [DIRS 177982],
- NFPA 70E, *Standard for Electrical Safety In the Workplace* [DIRS 178067],
- NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response* [DIRS 177983],
- NFPA 75, *Standard for the Protection of Information Technology Equipment, with Errata* [DIRS 177985],
- NFPA 750, *Standard on Water Mist Fire Protection Systems* [DIRS 177987],
- NFPA 780, *Standard for the Installation of Lightning Protection Systems* [DIRS 173517],
- NFPA 80, *Standard for Fire Doors and Other Opening Protectives* [DIRS 177988],
- NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems, with Errata* [DIRS 176267],
- NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems* [DIRS 177857].

[NAC 477.281.2 [DIRS 182445] documents that the State of Nevada has adopted 10, 11, 13, 13D, 13R, 14, 15, 17, 17A, 20, 22, 24, 25, 30B, 50, 50B, 52, 58, 72, 86, 90A, 90B, 96, 99, 110, 111, 140, 160, 385, 407, 409, 410, 704, 1123, 1126, 1403 and 2001 of the National Fire Codes. Engineering determined that 13D, 13R, 17A, 30B, 50, 50B, 58, 96, 99, 140, 160, 407, 409, 410, 1123, 1126, and 1403 are not applicable to design activities. NAC 459.95528 [DIRS 104042] also specifies some of these documents, but specifies earlier versions. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.9.2 Surface Heating, Ventilation, and Air Conditioning System Design Criteria

4.9.2.1 Surface HVAC Systems General Criteria

4.9.2.1.1 Codes and Standards

The following are the codes, standards, industry guides, regulatory guides, CFRs, and DOE orders and standards that could be applied in the design of the surface HVAC systems:

- *TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* (ACGIH 2006 [DIRS 180457]),
- ANSI/AMCA 210-99, *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating* [DIRS 153079],
- ANSI/ASHRAE 33-2000, *Method of Testing Forced Circulation Air Cooling and Air Heating Coils* [DIRS 169815],
- ANSI/ASHRAE 52.1-1992, *Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter* [DIRS 164197],
- ASME N509-2002,*Nuclear Power Plant Air-Cleaning Units and Components* [DIRS 176247],
- ASME N510-1989 (R 1995), *Testing of Nuclear Air Treatment Systems, with Errata* [DIRS 177879],
- *International Mechanical Code 2006* (ICC 2006 [DIRS 179998]),

- • IEEE Std 603-1998, *IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations* [DIRS 125916],
- • NFPA 90A-2005 [DIRS 176267],
- • NFPA 90B-2005 [DIRS 177857],
- • *HVAC Air Duct Leakage Test Manual* (SMACNA 1985 [DIRS 161833]),
- • *HVAC Duct Construction Standards Metal and Flexible* (SMACNA 1995 [DIRS 158927]),
- • UL-555-2006, *Fire Dampers* [DIRS 177868],
- • UL 900-2004, *Air Filter Units* [DIRS 178047],
- • NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, Draft Report for Comment* [DIRS 177328],
- • 10 CFR 73, Energy: Physical Protection of Plants and Materials [DIRS 181969],
- • 64 FR 30851, Greening the Government through Efficient Energy Management [DIRS 104026],
- • DOE O 430.2A, *Departmental Energy and Utilities Management* [DIRS 158913],
- • DOE O 450.1 Change 2, *Environmental Protection Program* [DIRS 176641],
- • DOE-STD-1027-92 Change Notice No. 1,*Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports* [DIRS 177919],

[Applicable sections of these codes, standards and industry guides will be determined during the design process and in the development of the design products. The regulatory guide have been determined to be applicable to the design of the surface nuclear confinement HVAC system. The level of conformance with the regulatory position will be determined during the design process and in the development of the design products.]

4.9.2.1.2 Type of HVAC Systems

The surface facilities of the repository shall be provided with the following HVAC systems:

1. Surface nuclear confinement HVAC system for contamination control in the potentially contaminated areas of the nuclear facilities
   a. Initial Handling Facility (IHF)
   b. Wet Handling Facility (WHF)
   c. Cask Receipt and Closure Facilities (CRCF's)
   d. Receipt Facility (RF)
   e. Low Level Waste Facility
2. Surface non-confinement HVAC system for personnel comfort and proper equipment operation in the clean and/or non-contaminated areas
   a. Non-contaminated areas of the nuclear facilities not served by the surface nuclear confinement HVAC system
   b. Emergency Diesel Generator Facility
   c. Balance of Plant Facilities (e.g., Central Control Center Facility, Administration Facility, Warehouse and Non-nuclear Receipt Facility, Security Facilities, Utility Facilities, Emergency Response Facilities, Offsite Facilities, Maintenance and Repair Facilities, and Materials and Consumable Facilities).

[The HVAC systems have been segregated based on their application to the level of potential for airborne radioactive contamination in the facilities. The interfaces of the infrastructure systems for the surface HVAC systems are shown on Repository System Codes (BSC 2007 [DIRS 182471]), Figure 2, Repository System and Facility Architecture.]

4.9.2.1.3 Ventilation Enclosures and Hoods

HVAC and mechanical design of enclosures or hoods used for abrasive blasting, grinding, buffing, polishing, or spraying shall meet the applicable requirements of 29 CFR 1910 [DIRS 177507], Section 94.

[29 CFR 1910.94 (a)-(c), including (c)(6).]

4.9.2.1.4 Engineering Controls for Asbestos, Lead, and Other Hazardous Materials

Local exhaust ventilation, or other engineering controls, shall be provided for controlling exposures to toxic and hazardous substances, such as asbestos in brakes and clutches, lead, cadmium, benzene, acrylonitrile, formaldehyde, methylenedianiline, 1,3-butadiene, and methylene chloride, where necessary.

[29 CFR 1910 [DIRS 177507], Sections 1001(f) including Appendix F, 1025, 1027, 1028, 1045, 1048, 1050, 1051, and 1052 require engineering controls to limit exposure to asbestos, lead, cadmium, benzene, acrylonitrile,

formaldehyde, methylenedianiline, 1,3-butadiene, and methylene chloride, respectively. Although not all of these substances may be currently planned (cadmium and benzene, for example), similar controls are necessary. The wet cleaning method of control is not expected to be necessary for asbestos. Hygiene facilities are not required for asbestos, lead, and cadmium as the exposures are not expected to be anywhere near the particulate exposure limit for any of these substances.]

4.9.2.1.5 HVAC Opening Protection for Vital Area Barriers

Heating ventilation-air conditioning ducts, cable tray penetrations, ventilation fans, etc. in vital area barriers should be protected by gratings or other materials so that the integrity of the barriers are not decreased. In addition, the barrier should be constructed of materials that provide delay to forced entry. Such materials should be resistant to cutting, drilling, and puncture by small hand tools or tool substitutes. The design should also ensure that safety systems are not compromised by the installation of such barriers.

[RGA REG-CRW-RG-000307, Agreement for Regulatory Guide 5.65 Rev 0, Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls [DIRS 181805] provides agreement to utilize Regulatory Guide 5.65 [DIRS 158858] in the design. Section C.1.1 of Regulatory Guide 5.65 provides a statement that specifically applies to HVAC systems. Examples of hardening techniques are described in the regulatory guide appendix. These techniques serve as guidelines for several cost-effective ways of increasing penetration resistance time without impairing the function of the penetration. Other techniques are acceptable, as long as the penetration area is hardened at least to the level of the weakest part of the barrier.]

4.9.2.1.6 Operations Rooms and CCC Habitability Evaluations

Nuclear facility operations rooms and the CCC in the Central Control Center Facility (CCCF) shall be evaluated to determine specific habitability requirements as follows:

4.9.2.1.6.1 Assessing Operations Rooms and CCC χ/Q Values

The May 9, 1997 version of the ARCON96 code, as described in Revision 1 of NUREG/CR-6331 (Ramsdell and Simonen 1997 [DIRS 164547]), is an acceptable methodology for assessing control room χ/Q values for use in event sequence radiological analyses, subject to the positions in this guide, unless unusual sitting, building arrangement, release characterization, source-receptor configuration, meteorological regimes, or terrain conditions indicate otherwise. The evaluations should be conducted in accordance with Regulatory Guide 1.194, *Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants* [DIRS 165736], with the following exceptions:

- In Section C.2, TID-14844 does not apply to the repository since the repository relies on the alternative source term methodology,
- In Sections C.3 and C.7, reference to 10 CFR 50 does not apply to the repository which is licensed per 10 CFR 63,
- Section C.6 allows the repository to make adjustments to the plume rise height and provides criteria for making the adjustment if this option is selected, and
- Section C.7 allows the repository to use experimental data in lieu of the guide methods, and
- Sections C.4 and C.5 do not apply to the repository.

[RGA REG-CRW-RG-000169, Agreement for Regulatory Guide 1.194, Rev. 0 - Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants (BSC 2007 [DIRS 181814]) provides agreement to utilize Regulatory Guide 1.194.]

4.9.2.1.6.2 Identification of Licensing Basis for Operations Rooms and CCC Habitability

Operations rooms and CCC habitability requirements (and technical specifications) should be determined and documented in accordance with Regulatory Guide 1.196, *Control Room Habitability at Light-Water Nuclear Power Reactors* [DIRS 174882], Sections C.2.1 through C.2.4 and C.2.6, with the following clarifications:

- In Section C.2.1, reference to 10 CFR 50 and 10 CFR 52 does not apply to the repository which is licensed per 10 CFR 63,
- In Section C.2.4, RG-1.195 does not apply since the repository relies on the alternative source term methodology of Regulatory Guide 1.183, *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors* [DIRS 173584] ,
- Section C.2.5 is contingent on the results of the hazardous chemical evaluation performed per Regulatory Guide 1.78, *Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release* [DIRS 161986], and

- In Section C.2.6, conditions shall be monitored, mitigating actions will be taken, and the repository shall be maintained in a safe condition (instead of controlling a reactor). RG-1.195 and TID-14844 do not apply since the repository relies on the alternative source term methodology of Regulatory Guide 1.183

[RGA REG-CRW-RG-000171,Agreement for Regulatory Guide 1.196, Rev. 1 - Control Room Habitability at Light-Water Nuclear Power Reactors (BSC 2007 [DIRS 181815]) provides agreement to utilize Regulatory Guide 1.196. REG-CRW-RG-000158, Agreement for Regulatory Guide 1.183, Rev 0 - Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors (BSC 2007 [DIRS 182773]), has adopted Regulatory Guide 1.183 with clarification to develop event sequences consequence analysis using an AST-Type method subject to the elements of Sections C.2 and Appendix B, with the need for literal compliance. RGA REG-CRW-RG-000066, Agreement for Regulatory Guide 1.78, Rev. 1 - Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release (BSC 2007 [DIRS 181950]) provides agreement to utilize Regulatory Guide 1.78.]

4.9.2.1.6.3 Habitability of a Control Room During Hazardous Chemical Release

Repository operations rooms, including the CCC, shall comply in the areas of hazard screening, risk evaluation, and control room habitability evaluation with the Regulatory Guide 1.78, Rev 1 [DIRS 161986]. Individual facility operations rooms at YMP perform the functions of control rooms and are relied upon in the YMP Emergency Plan to remain habitable during an event so that the operators can take appropriate actions to mitigate the consequences of any event.

[RGA REG-CRW-RG-000066, Agreement for Regulatory Guide 1.78, Rev. 1 - Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release (BSC 2007 [DIRS 181950]) provides agreement to utilize Regulatory Guide 1.78. "Control room" refers to YMP individual facility operations rooms. Protection Measures are contingent on the outcome of the evaluation.]

4.9.2.2 Surface Nuclear Confinement HVAC System

4.9.2.2.1 Confinement HVAC System Function

The confinement HVAC system shall provide a cascading ventilation system (supply air into areas of lesser contamination and exhaust from areas of higher level of contamination).

[This criterion supports the requirements in ANSI/ANS-57.7-1988 (R 1997) [DIRS 177851], Section 6.6.2.2.3.1, and ANSI/ANS-57.9-1992 (R 2000) [DIRS 176945], Section 6.5.1.2.3, which require that the system with high potential for contamination be designed for once-through flow (i.e., cascading flow). This criterion also supports the general requirement of 10 CFR 63.112(e)(1) [DIRS 180319], and 10 CFR 63.111(a)(1), which requires the GROA to meet the requirements of 10 CFR 20 [DIRS 181962].]

4.9.2.2.2 Air Flow Direction

The confinement HVAC system shall maintain a controlled airflow path directed from areas of low potential for radioactive contamination to areas of higher potential for radioactive contamination. This limits the spread or releases of those airborne radioactive materials and helps to reduce the potential for cross-contamination between areas within the confines of the waste handling facilities.

[This criterion is based on the general requirement of ASHRAE DG-1-93, Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities [DIRS 124644], Figure 1-1, and in accordance with ANSI/ANS-57.7-1988 (R 1997) [DIRS 177851], Section 6.6.2.1.2, and ANSI/ANS-57.9-1992 (R 2000) [DIRS 176945], Section 6.5.1.1.3.]

4.9.2.2.3 System Interface

The confinement HVAC system shall be designed such that the confinement and non-confinement areas ventilation systems are separate and independent from each other.

[This criterion is a general requirement for designing the ventilation system based on the level of potential for airborne radioactive contamination in accordance with the guidance provided in ANSI/ANS-57.7-1988 (R 1997) [DIRS 177851], Section 6.6, and ANSI/ANS-57.9-1992 (R 2000) [DIRS 176945], Section 6.5, to reduce the potential for cross contamination within the facility.]

4.9.2.2.4 Confinement Zoning

The confinement HVAC system shall, in conjunction with physical barriers, divide and arrange the waste processing facilities into prescribed contamination confinement compartments based on their level of, or potential for, airborne radioactive or hazardous contamination. The confinement zoning shall also be based on the Classification of Contamination Zones as shown in Section 4.10.3.7, Table 4.10.3-2.

[This criterion is in accordance with ASHRAE DG-1-93 [DIRS 124644], Section 1; and DOE-HDBK-1169-2003, Nuclear Air Cleaning Handbook [DIRS 167097], Chapter 2.]

4.9.2.2.5 Confinement Differential Pressures

The confinement HVAC system shall maintain the differential pressures between the prescribed contamination confinement areas of the facilities in accordance with ASHRAE DG-1-93 [DIRS 124644], Sections 1 and 2, and DOE HDBK-1169-2003 [DIRS 167097], Chapter 2.

[The confinement zone classifications, definitions, and pressure requirements described in ASHRAE DG-1-93 are also similarly described in DOE HDBK-1169-2003.]

4.9.2.2.6 HEPA Filter Plenum

The exhaust HEPA filter plenums shall be provided with the required stages of HEPA filters with a removal efficiency of 99.97 percent on particles measuring 0.3 micrometer or larger and 90% ASHRAE prefilters. If applicable, a demisters shall be provided for ITS HEPA filter plenum if fire protection spray system is used as determined by the Fire Hazard Analysis. The maximum size of an exhaust HEPA filter plenum shall be limited to 30,000 cfm in accordance with the guidance provided in DOE HDBK-1169-2003 [DIRS 167097], Chapter 2, Section 2.7.2.1, Regulatory Guide 1.52, *Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants* [DIRS 171692]), Paragraph 3.6; and Regulatory Guide 1.140, *Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants* [DIRS 158855]), Paragraph 3.2.

[RGA REG-CRW-RG-000043,Agreement for Regulatory Guide 1.52, Rev. 3 - Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants (BSC 2007 [DIRS 182079]) and REG-CRW-RG-000118, Agreement for Regulatory Guide 1.140, Rev. 2 - Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants (BSC 2007 [DIRS 181751]) has provided guidance for Regulatory Guide 1.52 and Regulatory Guide 1.140, respectively. The HEPA filter used in nuclear facilities is defined in ASME AG-1a-2004, Addenda to ASME AG-1-2003, Code on Nuclear Air and Gas Treatment [DIRS 177029], Section FC, as filters that exhibit a minimum efficiency of 99.97 percent when tested with an aerosol of essentially monodispersed 0.3 micrometer diameter test aerosol particles.]

4.9.2.2.7 HEPA Filter Sizing

HEPA filter sizing shall be in accordance with DOE-STD-3022-98, *DOE HEPA Filter Test Program* [DIRS 158616]; DOE-STD-3020-2005, *Specification for HEPA Filters Used by DOE Contractors* [DIRS 177923], Table 1; and ASME AG-1a-2004 [DIRS 177029], Table FC-4110. Each HEPA filter shall be 24 in. by 24 in. by 11½ in. with an airflow capacity between 1,000 cfm to 2,000 cfm at a maximum clean filter resistance of 1.3-in. wg. The HEPA filters shall have a UL label indicating full compliance with UL 586-2004, *High-Efficiency, Particulate, Air Filter Units* [DIRS 178045].

[The HEPA filter size is based on the standard sizes that are generally used in the nuclear industry. The maximum size of the HEPA filter plenum is based on DOE-HDBK-1169-2003 [DIRS 167097], Section 4.4.11. DOE-STD-3022-98 is appropriate DOE design guidance.]

4.9.2.2.8 HEPA Filter Protection

The ITS exhaust HEPA filter plenums in the confinement HVAC system shall be provided with a deluge fire suppression system if determined to be required by the fire hazard analysis. The deluge suppression system will prevent combustion products (e.g., burning embers, superheated air) entrained in the system from damaging the filter media and causing a possible release of airborne radioactive material.

[DOE-STD-1066-99 [DIRS 154954], Section 14.8]

4.9.2.2.9 HEPA Filter for Recirculation System

The confinement HVAC system design utilizing a recirculation system for any contamination confinement area shall include at least one stage of HEPA filters.

[This criterion is based on ANSI/ANS-57.7-1988 (R 1997) [DIRS 177851], Section 6.6.2.2.2.2, and ANSI/ANS-57.9-1992 (R 2000) [DIRS 176945], Section 6.5.1.2.2(2), which require filtration of the recirculated air through a HEPA filter unit to prevent buildup of radioactive particulate in the air.]

4.9.2.2.10 Facility Ventilation Exhaust

The confinement HVAC system exhaust shall be provided with elevated release through exhaust duct or stack in accordance with the guidance provided in *2007 ASHRAE Handbook, Heating, Ventilating, and Air-Conditioning Applications* (ASHRAE 2007 [DIRS 182903], Chapter 44). The exhaust duct or stack shall be located to prevent recirculation of exhaust effluents to any of the facilities air intake. The discharge (exit) velocity through the exhaust duct or stack shall be in accordance with the recommendation of *DOE-HDBK-1169-2003 [DIRS 167097]*.

[DOE-HDBK-1169-2003, Section 5.5 describes the facility exhaust system and the minimum velocity criteria.]

4.9.2.2.11 Exhaust Monitoring

The confinement HVAC system exhaust shall be provided with continuous air emission monitoring system in accordance with ANSI/HPS N13.1-1999, *American National Standard Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities* [DIRS 152380].

[This criterion is based on 40 CFR 61.93(c), Protection of Environment: National Emission Standards for Hazardous Air Pollutants [DIRS 177522]. This criterion ensures that the facility workers are forewarned of unsafe system conditions.]

4.9.2.2.12 Contaminated Ductwork and HVAC Design

Ductwork conveying air that is potentially contaminated with airborne radioactive contaminants shall be designed to minimize accumulation or trapping of such contaminants, and shall be provided with access doors or hatches at strategic and accessible locations. The HVAC units shall be designed to maintain ALARA during operation and maintenance in accordance with Section 3.10 of Regulatory Guide 1.52 [DIRS 171692]) and Section 3.4 of Regulatory Guide 1.140 [DIRS 158855].

[This criterion is based on the guidance provided in DOE-HDBK-1169-2003 (DOE 2003 [DIRS 167097]), Section 2.3.8. RGA REG-CRW-RG-000043 (BSC 2007 [DIRS 182079]) has provided guidance for Regulatory Guide 1.52. RGA REG-CRW-RG-000181 (BSC 2007 [DIRS 181751]) has provided guidance for Regulatory Guide 1.140.]

4.9.2.2.13 Controls and Instrumentation

The confinement HVAC system shall be provided with all the necessary instrumentation and control hardware in accordance with the recommendation of DOE-HDBK-1169-2003 (DOE 2003 [DIRS 167097]), Section 5.6 and ASME AG-1a-2004 (ASME 2004 [DIRS 177029]), Section IA, non-mandatory Appendix IA-C, Section 3.3 of Regulatory Guide 1.140 [DIRS 158855] and Section 3.7 of Regulatory Guide 1.52 [DIRS 171692].

[This criterion provide means to control, monitor, and limit the spread or release of radioactive contaminants. It facilitates prompt termination of operations and permits an evacuation of personnel during an emergency. RGA REG-CRW-RG-000043 (BSC 2007 [DIRS 182079]) has provided guidance for Regulatory Guide 1.52. RGA REG-CRW-RG-000118 (BSC 2007 [DIRS 181751]) has provided guidance for Regulatory Guide 1.140.]

4.9.2.2.14 Reliability and Redundancy

The ITS nuclear confinement HVAC system and components shall be provided with redundant units to ensure continued operation in the event of a failure of any of its components during normal operation, an event sequence, or maintenance, specifically those systems that provide cooling to the ITS equipment in accordance with sections 3.1, 3.2, 3.10 and 5 of Regulatory Guide 1.52 [DIRS 171692]. The ITS battery rooms shall be provided with redundant exhaust fans.

[NRC Regulatory Guide 1.53 [DIRS 171817] and IEEE Std-379-2000 [DIRS 166688]. This criterion supports the requirement of ASHRAE DG-1-93 [DIRS 124644], Section 9, to ensure that the system is capable of operating

continuously to protect the personnel from airborne radioactivity. RGA REG-CRW-RG-000043 [DIRS 182079] has provided guidance for Regulatory Guide 1.52. RGA REG-CRW-RG-000044, Agreement for Regulatory Guide 1.53, Rev. 2 - Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems (BSC 2007 [DIRS 181680]), which endorses Regulatory Guide 1.53, Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems [DIRS 171817].]

4.9.2.2.15 Design Basis Tornado

The ITS HVAC system shall comply with Regulatory Guide 1.117, *Tornado Design Classification*, [DIRS 144751] to protect the system and components from tornado generated missiles and sudden depressurization.

[RGA REG-CRW-RG-000098 (BSC 2007 [181701]) has adopted Regulatory Guide 1.117 with clarification. Regulatory Guide 1.117 has historically been used to define system functions.]

4.9.2.2.16 Fire Protection

Fire dampers shall not be installed for duct systems exhausting from potentially contaminated areas in accordance with ASHRAE 2007 [DIRS 182903], Chapter 26 (Page 26.5).

[Exclusion of fire dampers is to maintain continuous exhaust airflow in duct system for the potentially contaminated areas.]

4.9.2.2.17 HEPA Filter In-Place Testing

The confinement HVAC system exhaust HEPA filter units shall be designed, constructed, and tested in accordance with the applicable requirements of ASME AG-1a-2004 [DIRS 177029]. The in-place testing of the HEPA filters shall be in accordance with guidance provided in Regulatory Guide 1.52 [DIRS 171692] for ITS exhaust system and Regulatory Guide 1.140 [DIRS 158855] for non-ITS exhaust system.

[RGA REG-CRW-RG-000043 (BSC 2007 [DIRS 182079]) and REG-CRW-RG-000118 (BSC 2007 [DIRS 181751]) adopted Regulatory Guide 1.52 and Regulatory Guide 1.140, respectively, with clarification. This criteria supports the in-place testing requirements of these Regulatory Guides.]

4.9.2.2.18 Filter Test Program

HEPA filters shall be tested in accordance with a program that complies with DOE-STD-3022-98, *DOE HEPA Filter Test Program*, [DIRS 158616].

[This DOE standard provides guidance in the performance acceptance testing of HEPA filters prior to installation in a DOE nuclear facility.]

4.9.2.2.19 Equipment Environmental Qualification

The ITS confinement HVAC system components shall be designed and environmentally qualified in accordance with IEEE Std 323-2003 [DIRS 166907], endorsed by Regulatory Guide 1.89 [DIRS 102609]. Regulatory Guide 1.52 [DIRS 171692), Sections C.2, C.3.5, and C.3.8 requires ITS components to be environmentally qualified within environmental limits established for their location, including, but not limited to, temperature, humidity, and radiation levels.

[These regulatory guides provide appropriate guidance for environmental qualification of ITS equipment. RGA REG-CRW-RG-000074 (BSC 2007 [DIRS 181952]) has adopted Regulatory Guide 1.89 with clarification that IEEE Std 323-2003 be used instead of IEEE Std 1974. RGA REG-CRW-RG-000043 (BSC 2007 [DIRS 182079]) has provided guidance for Regulatory Guide 1.52.]

4.9.2.2.20 Seismic Qualification

The ITS surface nuclear confinement HVAC systems shall be seismically qualified in accordance with IEEE Std 344 - 2004 (IEEE 2004 [DIRS 176259]) , using YMP site specific DBGM, to comply with the guidance provided in Regulatory Guide 1.100 [DIRS 110810]).

[RGA REG-CRW-RG-000084, Agreement for Regulatory Guide 1.100, Rev. 2 - Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants (BSC 2007 [DIRS 181689]) has provided guidance for Regulatory Guide 1.100. This regulatory guide describes a methodology acceptable to the NRC staff for satisfying NRC regulations pertaining to the seismic qualification of electrical and mechanical equipment.]

4.9.2.2.21 HVAC Equipment Fire Protection

HVAC systems shall be designed to limit consequences of fire in accordance with Regulatory Guide 1.189 [DIRS 155040] Section C4.1.4.

[RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) has adopted RG 1.189.]

4.9.2.3 General Criteria for Surface Nuclear Confinement and Non-Confinement HVAC Systems

4.9.2.3.1 Outdoor Design Condition

Surface HVAC systems shall be designed based on the meteorological outdoor design conditions as found in Tables 1A and 1B of *2005 ASHRAE Fundamentals Handbook* (ASHRAE 2001 [DIRS 157789], for Mercury, Nevada, or based on the meteorological data collected at the Yucca Mountain site. From Tables 1A and 1B of the ASHRAE handbook, the conditions under the following annual percentile values shall be used:

- For the confinement and sensitive areas: 0.4% cooling, 99.6% heating
- For the non-confinement areas or personnel comfort: 1.0% cooling, 99.0% heating.

The surface HVAC system shall be designed considering the air in-leakage to the surface facilities based on a sustained wind speed of 40 mph, or 15 second gusts of wind speed higher than 40 mph to a maximum wind speed of 90 mph.

[This criterion establishes the outdoor environmental conditions to be used in the heating and cooling load calculations and establishes a temperature range in which the system components are expected to operate. The selection of Mercury, Nevada, as the representative site is appropriate due to its close proximity to the North Portal area, as opposed to Elko and Las Vegas. The Mercury ambient tables of conditions were eliminated from the 2005 version of the ASHRAE handbook, thus requiring use of the 2001 version. Additional data may be obtained from qualified sources to implement the requirement of the Energy Conservation Program.

The wind criteria is provided for the purpose of determining the surface facilities in-leakage. The sustained wind speed of 40 mph is based on Table 1A of 2001 ASHRAE Fundamentals Handbook, for extreme wind speed at 1% occurrence for Mercury, Nevada at 25 mph. A safety factor of 50% is used for conservatism resulting in 37.5 mph sustained wind conditions, and rounded off to 40 mph. The North Portal Basic Wind Speed Calculation (BSC 2006 [DIRS 178591, Section 7) provides a 3 seconds gust wind of 90 mph expected at North Portal areas. A safety factor of 5 times is used for the 3 seconds gust wind speed of 90 mph resulting in 15 seconds gusts. Finally, a 40 mph sustained wind condition or a maximum of a 15 second gust of 90 mph is used in the air in-leakage estimate.]

4.9.2.3.2 Indoor Design Condition

Surface HVAC systems shall maintain an indoor environmental condition in accordance with:

- ANSI/ASHRAE Std 55-2004, *Thermal Environmental Conditions for Human Occupancy* [DIRS 174322]
- *2005 ASHRAE® Handbook, Fundamentals* (ASHRAE 2005 [DIRS 174692]), Chapter 8
- *2007 ASHRAE® Handbook, Heating, Ventilating, and Air-Conditioning Applications*, (ASHRAE 2007 [DIRS 182903]), Chapter 17 and 25)
- ANSI/ANS-57.7-1988 (R 1997), *American National Standard, Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)* [DIRS 177851] Appendix E
- *Industrial Ventilation, A Manual of Recommended Practices* (ACGIH 2004 [DIRS 176297])
- *TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* (ACGIH 2006 [DIRS 180457]).

[This criterion is to provide appropriate thermal environmental conditions for human occupancy and the safety, health, and comfort of facility workers, as well as proper operation of SSCs. Although this criterion previously referenced 10 CFR 434, it has been replaced by 10 CFR 433 [DIRS 181833].]

4.9.2.3.3 Outdoor Air Requirement

Surface HVAC systems utilizing the recirculation system for normally occupied confinement and non-confinement areas shall be designed to provide the required quantity of outdoor air in accordance with ANSI/ASHRAE 62.1-2004, *Ventilation for Acceptable Indoor Air Quality* [DIRS 174320].

[The criterion is to maintain proper indoor air quality for the safety, comfort, and health of the occupational

workers in the normally occupied areas of the facilities. Although a later version of ANSI/ASHRAE 62.1 is available, the responsible DEM has elected to utilize the referenced version.]

4.9.2.3.4 Outdoor Air Filtration

Surface HVAC systems shall be designed to provide for filtration of inlet (outdoor) air to prevent the accumulation of dust or other particulate matter in the facility.

[This criterion is in accordance with ANSI/ANS-57.7-1988 (R 1997) [DIRS 177851], Section 6.6.2.1.1; ANSI/ANS-57.9-1992 (R 2000) [DIRS 176945], Section 6.5.1.1.2; and DOE-HDBK-1169-2003 [DIRS 167097], which emphasizes the importance of protecting the supply air from the environmental elements.]

4.9.2.3.5 HVAC Systems Air Handling Units Components

The surface HVAC system air handling units, serving the confinement and the occupied areas of the facilities, shall be equipped with prefilters and high-efficiency filters, and as required, heating coils, cooling coils, and humidifiers to condition the supply air to these areas. The prefilters (25 - 40%) and high efficiency filters (80 - 95%) shall be as recommended in *2004 ASHRAE Handbook, Systems and Equipment* (ASHRAE 2004 [DIRS 171799], Chapter 24, Table 2). The recommended sizing criteria for the filters and coils shall be as described in *2005 ASHRAE Handbook, Fundamentals* (ASHRAE 2005 [DIRS 174692], Chapter 35, Table 10). The cooling coils and heating coils shall be in accordance with ARI Std 410-2002, *Forced-Circulation Air-Cooling and Air-Heating Coils, with Addendum* [DIRS 164310]. The efficiency of the prefilters and high-efficiency filters shall be confirmed in accordance with ANSI/ASHRAE 52.1-1992, *Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter* [DIRS 164197].

[This criterion is to ensure that the indoor design environmental conditions are met for the health and safety of the facility workers.]

4.9.2.3.6 Energy Conservation

Surface nuclear confinement and surface non-confinement HVAC systems and equipment shall be designed in accordance with ANSI/ASHRAE/IESNA Std 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [DIRS 174321], Section 6.

[Although this criterion previously referenced 10 CFR 434, it has been replaced by 10 CFR 433 [DIRS 181833], which directly imposes ANSI/ASHRAE/IESNA Std 90.1-2004.]

4.9.2.3.7 Fire Protection

Surface HVAC system designs shall conform to the requirements or recommendation of NFPA 90A-2005, *Standard for the Installation of Air-Conditioning and Ventilating Systems, with Errata* [DIRS 176267]; and NFPA 801-2003, *Standard for Fire Protection for Facilities Handling Radioactive Materials* [DIRS 165077]. The surface HVAC system ductwork penetrating a fire barrier shall be equipped with fire and smoke dampers, where appropriate, except for duct systems exhausting from potentially contaminated areas.

[This criterion is in accordance with the criteria specified in Section 4.9.1, Fire Protection Design Criteria. Exclusion of fire dampers in exhaust ducts for potentially contaminated areas is in accordance with ASHRAE 2007 [DIRS 182903], Chapter 26.]

4.9.2.3.8 ALARA

Surface HVAC system configurations shall be designed to ensure that occupational doses are ALARA to maintain radiation doses to all occupational workers to below regulatory limits in accordance with the applicable guidelines of Regulatory Guide 8.8 [DIRS 103312] and 10 CFR 20 [DIRS 181962].

[This criterion ensures the continuous operation and readiness of the system to perform its safety function while achieving the occupational ALARA goals during the planning, design, and maintenance and operations phases. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.9.2.3.9 Personnel Protection

Surface HVAC system designs shall include environmental, safety, and health requirements related to personnel safety and OSHA considerations. Included are considerations to minimize noise and confined spaces that may compromise work during component installation, maintenance, and/or replacement. This also ensures that all rotating equipment or moving parts are adequately provided with safety enclosures, guardrails or safety screens, safety disconnect switches, and lighting to protect personnel from accidentally getting caught in the rotating machine during all system operating or maintenance modes.

[This criterion supports the applicable requirements of 29 CFR 1910 [DIRS 177507] and DOE-HDBK-1169-2003 [DIRS 167097], Chapter 11.]

4.9.2.3.10 Testing and Balancing

Surface HVAC systems shall be tested, balanced, and adjusted in accordance with ASHRAE 111-1988, *Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems, with Errata* [DIRS 169817].

[The criteria is based on the guidance provided in 2007 ASHRAE Handbook, Heating, Ventilating, and Air-Conditioning Applications (ASHRAE 2007 [DIRS 182903], Chapter 37) and ANSI/ASHRAE/IESNA Std 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings [DIRS 174321], Section 6.7, which is endorsed by 10 CFR 433.4 [DIRS 181833].]

4.9.2.3.11 As-Built Drawings

Construction documents shall require that within 90 days after the date of system acceptance, record drawings of the actual installation be provided to the Federal agency. The drawings shall include details of the air barrier installation in every envelope component, demonstrating continuity of the air barrier (barrier to prevent air leakage through the building envelope) at all joints and penetrations.

[ANSI/ASHRAE/IESNA Std 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings [DIRS 174321], Section 6.7, which is endorsed by 10 CFR 433.4 [DIRS 181833].]

4.9.2.3.12 Procurement Specification

Procurement specifications shall identify vendor submission of operating and maintenance manuals to be provided to the Federal Agency. The manual shall include, at a minimum, the following:

1. Submittal data shall state equipment size and selected options for each piece of equipment requiring maintenance, including assumptions used in outdoor design calculations.
2. Operating and maintenance manuals for each piece of equipment requiring maintenance. Required maintenance activity shall be specified.
3. Names and addresses of at least one qualified service agency to perform the required periodic maintenance shall be provided.
4. HVAC controls systems maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field determined setpoints shall be permanently recorded on control drawings, at control devices, or, for digital control systems, in programming comments.
5. A complete narrative, prepared by the designer, of how each system is intended to operate shall be included with the Engineering Design Documents.

[ANSI/ASHRAE/IESNA Std 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings [DIRS 174321], Section 6.7, which is endorsed by 10 CFR 433.4 [DIRS 181833].]

4.9.2.3.13 CCC HVAC

The CCC ventilation system shall function in a manner comparable to the control room ventilation system. The CCC ventilation system need not be seismically qualified, redundant, instrumented in the control room, or automatically activated to fulfill its role. A CCC ventilation system that includes high-efficiency particulate air (HEPA) and charcoal filters is needed, as a minimum.

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 2.6 defines specific HVAC requirements of the CCC. The agreement defining the applicability of General Design Criterion 19, Standard Review Plan 6.4, and NUREG-0737 referenced in section 2.6, and the referenced Regulatory Guides included in them, associated with nuclear power plant control room habitability have not yet been approved. Therefore, the application of these guides to the habitability of the repository operations rooms and the CCC cannot be specified at this time.]

4.9.2.3.14 EOC HVAC

The HVAC system shall function in a manner comparable to the CCC HVAC system. The HVAC system shall provide for isolation of the EOC and be provided with HEPA filters (no charcoal).

[RGA REG-CRW-RG-000455 (BSC 2007 [DIRS 181426]) has adopted NUREG-0696 (NRC 1981 [DIRS 104098]) with clarification. NUREG-0696 Section 4.2 provides for the functions being performed by the facilities and systems and their requirements. Although the CBCN017 to PDC Revision 6 identified criterion location 4.9.2.3.15, this is the next subsection number.]

4.9.3 Subsurface Ventilation Design Criteria

4.9.3.1 Monitoring Program

Subsurface ventilation monitoring shall be implemented so that it provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities, and monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a repository.

[This is to ensure that the subsurface ventilation system includes interface with general requirements of the monitoring program. 10 CFR 63.131d [DIRS 180319], 2 and 3.]

4.9.3.2 Contaminant Control

Whenever hazardous substances such as dusts, fumes, mists, vapors, or gases exist or are produced in the course of construction work, their concentrations shall not exceed the limits specified in *TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* (ACGIH 2006 [DIRS 180457]). When ventilation is used as an engineering control method, the system shall be installed and operated according to the requirements of this section. This shall be feasibly accomplished by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to this section.

[This is to limit the concentration of hazardous substances and to provide acceptable working environmental conditions. Use of TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices is required by DOE O 440.1A [DIRS 102288], Section 4.1(1). In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective is to prevent breathing atmosphere contamination.]

4.9.3.3 Threshold Limit Value Limits

Employee exposure to inhalation, ingestion, skin absorption, or contact with any material or substance at a concentration above those specified in (ACGIH 2006 [DIRS 180457]), shall be avoided.

[This requirement protects the employees' health. Air pollutants may not be vented from the underground facilities without control if such a release will exceed any of the National Ambient Air Quality Standards for carbon monoxide, lead, nitrogen dioxide, ozone, sulfuroxides, and particulate matter in accordance with 40 CFR 50 [DIRS 177844] and DOE O 440.1A [DIRS 102288], Section 4.1(1).]

4.9.3.4 Underground Construction Ventilation Design Parameters

1. Ventilation—Fresh air shall be supplied to all underground work areas in sufficient quantities by means of mechanical ventilation, except when the employer can demonstrate that natural ventilation provides the necessary air quality through sufficient air volume and airflow. The direction of mechanical air flow shall be reversible.
2. Ventilation Volume Per Employee—A minimum of 200 cu ft/min of fresh air shall be supplied for each employee underground.
3. Drift Velocity—The linear velocity of air flow in the tunnel bore, shafts, and all other underground work areas shall be at least 30 ft/min where blasting or rock drilling is conducted or where other conditions likely to produce dust, fumes, mists, vapors, or gases in harmful or explosive quantities are present.
4. Blast Fume Clearing—Following blasting, ventilation systems shall exhaust smoke and fumes to the outside atmosphere before work is resumed in affected areas.
5. Ventilation Door Design—Ventilation doors shall be designed and installed so that they remain closed when not in use, regardless of the direction of the airflow.

6. Dust Control—When drilling rock or concrete, appropriate dust control measures shall be taken to maintain dust levels within limits set in the recent edition of (ACGIH 2006 [DIRS 180457]). Such measures may include, but are not limited to, wet drilling, the use of vacuum collectors, and water mix spray systems. Dust shall be controlled at muck piles, material transfer points, crushers, and on haulage roads where hazards to persons would be created as a result of impaired visibility.
7. Diesel Use—Internal combustion engines, except diesel-powered engines on mobile equipment, are prohibited underground: "Mobile diesel-powered equipment used underground in atmospheres other than gassy operations shall be either approved by the Federal Mine Safety and Health Act of 1977 (MSHA) [DIRS 131950] or demonstrated by the employer to be fully equivalent to such MSHA-approved equipment, and shall be operated in accordance with that part. Each brake horsepower of a diesel engine requires at least 100 cu ft/min of air for suitable operation in addition to the air requirements for personnel. Some engines may require a greater amount of air to ensure that the allowable levels of carbon monoxide, nitric oxide, and nitrogen dioxide are not exceeded."

[This criterion provides air quality standards and general ventilation requirements for the construction work area. The emplacement area is regulated by the NRC and does not require the reversibility of the ventilation system. The construction area will have reversibility in ventilation, as necessary, to comply with OSHA standards, 29 CFR 1926.800 [DIRS 177634]. Diesel use underground is restricted per 29 CFR 1926.800(k)(10) [DIRS 177634], 30 CFR 57 [DIRS 177661],and 30 CFR 36 [DIRS 177830].]

4.9.3.5 Underground Fan Installations

1. Fan houses, fan bulkheads for main and booster fans, and air ducts connecting main fans to underground openings shall be constructed of noncombustible materials.
2. Areas within 100 ft (30.5 m) of underground access openings shall be free from stored flammable or combustible materials.
3. When auxiliary fan systems are used, such systems shall minimize recirculation and be maintained to provide ventilation air that effectively sweeps the working places.
4. Primary or auxiliary fans are provided with appropriate design features and procedures responsive to a fan shutdown or failure to maintain maximum utilization of the ventilation system.

[This is to provide general guidance for underground ventilation fan installations, provided for in 29 CFR 1926.800(m) [DIRS 177634]]

4.9.3.6 Underground Shops

To confine or prevent the spread of toxic gases from a fire originating in an underground shop where maintenance work is routinely done on mobile equipment, one of the following measures shall be taken: use of control doors or bulkheads, routing of the mine shop air directly to an exhaust system, reversal of mechanical ventilation, or use of an automatic fire suppression system in conjunction with an alternate escape route. The alternative used shall at all times provide at least the same degree of safety as control doors or bulkheads.

[This is to provide general guidance for ventilation fan installations. The alternate measures and decision regarding the use of an automatic fire suppression system in conjunction with an alternate escape route shall be made by the Fire Protection Engineering Group.]

4.9.3.7 Radon Annual Exposure Limits

No person shall be permitted to receive a Rn-222 exposure in excess of 4 working level months in any calendar year.

[This is to limit the annual radon exposure and is provided in 29 CFR 1910.1096 [DIRS 177507].]

4.9.3.8 Diesel Particulate Regulations

Mobile diesel-powered equipment used underground in atmospheres other than gassy operations shall be either approved by MSHA or demonstrated by the employer to be fully equivalent to such MSHA-approved equipment and shall be operated in accordance with 29 CFR 1926.800(k)(10)(ii) [DIRS 177634].

[This is to provide a basis for limiting worker exposure to the emissions from diesel equipment if used in the subsurface facility.]

4.9.3.9 Construction, Maintenance, and Use of Ventilation Doors

Ventilation doors shall be:

1. Substantially constructed
2. Fire rated as required by the fire hazards analysis (Section 4.9.1.6)
3. Maintained in good condition
4. Self-closing, if manually operated
5. Equipped with audible or visual warning devices, if mechanically operated.

When ventilation control doors are opened or controlled, they shall be repositioned as soon as possible to reestablish normal ventilation to working places as identified in ventilation models.

Ventilation control measures shall be designed effectively in conjunction with:

1. Control doors
2. Mechanical ventilation reversal (Section 4.9.3.4)
3. Evacuation.

[This is to provide general guidance for the design, maintenance, and operation of ventilation doors.]

4.9.3.10 Ventilation Barriers

Subsurface ventilation barriers shall be designed to regulate air leakage from subsurface zones of low potential for contamination to zones of higher potential for contamination.

[This is to provide a basis for development of ventilation network modeling and planning for various operating stages.]

4.9.3.11 Isolation Features

Subsurface ventilation systems and components shall have engineered features to prevent leakage of ventilation air from the emplacement area to the development area normally occupied by personnel in accordance with Regulatory Guide 3.18, *Confinement Barriers and Systems for Fuel Reprocessing Plants* [DIRS 158804].

[This is to protect workers in the development area from potential contamination of the emplacement area during simultaneous repository development and waste emplacement operations. RGA REG-CRW-RG-000201,Agreement for Regulatory Guide 3.18, Revision 0 - Confinement Barriers and Systems for Fuel Reprocessing Plants (BSC 2007 [DIRS 181817]) has adopted Regulatory Guide 3.18.]

4.9.3.12 Human Engineering

Subsurface ventilation design shall utilize, where necessary and applicable, MIL-STD-1472F, *Department of Defense Design Criteria Standard, Human Engineering* [DIRS 170418], Notice 1, .

[This standard establishes general human engineering criteria for the design of systems, equipment, and facilities to (1) achieve required performance by operator, control, and maintenance personnel; (2) minimize skill and personnel requirements and training time; (3) achieve required reliability of personnel-equipment/software combinations; and (4) foster a design standardization within and among systems.]

4.9.3.13 Structures

Subsurface ventilation related structures shall interface with subsurface structural design and use *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525], wherever applicable.

[This is to ensure the integration of appropriate structural codes and standards in structural designs that affect subsurface ventilation.]

4.9.3.14 System Availability

Equipment in the subsurface ventilation system shall be designed with an availability of 0.9825 (about 359 days per year).

[The requirement ensures the availability of the subsurface ventilation system and is based on engineering judgment consistent with industry operating experience.]

4.9.3.15 Additional Codes and Standards

Subsurface ventilation shall also follow ACI 349-01/349R-01, *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01) and Commentary (ACI 349R-01)* [DIRS 181670], and *The Electrical Engineering Handbook* (Dorf 1993 [DIRS 125707]).

[These documents have been determined to be applicable to the design of the subsurface ventilation system.]

4.9.3.16 HVAC Equipment Fire Protection

Subsurface ventilation system shall be designed to limit consequences of fire in accordance with Regulatory Guide 1.189 [DIRS 155040] Section C4.1.4.

[Regulatory Guidance Agreement REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189 with clarification.]

4.9.4 Site-Generated Radioactive Waste Management Design Criteria

4.9.4.1 Site-Generated Radioactive Waste Management Codes and Standards

4.9.4.1.1 SSC Design Code

LLW management system SSCs shall be designed in accordance with *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]).

[This is the general industry standard for SSC design and construction.]

4.9.4.1.2 LLW Classification

LLW SSCs shall be classified as described in Regulatory Position 5 and designed in accordance with Regulatory Position 6 of Regulatory Guide 1.143, *Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants* [DIRS 157566]).

[This criterion is required to comply with 10 CFR 20 [DIRS 181962]. It presents the position on design of LLW treatment facilities for light water reactor (LWR) plants, which should be an acceptable approach for this LLW management system. RGA REG-CRW-RG-000121, Agreement for Regulatory Guide 1.143, Rev. 2 - Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in Table 1(excluding footnotes) of the guide.]

4.9.4.1.3 Minimize Generation of LLW

LLW processing systems and equipment shall consider minimizing the generation of LLW streams prior to recycling, treatment, and disposal.

[63 FR 49643, Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition, Executive Order 13101 [DIRS 104024]) requires, whenever feasible and cost effective, pollution prevention through source reduction prior to recycling, treatment, or disposal. This is required to be consistent with the demands of efficiency and cost effectiveness.]

4.9.4.1.4 Process Equipment Design

LLW management system process equipment shall be designed and tested to the requirements set forth in the codes and standards identified in Regulatory Guide 1.143 [DIRS 157566], Table 1.

[This criterion establishes design requirements for LLW process equipment. In addition, pipelines and auxiliary facilities necessary to transfer high activity or high hazard LLW to contingency storage will be maintained in an operational condition when waste is present. (NOTE: Table 1 in Regulatory Guide 1.143 [DIRS 157566] shows API Std 620 [DIRS 176388] and API Std 650 [DIRS 171925] reversed.) RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1(excluding footnotes) of the guide.]

4.9.4.1.5 Waste Volume

The LLW management system shall be designed in accordance with ANSI/ANS-55.1-1992 (R 2000) [DIRS 177848] to accommodate waste volumes generated during normal operation as well as those from anticipated maintenance activities. In addition, the system should accommodate solid LLW input for a reasonable period of time when normal shipment of packaged solid LLW from the plant is not possible (i.e., up to 30 days of anticipated normal waste generation).

[This criterion is in accordance with ANSI/ANS-55.1-1992 (R 2000) Paragraph 8.1, that defines a basis for sizing the LLW management system and provides for a contingency storage capacity.]

4.9.4.1.6 Control of Liquid Releases

LLW management system for site-generated LLW shall be designed and constructed to meet the guidance in Regulatory Guide 1.143 [DIRS 157566].

[This criterion is required to facilitate compliance with design guidance acceptable to the NRC in regard to mitigating event sequences and controlling releases of liquids containing radioactive materials (e.g., spills or tank overflows). RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1(excluding footnotes) of the guide.]

4.9.4.1.7 Seismic Criteria

Solid LLW management system equipment shall not be required to be designed to withstand the effects of a seismic event.

[This criterion reflects the NRC position on the seismic design of LLW treatment facilities for LWR plants, which should be an acceptable approach for this system. This is provided for in ANSI/ANS-55.1-1992 (R 2000) [DIRS 177848], Paragraph 4.2.2.1.]

4.9.4.1.8 Building Criteria

The foundation and walls up to the spill height of the buildings housing LLW management systems shall be designed to the criteria specified in Regulatory Guide 1.143 [DIRS 157566], Paragraph 6.2.

[This criterion reflects the NRC position on the seismic design of the buildings housing LLW management systems for LWR plants, which should be an acceptable approach for this system. RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has adopted Regulatory Guide 1.143 with clarification to use the codes and standards listed in the Table 1(excluding footnotes) of the guide.]

4.9.4.1.9 Component Requirement

The SSCs of the solid LLW management system shall be designed and tested to the requirements set forth in the codes and standards listed in Regulatory Guide 1.143 [DIRS 157566], Paragraph 3.1.

[This criterion is required to establish a set of accepted codes and standards for the design, construction, materials, welder and welding procedure qualification, and inspection and testing for various categories of mechanical equipment utilized in the LLW management system. RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1 (excluding footnotes) of the guide.]

4.9.4.1.10 Material Requirement

Materials for pressure related components, excluding HVAC ducts and fire protection piping, shall conform to the requirements of the specifications for materials listed in Section II of the *2004 ASME Boiler and Pressure Vessel Code* [DIRS 171846], except that malleable, wrought, or cast iron materials and plastic pipe shall not be used.

[This criterion is in accordance with the guidance provided in Regulatory Guide 1.143 [DIRS 157566], Paragraph 3.2, to define acceptable materials of construction, including material properties, for pressure containing components of this system. RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1(excluding footnotes) of the guide.]

4.9.4.1.11 Piping Connection

Pressure-retaining components of process systems shall use welded construction to the maximum practical extent. Flanged joints or suitable rapid-disconnect fittings shall be used only where maintenance or operational requirements clearly indicate such construction is preferable. Screwed connections in which threads provide the only seal shall not be used except for instrumentation, a cast pump body drain, and vent connections where welded connections are not suitable.

[This criterion is in accordance with the guidance provided in Regulatory Guide 1.143 [DIRS 157566], Paragraph 4.3, to establish a preferred piping connection method for these systems. RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1(excluding footnotes) of the guide.]

4.9.4.1.12 Leakage Control

LLW waste management SSCs shall be designed to control leakage and facilitate access, operation, inspection, testing, and maintenance in order to minimize radiation exposures to operating and maintenance personnel ALARA in accordance with 10 CFR 20 [DIRS 181962] and Regulatory Guide 8.8 [DIRS 103312].

[This criterion is required to facilitate compliance with ALARA, Regulatory Guide 1.143 [DIRS 157566], Paragraph 4.1. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria. RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1(excluding footnotes) of the guide.]

4.9.4.1.13 Solidification of Liquid LLW

Liquid LLW shall be satisfactorily solidified or absorbed using approved absorbent material in sufficient volume to meet the disposal facility's criteria in accordance with ANSI/ANS-55.1-1992 (R 2000) [DIRS 177848], Paragraph 4.1.2.1.

[The criterion for the solidification or absorption of site-generated liquid LLW is in preparation for offsite disposal by the LLW management system.]

4.9.4.1.14 Gaseous Waste Treatment Strategy

The LLW SSC design shall incorporate gaseous waste treatment that can filter radioactive particulates from the gas prior to release to the building and ventilation exhaust system in accordance with ANSI/ANS-55.1-1992 (R 2000) [DIRS 177848], Paragraph 5.6.5.4.

[This criterion is required in order to define a gaseous waste treatment strategy.]

4.9.4.1.15 Monitoring of Liquid Waste

Continuous monitoring shall be provided for liquid waste effluent in accordance with Regulatory Guide 1.21, *Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants* [DIRS 105991].

[RGA REG-CRW-RG-000015, Agreement for Regulatory Guide 1.21, Rev. 1 - Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants (BSC 2007 [DIRS 182077]) has adopted Regulatory Guide 1.21 with clarification]

4.9.4.1.16 Packaging and Waste Form Stabilization

Packaging and waste form stabilization shall meet the requirements in 10 CFR 61, *Energy: Licensing Requirements for Land Disposal of Radioactive Waste* [DIRS 181966], as well as specific disposal facility requirements.

[This criterion is required to define acceptable packaging and waste form stabilization requirements and is provided for by ANSI/ANS 55.1-1992 (R 2000) [DIRS 177848], Paragraph 3.1.]

4.9.4.1.17 LLW Containers

All LLW containers that will ultimately be disposed of by near-surface disposal shall comply with the requirements of 10 CFR 61 [DIRS 181966], Subpart D, Sections 61.55, 61.56, and 61.58. In addition, wastes that are not stabilized are classified B or C and rely on the waste container for stability shall be packaged in the NRC or state approved high integrity containers.

[This criterion identifies the requirements for LLW containers to be used for the disposal of LLW in shallow land burial sites. B and C waste containers are provided for by ANSI/ANS-55.1-1992 (R 2000) [DIRS 177848], Paragraph 5.9.]

4.9.4.1.18 LLW Containment and Protection

LLW shall be packaged and transported in accordance with 49 CFR 173, *Transportation: Shippers - General Requirements for Shipments and Packagings* [DIRS 181975].

[LLW will be packaged in a manner that provides containment and protection until disposal is achieved.]

4.9.4.1.19 LLW Management

LLW, including greater than Class C wastes, generated during operations shall be managed in accordance with 10 CFR 20 [DIRS 181962] and 10 CFR 61 [DIRS 181966].

[This criterion is required to ensure Greater than Class C LLW that is generated during operations is managed per federal regulation for disposition.]

4.9.4.1.20 Design of Mobile LLW Processing Systems

Mobile LLW processing systems shall be designed and fabricated such that they are capable of being operated in a manner that complies with the requirements specified in ANSI/ANS-40.37-1993, *American National Standard for Mobile Radioactive Waste Processing Systems* [DIRS 164322], Paragraph 3.

[The purpose of this criterion is to ensure that the mobile LLW processing systems are designed, fabricated, installed, and operated in a manner commensurate with the need to protect the health and safety of the public and plant personnel and the environment.]

4.9.4.1.21 Seismic Criteria

Mobile LLW processing systems do not have to be designed to withstand the effects of a seismic event. However, in the case where the system is not housed in a nuclear facility structure, it shall be designed to prevent a release, as a result of an operating basis earthquake or design basis tornado or hurricane, of liquid or gaseous radioactive material in excess of a small fraction of the limits specified in 10 CFR 20 [DIRS 181962] and ANSI/ANS-40.37-1993 [DIRS 164322], Paragraphs 5.3.4 and 5.3.23.

[This criterion establishes seismic design requirements for mobile LLW processing systems.]

4.9.4.1.22 Shielding

Mobile LLW processing equipment and components within the system shall be located, arranged, and shielded to minimize radiation exposure to operating personnel during operation and maintenance per the guidance provided in ANSI/ANS-40.37-1993 [DIRS 164322], Paragraph 9.1.

[This criterion is required to facilitate compliance with ALARA.]

4.9.4.1.23 Additional Codes and Standards

The LLW management system shall comply with these additional codes, standards, industry guides, regulatory guides, CFRs, and DOE orders and standards:

- *TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* (ACGIH 2006 [DIRS 180457]),
- ANSI/ANS-40.35-1991, *Volume Reduction of Low-Level Radioactive Waste or Mixed Waste* [DIRS 122381],
- ANSI/ANS-55.4-1993,*Gaseous Radioactive Waste Processing Systems for Light Water Reactor Plants* [DIRS 166935],
- ANSI/ANS-55.6-1993 (R 1999), *American National Standard for Liquid Radioactive Waste Processing System for Light Water Reactor Plants* [DIRS 177849],

- ANSI/ANS-57.7-1988 (R 1997), *American National Standard, Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)* [DIRS 177851],
- ANSI/ANS-57.9-1992 (R2000), *merican National Standard, Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)* [DIRS 176945],
- IESNA-RP-7-01-2004, *Recommended Practice for Industrial Lighting, with Errata* [DIRS 176343],
- IEEE Std 142-1991, *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (with Erratum)* [DIRS 176545],
- IEEE Std 383-2003, *Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations* [DIRS 171695],
- IEEE Std 80-2000, *IEEE Guide for Safety in AC Substation Grounding* [DIRS 164256],
- NFPA 1144-2002, *Standard for Protection of Life and Property from Wildfire* [DIRS 160936],
- NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982],
- NFPA 780-2004, *Standard for the Installation of Lightning Protection Systems* [DIRS 173517],
- NFPA 801-2003, *Standard for Fire Protection for Facilities Handling Radioactive Materials* [DIRS 165077],
- *IESNA Lighting Handbook, Reference and Application, with Errata* (Rea 2005 [DIRS 176384]),
- UL 96A, *Installation Requirements for Lightning Protection Systems*
- Regulatory Guide 1.189 [DIRS 155040],
- 10 CFR 71 [DIRS 181967],
- 49 CFR 172 [DIRS 181974].

[Applicable sections of these codes and standards will be determined during the design process and in the development of design products. The regulatory guides have been determined to be useful to the development of design products for the preliminary design and the level of conformance will be determined during the design process and in the development of design products. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189. UL 96A *is a constraint and not input requiring referencing. The latest version should be utilized. UL 96A has been removed from the reference list (Section 8.2, Codes, Standards and Regulations) and move to Section 8.4 (Output Constraint) of this document. Although a later version of* NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.9.5 Plant Services System Design Criteria

4.9.5.1 Plant Services System General Criteria

4.9.5.1.1 Boiler and Pressure Vessel Safety

Pressure vessels, boilers, air receivers, and supporting piping systems shall conform to the applicable sections of the codes or standards:

1. *2004 ASME Boiler and Pressure Vessel Safety Code* [DIRS 171846] Sections I through X and Section XII including applicable Code Cases
2. ASME B31.3-2004 (R2005), *Process Piping* [DIRS 176242]
3. The strictest applicable state and local codes.

[DOE O 440.1A [DIRS 102288], Contractor Requirement 20.b. requires the use of ASME codes. RGA REG-CRW-RG-000071,Regulatory Guidance Agreement, Regulatory Guide 1.84, Rev. 33 - Design, Fabrication, and Materials Code Case Acceptability, ASME Section III (BSC 2006 [DIRS 181679]) has adopted Regulatory Guide 1.84 Rev 33, *Design, Fabrication, and Materials Code Case Acceptability, ASME Section III, Division I [DIRS 177621], to allow the option of using NRC approved ASME Section III code cases. RGA REG-CRW-RG-000168, Regulatory Guidance Agreement, Regulatory Guide 1.193, Rev. 1 - ASME Code Cases Not Approved for Use (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 Rev 1 ,ASME Code Cases Not Approved for Use [DIRS 177622]. The Code Cases pertaining to ASME Section III listed therein shall not be used.*

Although a later version of ASME B31.3 is available, the responsible DEM has elected to utilize the referenced version.]

4.9.5.1.2 Stainless Steel Components and Piping Design

Piping and components made from unstabilized austenitc stainless steel of the 300 series shall be designed and fabricated in accordance with the applicable sections of Regulatory Guide 1.44, *Control of the Use of Sensitized Stainless Steel,* [DIRS 110548].

[RGA REG-CRW-RG-000038, Agreement for Regulatory Guide 1.44, Rev. 0 - Control of the Use of Sensitized Stainless Steel (BSC 2007 [DIRS 181995]) has adopted Regulatory Guide 1.44 with clarification. The repository intends to use unstabilized austenitic stainless steel materials (such as Types 304 or 316) and the methods and practices shown in this regulatory guide will be helpful in preventing stress corrosion cracking.]

4.9.5.2 Water Supply

4.9.5.2.1 Water Wells

Water wells shall comply with NAC 445A, *Water Controls* [DIRS 104040], Section*s* 66855-6693, including well location restrictions in NAC 445A.66865.

[The State of Nevada regulations provide acceptable standards for water well placement and construction. Injection wells for tracers and such are addressed in Section 4.2.10.4. CBCN003 to PDC Revision 6 provided change.]

4.9.5.2.2 Raw Well Water Source

Raw well water shall be in accordance with NRS 534.060, *Underground Water and Wells* [DIRS 103014]. Well water could be used for (1) initial supply and make-up to the fire water system; (2) initial supply and makeup to the cooling tower; (3) supply to the deionized water system; (4) supply to the potable water system; and (5) construction water supply.

[Nevada regulations at NRS 534.060 apply to our wells.]

4.9.5.2.3 C-Wells Design

The C-wells shall be designed to provide water for repository operations. The J-wells shall be a water source for ESF operations and repository construction. If the existing well cannot be reconditioned and no longer produces the quantity of water allowed by the permit, a replacement raw water well shall be drilled in accordance with the requirements of NAC 534.300, *Underground Water and Wells* [DIRS 151873]. The existing well shall be plugged at the time the replacement well is drilled.

[Technical Direction to Bechtel SAIC Company, LLC, Contract Number DE-AC28-01RW12101, Use of J-Wells and C-Wells for Repository Water Sources, TDL 04-043 (Arthur 2004 [DIRS 171910]). The C-wells will not be designed to support ESF operations or repository construction specifically, however, use of the C-wells by either ESF operations or repository construction will not be precluded. NAC 534.300 [DIRS 151873] provides the criteria for drilling replacement wells.]

4.9.5.2.4 Potable Water and Monitoring System

The potable water system shall be designed in accordance with the applicable requirements of NAC 445A *Water Controls* [DIRS 104040], 40 CFR 141, *Protection of Environment: National Primary Drinking Water Regulations* [DIRS 181986], NSF/ANSI 60-2005 Addendum 1, *Drinking Water Treatment Chemicals - Health Effects* [DIRS 182875], and NSF/ANSI 61-2007, *Drinking Water System Components - Health Effects* [DIRS 182876]. The water quality monitoring system shall have the capability to sample, measure, and analyze physical, chemical, and biological conditions.

[These are federal regulations and standards governing potable water and are applicable to this system. Water quality standards from 40 CFR 141 and 40 CFR 143, Protection of Environment: National Secondary Drinking Water Regulations [DIRS 181987] are provided in the BOD (BSC 2007 [DIRS 182131]), Chapter 24.]

4.9.5.2.5 Nevada Criteria for Potable Water

The potable water system shall be designed in accordance with NAC 445A, *Water Controls* [DIRS 104040], NAC 445B, *Air Controls* [DIRS 104041], and NRS 445A-C [DIRS 176458], [DIRS 176373], [DIRS 178071], respectively. The specific criterion applicable to the water system shall be as follows:

- The water system pumping facilities shall comply with NAC 445A, *Water Controls*, Sections 66965-67065
- The water system storage structures shall comply with NAC 445A, *Water Controls*, Sections 67065-67095
- The water system distribution systems shall comply with NAC 445A, *Water Controls*, Sections 67105-67255
- The water system treatment facilities shall comply with NAC 445A, *Water Controls*, Sections 6676.1 - 6685

[Source documents allocated to Engineering through the requirements management system. CBCN 003 to PDC Revision 6 provided change.]

4.9.5.2.6 Cross-Connection

Cross-connection control for the potable water system shall be provided with approved reduced-pressure backflow preventers and shall be designed in accordance with:

- *Recommended Practice for Backflow Prevention and Cross-Connection Control* (AWWA 2004 [DIRS 175594])
- *Potable Water System Operations and Maintenance Manual* (BSC 2006 [DIRS 179878])
- NAC 445A.6718.5 through 445A.67255.2, *Water Controls* [DIRS 104040].

[Provides acceptable industry guidance and regulations for design.]

4.9.5.2.7 Water Demand

The potable water supply systems shall be designed to deliver a peak flow of 2.5 times the average daily demand, plus any special water demands. Construction requirements and permanent operation requirements will be provided later. The water pressure shall have a minimum residual pressure of 30 psi. Water supply systems shall be designed to maintain a normal operating pressure of 40 to 150 psi in the water main lines and service lines. Working pressure for potable water and fire water is 150 psi for the lines from the water tanks to and on the pad. The minimum test pressure is 200 psi.

[Engineering judgment.]

4.9.5.2.8 Water Pipelines

The potable water pipeline shall be designed as follows:

- The material for water mains shall have a minimum pressure rating of 200 psi.
- Water mains shall be a minimum of 4 in. in diameter. Pipes for water mains shall be PVC rated for the maximum pressure encountered.
- Service lines shall be a minimum of 1 in. in diameter. Service lines less than 2 in. in diameter shall be connected to the main line by a corporation stop. Service lines 2 in. and larger in diameter shall be connected to the main line by a rigid connection. Service line materials shall be selected on a project-specific requirement basis.
- Underground pressure pipe joints and appurtenances shall have adequate thrust blocks. Aboveground pipe joints and appurtenances shall have adequate anchorage systems.
- Underground pipelines shall be installed with at least 36 in. of cover over the piping or at least 12 in. below frost depth, whichever is deeper according to NAC 445A, *Water Controls* [DIRS 104040]. Additional cover shall be provided at roadway crossings in heavy traffic areas and at railroad crossings.

[Engineering judgment.]

4.9.5.2.9 Fire Protection Water Supply

The water supply system shall supply water to the fire water storage tanks with sufficient flow to totally refill the tank in eight continuous hours or less.

[Regulatory Guide 1.189 [DIRS 155040], Sections C.3.2.1.(a) and (c). RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) adopted Regulatory Guide 1.189.]

4.9.5.2.10 Disinfection

Newly constructed potable water mains, mains that have been removed from service for planned repairs or maintenance that exposes them to contamination, mains that have undergone emergency repairs due to physical failure, and mains that under normal operation continue to show the presence of coliform organisms shall be disinfected in accordance with a standard that has been identified and is being procured. Disinfection of the potable water system shall be in accordance with NAC 445A, *Water Controls* [DIRS 104040], Section 6726, and *Potable Water System Operation and Maintenance Manual* [DIRS 179878].

[Provided by regulation and previous Engineering work that should provide adequate criteria.]

4.9.5.2.11 Lead Free Piping

Any pipe, solder, or flux, that is used in the installation or repair of any public water system (raw water supplying potable water or potable water) or any plumbing in a residential or nonresidential facility providing water for human consumption that is connected to a public water system, shall be lead free. Lead free solders and flux contain not more than 0.2 % lead. Lead free pipes and pipe fittings contain not more than 8.0 % lead. Lead free plumbing fittings and fixtures intended by the manufacturer to dispense water for human ingestion are in compliance with standards established in accordance with *Project Grants and Contracts for Family Planning Services,* 42 U.S.C. 300g-6(e) [DIRS 165621]. This shall not apply to leaded joints necessary for the repair of cast iron pipes.

[40 CFR 141.43(a)(1)(i and ii) and (d) [DIRS 181986]. The reference to USC was provided as part of the source quote and is not included in this document. The quality standard for potable water are described in the BOD (BSC 2007 [DIRS 182131]), Chapter 24.]

4.9.5.2.12 Electric Power to Water Systems

Electrical power to system equipment shall comply with NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005Edition [DIRS 177982].

[DOE O 440.1A [DIRS 102288], Contractor Requirement 12.k, directs use of the National Electrical Code. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.9.5.2.13 Potable Water System Operation and Maintenance

The potable water system shall be designed, operated, and maintained in accordance with *Potable Water System Operations and Maintenance Manual* (BSC 2006 [DIRS 179878]).

[Engineering judgment dictates that Engineering utilize previous experience in the Exploratory Studies Facility for use with the repository systems.]

4.9.5.2.14 Service Water Heating System

Service water heating systems shall be designed for water conservation and energy efficiency in accordance with ANSI/ASHRAE/IESNA Std 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [DIRS 174321], Section 7.

[Although this criterion previously referenced 10 CFR 434, it has been replaced by 10 CFR 433 [DIRS 181833], which directly imposes ANSI/ASHRAE/IESNA Std 90.1-2004.]

4.9.5.3 Fuel Oil

4.9.5.3.1 Fuel Oil System and Storage Tank Design

Fuel storage tanks shall be designed, located, and installed in accordance with:

- API Std 650, *Welded Steel Tanks for Oil Storage, with Addendum 3* [DIRS 171925]
- NFPA 30-2006, *Flammable and Combustible Liquids Code* [DIRS 177974]
- 40 CFR 280, *Protection of Environment: Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)* [DIRS 181972] Subpart B (parts 20) and Subpart D (parts 40, 41, 43, and 44).

[These standards provide best industry criteria for fuel oil tanks. Although a later version of API Std 650 is available, the responsible DEM has elected to utilize the referenced version.]

4.9.5.3.2 Type of Fuel Oil

The fuel oil subsystem shall supply low sulfur diesel fuel No. 2-D (S15) in accordance with ASTM D 975-06, *Standard Specification for Diesel Fuel Oils* [DIRS 177902] for equipment requiring diesel fuel, including the hot water boilers and diesel tanks that support the diesel-driven fire water pumps, diesel-fueled transport vehicles, and diesel generators.

[This is appropriate industry standard for fuel oil for emergency and standby diesels].

4.9.5.3.3 Storage Tank Protection

Cathodic protection or corrosion control and lightning protection for the fuel oil storage tank shall be in accordance with:

- API RP 651 (1997), *Cathodic Protection of Aboveground Petroleum Storage Tanks* [DIRS 166749]
- NFPA 780-2004, *Standard for the Installation of Lightning Protection Systems* [DIRS 173517].

[These are the industry standards for this function. Although a later version of API Std 651 is available, the responsible DEM has elected to utilize the referenced version.]

4.9.5.3.4 Fuel Oil Storage Tanks Containment

Fuel oil storage tanks shall comply with NFPA-30-2006 [DIRS 177974] and be provided with secondary containment to protect from oil spillage and for fire protection.

[NFPA standards are appropriate for this installation.]

4.9.5.3.5 Diesel Day Tanks Size

The diesel day tanks for the diesel generators shall comply with Regulatory Guide 1.189 [DIRS 155040] Section C.6.1.8 and NFPA 70 [DIRS 177982], and shall be sized for not less than 2 hours of full-demand operation of the system.

[NFPA standards are appropriate for this installation. NFPA 70, Chapter 7, Article 701, Section III, Paragraph 701.11(B)(2), provides for the tank sizing. RGA REG-CRW-RG-000164 (BSC 2007 [DIRS 181799]) has provided guidance for Regulatory Guide 1.189.]

4.9.5.3.6 Diesel Fire Water Pump Tank Size

The diesel driven fire water pump fuel tanks shall comply with NFPA 20-2006 [DIRS 177971] and be sized for at least equal to 5.07 L per kW (1 gal per hp), plus 5 % volume for expansion and 5 % volume for sump.

[NFPA standards are appropriate for this installation.]

4.9.5.3.7 Diesel Generator Fuel Oil Design

The fuel oil system shall be designed in accordance with the guidance provided in Regulatory Guide 1.137 Rev 1, *Fuel-Oil Systems For Standby Diesel Generators*, [DIRS 144752] Sections C.1 (a) through (d) and (f) through (h) .

[RGA REG-CRW-RG-000115, Agreement for Regulatory Guide 1.137, Rev 1 - Fuel Oil Systems for Standby Diesel Generators (BSC 2007 [DIRS 181745]) has provided guidance for Regulatory Guide 1.137.]

4.9.5.4 Service Gases

4.9.5.4.1 Service Gases Purity

Nitrogen, helium, and argon gases shall be at a purity of 99.9, 99.995, and 99.997 percent or greater, respectively, in accordance with ANSI/AWS A5.32/A5.32M-97 (R2007), *Specification for Welding Shielding Gases* [DIRS 182873]. Liquid nitrogen shall be at a purity of 99.998 percent.

[This is the industry standard for services gases and is suitable for transportation casks and systems piping purging or inerting operations. Table 1 of the standard provides the specifications.]

4.9.5.4.2 Backfill Inerting Gas

Helium gas should be used for evacuating and backfilling the aging casks, transportation casks (if reshipping loaded casks), TAD canisters, and waste packages in accordance with NUREG-1536, *Standard Review Plan for Dry Cask Storage Systems* [DIRS 101903].

[RGA REG-CRW-RG-000448, Agreement for NUREG-1536, January 1997, Standard Review Plan for Dry Cask Storage Systems - Final Report (BSC 2007 [DIRS 181827]) provides agreement that NUREG-1536 should be utilized to ensures that fuel assemblies will be sufficiently protected against degradation by minimizing the presence of oxidizing gases, predominantly oxygen, evacuated from within the loaded and sealed transportation cask and waste packages. The NRC guidance is appropriate to this application.

Although the RGA for SFPO-ISG-22, Rev 0, Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel (NRC 2006 [DIRS 178006]), RGA REG-CRW-RG-000433, (BSC 2007 [DIRS 181824]) provides agreement that the aging casks maintain the SNF in a non-oxidizing environment that could include helium, argon, and nitrogen, the BOD (BSC 2007 [DIRS 182131]) provides only for the TAD canister backfill as helium.]

4.9.5.4.3 Welding Gas

Argon and helium gas shall be blended in a 3/1 (argon/helium) by volume ratio in accordance with ANSI/AWS A5.32/A5.32M-97 (R2007) [DIRS 182873] for welding the Alloy 22 (UNS N06022) middle and outer lids to the Alloy 22 (UNS N06022) outer corrosion barrier of the waste package. The welding shall be conducted in accordance with *2004 ASME Boiler and Pressure Vessel Code* (ASME 2004 [DIRS 171846] Section III, Subsection NC, and Section IX).

[The welding procedures (including the ratio) are qualified in accordance with 2004 ASME Boiler and Pressure Vessel Code. The criterion for the volume ratio of the gas blend is in accordance with ANSI/AWS A5.32/A5.32M-97.Although 2007 version of ASME 2004 is available, the responsible DEM has elected to utilize the 2004 version.]

4.9.5.4.4 Control and Monitoring System

Instrumentation and control systems shall comply with the *Handbook of Compressed Gases* (Compressed Gas Association 2003 [DIRS 171615]) include provisions to monitor and control the behavior of service gas systems for normal operation. The facilities shall be monitored and alarmed to indicate when oxygen levels falls below 19.5 % in confined spaces.

[This criterion is required to define the integral functional requirements that ensure proper operation of the system and the alarming of unsafe conditions to protect the health and safety of occupational workers.]

4.9.5.4.5 TAD Interior Drying Gas

The TAD assembly drying system shall use helium gas capable of drying the interior of the TAD canisters in accordance with NUREG-1536 (NRC 1997 [DIRS 101903]) Section 8.V.1 to limit the maximum quantity of oxidizing gases (such as O_2, CO_2, and CO) to no more than 1 gram-mole per cask.

[RGA REG-CRW-RG-000448 (BSC 2007 [DIRS 181827]) provides agreement that NUREG-1536 should be utilized.]

4.9.5.4.6 Liquefied Natural Gas Tanks and Piping

Design and installation of liquefied petroleum gas tanks, including propane and liquefied natural gas tanks, shall comply with NFPA 58-2004, *Liquefied Petroleum Gas Code* [DIRS 177981]. Special attention shall be paid to Section 6.8.3.9 requiring sufficient flexible piping joints.

[BOP is expecting to install a propane or liquefied natural gas tank to support the repository. NFPA 58-2004 is applicable to this class of tanks. Lessons Learned EM-ID-CWI-RWMC-2005-0009 indicated a concern for meeting Section 6.8.3.9, "Piping systems including interconnecting of permanently installed containers shall compensate for expansion, contraction, jarring, vibration, and settling."]

4.9.5.5 Piping System

The plant services piping system shall be designed in accordance with ASME B31.3-2004 (R2005) [DIRS 176242] and piping flanges and fitting shall be in accordance with ASME B16.5-2003 [DIRS 169366] and ASME B16.5a-1998 [DIRS 164190].

[This criteria establishes the requirement in the design of water piping to support compliance with Regulatory Guide 1.143 [DIRS 157566], Table 1. RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1(excluding footnotes) of the guide. These are appropriate industry standards for this application. Although a later version of ASME B31.3 is available, the responsible DEM has elected to utilize the referenced version.]

4.9.5.6 Hazard Labels

Pipe, hose, and tube-line for liquids and gases shall comply with CGA P-9-2001, *The Inert Gases: Argon, Nitrogen and Helium* [DIRS 166794] and shall provide identification and be clearly labeled or coded as to contents, pressure, temperature, direction of flow, or other specific hazard information.

[This is an acceptable industry standard for gases.]

4.9.5.7 Personal Protection Requirement

The system design shall include provisions for the protection of the occupational workers during the installation, maintenance, and replacement of SSCs with consideration to rotating equipment, confined spaces, noise barriers, chemical leaks, and respiratory hazards.

[This criterion is required to ensure that personnel are protected from all rotating equipment by the use of safety guards or safety screens and equipment rooms that provide sensors, alarms, escape provisions, and respiratory protection equipment.]

4.9.5.8 Equipment Protection Requirement

The system components located underground and outdoors shall be designed to withstand and operate in the extreme underground and outside temperature environment. Interlocks, alarms, access, hazard access, and edge rounding shall be provided and designed in accordance with the applicable requirements of 29 CFR 1910 [DIRS 177507].

[This criterion is required for the operational integrity of the system components. Underground and outdoor temperature can affect component performance, equipment degradation (coatings, seals, fluids), and the operation and capability of the system.]

4.9.5.9 Additional Plant Services Codes and Standards

The Plant Services subsystems shall be designed in accordance with the following additional codes, standards, industry guides, regulatory guides, CFRs, and DOE orders and standards:

- ANSI Z88.2-1992,*American National Standard for Respiratory Protection* [DIRS 114614],
- ANSI/AWWA C652-02,*AWWA Standard for Disinfection of Water-Storage Facilities* [DIRS 164242],
- ANSI/AWWA D100-05 [DIRS 177866],
- AWWA D102-03, *Coating Steel Water-Storage Tanks* [DIRS 176339],
- ANSI/ISA-S7.0.01-1996 [DIRS 164287],
- ANSI/API Std 610, *Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries* [DIRS 176349],
- API Std 619, *Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries* [DIRS 176350],
- API Std 620 [DIRS 176388],
- *2005 ASHRAE Handbook, Fundamentals* (ASHRAE 2005 [DIRS 174692]),
- ASME B73.1-2001, *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process* [DIRS 165719],
- CGA G-10.1-2004, *Commodity Specification for Nitrogen* [DIRS 176430],
- CGA G-11.1-2004, *Commodity Specification for Argon* [DIRS 176431],
- CGA G-7.1-2004, *Commodity Specification for Air* [DIRS 176434],
- CGA G-9.1-2004, *Commodity Specification for Helium* [DIRS 176435],
- CGA P-18-2006, *Standard for Bulk Inert Gas Systems* [DIRS 176437],

- CGA V-1-2005, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections, with Amendment 1* [DIRS 176436],
- *2006 International Plumbing Code* (ICC 2006 [DIRS 176292]),
- NAC 445A [DIRS 104040],
- NAC 445B [DIRS 104041],
- DOE O 420.1A [DIRS 159450],
- DOE O 450.1 Change 2 [DIRS 176641],
- NSF/ANSI 60-2005 [DIRS 182875],
- NSF/ANSI 61-2007 [DIRS 182876],
- NFPA 20-2006 [DIRS 177971],
- NFPA 30-2003 [DIRS 177974],
- NFPA 70-2005 [DIRS 177982],
- NFPA 780-2004 [DIRS 173517],
- 29 CFR 1910 [DIRS 177507],
- 40 CFR 141 [DIRS 181986],
- 40 CFR 143 [DIRS 181987]

[Applicable sections of these codes and standards and level of conformance will be determined during the design process and in the development of design products. Although a later version of API Std 650 and AWWA D102 is available, the responsible DEM has elected to utilize the referenced version. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.9.6 Plant Heating and Cooling System Design Criteria

4.9.6.1 Plant Heating and Cooling System General Criteria

[NOTE: The criteria in this section are not applicable to the direct expansion or evaporative cooling or the use of electric heating to support the Energy Conservation program and economics.]

4.9.6.1.1 Type of Heating and Cooling Systems

The plant heating and cooling system shall consist of the chilled water cooling system and hot water heating system.

[The plant heating and cooling system, in conjunction with the surface nuclear confinement and non-confinement HVAC systems, is required to ensure that proper environmental conditions are maintained in the surface facilities. The chilled water is provided to the cooling coils for cooling and hot water is provided to the preheat and reheat coils for heating. The cooling coils, preheat coils, and reheat coils are part of the surface nuclear confinement and non-confinement HVAC systems.]

4.9.6.1.2 Freeze Protection

The freeze protection of the plant heating and cooling system shall be based on the recommendation of *ASHRAE Handbook, Fundamentals* (ASHRAE 2005 [DIRS 174692], Chapter 21) for appropriate glycol concentration. The system shall use a glycol concentration with a freezing point 5°F below the lowest expected outdoor air temperature.

[The appropriate concentration of glycol in the water systems will provide freeze protection and prevent equipment damage during idle periods in cold weather.]

4.9.6.1.3 Piping System

The plant heating and cooling water piping system shall be designed in accordance with ASME B31.3-2004 (R2005) [DIRS 176242].

[This criteria establishes the requirement in the design of water piping to support compliance with Regulatory Guide 1.143 [DIRS 157566], Table 1. RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1(excluding footnotes) of the guide. Although a later version of ASME B31.3 is available, the responsible DEM has elected to utilize the referenced version.]

4.9.6.1.4 Distribution Piping

The plant heating and cooling water piping distribution shall be designed in accordance with *2005 ASHRAE Handbook, Fundamentals* (ASHRAE 2005 [DIRS 174692], Chapter 36), including performance requirement for the pipe friction loss and water velocity. The piping distribution system shall be insulated and shall utilize pipe trenches or pipe racks for distribution throughout the facilities.

[This criterion will ensure that the piping is designed for economical pipe sizes based on allowable pressure drop, flow rate, and pump selection criteria. This criterion will also avoid the undesirable effects of high velocities in the piping system (e.g., noise, erosion, and water hammer). Pipe insulation will provide thermal resistance against heat loss or heat gain.]

4.9.6.1.5 Corrosion Protection

The plant heating and cooling systems chemical treatment shall comply with the guidelines in *2007 ASHRAE® Handbook, Heating, Ventilating, and Air-Conditioning Applications* (ASHRAE 2007 [DIRS 182903] Chapter 48).

[The proper chemical treatment of the chilled and hot water systems will prevent corrosion and, hence, will ensure reliability, maintainability, and availability of the systems.]

4.9.6.1.6 Instrumentation, Controls, and Monitoring

The plant heating and cooling systems shall be designed to include the required controls and instrumentation in accordance with the guidance provided in *2007 ASHRAE® Handbook, Heating, Ventilating, and Air-Conditioning Applications* (ASHRAE 2007 [DIRS 182903] Chapter 46) . The system instrumentation shall include all the necessary alarms and equipment status indication required for the parameters. The required instrumentation shall be provided locally and remotely such that they are readily visible, accessible, and, where feasible, located in the least contaminated area.

[The provision of monitoring, control, and alarm capabilities are integral functional requirements that ensure the proper operation of the system and alarming of unsafe conditions for the protection of the equipment and safety of the occupational workers. The criteria to monitor the system performance are in accordance with industry practices.]

4.9.6.1.7 Energy Conservation

The plant heating and cooling systems and equipment shall be designed to conserve energy in accordance with

- ANSI/ASHRAE/IESNA Std 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [DIRS 174321] Section 6
- 64 FR 30851, Greening the Government Through Efficient Energy Management, Executive Order 13123 (64 FR 30851 [DIRS 104026]).

[ANSI/ASHRAE/IESNA Std 90.1-2004 is the industry standard applicable to this application. Although this criterion previously referenced 10 CFR 434, it has been replaced by 10 CFR 433 [DIRS 181833], which directly imposes ASHRAE 90.1-2004. 10 CFR 433 and Executive Order 13123 are mandated through the contract.]

4.9.6.1.8 Service Water Heating Equipment Efficiency

The plant heating and cooling systems and equipment shall be designed for equipment efficiency in accordance with 10 CFR 433.4, 433.5, and 433.8 [DIRS 181833].

[Although this criterion previously referenced 10 CFR 434, it has been replaced by 10 CFR 433.]

4.9.6.1.9 HVAC Equipment Fire Safety

Repository HVAC equipment shall follow NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982].

[DOE O 440.1A. [DIRS 102288], Contractor Requirement 12.k, mandates use of NFPA 70-2005. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.9.6.2 Chilled Water Cooling System

4.9.6.2.1 Chilled Water Temperature

The chilled water supply temperature shall be in accordance with the recommendations provided in *ASHRAE Handbook, Heating, Ventilating, and Air-Conditioning Systems and Equipment* (ASHRAE 2004 [DIRS 171799] Chapter 11), and ARI 550/590, *Standard for Water Chilling Packages Using the Vapor Compression Cycle, with Addendum* [DIRS 176391].

[The standard ratings of supply water temperatures and water flow rate per ton of refrigeration are specified in ARI Standard 550/590, Table 1, and the range of chilled water supply temperature are described in ASHRAE 2004, Chapter 11).]

4.9.6.2.2 Condenser Water Temperature

The chilled water cooling system shall be water cooled, provided by the cooling tower, with the entering temperature to the chiller condenser and a 12°F to 14°F temperature differential in accordance with the recommendations provided in ARI 550/590, *Standard for Water Chilling Packages Using the Vapor Compression Cycle, with Addendum* [DIRS 176391].

[ARI Std 550/590, Table 1, provides the standard ratings of supply water temperatures and water flow rate per ton of refrigeration.]

4.9.6.2.3 Refrigerant Classification

The chilled water cooling system design shall utilize environmentally acceptable refrigerant (e.g., R-134a) and be equipped with protective devices to reduce refrigerant loss and minimize refrigerant emissions during service. The safety classification of refrigerants shall be in accordance with ANSI/ASHRAE Std 34-2004, *Designation and Safety Classification of Refrigerants* [DIRS 174323].

[This criterion complies with the applicable provisions of 65 FR 24595, Greening the Government Through Leadership in Environmental Management [DIRS 154538], Executive Order 13148.]

4.9.6.2.4 ASME Code Requirement

The chilled water cooling system and associated components shall be designed and fabricated in accordance with *ASME Boiler and Pressure Vessel Code* [DIRS 171846] Section VIII, Division I. The chilled water system shall be provided with pressure relief protection or any other approved means to safely relieve the system overpressure due to an abnormal operating condition. The pressure relief discharge shall be directed to the atmosphere.

[ASME is the industry standard for pressure vessels. This criterion ensures preventing or minimizing the possibility of harm to personnel caused by pressure vessel failure.]

4.9.6.2.5 Refrigerant Leak Detection

A refrigerant leak detection system and proper ventilation shall be provided for the Mechanical Refrigeration Room for removal of non-condensable gases in accordance with ANSI/ASHRAE Std 15-2007, *Safety Standard for Refrigeration Systems* [DIRS 182931]. The refrigerant detector sensors shall be located in areas where refrigerant from a leak will concentrate. The leak detection system shall actuate an alarm and the mechanical purge ventilation system for worker safety.

[ANSI/ASHRAE Std 15 is the industry standard for refrigeration systems.]

4.9.6.3 Hot Water Heating System

4.9.6.3.1 Heating System Classification

The hot water heating system shall be oil fired and designed in accordance with *2004 ASME Boiler and Pressure Vessel Code* (ASME 2004 [DIRS 171846]) for low temperature water application to operate within the pressure and temperature limits for low-pressure vessels. The hot water heating system performance shall be in accordance with the recommendation of *ASHRAE Handbook, Heating, Ventilating, and Air-Conditioning Systems and Equipment* (ASHRAE 2004 [DIRS 171799] Chapters 11 and 12) for low temperature water system application.

[The criterion is required to support the associated HVAC system function to maintain the environmental conditions in the surface facilities. The low temperature water system as defined in (ASHRAE 2004) are those with an operating temperature of less than 250°F and operating pressure not exceeding 160 psi. Although 2007 version of ASME 2004 is available, the responsible DEM has elected to utilize the 2004 version.]

4.9.6.3.2 ASME Code Requirement

The hot water heating system and associated components shall be designed and fabricated in accordance with *2004 ASME Boiler and Pressure Vessel Code,* Section IV [DIRS 171846], and shall be provided with appropriate pressure relief protection or any other approved means to safely relieve the system overpressure due to an abnormal operating condition.

[ASME is the industry standard addressing this criteria. Section IV will help to prevent or minimize the possibility of harm to personnel caused by equipment or component failure. Although 2007 version of ASME 2004 is available, the responsible DEM has elected to utilize the 2004 version.]

4.9.6.3.3 Boiler Room Combustion and Ventilation Air

The hot water heating boiler room shall comply with NFPA 31-2006, *Standard for the Installation of Oil- Burning Equipment, with Errata* [DIRS 177976] including providing the combustion air and ventilation air in accordance with Chapters 5 and 6.

[NFPA 31-2006 is the appropriate industry standard for this purpose. The combustion air requirement will ensure proper operation of the boilers and the ventilation air will ensure proper environmental conditions in the boiler room.]

4.9.6.3.4 Boiler Emission

The hot water heating system shall have provisions to reduce air pollutants such as nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter nominally 10 micrometers or smaller in diameter in accordance with the 40 CFR 50 [DIRS 177844].

[40 CFR 50.6 is mandated through the contract and provides the regulatory basis to protect the public from adverse effect of certain air pollutants.]

4.9.6.3.5 Boiler Exhaust Stack

The hot water boilers shall be provided with an exhaust stack in accordance with NFPA 31-2006 [DIRS 177976] Chapter 6, to convey the products of combustion to a point of safe discharge (atmosphere). The exhaust stack shall be made of noncorrosive material and located to prevent recirculation of exhaust gases to any of the facilities air intake.

[This criterion is required to comply with the national safety standards, building codes, and industry practices. The stack material requirement is to prevent corrosion or deterioration of the stack due to condensation.]

4.9.6.4 Additional Plant Heating and Cooling System Codes and Standards

The plant heating and cooling systems shall also comply with the following additional codes, standards, industry guides, CFRs, and DOE orders and standards:

- ASME AG-1a-2004 [DIRS 177029],
- ASME B16.3-1998, *Malleable Iron Threaded Fittings, Classes 150 and 300* [DIRS 165262],
- ASME B73.1-2001 [DIRS 165719],
- ASTM A 234/A 234M-06a, *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service* [DIRS 177884],
- ASTM A 53/A 53M,
- AWS D1.1/D1.1M,
- IEEE Std 1202-2006 [DIRS 177949],
- 29 CFR 1910 [DIRS 177507],
- DOE O 430.2A [DIRS 158913],
- DOE O 440.1A [DIRS 102288].

[Applicable sections of these codes and standards and level of conformance will be determined during the design process and in the development of design products. Although a later version of ASTM A 234 is available, the responsible DEM has elected to utilize the referenced version. AWS D1.1/D1.1M-2006 [DIRS 176256] and ASTM A 53/A 53M-2006 [DIRS 177894] are constraints and not inputs requiring referencing. The latest version should be utilized.]

4.9.7 Cask / TAD / Waste Package / Pool Process Systems Design Criteria

4.9.7.1 Codes and Standards

The following are the codes, standards, industry guides, regulatory guides, CFRs, and DOE orders and standards that should be applied in the design of the LLW management system:

- ANSI/ISA-S84.01-1996, *Application of Safety Instrumented Systems for the Process Industries* [DIRS 112340],
- ASME 2004 [DIRS 171846] Section II; Section VIII, Div. 1 or 2; Section IX; and Section III,
- IEEE Std 383-2003 [DIRS 171695],
- NFPA 55-2006,*Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks, with Errata* [DIRS 177980],
- NFPA 70 [DIRS 177982],
- UL 96A,
- 10 CFR 63 [DIRS 180319],
- 29 CFR 1910 [DIRS 177507],
- 49 CFR 172 [DIRS 181974],
- DOE O 420.1A [DIRS 159450],
- DOE O 450.1 Change 2 [DIRS 176641]

[Applicable sections of these codes and standards will be determined during the design process and in the development of design products. The regulatory guides have been determined to be useful to the development of design products for the preliminary design, and the level of conformance will be determined during the design process and in the development of design products.
RGA REG-CRW-RG-000071,Regulatory Guidance Agreement, Regulatory Guide 1.84, Rev. 33 - Design, Fabrication, and Materials Code Case Acceptability, ASME Section III (BSC 2006 [DIRS 181679]) has adopted Regulatory Guide 1.84 Rev 33, *Design, Fabrication, and Materials Code Case Acceptability, ASME Section III, Division I [DIRS 177621], to allow the option of using NRC approved ASME Section III code cases.*
REG-CRW-RG-000168 (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 Rev 1 [DIRS 177622], ASME Code Cases Not Approved for Use. The Code Cases listed therein shall not be used. UL 96A-2005 *is a constraint and not input requiring referencing.*
The latest version should be utilized. UL 96A has been removed from the reference list (Section 8.2, Codes, Standards and Regulations) and move to Section 8.4 (Output Constraint) of this document. Although 2007 version of ASME 2004 is available, the responsible DEM has elected to utilize the 2004 version. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.9.7.2 Pollution Prevention

The Cask / TAD / Waste Package / Pool Process Systems design shall incorporate source reduction and treatment in accordance with the guidance from 63 FR 49643 [DIRS 104024].

[NRC guidance specifically addresses the function of this system.]

4.9.7.3 Design Criteria for Gaseous Systems

4.9.7.3.1 Cask Sampling and Analysis

The gaseous systems shall be designed to provide for cask cavity sampling and analysis, cooling, venting, drying, and inerting of cask and waste package cavities, and TAD canisters as required, for the subsequent unloading and shipping of casks or loading and emplacement of waste packages in accordance with ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851], Section 6.4.2.3.1 and ANSI/ANS 57.9-1992 (R2000) [DIRS 176945], Sections 5.1.4.3 and 6.1.4.1.3.

[These codes are the industry standards applicable to this function.]

4.9.7.3.2 Radioactive Gas Collection

The gaseous systems design shall provide for radioactive gas collection, condensate removal, air sampling, and chemical monitoring. The gaseous system shall provide the ability to handle condensable and non-condensable gases generated in process operations and waste storage to limit the release of radioactive materials during normal operations in accordance with:

- 10 CFR 20 [DIRS 181962]
- ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851]

- Regulatory Guide 3.20 [DIRS 171701].

[10 CFR 20 as described in ANSI/ANS 57.7-1988 (R 1997), Section 6.8.2.4. The release of noxious materials will be limited to comply with federal and State of Nevada statutes and implementing regulations in accordance with Regulatory Guide 3.20, Sections B and C.1.b.

Note: The RGA REG-CRW-RG-000203 [DIRS 183131] for Regulatory Guide 3.20 will be revised for use in the YMP and is being used prior to final RGA adoption.]

4.9.7.3.3 Hazardous Material Confinement

The gaseous systems shall be designed utilizing the guidance from Regulatory Guide 3.20, *Process Offgas Systems for Fuel Reprocessing Plants* [DIRS 171701] to (1) confine hazardous chemicals and radioactive materials evolved during process operations and radioactive waste storage and (2) maintain offsite doses ALARA in accordance with 10 CFR 20 [DIRS 181962].

[NRC guidance specifically addresses the function of this system.

Note: The RGA REG-CRW-RG-000203 [DIRS 183131] for Regulatory Guide 3.20 will be revised for use in the YMP and is being used prior to final RGA adoption.]

4.9.7.3.4 System Material Composition

The gaseous systems shall use stainless steel for process lines and vessels and internals such as filters should be resistant to fire. To assure system reliability, the materials used in lines and equipment shall be noncombustible, resistant to heat, and resistant to the corrosive effects of the collected gases and the strong chemicals used for equipment decontamination in accordance with Regulatory Guide 3.20 [DIRS 171701], Section B.

[NRC guidance specifically addresses the function of this system.

Note: The RGA REG-CRW-RG-000203 [DIRS 183131] for Regulatory Guide 3.20 will be revised for use in the YMP and is being used prior to final RGA adoption.]

4.9.7.3.5 Particulate Removal Capability

The design of the gaseous systems shall provide the capability for particulate removal. To prevent potential damage from condensate, filters and adsorbents may be preceded by heaters or by electrical or steam traced lines, which maintain the gas stream above the dew point. It may also be achieved by providing low-point traps and drains on supply headers in accordance with Regulatory Guide 3.20 [DIRS 171701], Section B.

[NRC guidance specifically addresses the function of this system.

Note: The RGA REG-CRW-RG-000203 [DIRS 183131] for Regulatory Guide 3.20 will be revised for use in the YMP and is being used prior to final RGA adoption.]

4.9.7.3.6 Inspection, Testing and Maintenance

The design of the gas handling systems shall facilitate inspection, maintenance, and testing of systems and components to ensure continued functioning for the life of the facility in accordance with Regulatory Guide 3.20 [DIRS 171701], Section C.1.f.

[NRC guidance specifically addresses the function of this system.

Note: The RGA REG-CRW-RG-000203 [DIRS 183131] for Regulatory Guide 3.20 will be revised for use in the YMP and is being used prior to final RGA adoption.]

4.9.7.3.7 Gas Handling Equipment

The gas handling equipment shall be designed to:

1. Collect gases near points of generation, conduct them in closed piping systems to filters, and vent into the surface nuclear confinement HVAC ducting.
2. Prevent header flooding and unsafe accumulation of fissionable materials by sloping the collection piping to drain to appropriate process vessels.
3. Size vessel vapor lines to provide low gas velocities and separate vessel vent lines from other vessel lines.
4. Operate at negative pressures relative to surrounding cells where practical.

5. Limit the spread of contamination by providing top entry of gas branch lines into headers and by providing pressure relief devices to guard against pressure increases due to flow blockages or gas flows in excess of design specifications.
6. Locate process piping containing radioactive material away from areas frequently occupied by personnel or provide local biological shielding.

[Regulatory Guide 3.20 [DIRS 171701], Section C.2. The specifics for condensers, knockout pots, vessel overflow lines, and deentrapment devices are specific to fuel reprocessing plants and are not necessarily appropriate for the repository SSCs. These specifics were removed from the text.

Note: The RGA REG-CRW-RG-000203 [DIRS 183131] for Regulatory Guide 3.20 will be revised for use in the YMP and is being used prior to final RGA adoption.]

4.9.7.4 Instrumentation, Controls, and Monitoring of Gaseous Systems

4.9.7.4.1 Instrumentation and Monitoring

The design of the gaseous systems shall include instrumentation, monitoring, and control equipment that provide current indication to the respective control area of temperature, pressure, and radiation levels for key points in each gas handling system. For cavity gas sampling, some of these instruments provide indication of seal integrity and the condition of the cask cavity that is required for the safe handling of transportation casks. Additional instrumentation and indication is provided as required to support the unique requirements of each gas handling system.

[ANSI/ANS 57.9-1992 (R 2000) [DIRS 176945], Section 6.1.4.1.3.]

4.9.7.4.2 Sampling Points

The sampling system shall provide sampling points for gaseous streams on each cask or waste package and dual purpose canister testing station and at the process gas discharge points. The sampling system shall provide ports for testing filter efficiency on each safety-related stage of filtration.

[ANSI/ANS 55.4-1993, Gaseous Radioactive Waste Processing Systems for Light Water Reactor Plants [DIRS 166935], Section 5.4, and ANSI/ANS 57.9-1992 (R 2000) [DIRS 176945], Section 6.8.1.4.]

4.9.7.5 Pool Water Treatment and Cooling System Design

The Pool Water Treatment and Cooling System shall be designed to the codes and standards identified in Section 6.3.1 of ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851].

[Engineering judgment determined that the ANSI/ANS 57.7-1988 (R 1997) is the industry standard for nuclear pool system design and is appropriate for our use in the WHF pools. The standard was reaffirmed without change in 1997.]

4.9.7.5.1 Pool Water Treatment and Cooling Functions

The Pool Water Treatment and Cooling System shall include the following functions:

1. Remove dissolved and suspended radioactive material.
2. Provide a closed system capable of recovering from the loss of cooling before bulk boiling of the storage pool water occurs.
3. Maintain an annual average gross pool water activity level such that worker dose is maintained ALARA.
4. Detect leakage from the pool.
5. Remove decay heat.
6. Achieve pool water turnover time of 72 hours or less.
7. Control, retain, and dispose of radioactive material removed from the pool water, spent equipment, and material contaminated during operation of the system.
8. Control water chemistry to maintain fuel assembly cladding and structural member material properties during storage within the pool.
9. Eliminate traps and loops, and minimize flanges that might accumulate radioactive material.
10. Avoid the use of built-in crud traps (such as flanged couplings) and dead legs. Construction materials and surface finishes shall be considered to minimize porosity, crevices, and rough machine marks to limit the possibility of tightly adherent contamination and criticality, and to facilitate ease of decontamination.
11. Provide for full draining of contaminated piping systems by including the installation of low-point drains,

pump drains, tank vent and drain systems, and the elimination of dead legs between valves in system designs.
12. Consider that radioactive materials may be concentrated or plated out and have provisions in the design to minimize exposure to radiation in its operation and maintenance. Equipment such as ion exchangers and filters shall be individually shielded or located in a shielded cell. In addition, the provision shall be made for isolation and flushing with decontamination solution.

[ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851]]

4.9.7.5.2 Pool Water Quality

The Pool Water Treatment and Cooling System shall provide for removal of radioactive materials and particulates from the pool water by circulation through filters and ion exchange units to meet the following quality standards:

1. Maintain water clarity such that fuel assembly identification can be established by direct viewing through standard underwater viewing devices.
2. Provide for an annual average pool water conductivity less than 3 micro-mho/cm.
3. Ensure that water chloride concentration is less than 0.5 ppm.
4. Ensure that average pool water pH is between 5.3 and 7.5.

[ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851] provided quality standard 1 and BNWL-2256, Behavior of Spent Nuclear Fuel in Water Pool Storage (Johnson 1977 [DIRS 101687]) provided quality standards 2-4.]

4.9.7.5.3 Pool Water Temperatures

The Pool Water Treatment and Cooling System shall provide:

1. Equipment for removal of decay heat by an external heat exchanger and for removal of radioactive materials and particulates from the pool water by circulation through filters and ion units.
2. Maintain an annual average normal pool water operating temperature 90°F or less with a normal pool water operating temperature not to exceed 110°F more than 5% of the time, on the average, during the warmest four consecutive months as determined by the mean wet bulb temperature.

[ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851].]

4.9.7.5.4 Pool Water Makeup System

The Pool Water Makeup System shall:

1. Provide for a system to compensate for pool water losses.
2. Provide capability to recover from loss of cooling before the design limits of the pool structure are exceeded.
3. Provide capability to add deionized water to the storage pool at a rate greater than the loss of pool water by evaporation during normal operations.
4. Provide capability to maintain minimum water depth.
5. Inhibit the escape of contaminated pool water.

[ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851]

4.9.7.5.5 Testing, Inspection, and Maintenance

The Pool Water Treatment and Cooling System shall ensure that:

1. Pumps, valves, filters, and other components are readily accessible for maintenance.
2. Filters are capable of being either remotely back flushed or designed so that cartridges can be directly removed into a shielded container.
3. Equipment is provided for periodic functional testing of the pool water cleanup system performance.
4. Instrumentation is provided for periodic functional testing of the heat exchanger(s) (i.e., inlet pressure and pressure drop).

[ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851], Section 6. It is essential that pool water systems be designed to control leakage and facilitate access, operation, inspection, testing, and maintenance in order to maintain radiation exposures to operating and maintenance personnel ALARA per the guidance of Regulatory Guide 1.143 [DIRS 157566], Section 4.1. RGA REG-CRW-RG-000121 (BSC 2007 [DIRS 181764]) has provided guidance for Regulatory Guide 1.143 to use the codes and standards listed in the Table 1(excluding footnotes) of the guide.]

4.9.7.6 Surveying for Radioactive Contamination of Waste Packages

Where waste package surveys are required and are conducted by mechanical systems, the following surveying requirements shall apply:

1. The surveying system shall provide for efficient removal of loose radiological contamination from the surface of the waste package.
2. The surveying system shall not damage the waste package surface.
3. The surveying system shall not leave any chemical residue on the waste package surface.
4. The surveying system shall have the capability to be operated remotely.
5. The surveying system equipment shall be robust, easy to repair, reliable with low need for maintenance, and able to disengage and re-engage end effectors and tools remotely.
6. The surveying system shall operate in fail-safe mode and shall not release grip pressure causing tools or materials to be dropped.
7. The surveying system shall be able to withstand up to 100 % relative humidity, high ambient temperature (up to 150°C at the waste package surface), high intensity ionizing radiation (gamma and neutron), and the presence of fine abrasive dust (present in ambient external atmosphere).

[Recommended Surface Contamination Levels for Waste Packages Prior to Placement in the Repository (Edwards and Yuan 2003 [DIRS 164177].]

4.9.7.7 Waste Package Decontamination

The following design requirements shall apply for the decontamination of external surfaces of waste packages, if such decontamination is required:

1. The system shall be capable of decontaminating the waste package to a level such that contamination, worker dose, and environmental releases are maintained ALARA.
2. The system shall be designed to control radioactive materials and to minimize radiation exposures to personnel during operation and maintenance. The design shall be consistent with the regulatory requirements in 10 CFR 20 [DIRS 181962] and the guidance in Regulatory Guide 8.8 [DIRS 103312].
3. Grapples and tools shall be designed to facilitate decontamination, nondestructive testing, maintenance, handling, collection, and remote operation (ANSI/ANS-57.9-1992 (R 2000) [DIRS 176945], Sections 6.2.1.1.5 and 6.2.1.1.11).
4. SSCs (for operations, maintenance, and required inspections involving exposure to radiation) shall be designed, fabricated, located, shielded, controlled, and tested so as to control external and internal radiation exposure to onsite personnel and the public to levels consistent with ALARA principles (ANSI/ANS-57.9-1992 (R 2000), Section 6.13.1).
5. All surfaces of systems for the control and decontamination shall be designed to prevent conditions (such as crevices) where contaminants could accumulate (ANSI/ANS-57.9-1992 (R 2000), Section 6.4.1.10).

[RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8, with all sections in the RGA designated for engineering action to be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.9.7.8 Decontamination Water Treatment System

The design criteria for the decontamination water treatment system shall be as follows:

1. General design requirements for volume reduction of liquid LLW shall be in accordance with ANSI/ANS 40.35-1991 [DIRS 122381].
2. The system design shall provide for treatment of decontamination water, as appropriate, to ensure that the receiving system design limits are not exceeded. These design limits may include requirements for parameters such as pH, conductivity, pressure, temperature, total suspended solids, total organic components, and oil and grease concentration (ANSI/ANS 40.35-1991, Section 9.2).
3. The process and radiation monitoring devices shall be designed to provide continuous monitoring and recording of information about treated liquids (ANSI/ANS-55.6-1993 (R 1999) [DIRS 177849], Section 5.5).
4. The decontamination water treatment system piping (ASME B31.3-2004 (R2005) [DIRS 176242]) shall be designed to eliminate traps, loops and minimize flanges that might accumulate radioactive material (ANSI/ANS 57.7-1988 (R 1997) [DIRS 177851], Section 6.3.2.10).
5. The design shall avoid the use of built-in crud traps, such as flanged couplings, and dead legs. Construction materials and surface finishes shall be considered to minimize porosity, crevices, and rough machine marks to limit the possibility of tightly adherent contamination, criticality, and to facilitate ease of decontamination (ANSI/ANS 57.7-1988 (R 1997), Section 2.8).
6. The design shall provide for full draining of contaminated piping systems by including the installation of

low-point drains, pump drains, tank vent systems, and drain systems and the elimination of dead legs between valves in system designs (ANSI/ANS 57.7-1988 (R 1997), Section 6.3.2.10).
7. System equipment and piping shall be designed, constructed, and tested in accordance with requirements in ANSI/ANS-55.6-1993 (R 1999), Table 1.
8. The design for the decontamination water treatment system shall have the ability through tank storage and processing rate to accommodate system liquid volumes (ANSI/ANS-55.6-1993 (R 1999), Section 4.9).
9. Collection tank volumes shall be designed to accommodate the maximum liquid input that occurs for that portion of the day when processing is not available as determined by ANSI/ANS-55.6-1993 (R 1999), Sections 4.7.3 (b) and (c). The final tank volumes shall contain an additional 20 % safety factor and 10 % freeboard (ANSI/ANS-55.6-1993 (R 1999), Section 4.8).
10. Dikes and retention basins for outdoor liquid storage shall be capable of preventing runoff in case of a tank overflow (ANSI/ANS-55.6-1993 (R 1999), Sections 4.2 and 5.2.1.1).
11. The system is not designed to process decontamination water containing excessive quantities of oil or other organic materials. Specific design measures shall be incorporated to prevent oil or other organic materials from entering the water stream and shall be provided with a means to detect and eliminate such materials from the system during operations (ANSI/ANS-55.6-1993 (R 1999), Section 5.1).
12. Equipment or components of the system shall be selected on the basis of performance requirements, ease of operations, reliability, and ease of maintenance or replacement of components in accordance with ANSI/ANS-55.6-1993 (R 1999), Section 5.1.1.
13. A tank design that eliminates crevices and pockets shall provide for complete drainage. Conical or sloped bottom tanks shall be used (ANSI/ANS 55.1-1992 (R 2000) [DIRS 177848], Section 5.2.2).
14. Sampling of effluent shall be in accordance with applicable provisions of ANSI/ANS-55.6-1993 (R 1999), Section 4.6.

[ANSI/ANS 40.35-1991, ANSI/ANS-55.6-1993 (R 1999), ANSI/ANS 57.7-1988 (R1997), and ASME B31.3-2004. Although a later version of ASME B31.3 is available, the responsible DEM has elected to utilize the referenced version.]

4.9.8 Site-Generated Non-Radioactive Waste Management Design Criteria

4.9.8.1 Waste Processing Codes and Standards

The following are the codes, standards, industry guides, regulatory guides, CFRs, and DOE orders and standards that should be applied in the design of the Site-Generated Non-Radioactive Waste Management System:

- *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]),
- IEEE Std 142-1991 [DIRS 176545],
- IEEE Std 383-2003 [DIRS 171695],
- NFPA 70 [DIRS 177982],
- NFPA 780-2004 [DIRS 173517],
- NRS 444 [DIRS 178072],
- 29 CFR 1910 [DIRS 177507],
- 29 CFR 1926 [DIRS 177634],
- 40 CFR 110, *Protection of Environment: Discharge of Oil* [DIRS 181980],
- 40 CFR 133, *Protection of Environment: Secondary Treatment Regulation* [DIRS 181984],
- 40 CFR 243, *Protection of Environment: Guidelines for the Storage and Collection of Residential, Commercial, and Institutional Solid Waste* [DIRS 177837],
- 40 CFR 279, *Protection of Environment: Standards for the Management of Used Oil* [DIRS 181971],
- *Clean Water Act of 1977* (33 U.S.C. 1251) [DIRS 160406],
- *Pollution Prevention Act of 1990* (42 U.S.C. 13101)[DIRS 103930]

[*Although a later version of* NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

4.9.8.2 Not Used

4.9.8.3 General Design Criteria for Processing RCRA Hazardous Waste

4.9.8.3.1 Hazardous Waste Processing

The design of the hazardous waste processing system, equipment, and facilities shall minimize the generation of hazardous waste streams prior to recycling and disposal.

[40 CFR 35, Protection of Environment: State and Local Assistance [DIRS 178224].]

4.9.8.3.2 Solid Waste Capacity

The hazardous waste processing system shall accommodate waste volumes generated during normal operation as well as those from anticipated maintenance activities. In addition, the system should accommodate solid waste input for a reasonable period of time when normal shipment of packaged hazardous solid waste from the repository is not possible (i.e., up to 180 days of anticipated normal waste generation).

[40 CFR 265, Protection of Environment: Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities [DIRS 178105], Subparts J, AA, BB, and CC , except 40 CFR 265.197(c) and 265.200; and/or containment buildings complying with Subpart DD of 40 CFR 265 (design standards specified in 40 CFR 265.1101), 40 CFR 262.34(a)(1)(ii and v), Protection of Environment: Standards Applicable to Generators of Hazardous Waste [DIRS 177843].]

4.9.8.3.3 Handling of Universal Waste

The hazardous waste processing system shall take into account the design measures necessary to implement requirements for the handling of universal waste. Electrical system design and components should minimize the use of batteries and lead-acid batteries, mercury containing equipment, and common universal waste electric lamps to minimize the generation of solid waste controlled.

[40 CFR 273, Protection of Environment: Standards for Universal Waste Management [DIRS 181970].]

4.9.8.3.4 Satellite Accumulation Areas

Provisions shall be made for the collection and accumulation of hazardous waste at or near the point of generation. These areas are known as satellite accumulation areas (SAAs) and are used for the temporary accumulation of hazardous waste. SAAs shall be located away from areas that may generate or stage LLW in order to prevent the generation of mixed waste. The SAAs shall be marked as hazardous waste accumulation areas.

[40 CFR 262 [DIRS 177843].]

4.9.8.3.5 Permanent Accumulation Areas

Full containers of hazardous waste shall be moved from a SAA to a project accumulation area (PAA) located away from the generation site. The PAA shall consist of separate facilities to segregate the hazardous waste types for consolidation, staging, and transportation. The PAA shall be furnished with electrical power, heating, ventilation, and air-conditioning. Universal waste handling shall be provided as part of the PAA.

[40 CFR 262 [DIRS 177843.]]

4.9.8.3.6 Hazardous Load Weight

A means shall be provided for obtaining the load weight of hazardous material being transported to a treatment, storage, or disposal facility.

[49 CFR 172, Transportation: Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements [DIRS 181974] and 49 CFR 173, Transportation: Shippers--General Requirements for Shipments and Packagings [DIRS 181975].]

4.9.8.4 General Design Criteria for Processing Non-Hazardous Solid Waste

4.9.8.4.1 Non-Hazardous Solid Waste Processing

The design of non-hazardous solid waste processing systems, equipment, and facilities shall minimize the generation of non-hazardous waste streams prior to recycling and disposal.

[40 CFR 35 [DIRS 178224].]

4.9.8.4.2 Environment Protection

The design of the non-hazardous solid waste processing system shall ensure that the environment is protected.

[40 CFR 257, Protection of Environment: Criteria for Classification of Solid Waste Disposal Facilities and Practices [DIRS 177840].]

4.9.8.4.3 Facility Size

A fenced in area of sufficient size to accommodate the PAA facilities, office facilities, and non-hazardous waste processing facilities shall be provided.

[Design of the operating area must allow for the segregation of waste types.]

4.9.8.4.4 Rock Excavation and Storage

Subsurface excavated rock from repository development shall be transported to the surface and stored in appropriate sized excess rock storage piles in the vicinity of the South Portal and the North Construction Portal area. The excess rock will be placed in a controlled manner to ensure that runoff will not degrade surface or underground water, the fill is stable and designed using standard engineering practices, and pollution controls meet existing regulations.

[30 CFR 817, Mineral Resources: Permanent Program Performance Standards--Underground Mining Activities [DIRS 177832].]

4.9.8.4.5 Topsoil Stockpiles

Topsoil shall be removed from areas where construction of facilities is designated and placed in topsoil stockpiles in accordance with *Reclamation Implementation Plan* (YMP 2001 [DIRS 154386]).

[30 CFR 817 [DIRS 177832] and NAC 519A, Reclamation of Land Subject to Mining Operations or Exploration Projects [DIRS 172702].]

4.9.8.5 General Design Criteria for Processing Non-Hazardous Liquid Waste

4.9.8.5.1 Design of Non-Hazardous Liquid Waste Processing

The SSCs of the non-hazardous liquid waste processing system shall be designed and tested to the requirements set forth in codes and standards for non-ITS SSCs.

[This criterion is required in order to establish a set of accepted codes and standards for design, construction, materials, welder and welding procedure qualification, and inspection and testing for various categories of mechanical equipment used in the system.]

4.9.8.5.2 Environmental Protection

The design for the non-hazardous liquid waste processing system shall ensure that non-hazardous liquid waste systems are designed, installed, and operated in a manner commensurate with the need to protect personnel and the environment.

[40 CFR 125, Protection of Environment: Criteria and Standards for the National Pollutant Discharge Elimination System [DIRS 181983].]

4.9.8.5.3 Waste Minimization

The design for the non-hazardous liquid waste processing systems shall ensure that the SSCs for the non-hazardous liquid waste processing systems provides for the development of procedures and programs to emphasize waste minimization and pollution prevention practices.

[40 CFR 35 [DIRS 178224].]

4.9.8.5.4 Sanitary Sewage Collection System

The design and construction of the sanitary sewage collection system shall comply with the requirements of NAC 444 [DIRS 104039] and Section 4.2.6.

[This criterion ensures that the design of the sanitary sewage collection system meets State of Nevada

requirements and good engineering practices.]

4.9.8.5.5 Treatment of Effluent in Secondary Wastewater

The system for the processing of non-hazardous liquid wastes shall ensure that applicable procedures are developed and implemented for the control and treatment of effluent pollutants in secondary wastewater.

[40 CFR 136, Protection of Environment: Guidelines Establishing Test Procedures for the Analysis of Pollutants [DIRS 181985].]

4.9.8.5.6 Oil Pollution Prevention

Non-hazardous liquid waste processing systems shall be designed to minimize oil pollution of the environment.

[40 CFR 112 [DIRS 181981].]

4.9.8.5.7 Storm Water Run-off

All disturbed surface areas of the repository shall be designed to accommodate storm water run-off depending on the functional requirements of the associated facility. Design requirements shall be in accordance with Section 4.2.7.1.

[30 CFR 817 [DIRS 177832].]

4.9.8.5.8 Evaporation Pond

Industrial wastewater evaporation ponds shall be constructed to contain wastewater generated by surface and subsurface operations. The evaporation ponds shall be constructed with impermeable liners, where warranted, to prevent wastewater percolation into the underlying ground water system. Evaporation ponds shall be constructed in accordance with requirements to be developed in Section 4.2.7.

Oil-contaminated wastewater evaporation ponds shall be constructed to contain processed oil-contaminated wastewater generated by surface and subsurface operations. These evaporation ponds shall be constructed to allow collected oil-contaminated wastewater to percolate to the bottom of the pond in accordance with requirements to be developed in section 4.2.7.

[40 CFR 35 [DIRS 178224].]

4.9.8.6 Processing of Non-Radioactive Recyclable Solids and Liquids

Non-radioactive waste handling facilities shall provide for the processing of recyclable solids and liquids that are removed from the waste stream and shipped to commercial recyclers.

[Recyclables will be separated from the non-hazardous waste stream as a matter of practice according to the provisions in NAC 444 [DIRS 104039], NAC 444A, Programs for Recycling [DIRS 166414], and 40 CFR 246, Protection of Environment: Source Separation for Materials Recovery Guidelines [DIRS 177838].]

4.10 Nuclear Design Criteria

4.10.1 Nuclear Engineering Design Criteria

4.10.1.1 Nuclear Engineering Codes and Standards

4.10.1.1.1 Codes and Standards

The following are the codes, standards, industry guides, regulatory guides, CFRs, and DOE orders and standards that should be applied in Nuclear Engineering Design:

- ANSI N13.8-1973, *American National Standard Radiation Protection in Uranium Mines* [DIRS 124614],
- ANSI N305-1975, *Design Objectives for Highly Radioactive Solid Material Handling and Storage Facilities in a Reprocessing Plant* [DIRS 108309],
- ANSI/ANS-57.1-1992 (R 2005), *American National Standard, Design Requirements for Light Water Reactor Fuel Handling Systems* [DIRS 177850],
- ANSI/ANS-59.3-1992 (R 2002), *American National Standard, Nuclear Safety Criteria for Control Air Systems* [DIRS 177854],
- ANSI/ANS-6.4.2-1985 (R2004), *American National Standard Specification for Radiation Shielding*

Materials [DIRS 177856],
- ASTM C 1217-00 (R 2006),*Standard Guide for Design of Equipment for Processing Nuclear and Radioactive Materials* [DIRS 177899],
- Regulatory Guide 8.38 [DIRS 177548],
- Regulatory Guide 8.8 [DIRS 103312],
- 10 CFR 61 [DIRS 181966],
- 10 CFR 71 [DIRS 181967],
- 49 CFR 173 [DIRS 181975],
- DOE-HDBK-1169-2003 [DIRS 167097]

[These regulatory guides have been determined to be useful to the development of design products for the preliminary design. The level of conformance with regulatory positions in the regulatory guides will be determined during the design process and in the development of design products that are affected by these regulatory guides. Applicable sections of these documents will be determined during the design process and in the development of design products. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8 with all sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria. RGA REG-CRW-RG-000364, Agreement for Regulatory Guide 8.38, Revision 1 - Control of Access to High and Very High Radiation Areas of Nuclear Plants (BSC 2007 [DIRS 181631]) has adopted requirements of Regulatory Guide 8.38. Although ANSI N13.8-1973 is inactive and was reaffirmed in 1989, the text of this version is still appropriate for use.]

4.10.1.2 General Radiation Dose Criteria for Occupationally Exposed Personnel

The repository surface and subsurface facility design shall meet the following general dose criteria for occupationally exposed personnel.

- Maximum individual total effective dose equivalent (TEDE) is limited to less than or equal to 5 rem/yr.
- Maximum sum of deep-dose equivalent and committed dose equivalent to any organ or tissue other than the lens of the eye is limited to less than or equal to 50 rem/yr.
- Maximum lens dose equivalent is limited to less than or equal to 15 rem/yr.
- Maximum shallow-dose equivalent to the skin or any extremity is limited to less than or equal to 50 rem/yr.

[The general radiation dose criteria are required to meet the occupational dose requirements in 10 CFR 20.1201 [DIRS 181962]. The YMP ALARA design goals are specified in Section 4.10.3. The dose criteria for the general public are addressed separately in the BOD (BSC 2007 [DIRS 182131]), Chapter 2, Section 2.2.3.1. RGA REG-CRW-RG-000122, Agreement for Regulatory Guide 1.145, Rev. 1 - Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants (BSC 2007 [DIRS 181763]) has provided guidance for Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants [DIRS 103651] to develop a site specific source term for occupational dose calculations in Section C and Appendix A.]

4.10.1.3 Specific Dose Rate Criteria for Shielding Design

The specific dose rate criteria for use in shielding design for the surface and subsurface facilities (below) shall be consistent with the general dose criteria established in Section 4.10.1.2 and the ALARA design goals specified in Section 4.10.3.

Table 4.10.1-1. Dose Rate Criteria

Description Dose Rate Criteria	Criteria[a]	Basis
Dose rates exterior to SNF/HLW process facilities at personnel level[b]	≤ 0.25 mrem/hr[d]	To allow continuous occupational access in support of ALARA goal of 500 mrem/yr.
Dose rates exterior to SNF/HLW process facilities above the personnel level[b]	≤ 2.5 mrem/hr	Higher dose rate is allowed above personnel level provided the contribution from the high level will not cause the dose rate on the personnel level to exceed the criterion. Does not include areas that affect external stairways.

Operating galleries, support rooms, offices at personnel level[b]	≤ 0.25 mrem/hr[d]	To allow continuous occupational access in support of ALARA goal of 500 mrem/yr.
Operating galleries, support rooms, offices above personnel level[b]	≤ 2.5 mrem/hr	Higher dose rate is allowed above personnel level provided the contribution from the high level will not cause the dose rate on the personnel level to exceed the criterion.
Intermittent access in restricted areas	≤ 100 mrem/hr	Dose rate criterion will vary with the access requirement for each area provided the general dose criteria are met.
Waste Package (WP) Transfer Trolley and Canister Transfer Machine (CTM) contact dose rate	≤ 100 mrem/hr	Minimal access is required around the WP Transfer Trolley and CTM. Shielding is to protect operators when working around the WP Transfer Trolley and CTM. This limit will prevent the area around the WP Transfer Trolley and CTM from being a high radiation area thus eliminating the need for additional controls around the WP Transfer Trolley and CTM.
TAD, DOE Canister and Port Slide Gates contact dose rate	≤ 100 mrem/hr	Minimal access is required around the Slide Gates. Shielding is to protect operators when working around the Slide Gates. This limit will prevent the area around the Slide Gates from being a high radiation area thus eliminating the need for additional controls around the Slide Gates.
Outside or beyond the restricted area boundary	≤ 0.05 mrem/hr[d]	Applicable to controlled and unrestricted areas where members of the public have access to comply with 10 CFR 20.1301(a)(1) [DIRS 181962]. Includes normal operations and Category 1 event sequences.
TEV at 11.81 in. (30 cm[c]) from external accessible surface	≤ 100 mrem/hr	Minimal access is required around the TEV. Shielding is to protect operators when working around the TEV. These activities include, but are not limited to, locomotive operation, transport survey, and decontamination activities.
Access main	≤ 5 mrem/hr	For the area facing each emplacement drift. The dose rate for the area between the two adjacent drifts is considerably lower because of substantial shielding by the host rock for conditions without the TEV present in the access main.
Turnout bulkhead location	≤ 20 mrem/hr	For the dose rates on the access main side of the door. Access is only expected for door maintenance.
Exhaust main	N/A	Normal access is precluded, because of thermal conditions in the exhaust main.
Shielded Transfer Cask	≤ 100 mrem/hr	Shielding on all sides of the Shielded Transfer Casks is to protect operators when working around the Shielded Transfer Casks. This limit will prevent the area around the Shielded Transfer Cask from being a high radiation area thus eliminating the need for additional controls around the Shielded Transfer Cask.
Aging Overpack and Horizontal Aging Module for Vertical and Horizontal Dual Purpose Canisters	≤ 40 mrem/hr	The combined neutron and gamma contact dose rate on any accessible exterior surface shall not exceed 40 mrem/hr at any location on a loaded aging overpack. This includes air circulation ducts, penetrations and any other potential streaming paths on the

		overpack surface. This limit will prevent the area around the aging overpack from being a high radiation area during transport to the aging pad and once the aging overpack is placed on the pad.

NOTES:
[a] The dose rate criteria are set on the basis of deep dose equivalent for static whole body radiation fields. Higher dose rates may be accepted for transient radiation fields (e.g., source movements). Higher dose rates may also be accepted for localized radiation fields (e.g., beams) that are not likely to result in significant whole body dose. Dose rate criterion exceptions are subject to an appropriate ALARA justification that may include the effect on individual annual doses.
[b] Personnel level is defined as the level within 8-ft height.
[c] The distance criterion is per definition of high radiation area in 10 CFR 20.1003 [DIRS 181962].
[d] The dose rate provided is based on 2000 hours occupancy per year. If the hours of occupancy are increased to 2500 hours, the dose rates will change to ≤ 0.04 mrem/hr (from ≤ 0.05 mrem/hr) and ≤ 0.20 mrem/hr respectively.

[The specific dose rate criteria are required for the surface and subsurface facility shielding design to determine shielding thickness. These criteria are consistent with the general dose criteria provided in Section 4.10.1.2 and based on the personnel access requirements and radiological classifications for the various facility areas.]

4.10.1.4 Shielding Source Term Criteria

Shielding source terms for the surface and subsurface facility design shall be based on the limiting waste form as well as the limiting waste package type.

Design basis and maximum source terms shall be established to provide sufficient and bounding coverage, respectively, of the historical and projected fuel inventory for normal operations and Category 1 event sequences. The design basis source term shall cover a minimum of 95 % of the total inventory, with provisions made available to accommodate the remaining 5 %. The maximum source term shall represent the bounding fuel assembly in the entire inventory to be received at the repository. Use of the design basis or maximum source term shall be justified on a case-by-case basis.

Minimum initial enrichment shall be established in accordance with "SFPO-ISG- 6, *Establishing Minimum Initial Enrichment for the Bounding Design Basis Fuel Assembly(s)* [DIRS 175987] for the selected fuel assembly used in determining the source term because lower enriched fuel irradiated to the same burnup as higher enriched fuel produces a higher source term.

[The source term criteria are required to provide the radiation source terms as a basis for the surface and subsurface facility shielding design. These criteria are consistent with those used in the previous YMP shielding calculations and NRC regulatory guidance. "Contract No. DE-AC28-01RW12101 - Licensing Position-009, Waste Stream Parameters" (Williams 2003 [DIRS 166132]) provides guidance and design requirements for the waste stream parameters. RGA REG-CRW-RG-000418 (BSC 2007 [DIRS 181783]) adopted SFPO-ISG-6 with clarification.]

4.10.1.5 Flux-to-Dose Rate Conversion Factors

Shielding calculations shall use the flux-to-dose-rate conversion factors as provided in ANSI/ANS-6.1.1-1977, *Neutron and Gamma-Ray Flux-to-Dose-Rate Factors* [DIRS 107016], for converting the calculated neutron and gamma fluxes to the respective dose rates.

[The selection of this standard complies with 10 CFR 20.1004 [DIRS 181962], Table 1004 (b) 2, and is consistent with the specifications in NUREG-1804 (NRC 2003 [DIRS 163274]), section 2.1.1.5.1.2. Impacts of other dose conversion factors, such as those in conversion coefficients for use in radiological protection against external radiation (ICRP 1997 [DIRS 152060]) on shielding design, shall be evaluated as the need arises. RGA REG-CRW-RG-000399, Agreement for NUREG-1804, Rev 2 Yucca Mountain Review Plan, Final Report (BSC 2007 [DIRS 182359]) with clarification by mapping a crosswalk to the License Application.

The flux-to-dose-rate conversion factors are required to convert the calculated neutron and gamma fluxes to dose rates for demonstration of regulatory compliance. The NRC has accepted the use of the ANSI/ANS-6.1.1-1977 [DIRS 107016] standard for this conversion. Although a later version of ANSI/ANS-6.1.1 is available, the responsible DEM has elected to utilize the referenced version.

Although DOE provide Contracting Officer direction to implement an updated dose modeling protocol utilizing more recent International Commission on Radiation Protection (ICRP) publications (Miller 2004 [DIRS 178320]) and BSC provided a plan to update the models (Mitchell 2005 [DIRS 178319]), DOE did not approve the changes and a BCP was not completed. Therefore, the updated conversion factors will not be utilized for shielding calculations.]

4.10.1.6 Shielding Computational Methods

Shielding calculations shall be performed using the NRC-accepted computer codes that have been benchmarked, validated, qualified, and baselined in accordance with the project software management procedure. The analytical tools may include codes that use Monte Carlo, and deterministic transport techniques for the various shielding problems encountered in the repository design. Currently, these codes include Monte Carlo N-Particle and SCALE.

[The qualified shielding codes are required to perform shielding calculations. The NRC has accepted these computer codes for shielding analyses for spent fuel storage facilities and transportation packaging. The NRC recognizes the acceptance or applicability of these codes for analysis for spent fuel storage facilities in NUREG-1567, Standard Review Plan for Spent Fuel Dry Storage Facilities [DIRS 149756], section 7.5.4.1. RGA REG-CRW-RG-000392 (BSC 2007 [DIRS 182585]) has adopted NUREG-1567 with clarification.]

4.10.1.7 Concrete Shielding Design

Concrete shielding shall be analyzed and designed in accordance with ANSI/ANS-6.4-2006, *Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants* (ANSI 2006 [DIRS 181669]) .

[RGA REG-CRW-RG-000058, Agreement For Regulatory Guide 1.69, Rev. 0 - Concrete Radiation Shields for Nuclear Power Plants (BSC 2007 [DIRS 181671]) has provided guidance for ANSI/ANS-6.4-2006 and ACI 349-01(ACI 2001[DIRS 181670]), as acceptable alternative to Regulatory Guide 1.69 [DIRS 158959]. These are an industry standards. Although the repository is not a power plant, the design standards for shielding apply to the design.]

4.10.1.8 General Dose Criteria for the Site

The site dose calculation shall be in accordance with Regulatory Guide 1.109, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50 , Appendix I* [DIRS 100067].

[RGA REG-CRW-RG-000090, Agreement for Regulatory Guide 1.109, Rev. 1 - Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I (BSC 2007 [DIRS 182078]) has provided guidance for Regulatory Guide 1.109, Appendices A through F, to develop a site specific source term for dose calculations (Paragraph C).]

4.10.2 Criticality Design Criteria

4.10.2.1 Deleted

[Deleted specific regulations addressing criticality.]

4.10.2.1.1 Criticality Safety Design Criterion

SSCs shall be designed such that adequate controls and procedures can be effectively implemented to:

- prevent criticality and institute controls that are relied on to limit or prevent potential event sequences or mitigate their consequences during processing, handling, transfer, or transport of the waste form or waste package in the preclosure period and
- ensure compliance with the waste form and waste package performance objectives during the postclosure period.

[This criterion is supported by the requirements in 10 CFR 63.112(e)(6) [DIRS 180319] for the preclosure period

and 10 CFR 63.113 for the postclosure period. Bullets added in response to CR 10685 and CBCN016 to Revision 6.]

4.10.2.1.2 Criticality Safety Design Margin

For the Preclosure period, the repository facilities and TAD canisters shall be designed for nuclear criticality safety. The criteria for nuclear criticality safety shall be met by ensuring that under all normal conditions and Category 1 and Category 2 event sequences, the calculated multiplication factor, k_{eff}, at the upper limit of a two-sided 95 % confidence interval, shall not exceed the upper subcritical limit (a limiting value of k_{eff} that accounts for biases and uncertainties and an administrative margin to ensure subcriticality).

[This criterion is a consequence of 10 CFR 63.112(e)(6) [DIRS 180319] which requires that the repository provide the means to prevent and control criticality. Statement added for preclosure period in response to CR 10685.]

4.10.2.2 Facility Criticality Safety

For the Preclosure period, the repository surface nuclear facilities, mechanical handling systems, Subsurface Facility, and TAD canisters shall be designed to comply with the criticality criteria in DOE O 420.1A, *Facility Safety* [DIRS 159450], Section 4.3, except that the double contingency principle in Section 4.3.2(d)(1) may not be demonstrated.

[DOE O 420.1A [DIRS 159450] is allocated to Engineering through the requirements management system. Although DOE O 420.1A identifies the double contingency principle, all facility and waste package designs are using the risk-informed, performance-based methodology as required by 10 CFR 63 [DIRS 180319], which takes precedence over DOE O 420.1A. The introduction to 10 CFR 63 actually uses the risk-informed, performance-based terminology, and is consistent with the NRC policy statement in 60 FR 42622 [DIRS 103662], Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities: Final Policy Statement. The abstract of the Yucca Mountain Review Plan Final Report, NUREG-1804, Rev 2 (NRC 2003 [DIRS 163274]) indicates that 10 CFR 63 and the review plan are risk-informed, performance-based to the extent practical. Statement added for preclosure period in response to CR 10685. RGA REG-CRW-RG-000399, Agreement for NUREG-1804, Rev 2 Yucca Mountain Review Plan, Final Report (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application.]

4.10.2.2.1 Referenced Criticality Standards

The basic elements and control parameters of programs for nuclear criticality safety should be consistent with the criteria given in the following ANSI/ANS nuclear criticality safety standards:
Preclosure and Postclosure periods

- ANSI/ANS-8.1-1998, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors* [DIRS 123801], however, paragraphs 4.2.2, 4.2.3 and 3.3 shall be followed (as modified in Section 4.3.3.d of DOE O 420.1A [DIRS 159450])
- ANSI/ANS-8.17-2004 [DIRS 176225], R89, American National Standard, *Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors*, however, paragraph 4.3 shall be followed (as modified in Section 4.3.2.g of DOE O 420.1A [DIRS 159450])
- ANSI/ANS-8.21-1995 (R 2001), *Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors* [DIRS 176893].

Preclosure period

- ANSI/ANS-8.3-1997, (R 2003), *Criticality Accident Alarm System* [DIRS 176884], however, paragraphs 4.1.2, 4.2.1, and 4.2.2 shall be followed (as modified in Sections 4.3.3.c and 4.3.3.e of DOE O 420.1A [DIRS 159450])
- ANSI/ANS-8.14-2004 , *American National Standard, Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors* [DIRS 178573],
- ANSI/ANS-8.22-1997, *American National Standard for Nuclear Criticality Safety Based on Limiting and Controlling Moderators* [DIRS 158946] .

[DOE O 420.1A Contractor Requirement 4.3.3 b provides for the list of standards to be used. Standards for subcritical activities, cubic storage, aqueous solutions, special actinides, shielding and confinement, operational controls, and fuel mixtures are not applicable to YMP Engineering activities. Revisions to any of the ANSI/ANS standards listed above will require review by DOE. Statements added for preclosure and postclosure periods, ANSI/ANS-8.14, ANSI/ANS-8.21, and ANSI/ANS-8.22 in response to CR 10688 and CBCN016 to Revision 6.]

4.10.2.3 Revised Criticality Standards not Specified by DOE

The following ANSI/ANS codes and standards may be considered in criticality design: ANSI/ANS-8.1-1998 [DIRS 123801] and ANSI/ANS-8.3-1997 (R 2003) [DIRS 176884]. These standards are date revisions that have not been specifically reviewed by DOE as required by DOE Order 420.1A.

4.10.2.4 Standards Not Listed by DOE

The following ANSI/ANS standards should be used in criticality design:

- ANSI/ANS-8.22-1997 [DIRS 158946]
- ANSI/ANS-57.9-1992 (R2000) [DIRS 176945].

[Previously listed in PDC but not cited by DOE. RGA REG-CRW-RG-000240, Agreement for Regulatory Guide 3.71 - Nuclear Criticality Safety Standards for Fuels and Materials Facilities (BSC 2007 [DIRS 182784]) has provided guidance for Regulatory Guide 3.71 to use ANSI/ANS 8.22-1997 standard.]

4.10.2.5 Postclosure Criticality Methodology

4.10.2.5.1 Deleted

[Moved to BOD (BSC 2007 [DIRS 182131]), Section 33 as a duplicate requirement.]

4.10.2.5.2 Verification of Burnup Assignment

For the Postclosure period, SSCs shall be designed such that adequate controls and procedures can be effectively implemented to ensure that acceptable verification of the burnup assignment of received CSNF has been made and to meet the probability levels used in the criticality features, events, and processes (FEPs) screening evaluation.

[This criterion is required by Disposal Criticality Analysis Methodology Topical Report (YMP 2003 [DIRS 165505], Section 3.5.2.1.3). Statement added for postclosure period in response to CR 10685 and CBCN016 Revision 6.]

4.10.2.6 NUREG-1520 Guidance

For the Preclosure period, the repository Criticality Design should consider the guidance in NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility* [DIRS 159567].

[This guidance is considered potentially applicable to the design of the repository based on expected functions. Statement added for preclosure period in response to CR 10685 and CBCN016 to Revision 6.

Note: The RGA for NUREG-1520 is being developed but not finalized, and is being used prior to final RGA adoption.]

4.10.2.6.1 Moderator Control

For the Preclosure period, where moderator control is needed for nuclear criticality safety during preclosure, the facility or waste package shall:

1. Limit the amount of moderator that may be present in any area where fissionable materials are being handled (cask unloading, storage areas, waste package loading area, and waste package closure area) to show that there is no criticality concern under all normal conditions, Category 1 event sequences, and Category 2 event sequences.
2. Have engineered barriers (e.g., seals, walls, barriers, curbs, and drains) to prevent moderator from other areas entering the area where fissionable materials are being handled, considering the potential hazards (e.g., seismic activity and fire fighting activities in adjacent areas) that could compromise the integrity of the engineered barriers.
3 Minimize the number of penetrations into moderator control areas, and provide limits and controls as necessary to maintain the moderator control.
4. Design any instrumentation and controls, which are used to detect or prevent the presence of moderator, to fail safe and function under normal conditions, Category 1 event sequences, and Category 2 event sequences.
5. Limit the use of oils or other lubricants that may be present in any moderator control areas to those that have no more moderating effect than water.

[This criterion is based on ANSI/ANS-8.22-1997 [DIRS 158946], Section 5 and NUREG-1520 [DIRS 159567], Section 5.4.3.4.2. Item number 6 from the previous version of this criterion was deleted as a result of the change to the TAD canister-based repository disposal concepts. The TAD canisters by definition are disposable without

the addition of filler materials or additional moderator controls. Statement added for preclosure period in response to CR 10685 and CBCN016 to Revision 6.]

4.10.2.6.2 Design CSNF TAD Canisters for Verification of Neutron Absorber Material

For the Preclosure and Postclosure periods, SSCs shall be designed such that adequate controls and procedures can be effectively implemented to ensure that neutron absorber materials are inserted into the CSNF TAD canisters, as required, to meet preclosure criticality requirements and to meet the probability levels used in the criticality FEPs screening evaluation.

[This criterion is based on NUREG-1520 [DIRS 159567], Section 5.4.3.4.2 and ANSI/ANS-8.21-1995 (R 2001) [DIRS 176893], Section 5. Statement added for preclosure and postclosure periods in response to CR 10685 and CBCN016 to PDC Revision 6.]

4.10.2.6.3 Design SSCs to Ensure Correct Loading of CSNF Assemblies

For the Postclosure period, SSCs shall be designed such that adequate controls and procedures can be effectively implemented to ensure correct loading of the CSNF assemblies into a TAD canister as prescribed by the derived TAD canister loading curves, to meet the probability levels used in the criticality FEPs screening evaluation.

[This criterion is based on NUREG-1520 [DIRS 159567], Section 5.4.3.4.2. Statement added for postclosure period in response to CR 10685. CBCN016 to Revision 6 provided the period statement.]

4.10.2.6.4 Ensure TAD Canister Closure Precludes Moderator Intrusion

For the Preclosure and Postclosure periods, SSCs shall be designed such that adequate controls and procedures can be effectively implemented to ensure closure of the TAD canister is performed in a manner to preclude moderator intrusion unless the proposed quantity of moderator material can be shown to impose no criticality concerns through providing moderation (preclosure) or enhanced corrosion (postclosure).

[This criterion is based on NUREG-1520 [DIRS 159567], Section 5.4.3.4.2. Statement added for preclosure and postclosure periods in response to CR 10685 and CBCN016 to Revision 6.]

4.10.2.7 NUREG-1567 Guidance

For the Preclosure period, the repository criticality design should consider the guidance provided in NUREG-1567 (NRC 2000 [DIRS 149756]).

[RGA REG-CRW-RG-000392, Agreement for NUREG-1567, March 2000, Standard Review Plan for Spent Fuel Dry Storage Facilities - Final Report (BSC 2007 [DIRS 182585]) adopted NUREG-1567 with clarification. NRC guidance is potentially appropriate for this function. Statement added for preclosure period in response to CR 10685 and CBCN016 to PDC Revision 6.]

4.10.2.7.1 Credit for Fixed Neutron Absorber

For the Preclosure period, fixed-neutron absorbers used for criticality control such as grid plates or inserts, no more than 75 % credit of the neutron absorber content shall be used for preclosure criticality analyses, unless comprehensive fabrication acceptance tests verify that the presence and uniformity of the neutron absorber are more effective.

[This criterion is based on NUREG-1567 [DIRS 149756], Section 8.4.1.1. RGA REG-CRW-RG-000392, Agreement for NUREG-1567, March 2000, Standard Review Plan for Spent Fuel Dry Storage Facilities - Final Report (BSC 2007 [DIRS 182585]) adopted NUREG-1567 with clarification. Statement added for preclosure period in response to CR 10685 and CBCN016 to Revision 6.]

4.10.2.8 Criticality Regulatory Guides

For the Preclosure period, Regulatory Guide 3.71, *Nuclear Criticality Safety Standards for Fuels and Materials Facilities* [DIRS 176331] should be applied in criticality design.

[This regulatory guide has been determined to be useful to the development of design products for the committed design. The level of conformance with regulatory positions in the regulatory guide will be determined during the design process and in the development of design products that are affected by this regulatory guide. Statement added for preclosure period in response to CR 10685 and CBCN016 to Revision 6. RGA REG-CRW-RG-000240, Agreement for Regulatory Guide 3.71 - Nuclear Criticality Safety Standards for Fuels and Materials Facilities (BSC 2007 [DIRS 183187]) has provided guidance for Regulatory Guide 3.71 to use the ANSI/ANS 8.3-1997 and

ANSI/ANS 8.22-1997 standards.]

4.10.2.9 ASTM Criticality Standard

For the Preclosure period, ASTM C 992-06, *Standard Specification for Boron-Based Neutron Absorbing Material Systems for Use in Nuclear Spent Fuel Storage Racks* [DIRS 177901] should be applied in criticality design.

[This is an appropriate industry standard for criticality design. Statement added for preclosure period in response to CR 10685 and CBCN016 to Revision 6.]

4.10.3 As Low As is Reasonably Achievable Design Criteria

4.10.3.1 ALARA Codes and Standards

The following are the codes, standards, industry guides, regulatory guides, CFRs, and DOE orders and standards that should be applied in ALARA Design:

- NUREG-1567 (NRC 2000 [DIRS 149756]),
- Regulatory Guide 8.19, *Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants -- Design Stage Man-Rem Estimates* [DIRS 148894],
- DOE-HDBK-1169-2003 [DIRS 167097].

[These have been determined to be useful to the development of design products. Applicable sections of these documents will be determined during the design process and in the development of design products. RGA REG-CRW-RG-000392, Agreement for NUREG-1567, March 2000, Standard Review Plan for Spent Fuel Dry Storage Facilities - Final Report (BSC 2007 [DIRS 182585]) adopted NUREG-1567 with clarification. RGA REG-CRW-RG-000345, Agreement for Regulatory Guide 8.19, Revision 1 - Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants -- Design Stage Man-Rem Estimates (BSC 2007 [DIRS 181779]) has provided guidance for Regulatory Guide 8.19 to perform a site specific dose assessment.]

4.10.3.2 Implement ALARA in GROA Design

All repository facilities shall be analyzed and designed in accordance with EG-DSK-3701, *Application of ALARA in the YMP Design Process* and appropriate sections of Regulatory Guide 8.8 [DIRS 103312], *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will be as Low as is Reasonably Achievable*.

[10 CFR 63.111(a) [DIRS 180319] references 10 CFR 20 [DIRS 181962]. 10 CFR 20.1101(b) requires: "The licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are ALARA." The criteria in this section and in the design guide fulfill that requirement. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8 with all sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.10.3.3 ALARA Design Goals

4.10.3.3.1 ALARA Design Goals

The ALARA design goals for occupational workers are to ensure that individual and collective doses shall be maintained at ALARA levels during normal operations and as a result of Category 1 event sequences. Category 1 event sequences shall be included in worker dose assessments. The design process shall meet the following ALARA design goals:

- The ALARA design goal for individual radiation worker doses is to minimize the number of individuals that have the potential of receiving more than 500 mrem/yr TEDE. That goal is 10 % of the annual TEDE limit in 10 CFR 20.1201 [DIRS 181962], and includes internal and external doses.
- The ALARA design process is to ensure that the collective dose is maintained ALARA.
- The ALARA goal for onsite members of the public is to maintain individual doses ALARA below the annual TEDE limit of 100 mrem (10 CFR 20.1301 [DIRS 181962]).
- The annual TEDE to any real member of the public from air emissions of radioactive material to the environment will be limited to an annual dose limit of 10 mrem (10 CFR 20.1101(d) [DIRS 181962]).

[The individual dose goal criterion is required to meet the regulatory guidance contained in Regulatory Guide 8.8 [DIRS 103312], which is a method acceptable to the NRC for implementing the regulatory requirements in 10

CFR 20.1101(b)[DIRS 181962]. This criterion supports compliance with 10 CFR 63.111 (b)(1) [DIRS 180319], which requires, in part, meeting the 10 CFR 20 requirement to achieve occupational doses and doses to members of the public that are ALARA. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.10.3.3.2 Control Concentration of Radioactive Material In Air

Engineering shall design, to the extent practical, process or other engineering controls (e.g., containment, decontamination, or ventilation) to control the concentration of radioactive material in air.

[10 CFR 20.1701 [DIRS 181962].]

4.10.3.3.3 Aging Overpack and/or Shielded Transfer Cask Contamination

The Aging Overpack and/or Shielded Transfer Cask handled in the WHF, CRCF and Receipt Facility shall meet the following surface contamination limits before exiting the facility. The exterior of the shielded transfer cask, and/or the exterior of aging overpack and the interior of the aging overpack (or the exterior surface of the canister contained in an aging overpack), that utilize natural circulation cooling, shall not have removable contamination in excess of:

1. 1,000 dpm/100 cm^2 for non-fixed beta and gamma emitting radionuclide contamination
2. 20 dpm/100 cm^2 for alpha emitting radionuclides

If a loaded overpack is placed into Aging after transport from an off-site location, verification that the removable contamination on the exterior surface of the Overpack and accessible portion of the canister must be made and confirmed to be within limits stated above after receipt of the Overpack and prior to Aging operations.

[IICD (DOE 2007 [DIRS 178792], Section 9.2.1. Though the IICD rerquirement for alpha emitting radionuclides is 110 dpm/100 cm^2 , the value 20 dpm/100 cm^2 is used based on commercial nuclear power industry operating experience and requirements. 10 CFR 20.1406 [DIRS 181962] requires that applicants for licenses, other than renewals, after August 20, 1997, describe in the application how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.]

4.10.3.3.4 Facility Contamination

Contamination within the radiologically controlled areas of the CRCF, Receipt Facility, LLW Facility, IHF and WHF (with the exception of the areas around the WHF pool) shall be maintained at the level defined below to enable maintenance or operational personnel to perform work without any additional controls being imposed such as protective clothing.

1. 1,000 dpm/100 cm^2 for non-fixed beta and gamma emitting radionuclide contamination
2. 20 dpm/100 cm^2 for alpha emitting radionuclides

[IICD (DOE 2007 [DIRS 178792], Section 9.2.1. Though the IICD rerquirement for alpha emitting radionuclides is 110 dpm/100 cm^2 , the value 20 dpm/100 cm^2 is used based on commercial nuclear power industry operating experience and requirements. 10 CFR 20.1406 [DIRS 181962] requires that applicants for licenses, other than renewals, after August 20, 1997, describe in the application how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

4.10.3.4 Cost Benefit Analysis for Design Alternatives

During development of a mature design or when designing modifications to operating facilities, qualitative cost benefit considerations shall be used for comparing design alternatives and justifying design decisions, where appropriate. In determining whether a dose-reducing design alternative is reasonable, $10,000 per person-rem averted shall guide decisions based on current industry practices. Other values may be used, as appropriate, with adequate justification and documentation.

[This criterion is in accordance with the guidance provided in Regulatory Guide 8.8 [DIRS 103312] and related NUREGs. This guidance is a method acceptable to the NRC for implementing the regulatory requirements in 10 CFR 20.1101(b) [DIRS 181962]. 10 CFR 20 is applicable as required by 10 CFR 63.111(b)(1) [DIRS 180319]. The dollar person-rem value is required in order to perform cost benefit considerations. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8 with all sections in the RGA designated for

engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.]

4.10.3.5 Radiological Classification of Facilities

Radiological conditions in facility areas during normal operations and as a result of Category 1 event sequences are fundamental inputs for the ALARA design process. The classification of facility areas shall provide information to designers and engineers for minimizing occupational and public radiation doses by incorporating design features such as access control, equipment layout, and shielding design. Each area of the facility shall be classified by radiological conditions, including dose rate range and contamination information. This classification information is available to designers and engineers in developing and evaluating designs and alternatives. Areas shall be reevaluated as the expected radiological conditions change or as the facility design or functions change during the design evolution.

In the classification process, the dose rate ranges do not include dose rates due to background radiation. The classification of dose rates for a given area or room is normally based on the highest anticipated dose rates. Consideration may be made for localized elevated dose rates or transient elevated dose rates when determining the appropriate dose rate category for the area or room.

Onsite facility areas are classified by radioactive material contamination levels (surface and airborne) to support the ALARA design process. The classification of an area in terms of contamination will be more dependent on the type of control regime necessary than the mean or maximum contamination level present. This reflects the fact that the potential contamination is as important as the actual contamination. The contamination considered is due to licensed material and does not include exposure due to naturally occurring radioactive material.

[This criterion is required to mitigate potential risk associated with radiation dose to occupational workers and the public, and as an element of engineering controls applied to the GROA to support the ALARA philosophy. This criterion is based on the requirements of 10 CFR 20 [DIRS 181962] and the guidance of Regulatory Guide 8.8 [DIRS 103312], NUREG-0800 (12.3) (NRC 1996 [DIRS 177328]), and Interim Staff Guidance HLWRS-ISG-03, Preclosure Safety Analysis - Dose Performance Objectives and Radiation Protection Program [DIRS 182588]. RGA REG-CRW-RG-000338 (BSC 2007 [DIRS 181778]) has adopted Regulatory Guide 8.8 with all sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria. RGA REG-CRW-RG-000385, Agreement for HLWRS-ISG-03, Rev 0, Preclosure Safety Analysis - Dose Performance Objectives and Radiation Protection Program (BSC 2007 [DIRS 181818]) has adopted Interim Staff Guidance HLWRS-ISG-03 with clarification.]

4.10.3.6 Worker Dose Assessments

Worker dose assessments for demonstration of regulatory compliance shall include annual doses for both normal operations and Category 1 event sequences in compliance with 10 CFR 63.111(b)(1) [DIRS 180319]. Annual TEDEs, including internal and external exposures, shall be calculated by summing the contributions from normal operations and frequency-weighted doses from Category 1 event sequences.

[The worker dose assessment criterion is required to calculate annual individual and collective doses to workers, including normal operations and Category 1 event sequences. The summation approach is consistent with that used for offsite dose consequence calculations as part of the preclosure analysis and is consistent with 10 CFR 20.1003 [DIRS 181962] definition of TEDE which is endorsed by 10 CFR 63.111(b)(1).]

4.10.3.7 Classification of Radiation and Contamination Zones

The GROA shall be classified in terms of radiation and contamination zones per Tables 4.10.3-1 and 4.10.3-2 respectively.

Table 4.10.3-1 – Classification of Radiation Zones

Classification	Dose Rate Change (mrem/hr)	Description	Comments[1, 2]	Radiation Protection Controls Training
R1	Background to <0.05	Unlimited Occupancy	Areas including those outside restricted area(s).	No radiation protection controls, no posting, and no training required.
R2	0.05 to 2.5	Routine Occupancy	Routine occupancy, ≤ 2,000 hours per worker per year.	Radiological worker training and dosimetry required. Additionally, access is limited to carry out prescribed tasks in accordance with normal procedures and RWP.
R3	>2.5 to 15	Occasional Occupancy	Areas are occasional access. < 200 hours per worker per year expected.	Same as R2 requirements.
R4	>15 to 100	Infrequent Occupancy	Access in areas is infrequent. <35hours per worker per year expected.	Additional controls or training may be required based on work activities and operational conditions.
R5	>100	Limited or No Occupancy	Access is limited. Occupancy is not normally allowed in these areas. The design intent is that in order to permit access to these areas, the source of radiation must be removed or shielded and dose rate reduced to allow temporary reclassification to R2 or R3.	Normally locked with work done by remote-controlled equipment. Entry is unusual. Supplemental alarming dosimeter, specific RWP, management approved procedure, HP escort. And special hi-rad area training required.

Notes:

1. R5 zone is consistent with 10 CFR 20 definition of High Radiation Area and Very High Radiation Area.
2. Access to zones R4 and R5 normally requires an ALARA evaluation and approval from higher levels of management.
3. R1 through R5 exposure rates are whole body dose rates on contact with the source.

Table 4.10.3-2 – Classification of Contamination Zones

Classification	Removable Surface Contamination Limit (dpm/100cm2)	Average airborne Radioactivity	Verification System Correlation	Description	Radiation Protection Controls[3] (Dosimetry based on radiation zone requirement)
C1 (Non-Contaminated Area)	$\beta\gamma \leq 1{,}000$ $\alpha \leq 20$	N/A	Industrial Grade Ventilation	C1 areas are maintained to have no contamination. This includes areas outside of surface waste processing facilities. For waste processing facilities, these areas include: • Control rooms • Break and rest rooms • Stairways, elevators, and elevator vestibules	No contamination control, and no training are needed. Minimal surveys, exit walk-through monitors
C2 (Potential Contamination Area)	$\beta\gamma \leq 1{,}000$ $\alpha \leq 20$	N/A	Tertiary Ventilation System	C2 areas are the operational areas of the repository facilities and have their interfaces with contaminated areas (C3, C4, and C4 areas), and have the potential to be contaminated. C2 areas include: • Operating galleries • Subsurface access main (portions)	Routine surveys, exit monitoring of personnel and equipment, Radiation Worker Training (RWT), general RWP
C3 (Contamination Area)	$1{,}000 < \beta\gamma \leq 100{,}000$ >10,000H3 $20 < \alpha \leq 2{,}000$	[Air]≤0.1 DAC (Normally expected ≤0.01 DAC, i.e., <50 mrem/yr)]	Secondary Ventilation System	C3 areas are the process areas where the direct contact with the radioactive material and/or contaminated system components exists. C3 areas include: • Some equipment maintenance areas • Laboratory fume hoods • Subsurface emplacement drift (turnout area)	Routine surveys, exit monitoring (at step-off pads-SOP) for personnel/ equipment, PPE, potential for respiratory protection, RWT, specific sampling
C4 (High Contamination Area)	$\beta\gamma > 100{,}000$ $\alpha > 2{,}000$	0.1 DAC<[Air] ≤ 1 DAC	Primary Ventilation System	C4 areas are highly contaminated areas that potentially require confinement control and include: • Primary Ventilation System HEPA filter rooms	Surveys, as needed, exit monitoring, decontamination as needed, RWT, specific sampling, PPE, respiratory protection as needed.
C5 (Airborne Radioactivity Area)	$\beta\gamma > 500{,}000$ $\alpha > 10{,}000$	Air>1 DAC	Primary Ventilation System	C5 areas are airborne radioactivity areas that require total confinement. C5 areas include: • Bare-fuel transfer rooms/cells • DPC cutting/WP remediation	Access to C5 normally not permitted. High-Integrity protective clothing, respirator and monitoring, specific RWP, RWT, decontamination and survey as needed

Notes:
1. Levels based on accepted industry practice (NRC and DOE) and DOE Radiological Control Manual.
2. Generally, areas >~200,000 DPM/100cm^2 are measured with dose rate instrument and values recorded in mrad/hr
3. Types and layering PPE and types of respiratory protection are dependent on levels of contamination and specific airborne contamination levels.

[The Classification of Radiation Zones is being added per TMRB 2004-051, Technical Management Review Board (TMRB) Decision Proposal [DIRS 174877]. At the direction of the Discipline Engineering Manager of Nuclear and Radiological, the Classification of Contamination Zones is being added. CBCN010 to Revision 6 added these classifications.]

4.10.4 Control of Access to High Radiation Areas

4.10.4.1 Control of Access to High Radiation Areas with Dose Rates Greater Than 100 mrem/hr but Less Than or Equal to 1.0 rem/hr at 30 cm from the Radiation Source or from Any Surface Penetrated by the Radiation

As provided in 10 CFR 20.1601(c) [DIRS 181962], the following controls, as described in Regulatory Guide 8.38, *Control of Access to High and Very High Radiation Areas in Nuclear Power Plants* [DIRS 177548], C.2, shall be applied to high radiation areas in place of the controls required by 10 CFR 20.1601(a) and 10 CFR 20.1601(b) [DIRS 181962]:

1. High radiation areas with dose rates not exceeding 1.0 rem/hr at 30 centimeters from the radiation source or from any surface penetrated by the radiation:

a. Each entryway to such an area shall be barricaded and conspicuously posted as a high radiation area. Such barricades may be opened, as necessary, to permit entry or exit of personnel or equipment.

b. Access to, and activities in, each such area shall be controlled by means of a radiation work permit (RWP) or equivalent that includes the specification of radiation dose rates in the immediate work area(s) and other appropriate radiation protection equipment and measures.

c. Individuals qualified in radiation protection procedures and personnel continuously escorted by such individuals may be exempted from the requirement for an RWP or equivalent while performing their assigned duties provided that they are otherwise following plant radiation protection procedures for entry to, exit from, and work in such areas.

d. Each individual or group entering such an area shall possess:

- 1) A radiation monitoring device that continuously displays radiation dose rates in the area, or
- 2) A radiation monitoring device that continuously integrates the radiation dose rates in the area and alarms when the dose alarm setpoint for the device is reached, with an appropriate alarm setpoint, or
- 3) A radiation monitoring device that continuously transmits dose rate and cumulative dose information to a remote receiver monitored by radiation protection personnel responsible for controlling personnel radiation exposure within the area, or
- 4) A self-reading dosimeter (e.g., pocket ionization chamber or electronic dosimeter) and,
  - a) Be under the surveillance, as specified in the RWP or equivalent and while in the area, of an individual qualified in radiation protection procedures who is equipped with a radiation monitoring device that continuously displays radiation dose rates in the area and responsible for controlling personnel exposure within the area, or
  - b) Be under the surveillance, as specified in the RWP or equivalent and while in the area, by means of CCTV, of personnel qualified in radiation protection procedures who are responsible for controlling personnel radiation exposure in the area and have the means to communicate with individuals in the area who are covered by such surveillance.

e. Except for individuals qualified in radiation protection procedures or personnel continuously escorted by such individuals, entry into such areas shall be made only after dose rates in the area have been determined and entry personnel are knowledgeable of them. These continuously escorted personnel will receive a prejob briefing prior to entry into such areas. This dose rate determination, knowledge, and prejob briefing does not require documentation prior to initial entry.

[This is to ensure the regulatory mandated access controls to high radiation areas are incorporated into applicable facilities. This alternate method of control allowed by 10 CFR 20.1602(c) [DIRS 181962] follows the direction provided in Regulatory Guide 8.38 [DIRS 177548]. RGA REG-CRW-RG-000364, Agreement for Regulatory Guide 8.38, Revision 1 - Control of Access to High and Very High Radiation Areas of Nuclear Plants (BSC 2007 [DIRS 181631]) has adopted requirements of Regulatory Guide 8.38 [DIRS 177548] Section C.2]

4.10.4.2 Control Access to High Radiation Areas with Dose Rates Greater Than 1.0 rem/hr at 30 cm From Radiation Source or From Any Surface Penetrated By Radiation But Less Than 500 rads/hr at 1 m From Radiation Source or From Any Surface Penetrated By Radiation

As provided in 10 CFR 20.1601(c) [DIRS 181962], the following controls, as described in Regulatory Guide 8.38 [DIRS 177548], C.2, shall be applied to high radiation areas in place of the controls required by 10 CFR 20.1601(a) and 10 CFR 20.1601(b) [DIRS 181962]:

1. Each entryway to such an area shall be conspicuously posted as a high radiation area and provided with a locked or continuously guarded door or gate that prevents unauthorized entry and, in addition:
   a. All such door and gate keys shall be maintained under the administrative control of the shift supervisor, radiation protection manager, or his or her designees, and
   b. Doors and gates shall remain locked except during periods of personnel or equipment entry or exit.
2. Access to, and activities in, each such area shall be controlled by means of an RWP or equivalent that includes the specification of radiation dose rates in the immediate work area(s) and other appropriate radiation protection equipment and measures.
3. Individuals qualified in radiation protection procedures may be exempted from the requirement for an RWP or equivalent while performing radiation surveys in such areas provided that they are otherwise following plant radiation protection procedures for entry to, exit from, and work in such areas.
4. Each individual or group entering such an area shall possess:
   a. A radiation monitoring device that continuously integrates the radiation dose rates in the area and alarms when the dose alarm setpoint for the device is reached, with an appropriate alarm setpoint, or
   b. A radiation monitoring device that continuously transmits dose rate and cumulative dose information to a remote receiver monitored by radiation protection personnel responsible for controlling personnel radiation exposure within the area and with the means to communicate with and control every individual in the area, or
   c. A self-reading dosimeter (e.g., pocket ionization chamber or electronic dosimeter) and,
      1) Be under the surveillance, as specified in the RWP or equivalent and while in the area, of an individual qualified in radiation protection procedures who is equipped with a radiation monitoring device that continuously displays radiation dose rates in the area and responsible for controlling personnel exposure within the area, or
      2) Be under the surveillance, as specified in the RWP or equivalent and while in the area, by means of CCTV, or personnel qualified in radiation protection procedures who are responsible for controlling personnel radiation exposure in the area and have the means to communicate with individuals in the area who are covered by such surveillance.
   d. In cases where options b) and c) above are impractical or determined to be inconsistent with the ALARA principle, a radiation monitoring device that continuously displays radiation dose rates in the area will be used.
5. Except for individuals qualified in radiation protection procedures or personnel continuously escorted by such individuals, entry into such areas shall be made only after dose rates in the area have been determined and entry personnel are knowledgeable of them. These continuously escorted personnel will receive a prejob briefing prior to entry into such areas. This dose rate determination, knowledge, and prejob briefing does not require documentation prior to initial entry.
6. Such individual areas that are within a larger area where no enclosure exists for the purpose of locking and no enclosure can reasonably be constructed around the individual area need not be controlled by a locked door or gate, nor continuously guarded, but shall be barricaded and conspicuously posted. A clearly visible flashing light shall be activated at the area as a warning device.

[This is to ensure the regulatory mandated access controls to high radiation areas are incorporated into applicable facilities. This alternate method of control allowed by 10 CFR 20.1602(c) follows the direction provided in Regulatory Guide 8.38. RGA REG-CRW-RG-000364 (BSC 2007 [DIRS 181631]) has adopted requirements of Regulatory Guide 8.38 Section C.2]

4.10.4.3 Control of Access to Very High Radiation Areas

The licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates (10 CFR 20.1602 [DIRS 181962]).

In the case of GROA routine operations and repetitive tasks, control measures shall be provided in accordance with the requirement of 10 CFR 36 [DIRS 173312], specifically Section 36.23 paragraphs (d) and (f) and 36.31 (a).

[This is to ensure that the regulatory mandated access controls to very high radiation areas are incorporated into applicable facilities. For GROA operations involving the moving and transferring unshielded canisters and waste packages, this control measures required by 10 CFR 36 is to reduce human error or error precursors to prevent serious worker overexposure. Regulatory Guide 8.38 [DIRS 177548], C.3, provides the description for additional measures for controlling access to very high radiation areas. RGA REG-CRW-RG-000364 (BSC 2007 [DIRS 181631]) has adopted requirements of Regulatory Guide 8.38.]

4.10.4.4 High Radiation Area Egress

Controls established and utilized to provide the access restriction requirements of 4.10.4.1, 4.10.4.2, and 4.10.4.3 shall be established in a way that does not prevent individuals from leaving a high radiation area.

[Required to ensure access controls established for high and very high radiation areas do not prevent egress from those areas. 10 CFR 20.1601(d) [DIRS 181962].]

4.10.4.5 High Radiation Areas Physical Controls

Physical barriers, such as fencing and walls, shall be provided around high and very high radiation areas. Physical barriers shall be high enough to prevent inadvertent entry into the high and very high radiation areas and cannot be easily circumvented.

[RGA REG-CRW-RG-000364 (BSC 2007 [DIRS 181631]) adopts the barrier requirements of Regulatory Guide 8.38 [DIRS 177548] Section C.1.5.]

4.10.4.6 High and Very High Radiation Area Communications

Communications equipment shall be provided to facilitate coordination between departments during entry into and exit from high and very high radiation areas in accordance with Regulatory Guide 8.38 [DIRS 177548] Section C.1.4.

[RGA REG-CRW-RG-000364 (BSC 2007 [DIRS 181631]) adopts communication requirements of Regulatory Guide 8.38.]

4.10.5 General Radiological Criteria

4.10.5.1 Standard Radiation Symbol

Unless otherwise authorized by the NRC, the symbol prescribed by 10 CFR 20.1901(a) [DIRS 181962] shall be utilized. The symbol, as shown part 20.1901(a), is a three-bladed design with the cross-hatched area to be magenta or purple or black, and the background to be yellow.

[Whenever the use of a radiation caution symbol is required, the symbol shall meet the requirements of 10 CFR 20.1901(a) [DIRS 181962].]

4.10.5.2 Exception to color requirements for standard radiation symbol

Notwithstanding the requirements of Section 4.10.5.1, licensees are authorized to label sources, source holders, or device components containing sources of licensed materials that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.

[This exception to the standard radiation symbol requirements is authorized by 10 CFR 20.1901(b) [DIRS 181962].]

4.11 Offsite Interface Design Criteria

4.11.1 Offsite Utility Interface Design Criteria

No requirements pertinent to this activity have been identified at this time.

4.11.2 Transportation Project Interface Design Criteria

No requirements pertinent to this activity have been identified at this time.

4.12 Plant Design Criteria

4.12.1 Nonmetallic Insulation for Stainless Steel

The levels of leachable contaminants in nonmetallic insulation materials that come in contact with austenitic stainless steels of the American Iron & Steel Institute (AISI) Type 3XX series used in fluid systems important to safety shall be carefully controlled so that stress-corrosion cracking is not promoted. In particular, the leachable chlorides and fluorides shall be held to the lowest practicable levels in accordance with Regulatory Guide 1.36, *Nonmetallic Thermal Insulation for Austenitic Stainless Steel [DIRS 178424].*

[This criterion is based on RGA REG-CRW-RG-000031, Regulatory Guidance Agreement, Regulatory Guide 1.36, Rev. 0 - Nonmetallic Thermal Insulation for Austenitic Stainless Steel (BSC 2006 [DIRS 181642]) which endorses Regulatory Guide 1.36.]

4.12.2 Deleted

[Deleted Subsurface design criteria, Sections 4.12.2.1 through 4.12.2.6 per CR 10501. These criteria were consolidated into Sections 4.2.13.8.1 through 4.2.13.8.6. CR 10501 was initiated to document the duplication of the Subsurface design criteria in Section 4.12.CBCN016 to Revision 6 provided changes.]

4.12.3 Piping Design Criteria

Piping design shall comply with ASME B31.3-2004 (R2005), *Process Piping* [DIRS 176242].

[This standard provides for all the piping design needs. This industry standard is an acceptable source of design criteria. Although a later version of ASME B31.3 is available, the responsible DEM has elected to utilize the referenced version.]

4.13 Solar Power Station Design Criteria

The solar power station requirements have been eliminated from the CRD (DOE 2006 [DIRS 176715]) and from the MGR-RD (DOE 2006 [DIRS 177491]). The criteria have, therefore, been removed.

5 Waste Package And Components Design Criteria

5.1 Waste Package Mechanical Design Criteria

5.1.1 Structural Design Criteria

Structural design criteria shall be in accordance with ANSI N14.6-1993, *American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More* [DIRS 102016], NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants* [DIRS 104939], and *2001 ASME Boiler and Pressure Vessel Code* (ASME 2001 [DIRS 158115]), Section II and Section III, Division I. American Society of Mechanical Engineers (ASME) Section III Code Cases identified in Regulatory Guide 1.193 [DIRS 177622] shall not be used. RGA REG-CRW-RG-000071, *Agreement for Regulatory Guide 1.84, Rev. 33 - Design, Fabrication, and Materials Code Case Acceptability, ASME Section III* (BSC 2006 [DIRS 181679]) has adopted Regulatory Guide 1.84 [DIRS 177621], to allow the option of using NRC approved ASME Section III code cases.

Note: *2001 ASME Boiler and Pressure Vessel Code*, Section II, does not contain an exhaustive list of material properties and it may be necessary to obtain values from other sources as appropriate. Possible additional sources of material properties are identified in *Waste Package Component Design Methodology Report* (BSC 2007 [DIRS 179975], Sections 4.2.2 and 4.2.3).

[Yucca Mountain Review Plan, Final Report, NUREG-1804, [DIRS 163274] Section 2.1.1.7.2.3, requires confirmation that structural design, fabrication, and testing of waste packages for storage of SNF is in accordance with the Boiler and Pressure Vessel Code of the ASME.

RGA REG-CRW-RG-000399, Agreement for NUREG-1804, Rev 2, Yucca Mountain Review Plan - Final Report (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. The application of the 2001 ASME Boiler and Pressure Vessel Code to the design of the waste package is described in position paper BSC Position on the Use of the ASME Boiler and Pressure Vessel Code for the Yucca Mountain Project Waste Packages (BSC 2007 [DIRS 182357) that states in detail which sections of the code are applicable and how those sections are applied. Although ANSI N14.6-1993 [DIRS 102016] has been withdrawn pending revision, it will continue to be used as guidance for demonstrating the performance of lifting features until the release of the revision. CBCN015 to Revision 6 provided the note on material properties and the methodology reference. RGA REG-CRW-RG-000168, Agreement for Regulatory Guide 1.193, Rev. 1 - ASME Code Cases Not Approved for Use (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 for use in the YMP. RGA REG-CRW-RG-000383, Agreement for NUREG-0612, January 1980 - Control of Heavy Loads at Nuclear Power Plants - Resolution of Generic Technical Activity A-36 (BSC 2007 [DIRS 181781]) has adopted NUREG-0612 Sections 5.1.1, 5.1.2, 5.1.5, and 5.1.6 as an acceptable alternative for lifting mechanism design.]

5.1.2 Metallurgical Design Criteria

Metallurgical design criteria shall be in accordance with *2001 ASME Boiler and Pressure Vessel Code* (ASME 2001[DIRS 158115]), Section III, Division I, Subsection NC. ASME Section III Code Cases identified in Regulatory Guide 1.193 [DIRS 177622] shall not be used.

NOTE: *2001 ASME Boiler and Pressure Vessel Code*, Section III, does not contain an exhaustive list of material properties and it may be necessary to obtain values from other sources as appropriate. Possible additional sources of material properties are identified in *Waste Package Component Design Methodology Report* (BSC 2007 [DIRS 179975]), Sections 4.2.2 and 4.2.3.

[Yucca Mountain Review Plan, Final Report, NUREG-1804 [DIRS 163274], Section 2.1.1.7.2.3 requires confirmation that structural design, fabrication, and testing of waste packages for storage of SNF is in accordance with the Boiler and Pressure Vessel Code of the ASME. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. The application of the ASME Boiler and Pressure Vessel Code to the design of the waste package is described in position paper BSC Position on the Use of the ASME Boiler and Pressure Vessel Code for the Yucca Mountain Project Waste Packages (BSC 2007 [DIRS 182357]) that states in detail which sections of the code are applicable and how those sections are applied. 2001 ASME Boiler and Pressure Vessel Code, Section II and Section III, Division 1, Subsection NC 2000, provides structural and thermal properties for materials used in the design and fabrication

of nuclear components. RGA REG-CRW-RG-000168 (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 [DIRS 177622] for use in the YMP. CBCN015 to Revision 6 provided the note and reference to the methodology.]

5.1.3 Waste Package Thermal Design Criteria

Waste package thermal design criteria shall be met as outlined throughout the BOD (BSC 2007 [DIRS 182131]) including thermal power requirements and temperature limits. The waste package, in concert with the canister containing the waste form, shall maintain the commercial SNF in an inert environment and limit the zircaloy peak cladding temperature below 400°C during normal aging (inerted environment) and short term loading operations (in air) and below 570°C during and accident condition involving a fire (inerted environment).

[RGA REG-CRW-RG-000454, Agreement for SFPO-ISG-11, Rev 3, Cladding Considerations for the Transportation and Storage of Spent Fuel (BSC 2007 [DIRS 181828]) provides agreement to utilize Interim Staff Guidance 11, Cladding Considerations for the Transportation and Storage of Spent Fuel (NRC 2003 [DIRS 170332]) for aging and short-term operations including TAD/cask drying and backfilling. Although the RGA does not specifically address waste packages, the criterion should also be applied to the SNF in waste packages. This assures waste packages will have sufficient heat removal capability without exceeding temperature limits for the various waste forms and waste package materials. Also see Section 6.2.]

5.2 Waste Package Fabrication Criteria

The following fabrication codes and standards shall be utilized for the fabrication of waste packages:

- ANSI/AWS A2.4-98 (2007), *Standard Symbols for Welding, Brazing, and Nondestructive Examination* [DIRS 182922], provides the standard symbols for the welding, brazing, and nondestructive examination of nuclear components.
- ANSI/AWS A5.32/A5.32M-97 (R2007) 2007, *Specification for Welding Shielding Gases* [DIRS 182873], provides the specifications of welding shielding gases used in the welding processes of nuclear components.
- ANSI N14.6-1993, *American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More* [DIRS 102016], used as guidance for demonstrating the performance of lifting features.
- ASME 2001 [DIRS 158115], Section II, provides the properties for the materials used in the design and fabrication of Class NF nuclear components.
- ASME 2001 [DIRS 158115], Section III, Subsection NCA, provides the rules and general requirements for the construction of Division 1 components, including the requirements for affixing a code stamp.
- ASME 2001 [DIRS 158115], Section III, Division I, Subsection NB, NC, and NF, (including 2002 Addenda) or, as negotiated, the ASME Code version in effect at the time of procurement and provides the general requirements for the design and fabrication of supports for Class 2 nuclear components.
- ASME 2001 [DIRS 158115], Section V, provides the requirements for the nondestructive examination of nuclear components.
- ASME 2001 [DIRS 158115], Section IX, provides welding and brazing qualifications for the welding of nuclear components.
- ASME B46.1-2002, *Surface Texture (Surface Roughness, Waviness and Lay)* [DIRS 166013], provides surface texture (surface roughness, waviness, and lay) requirements for fabrication of nuclear components.
- ANSI Y14.36M-1996 (R2002) 2002, *Surface Texture Symbols* [DIRS 176401], provides the requirements for surface texture symbols used in the designing of nuclear components.
- ASME Y14.38-1999 (1999-2002), *Abbreviations and Acronyms (with Addenda, ASME Y14.38a-2002)* [DIRS 177881], provides the requirements for abbreviations and acronyms used in the designing of nuclear components.
- ASME Y14.5M-1994 (R 2004) 2004, *Dimensioning and Tolerancing* [DIRS 177882], provides the requirements for dimensioning and tolerancing used in the designing of nuclear components.

ASME Section III Code Cases that shall not be used are those listed in Regulatory Guide 1.193 [DIRS 177622].

[CBCN005 on Revision 6 made changes to the list to remove NQA-1 to become a separate criterion. RGA REG-CRW-RG-000422, Agreement for SFPO-ISG-10, Rev 1, Alternatives to the ASME Code (BSC 2007 [DIRS 181997]) has adopted Interim Staff Guidance document SFPO-ISG-10, Alternatives to the ASME Code [DIRS 168110] that requires identification of design codes and standards for use in the repository design and identify associated exceptions. This includes all surface and subsurface facilities and systems as well as the waste

package. This information will be included in the License Application. RGA REG-CRW-RG-000168 (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 for use in the YMP. RGA REG-CRW-RG-000071 (BSC 2006 [DIRS 181679]) has adopted Regulatory Guide 1.84 [DIRS 177621], to allow the option of using NRC approved ASME Section III code cases. The application of the 2001 ASME Boiler and Pressure Vessel Code to the design of the waste package is described in position paper BSC Position on the Use of the ASME Boiler and Pressure Vessel Code for the Yucca Mountain Project Waste Packages (BSC 2007 [DIRS 182357) that states in detail which sections of the code are applicable and how those sections are applied.]

5.2.1 Waste Package QA Criteria

Cleaning, packaging, shipping, receiving, storage, and handling of the waste package components shall be in accordance with ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications* [DIRS 159544], Subparts 2.1 and 2.2.

[Neither the 1983 version of NQA-1 nor the Quality Management Directive (QMD) QA-DIR-10, Rev 001 (BSC 2007 [DIRS 180474]) provides specific technical requirements for cleaning, packaging, shipping, storage, and handling of items of nuclear components such as waste packages. These sections of NQA-1-2000 must be used to supplement the QMD for use on the waste package components. NQA-1 became a separate criterion on CBCN005 of Revision 6. Although a later version of the ASME NQA-1 is available (2004), BSC has elected to utilize the 2000 version.]

5.3 Waste Package Closure System Design Criteria

5.3.1 Waste Package Closure System Equipment Design Criteria

5.3.1.1 Inerting Equipment Design Criteria

Inerting equipment design shall be in accordance with CGA P-9-2001, *The Inert Gases: Argon, Nitrogen, and Helium* [DIRS 166794].

[CGA P-9-2001 provides industry guidance for users of the inert gases Argon, Nitrogen, and Helium.]

5.3.1.2 Remote Handling Equipment Design Criteria

Remote handling equipment design shall be compatible with ASME B30.20-2003, *Below-the-Hook Lifting Devices* [DIRS 171688], CMAA 70-2004, *Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes* [DIRS 176257], and DOE-STD-1090-2004, *Hoisting and Rigging (Formerly Hoisting and Rigging Manual)* [DIRS 176661].

[Although a later version of ASME B30.20 is available, BSC has elected to utilize the above version. ASME B30.20-2003 provides the lifting device requirements for the design of the waste package closure cell. CMAA-70-2004 provides the crane and gantry requirements for the design of the waste package closure cell. DOE-STD-1090-2004 provides the crane and gantry requirements for the design of the waste package closure cell.]

5.3.1.3 Control Equipment Design Criteria

Control equipment design shall be compatible with NFPA 70, *National Electrical Code, with Tentative Interim Amendment,* 2005 Edition [DIRS 177982], IEEE Std 1202-2006, *IEEE Standard for Flame-Propagation Testing of Wire and Cable* [DIRS 177949], and IEEE Std 383-2003, *Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations* [DIRS 171695].

[NFPA 70 provides electrical requirements used in the design of the waste package closure cell. IEEE Std 1202-2006 provides electrical requirements used in the design of the waste package closure cell. IEEE Std 383-2003 provides electrical requirements used in the design of the waste package closure cell. Although a later version of NFPA 70 *is available, the responsible DEM has elected to utilize the referenced version.]*

5.3.2 Waste Package Closure System Process Criteria

5.3.2.1 Welding Process Criteria

Control equipment design criteria from (1) *2001 ASME Boiler and Pressure Vessel Code* (ASME 2001 [DIRS 158115], Section II (SFA-5.9, 5.12, 5.14, and 5.32), shall be used to define the material requirements for the weld filler metal with additional requirements being derived from project development studies, and (2) 2001 ASME, Section IX), shall be used to provide requirements for the qualification of welders, welding operators, and the procedures employed in welding operations.

The TAD/cask closure welds shall be in accordance with SFPO-ISG-15, *Materials Evaluation* [DIRS 161724], Section X.5.2.3. The design/qualification of the final closure welds of austenitic stainless steel canisters shall be in accordance with SFPO-ISG-18, *The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation* [DIRS 164538].

For all TADs/casks installed in the Aging System, two seal welds must be specified and verified. O-ring seals are not allowed. This is in accordance with SFPO-ISG-5, *Confinement Evaluation* [DIRS 160582].

[This requirement provides consistency between the waste package design and the welding process. RGA REG-CRW-RG-000426, Agreement for SFPO-ISG-15, Rev 0, Materials Evaluation (BSC 2007 [DIRS 181820]) has adopted SFPO-ISG-15 subject to clarification that the only guidance contained in Section X.5.2.3 for welded closure lids applies. RGA REG-CRW-RG-000429, Agreement for SFPO-ISG-18, Rev 0, The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation (BSC 2007 [DIRS 181821]) has adopted SFPO-ISG-18 with clarification that the guidance is applicable only to canisters (such as TADs) used for storage that are sealed at the repository and installed in the aging system. RGA REG-CRW-RG-000417, Agreement for SFPO-ISG-5, Rev 1, Confinement Evaluation (BSC 2007 [DIRS 182075]) has adopted SFPO-ISG-5 with clarification that all TADs/casks used for storage in the aging system must have two welded seals.]

5.3.2.2 Nondestructive Examination Process Criteria

Nondestructive Examination Process Criteria from *2001 ASME Boiler and Pressure Vessel Code* (ASME 2001 [DIRS 158115]), Section III, Division 1, Subsection NC and Section V, shall be used as a guide and modified as directed by the project to define nondestructive processes, performance qualifications, and acceptance requirements.

[This requirement provides consistency between the waste package design and the nondestructive examination process.]

5.3.2.3 Inerting Process Criteria

The inerting process shall use helium quality as found in *2001 ASME Boiler and Pressure Vessel Code* (ASME 2001 [DIRS 158115]), Section II (SFA-5.32), and be designed using the guidance in NUREG-1536, [DIRS 101903].

[The ASME Boiler and Pressure Vessel Code is the industry standard and the NRC guidance is considered valuable to the design. RGA REG-CRW-RG-000448, Agreement for NUREG-1536, January 1997, Standard Review Plan for Dry Cask Storage Systems - Final Report (BSC 2007 [DIRS 181827]) provides agreement that NUREG-1536, Standard Review Plan for Dry Cask Storage Systems should be utilized with clarification.]

5.3.2.4 Stress Mitigation Process Criteria

Stress mitigation process criteria shall be developed to assure adequate corrosion resistance.

[Stress mitigation of the closure weld provides corrosion resistance in this area of the outer corrosion barrier. All other areas of the outer corrosion barrier are heat treated.]

5.4 Emplacement Pallet Design Criteria

Structural design criteria for the emplacement pallet shall be in accordance with *2001 ASME Boiler and Pressure Vessel Code* (ASME 2001 [DIRS 158115]), Section II and III, Division I. ASME Section III Code Cases identified in Regulatory Guide 1.193 [DIRS 177622] shall not be used. RGA REG-CRW-RG-000071 (BSC 2006 [DIRS 181679]) has adopted Regulatory Guide 1.84 [DIRS 177621], to allow the option of using NRC approved ASME Section III code cases.

[2001 ASME Boiler and Pressure Vessel Code, Section II and Section III, Division 1 provides the properties and general requirements, respectively, for materials used in the design and fabrication of nuclear components. RGA REG-CRW-RG-000168 (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 for use in the YMP. The application of the 2001 ASME Boiler and Pressure Vessel Code to the design of the waste package is described in

position paper BSC Position on the Use of the ASME Boiler and Pressure Vessel Code for the Yucca Mountain Project Waste Packages (BSC 2007 [DIRS 182357]) that states in detail which sections of the code are applicable and how those sections are applied.]

NOTE: ASME 2001, Section II, does not contain an exhaustive list of material properties, and it may be necessary to obtain values from other sources as appropriate. Possible additional sources of material properties are identified in the Waste Package Component Design Methodology Report (BSC 2007 [DIRS 179975]), Sections 4.2.2.3 and 4.2.3.1.]

5.5 Emplacement Pallet Fabrication Criteria

Pallets shall be fabricated in accordance with the following:

- ANSI/AWS A2.4-98 (2007) [DIRS 182922] provides the standard symbols for the welding, brazing, and nondestructive examination of nuclear components.
- ANSI/AWS A5.32/A5.32M-97 (R2007) 2007 [DIRS 182873] provides the specifications of welding shielding gases used in the welding processes of nuclear components.
- ASME 2001 [DIRS 158115], Section II, provides the properties for the materials used in the design and fabrication of Class NF nuclear components.
- ASME 2001, Section III, Division I, Subsection NF, (including 2002 Addenda) or, as negotiated, the ASME Code version in effect at the time of procurement and provides the general requirements for the design and fabrication of supports for Class 2 nuclear components.
- ASME 2001, Section V, provides the requirements for the nondestructive examination of nuclear components.
- ASME 2001, Section IX, provides welding and brazing qualifications for the welding of nuclear components.
- ASME B46.1-2002 [DIRS 166013] provides surface texture (surface roughness, waviness, and lay) requirements for fabrication of nuclear components.
- ANSI Y14.36M-1996 (R2002) 2002 [DIRS 176401] provides the requirements for surface texture symbols used in the designing of nuclear components.
- ASME Y14.38-1999 (1999-2002) [DIRS 177881] provides the requirements for abbreviations and acronyms used in the designing of nuclear components.
- ASME Y14.5M-1994 (R 2004) 2004 [DIRS 177882] provides the requirements for dimensioning and tolerancing used in the designing of nuclear components.

ASME Section III Code Cases that shall not be used are those listed in Regulatory Guide 1.193 [DIRS 177622]. RGA REG-CRW-RG-000071 (BSC 2006 [DIRS 181679]) has adopted Regulatory Guide 1.84 [DIRS 177621], to allow the option of using NRC approved ASME Section III code cases.

[CBCN005 to Revision 6 removed NQA-1 from this list to become a separate criterion. RGA REG-CRW-RG-000422, Agreement for SFPO-ISG-10, Rev 1, Alternatives to the ASME Code (BSC 2007 [DIRS 181997]) has adopted Interim Staff Guidance document SFPO-ISG-10 (NRC 2000 [DIRS 168110]) that requires to identification of design codes and standards for use in the repository design and identification of associated exceptions. This includes all surface and subsurface facilities and systems as well as the waste package. This information will be included in the License Application. 2001 ASME Boiler and Pressure Vessel Code, Section II and Section III, Division 1 provides the properties and general requirements, respectively, for materials used in the design and fabrication of nuclear components. RGA REG-CRW-RG-000168 (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 for use in the YMP. The application of the 2001 ASME Boiler and Pressure Vessel Code to the design of the waste package is described in position paper BSC Position on the Use of the ASME Boiler and Pressure Vessel Code for the Yucca Mountain Project Waste Packages (BSC 2007 [DIRS 182357]) that states in detail which sections of the code are applicable and how those sections are applied.]

NOTE: ASME 2001, Section II, does not contain an exhaustive list of material properties, and it may be necessary to obtain values from other sources as appropriate. Possible additional sources of material properties are identified in the Waste Package Component Design Methodology Report (BSC 2007 [DIRS 179975]), Sections 4.2.2.3 and 4.2.3.1.]

5.5.1 Emplacement Pallet QA Criteria

Cleaning, packaging, shipping, receiving, storage, and handling of emplacement pallets shall be in accordance with ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications* [DIRS 159544], Subparts 2.1 and 2.2.

[Neither the 1983 version of NQA-1 nor the QMD QA-DIR-10, Rev 001 (BSC 2007 [DIRS 180474]) provides specific technical requirements for cleaning, packaging, shipping, storage, and handling of items of nuclear components such as emplacement pallets. These sections of NQA-1-2000 must be used to supplement the QMD for use on the emplacement pallet components. NQA-1 became a separate criterion on CBCN005 of Revision 6. Although a later version of the ASME NQA-1 is available (2004), BSC has elected to utilize the 2000 version.]

5.6 Drip Shield Design Criteria

No codes or standards have been identified at this time for structural design of the drip shield.

5.7 Drip Shield Fabrication Criteria

Drip shields shall be fabricated in accordance with the following:

- ANSI/AWS A2.4-98 (2007) [DIRS 182922] provides the standard symbols for the welding, brazing, and nondestructive examination of nuclear components.
- ANSI/AWS A5.32/A5.32M-97 (R2007) 2007 [DIRS 182873] provides the specifications of welding shielding gases used in the welding processes of nuclear components.
- ASME 2001 [DIRS 158115], Section II, provides the properties for the materials used in the design and fabrication of Class NF nuclear components.
- ASME 2001 Section III, Subsection NCA, provides the rules and general requirements for the construction of Division 1 components, including the requirements for affixing a code stamp.
- ASME 2001 Section III, Division I, Subsection NC, (including 2002 Addenda) or, as negotiated, the ASME Code version in effect at the time of procurement and provides the general requirements for the design and fabrication of supports for Class 2 nuclear components.
- ASME 2001 Section V, provides the requirements for the nondestructive examination of nuclear components.
- ASME 2001 Section IX, provides welding and brazing qualifications for the welding of nuclear components.
- ASME B46.1-2002 [DIRS 166013] provides surface texture (surface roughness, waviness, and lay) requirements for fabrication of nuclear components.
- ANSI Y14.36M-1996 (R 2002) 2002 [DIRS 176401] provides the requirements for surface texture symbols used in the designing of nuclear components.
- ASME Y14.38-1999 (1999-2002) [DIRS 177881] provides the requirements for abbreviations and acronyms used in the designing of nuclear components.
- ASME Y14.5M-1994 (R 2004) 2004 [DIRS 177882] provides the requirements for dimensioning and tolerancing used in the designing of nuclear components.

ASME Section III Code Cases that shall not be used are those listed in Regulatory Guide 1.193 [DIRS 177622]. RGA REG-CRW-RG-000071 (BSC 2006 [DIRS 181679]) has adopted Regulatory Guide 1.84 [DIRS 177621], to allow the option of using NRC approved ASME Section III code cases.

[CBCN005 to Revision 6 removed NQA-1 to become a separate criterion. RGA REG-CRW-RG-000422 (BSC 2007 [DIRS 181997]) has adopted Interim Staff Guidance document SFPO-ISG-10 (NRC 2000 [DIRS 168110]) that requires identification of design codes and standards for use in the repository design and identification of associated exceptions. This includes all surface and subsurface facilities and systems as well as the waste package. This information will be included in the License Application. The application of the 2001 ASME Boiler and Pressure Vessel Code to the design of the waste package is described in position paper BSC Position on the Use of the ASME Boiler and Pressure Vessel Code for the Yucca Mountain Project Waste Packages (BSC 2007 [DIRS 182357]) that states in detail which sections of the code are applicable and how those sections are applied.RGA REG-CRW-RG-000168 (BSC 2007 [DIRS 183186]) has adopted Regulatory Guide 1.193 for use in the YMP.]

5.7.1 Drip Shield QA Criteria

Cleaning, packaging, shipping, receiving, storage, and handling of drip shields shall be in accordance with ASME NQA-1-2000 [DIRS 159544], Subparts 2.1 and 2.2.

[Neither the 1983 version of NQA-1 nor the QMD QA-DIR-10, Rev 001 (BSC 2007 [DIRS 180474]) provides specific technical requirements for cleaning, packaging, shipping, storage, and handling of items of nuclear components such as drip shields. These sections of NQA-1-2000 must be used to supplement the QMD for use on the drip shield components. NQA-1 became a separate criterion on CBCN005 of Revision 6. Although a later version of the ASME NQA-1 is available (2004), BSC has elected to utilize the 2000 version.]

6 Site Specific Criteria

6.1 Natural Phenomena

The repository facilities and SSCs shall be designed, constructed, and operated so that the general public, workers, and environment are protected from the impact of all natural phenomena hazards. Where no specific requirements are specified, model building codes or national consensus industry standards shall be used. The site investigations shall be performed in accordance with Regulatory Guide 1.132, *Site Investigations for Foundations of Nuclear Power Plants* [DIRS 169347].

[DOE O 420.1A, Facility Safety [DIRS 159450] CRD 4.4 is currently imposed through the contract. It is expected that a 1B version will be placed on the contract within the next year, but this requirement will not change substantially. RGA REG-CRW-RG-000110, Agreement for Regulatory Guide 1.132, Rev. 2 - Site Investigations for Foundations of Nuclear Power Plants (BSC 2007 [DIRS 181611]) has adopted Regulatory Guide 1.132 with clarification.]

6.1.1 Snowfall

The repository facilities and SSCs shall be designed to withstand and operate under a maximum daily snowfall of 6.0 in. (15.2 cm) and a maximum monthly snowfall of 6.6 in. (16.8 cm).

[Snowfall and snow depth measurements were not part of the meteorological monitoring program at Yucca Mountain. Reasonable estimates of the repository snowfall environment are based upon climatological records from the Desert Rock Weather Service Meteorological Observatory (WSMO), Nevada, which is located approximately 45 km southeast of the repository site. The Desert Rock period of record is 01/01/1983 to 02/28/2005. These extremes are the actual observations recorded by the National Weather Service observers and are documented in DTN: MO0504DSRKSNOW.001, Climatological Snow Data for Desert Rock WSMO, Nevada, 01/01/1983 to 02/28/05 [DIRS 173394]. IED Surface Facility and Environment [DIRS 179915] now includes this DTN. CBCN008 to Revision 6 provided reference to this IED. This IED is currently under revision but will not be released in time for Rev 7 of the PDC but will be incorporated in Rev 8 through a CBCN.]

6.1.2 Rainfall

The repository facilities and SSCs shall be designed to withstand and operate in the precipitation environment including a maximum annual precipitation of 20 in./yr (50.8 cm) with the following maximum 1-hour and 24-hour precipitation frequency estimates:

Parameter and Frequency	Nominal Estimate	Upper Bound 90% Confidence Interval
Maximum 24-hr Precipitation (50-year return period)	2.79 in./day (7.1 cm)	3.30 in./day (8.4 cm)
Maximum 24-hr Precipitation (100-year return period)	3.23 in./day (8.2 cm)	3.84 in./day (9.8 cm)
Maximum 24-hr Precipitation (500-year return period)	4.37 in./day (11.1 cm)	5.25 in./day (13.3 cm)
Precipitation 1-hr intensity (50-year return period)	1.35 in./hr (3.4 cm)	1.72 in./hr (4.4 cm)
Precipitation 1-hr intensity (100-year return period)	1.68 in./hr (4.3 cm)	2.15 in./hr (5.5 cm)

The probable maximum precipitation and its associated time distribution shall be determined in accordance with Hydrometeorological Report 49, *Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages*, (Hansen et al. 1977 [DIRS 108888]).

[Precipitation is an environmental parameter that can affect site drainage and erosion, buried utilities, outdoor equipment seals, and roof drain system sizing. This criterion establishes the rainfall rates through which the affected systems must be able to endure and function and is based on a water year, defined as the 12-month period from October 1 through September 30 of the following year. The local 6-hours duration data was obtained from the Yucca Mountain Project Drainage Report and Analysis (BSC 2007 [DIRS 183261]). The maximum annual precipitation is conservatively based on the actual 12-month amount (18.97 in.) recorded at Yucca Mountain meteorological Site 6, Technical Work Plan for: Meteorological Monitoring and Data Analysis (BSC 2006 [DIRS 176722], Addendum A) during water year 1997-1998 (DTN: MO0303SGPM9502.000, Storage Gauge

Precipitation Measurements, Yucca Mountain 1995-2002 [DIRS 162490]). Because the period of record for Yucca Mountain site-specific precipitation data is limited to seven full years, a survey of nearby National Oceanic and Atmospheric Administration meteorological locations was conducted. These locations surround Yucca Mountain and provide a much longer record to further substantiate the conservative value provided. The sites surveyed with the annual recorded extreme amount are Beatty 8N (12.62 in., 1972-2004); Amargosa Farms Garey (10.37 in., 1965-2004); Desert Rock WSMO (10.64 in., 1984-2004); and Nevada Test Site area 25 climate precipitation site, 4JA (14.40 in., 1957-2004). These annual extremes are documented in DTN: MO0409SEPNOAPD.000, NOAA Extreme Annual Precipitation Data [DIRS 171885]).

The 1-hour and 24-hour precipitation estimates were derived from the National Oceanic and Atmospheric Administration Atlas 14 and were specifically calculated for the Site 1 location. For comparison, a survey of 1-hour precipitation records at Yucca Mountain from 1998 through 2002 (DTNS: MO0206SEPQ1998.001, Meteorological Monitoring Data for 1998 [DIRS 166731]; MO0302METMON99.001, Meteorological Monitoring Data for 1999, Sites 1-9, Hourly and Ten Minute [DIRS 166165]; MO0209SEPQ2000.001, Meteorological Monitoring Data for 2000 [DIRS 166730]; MO0305SEP01MET.002, Meteorological Monitoring Data for 2001 [DIRS 166164]; and MO0305SEP02MET.002, Meteorological Monitoring Data for 2002 [DIRS 166163]) indicates that the maximum observed hourly precipitation event amounted to 1.24 in. (3.15 cm) at Site 7 on July 13, 1999 (1400 hrs), and the observed 24-hr precipitation event was 2.55 in. (6.48 cm) also at Site 7 on July 13, 1999 (DTN: MO0302METMON99.001 [DIRS 166165]). National Oceanic and Atmospheric Administration Atlas 14 Website: <http://hdsc.nws.noaa.gov/hdsc/pfds/>, DTN: MO0403SEPPRFQE.000, Hourly and Daily Precipitation Return Frequency Estimates at Yucca Mountain Meteorological Tower, Site 1 [DIRS 169194]. For conservative design, values for upper bound 90% Confidence Interval are selected. IED Surface Facility and Environment (BSC 2007 [DIRS 179915]) now includes this DTN. The IED is currently under revision but will not be released in time for Rev 7 of the PDC but will be incorporated in Rev 8 through a CBCN. The following DTNs: MO0503SEPMMD03.001 Meteorological Monitoring Data for 2003 [DIRS 176097], MO0607SEPMMD04.001Meteorological Monitoring Data for 2004 [DIRS 178311], MO0610METMND05.001 Meteorological Monitoring Data for 2005 [DIRS 182647], MO0412SEPSGP03.000 Storage Gauge Precipitation 2003 [DIRS 178864], MO0607SEPSGP04.001 Storage Gauge Precipitation 2004 [DIRS 178865], and MO0605SEPSGP05.000 Storage Gauge Precipitation 2005 [DIRS 178663] are also included in this IED. The data contained in these DTNs does not materially alter the precipitation and intensity data in the above table.]

6.1.3 Winds

The repository facilities and SSCs that are exposed to outside [ambient] wind conditions shall be designed for a basic wind speed of 90 miles per hour. This value shall be used for design wind loads for ITS and non-ITS SSCs. The system shall operate during and after exposure to a surface basic wind speed of 90 miles per hour.

[Wind is one of the primary external environmental parameters that can affect buildings and structures located outside. This criterion is needed to ensure the system equipment remains operational during and after exposure to expected environmental extremes. Proper consideration of wind is required to ensure that buildings and structures can withstand the wind forces and that system components are adequately protected from the wind. NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (NRC 1987 [DIRS 103124]) discusses relevant design criteria in Sections 2.3.1 and 3.3.1. Section 3.3.1.II.1 states: "The wind used in the design [of safety related buildings or structures] shall be the most severe wind that has been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data has been accumulated."

The maximum daily observed 3-second gust wind speed data for 1994 through 2002 were collected at the Yucca Mountain 10-m meteorological tower, Site 1, located approximately 1 km south of the North Portal of the Exploratory Studies Facility and Sites 7 and 8 and documented in the North Portal Basic Wind Speed Calculation (BSC 2006 [DIRS 178591], Section 4.) The Site 1 location represents terrain exposure similar to that of the planned surface facility area on the western side of Midway Valley per the Technical Work Plan for Meteorological Monitoring and Data Analysis (BSC 2006 [DIRS 176722]), Addendum A. The estimated basic wind speed of a 3-second gust, the standard deviation, and the upper 90 percent confidence interval speed for the 50-year and 100-year return periods are presented in North Portal Basic Wind Speed Calculation, Section 6.4. This analysis was performed to determine whether estimates of extreme wind speeds, using onsite data, exceeded default values. Three standard deviations above the mean wind speed for the 50-year recurrence interval is 79.5 mph while for the 100-year recurrence interval is 83.6 mph.

ASCE 7-98, Minimum Design Loads for Buildings and Other Structures [DIRS 149921], Figure 6-1, contains a map of basic wind speed values for the United States and identifies special wind regions to be examined for *unusual wind conditions. The default value, outside the special region within which Yucca Mountain is located and for much of the continental United States, is 90 mph at 10 meters above the ground. The calculated and observed values taken from five years of onsite data support the nominal design 3-second gust wind speed of 90 mph shown in ASCE 7-98, Figure 6-1, and North Portal Basic Wind Speed Calculation. A later version of ASCE 7 is available but is not adopted for the repository. The responsible DEM has elected to utilize the ASCE 7-98, since the current design were based on this version of the standard and the later version has not yet been evaluated for suitability. CBCN008 to Revision 6 provided changes.]*

6.1.3.1 Wind Speed

Wind speed data is taken from the DTNs listed on *IED Surface Facility and Environment* (BSC 2007 [DIRS 179915]).

[The DTNs approved for calculating the basic wind speed must be obtained from the available IEDs. The IED lists DTNs from 1994 through 2006. CBCN008 to Revision 6 provided this criterion. The IED 100-IED-WHS0-00201-000-00B is currently under revision but will not be released in time for Rev 7 of the PDC but will be incorporated in Rev 8 through a CBCN.]

6.1.4 Tornadoes

The basic parameters for the tornado loads for ITS structures shall be:

- Maximum speed-189 mph
- Pressure drop-0.81 psi
- Rate of pressure drop-0.30 psi/sec
- Tornado generated missiles shall be defined as Spectrum II missiles and are applicable for the YMP site.

[Maximum speed, pressure drop, and rate of pressure drop are from Extreme Wind/Tornado/Tornado Missile Hazard Analysis (BSC 2005 [DIRS 174429]) and RGA REG-CRW-RG-000064, Agreement for Regulatory Guide 1.76, Rev 0 - Design Basis Tornado for Nuclear Power Plants (BSC 2006 [DIRS 181681]) has provided guidance for Regulatory Guide 1.76 [DIRS 106281] by the application of site-specific meteorological data that supports lower maximum wind speeds for credible tornadoes in keeping with the risk-informed licensing basis. The definition of Spectrum is from NUREG-0800 (NRC 1996 [DIRS 177328], Section 3.5.1.4) and from the Extreme Wind/Tornado/Tornado Missile Hazard Analysis, Table 11.]

6.1.5 Lightning

Data for lightning is not availabe. For lightning protection see Section 4.3.1.5.

6.1.6 Ambient Temperature

The repository facilities and SSCs shall be designed to withstand and operate in the extreme outside (surface) temperature environment of 2°F to 116°F (-17°C to 47°C).

[This criterion establishes the outdoor temperature environment in which SSCs are expected to operate. Temperature is considered to be one of the primary environmental parameters that can effect component performance or result in advanced degradation. The extreme outside temperature range (2°F to 116°F) is based on a survey of records (1998 to 2002) for nine meteorological monitoring sites located at Yucca Mountain (DTN: MO0405XTMP9802.000, Extreme Temperature Values for Meteorological Monitoring Sites from 1998-2002 [DIRS 169326]) and three nearby National Oceanic and Atmospheric Administration stations (Beatty, Amargosa Farms, and Desert Rock WSMO) located in the area surrounding Yucca Mountain (DTN: MO0211HISTMPEX.000, Summary of Ambient Temperature Extremes at Amargosa Farms, Beatty, and Desert Rock WSMO, Nevada [DIRS 161983]. IED Surface Facility and Environment (BSC 2007 [DIRS 179915]) now includes this DTN. CBCN008 to Revision 6 provided reference to the IED. This IED 1is currently under revision but will not be released in time for Rev 7 of the PDC but will be incorporated in Rev 8 through a CBCN.]

6.1.7 Humidity

The repository facilities and SSCs shall be designed to withstand and operate in the surface external relative humidity environment including an annual mean humidity value of 30%, a minimum summer monthly mean value of 10%, and a maximum winter monthly mean value of 59%.

[Humidity is considered to be a primary environmental parameter that can affect performance and anticipated life expectancy of SSCs. This criterion establishes the external humidity environment at the site. The site-specific values are based on an updated analysis of Site 1 records that includes the period from 1998 to 2002 (DTN:

MO0405SEPRHVMM.000, Mean Relative Humidity Values for Meteorological Monitoring Site 1 from 1998-2002 [DIRS 170462]). The summer mean is from June and the winter mean is from December. Values were adjusted to the nearest whole percentage that envelope the values in this DTN. Example: Min RH is 10.6 % in DTN adjusted to 10 %. Maximum is 58.1 % adjusted to 59 %. IED Surface Facility and Environment (BSC 2007 [DIRS 179915]) now includes this DTN. CBCN008 to Revision 6 provided reference to the IED. This IED is currently under revision but will not be released in time for Rev 7 of the PDC but will be incorporated in Rev 8 through a CBCN.]

6.1.8 Frost Line

The repository facilities and SSCs shall be designed to withstand a potential penetration depth of 10 in.

[Frost line is one of the external environmental parameters that can affect the foundation and footing design for the structures that must be embedded in the ground. The frost line depth will be based on the conditions at the Nevada Test Site. This information is referenced in Supplemental Soils Report (BSC 2007 [DIRS 182582], Section 7.1.11).]

6.1.9 Flood Events

The repository facilities and SSCs shall be designed to protect against flooding consequences as identified in the *Yucca Mountain Project Drainage Report and Analysis* (BSC 2007 [DIRS 183261]). ANSI/ANS -2.8-1992, *American National Standard for Determining Design Basis Flooding at Power Reactor Sites* [DIRS 103071] shall be utilized to protect the ITS SSCs. Man-made channels shall be sized to transport the probable maximum flood around the North Portal pad. Berms shall be added where necessary to ensure that probable maximum flood elevations do not affect the facilities.

[This criterion is supported in the conclusions from (BSC 2007 [DIRS 183261]). The standard is acceptable industry wide to practice for these determinations.]

6.1.10 Seismic

Seismic input for the design of ITS SSCs at the repository are provided in terms of acceleration response spectra and acceleration time histories at locations B, C, D, and E as defined in Figure 6.1.3-1. Locations B and C correspond to the design of subsurface facilities, and Locations D and E correspond to the design of surface facilities.

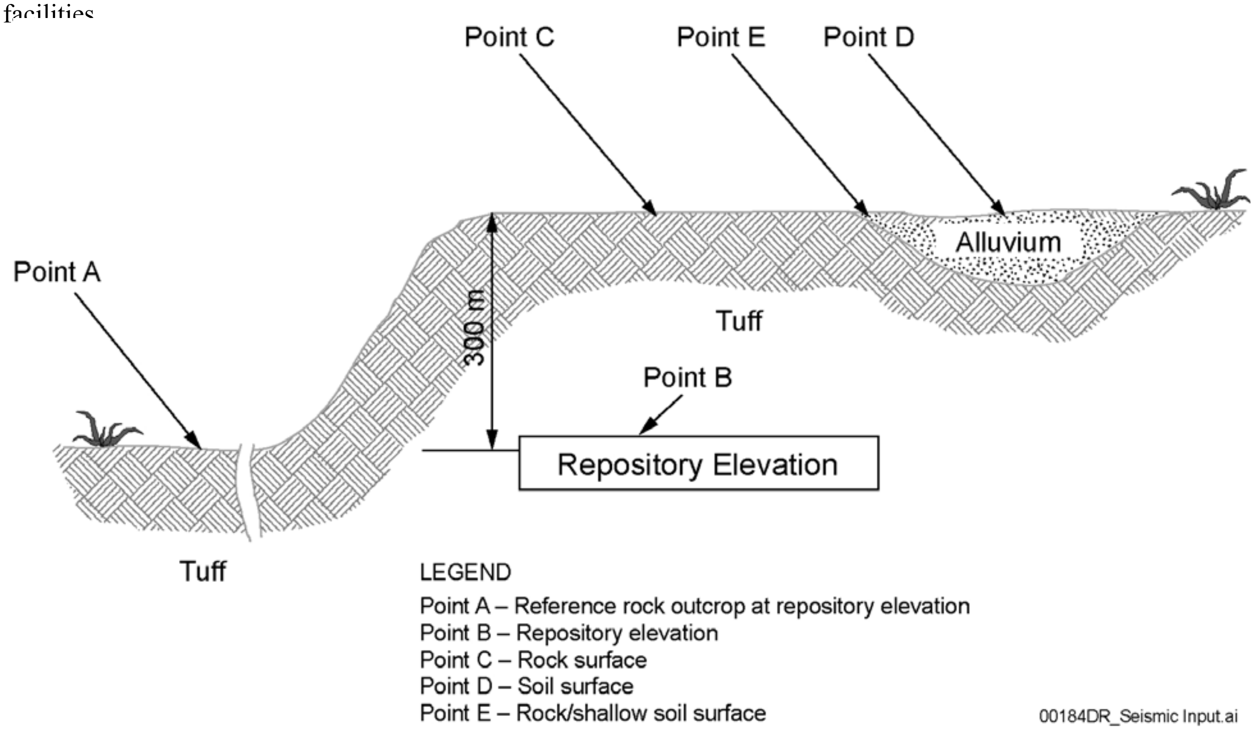

Figure 6.1.3-1. Seismic Design Input Locations

The seismic input generated for ITS SSCs are for different annual probability of occurrence of the seismic hazard.

6.1.10.1 Seismic Input for the Design of Structures, Systems, and Components that are Important to Safety

Acceleration response spectra and acceleration time histories for ITS SSCs shall be used from Table 6.1-1, Baseline Seismic Design Input Identifiers and Table 6.1-2, Updates to Seismic Design Input Identifiers.

[The acceleration response spectra and time histories provided in Tables 6.1-1 and 6.1-2 are based on site-specific information.]

6.1.10.1.1 Baseline Seismic Design Input Identifiers

Table 6.1-1 Baseline Seismic Design Input Ground Motion for Mean Annual Probability of Exceedance.

Loc.	**1E-3 (1,000-Yr Return Period)**	**5E-4 (2,000 Yr Return Period)**	**1E-4 (10,000 Yr Return Period)**
B	Response Spectrum DTN: MO0405SDSTPNTB.001 [DIRS 169851] Time History DTN: MO0405SDSTPNTB.001 [DIRS 169851]	Response Spectrum DTN: MO0407SDARS104.001 [DIRS 170683] Time History DTN: MO0407TMIS104.003 [DIRS 170599]	Response Spectrum DTN: MO0306SDSAVDTH.000 [DIRS 164033] Time History DTN: MO0306SDSAVDTH.000 [DIRS 164033]

C	Response Spectrum DTN: to be provided later [DIRS later] Time History DTN: to be provided later [DIRS later]	Response Spectrum DTN: to be provided later [DIRS later] Time History DTN: to be provided later [DIRS later]	Response Spectrum DTN: to be provided later [DIRS later] Time History DTN: to be provided later [DIRS later]
D/E	Response Spectrum DTN: MO0411SDSDE103.003 [DIRS 172425] Time History DTN: MO0411SDSDE103.003 [DIRS 172425]	Response Spectrum DTN: MO0411SDSTMHIS.006 [DIRS 172426] Time History DTN: MO0411SDSTMHIS.006 [DIRS 172426]	Response Spectrum DTN: MO0411WHBDE104.00 3 [DIRS 172427] Time History DTN: MO0411WHBDE104.00 3 [DIRS 172427]

[Table 6.1-1 provides the baseline information previously included in the PDC, and provided on IED Seismic Data, 800-IED-MGR0-00701-000-00A [DIRS 179278]. CBCN007 to Revision 6 provided the last updates to the baseline DTNs and the IED.]

6.1.10.1.2 Updated Seismic Design Input Identifiers

Table 6.1-2 Updated Seismic Design Input Ground Motion for Mean Annual Probability of Exceedance.

Loc.	1E-3 (1,000-Yr Return Period)	5E-4 (2,000 Yr Return Period)	1E-4 (10,000 Yr Return Period)
B	Response Spectrum DTN: MO0707DSRB1E3A.000 [DIRS 183128] Time History DTN: to be provided later [DIRS later]	Response Spectrum DTN: MO0707DSRB5E4A.000 [DIRS 183130] Time History DTN: to be provided later [DIRS later]	Response Spectrum DTN: MO0707DSRB1E4A.000 [DIRS 183129] Time History DTN: to be provided later [DIRS later]
C	Response Spectrum DTN: to be provided later [DIRS later] Time History DTN: to be provided later [DIRS later]	Response Spectrum DTN: to be provided later [DIRS later] Time History DTN: to be provided later [DIRS later]	Response Spectrum DTN: to be provided later [DIRS later] Time History DTN: to be provided later [DIRS later]
D/E	Response Spectrum DTN: MO0706DSDR1E3A.000 [DIRS 181423] Time History: DTN: MO0706TH1E3APE.000 [DIRS 182460]	Response Spectrum DTN: MO0706DSDR5E4A.001 [DIRS 181422] Time History DTN: MO0706TH5E4APE.001 [DIRS 181961]	Response Spectrum DTN: MO0706DSDR1E4A.001 [DIRS 181421] Time History DTN: MO0706TH1E4APE.001 [DIRS 181960]

[Table 6.1-1 provides the baseline information previously included in the PDC and on the IED. Table 6.1-2 provides updated seismic design input ground motion. Although, the revised information is still unqualified, Engineering will qualify the software and data before submitted at License Application. Following qualification, the information will be placed on an appropriate IED and included here on a future change. There is sufficient confidence in the DTNs to utilize these updates for design products.]

6.1.10.2 Seismic Input for the Design of Conventional Structures, Systems, and Components

6.1.10.2.1 Non-ITS Surface SSCs

Non-ITS SSCs in the surface facilities shall be designed for *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), Section 1615 requirements. The location of the North Portal is N765352.70, E569814.37, from *Transportation Cask Receipt and Return Facility Worker Dose Assessment* (BSC 2004 [DIRS 172983]), which corresponds to 36.85° N Latitude and 116.43° W Longitude. The design acceleration spectra for the non-ITS surface SSCs shall be developed using the approach in the IBC and the following:

1. Determine the site-specific surface spectra for 2,500 year return period for 5% damping that corresponds to the "maximum considered earthquake" in the IBC, based on the spectra defined at points D/E.
2. Apply the two-thirds factor to the 2,500-yr return period accelerations to obtain the approximate 500-yr return period design parameters.

[Based on engineering judgment, the IBC is determined to be appropriate for the design of non-ITS SSCs.]

6.1.10.2.2 Non-ITS Subsurface SSCs

Non-ITS SSCs in the subsurface facilities shall be designed for the *International Building Code 2000, with Errata to the 2000 International Building Code* (ICC 2003 [DIRS 173525]), Section 1622) requirements. The location of the North Portal is N765352.70, E569814.37, from *Transportation Cask Receipt and Return Facility Worker Dose Assessment* (BSC 2004 [DIRS 172983]), which corresponds to 36.85° N Latitude and 116.43° W Longitude. The design acceleration spectra for the non-ITS surface SSCs shall be developed using the approach in the IBC and the following:

1. Determine the site-specific surface spectra for 2,500 year return period for 5% damping that corresponds to the "maximum considered earthquake" in the IBC, based on the spectra provided at point B.
2. Apply the two-thirds factor to the 2,500-year return period accelerations to obtain the approximate 500-year return period design parameters.

[Based on engineering judgment, the IBC is determined to be appropriate for the design of non-ITS SSCs.]

6.1.10.2.3 Non-ITS SSCs Interactions with ITS SSCs

ITS SSCs shall be designed such that interfaces between non-ITS SSCs and ITS SSCs that upon failure could prevent functions from being performed:

- have a probability of failure of less than 1E-04 over the preclosure period (as determined by PCSA),
- will not damage the ITS component if not screened out, or
- damage to the ITS SSC does not result in an off-site dose in excess of the 10 CFR 63.111 [DIRS 180319] performance standard (as determined by PCSA).

The design of the interface shall include the dynamic loads and displacements produced by both sets of SSCs up to the first anchor point beyond the interface. Additionally, either:

- The collapse of the non-ITS SSC shall not cause it to strike an ITS SSC,
- The collapse of the non-ITS SSC shall not impair the integrity of the ITS SSC, or
- The non-ITS SSC shall be analyzed and designed to the same seismic DBGM as the ITS SSCs subjected to the potential unacceptable interaction.

Acceptable methods of isolating each non-ITS with an adverse interaction include constraints, barriers, or relocation of the non-ITS SSC.

[This requirement is based on ensuring that the repository meets required preclosure safety objectives as stated in the Preliminary Preclosure Nuclear Safety Design Bases (BSC 2007 [DIRS 182329]). The wording has been changed from the Preliminary Preclosure Nuclear Safety Design Bases to paraphrase the wording in NUREG-0800, Section 3.7.2., subsection II.8 (NRC 1989 [DIRS 165111]) by incorporating the 2nd set of bullets. The discussion of isolation and anchor point boundary for the design is from NUREG-0800, Section 3.7.3., subsection II.8 (NRC 1989 [DIRS 165112]). Although the NUREG is not directly applicable to the repository as it is not a reactor plant, the repository does have both non-ITS and ITS SSCs that should have the same design considerations of the interactions. This requirement is commonly called the two-over-one requirement. CBCN006 to Revision 6 provided editorial changes.]

6.1.10.3 Consideration of Fault Displacement Hazards

The repository shall consider fault displacement hazards in the geologic repository design in accordance with the guidance in NUREG-1494, *Staff Technical Position on Consideration of Fault Displacement Hazards in Geologic Repository Design* [DIRS 110957]. The repository shall utilize NUREG-1451, *Staff Technical Position On*

Investigations To Identify Fault Displacement Hazards And Seismic Hazards At A Geologic Repository (McConnell et al. 1992 [DIRS 105205]), Sections C.3.1 through C.3.3 for guidance on appropriate investigations that can be used to identify fault displacement hazards and seismic hazards.

[RGA REG-CRW-RG-000447 (BSC 2007 [DIRS 181826]) provides agreement to utilize NUREG-1494. The terminology "Quaternary faults with potential for significant displacement" is used to indicate those faults that may potentially be Type I Faults. The performance objectives of 10 CFR 63 [DIRS 180319] are the current requirements that will be used to demonstrate repository compliance with pre- and post-closure performance objectives. RGA REG-CRW-RG-000445 (BSC 2007 [DIRS 181825]) provides agreement to utilize the guidance in NUREG-1451. Although faults were identified, classification of faults in terms of Type I, Type II, and Type III criteria were not carried out. Faults with known or suspected Quaternary displacement were investigated in detail. For historically reported and instrumentally recorded earthquakes, no assessment is made of peak ground acceleration. Expert elicitation was used to identify and characterize seismic sources for inclusion in the preliminary seismic hazards analysis, rather than an assessment of whether sources could generate an acceleration of at least 0.1g. Fault parameters and their uncertainties are determined for all faults identified and characterized as seismic sources by the expert teams.]

6.1.11 Volcanoes

Structural loading shall take into account volcanic ash fall with a roof live load of 21 lb/ft^2.

[Ash load is based on Categorization of Event Sequences for License Application (BSC 2005, [DIRS 174467]), Assumption 5.1.2.7 and Section 6.2.9.]

6.1.12 Radon

See Section 4.9.3.7.

6.1.13 Silica Dust

Airborne exposures to crystalline silica shall not exceed the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) of 0.05 mg/m^3 for an eight-hour time-weighted average provided in, *TLVs® and BEIs®, Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices* (ACGIH 2006 [DIRS 180457]). The immediate danger to life and health limit for cristobolite and tridymite silica is 25 mg/m^3 and the immediate danger to life and health limit for quartz is 50 mg/m^3 in accordance with *National Institute for Occupational Safety and Health "Silica, Crystalline (as Respirable Dust)"* (NIOSH 1996 [DIRS 147940]).

[DOE O 440.1A [DIRS 102288], Attachment 2, Section 12.g, invokes the ACGIH TLV requirements which are lower (more protective) than the OSHA-permissible exposure limits for silica (0.1 mg/m^3) (NIOSH 1996 [DIRS 147940]) and represents a more protective work environment.]

6.1.14 Rockfall

The subsurface facility shall be designed to minimize rockfall.

[Rockfall within underground openings as a function of time is a natural and expected occurrence for any subsurface excavation. Over time, changes occur to both the stress condition and the strength of the rock mass due to several interacting factors, which are discussed in the Drift Degradation Analysis (BSC 2004 [DIRS 166107]). Rockfall can typically be minimized through appropriate design and construction, and as specified by engineering judgment. Factors for minimizing rockfall include the following:

- *Drift orientation—The subsurface opening orientations relative to the orientation of the dominant rock joints affect opening stability. The orientation of emplacement drifts relative to the dominant rock joint is, therefore, a consideration for ground stability and rockfall. A drift orientation perpendicular to the strike of the dominant joint set will maximize opening stability and minimize rockfall.*
- *Drift size—Rockfall increases with increasing drift diameter. The effects of a change in drift diameter on rockfall development in repository emplacement drifts have been quantified in accordance with CAL-EBS-MD-000029, Assessment of Drift Diameter Variation on Rock Fall Development (BSC 2002 [DIRS 172986]). The emplacement drift diameter is the nominal opening for use in designing emplacement drift fittings and the mobile equipment that is intended to use the emplacement drifts.*
- *Ground support system—The ground support system ensures opening stability is maintained in the range of geologic formations in the repository horizon and for all expected loading conditions, including in situ rock loads, construction, operation, thermal, and seismic loads. Ground support provides protection against*

rockfall for all subsurface personnel, equipment, and the engineered barrier systems, including the waste packages, during the preclosure period (Sections 4.5.2.1 and 4.5.2.2).

- *Scaling—Rockfall can be mitigated by scaling, which is the removal of loose rocks from the roof or walls. Scaling is typically performed immediately after excavation to identify and prevent potential rockfall hazards.]*

6.1.15 Structural Geology

The subsurface facility shall be located to minimize the effects of fault displacement.

[The distribution and properties of faults and fractures are important elements of the structural geology of a repository at Yucca Mountain. Faults could have an impact on repository performance by affecting the stability of underground openings or by acting as pathways for water flow. The repository is an area of known faults but these faults are inactive and, therefore, have a limited effect on repository operations. To mitigate possible effects from fault displacement, emplacement drifts will be set back an adequate distance from faults.]

6.2 Thermal

Thermal requirements allocated to the Repository and the SSCs are identified in the BOD (BSC 2007 [DIRS 182131]).

[Drift spacing is covered in Chapter 8 of the BOD. DOE SNF cladding temperatures are covered in Chapters 4 and 11 of the BOD. Preclosure and postclosure drift wall temperature limits are covered in Chapter 22 of the BOD. Ground surface temperature limits are covered in Chapter 8 of the BOD. Waste package thermal limits are covered in Chapters 3, 4, 8, 10, 11, 12 and 13 of the BOD. The average drift thermal line load is covered in Chapter 8 of the BOD.]

6.2.1 Cladding Temperatures

The CSNF peak cladding temperature limits are:

- In Surface facilities, normal conditions - 400°C
- For off-normal conditions - 570°C

[Level 2 Directed Baseline Change (DOE/RW-0600, Rev. 0) (Arthur 2003 [DIRS 164983]) provides guidance on the cladding criteria for normal conditions in the subsurface drifts. RGA REG-CRW-RG-000454 (BSC 2007 [DIRS 181828]) provides agreement to utilize Interim Staff Guidance 11, Cladding Considerations for the Transportation and Storage of Spent Fuel (NRC 2003 [DIRS 170332]) for aging and short-term operations including TAD/cask drying and backfilling in the surface facilities. Although the RGA does not specifically address waste packages, the criterion should also be applied to the SNF in waste packages. This assures waste packages will have sufficient heat removal capability without exceeding temperature limits for the various waste forms and waste package materials. Also see Section 5.1.3.]

7 Preclosure Safety Analysis Criteria

7.1 General Criteria for Repository Preclosure Safety Analysis

Repository facilities and packages shall be designed to ensure that safety functions of ITS SSCs meet the performance requirements of 10 CFR 63.111[DIRS 180319]. This criterion for PCSA shall be met by providing design features that prevent initiation, reduce the probability of, or mitigate the consequence of event sequences, as defined in 10 CFR 63.2. The SSCs credited for meeting this criterion are designated ITS in accordance with the definition of *important to safety* in 10 CFR 63.2. The ITS SSCs are identified through a PCSA process as required by 10 CFR 63.112. NUREG-1804, *Yucca Mountain Review Plan (YMRP),* NUREG-1804 (NRC 2003 [DIRS 163274] and supplemental criteria provide specific elements of the PCSA process that must be supported by the design of the repository facilities and packages.

[This criterion is from 10 CFR 63.111 and 10 CFR 63.112 and the derived guidance from NUREG-1804. 10 CFR 63.111(c) specifies that compliance with the preclosure performance objectives in 10 CFR 63.111(a) and 10 CFR 63.111(b) will be demonstrated through a PCSA in accordance with 10 CFR 63.21 (c)(5). The PCSA is to ensure that internal and external hazards that could result in unacceptable consequences have been evaluated and that preventive or mitigative features are included in the repository design such that the limits on radiation exposures specified in 10 CFR 63.111(a) will not be exceeded and the design will meet the requirements in 10 CFR 63.111 (b).

Section 2.1.1 of NUREG-1804 describes the scope and requirements for the NRC Staff to review for compliance with 10 CFR 63.21, 10 CFR 63.111, and 10 CFR 63.112. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. ASME RA-Sb-2005, Addenda B to ASME RA-S-2002, The Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications (ASME 2005 [DIRS 177880]) was developed from the scope and methods use in the nuclear power plant probabilistic risk assessment (PRA) as a standard for ensuring a comprehensive evaluation. These methods comprise standard industry practice and are relevant to the risk-informed PCSA process. Therefore, subsections of this PCSA criteria refer to guidance from the relevant portions of 10 CFR 63, NUREG-1804, and ASME RA-Sb-2005.]

7.2 Preclosure Period for Preclosure Safety Analysis

Repository facilities and packages shall be designed to ensure that safety functions of ITS SSCs can be fulfilled over the preclosure period. This criterion requires that the reliability, availability, and mitigative features of SSCs can be achieved throughout the preclosure period due to inspections, maintenance, and refurbishment of SSCs. Furthermore, this criterion establishes the bases for categorizing event sequences by frequency or probability and evaluating the associated radiological consequences against the 10 CFR 63.111 [DIRS 180319] performance requirements. The preclosure period shall encompass the phase of preclosure operations proceeding permanent closure of the repository.

[This criterion is dictated by 10 CFR 63.2, wherein, the definitions of Category 1 and Category 2 event sequences are defined in terms of frequency or probability of occurrence during the preclosure period. This criterion supports information relative to NUREG-1804, Section 2.1.1.3.2, Review Methods 3 and 4 and Section 2.1.1.4.2, Review Method 2 (NRC 2003 [DIRS 163274]) and the associated Acceptance Criteria. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. For simplicity, a 100-yr preclosure period may be adopted for analyses associated with the PCSA for all facilities. The duration for emplacement activities is expected to be less than 50 yrs. Therefore, it would be more accurate for risk analysis to use 50 years for surface and emplacement activities and 100 yrs for the remaining preclosure phases.]

7.3 Identification and Systematic Analysis of Hazards and Event Sequences

The classification of ITS SSCs and demonstration of compliance with 10 CFR 63.111 [DIRS 180319] shall be developed from a systematic process to identify naturally occurring and human-induced hazards and comprehensively identify potential event sequences.

[This criterion is dictated by 10 CFR 63.112(b); NUREG-1804,Sections 2.1.1.3.2, Review Methods 1 - 5, and Section 2.1.1.4.2 Review Methods 1 and 2, (NRC 2003 [DIRS 163274]) and the associated Acceptance Criteria; NUREG/CR-2300, PRA Procedures Guide, A Guide to the Performance of Probabilistic Risk Assessments for Nuclear Power Plants (NRC 1983 [DIRS 106591]); and NUREG-1513, Integrated Safety Analysis Guidance

Document (Milstein 2001 [DIRS 169805]). NUREG-1804, also references Guidelines for Hazard Evaluation Procedures (AIChE 1992 [DIRS 103763]). RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. Guidance on nuclear PRA practices is provided in ASME RA-Sb-2005 [DIRS 177880], Section 4.5.1. RGA REG-CRW-RG-000452, Agreement for NUREG/CR 2300, September 1981, PRA Procedures Guide (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300. RGA REG-CRW-RG-00389, Agreement for NUREG-1513, May 2001, Integrated Safety Analysis Guidance Document (BSC 2007 [DIRS 182732]) provides agreement that use the methodology in NUREG-1513 is based on the professional judgment of the user.]

7.3.1 Identification and Systematic Analysis of Hazards and Initiating Events

Identification of hazards and initiating events applies to sources internal to the operations within the GROA and external to such operations. Examples of the latter are earthquakes, windstorms, floods, aircraft crashes. Examples of the former are random equipment failures and fires within a facility. The output of this part of the PCSA is a list of naturally occurring or human-induced events, which could potentially initiate event sequences that results in an exposure to radioactivity. Systematic identification is followed by screening using LS-PRO-0201, *Preclosure Safety Analyses Process*. Screening is accomplished on the basis of a) applicability to the site and/or operations, b) probability of occurrence at the site, and c) probability of inducing damage to SSCs. If either the probability in b) or in c) is less than 1E-04 over the preclosure period, the hazard or initiating event is not further considered in the analysis.

[This criterion is dictated by 10 CFR 63.112(b) and (d) [DIRS 180319], NUREG-1804 Sections 2.1.1.3.2, Review Methods 1 - 5, (NRC 2003 [DIRS 163274]) and the associated Acceptance Criteria; NUREG/CR-2300 (NRC 1983 [DIRS 106591]); and NUREG-1513 (Milstein 2001 [DIRS 169805]). The probabilistic screening criterion is based on the definition of Category 2 event sequences in accordance with 10 CFR 63.2. The NUREG-1804 also references Guidelines for Hazard Evaluation Procedures (AIChE 1992 [DIRS 103763]). RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. Guidance on nuclear PRA practices is provided in ASME RA-Sb-2005 [DIRS 177880], Section 4.5.1. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300. RGA REG-CRW-RG-00389 (BSC 2007 [DIRS 182732]) provides agreement that use the methodology in NUREG-1513 is based on the professional judgment of the user. ANSI/ANS-58.21-2007, External Events in PRA Methodology [DIRS 181218] includes guidance on the application of hazards and fragility. NUREG/CR-5042, Evaluation of External Hazards to Nuclear Power Plants in the United States [DIRS 181517]. NUREG-1407, Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities, Final Report [DIRS 162002]. *NUREG/CR-5042 Supplement 1. Evaluation of External Hazards to Nuclear Power Plants in the United States: Seismic Hazard [DIRS 183364].]*

7.3.2 Comprehensive Identification of Potential Event Sequences

The PCSA shall employ means that comprehensively identify event sequences associated with each hazard and initiating event that has not been excluded during the screening analyses. The PCSA shall employ logic structures commonly used in probabilistic risk assessment such as event sequence diagrams, fault trees and event trees to identify the potential sequence of events that could occur following an initiating event . An event sequence, which is defined in 10 CFR 63.2 [DIRS 180319] includes a one or more initiating events and one or more pivotal events and an end state. Each event sequence ends in an end state defined on the basis of radiological release, exposure to workers or/and also being important to criticality. Event sequences, modeled in the PCSA, provide an appropriate framework for the identification of ITS SSCs, categorization of event sequences, the basis for the need to determine consequences (i.e. dose and criticality), and nuclear safety design basis for ITS SSCs, and procedural safety controls for actions of repository personnel.

[This criterion is dictated by 10 CFR 63.112(b) and 10 CFR 63.112(d) [DIRS 180319], NUREG-1804, Section 2.1.1.4.2, Review Methods 1 and 2 (NRC 2003 [DIRS 163274]) and the associated Acceptance Criteria. 10 CFR 63 is a risk-informed rule. The NRC has adopted risk-informed regulation for the YMP based on experience gained in performing PRAs of nuclear power plants. The methods for performing PRAs include event tree development as documented in NUREG/CR-2300 (NRC 1983 [DIRS 106591]). RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. Guidance on industry practices is provided in ASME RA-Sb-2005 [DIRS 177880], Section 4.5.2. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300.]

7.3.3 Quantifying Initiating Event Frequency

The quantification of initiating event frequency for an event sequence shall be based on conditions appropriate for the planned operational characteristics of the site and repository, and shall consider the of frequency of handling operations and rates associated with processing and emplacing the various waste forms and on the documented frequency of occurrences of applicable SSCs representative of repository operations.

[This criterion is associated with the process of event sequence frequency quantification and categorization and is dictated, in part, by 10 CFR 63.21(c)(5) [DIRS 180319].]

7.3.4 Initiating Event and Event Sequence Screening Analyses

Initiating events or event sequences whose probabilities are less than one in 10,000 before permanent closure are termed Beyond Category 2 event sequences and are screened out from any further analysis. No radiological consequence analysis or criticality analysis need be performed for Beyond Category 2 event sequences.

The PCSA shall perform quantitative analyses of event sequences to establish bases for including or excluding a particular event sequence. Event sequences may also be screened out on the basis of a low frequency of the initiating event alone. The analyses shall result in the designation of ITS SSCs and procedural safety controls which are relied upon to prevent or mitigate an event sequence. In this context prevent means reduce the probability of, and mitigate means reduce the consequences of.

Either demonstrably conservative estimates or the mean value of an event sequence frequency, appropriately considering uncertainties, shall be used for screening and categorization. If the estimated mean frequency of an initiating event or a full event sequence is less than 1x 10-4 over the preclosure period, the event sequence is categorized as Beyond Category 2 and is screened out.

[This criterion is from 10 CFR 63.112(d) and 10 CFR 63.102(f) [DIRS 180319], and NUREG-1804, Section 2.1.1.3, Review Methods 1 and 4 (NRC 2003 [DIRS 163274]) to provide technical bases for including or excluding a hazard as an initiating event. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. Screening of unlikely initiating events is a standard practice that avoids unnecessary analyses, consistent with precedents from other nuclear facilities according to 10 CFR 63.102(f)). A Category 2 event sequence is defined in 10 CFR 63.2 as having a probability of occurrence of at least one in 10,000 during the preclosure period; but a frequency of less than 1 over the preclosure period. For a 50-year or 100-year preclosure period, the corresponding frequency of occurrence is 2 × 10-4 per year or 1 × 10-4 per year, respectively. Industry guidance is presented in ASME RA-Sb-2005 [DIRS 177880], Section 4.5.1.]

7.3.5 Quantification of Event Sequence Frequency

The technical basis for categorizing an event sequence as Category 1, Category 2, or excluding it from further consideration is the quantification of the frequency of an event sequence. Frequency, as used in the PCSA, is the number of occurrences over a specified time duration or number of demands. The frequency of each event sequence is calculated as the product of the initiating event frequency and the conditional probabilities of all the pivotal events that appear in the sequence. Event sequence quantification may be performed as point estimates when applied to preliminary evaluations or performed using uncertainty propagation when applied to categorization of event sequences. When the latter is used, the mean value of the underlying uncertainty distribution is used for categorization. Event tree construction and quantification of event sequences may be performed by any means including hand calculations, spreadsheet models in EXCEL, or specialized programs such as *Systems Analysis Programs for Hands-On Integrated Reliability Evaluations (SAPHIRE) Code Reference Manual* (Kvarfordt et al. 2005 [DIRS 178307]).

[This criterion is dictated by 10 CFR 63.112(b) and (d) [DIRS 180319], NUREG-1804, Section 2.1.1.4, Review Methods 1 and 2 (NRC 2003 [DIRS 163274]) and the associated Acceptance Criteria. Review Method 2 includes verification that acceptable event sequence analysis methods per NUREG/CR-2300 (NRC 1983 [DIRS 106591]) have been applied and human reliability analysis (HRA) methods have been included. The NRC has adopted risk-informed regulation for the YMP based on experience gained in performing PRAs of nuclear power plants. The methods for performing PRAs include event sequence quantification as documented in NUREG/CR-2300 and guidance as provided in ASME RA-Sb-2005 [DIRS 177880], Sections 4.5.2 - 4.5.6. The application of a specialized program such as SAPHIRE (Kvarfordt et al. 2005 [DIRS 178307]) provides the ability to link event tree pivotal events to system reliability models (i.e., fault tree models) and to a database library of failure event data. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by

mapping a crosswalk to the License Application. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300.]

7.4 Reliability Modeling and Quantification

The quantification of event sequence frequencies, uses techniques of reliability engineering such as fault tree analysis, structural reliability analysis, seismic fragility analysis, and human reliability analysis. Fault tree models are populated with inputs derived from industry-wide sources of failure rates, human reliability analysis, and engineering judgment. Structural reliability includes stress/strain analysis of SSCs and material capacities. Each of these are uncertain and the appropriate integration of these two uncertain inputs provides a structural reliability mean estimate. Seismic fragilities are developed using the methods found in the seismic analysis methodology document. Human reliability is developed using the process described in Section 7.4.4.

[This criterion is dictated by 10 CFR 63.112(d) and 10 CFR 63.112(e)(8) [DIRS 180319] and NUREG -1804, Section 2.1.1.4, Review Method 2 and Section 2.1.1.6, Review Method 1(NRC 2003 [DIRS 163274]) and the associated Acceptance Criteria. Event sequence frequency quantification includes inputs from detailed systems reliability analyses and modeling of failures of passive SSCs. NRC guidance for system reliability modeling is presented in NUREG/CR-2300 (NRC 1983 [DIRS 106591]) and NUREG-0492, Fault Tree Handbook (Vesely et al. 1981 [DIRS 128494]) and for HRA modeling in NUREG-1792, Good Practices for Implementing Human Reliability Analysis (HRA) (Kolaczkowski, A. , et al. 2005 [DIRS 177323]) and NUREG-1624 (NRC 2000 [DIRS 157661]). Industry guidance is provided in ASME RA-Sb-2005 [DIRS 177880]), Sections 4.5.3, 4.54, and 4.5.5. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300. RGA REG-CRW-RG-000441 (BSC 2007 [DIRS 182733]) provides guidance to individuals performing probabliistic risk analysis (PRA) or PRA-type analyses using NUREG-0492. RGA REG-CRW-RG-00394 (BSC 2007 [DIRS 182734]) provides agreement that use the methodology in NUREG-1624 is based on the professional judgment of the user. RGA-REG-CRW-RG-0434 for NUREG/CR-1278 [DIRS 183135] will be revised for use in the YMP and is being used prior to final RGA adoption.]

7.4.1 Reliability Modeling and Quantification: Active Systems and Components

The PCSA shall provide technical bases for statements of reliability of active systems or components that are credited in event sequence frequency analyses or consequence mitigation. The reliability assessment shall be based on a definition of a success criterion that defines the safety function, loss of which requires an estimate of unreliability. The credited safety function limit can be different for a given system or component in different event sequences. The reliability analysis shall apply a system logic model that allows decomposition of the system reliability into subsystem and component reliability factors. Fault tree analysis (FTA) is an accepted method for developing and quantifying system reliability logic models, including analysis of uncertainties. The decomposition of faults shall be developed to lower levels of assembly until reaching the highest level of assembly for which failure information is available. The events this level are called basic events in a fault tree. Each basic event represents a specific failure mode for a given component, a human failure event (HFE), or a common cause failure (CCF). Although FTA may be performed by hand, PCSA may employ a computer program, such as SAPHIRE (Kvarfordt et al. 2005 [DIRS 178307]), that can be used to construct and quantify the logic model.

[This criterion is driven by 10 CFR 63.112(d) and 10 CFR 63.112(e)(8) [DIRS 180319] and NUREG-1804 Section 2.1.1.4, Review Method 2, and Section 2.1.1.6, Review Method 1 (NRC 2003 [DIRS 163274]) and the associated Acceptance Criteria. Event sequence frequency quantification includes inputs from detailed systems reliability analyses and HRA. NRC guidance for system reliability modeling is presented in NUREG/CR-2300 (NRC 1983 [DIRS 106591]) and NUREG-0492, Fault Tree Handbook (Vesely et al. 1981 [DIRS 128494]), and for HRA modeling in NUREG/CR-1278 (Swain and Guttmann 1983 [DIRS 139383]) and NUREG-1624 (NRC 2000 [DIRS 157661]). FTA is an accepted methodology for assessing the reliability of a system as described in the Fault Tree Handbook, NUREG-0492 (Vesely et al. [DIRS 128494]). RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabliistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300. RGA REG-CRW-RG-000441 (BSC 2007 [DIRS 182733]) provides guidance to individuals performing probabliistic risk analysis (PRA) or PRA-type analyses using NUREG-0492. RGA REG-CRW-RG-00394 (BSC 2007 [DIRS 182734]) provides agreement that use the methodology in NUREG-1624 is based on the professional judgment of the user.]

7.4.2 Reliability Modeling and Quantification: Passive Structures and Components

The PCSA shall provide technical bases for implicit or explicit statements of reliability of passive SSCs that are credited in event sequence frequency analyses or consequence mitigation. The reliability assessment shall be based on a definition of what constitutes loss of ITS safety function for a given SSC. Examples of loss of ITS function are loss of confinement or breach of canister. To the extent achievable, the technical bases shall use structural reliability methods. When designs are not well known, a population of similar equipment will serve as the basis of analysis. Similarity is established by the use of the same or similar industry consensus codes, or by precedent in NRC and IAEA regulatory guides, NUREGs, and standards.

[This criterion is driven by 10 CFR 63.112(d), and (e)(3) and (e)(8) [DIRS 180319] and is addressed in NUREG-1804, Sections 2.1.1.4 (RM 2)and 2.1.1.6 (RM 1) (NRC 2003 [DIRS 163274]) and their counterpart Acceptance Criteria. Event sequence frequency quantification includes an assessment of the probability of loss of ITS SSC safety functions. NRC guidance for PRA is discussed in NUREG/CR-2300 (NRC 1983 [DIRS 106591]), Section 10.3.4, in the context of structural response to natural phenomena. The method applies a probabilistic hazard function, e.g., annual probability of exceedance for a given wind speed, as a probabilistic applied load, and the structural fragility for wind loading, i.e., the conditional probability of loss of safety function, given a certain wind load. The unconditional annual probability of loss of safety function, e.g., due to wind, is calculated from the integration over the product of hazard and fragility. ANSI/ANS-58.21-2007, External Events in PRA Methodology [DIRS 181218] includes guidance on the application of hazards and fragility. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300.]

7.4.3 Dependent and Common Cause Failures

PCSA reliability models for active systems shall include treatment of dependent and common-cause failures to account for the possibility that some pivotal events modeled in an event tree or some component failures modeled in the fault tree may not necessarily be independent from other events or failures. The PSCA shall consider the following types of dependent events: spatial, enviromental, functional, human-induced. Common-cause failures (CCFs) are considered when two or more identical subsystems or components are relied upon to achieve requisite reliability of a safety function. CCFs shall be included in system reliability models using an implicit technique, such as the beta-factor, alpha-factor, or multiple-Greek-letter. Factors used in PCSA for the selected CCF technique shall include technical justification.

[This criterion is driven by 10 CFR 63.112(e)(3), (e)(8) and (e)(11) [DIRS 180319] and YMRP, NUREG-1804, Sections 2.1.1.4 (RM 2)and 2.1.1.6 (RM 1) (NRC 2003 [DIRS 163274]) and the associated Acceptance Criteria. This criterion derives from the generally accepted practice used in NPP PRAs. Regulatory guidance is given in NUREG/CR-2300 (NRC 1983[DIRS 106591]), and NUREG/CR-5485, Guidelines on Modeling Common-Cause Failures in Probabilistic Risk Assessment (Mosleh et al. 1998 [DIRS 167711]). Industry guidance is presented in ASME RA-Sb-2005 [DIRS 177880], Section 4.5.4. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300. RGA REG-CRW-RG-437, Agreement For NUREG/CR 5485, November, 1998, Guidelines On Modeling Common Cause Failures In Probabilistic Risk Assessment (BSC 2007 [DIRS 182737]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 5485.]

7.4.4 Human Reliability Analysis

The PCSA shall identify and quantify human failure events that contribute to event sequences using an appropriate method for HRA. In cases where it is determined that the effects of HFEs are implicitly imbedded in the historical failure rate information for a given system or component, and the human involvement or interface at the repository is judged to be represented in the historical data, then a separate (explicit) HRA may not be required. When this is not the case, the HRA methods will be employed at a suitable level of detail. The level of detail is determined by the importance to the event frequency.

HFEs shall be systematically identified for potential effects on pivotal events or system reliability in a manner consistent with a technique for human event analysis (ATHEANA). The HRA for PCSA may be performed with any generally accepted HRA technique consistent with current good practices applicable to YMP operations.

[This criterion is driven by 10 CFR 63.112(d), (e)(3) and (e)(8) [DIRS 180319] and is addressed in NUREG-1804, Sections 2.1.1.3 (RM 3), 2.1.1.4 (RM 2) and 2.1.1.6 (RM 1) (NRC 2003 [DIRS 163274]) and their counterpart Acceptance Criteria. Industry guidance is provided in ASME RA-Sb-2005, Section 4.5.5.[DIRS 177880]. As referenced in the NUREG-1804, NRC guidance has been presented in NUREG/CR-2300 (NRC 1983 [DIRS 106591]), NUREG-1742 (Kolaczkowski, A. , et al. 2005 [DIRS 177323]) and NUREG-1624 (NRC 2000 [DIRS 157661]). RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabliistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300. RGA REG-CRW-RG-00394 (BSC 2007 [DIRS 182734]) provides agreement that use the methodology in NUREG-1624 is based on the professional judgment of the user.

Note: RGA-REG-CRW-RG-0434 for NUREG/CR-1278 [DIRS 183135] will be revised for use in the YMP and is being used prior to final RGA adoption.]

7.4.5 Modeling for Active Components

Initiating event frequency and basic event parameters used in event sequence frequency quantification and SSC reliability modeling shall be developed using standard practices. No historical data currently exists for SSCs planned for the repository. Therefore, reliability data shall be obtained from industry-wide sources of information about similar equipment. The population variability of reliability parameters (e.g. failure frequencies) of such similar equipment will be the basis for the uncertainties in active component reliability parameters. Generally, reliability parameter estimates for PCSA reliability modeling and event sequence quantification shall apply the methods based on Bayes' Theorem.

[This criterion is driven by 10 CFR 63.112(d), (e)(3) and (e)(8) [DIRS 180319] and is addressed in NUREG-1804, Sections 2.1.1.3 (RM 3) and 2.1.1.4 (RM 2) (NRC 2003 [DIRS 163274]) and their counterpart Acceptance Criteria. NRC guidance is provided in NUREG/CR-2300 (NRC 1983 [DIRS 106591]) and NUREG/CR-6823 (Atwood et al. 2003 [DIRS 177316]). Industry guidance is provided in ASME RA-Sb-2005 [DIRS 177880], Section 4.5.6. It is noted that application of Bayes' Theorem is the generally accepted practice used in nuclear industry PRAs as described in Probability and Risk Assessment: The Subjectivistic Viewpoint and Some Suggestions (Apostolakis 1978 [DIRS 177724]);and Bayesian Methods in Risk Assessment (Apostolakis 1981 [DIRS 177812]). No historical data currently exists for SSCs planned for the repository. Therefore, reliability data must be obtained from generic, surrogate sources. Bayes' Theorem has been proven to be a coherent method that is able to combine data. It mathematically expresses a decrease in uncertainty gained by an increase in knowledge. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300.

Note: RGA-REG-CRW-RG-0434 for NUREG/CR-6823 [DIRS 183137] will be revised for use in the YMP and is being used prior to final RGA adoption.]

7.5 Treatment of Uncertainties and Sensitivity Analysis

The PCSA shall identify and quantify the uncertainties associated with input data or parameters and results of event sequence frequency analyses and associated reliability analyses, where deemed appropriate for event sequence categorization. Uncertainties are expressed in terms of probability distributions, e.g., normal, lognormal, Weibull, and the parameters necessary to uniquely specify the probability distribution function, e.g., the mean and standard deviation for a normal distribution, or the median and range factor for a lognormal distribution. An uncertainty distribution may be specified for any parameter that is used in a PCSA calculation.

The uncertainty specified for each parameter used in event sequence quantification are combined through probabilistic analyses to produce the resulting uncertainty in the frequency of the event sequence. From the probability distribution, the mean value, median value, variance and other statistical parameters may be derived. Uncertainty propagation may be analyzed by any appropriate method, including hand calculations, numerical analyses using discrete probability distribution method, or using a computer program that performs Monte Carlo or Latin Hypercube analyses.

[This criterion is driven by 10 CFR 63.112(d), and (e)(3) and (e)(8) [DIRS 180319] and is addressed in NUREG-

1804, Sections 2.1.1.3 (RM 3 and 2.1.1.4 (RM 2) (NRC 2003 [DIRS 163274]) and their counterpart Acceptance Criteria. Industry guidance is provided in ASME RA-Sb-2005 [DIRS 177880], Section 4.5.8. Additional discussion of uncertainty analysis methods, including Bayes' Theorem, is provided in NUREG/CR-6823 (Atwood et al. 2003 [DIRS 177316]) and NUREG/CR-2300 (NRC 1983 [DIRS 106591]). RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application. RGA REG-CRW-RG-000452 (BSC 2007 [DIRS 182731]) provides guidance to individuals performing probabilistic risk analysis (PRA) or PRA-type analyses using NUREG/CR 2300.

Note: RGA-REG-CRW-RG-0434 for NUREG/CR-6823 {DIRS 183137] will be revised for use in the YMP and is being used prior to final RGA adoption.]

7.6 List of SSCs and Associated Failure Frequencies

The PCSA shall develop and maintain a failure rate (i.e. frequency) information to serve as the basis of reliability estimates of SSCs and event sequence quantification info for systems and components that has been included in event sequence or reliability analyses. The database shall provide documented bases for selection, adjustment, combinations, and uncertainty evaluation of each SSC.

[This criterion is based on good practices for performing and documenting risk and reliability analyses. ASME RA-Sb-2005 [DIRS 177880], Section 4.5.6, requires that data analyses be documented.

7.7 Event Sequences Leading to Criticality

The PCSA hazards and event sequence analyses shall include potential criticality conditions in the event sequence end states that could result in exposure to radioactivity. The event tree format provides a framework for identifying the SSCs ITS and for calculating the frequency of each event sequence for the purposes of event sequence categorization or exclusion from further analyses. Event sequences that are categorized by frequency as Category 1 or Category 2 are subjected to neutronic calculations for the purpose of demonstrating that criticality does not occur. No radiological consequences are performed for event sequences that result in potential criticality.

Each end state that represents a potential exposure to radioactivity is termed an "event sequence" in accordance with the definition of 10 CR 63.2 [DIRS 180319]. A potential exposure to radiation can result from an inadvertent criticality. Design requirements are in place to ensure that criticality is prevented, and neutronic calculations shall confirm that criticality does not occur.

[This criterion is driven by 10 CFR 63.112(d) and (e)(6) and is addressed in NUREG-1804, Sections 2.1.1.3 (RM 3), 2.1.1.4 (RM 2)and 2.1.1.6 (RM 1) (NRC 2003 [DIRS 163274]) and their counterpart Acceptance Criteria. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application.]

7.8 Calculation of Seismic Event Sequence Frequency

The PCSA shall quantify the frequency of seismically induced event sequences. The event sequence frequency shall use a site-specific probabilistic seismic hazard curve developed for the repository as the initiating event. A fragility function for the conditional probability of failure (i.e., loss of credited safety function) is developed for each ITS SSC. The fragility function shall be developed using a generally accepted method such as EPRI (Electric Power Research Institute) 1994. *Methodology for Developing Seismic Fragilities.* EPRI-TR-103959 [DIRS 161329]. The calculation of the frequency of a given seismic event sequence shall employ an integration of the joint probabilities of the hazard function and the fragility function(s) for all of the SSC that contribute to the sequence. The frequency for seismically initiated event sequence may also include consideration of non-seismic probability factors that can reduce or increase the frequency, such as exposure factors that account for the lack of susceptibility when no waste form is present at the time of the earthquake and thereby reduce the frequency, or random failures of mechanical components that could increase the frequency.

[This criterion is driven by requirements to meet 10 CFR 63.111 [DIRS 180319] for seismic sequences as for any other event sequence.

Earthquake risk analysis typically develops fragility functions to represent the structural resistance of structures and components to earthquakes and seismicity functions to represent the earthquakes, Earthquake Risk Assessment of Building Structures (Ellingwood 2001[DIRS 177340]; Probabilistic Seismic Safety Study of an Existing Nuclear Power Plant(Kennedy et al. 1980 [DIRS 164660]).

The probabilistic seismic hazard function is developed from a detailed study of the regional seismic activity and ground faulting conducted by seismologists and geologists Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on the Uncertainty and Use of Experts (Budnitz et al. 1997 [DIRS 103635]).

There are two common methods for determining a fragility curve. The first method relies on a study of the design basis, the assumption in the use of codes and standards, and relevant test data (Kennedy and Ravindra 1984 [DIRS 102182]). The second method relies on a conservative calculation, called the conservative deterministic failure margin method Overview of Methods for Seismic PRA and Margin Analysis Including Recent Innovations, Seismic Fragilities for Nuclear Power Plant Risk Studies (Kennedy 2001 [DIRS 155940]; EPRI NP-6041-SL, A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1) (EPRI 1991 [DIRS 161330]). Industry guidance is presented in ANSI/ANS-58.21-2007 [DIRS 181218].]

7.9 Classification of ITS SSCs, Identification of Procedural Safety Controls, and Development of Nuclear Safety Design Bases

The PCSA shall apply the framework of event sequence development and supporting reliability analyses to identify the safety function of any SSCs or procedural controls that shall be credited to ensure that the frequencies of analyzed event sequences are achievable in the as-built repository. Such SSCs are classified as ITS. Such procedural controls are classified as procedural safety controls. The safety function and any quantitative reliability goal that are attributed to a given ITS SSC become part of the Nuclear Safety Design Bases and are subject to confirmatory analysis as part of the PCSA. The safety function and any quantitative reliability goal that are attributed to procedural safety controls are captured in a procedural safety control document, used as bases for operating procedures, and are subject to confirmation as part of the PCSA.

[This criterion derives from 10 CFR 63.111 and 10 CFR 63.112(e) [DIRS 180319]. NUREG-1804, Section 2.1.1.6 (RM 1 and RM2) (NRC 2003[DIRS 163274]) addresses this area. The SSC ITS and procedural safety controls are an outcome of the PCSA process. Safety functions, system mission times, system and component reliability, and human actions that are credited in prevention or mitigation of event sequences or their consequences are identified from the PCSA process. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application.]

7.10 Consequence Analyses for Exposure to Radiation from Event Sequences

Design requirements for repository facilities and packages shall be based, in part, on PCSA consequence analyses that are performed for Category 1 and Category 2 event sequences using accepted and qualified methods, source terms, and physical parameters appropriate to the repository site, facility design and operation, and waste forms. Where appropriate, consequence analyses shall be based on maximum capacity and throughput.

The analyses of consequences for Category 1 shall be performed on the basis of aggregating annual doses for normal operations and event sequences whose frequency evaluation meets the Category 1 definition. Category 1 exposures shall be evaluated for four kinds of receptors: involved workers, noninvolved workers, onsite public, and offsite public. Technical bases shall be provided for including or excluding applicable exposure pathways for each category of receptor. Calculated exposures for Category 1 event sequences shall meet the requirements of 10 CFR 63.111(a) and 63.111(b)(1)[DIRS 180319].

The analyses of consequences for Category 2 shall be performed on the basis of per-event doses for each event sequences whose frequency evaluation meets the Category 2 definition. Technical bases shall be provided for including or excluding applicable exposure pathways for offsite receptors. Calculated exposures for Category 2 event sequences shall meet the requirements of 10 CFR 63.111(b)(2).

As appropriate, a given consequence analysis for either Category 1 or Category 2 may be used as representative or bounding for several specific event sequences in the respective category.

As necessary, the facility design and operations may have to be altered if the results of the consequence analyses indicate that 10 CFR 63.111 is not satisfied with appropriate margin.

[This criterion is driven by 10 CFR 63.111. NUREG-1804, Sections 2.1.1.5, 2.1.1.5.1 and 2.1.1.5.2 (NRC 2003 [DIRS 163274]) address this area. The PCSA and supporting design and operational criteria must demonstrate that radiological consequences from Category 1 (including normal operations) and Category 2 event sequences will meet the respective Category 1 and Category 2 regulatory limits as specified in 10 CFR 63.111. This is the fundamental basis for compliance in the risk-informed framework of 10 CFR 63. The design features of repository

facilities and waste forms influence the conditions of release, mitigation, and exposure. Features credited in the consequence analyses to meet 10 CFR 63.111 form the bases for design criteria. 10 CFR 63.21(c)(5) requires that PCSA consider maximum capacity and throughput. RGA REG-CRW-RG-000399 (BSC 2007 [DIRS 182359]) adopted with clarification NUREG-1804 by mapping a crosswalk to the License Application.]

7.11 Margins for Event Sequence Categorization and Consequence Analyses

Repository facilities and packages shall be designed to ensure that sufficient margins are provided with respect to event sequence categorization by frequency and to radiological limits at the time of license application for construction authorization. For event sequence categorization, mean values (based on uncertainty analyses) shall be used and no margin is required so long as the calculated mean is less than the frequency limit for Category 1 or Category 2, respectively. If, the dose consequence analysis is performed using bounding parameters and assumptions, then no margin is needed. Justification that the analysis is bounding shall be included. If it is performed using representative parameters and assumptions, then a justification that the uncertainties are sufficiently small so that the 10 CFR 63.111 limits are still met with uncertainties shall be included.

[Federal Register/Vol. 72, No. 55/Thursday, March 22, 2007 [DIRS 183467] states: "NRC agrees that DOE can use the mean value of an event sequence frequency distribution to categorize an event sequence. However, DOE should consider the uncertainty in any mean value used to categorize event sequences." Division of High Level Waste Repository Safety - Interim Staff Guidance HLWRS-ISG-03 Preclosure Safety Analysis - Dose Performance Objectives and Radiation Protection Program (NRC 2007 [DIRS 182588]) states: "DOE should define and provide a technical base for bounding or representative source terms assumed in the analyses."]

7.12 Assessment of Rail Equipment Maintenance Yard Risks

The Rail Equipment Maintenance Yard and Cask Maintenance Facility are physically located outside the GROA. The PCSA designation for these facilities, operations and materials located at the Rail Equipment Maintenance Yard and Cask Maintenance Facility shall be non-ITS nearby industrial facilities.

[CO Letter 07-020, Contracting Officer Authorization to Bechtel SAIC Company, LLC (BSC), Directing BSC to Consider Interface Requirements and Include Utility Feed Connections from the Monitored Geological Repository to the Transportation Facilities, Contract No. DE-AC28-01RW12101, LTR. No. 07-020 [DIRS 181033] provides this direction. Electrical and water supply capability from the GROA to the REMY are defined in the BOD (BSC 2007 [DIRS 182131]), Criteria 9.10.2.2.14, 16.2.2.9, and 24.2.2.2.8]

7.13 Guidance in Support of Generally Accepted PCSA Methods

The following resources of the technical bases, reliability methods, generally accepted industry practices and NRC guidance in support probabilistic risk assessment (PRA) shall be considered relevant to the PCSA process for demonstrating compliance to the preclosure performance objectives in 10 CFR 63.111 [DIRS 180319].

- *Probabilistic Risk Assessment (PRA) of Bolted Storage Casks, Updated Quantification and Analysis Report (Canavan et al. 2004* [DIRS 177319])
- NUREG-1407, *Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities, Final Report* [DIRS 162002]
- NUREG/CR-5042, *Evaluation of External Hazards to Nuclear Power Plants in the United States* [DIRS 181517]
- *Bayesian Reliability Analysis (*Martz, H.F. and Waller, R.A. 1991 [DIRS 160924])
- 1990 Recommendations of the International Commission on Radiological Protection (ICRP 1991 [DIRS 101836])
- *Dose Coefficients for Intakes of Radionuclides by Workers, Replacement of ICRP Publication 61* (ICRP 1995 [DIRS 172721])
- *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients* (ICRP 1996 [DIRS 152446])
- NUREG-1567, *Standard Review Plan for Spent Fuel Dry Storage Facilities* [DIRS 149756]
- ISG-5, *Interim Staff Guidance - 5, Confinement Evaluation* [DIRS 160582]
- NUREG/CR-6331, *Atmospheric Relative Concentrations in Building Wakes* [DIRS 164547]
- Regulatory Guide 1.111, *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors* [DIRS 103765]
- Regulatory Guide 1.145*, Atmospheric Dispersion Models for Potential Accident Consequence Assessments*

at Nuclear Power Plants [DIRS 103651]

- Regulatory Guide 1.183, *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors* [DIRS 173584]
- NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook* [DIRS 103695]
- NUREG/CR-6672, *Reexamination of Spent Fuel Shipment Risk Estimates* [DIRS 152476]
- Regulatory Guide 8.8, *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will be as Low as is Reasonably Achievable* [DIRS 103312]

[The use of these technical bases, reliability methods, generally accepted industry practices and NRC guidance is left to the professional judgment of the personnel performing PRA related activities.
RGA REG-CRW-RG-000122, Agreement for Regulatory Guide 1.145, Rev. 1 - Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants (BSC 2007 [DIRS 181763]) has provided guidance for Regulatory Guide 1.145, to develop a site specific source term for occupational dose calculations in Section C and Appendix A.
RGA REG-CRW-RG-000417, Agreement for SFPO-ISG-05, Rev 1, Confinement Evaluation (BSC 2007 [DIRS 182075]) has adopted SFPO-ISG-05 with clarification that all TADs/casks used for storage in the aging system must have two welded seals.
RGA REG-CRW-RG-000392 (BSC 2007 [DIRS 182585]) has adopted NUREG-1567 with clarification.
REG-CRW-RG-000092, *Agreement For Regulatory Guide 1.111, Rev.1 - Methods For Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases From Light-Water-Cooled Reactors [DIRS 182770] has adopted Regulatory Guide 1.111 with clarification to use criteria listed in Table 1of the regulatory guide agreement.*
REG-CRW-RG-000158, Agreement for Regulatory Guide 1.183, Rev 0 - Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors (BSC 2007 [DIRS 182773]), has adopted Regulatory Guide 1.183 with clarification to develop event sequences consequence analysis using an AST-Type method subject to the elements of Sections C.2 and Appendix B, with the need for literal compliance.
RGA REG-CRW-RG-000338,Agreement For Regulatory Guide 8.8, Revision 3 - Information Relevant To Ensuring That Occupational Radiation Exposures At Nuclear Power Stations Will Be As Low As Is Reasonably Achievable (BSC2007 [DIRS 181778]) adopted Regulatory Guide 8.8. All sections in the RGA designated for engineering action will be complied with in the design, except Section C.1.d, which is not appropriate to the design criteria.
RGAs for NUREG-1407, NUREG/CR-5042, NUREG/CR-6331, NUREG/CR-6410, and NUREG/CR-6672 are being developed but not finalized, and are being used prior to final RGA adoption.]

8 References

8.1 Documents Cited

[DIRS 100252]
CRWMS M&O 1997. *Subsurface Waste Package Handling - Remote Control and Data Communication Analysis*. BCA000000-01717-0200-00004 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19970714.0655.

[DIRS 101687]
Johnson, A.B., Jr. 1977. *Behavior of Spent Nuclear Fuel in Water Pool Storage*. BNWL-2256. Richland, Washington: Pacific Northwest Laboratory. TIC: 234703.

[DIRS 101877]
Hartman, H.L.; Mutmansky, J.M.; Ramani, R.V.; and Wang, Y.J. 1997. *Mine Ventilation and Air Conditioning*. 3rd Edition. New York, New York: John Wiley & Sons. TIC: 236391.

[DIRS 102182]
Kennedy, R.P. and Ravindra, M.K. 1984. "Seismic Fragilities for Nuclear Power Plant Risk Studies." *Nuclear Engineering and Design, 79,* 47-68. Amsterdam, The Netherlands: Elsevier. TIC: 243985.

[DIRS 103763]
AIChE (American Institute of Chemical Engineers) 1992. *Guidelines for Hazard Evaluation Procedures.* 2nd Edition with Worked Examples. New York, New York: American Institute of Chemical Engineers. TIC: 239050.

[DIRS 108888]
Hansen, E.M.; Schwarz, F.K.; and Riedel, J.T. 1977. *Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages.* Hydrometeorological Report No. 49. Silver Spring, Maryland: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. TIC: 220224. ACC: NNA.19890714.0070.

[DIRS 111187]
CRWMS M&O 1997. *Yucca Mountain Site Geotechnical Report.* B00000000-01717-5705-00043 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980212.0354.

[DIRS 115042]
CRWMS M&O 1999. *TBV-361 Resolution Analysis: Emplacement Drift Orientation.* B00000000-01717-5705-00136 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990802.0316.

[DIRS 125707]
Dorf, R.C., ed. 1993. *The Electrical Engineering Handbook*. Boca Raton, Florida: CRC Press. TIC: 209253.

[DIRS 154386]
YMP (Yucca Mountain Site Characterization Project) 2001. *Reclamation Implementation Plan*. YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

[DIRS 155246]
BSC (Bechtel SAIC Company) 2001. *ANSYS Calculations in Support of Natural Ventilation Parametric Study for SR.* CAL-SVS-HV-000003 REV 00 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010613.0250.

[DIRS 155940]
Kennedy, R.P. 2001. "Overview of Methods for Seismic PRA and Margin Analysis Including Recent Innovations." *Proceedings of the OECD/NEA Workshop on Seismic Risk, Committee on the Safety of Nuclear Installations PWG3 and PWG5, Hosted by the Japan Atomic Energy Research Institute under the Sponsorship of the Science Technology Agency, 10-12 August, 1999, Tokyo, Japan. NEA/CSNI/R(99)28,* 33-63. Paris, France: Organization for Economic Co-operation and Development, Nuclear Energy Agency. TIC: 253825.

[DIRS 156051]
Barrett, L.H. 2001. "Units of Measure to be Used in Design, Fabrication, Construction, Component Testing, and Operation of Procured Items for a Repository." Letter from L.H. Barrett (DOE) to S.P. Mellington (DOE), September 13, 2001, MFR:OPE:SPM-1709. ACC: MOL.20011003.0303.

[DIRS 157529]
Williams, R.D. 2001. "Final Biological Opinion for the Effects of Construction, Operation and Monitoring, and Closure of a Geologic Repository at Yucca Mountain, Nye County, Nevada." Letter from R.D. Williams (U.S. Fish and Wildlife Service) to S. Brocoum (DOE), August 28, 2001, File No. 1-5-00-F-518. ACC: MOL.20011011.0219.

[DIRS 159262]
BSC (Bechtel SAIC Company) 2002. *Soils Report for North Portal Area, Yucca Mountain Project.* 100-00C-WRP0-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021015.0323; ENG.20050823.0018.

[DIRS 159274]
Linderman, R.B.; Rotz, J.V.; and Yeh, G.C.K. 1974. *Design of Structures for Missile Impact, Topical Report*. BC-TOP-9-A, Rev. 2. San Francisco, California: Bechtel Power. TIC: 253115.

[DIRS 159359]
Cook, R.A. 1999. *Strength Design of Anchorage to Concrete*. Skokie, Illinois: Portland Cement Association. TIC: 252912.
[DIRS 160836]
Hamilton-Ray, B.V. 2002. "Contracting Officer Guidance for Implementation of Policy Statement; Contract No. DE-AC08-01RW12101; Letter No. 02-046." Letter from B.V. Hamilton-Ray (DOE/YMSCO) to K.G. Hess (BSC), February 20, 2002, OPE:PGH-0653, with enclosure. ACC: MOL.20020312.0048.
[DIRS 160924]
Martz, H.F. and Waller, R.A. 1991. *Bayesian Reliability Analysis.* Malabar, Florida: Krieger Publishing Company. TIC: 252996.
[DIRS 162448]
BSC (Bechtel SAIC Company) 2003. *Corrosion Evaluation of Steel Ground Support Components*. 800-K0C-TEG0-00300-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030224.0001.
[DIRS 164177]
Edwards, T.A. and Yuan, Y. 2003. *Recommended Surface Contamination Levels for Waste Packages Prior to Placement in the Repository*. 000-30R-OSS0-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030903.0001.
[DIRS 164660]
Kennedy, R.P.; Cornell, C.A.; Campbell, R.D.; Kaplan, S.; and Perla, H.F. 1980. "Probabilistic Seismic Safety Study of an Existing Nuclear Power Plant." *Nuclear Engineering and Design, 59,* 315-338. [Amsterdam, The Netherlands]: North-Holland. TIC: 254898.
[DIRS 164983]
Arthur, W.J., III 2003. "Level 2 Directed Baseline Change (DOE/RW-0600, Rev. 0)." Letter from W.J. Arthur, III (DOE/ORD) to J.T. Mitchell (BSC), March 6, 2003, OPC andM:JCD-0610, 0307036365, with enclosure. ACC: DOC.20030528.0004.
[DIRS 165425]
BSC (Bechtel SAIC Company) 2003. *Longevity of Emplacement Drift Ground Support Materials for LA.* 800-K0C-TEG0-01200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030922.0004; ENG.20050816.0017.
[DIRS 165505]
YMP (Yucca Mountain Site Characterization Project) 2003. *Disposal Criticality Analysis Methodology Topical Report.* YMP/TR-004Q, Rev. 02. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: DOC.20031110.0005.
[DIRS 165572]
BSC (Bechtel SAIC Company) 2003. *Underground Layout Configuration.* 800-P0C-MGR0-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031002.0007; ENG.20050817.0005.
[DIRS 166107]
BSC (Bechtel SAIC Company) 2004. *Drift Degradation Analysis.* ANL-EBS-MD-000027 REV 03. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040915.0010; DOC.20050419.0001; DOC.20051130.0002; DOC.20060731.0005.
[DIRS 166132]
Williams, N.H. 2003. "Contract No. DE-AC28-01RW12101 - Licensing Position-009, Waste Stream Parameters." Letter from N.H. Williams (BSC) to J.D. Ziegler (DOE/ORD), November 13, 2003, 1105039412, with enclosure. ACC: MOL.20031215.0076.
[DIRS 167332]
CRWMS M&O 2000. *ESF Sanitary Sewer System Operation and Maintenance Manual.* BA0000000-01717-3500-00003 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000912.0214.
[DIRS 169992]
DOE/RW-0351, Rev. 5. *DOE (U.S. Department of Energy) 2007. Waste Acceptance System Requirements Document. DOE/RW-0351, Rev. 5. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.* ACC: DOC.20070522.0007.
[DIRS 170191]
DOE (U.S. Department of Energy) 2004. *Site Development Plan.* 000-PLN-MGR0-00100-000-001. Las Vegas, Nevada: U.S. Department of Energy, Office of Repository Development. ACC: ENG.20040217.0006.
[DIRS 171910]
Arthur, W.J., III. 2004. "Technical Direction to Bechtel SAIC Company, LLC, Contract Number DE-AC28-01RW12101, Use of J-Wells and C-Wells for Repository Water Sources; TDL No. 04-043." Letter from W.J. Arthur, III (DOE/ORD) to J.T. Mitchell, Jr. (BSC), August 31, 2004, 0902043036, with enclosure. ACC: MOL.20041005.0337; MOL.20041005.0338.

[DIRS 172983]
YMP (Yucca Mountain Site Characterization Project) 2005. *Exploratory Studies Facility Package 1A Starter Tunnel General Arrangement Plan (Sht 2).* YMP-025-1-MING-MG121, Rev. 05. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: SIT.20050110.0008.
[DIRS 172986]
BSC (Bechtel SAIC Company) 2002. *Assessment of Drift Diameter Variation on Rock Fall Development*. CAL-EBS-MD-000029 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20020613.0194.

[DIRS 173469]
Obert, L. and Duvall, W.I. 1967. *Rock Mechanics and the Design of Structures in Rock.* New York, New York: John Wiley & Sons. TIC: 257123.
[DIRS 174235]
BSC (Bechtel SAIC Company) 2005. *Monitored Geologic Repository External Events Hazards Screening Analysis.* 000-00C-MGR0-00500-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050829.0012.
[DIRS 174429]
BSC (Bechtel SAIC Company) 2005. *Extreme Wind/Tornado/Tornado Missile Hazard Analysis.* 000-00C-WHS0-00100-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050819.0005; ENG.20050926.0007.
[DIRS 174467]
BSC (Bechtel SAIC Company) 2005. *Categorization of Event Sequences for License Application.* 000-00C-MGR0-00800-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050808.0003 ENG.20050929.0003.
[DIRS 174877]
BSC (Bechtel SAIC Company) 2004. *Technical Management Review Board (TMRB) Decision Proposal.* TMRB-2004-051. [Las Vegas, Nevada: Bechtel SAIC Company]. ACC: MOL.20041025.0216.
[DIRS 175546]
BSC (Bechtel SAIC Company) 2005. *Nuclear Safety Design Bases for License Application.* 000-30R-MGR0-00400-000-003. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050929.0005.
[DIRS 176715]
DOE (U.S. Department of Energy) 2006. *Civilian Radioactive Waste Management System Requirements Document (CRD).* DOE/RW-0406, Rev. 07. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20060509.0008.
[DIRS 176722]
BSC (Bechtel SAIC Company) 2006. *Technical Work Plan for: Meteorological Monitoring and Data Analysis.* TWP-MGR-MM-000001 REV 03. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20060206.0003.
[DIRS 177194]
BSC (Bechtel SAIC Company) 2004. *Technical Management Review Board (TMRB) Decision Proposal.* TMRB-2004-073. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20041022.0201.
[DIRS 177339]
Ellingwood, B.; Galambos, T.V.; MacGregor, J.G.; and Cornell, C.A. 1980. *Development of a Probability Based Load Criterion for American National Standard A58: Building Code Requirements for Minimum Design Loads in Buildings and Other Structures.* Washington, D.C.: U.S. Department of Commerce, National Bureau of Standards. ACC: MOL.20061115.0081.
[DIRS 177340]
Ellingwood, B.R. 2001. "Earthquake Risk Assessment of Building Structures." *Reliability Engineering and System Safety, 74,* 251-262. [New York, New York]: Elsevier. TIC: 258805.
[DIRS 177491]
DOE (U.S. Department of Energy) 2006. *Monitored Geologic Repository Systems Requirements Document.* YMP/CM-0026, Rev. 1, ICN 0. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20060921.0002.
[DIRS 177724]
Apostolakis, G. 1978. "Probability and Risk Assessment: The Subjectivistic Viewpoint and Some Suggestions." *Nuclear Safety, 19,* (3), 305-315. [Oak Ridge, Tennessee]: [Technical Information Center of the U.S. Department of Energy]. TIC: 258650.
[DIRS 177812]
Apostolakis, G. 1981. *Bayesian Methods in Risk Assessment.* Advances in Nuclear Science and Technology. Lewins, J. and Becker, M., eds. Volume 13, Pages 415-465. New York, New York: Plenum Press. TIC: 5813.
[DIRS 178307]
Kvarfordt, K.J.; Wood, S.T.; and Smith, C.L. 2005. *Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) Code Reference Manual.* INL/EXT-05-00644. Idaho Falls, Idaho: Idaho National Laboratory. ACC: MOL.20061115.0082.

[DIRS 178319]
Mitchell, J.T., Jr. 2005. "Contract No. DE-AC28-01RW12101 - Response to Contracting Officer Authorization Letter No. 05-008, Regarding Updating of Biokinetic and Dosimetric Models." Letter from J.T. Mitchell, Jr. (BSC) to B. Hamilton-Ray (DOE/ORD), January 14, 2005, JTM:mal-0112054438, with enclosure. ACC: MOL.20050310.0001.
[DIRS 178320]
Miller, W.B. 2004. "Contracting Officer (CO) Authorization to Bechtel SAIC Company, LLC (BSC) to Initiate Update Biokinetic and Dosimetric Models and Provide Cost and Schedule Impact Estimates for the Effort, Contract Number DE-AC28-01RW12101, LTR No. 05-008." Letter from W.B. Miller (DOE/ORD) to J.T. Mitchell, Jr. (BSC), December 27, 2004, 0103054310, OLA&S:AEV-0469. ACC: MOL.20050201.0369.
[DIRS 180112]
BSC (Bechtel SAIC Company) 2007. *Frequency Analysis of Aircraft Hazards for License Application.* 000-00C-WHS0-00200-000-00F. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070925.0012.
[DIRS 178591]
BSC (Bechtel SAIC Company) 2006. *North Portal Basic Wind Speed Calculation.* 100-S0C-MGR0-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061207.0036.
[DIRS 178693]
BSC (Bechtel SAIC Company) 2007. *Subsurface Geotechnical Parameters Report.* ANL-SSD-GE-000001 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070115.0006.
[DIRS 179342]
BSC (Bechtel SAIC Company) 2007. *Postclosure Modeling and Analyses Design Parameters.* TDR-MGR-MD-000037 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070521.0012; ENG.20070829.0011.
[DIRS 179878]
BSC (Bechtel SAIC Company) 2006. *Public Water System Operation and Maintenance Manual.* ESF-BSC-PRWS-MECH-0021 REV 00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: SIT.20060501.0001.
[DIRS 179915]
BSC (Bechtel SAIC Company) 2007. *IED Surface Facility and Environment.* 100-IED-WHS0-00201-000 REV 00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG20070323.0004.
[DIRS 179975]
BSC (Bechtel SAIC Company) 2007. *Waste Package Component Design Methodology Report.* 000-30R-WIS0-00100-000-003. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070927.0034.
[DIRS 180112]
BSC (Bechtel SAIC Company) 2007. *Frequency Analysis of Aircraft Hazards for License Application.* 000-00C-WHS0-00200-000-00F. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070925.0012.
[DIRS 180412]
BSC (Bechtel SAIC Company) 2007. *IED Emplacement Drift Configuration and Environment.* 800-IED-MGR0-00501-000 REV 00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070716.0006.
[DIRS 180531]
BSC (Bechtel SAIC Company) 2006. *Seismic Analysis and Design Approach Document*. 000-30R-MGR0-02000-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061214.0008; ENG.20061214.0008; ENG.20070501.0001.
[DIRS 181033]
Hamilton-Ray, B.V. 2007. "Contracting Officer Authorization to Bechtel SAIC Company, LLC (BSC), Directing BSC to Consider Interface Requirements and Include Utility Feed Connections from the Monitored Geological Repository to the Transportation Facilities, Contract No. DE-AC28-01RW12101, LTR. No. 07-020." Letter from B.V. Hamilton-Ray (DOE/OCRWM) to T.C. Feigenbaum (BSC), May 9, 2007, 0509070891, OCE:SB-0992. ACC: CCU.20070509.0005.
[DIRS 181224]
Peterson, Spencer R. 2007. *Bechtel SAIC Company, LLC (BSC), Response to Technical Direction Letter No. 07-003, to Develop a Baseline Change Proposal to Establish and Maintain an Emergency Operations Center in Las Vegas, Nevada, Within the Summerlin Office Complex. Contract Number DE-AC28-01RW12101*. Letter from Spencer R. Peterson (DOE/OCRWM) to Ted Feigenbaum (BSC), May 3, 2007 ACC: CCU.20070504.0007.
[DIRS 181426]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG-0696, Functional Criteria for Emergency Response Facilities - Final Report.* REG-CRW-RG-000455 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070605.0009.
[DIRS 181517]
Kimura, C.Y. and Budnitz, R.J. 1987. *Evaluation of External Hazards to Nuclear Power Plants in the United States.* NUREG/CR-5042. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 234463.

[DIRS 181572]
DOE (U.S. Department of Energy) 2007. *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report.* YMP/TR-003-NP, Rev. 5. Las Vegas, Nevada: U.S. Department of Energy, Office of Repository Development. ACC: DOC.20070625.0013.
[DIRS 181611]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.132, Rev. 2 - Site Investigations for Foundations of Nuclear Power Plants* REG-CRW-RG-000110 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070611.0001.
[DIRS 181631]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 8.38, Revision 1 - Control of Access to High and Very High Radiation Areas of Nuclear Plants.* REG-CRW-RG-000364 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070507.0014.
[DIRS 181632]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.6, Rev. 0 - Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems (Safety Guide 6).* REG-CRW-RG-000005 REV 00. Las Vegas, Nevada: Bechtel SAIC company. ACC: DOC.20070222.0002.
[DIRS 181639]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.32, Rev. 3 - Criteria for Power Systems for Nuclear Power Plants.* REG-CRW-RG-000026 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070222.0004.
[DIRS 181642]
BSC (Bechtel SAIC Company) 2006. *Regulatory Guide 1.36, Rev. 0 - Nonmetallic Thermal Insulation for Austenitic Stainless Steel.* REG-CRW-RG-000031 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20061012.0019.
[DIRS 181665]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.68.3, Rev. 0 - Preoperational Testing of Instrument and Control Air Systems.* REG-CRW-RG-000057 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070425.0004.
[DIRS 181671]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.69, Rev. 0 - Concrete Radiation Shields for Nuclear Power Plants.* REG-CRW-RG-000058 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070501.0008.
[DIRS 181679]
BSC (Bechtel SAIC Company) 2006. *Agreement for Regulatory Guide 1.84, Rev. 33 - Design, Fabrication, and Materials Code Case Acceptability, ASME Section III.* REG-CRW-RG-000071 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20061012.0020.

[DIRS 181680]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.53, Rev. 2 - Application of the Single-Failure Criterion to Nuclear Power Plant Protective Systems.* REG-CRW-RG-000044 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070226.0002.
[DIRS 181681]
BSC (Bechtel SAIC Company) 2006. *Agreement for Regulatory Guide 1.76, Rev. 0 - Design Basis Tornado for Nuclear Power Plants.* REG-CRW-RG-000064 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20061208.0005.
[DIRS 181682]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.54, Rev. 1 - Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants.* REG-CRW-RG-000045 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070206.0013.
[DIRS 181689]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.100, Rev. 2 - Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants.* REG-CRW-RG-000084 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070522.0011.
[DIRS 181691]
BSC(Bechtel SAIC Company) 2006. *Agreement for Regulatory Guide 1.102, Rev. 1 - Flood Protection for Nuclear Power Plants.* REG-CRW-RG-000086 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20061208.0006.
[DIRS 181701]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.117, Rev. 1 - Tornado Design Classification.* REG-CRW-RG-000098 Revision 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC:

DOC.20061208.0007.
[DIRS 181711]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.128, Rev. 1 - Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants.* REG-CRW-RG-000106 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070226.0005.
[DIRS 181728]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.12 Rev. 0, General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials*. REG-CRW-RG-000268 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0010.
[DIRS 181732]
BSC (Bechtel SAIC Company) 2006. *Agreement for Regulatory Guide 1.59, Rev. 2 - Design Basis Floods for Nuclear Power Plants (Errata Published 07/30/1980).* REG-CRW-RG-000048 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20061208.0004.
[DIRS 181743]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.129, Rev. 1 - Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants.* REG-CRW-RG-000107 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070226.0006.
[DIRS 181745]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.137, Rev. 1 - Fuel Oil Systems for Standby Diesel Generators.* REG-CRW-RG-000115 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070425.0006.
[DIRS 181746]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.142, Rev. 2 - Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments).* REG-CRW-RG-000120 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070425.0009.
[DIRS 181750]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.26, Rev. 1, Selection of Material Balance Areas (MBAs) and Item Control Areas (CAs).* REG-CRW-RG-000278 Rev. 0. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0011.
[DIRS 181751]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.140, Rev. 2 - Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants.* REG-CRW-RG-000118 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070402.0013.
[DIRS 181752]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.27 Rev. 0, Special Nuclear Material Doorway Monitors.* REG-CRW-RG-000279 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0012.
[DIRS 181753]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.44 Rev. 3, Perimeter Intrusion Alarm Systems.* REG-CRW-RG-000291 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0014.
[DIRS 181754]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.49 Rev 0, Internal Transfers of Special Nuclear Material.* REG-CRW-RG-000293 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0013.
[DIRS 181763]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.145, Rev. 1 - Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants (Reissued 02/1983 to Correct Page 1.145-7).* REG-CRW-RG-000122 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070522.0015.
[DIRS 181764]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.143, Rev. 2 - Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants.* REG-CRW-RG-000121 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070522.0014.
[DIRS 181767]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.151, Rev. 0 - Instrument Sensing Lines.* REG-CRW-RG-000127 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070608.0005.

[DIRS 181768]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.155, Rev. 0 - Station Blackout.* REG-CRW-RG-000131 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070226.0008.
[DIRS 181769]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.12, Rev. 0 - Nuclear Power Plant Instrumentation for Earthquakes.* REG-CRW-RG-000010 REV 001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070702.0013.
[DIRS 181771]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.153, Rev. 1 - Criteria for Safety Systems.* REG-CRW-RG-000129 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070226.0007.
[DIRS 181773]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.158, Rev. 0 - Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants.* REG-CRW-RG-000134 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070226.0009.
[DIRS 181775]
BSC (Bechtel SAIC Company) 2007. *Agreement for Guide 1.199, Rev. 0 - Anchoring Components and Structural Supports in Concrete.* REG-CRW-RG-000174 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070425.0008.
[DIRS 181778]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 8.8, Revision 3 - Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable.* REG-CRW-RG-000338 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070507.0013.
[DIRS 181779]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 8.19, Revision 1 - Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants -- Design Stage Man-Rem Estimates.* REG-CRW-RG-000345 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070608.0006.
[DIRS 181781]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG-0612, January 1980 - Control of Heavy Loads at Nuclear Power Plants - Resolution of Generic Technical Activity A-36.* REG-CRW-RG-000383 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070315.0011.
[DIRS 181782]
BSC (Bechtel SAIC Company) 2007. *Agreement for HLWRS-ISG-02, Draft September 2006, Preclosure Safety Analysis - Level of Information and Reliability Estimation - Draft.* REG-CRW-RG-000413 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070608.0010.
[DIRS 181783]
BSC (Bechtel SAIC Company) 2007. *Agreement for SFPO-ISG-06, Rev 0, Establishing Minimum Initial Enrichment for the Bounding Design Basis Fuel Assembly(s).* REG-CRW-RG-000418 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070608.0013.
[DIRS 181785]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.7, Rev. 1 - Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas.* REG-CRW-RG-000263 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0009.
[DIRS 181799]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.189, Rev. 0 - Fire Protection for Operating Nuclear Power Plants.* REG-CRW-RG-000164 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070130.0004.
[DIRS 181803]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.52 Rev 3, Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material at Fixed Sites (Other than Nuclear Power Plants).* REG-CRW-RG-000295 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0015.
[DIRS 181804]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.61 Rev 0, Intent and Scope of the Physical Protection Upgrade Rule Requirements for Fixed Sites.* REG-CRW-RG-000304 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0017.
[DIRS 181805]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.65 Rev 0, Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls.* REG-CRW-RG-000307 REV 00. Las

Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0019.
[DIRS 181806]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 5.68 Rev 0, Protection Against Malevolent Use of Vehicles at Nuclear Power Plants.* REG-CRW-RG-000310 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070201.0020.

[DIRS 181807]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 8.25, Rev 1 - Air Sampling in the Workplace.* REG-CRW-RG-000351 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070608.0008.
[DIRS 181809]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.131,Rev 0 - Qualification Tests of Electric Cables, Field Splices, and Connections for Light Water Cooled Nuclear Power Plants.* REG-CRW-RG-000109 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070620.0016.
[DIRS 181810]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.138, Rev. 2 - Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants.* REG-CRW-RG-000116 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070611.0002.
[DIRS 181811]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.156, Rev. 0 - Environmental Qualification of Connection Assemblies for Nuclear Power Plants.* REG-CRW-RG-000132 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070625.0006.
[DIRS 181813]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.165, Rev. 0, Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion.* REG-CRW-RG-000140 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070611.0003.
[DIRS 181814]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.194, Rev. 0 - Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants.* REG-CRW-RG-000169 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070625.0012.
[DIRS 181815]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.196, Rev. 1 - Control Room Habitability at Light-Water Nuclear Power Reactors.* REG-CRW-RG-000171 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070625.0007.
[DIRS 181816]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.197, Rev. 0 - Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors.* REG-CRW-RG-000172 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070619.0010.
[DIRS 181817]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 3.18, Revision 0 - Confinement Barriers and Systems for Fuel Reprocessing Plants.* REG-CRW-RG-000201 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070619.0011.
[DIRS 181818]
BSC (Bechtel SAIC Company) 2007. *Agreement for HLWRS-ISG-03, Rev 0, Preclosure Safety Analysis - Dose Performance Objectives and Radiation Protection Program.* REG-CRW-RG-000385 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070625.0008.
[DIRS 181820]
BSC (Bechtel SAIC Company) 2007. *Agreement for SFPO-ISG-15, Rev 0, Materials Evaluation.* REG-CRW-RG-000426 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070620.0019.
[DIRS 181821]
BSC (Bechtel SAIC Company) 2007. *Agreement for SFPO-ISG-18, Rev 0, The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation.* REG-CRW-RG-000429 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070620.0020.
[DIRS 181824]
BSC (Bechtel SAIC Company) 2007. *Agreement for SFPO-ISG-22, Rev 0, Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel.* REG-CRW-RG-000433 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070619.0012.
[DIRS 181825]

BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG-1451, July 1992, Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository.* REG-CRW-RG-000445 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070611.0005.
[DIRS 181826]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG-1494, September 1994, Staff Technical Position on Consideration of Fault Displacement Hazards in Geologic Repository Design.* REG-CRW-RG-000447 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070611.0006.
[DIRS 181827]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG-1536, January 1997, Standard Review Plan for Dry Cask Storage Systems - Final Report.* REG-CRW-RG-000448 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070620.0021.
[DIRS 181828]
BSC (Bechtel SAIC Company) 2007. *Agreement for SFPO-ISG-11, Rev 3, Cladding Considerations for the Transportation and Storage of Spent Fuel.* REG-CRW-RG-000454 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070625.0011.
[DIRS 181836]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.97, Rev. 4 - Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants.* REG-CRW-RG-000081 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070625.0005.
[DIRS 181839]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.41, Rev. 0 - Preoperational Testing of Redundant On-Site Electric Power Systems To Verify Proper Load Group Assignments.* REG-CRW-RG-000036, Rev 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070226.0001.
[DIRS 181943]
BSC (Bechtel SAIC Company) 2007. *Agreement for SFPO-ISG-01, Rev 2, Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation Based on Function.* REG-CRW-RG-000414 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070618.0018.
[DIRS 181944]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.23, Revision 1, Meteorological Monitoring Programs for Nuclear Power Plants.* REG-CRW-RG-000017, Rev. 0. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070402.003.
[DIRS 181947]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.9, Rev. 3 - Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants.* REG-CRW-RG-000008 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070625.0002.
[DIRS 181948]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.47, Rev 0 - Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.* REG-CRW-RG-000040 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070625.0003.
[DIRS 181949]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.63, Rev. 3 - Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants.* REG-CRW-RG-000052 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070620.0018.
[DIRS 181950]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.78, Rev. 1 - Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release.* REG-CRW-RG-000066 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070627.0010.
[DIRS 181951]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.180, Rev. 1 - Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems.* REG-CRW-RG-000155 Rev 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070618.0011.
[DIRS 181952]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.89. Rev. 1 - Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants.* REG-CRW-RG-000074 Rev 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070620.0012.
[DIRS 181994]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.204, Guidelines for Lightning Protection of Nuclear Power Plants.* REG-CRW-RG-000179 Rev 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC:

DOC.20070703.0002.
[DIRS 181995]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.44, Rev. 0 - Control of the Use of Sensitized Stainless Steel.* REG-CRW-RG-000038 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070702.0018.
[DIRS 181996]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.75, REV. 3 - Criteria for Independence of Electrical Safety Systems.* REG-CRW-RG-000063 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070702.0019.
[DIRS 181997]
BSC (Bechtel SAIC Company) 2007. *Agreement for SFPO-ISG-10, Rev 1, Alternatives to the ASME Code.* REG-CRW-RG-000422 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070226.0012.
[DIRS 182071]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.38, Revision 1 - Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants.* REG-CRW-RG-000033 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070702.0017.
[DIRS 182075]
BSC (Bechtel SAIC Company) 2007. *Agreement for SFPO-ISG-05, Rev 1, Confinement Evaluation.* REG-CRW-RG-000417 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070718.0008.
[DIRS 182077]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.21, Rev. 1 - Measuring, Evaluating, and Reporting Radioctivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants.* REG-CRW-RG-000015 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070718.0004.

[DIRS 182078]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.109, Rev. 1 - Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I.* REG-CRW-RG-000090 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070718.0005.
[DIRS 182079]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.52, Rev. 3 - Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineering-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants.* REG-CRW-RG-000043 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070315.0012.
[DIRS 182086]
BSC (Bechtel SAIC Company) 2007. *Agreement for HLWRS-ISG-01, Rev 0, Review Methodology for Seismically Initiated Event Sequences.* REG-CRW-RG-000412 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070718.0007.
[DIRS 182087]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.92, Rev. 1 - Combining Modal Responses and Spatial Components in Seismic Response Analysis.* REG-CRW-RG-000077 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070702.0005.
[DIRS 182131]
BSC (Bechtel SAIC Company) 2007. *Basis of Design for the TAD Canister-Based Repository Design Concept.* 000-3DR-MGR0-00300-000-001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071002.0042.
[DIRS 182329]
BSC (Bechtel SAIC Company) 2007. *Preliminary Preclosure Nuclear Safety Design Bases.* 000-PSA-MGR0-01000-000 REV 000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070808.0017.
[DIRS 182357]
BSC (Bechtel SAIC Company) 2007. *BSC Position on the Use of the ASME Boiler and Pressure Vessel Code for the Yucca Mountain Project Waste Packages.* 000-30R-WIS0-00200-000-002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070709.0041.
[DIRS 182359]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG-1804, Rev 2, Yucca Mountain Review Plan - Final Report.* REG-CRW-RG-000399 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070510.0012.
[DIRS 182471]
BSC (Bechtel SAIC Company) 2007. *Repository System Codes.* 000-30X-MGR0-01200-000 REV 00D. Las

Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070119.0001.
[DIRS 182576]
BSC (Bechtel SAIC Company) 2007. *Backbone Telecommunications Report.* 000-30R-EC00-00100-000. Las Vegas, NV: Bechtel SAIC Company. ACC:ENG.20070816.0002.
[DIRS 182582]
BSC (Bechtel SAIC Company) 2007. *Supplemental Soils Report.* 100-S0C-CY00-00100-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070222.0001.
[DIRS 182585]
BSC (Bechtel SAIC Company) 2007. *Agreement For NUREG-1567, March 2000, Standard Review Plan Fuel Dry Storage Facilities - Final Report.* REG-CRW-RG-000392. Las Vegas, NV: Bechtel SAIC Company. ACC: DOC.20070625.0009.
[DIRS 182731]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG/CR 2300, September 1981, PRA Procedures Guide.* REG-CRW-RG-000452 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070402.0011.
[DIRS 182732]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG-1513, May 2001, Integrated Safety Analysis Guidance Document.* REG-CRW-RG-000389 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070515.0006.
[DIRS 182733]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG 0492, January, 1981, Fault Tree Handbook.* REG-CRW-RG-000441 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070402.0010.
[DIRS 182734]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG-1624, Rev 1, Technical Basis and Implementation Guidelines for a Technique for Human Event Analysis (Atheana).* REG-CRW-RG-000394 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070515.0009.
[DIRS 182737]
BSC (Bechtel SAIC Company) 2007. *Regulatory Guidance Agreement, Agreement for NUREG/CR 5485, November, 1998, Guidelines on Modeling Common Cause Failures in Probabilistic Risk Assessment.* REG-CRW-RG-000437 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070402.0006.
[DIRS 182770]
BSC (Bechtel SAIC Company) 2007. *Agreement For Regulatory Guide 1.111, Rev.1 - Methods For Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases From Light-Water-Cooled Reactors.* REG-CRW-RG-000092 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070828.0003.
[DIRS 182773]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.183, Rev 0 - Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors.* REG-CRW-RG-000158. Las Vegas, NV: Bechtel SAIC Company. ACC: DOC.20070515.0002.
[DIRS 182781]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.122, Rev. 1 - Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components.* REG-CRW-RG-000101 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070702.0006.
[DIRS 182784]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 3.71 - Nuclear Criticality Safety Standards for Fuels and Materials Facilities.* REG-CRW-RG-000240 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070828.0005.
[DIRS 182802]
BSC (Bechtel SAIC Company) 2007. *Regulatory Guidance Agreement, Agreement for Regulatory Guide 1.61, Rev. 1 - Damping Values for Seismic Design of Nuclear Power Plants.* REG-CRW-RG-000050 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070807.0011.
[DIRS 182847]
BSC (Bechtel SAIC Company) 2007. *Agreement For NUREG-0700, May 2002, Human-System Interface Design Review Guidelines.* REG-CRW-RG-000442. Las Vegas, NV: Bechtel SAIC Company. ACC: DOC.20070322.0003.
[DIRS 183085]
BSC (Bechtel SAIC Company) 2007. *TMRB Decision Proposal - PLCs not used for Nuclear Safety. TMRB-2007-024.* Las Vegas, Nevada: Bechtel SAIC Company. ACC: RPM.20071015.0013.
[DIRS 183131]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 3.20, Revision 0 - Process Offgas Systems*

for Fuel Reprocessing Plants. REG-CRW-RG-000203. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070516.0011.
[DIRS 183135]
BSC (Bechtel SAIC Company 2007. *Agreement for NUREG/CR-1278, August 1983 - Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications Final Report.* REG-CRW-RG-000434 REV 000. Las Vegas, NV: Bechtel SAIC Company. ACC: DOC.20070322.0001.
[DIRS 183137]
BSC (Bechtel SAIC Company) 2007. *Agreement for NUREG/CR-6823, September 2003 - Handbook of Parameter Estimation for Probabilistic Risk Assessment.* REG-CRW-RG-000440. Las Vegas, NV: Bechtel SAIC Company. ACC: DOC.20070402.0009.
[DIRS 183182]
BSC (Bechtel SAIC Company) 2007. *Agreement for Regulatory Guide 1.13, Rev. 2 - Spent Fuel Storage Facility Design Basis.* REG-CRW-RG-000011 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070807.0010.
[DIRS 183186]
BSC (Bechtel SAIC Company) 2007.*Agreement for Regulatory Guide 1.193, Rev. 1 - ASME Code Cases Not Approved for Use.* REG-CRW-RG-000168 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC .20070730.0002.
[DIRS 183187]
BSC (Bechtel SAIC Company) 2007. *Agreement For Regulatory Guide 3.71, Revision 1 - Nuclear Criticality Safety Standards For Fuels and Material Facilities.* REG-CRW-RG-000240 Rev 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070828.0005.
[DIRS 183261]
BSC (Bechel SAIC Company) 2007. *Yucca Mountain Project Drainage Report and Analysis.* 000-CDC-MGR0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070924.0043.
[DIRS 183263]
BSC (Bechtel SAIC Company) 2007. *Technical Management Review Board (TMRB) Decision Proposal.* TMRB-2007-053. Las Vegas, NV: Bechtel SAIC Company.
[DIRS 183406]
BSC (Bechtel SAIC Company) 2007. *Ground Control for Non-Emplacement Drifts for LA.* 800-K0C-SSD0-00400-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071001.0042.

8.2 Codes, Standards, Regulations

The listing of any reference in this section does not indicate or imply the use, application, or compliance in part or whole with the document. This section does not include codes and standards that have been identified as strictly output constraints, such as material or fitting specifications. These constraints that should use latest versions of the standards are identified in section 8.4.

[DIRS 100067]
Regulatory Guide 1.109, Rev. 1. 1977. *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: NNA.19870806.0032.
[DIRS 101681]
Nuclear Waste Policy Act of 1982. 42 U.S.C. 10101 et seq. Internet Accessible.
[DIRS 101836]
ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, No. 1-3 of *Annals of the ICRP.* ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
[DIRS 101903]
NRC (U.S. Nuclear Regulatory Commission) 1997. *Standard Review Plan for Dry Cask Storage Systems*. NUREG-1536. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010724.0307.
[DIRS 102016]
ANSI N14.6-1993. 1993 *American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More*. New York, New York: American National Standards Institute. TIC: 236261.
[DIRS 102288]
DOE O 440.1A. 1998. *Worker Protection Management for DOE Federal and Contractor Employees.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050411.0143.
[DIRS 102325]

IEEE Std 81-1983. 1983. *IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 232605.
[DIRS 102609]
Regulatory Guide 1.89, Rev. 1. 1984. *Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238593.
[DIRS 103014]
NRS (Nevada Revised Statute) 534. 2005. Underground Water and Wells. 258985.
[DIRS 103071]
ANSI/ANS-2.8-1992. 1992. *American National Standard for Determining Design Basis Flooding at Power Reactor Sites*. La Grange Park, Illinois: American Nuclear Society. TIC: 236034.
[DIRS 103124]
NRC (U.S. Nuclear Regulatory Commission) 1987. *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants.* NUREG-0800. LWR Edition. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 203894.
[DIRS 103165]
Regulatory Guide 1.153, Rev. 1. 1996. *Criteria for Safety Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238375.
[DIRS 103170]
Regulatory Guide 1.12, Rev. 02. 1997. *Nuclear Power Plant Instrumentation for Earthquakes.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238335.
[DIRS 103312]
Regulatory Guide 8.8, Rev. 3. 1978. *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will be as Low as is Reasonably Achievable.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238609.
[DIRS 103532]
Regulatory Guide 5.26, Rev. 1. 1975. *Selection of Material Balance Areas and Item Control Areas*. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235878.
[DIRS 103534]
Regulatory Guide 5.7, Rev. 1. 1980. *Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235877.
[DIRS 103635]
Budnitz, R.J.; Apostolakis, G.; Boore, D.M.; Cluff, L.S.; Coppersmith, K.J.; Cornell, C.A.; and Morris, P.A. 1997. *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on the Uncertainty and Use of Experts.* NUREG/CR-6372. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235076; 235074.
[DIRS 103651]
Regulatory Guide 1.145, Rev. 1. 1982. *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: HQS.19880517.2794.
[DIRS 103662]
60 FR 42622. Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities; Final Policy Statement. TIC: 238369.
[DIRS 103695]
SAIC (Science Applications International Corporation) 1998. *Nuclear Fuel Cycle Facility Accident Analysis Handbook.* NUREG/CR-6410. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010726.0069.
[DIRS 103765]
Regulatory Guide 1.111, Rev. 1. 1977. *Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050516.0410.
[DIRS 103930]
Pollution Prevention Act of 1990. 42 U.S.C. 13101 et seq. Internet Accessible.
[DIRS 104024]
63 FR 49643. Greening the Government through Waste Prevention, Recycling, and Federal Acquisition. Executive Order 13101. TIC: 241928.
[DIRS 104026]
64 FR 30851. Greening the Government through Efficient Energy Management. Executive Order 13123. ACC: MOL.20050420.0201.
[DIRS 104039]

NAC (Nevada Administrative Code) 444. 2006. Sanitation. 258999.
[DIRS 104040]
NAC (Nevada Administrative Code) 445A. 2006. Water Controls. 258975.
[DIRS 104041]
NAC (Nevada Administrative Code) 445B. 2006. Air Controls. 258952.
[DIRS 104042]
NAC (Nevada Administrative Code) 459. 2006. Hazardous Materials. Internet Accessible. 258987.
[DIRS 104098]
NRC (U.S. Nuclear Regulatory Commission) 1981. *Functional Criteria for Emergency Response Facilities, Final Report.* NUREG-0696. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 102319.
[DIRS 104939]
NRC (U.S. Nuclear Regulatory Commission) 1980. *Control of Heavy Loads at Nuclear Power Plants*. NUREG-0612. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 209017.
[DIRS 105205]
McConnell, K.I.; Blackford, M.E.; and Ibrahim, A.B. 1992. *Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geological Repository.* NUREG-1451. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 204829.
[DIRS 105991]
Regulatory Guide 1.21, Rev. 1. 1974. *Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 223043.
[DIRS 106172]
Regulatory Guide 8.25, Rev. 1. 1992. *Air Sampling in the Workplace.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238394.
[DIRS 106281]
Regulatory Guide 1.76, Rev. 0. 1974. *Design Basis Tornado for Nuclear Power Plants*. Washington, D.C.: U.S. Atomic Energy Commission. TIC: 2717.
[DIRS 106591]
NRC (U.S. Nuclear Regulatory Commission) 1983. *PRA Procedures Guide, A Guide to the Performance of Probabilistic Risk Assessments for Nuclear Power Plants.* NUREG/CR-2300. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 205084.
[DIRS 107016]
ANSI/ANS-6.1.1-1977. *Neutron and Gamma-Ray Flux-to-Dose-Rate Factors.* La Grange Park, Illinois: American Nuclear Society. TIC: 239401.
[DIRS 107063]
AISC (American Institute of Steel Construction) 1997. *Manual of Steel Construction, Allowable Stress Design*. 9th Edition, 2nd Revision, 2nd Impression. Chicago, Illinois: American Institute of Steel Construction. TIC: 240772.
[DIRS 107719]
ANSI/ANS-6.1.1-1991. 1992. *American National Standard for Neutron and Gamma-Ray Fluence-to-Dose Factors.* La Grange Park, Illinois: American Nuclear Society. TIC: 236033.
[DIRS 108309]
ANSI N305-1975. *Design Objectives for Highly Radioactive Solid Material Handling and Storage Facilities in a Reprocessing Plant*. New York, New York: American Institute of Chemical Engineers. TIC: 231659.
[DIRS 110548]
Regulatory Guide 1.44. 1973. *Control of the Use of Sensitized Stainless Steel.* Washington, D.C.: U.S. Atomic Energy Commission. TIC: 4549.
[DIRS 110807]
Regulatory Guide 1.6, Rev. 0. 1971. *Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 239115.
[DIRS 110810]
Regulatory Guide 1.100, Rev. 2. 1988. *Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4636.
[DIRS 110957]
McConnell, K.I. and Lee, M.P. 1994. *Staff Technical Position on Consideration of Fault Displacement Hazards in Geologic Repository Design.* NUREG-1494. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 212360.
[DIRS 111337]
ANSI/ANS-57.2-1983. *American National Standard Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants*. La Grange Park, Illinois: American Nuclear Society. TIC: 8518.

[DIRS 112340]
ANSI/ISA-S84.01-1996. *Application of Safety Instrumented Systems for the Process Industries*. Research Triangle Park, North Carolina: Instrument Society of America. TIC: 244098.
[DIRS 114614]
ANSI Z88.2-1992. *American National Standard for Respiratory Protection*. New York, New York: American National Standards Institute. TIC: 233859.
[DIRS 116978]
IEEE Std 739-1995. 1996. *IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 231563.
[DIRS 117499]
Regulatory Guide 1.102, Rev. 1. 1976. *Flood Protection for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 3697.
[DIRS 118373]
ACI 506.2-95. 1995. *Specification for Shotcrete*. Detroit, Michigan: American Concrete Institute. TIC: 226412.
[DIRS 119139]
Regulatory Guide 1.165. 1997. *Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 233774.
[DIRS 122242]
IEEE Std 141-1993. 1994. *IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 240362.
[DIRS 122246]
IEEE Std 399-1997. 1998. *IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 242962.
[DIRS 122381]
ANSI/ANS-40.35-1991. *Volume Reduction of Low-Level Radioactive Waste or Mixed Waste*. La Grange Park, Illinois: American Nuclear Society. TIC: 240264.
[DIRS 123801]
ANSI/ANS-8.1-1998. 1998. *Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 242363.
[DIRS 124614]
ANSI N13.8-1973. *American National Standard Radiation Protection in Uranium Mines*. New York, New York: American National Standards Institute. TIC: 208902.
[DIRS 124644]
ASHRAE DG-1-93. 1993. *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 240280.
[DIRS 125763]
IEEE Std 446-1995. 1995. *IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 242952.
[DIRS 125916]
IEEE Std 603-1998. *IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 242993.
[DIRS 126007]
ANSI C84.1-1995. 1995. *Electric Power Systems and Equipment - Voltage Ratings (60 Hz).* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 242358.
[DIRS 128494]
Vesely, W.E.; Goldberg, F.F.; Roberts, N.H.; and Haasl, D.F. 1981. *Fault Tree Handbook.* NUREG-0492. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 208328.
[DIRS 131488]
Regulatory Guide 1.59, Rev. 2. 1977. *Design Basis Floods for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 2708.
[DIRS 131950]
Federal Mine Safety and Health Act of 1977. 30 U.S.C. 801 et seq. Internet Accessible.
[DIRS 132149]
ASCE (American Society of Civil Engineering) 1991. *Design and Construction of Sanitary and Storm Sewers.* 6th Printing. [New York, New York]: American Society of Civil Engineers. TIC: 4191.
[DIRS 139383]
Swain, A.D. and Guttmann, H.E. 1983. *Handbook of Human Reliability Analysis with Emphasis on Nuclear*

Power Plant Applications Final Report. NUREG/CR-1278. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 246563.

[DIRS 144423]
DOE G 440.1-5. 1995. *Implementation Guide for Use with DOE Orders 420.1 and 440.1 Fire Safety Program.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050518.0094.
[DIRS 144748]
Regulatory Guide 1.41, Rev. 0. 1973. *Preoperational Testing of Redundant On-Site Electric Power System to Verify Proper Load Group Assignments.* Washington, D.C.: U.S. Regulatory Commission. TIC: 2706.
[DIRS 144751]
Regulatory Guide 1.117, Rev. 1. 1978. *Tornado Design Classification.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4628.
[DIRS 144752]
Regulatory Guide 1.137, Rev. 1. 1979. *Fuel-Oil Systems for Standby Diesel Generators.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4597.
[DIRS 144753]
Regulatory Guide 1.155, Rev. 0. 1988. *Station Blackout.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4661.
[DIRS 145510]
Regulatory Guide 1.128, Rev. 1. 1978. *Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238334.
[DIRS 145515]
Regulatory Guide 1.129, Rev. 1. 1978. *Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235714.
[DIRS 145717]
ANSI/IEEE Std 535-1986. *IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 238290.
[DIRS 146732]
Regulatory Guide 1.9, Rev. 3. 1993. *Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238563.
[DIRS 147940]
NIOSH (National Institute for Occupational Safety and Health) 1996. *"Silica, Crystalline (as Respirable Dust)".* [Washington, D.C.]: National Institute for Occupational Safety and Health. Accessed April 8, 1999. TIC: 243424.
[DIRS 148894]
Regulatory Guide 8.19, Rev. 1. 1979. *Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants Design Stage Man-Rem Estimates.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: NNA.19870728.0014.
[DIRS 149756]
NRC (U.S. Nuclear Regulatory Commission) 2000. *Standard Review Plan for Spent Fuel Dry Storage Facilities.* NUREG-1567. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 247929.
[DIRS 149921]
ASCE 7-98. 2000. *Minimum Design Loads for Buildings and Other Structures.* Revision of ANSI/ASCE 7-95. Reston, Virginia: American Society of Civil Engineers. TIC: 247427.

[DIRS 151403]
Regulatory Guide 1.92, Rev. 1. 1976. *Combining Modal Responses and Spatial Components in Seismic Response Analysis.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 2775.
[DIRS 151404]
Regulatory Guide 1.122, Rev. 1. 1978. *Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components.* [Washington, D.C.]: U.S. Nuclear Regulatory Commission. TIC: 2787.
[DIRS 152060]
ICRP (International Commission on Radiological Protection) 1997. *Conversion Coefficients for Use in Radiological Protection Against External Radiation.* Volume 26, No. 3/4 of *Annals of the ICRP.* ICRP Publication 74. Tarrytown, New York: Elsevier. TIC: 248792.
[DIRS 152380]
ANSI/HPS N13.1. 1999. *American National Standard Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities*. McLean, Virginia: Health Physics Society. TIC:

248835.
[DIRS 152446]
ICRP (International Commission on Radiological Protection) 1996. *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients.* Volume 26, No. 1 of Annals of the ICRP. Smith, H., ed. ICRP Publication 72. New York, New York: Pergamon Press. TIC: 235870.
[DIRS 152476]
Sprung, J.L.; Ammerman, D.J.; Breivik, N.L.; Dukart, R.J.; Kanipe, F.L.; Koski, J.A.; Mills, G.S.; Neuhauser, K.S.; Radloff, H.D.; Weiner, R.F.; and Yoshimura, H.R. 2000. *Reexamination of Spent Fuel Shipment Risk Estimates.* NUREG/CR-6672. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20001010.0217.
[DIRS 153079]
ANSI/AMCA 210-99. 2000. *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating*. Arlington Heights, Illinois: Air Movement and Control Association International. TIC: 249168.
[DIRS 154538]
65 FR 24595. Greening the Government through Leadership in Environmental Management. Executive Order 13148. ACC: MOL.20050418.0101.
[DIRS 154954]
DOE-STD-1066-99. 1999. *Fire Protection Design Criteria.* Washington, D.C.: U.S. Department of Energy. TIC: 249984.
[DIRS 155040]
Regulatory Guide 1.189. 2001. *Fire Protection for Operating Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060105.0191.
[DIRS 157566]
Regulatory Guide 1.143, Rev. 2. 2001. *Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050516.0258.
[DIRS 157661]
NRC (U.S. Nuclear Regulatory Commission) 2000. *Technical Basis and Implementation Guidelines for a Technique for Human Event Analysis (ATHEANA).* NUREG-1624, Rev. 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 252116.
[DIRS 158115]
ASME (American Society of Mechanical Engineers) 2001. *2001 ASME Boiler and Pressure Vessel Code (includes 2002 addenda).* New York, New York: American Society of Mechanical Engineers. TIC: 251425.
[DIRS 158616]
DOE-STD-3022-98. 1998. *DOE HEPA Filter Test Program.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20020610.0216.
[DIRS 158761]
DOE M 440.1-1. 1996. *DOE Explosives Safety Manual.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050517.0203.
[DIRS 158804]
Regulatory Guide 3.18, Rev. 0. 1974. *Confinement Barriers and Systems for Fuel Reprocessing Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238370.
[DIRS 158830]
ACI 201.2R-01. 2001. *Guide to Durable Concrete*. Farmington Hills, Michigan: American Concrete Institute. TIC: 252729.
[DIRS 158831]
ACI 301-99. 1999. *Specifications for Structural Concrete*. Farmington Hills, Michigan: American Concrete Institute. TIC: 252730.
[DIRS 158832]
ACI 318-02/318R-02. 2002. *Building Code Requirements for Structural Concrete (ACI 318-02) and Commentary (ACI 318R-02).* Farmington Hills, Michigan: American Concrete Institute. TIC: 252731.
[DIRS 158835]
ANSI/AISC N690-1994. 1994. *American National Standard Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities*. Chicago, Illinois: American Institute of Steel Construction. TIC: 252734.
[DIRS 158844]
ASTM D 5144-00. 2000. *Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252740.

[DIRS 158851]
IEEE Std 308-2001. 2002. *IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronic Engineers. TIC: 252746.
[DIRS 158855]
Regulatory Guide 1.140, Rev. 2. 2001. *Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050516.0416.
[DIRS 158856]
Regulatory Guide 5.12, Rev. 0. 1973. *General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235802.
[DIRS 158857]
Regulatory Guide 5.44, Rev. 03. 1997. *Perimeter Intrusion Alarm Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 242395.
[DIRS 158858]
Regulatory Guide 5.65, Rev. 0. 1986. *Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235793.
[DIRS 158913]
DOE O 430.2A. 2002. *Departmental Energy and Utilities Management.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050411.0140.
[DIRS 158925]
ACI 530-02/ASCE 5-02/TMS 402-02. 2002. *Building Code Requirements for Masonry Structures.* Farmington Hills, Michigan: American Concrete Institute. TIC: 252752.
[DIRS 158927]
SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) 1995. *HVAC Duct Construction Standards Metal and Flexible.* 2nd Edition. Chantilly, Virginia: Sheet Metal and Air Conditioning Contractor National Association. TIC: 232331.
[DIRS 158930]
ASTM A 500-01a. 2001. *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 252768.
[DIRS 158946]
ANSI/ANS-8.22-1997. *American National Standard for Nuclear Criticality Safety Based on Limiting and Controlling Moderators*. La Grange Park, Illinois: American Nuclear Society. TIC: 235109.
[DIRS 158959]
Regulatory Guide 1.69, Rev. 0. 1973. *Concrete Radiation Shields for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: NNA.19870806.0031.
[DIRS 159029]
NRC (U.S. Nuclear Regulatory Commission) 1995. *Standard Format and Content Acceptance Criteria for the Material Control and Accounting (MC&A) Reform Amendment*. NUREG-1280, Rev. 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040401.0108.
[DIRS 159139]
DOE O 252.1. 1999. *Technical Standards Program.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050511.0211.
[DIRS 159140]
DOE HQ O 250.1. 1998. *Civilian Radioactive Waste Management Facilities -- Exemption from Departmental Directives.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20051210.0137.
[DIRS 159157]
AISC (American Institute of Steel Construction) 1989. *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, June 1, 1989, with Commentary.* Chicago, Illinois: American Institute of Steel Construction. TIC: 241419.
[DIRS 159250]
OMB Circular No. A-119. 1998. *Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities.* [Washington, D.C.]: Office of Management and Budget. ACC: MOL.20050516.0255.
[DIRS 159251]
National Technology Transfer and Advancement Act of 1995. Public Law No. 104-113, 110 Stat. 775. ACC: MOL.20050418.0130.
[DIRS 159258]
DOE-STD-1020-2002. 2002. *Natural Phenomena Hazards Design and Evaluation Criteria for Department of*

Energy Facilities. Washington, D.C.: U.S. Department of Energy. TIC: 253058.
[DIRS 159434]
ANSI/ANS-HPSSC-6.8.1-1981. *Location and Design Criteria for Area Radiation Monitoring Systems for Light Water Nuclear Reactors*. La Grange Park, Illinois: American Nuclear Society. TIC: 253112.
[DIRS 159450]
DOE O 420.1A. 2002. *Facility Safety.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050411.0135.
[DIRS 159544]
ASME NQA-1-2000. 2001. *Quality Assurance Requirements for Nuclear Facility Applications.* New York, New York: American Society of Mechanical Engineers. TIC: 253110.
[DIRS 159567]
NRC (U.S. Nuclear Regulatory Commission) 2002. *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility.* NUREG-1520. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 253141.
[DIRS 159618]
ASCE 4-98. 2000. *Seismic Analysis of Safety-Related Nuclear Structures and Commentary.* Reston, Virginia: American Society of Civil Engineers. TIC: 253158.
[DIRS 159667]
DOE G 420.1-1. 2000. *Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide for Use with DOE O 420.1, Facility Safety.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20050518.0091
[DIRS 159949]
66 FR 40571. Energy Efficient Standby Power Devices. Executive Order 13221. ACC: MOL.20050418.0115.

[DIRS 160406]
Clean Water Act of 1977. 33 U.S.C. 1251 et seq. ACC: MOL.20060105.0177.
[DIRS 160582]
NRC (U.S. Nuclear Regulatory Commission) 2003. "Interim Staff Guidance - 5, Revision 1. Confinement Evaluation." ISG-5, Rev 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed January 24, 2003. ACC: MOL.20030124.0247.
[DIRS 160936]
NFPA 1144. 2002. *Standard for Protection of Life and Property from Wildfire.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253676.
[DIRS 160951]
NFPA 17. 2002. *Standard for Dry Chemical Extinguishing Systems*. 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253680.
[DIRS 160952]
NFPA 25. 2002. *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253684.
[DIRS 160953]
NFPA 69. 2002. *Standard on Explosion Prevention Systems*. 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 253685.
[DIRS 161196]
ANSI N14.30-1992. 1993. *Semi-Trailers Employed in the Highway Transport of Weight-Concentrated Radioactive Loads - Design, Fabrication, and Maintenance.* New York, New York: American National Standard Institute. TIC: 10032.
[DIRS 161329]
EPRI (Electric Power Research Institute) 1994. *Methodology for Developing Seismic Fragilities.* EPRI TR-103959. Palo Alto, California: Electric Power Research Institute. TIC: 253770.
[DIRS 161330]
EPRI (Electric Power Research Institute) 1991. *A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1).* EPRI NP-6041-SL, Rev. 1. Palo Alto, California: Electric Power Research Institute. TIC 253771.
[DIRS 161724]
NRC (U.S. Nuclear Regulatory Commission) 2001. *Interim Staff Guidance - 15. Materials Evaluation.* ISG-15. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20030213.0154.
[DIRS 161833]
SMACNA (Sheet Metal and Air Conditioning Contractors National Association) 1985. *HVAC Air Duct Leakage Test Manual.* 1st Edition. Chantilly, Virginia: Sheet Metal and Air Conditioning Contractors National Association. TIC: 232334.
[DIRS 161842]
EPA (U.S. Environmental Protection Agency) 2000. *Meteorological Monitoring Guidance for Regulatory*

Modeling Applications. EPA-454/R-99-005. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency. TIC: 253879.
[DIRS 161986]
Regulatory Guide 1.78, Rev. 1. 2001. *Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050516.0263.
[DIRS 162002]
Chen, J.T.; Chokshi, N.C.; Kenneally, R.M.; Kelly, G.B.; Beckner, W.D.; McCracken, C.; Murphy, A.J.; Reiter, L.; and Jeng, D. 1991. *Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities, Final Report.* NUREG-1407. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 237269.
[DIRS 162264]
Americans with Disabilities Act of 1990. Public Law No. 101-336, 104 Stat. 327. TIC: 6718.
[DIRS 163274]
NRC (U.S. Nuclear Regulatory Commission) 2003. *Yucca Mountain Review Plan, Final Report.* NUREG-1804, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. TIC: 254568.
[DIRS 164133]
IEEE Std 802.11b-1999. 2000. *Supplement to IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan Area Networks-Specific Requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254758.
[DIRS 164144]
Droms, R. 1993. *Dynamic Host Configuration Protocol.* RFC 1541. [Reston, Virginia: Internet Society]. TIC: 254630.
[DIRS 164146]
Moy, J. 1994. *OSPF Version 2*. RFC 1583. [Reston, Virginia: Internet Society]. TIC: 254631.
[DIRS 164147]
Baker, F. 1995. *Requirements for IP Version 4 Routers.* RFC 1812. [Reston, Virginia: Internet Society]. TIC: 254959.
[DIRS 164148]
Rekhter, Y.; Moskowitz, B.; Karrenberg, D.; de Groot, G.J.; and Lear, E. 1996. *Address Allocation for Private Internets*. RFC 1918. [Reston, Virginia: Internet Society]. TIC: 254632.
[DIRS 164162]
T1.105-2001. 2002. *Synchronous Optical Network (SONET) -- Basic Description Including Multiplex Structure, Rates, and Formats, Including Supplement T1.105a-2002.* Washington, D.C.: Alliance for Telecommunications Industry Solutions. TIC: 254657.
[DIRS 164190]
ASME B16.5a-1998. 1998. *Addenda to ASME B16.5-1996 Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24.* New York, New York: American Society of Mechanical Engineers. TIC: 254184.
[DIRS 164191]
ANSI/ISA-50.00.01-1975 (R2002). 2002. *Compatibility of Analog Signals for Electronic Industrial Process Instruments.* Research Triangle Park, North Carolina: Instrumentation, Systems and Automation Society. TIC: 254096.
[DIRS 164197]
ANSI/ASHRAE 52.1-1992. 1992. *Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air Conditioning Engineers. TIC: 254102.
[DIRS 164198]
IEEE Std 519-1992. 1993. *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254111.
[DIRS 164202]
NEMA MG 11-1977 (R1997, R2001). 2001. *Energy Management Guide for Selection and Use of Single-Phase Motors.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 254110.
[DIRS 164222]
NEMA ICS 6-1993 (R 2001). 2001. *Industrial Control and Systems: Enclosures.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 254261.
[DIRS 164231]

ISA-MC96.1-1982. 2003. *Temperature Measurement Thermocouples.* Research Triangle Park, North Carolina: Instrumentation, Systems, and Automation Society. TIC: 254132.
[DIRS 164242]
ANSI/AWWA C652-02. 2002. *AWWA Standard for Disinfection of Water-Storage Facilities*. Denver, Colorado: American Water Works Association. TIC: 254108.
[DIRS 164256]
IEEE Std 80-2000. 2000. *IEEE Guide for Safety in AC Substation Grounding.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254157.
[DIRS 164263]
ISA-5.3-1983. 1983. *Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254147.
[DIRS 164267]
IEEE Std 1184-1994. 1995. *IEEE Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254113.
[DIRS 164268]
API Std 526. 2003. *Flanged Steel Pressure Relief Valves*. 5th Edition. Washington, D.C.: American Petroleum Institute. TIC: 254087.
[DIRS 164283]
ISA-S5.5-1985. 1986. *Graphic Symbols for Process Displays.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254080.
[DIRS 164286]
ANSI/ISA S5.2-1976 (R1992). 1992. *Binary Logic Diagrams for Process Operations.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254079.
[DIRS 164287]
ANSI/ISA-S7.0.01-1996. 1996. *Quality Standard for Instrument Air*. Research Triangle Park, North Carolina: Instrument Society of America. TIC: 254082.
[DIRS 164297]
NEMA TR 1-1993 (R 2000). 2002. *Transformers, Regulators and Reactors.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 254072.
[DIRS 164302]
Urban Water Resources Research Council, American Society of Civil Engineers [UWRRC/ASCE] 1992. *Design and Construction of Urban Stormwater Management Systems.* ASCE Manuals and Reports on Engineering Practice No. 77. Reston, Virginia: American Society of Civil Engineers. TIC: 254193.
[DIRS 164310]
ARI Std 410. 2002. *Forced-Circulation Air-Cooling and Air-Heating Coils, with Addendum.* Arlington, Virginia: Air-Conditioning and Refrigeration Institute. TIC: 254106.
[DIRS 164322]
ANSI/ANS-40.37-1993. 1994. *American National Standard for Mobile Radioactive Waste Processing Systems*. La Grange Park, Illinois: American Nuclear Society. TIC: 253794.
[DIRS 164489]
Cain, B.; Deering, S.; Kouvelas, I.; Fenner, B.; and Thyagarajan, A. 2002. *Internet Group Management Protocol,* Version 3. RFC 3376. [Reston, Virginia]: Internet Society. TIC: 254661.
[DIRS 164538]
NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 18. The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation.* ISG-18. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 254660.
[DIRS 164547]
Ramsdell, J.V., Jr. and Simonen, C.A. 1997. *Atmospheric Relative Concentrations in Building Wakes.* NUREG/CR-6331, Rev. 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 233690.
[DIRS 165075]
NFPA 22. 2003. *Standard for Water Tanks for Private Fire Protection*. 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 254860.
[DIRS 165077]
NFPA 801. 2003. *Standard for Fire Protection for Facilities Handling Radioactive Materials.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 254811.
[DIRS 165110]
NRC (U.S. Nuclear Regulatory Commission) [1989]. "Seismic Design Parameters." Revision 2 of Section 3.7.1 of *Standard Review Plan [for the Review of Safety Analysis Reports for Nuclear Power Plants]*. NUREG-0800.

Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20030910.0150.
[DIRS 165111]
NRC (U.S. Nuclear Regulatory Commission) [1989]. "Seismic System Analysis." Revision 2 of Section 3.7.2 of *Standard Review Plan [for the Review of Safety Analysis Reports for Nuclear Power Plants]*. NUREG-0800. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20030910.0151.
[DIRS 165112]
NRC (U.S. Nuclear Regulatory Commission) 1989. "Seismic Subsystem Analysis." Revision 2 of Section 3.7.3 of *Standard Review Plan [for the Review of Safety Analysis Reports for Nuclear Power Plants]*. NUREG-0800. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20030910.0152.
[DIRS 165132]
NACE Standard RP0169-2002. *Standard Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.* Houston, Texas: National Association of Corrosion Engineers. TIC: 254895.
[DIRS 165262]
ASME B16.3-1998. 1999. *Malleable Iron Threaded Fittings, Classes 150 and 300.* New York, New York: American Society of Mechanical Engineers. TIC: 254936.
[DIRS 165621]
Project Grants and Contracts for Family Planning Services. 42 U.S.C. 300. Internet Accessible.
[DIRS 165710]
Regulatory Guide 1.38, Rev. 2. 1977. *Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4648.
[DIRS 165716]
Regulatory Guide 1.47. 1973. *Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4548.
[DIRS 165719]
ASME B73.1-2001. 2002. *Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process.* New York, New York: American Society of Mechanical Engineers. TIC: 254619.
[DIRS 165736]
Regulatory Guide 1.194. 2003. *Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060105.0194.
[DIRS 165761]
Regulatory Guide 1.151. 1983. *Instrument Sensing Lines.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4665.
[DIRS 165773]
Regulatory Guide 1.156. 1987. *Environmental Qualification of Connection Assemblies for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4660.
[DIRS 165779]
Regulatory Guide 1.158. 1989. *Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4658.
[DIRS 165796]
Regulatory Guide 1.197. 2003. *Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060105.0196.
[DIRS 165827]
Regulatory Guide 5.27. 1974. *Special Nuclear Material Doorway Monitors.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4742.
[DIRS 165832]
Regulatory Guide 5.49, Rev. 0. 1975. *Internal Transfers of Special Nuclear Material.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235798.
[DIRS 165838]
Regulatory Guide 5.61, Rev. 0. 1980. *Intent and Scope of the Physical Protection Upgrade Rule Requirements for Fixed Sites*. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235795.
[DIRS 166013]
ASME B46.1-2002. 2003. *Surface Texture (Surface Roughness, Waviness and Lay)*. New York, New York: American Society of Mechanical Engineers. TIC: 257359.

[DIRS 166414]
NAC (Nevada Administrative Code) 444A. 2006. Programs for Recycling. 258951.
[DIRS 166681]

IEEE Std 1189-1996. 1996. *IEEE Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255426.
[DIRS 166684]
ANSI/IEEE Std 944-1986. 1996. *IEEE Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255429.
[DIRS 166688]
IEEE Std 379-2000. 2001. *IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255427.
[DIRS 166689]
IEEE Std 741-1997 (R2002). 2002. *IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255428.
[DIRS 166742]
ANSI/ISA-5.1-1984 (R1992). *Instrumentation Symbols and Identification.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 255175.
[DIRS 166749]
API RP 651. 1997. *Cathodic Protection of Aboveground Petroleum Storage Tanks*. 2nd Edition. Washington, D.C.: American Petroleum Institute. TIC: 255138.
[DIRS 166794]
CGA P-9-2001. 2001. *The Inert Gases: Argon, Nitrogen, and Helium*. 3rd Edition. Chantilly, Virginia: Compressed Gas Association. TIC 255315.
[DIRS 166813]
ISO/IEC 13818-2:2000(E). 2000. *Information Technology - Generic Coding of Moving Pictures and Associated Audio Information: Video.* Geneva, Switzerland: International Organization for Standardization. TIC: 254947.
[DIRS 166814]
ISO/IEC 13818-3:1998(E). 1998. *Information Technology - Generic Coding of Moving Pictures and Associated Audio Information - Part 3: Audio.* 2nd Edition. Geneve, Switzerland: International Organization for Standardization. TIC: 254950.
[DIRS 166815]
Rosenberg, J.; Schulzrinne, H.; Camarillo, G.; Johnston, A.; Peterson, J.; Sparks, R.; Handley, M.; and Schooler, E. 2002. *SIP: Session Initiation Protocol*. RFC 3261. [Reston, Virginia]: Internet Society. TIC: 254958.
[DIRS 166817]
Perkins, C. 2002. *IP Mobility Support for IPv4.* RFC 3344. [Reston, Virginia]: Internet Society. TIC: 254957.
[DIRS 166818]
Deering, S. and Hinden, R. 1998. *Internet Protocol, Version 6 (IPv6) Specification.* RFC 2460. [Reston, Virginia]: Internet Society. TIC: 255474.
[DIRS 166819]
Kent, S. and Atkinson, R. 1998. *Security Architecture for the Internet Protocol.* RFC 2401. [Reston, Virginia]: Internet Society. TIC: 255476.
[DIRS 166830]
Freed, N. 2000. *Behavior of and Requirements for Internet Firewalls.* RFC 2979. [Reston, Virginia]: Internet Society. TIC: 255477.
[DIRS 166835]
TIA (Telecommunication Industry Association) [2003]. *Project 25--The TIA-Published 102-Series Documents.* [Arlington, Virginia]: Telecommunications Industry Association. TIC: 255898.
[DIRS 166838]
Rose, M. and McCloghrie, K. 1990. *Structure and Identification of Management Information for TCP/IP-Based Internets*. RFC 1155. [Reston, Virginia]: Internet Society. TIC: 255475.
[DIRS 166847]
Lee, A. 1999. *Guideline for Implementing Cryptography in the Federal Government.* NIST Special Publication 800-21. Gaithersburg, Maryland: U.S. Department of Commerce, National Institute of Standards and Technology. ACC: MOL.20040305.0180.
[DIRS 166880]
ITU-T Rec. G.711. 1993. *General Aspects of Digital Transmission Systems, Terminal Equipments, Pulse Code Modulation (PCM) of Voice Frequencies.* Geneva, Switzerland: International Telecommunication Union. TIC: 255173.
[DIRS 166882]

ITU-T Rec. G.729. 1996. *General Aspects of Digital Transmission Systems, Coding of Speech at 8 kbit/s Using Conjugate-Structure Algebraic-Code-Excited Linear-Prediction (CS-ACELP).* Geneva, Switzerland: International Telecommunication Union. TIC: 255200.
[DIRS 166885]
Nichols, K.; Blake, S.; Baker, F.; and Black, D. 1998. *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers*. RFC 2474. [Reston, Virginia]: Internet Society. TIC: 255485.
[DIRS 166886]
Grossman, D. 2002. *New Terminology and Clarifications for Diffserv.* RFC 3260. [Reston, Virginia]: Internet Society. TIC: 255482.
[DIRS 166907]
IEEE Std 323-2003. 2004. *IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255697.
[DIRS 166931]
ISO/IEC 11172-1:1993/Cor.2:1999(E). 1999. *Information Technology - Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to About 1,5 Mbit/s - Part 1: Systems.* Genève, Switzerland: International Organization for Standardization. TIC: 254153.
[DIRS 166935]
ANSI/ANS-55.4-1993. 1999. *Gaseous Radioactive Waste Processing Systems for Light Water Reactor Plant*s. 1993 Edition/Reaf 1999. La Grange Park, Illinois: American Nuclear Society. TIC: 253793.
[DIRS 166977]
ANSI N320-1979 (Reaffirmed 1993). 1993. *Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255416.
[DIRS 166980]
NFPA 51B. 2003. *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*. 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 255487.
[DIRS 166981]
NFPA 1963. 2003. *Standard for Fire Hose Connections*. 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 255486.
[DIRS 167059]
Postel, J., ed. 1981. *Internet Protocol, DARPA Internet Program Protocol Specification*. RFC 791. Marina del Rey, California: University of Southern California, Information Sciences Institute. TIC: 255521.
[DIRS 167060]
Postel, J., ed. 1981. *Transmission Control Protocol, DARPA Internet Program Protocol Specification*. RFC 793. Marina del Ray, California: University of Southern California, Information Sciences Institute. TIC: 255520.
[DIRS 167087]
ISA-RP16.6-1961. 1982. *Methods and Equipment for Calibration of Variable Area Meters (Rotameters).* Research Triangle Park, North Carolina: Instrumentation Society of America. TIC: 255537.
[DIRS 167088]
ISA-RP16.5-1961. 1961 *Installation, Operation, and Maintenance Instructions for Glass Tube Variable Area Meters (Rotameters).* Research Triangle Park, North Carolina: Instrumentation Society of America. TIC: 255536.
[DIRS 167089]
ISA-RP16.1,2,3-1959. *Terminology, Dimensions and Safety Practices for Indicating Variable Area Meters (Rotameters), RP16.2 Glass Tube; RP16.2 Metal Tube; RP16.3 Extension-Type Glass Tube.* Research Triangle Park, North Carolina: Instrumentation Society of America. TIC: 255535.
[DIRS 167093]
ASME MFC-8M-2001. *Fluid Flow in Closed Conduits: Connections for Pressure Signal Transmissions Between Primary and Secondary Devices.* 2001 Edition. New York, New York: American Society of Mechanical Engineers. TIC: 255538.
[DIRS 167097]
DOE-HDBK-1169-2003. *Nuclear Air Cleaning Handbook.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20060105.0204.
[DIRS 167365]
Regulatory Guide 5.68, Rev. 0. 1994. *Protection Against Malevolent Use of Vehicles at Nuclear Power Plants*. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 235875.
[DIRS 167366]
Regulatory Guide 5.52, Rev. 3. 1994. *Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material at Fixed Sites (Other than Nuclear Power Plants)*. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 227031.
[DIRS 167696]

ISO/IEC 11172-3:1993/Cor. 1:1996(E). 1996. *Information Technology - Coding of Moving Pictures and Associated Audio for Digital Storage Media at Up to About 1,5 Mbit/s - Part 3: Audio.* Geneva, Switzerland: International Organization for Standardization. TIC: 254153.
[DIRS 167711]
Mosleh, A.; Rasmuson, D.M.; and Marshall, F.M. 1998. *Guidelines on Modeling Common-Cause Failures in Probabilistic Risk Assessment.* NUREG/CR-5485. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040220.0106.
[DIRS 168110]
NRC (U.S. Nuclear Regulatory Commission) 2000. *Interim Staff Guidance - 10, Revision 1. Alternatives to the ASME Code.* ISG-10, Rev. 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040510.0110.
[DIRS 169128]
IEEE Std 484-2002. 2003. *IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256025.
[DIRS 169217]
ASCE (American Society of Civil Engineers) 1982. *Gravity Sanitary Sewer Design and Construction.* ASCE Manuals and Reports on Engineering Practice No. 60. Reston, Virginia: American Society of Civil Engineers. TIC: 254192.
[DIRS 169311]
IEEE Std 1048-2003. *IEEE Guide for Protective Grounding of Power Lines.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255933.
[DIRS 169314]
IEEE Std 241-1990, Reaffirmed 1997. 1998. *IEEE Recommended Practice for Electric Power Systems in Commercial Buildings.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255956.
[DIRS 169316]
IEEE Std 524-2003. 2004. *IEEE Guide to the Installation of Overhead Transmission Line Conductors.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255989.
[DIRS 169318]
IEEE Std 525-1992. 1993. *IEEE Guide for the Design and Installation of Cable Systems in Substations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 255930.
[DIRS 169323]
NEMA SG 5-1995. 1996. *Power Switchgear Assemblies.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255921.
[DIRS 169324]
NEMA SG 6-2000. 2001. *Power Switching Equipment.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255922.
[DIRS 169346]
Regulatory Guide 1.131. 1977. *Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 4600.
[DIRS 169347]
Regulatory Guide 1.132, Rev. 2. 2003. *Site Investigations for Foundations of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050516.0257.
[DIRS 169366]
ASME B16.5-2003. 2003. *Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24 Metric/Inch Standard.* New York, New York: American Society of Mechanical Engineers. TIC: 255466.
[DIRS 169589]
Joy, D.R. 1995. *Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Facilities.* NUREG-1065, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040401.0109.
[DIRS 169620]
ASTM D 3843-00. 2000. *Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 256116.
[DIRS 169626]
ANSI/ISA S67.02.01-1999. 1999. *Nuclear Safety-Related Instrument- Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 258868.
[DIRS 169773]
IEEE Std 1050-1996. 1999. *Corrections to IEEE Guide for Instrumentation and Control Equipment Grounding in*

Generating Stations. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257452.
[DIRS 169799]
NEMA PE 1-2003. *Uninterruptible Power Systems (UPS) - Specification and Performance Verification.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255932.
[DIRS 169803]
IEEE Std 515-2004. *IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.* New York, New York: Institute of Electrical and Electronic Engineers. TIC: 256235.
[DIRS 169804]
ANSI/TIA-568-B.1-7-2006. *Commercial Building Telecommunications Cabling Standard - Part 1: General Requirements - Addendum 7 - Guidelines for Maintaining Polarity Using Array Connectors.* Arlington, Virginia: Telecommunications Industry Association. TIC: 256217; 256248; 256249; 256250; 256251; 256252; 258144.
[DIRS 169805]
Milstein, R.I. 2001. *Integrated Safety Analysis Guidance Document.* NUREG-1513. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040821.0183.
[DIRS 169812]
ISA-RP31.1-1977. *Specification, Installation, and Calibration of Turbine Flowmeters.* Research Triangle Park, North Carolina: Instrument Society of America. TIC: 256163.
[DIRS 169815]
ANSI/ASHRAE 33-2000. 2001. *Method of Testing Forced Circulation Air Cooling and Air Heating Coils.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256175.
[DIRS 169817]
ASHRAE 111-1988. 1997. *Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems, with Errata.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256165.
[DIRS 169966]
API Std 2000. 1999. *Venting Atmospheric and Low-Pressure Storage Tanks, Nonrefrigerated and Refrigerated, with Errata*. 5th Edition. Washington, D.C.: American Petroleum Institute. TIC: 255217.

[DIRS 170332]
NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 11, Revision 3. Cladding Considerations for the Transportation and Storage of Spent Fuel.* ISG-11, Rev. 3. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040721.0065.
[DIRS 170418]
MIL-STD-1472F, Notice 1. 2003. *Department of Defense Design Criteria Standard, Human Engineering.* Washington, D.C.: U.S. Department of Defense. TIC: 256247.
[DIRS 170491]
DOE-HDBK-1140-2001. *Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20060105.0203.
[DIRS 170498]
IEEE Std 751-1991. *IEEE Trial-Use Design Guide for Wood Transmission Structures.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256264.
[DIRS 170590]
ANSI/TIA-568-B.2-11-2005. *Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling Components, Addendum 11 - Specification of 4-Pair UTP and SCTP Cabling.* Arlington, Virginia: Telecommunications Industry Association. TIC: 256253; 256254; 256255; 256256; 256257; 256258; 256259; 258145.
[DIRS 170591]
ANSI/TIA/EIA-568-B.3-1-2002. *Optical Fiber Cabling Components Standard, Addendum 1 - Additional Transmission Performance Specifications for 50/125 um Optical Fiber Cables.* Arlington, Virginia: Telecommunications Industry Association. TIC: 256260; 256261.
[DIRS 170602]
Regulatory Guide 1.199. 2003. *Anchoring Components and Structural Supports in Concrete.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050516.0260.
[DIRS 170780]
O'Hara, J.M.; Brown, W.S.; Lewis, P.M.; and Persensky, J.J. 2002. *Human-System Interface Design Review Guidelines.* NUREG-0700, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research. ACC: MOL.20040816.0036.
[DIRS 171615]
Compressed Gas Association. 2003. *Handbook of Compressed Gases. 4th Edition*. Boston, Massachusetts: Kluwer

Academic Publishers. TIC: 256046.
[DIRS 171686]
ASME B30.9-2003. 2003. *Slings.* New York, New York: American Society of Mechanical Engineers. TIC: 256186.
[DIRS 171688]
ASME B30.20-2003. 2003. *Below-the-Hook Lifting Devices*. New York, New York: American Society of Mechanical Engineers. TIC: 256185.
[DIRS 171692]
Regulatory Guide 1.52, Rev. 3. 2001. *Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060105.0199.
[DIRS 171695]
IEEE Std 383-2003. 2004. *Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256201.
[DIRS 171696]
IEEE Std 450-2002. 2003. *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256581.
[DIRS 171701]
Regulatory Guide 3.20, Rev. 0. 1974. *Process Offgas Systems for Fuel Reprocessing Plants*. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238368.
[DIRS 171789]
ANSI/AISC 341-02. 2002. *Seismic Provisions for Structural Steel Buildings.* Chicago, Illinois: American Institute of Steel Construction. TIC: 256615.
[DIRS 171799]
ASHRAE (American Society of Heating, Refrigerating & Air-Conditioning Engineers) 2004. *2004 ASHRAE® Handbook, Heating, Ventilating, and Air-Conditioning Systems and Equipment.* Inch-Pound Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256641.
[DIRS 171817]
Regulatory Guide 1.53, Rev. 2. 2003. *Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050516.0261.
[DIRS 171818]
Regulatory Guide 1.180, Rev. 1. 2003. *Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050516.0259.
[DIRS 171846]
ASME (American Society of Mechanical Engineers) 2004. *2004 ASME Boiler and Pressure Vessel Code*. 2004 Edition. New York, New York: American Society of Mechanical Engineers. TIC: 256479.
[DIRS 171925]
API Std 650. 2003. *Welded Steel Tanks for Oil Storage, with Addendum 3.* 10th Edition. Washington, D.C.: American Petroleum Institute. TIC: 255499.
[DIRS 171932]
ISA-18.1-1979 (R2004). 2004. *Annunciator Sequences and Specification.* Research Triangle Park, North Carolina: Instrumentation, Systems, and Automation Society. TIC: 256621.
[DIRS 172087]
Regulatory Guide 1.32, Rev. 3. 2004. *Criteria for Power Systems for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060105.0198.
[DIRS 172090]
IEEE Std 485-1997 (R2003). 2003. *IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 256688.
[DIRS 172702]
NAC (Nevada Administrative Code) 519A. 2006. Reclamation of Land Subject to Mining Operations or Exploration Projects. 258957.
[DIRS 172721]
ICRP (International Commission on Radiological Protection) 1995. *Dose Coefficients for Intakes of Radionuclides by Workers, Replacement of ICRP Publication 61.* Volume 24, No. 4 of *Annals of the ICRP.* ICRP Publication 68. Tarrytown, New York: Pergamon. TIC: 235867.
[DIRS 172990]
IEEE Std 802.3ah-2004. 2004. *IEEE Standard for Information Technology-Telecommunications and Information*

Exchange Between Systems-Local and Metropolitan-Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications. Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257033.

[DIRS 172992]
IEEE Std 802.11j-2004. 2004. *IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan Area Networks-Specific Requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, Amendment 7: 4.9 GHz-5 GHz Operation in Japan.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257032.

[DIRS 173069]
ASTM C 1572-04. 2004. *Standard Guide for Dry Lead Glass and Oil-Filled Lead Glass Radiation Shielding Window Components for Remotely Operated Facilities.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 256821.

[DIRS 173093]
ANSI/IESNA RP-8-00. 2004. *Standard Practice for Roadway Lighting, with Errata*. New York, New York: Illuminating Engineering Society of North America. TIC: 257224.

[DIRS 173097]
NACE Standard RP0572-2001. 2001. *Standard Recommended Practice, Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds.* Houston, Texas: National Association of Corrosion Engineers. TIC: 257208.

[DIRS 173120]
ANSI Z358.1-2004. 2004. *American National Standard for Emergency Eyewash and Shower Equipment*. Arlington, Virginia: International Safety Equipment Association. TIC: 256278.

[DIRS 173312]
10 CFR 36. 2005. Energy: Licenses and Radiation Safety Requirements for Irradiators. ACC: MOL.20050523.0017.

[DIRS 173417]
NFPA 256. 2003. *Standard Methods of Fire Tests of Roof Coverings*. 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257159.

[DIRS 173418]
FM 4471. 1995. *Approval Standard for Class I Panel Roofs.* [Johnston, Rhode Island]: Factory Mutual Research Corporation. TIC: 257160.

[DIRS 173419]
UL 790. 2004. *Standard for Standard Test Methods for Fire Tests of Roof Coverings.* 8th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 257161.

[DIRS 173511]
NFPA 110. 2005. *Standard for Emergency and Standby Power Systems*. 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257240.

[DIRS 173514]
NFPA 497. 2004. *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*. 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257243.

[DIRS 173517]
NFPA 780. 2004. *Standard for the Installation of Lightning Protection Systems*. 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257246.

[DIRS 173525]
ICC (International Code Council) 2003. *International Building Code 2000, with Errata to the 2000 International Building Code.* Falls Church, Virginia: International Code Council. TIC: 251054; 257198.

[DIRS 173584]
Regulatory Guide 1.183. 2000. *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050518.0242.

[DIRS 173591]
IEEE Std 665-1995. 2001. *IEEE Guide for Generating Station Grounding.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257258.

[DIRS 173593]
IEEE Std C62.23-1995 (R2001). 2001. *IEEE Application Guide for Surge Protection of Electric Generating Plants.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257259.

[DIRS 173601]
NEMA WC 51-2003. 2004. *Ampacities of Cables Installed in Cable Trays.* Rosslyn, Virginia: National Electrical

Manufacturers Association. TIC: 255994.
[DIRS 173603]
NEMA WC 70/ICEA S-95-658-1999. 1999. *Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.* South Yarmouth, Massachusetts: Insulated Cable Engineers Association. TIC: 255996.
[DIRS 173604]
NEMA WC 71-1999. 1999. *Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 255997.
[DIRS 173805]
ASCE/SEI 43-05. 2005. *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities.* Reston, Virginia: American Society of Civil Engineers. TIC: 257275.
[DIRS 174317]
AWWA (American Water Works Association) 2002. *PVC Pipe - Design and Installation.* 2nd Edition. AWWA Manual M23. Denver, Colorado: American Water Works Association. TIC: 257432.
[DIRS 174320]
ANSI/ASHRAE 62.1-2004. 2004. *Ventilation for Acceptable Indoor Air Quality*. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 256875.
[DIRS 174321]
ANSI/ASHRAE/IESNA Std 90.1-2004. 2004. *Energy Standard for Buildings Except Low-Rise Residential Buildings*. I-P Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257067.
[DIRS 174322]
ANSI/ASHRAE Std 55-2004. 2004. *Thermal Environmental Conditions for Human Occupancy.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257066.
[DIRS 174323]
ANSI/ASHRAE Std 34-2004. 2004. *Designation and Safety Classification of Refrigerants.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257065.
[DIRS 174382]
Regulatory Guide 1.138, Rev. 2. 2003. *Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants.* Washington, D.C.: U. S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 174537]
ANSI/IESNA RP-1-04. 2004. *American National Standard Practice for Office Lighting.* New York, New York: Illuminating Engineering Society of North America. TIC: 257502.
[DIRS 174692]
ASHRAE (American Society of Heating, Refrigerating & Air-Conditioning Engineers) 2005. *2005 ASHRAE® Handbook, Fundamentals.* Inch-Pound Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air Conditioning Engineers. TIC: 257499.
[DIRS 174882]
Regulatory Guide 1.196. 2003. *Control Room Habitability at Light-Water Nuclear Power Reactors.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.

[DIRS 175594]
AWWA (American Water Works Association). 2004. *Recommended Practice for Backflow Prevention and Cross-Connection Control, Manual of Water Supply Practices.* 3rd Edition. AWWA Manual M14. Denver, Colorado: American Water Works Association. TIC: 256026.
[DIRS 175765]
NFPA 1. 2005. *Uniform Fire Code™.* 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 257842.
[DIRS 175834]
AASHTO (American Association of State Highway and Transportation Officials) 2004. *A Policy on Geometric Design of Highways and Streets.* 5th Edition. Washington, D.C.: American Association of State Highway and Transportation Officials. TIC: 257443.
[DIRS 175920]
DOT (U.S. Department of Transportation) 2004. *Heliport Design.* Advisory Circular 150/5390-2B. Washington, D.C.: U.S. Department of Transportation, Federal Aviation Administration. ACC: MOL.20060125.0188.
[DIRS 175926]
DOT (U.S. Department of Transportation) 2005. *Manual on Uniform Traffic Control Devices for Streets and Highways.* 2003 Edition. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration. ACC: MOL.20060125.0189.
[DIRS 175987]

NRC (U.S. Nuclear Regulatory Commission) 2005. *Interim Staff Guidance - 6. Establishing Minimum Initial Enrichment for the Bounding Design Basis Fuel Assembly(s).* ISG-6. [Washington, D.C.]: U.S. Nuclear Regulatory Commission. ACC: MOL.20060606.0265.
[DIRS 176223]
ICC/ANSI A117.1-2003. 2004. *Accessible and Usable Buildings and Facilities.* Country Club Hills, Illinois: International Code Council. TIC: 258036.
[DIRS 176225]
ANSI/ANS-8.17-2004. 2004. *American National Standard, Criticality Safety Criteria for the Handling, Storage and Transportation of LWR Fuel Outside Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 257593.
[DIRS 176238]
AISC 303-05. 2005. *Code of Standard Practice for Steel Buildings and Bridges.* Chicago, Illinois: American Institute of Steel Construction. TIC: 258072.
[DIRS 176239]
ASME NOG-1-2004. 2005. *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder).* New York, New York: American Society of Mechanical Engineers. TIC: 257672.
[DIRS 176242]
ASME B31.3-2004. 2005. *Process Piping.* New York, New York: American Society of Mechanical Engineers. TIC: 258076.
[DIRS 176247]
ASME N509-2002. 2002. *Nuclear Power Plant Air-Cleaning Units and Components.* New York, New York: American Society of Mechanical Engineers. TIC: 258075.
[DIRS 176252]
ASTM C 150-05. 2005. *Standard Specification for Portland Cement.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258053.
[DIRS 176253]
ASTM C 1240-05. 2005. *Standard Specification for Silica Fume Used in Cementitious Mixtures.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258049.
[DIRS 176255]
ASTM A 588/A 588M-05. 2005. *Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258058.
[DIRS 176257]
CMAA 70-2004. *Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes.* Charlotte, North Carolina: Crane Manufacturers Association of America. TIC: 258052.
[DIRS 176258]
CMAA 74-2004. *Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist.* Charlotte, North Carolina: Crane Manufacturers Association of America. TIC: 258051.
[DIRS 176259]
IEEE Std 344-2004. 2005. *IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258050.
[DIRS 176267]
NFPA 90A. 2005. *Standard for the Installation of Air-Conditioning and Ventilating Systems, with Errata.* 2002 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258045.
[DIRS 176292]
ICC (International Code Council) 2006. *2006 International Plumbing Code®.* Country Club Hills, Illinois: International Code Council. TIC: 258070.
[DIRS 176293]
ICC (International Code Council) 2006. *2006 International Fire Code.* Country Club Hills, Illinois: International Code Council. TIC: 258068.
[DIRS 176297]
ACGIH (American Conference of Governmental Industrial Hygienists) 2004. *Industrial Ventilation, A Manual of Recommended Practice.* 25th Edition. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists. TIC: 257140.
[DIRS 176319]
ACI 506R-05. 2005. *Guide to Shotcrete.* Farmington Hills, Michigan: American Concrete Institute. TIC: 258596.
[DIRS 176330]

Regulatory Guide 1.75, Rev. 3. 2005. *Criteria for Independence of Electrical Safety Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 176331]
Regulatory Guide 3.71, Rev. 1. 2005. *Nuclear Criticality Safety Standards for Fuels and Material Facilities.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060206.0325.
[DIRS 176339]
ANSI/AWWA D102-03. 2003. *Coating Steel Water-Storage Tanks.* Denver, Colorado: American Water Works Association. TIC: 258655.
[DIRS 176341]
IEEE Std 260.1-2004. 2004. *IEEE Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258588.
[DIRS 176343]
ANSI/IESNA RP-7-01. 2004. *Recommended Practice for Industrial Lighting, with Errata.* New York, New York: Illuminating Engineering Society of North America. TIC: 258807.
[DIRS 176349]
ANSI/API Std 610. 2004. *Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries.* 10th Edition. Washington, D.C.: American Petroleum Institute. TIC: 258671.
[DIRS 176350]
API Std 619. 2004. *Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries.* 4th Edition. Washington, D.C.: American Petroleum Institute. TIC: 258672.
[DIRS 176373]
NRS (Nevada Revised Statute) 445B. 2005. Air Pollution. 258980.
[DIRS 176384]
Rea, M.S., ed. 2005. *IESNA Lighting Handbook, Reference & Application, with Errata.* 9th Edition. New York, New York: Illuminating Engineering Society of North America. TIC: 257855.
[DIRS 176388]
API Std 620. 2004. *Design and Construction of Large, Welded, Low-Pressure Storage Tanks, with Addendum 1.* 10th Edition. Washington, D.C.: American Petroleum Institute. TIC: 256365.
[DIRS 176390]
AREMA (American Railway Engineering and Maintenance-of-Way Association) 2006. *Manual for Railway Engineering.* Four volumes. Lanham, Maryland: American Railway Engineering and Maintenance-of-Way Association. TIC: 258900.
[DIRS 176391]
ARI Std 550/590. 2003. *Standard for Performance Rating of Water-Chilling Packages Using the Vapor Compression Cycle.* Arlington, Virginia: Air-Conditioning and Refrigeration Institute. TIC: 258673.
[DIRS 176394]
ASME B16.34-2004. 2005. *Valves-Flanged, Threaded, and Welding End.* New York, New York: American Society of Mechanical Engineers. TIC: 258575.
[DIRS 176396]
ASME B30.5-2004. 2004. *Mobile and Locomotive Cranes.* New York, New York: American Society of Mechanical Engineers. TIC: 258675.
[DIRS 176398]
ASME MFC-3M-2004. 2005. *Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi.* New York, New York: American Society of Mechanical Engineers. TIC: 258576.
[DIRS 176400]
ASME PTC 19.3-1974 (Reaffirmed 2004). 2004. *Part 3, Temperature Measurement, Instruments and Apparatus, Supplement to ASME Performance Test Codes.* New York, New York: American Society of Mechanical Engineers. TIC: 258577.
[DIRS 176401]
ASME Y14.36M-1996 (Reaffirmed 2002). 2002. *Surface Texture Symbols.* New York, New York: American Society of Mechanical Engineers. TIC: 258843.
[DIRS 176418]
ASTM A 500-03a. 2003. *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 255924.
[DIRS 176426]
ASTM E 108-05. 2005. *Standard Test Methods for Fire Tests of Roof Coverings.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258686.

[DIRS 176430]
CGA G-10.1-2004. 2004. *Commodity Specification for Nitrogen.* 6th Edition. Chantilly, Virginia: Compressed Gas Association. TIC: 257369.
[DIRS 176431]
CGA G-11.1-2004. 2004. *Commodity Specification for Argon.* 6th Edition. Chantilly, Virginia: Compressed Gas Association. TIC: 258334.
[DIRS 176434]
CGA G-7.1-2004. 2004. *Commodity Specification for Air.* 5th Edition. Chantilly, Virginia: Compressed Gas Association. TIC: 258335.
[DIRS 176435]
CGA G-9.1-2004. 2004. *Commodity Specification for Helium.* 6th Edition. Chantilly, Virginia: Compressed Gas Association. TIC: 258336.
[DIRS 176436]
CGA V-1-2005. 2006. *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections, with Amendment 1.* 12th Edition. Chantilly, Virginia: Compressed Gas Association. TIC: 258338; 258375.
[DIRS 176437]
CGA P-18-2006. 2006. *Standard for Bulk Inert Gas Systems.* 3rd Edition. Chantilly, Virginia: Compressed Gas Association. TIC: 258337.
[DIRS 176458]
NRS (Nevada Revised Statute) 445A. 2005. Water Controls. 258979.
[DIRS 176545]
IEEE Std 142-1991. 2006. *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (with Erratum).* 5th Edition. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258141.
[DIRS 176558]
NDOT (Nevada Department of Transportation) 2001. *Standard Specifications for Road and Bridge Construction.* Carson City, Nevada: State of Nevada, Nevada Department of Transportation. ACC: MOL.20060410.0300.
[DIRS 176641]
DOE O 450.1, Change 2. 2005. *Environmental Protection Program.* Washington, D.C.: U.S. Department of Energy. ACC: MOL.20060413.0155.
[DIRS 176661]
DOE-STD-1090-2004. 2004. *Hoisting and Rigging (Formerly Hoisting and Rigging Manual).* Washington, D.C.: U.S. Department of Energy. ACC: ENG.20060407.0002.
[DIRS 176803]
U.S. Green Building Council 2005. *LEED-NC for New Construction, Reference Guide, Version 2.2, with Errata.* 1st Edition. Washington, D.C.: U.S. Green Building Council. TIC: 258168.
[DIRS 176884]
ANSI/ANS-8.3-1997: R2003. 2003. *American National Standard Criticality Accident Alarm System.* La Grange Park, Illinois: American Nuclear Society. TIC: 258157.
[DIRS 176893]
ANSI/ANS-8.21-1995 (Reaffirmed 2001). *American National Standard for the Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors*. La Grange Park, Illinois: American Nuclear Society. TIC: 258163.
[DIRS 176945]
ANSI/ANS-57.9-1992 [(Reaffirmed 2000)]. [2000]. *American National Standard, Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type).* La Grange Park, Illinois: American Nuclear Society. TIC: 256147.
[DIRS 176963]
ASME (American Society of Mechanical Engineers) 2005. "Supports." Section III, Division 1, Subsection NF of *2004 ASME Boiler and Pressure Vessel Code (includes 2005 Addenda).* New York, New York: American Society of Mechanical Engineers. TIC: 256479.

[DIRS 177028]
ANSI/AISC N690-1994 (R2004)s2.2005. *Supplement No. 2 to the Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities.* Chicago, Illinois: American Institute of Steel Construction. TIC: 252734; 258040.
[DIRS 177029]
ASME AG-1a-2004. 2005. *Addenda to ASME AG-1-2003, Code on Nuclear Air and Gas Treatment.* New York, New York: American Society of Mechanical Engineers. TIC: 258079; 258080.
[DIRS 177094]
UPRR (Union Pacific Railroad) 2005. *Track Standard Drawings.* Rev. 1/05. Omaha, Nebraska: Union Pacific

Railroad. TIC: 258355.
[DIRS 177316]
Atwood, C.L.; LaChance, J.L.; Martz, H.F.; Anderson, D.J.; Englehardt, M.; Whitehead, D.; and Wheeler, T. 2003. *Handbook of Parameter Estimation for Probabilistic Risk Assessment.* NUREG/CR-6823. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060126.0121.
[DIRS 177319]
Canavan, K.; Gregg, B.; Karimi, R.; Mirsky, S.; and Stokley, J. 2004. *Probabilistic Risk Assessment (PRA) of Bolted Storage Casks, Updated Quantification and Analysis Report.* 1009691. Palo Alto, California: Electric Power Research Institute. TIC: 257542.
[DIRS 177323]
Kolaczkowski, A.; Forester, J.; Lois, E.; and Cooper, S. 2005. *Good Practices for Implementing Human Reliability Analysis (HRA).* NUREG-1792. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20061103.0011.
[DIRS 177328]
NRC (U.S. Nuclear Regulatory Commission) 1996. *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, Draft Report for Comment.* NUREG-0800. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 255324.
[DIRS 177482]
ANSI/ANS-6.4.2-1985. 1985. *Specification for Radiation Shielding Materials.* La Grange Park, Illinois: American Nuclear Society. TIC: 238361.
[DIRS 177507]
29 CFR 1910. 2006. Labor: Occupational Safety and Health Standards. Internet Accessible.
[DIRS 177522]
40 CFR 61. 2006. Protection of Environment: National Emission Standards for Hazardous Air Pollutants. Internet Accessible.
[DIRS 177544]
NFPA 221. 2005. *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*. 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258552.
[DIRS 177548]
Regulatory Guide 8.38, Rev. 1. 2006. *Control of Access to High and Very High Radiation Areas in Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 177557]
ANSI/ANS-3.11-2005. 2005. *American National Standard for Determining Meteorological Information at Nuclear Facilities.* La Grange Park, Illinois: American Nuclear Society. TIC: 258445.
[DIRS 177558]
Regulatory Guide 1.63, Rev. 3. 1987. *Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 238592.
[DIRS 177587]
IEEE Std 336-2005. 2006. *IEEE Guide for Installation, Inspection, and Testing for Class 1E Power, Instrumentation, and Control Equipment at Nuclear Facilities.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258593.
[DIRS 177588]
IEEE Std 208-1995 (R2005). 2005. *IEEE Standard on Video Techniques: Measurement of Resolution of Camera Systems, 1993 Techniques.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258587.
[DIRS 177589]
IEEE Std 1289-1998(R2004). 2005. *IEEE Guide for the Application of Human Factors Engineering in the Design of Computer-Based Monitoring and Control Displays for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258586.
[DIRS 177592]
IEEE Std 1023-2004. 2005. *IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258591.
[DIRS 177594]
NEMA ICS 1-2000 (R2005). 2005. *General Standards for Industrial Control & Systems.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258578.
[DIRS 177595]
ANSI N42.17B-1989 (R2005). 2005. *American National Standard, Performance Specifications for Health Physics Instrumentation-Occupational Airborne Radioactivity Monitoring Instrumentation.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258573.

[DIRS 177596]
ANSI N42.18-2004. 2004. *American National Standard, Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258574.
[DIRS 177597]
IEEE Std 1100-2005. 2006. *IEEE Recommended Practice for Powering and Grounding Electronic Equipment.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258683.
[DIRS 177603]
Regulatory Guide 1.204. 2005. *Guidelines for Lightning Protection of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 177606]
ANSI/IESNA RP-22-05. 2005. *IESNA Recommended Practice for Tunnel Lighting.* New York, New York: Illuminating Engineering Society of North America. TIC: 258669.
[DIRS 177607]
IEEE Std 802.1Q-2005. 2006. *IEEE Standard for Local and Metropolitan Area Networks-Virtual Bridged Local Area Networks.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258690.
[DIRS 177608]
IEEE Std 112-2004. 2004. *IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258676.
[DIRS 177609]
IEEE Std 1188-2005. 2005. *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258685.
[DIRS 177610]
IEEE Std 946-2004. 2005. *IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258677.
[DIRS 177611]
NEMA ICS 7-2006. 2006. *Industrial Control and Systems: Adjustable-Speed Drives.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258808.
[DIRS 177612]
NEMA MG 1-2006. 2006. *Motors and Generators.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258678.
[DIRS 177613]
NEMA PB 1-2006. 2006. *Panelboards.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258680.
[DIRS 177614]
NEMA PB 2-2006. 2006. *Deadfront Distribution Switchboards.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258682.
[DIRS 177616]
IEEE Std 382-1996 (R2004). 2004. *IEEE Standard for Qualification of Actuators for Power-Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258806.
[DIRS 177621]
Regulatory Guide 1.84, Rev. 33. 2005. *Design, Fabrication, and Materials Code Case Acceptability, ASME Section III.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 177622]
Regulatory Guide 1.193, Rev. 1. 2005. *ASME Code Cases Not Approved for Use.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 177634]
29 CFR 1926. 2006. Labor: Safety and Health Regulations for Construction. Internet Accessible.
[DIRS 177651]
IEEE/ASTM SI 10-2002. 2002. *American National Standard for Use of the International System of Units (SI): The Modern Metric System.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 257712.
[DIRS 177654]
Regulatory Guide 1.142, Rev. 2. 2001. *Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments).* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 177828]
28 CFR 36. 2006. Judicial Administration: Nondiscrimination on the Basis of Disability by Public Accommodations and in Commercial Facilities. Internet Accessible.

[DIRS 177830]
30 CFR 36. 2006. Mineral Resources: Approval Requirements for Permissible Mobile Diesel-Powered Transportation Equipment. Internet Accessible.
[DIRS 177832]
30 CFR 817. 2006. Mineral Resources: Permanent Program Performance Standards--Underground Mining Activities. Internet Accessible.
[DIRS 177835]
40 CFR 64. 2006. Protection of Environment: Compliance Assurance Monitoring. Internet Accessible.
[DIRS 177837]
40 CFR 243. 2006. Protection of Environment: Guidelines for the Storage and Collection of Residential, Commercial, and Institutional Solid Waste. Internet Accessible.
[DIRS 177838]
40 CFR 246. 2006. Protection of Environment: Source Separation for Materials Recovery Guidelines. Internet Accessible.
[DIRS 177839]
40 CFR 247. 2006. Protection of Environment: Comprehensive Procurement Guideline for Products Containing Recovered Materials. Internet Accessible.
[DIRS 177840]
40 CFR 257. 2006. Protection of Environment: Criteria for Classification of Solid Waste Disposal Facilities and Practices. Internet Accessible.
[DIRS 177843]
40 CFR 262. 2006. Protection of Environment: Standards Applicable to Generators of Hazardous Waste. Internet Accessible.
[DIRS 177844]
40 CFR 50. 2006. Protection of Environment: National Primary and Secondary Ambient Air Quality Standards. Internet Accessible.
[DIRS 177848]
ANSI/ANS-55.1-1992 (Reaffirmed 2000). 2000. *American National Standard for Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants.* La Grange Park, Illinois: American Nuclear Society. TIC: 258657.
[DIRS 177849]
ANSI/ANS-55.6-1993 (Reaffirmed 1999). 1999. *American National Standard for Liquid Radioactive Waste Processing System for Light Water Reactor Plants.* La Grange Park, Illinois: American Nuclear Society. TIC: 258658.
[DIRS 177850]
ANSI/ANS-57.1-1992 (Reaffirmed 2005). 2005. *American National Standard, Design Requirements for Light Water Reactor Fuel Handling Systems.* La Grange Park, Illinois: American Nuclear Society. TIC: 258659.
[DIRS 177851]
ANSI/ANS-57.7-1988 (Reaffirmed 1997). 1997. *American National Standard, Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type).* La Grange Park, Illinois: American Nuclear Society. TIC: 258660.
[DIRS 177854]
ANSI/ANS-59.3-1992 (Reaffirmed 2002). 2002. *American National Standard, Nuclear Safety Criteria for Control Air Systems.* La Grange Park, Illinois: American Nuclear Society. TIC: 258661.
[DIRS 177855]
ANSI/ANS-6.4-1997 (REAF 2004). 2004. *Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants.* La Grange Park, Illinois: American Nuclear Society. TIC: 257554.
[DIRS 177856]
ANSI/ANS-6.4.2-1985 (R1997, R2004). 2004. *American National Standard Specification for Radiation Shielding Materials.* La Grange Park, Illinois: American Nuclear Society. TIC: 258662.
[DIRS 177857]
NFPA 90B. 2005. *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.* 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258663.
[DIRS 177862]
ANSI/ASHRAE Std 15-2004. 2006. *Safety Standard for Refrigeration Systems, 2006 Supplement with Errata.* Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257064; 258665.
[DIRS 177866]
ANSI/AWWA D100-05. 2006. *Welded Carbon Steel Tanks for Water Storage.* Denver, Colorado: American Water

Works Association. TIC: 258668.
[DIRS 177868]
ANSI/UL-555. 2006. *Fire Dampers.* 7th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258670.
[DIRS 177876]
ASME B31.1-2004. 2006. *Power Piping with Addenda, ASME B31.1a-2005.* New York, New York: American Society of Mechanical Engineers. TIC: 258692.
[DIRS 177879]
ASME N510-1989 (Reaffirmed 1995). 1995. *Testing of Nuclear Air Treatment Systems.* New York, New York: American Society of Mechanical Engineers. TIC: 239028.
[DIRS 177880]
ASME RA-Sb-2005. 2005. *Addenda to ASME RA-S-2002, Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications.* New York, New York: American Society of Mechanical Engineers. TIC: 258909.
[DIRS 177881]
ASME Y14.38-1999. 1999-2002. *Abbreviations and Acronyms (with Addenda, ASME Y14.38a-2002).* New York, New York: American Society of Mechanical Engineers. TIC: 258694.
[DIRS 177882]
ASME Y14.5M-1994 (Reaffirmed 2004). 2004. *Dimensioning and Tolerancing.* New York, New York: American Society of Mechanical Engineers. TIC: 258686.
[DIRS 177884]
ASTM A 234/A 234M-06a. 2006. *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258702.
[DIRS 177891]
ASTM A 615/A 615M-06a. 2006. *Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258705.
[DIRS 177892]
ASTM A 325-06. 2006. *Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258707.
[DIRS 177893]
ASTM A 490-06. 2006. *Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258710.
[DIRS 177896]
ASTM A 706/A 706 M-06a. 2006. *Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258719.
[DIRS 177899]
ASTM C 1217-00 (Reapproved 2006). 2006. *Standard Guide for Design of Equipment for Processing Nuclear and Radioactive Materials.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258725.
[DIRS 177900]
ASTM C 494/C 494M-05a. 2005. *Standard Specification for Chemical Admixtures for Concrete.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258726.
[DIRS 177901]
ASTM C 992-06. 2006. *Standard Specification for Boron-Based Neutron Absorbing Material Systems for Use in Nuclear Spent Fuel Storage Racks.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258727.
[DIRS 177902]
ASTM D 975-06. 2006. *Standard Specification for Diesel Fuel Oils.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258729.
[DIRS 177919]
DOE-STD-1027-92 Change Notice No. 1. 1997. *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.* Washington, D.C.: U.S. Department of Energy. Internet Accessible.
[DIRS 177923]
DOE-STD-3020-2005. 2005. *Specification for HEPA Filters Used by DOE Contractors.* Washington, D.C.: U.S. Department of Energy. Internet Accessible.
[DIRS 177934]
EPA (U.S. Environmental Protection Agency) 2002. *Onsite Wastewater Treatment Systems Manual.* EPA/625/R-00/008. [Washington, D.C.]: U.S. Environmental Protection Agency, Office of Research and Development. ACC:

MOL.20061103.0025.
[DIRS 177944]
IEEE C2-2007. 2006. *National Electrical Safety Code.* 2007 Edition. New York, New York: Institute of Electrical and Electronic Engineers. TIC: 258688.
[DIRS 177947]
IEEE Std 1115-2000 (R2005). 2005. *IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258698.
[DIRS 177949]
IEEE Std 1202-2006. 2006. *IEEE Standard for Flame-Propagation Testing of Wire and Cable.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258697.
[DIRS 177952]
IEEE Std 384-1992 (REAF 1998). 1998. *Standard Criteria for Independence of Class 1E Equipment and Circuits.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258693.
[DIRS 177954]
IEEE Std 650-2006. 2006. *IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258695.
[DIRS 177956]
IEEE Std 835-1994 (R2006). 2006. *IEEE Standard Power Cable Ampacity Tables.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 259267.
[DIRS 177958]
ISO/IEC 11172-2:1993/Cor.4:2006(E). 2006. *Information Technology - Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to about 1,5 Mbit/s - Part 2: Video, Technical Corrigendum 4.* Geneva, Switzerland: International Organization for Standardization. TIC: 258701.
[DIRS 177959]
ITU-T Recommendation . G.703 (11/2001). 2005. *Physical/Electrical Characteristics of Hierarchical Digital Interfaces - Series G: Transmission Systems and Media, Digital Systems and Networks Digital Terminal Equipments - General, with Errata.* Geneva, Switzerland: International Telecommunication Union. Union. TIC: 259269.

[DIRS 177962]
NEMA WC 50-1976 (R1982, 1988, 1999)/ICEA P-53-426 (Second Edition). 2001. *Ampacities Including Effect of Shield Losses for Single-Conductor Solid-Dielectric Power Cable, 15kV through 69kV (Copper and Aluminum Conductors).* 2nd Edition. Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258706.
[DIRS 177963]
NEMA WC 58-1997 (R2005)/ICEA S-75-381. 2005. *Portable and Power Feeder Cables for Use in Mines and Similar Application.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258724.
[DIRS 177964]
NFPA 10. 2006. *Standard for Portable Fire Extinguishers.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258708.
[DIRS 177965]
NFPA 101. 2006. *Life Safety Code, with Errata and Tentative Interim Amendments.* 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258709.
[DIRS 177966]
NFPA 11. 2006. *Standard for Low-, Medium-, and High-Expansion Foam, with Tentative Interim Amendment.* 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258711.
[DIRS 177967]
NFPA 111. 2005. *Standard on Stored Electrical Energy Emergency and Standby Power Systems.* 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258722.
[DIRS 177968]
NFPA 13. 2006. *Standard for the Installation of Sprinkler Systems.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258713.
[DIRS 177969]
NFPA 14. 2006. *Standard for the Installation of Standpipe and Hose Systems.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258714.
[DIRS 177970]
NFPA 15. 2006. *Standard for Water Spray Fixed Systems for Fire Protection.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258715.
[DIRS 177971]
NFPA 20. 2006. *Standard for the Installation of Stationary Pumps for Fire Protection.* 2007 Edition. Quincy,

Massachusetts: National Fire Protection Association. TIC: 258716.
[DIRS 177972]
NFPA 24. 2006. *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258718.
[DIRS 177974]
NFPA 30. 2006. *Flammable and Combustible Liquids Code, with Errata*. 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258720.
[DIRS 177976]
NFPA 31. 2006. *Standard for the Installation of Oil-Burning Equipment, with Errata*. Quincy, Massachusetts: National Fire Protection Association. TIC: 258728.
[DIRS 177977]
NFPA 418. 2006. *Standard for Heliports.* 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258730.
[DIRS 177978]
NFPA 502. 2005. *Standard for Road Tunnels, Bridges and Other Limited Access Highways, with Errata.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258731.
[DIRS 177979]
NFPA 52. 2006. *Vehicular Fuel Systems Code, with Errata.* 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258732.
[DIRS 177980]
NFPA 55. 2006. *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks, with Errata.* 2005 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258742.
[DIRS 177981]
NFPA 58. 2004. *Liquefied Petroleum Gas Code.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258734.
[DIRS 177982]
NFPA 70. 2005. *National Electrical Code, with Tentative Interim Amendment.* 2005 Edition. TIC: 258735.
[DIRS 177983]
NFPA 704. 2006. *Standard System for the Identification of the Hazards of Materials for Emergency Response.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258809.
[DIRS 177984]
NFPA 72. 2006. *National Fire Alarm Code.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258740.
[DIRS 177985]
NFPA 75. 2003. *Standard for the Protection of Information Technology Equipment, with Errata.* 2003 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258736.
[DIRS 177987]
NFPA 750. 2006. *Standard on Water Mist Fire Protection Systems.* 2006 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258744.
[DIRS 177988]
NFPA 80. 2006. *Standard for Fire Doors and Other Opening Protectives.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258737.
[DIRS 177989]
NFPA 80A. 2006. *Recommended Practice for Protection of Buildings from Exterior Fire Exposures.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258739.
[DIRS 178006]
NRC (U.S. Nuclear Regulatory Commission) 2006. *Interim Staff Guidance - 22. Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel.* ISG-22. [Washington, D.C.]: U.S. Nuclear Regulatory Commission. ACC: MOL.20061103.0012.
[DIRS 178008]
Regulatory Guide 1.97, Rev. 4. 2006. *Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 178018]
AASHTO (American Association of State Highway and Transportation Officials) 2005. *Standard Specifications for Highway Bridges, with 2004 and 2005 Errata.* 17th Edition - 2002. Washington, D.C.: American Association of State Highway and Transportation Officials. TIC: 259268.
[DIRS 178040]

SMPTE 170M-2004. 2004. *SMPTE Standard for Television - Composite Analog Video Signal - NTSC for Studio Applications.* White Plains, New York: Society of Motion Picture and Television Engineers. TIC: 258743.
[DIRS 178041]
DOD (U.S. Department of Defense) 1990. "Structures to Resist the Effects of Accidental Explosions." ARMY TM 5-1300. [Washington, D.C.]: U.S. Department of Defense, Explosives Safety Board. Accessed November 28, 2006. ACC: MOL.20070117.0058.
[DIRS 178042]
UL (Underwriters Laboratories) 2006. *Fire Resistance Directory 2006.* Volumes 1, 2A, 2B and 3. Northbrook, Illinois: Underwriters Laboratories. TIC: 258745.
[DIRS 178044]
UL 508. 2005. *Industrial Control Equipment.* 17th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258757.
[DIRS 178045]
UL 586. 2004. *High-Efficiency, Particulate, Air Filter Units.* 8th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258758.
[DIRS 178046]
UL 67. 2006. *Panelboards.* 11th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258759.
[DIRS 178047]
UL 900. 2004. *Air Filter Units.* 7th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258760.
TIC: 258761.
[DIRS 178051]
UL (Underwriters Laboratories) 2006. *Fire Protection Equipment Directory 2006.* Northbrook, Illinois: Underwriters Laboratories. TIC: 258762.
DIRS 178067]
NFPA 70E. 2004. *Standard for Electrical Safety In the Workplace.* 2004 Edition. Quincy, Massachusetts: National Fire Protection Association. TIC: 258788.
[DIRS 178071]
NRS (Nevada Revised Statute) 445C. 1997. Environmental Requirements. [Carson City, Nevada]: State of Nevada. Accessed October 30, 2006. TIC: 258986.
[DIRS 178072]
NRS (Nevada Revised Statute) 444. 2005. Sanitation. [Carson City, Nevada]: State of Nevada. Accessed November 27, 2006. TIC: 258866.
[DIRS 178084]
IEEE Std 387-1995 (REAF 2001). 2001. *Standard Criteria for Diesel-Generator Units Applied as Standby Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258750.
[DIRS 178086]
IEEE Std 317-1983 (R2003). 2003. *IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258751.
[DIRS 178088]
IEEE Std 497-2002. 2002. *IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258752.
[DIRS 178095]
ANSI/IEEE Std 572-1985(R2004). 2004. *IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258753.
[DIRS 178101]
Regulatory Guide 1.120, Rev. 1. 1977. *Fire Protection Guidelines for Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 2786.
[DIRS 178105]
40 CFR 265. 2006. Protection of Environment: Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities. Internet Accessible.
[DIRS 178130]
NRC (U.S. Nuclear Regulatory Commission) 2006. *Interim Staff Guidance HLWRS-ISG-01. Review Methodology for Seismically Initiated Event Sequences.* HLWRS-ISG-01. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20061128.0036.
[DIRS 178176]
Stephens, T.E. 2001. *Standard Specification for Road and Bridge Construction.* Carson City, Nevada: State of Nevada, Department of Transportation. ACC: MOL.20060410.0300.

[DIRS 178182]
ANSI/AWWA D103-97. 1998. *AWWA Standard for Factory-Coated Bolted Steel Tanks for Water Storage.* Denver, Colorado: American Water Works Association. TIC: 258871.
[DIRS 178224]
40 CFR 35. 2006. Protection of Environment: State and Local Assistance. Internet Accessible.
[DIRS 178263]
IEEE Std 666-1991. R1993. *IEEE Design Guide for Electrical Power Service Systems for Generating Stations.* New York, New York: The Institute of Electrical and Electronics Engineers. TIC: 242961.
[DIRS 178264]
IEEE Std 334-1994. *IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 258830.
[DIRS 178424]
Regulatory Guide 1.36. 1973. *Nonmetallic Thermal Insulation for Austenitic Stainless Steel.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 178562]
DOE M 470.4-2, Change 1. 2006. *Physical Protection.* Washington, D.C.: U. S. Department of Energy. Internet Accessible.

[DIRS 178573]
ANSI/ANS-8.14-2004. 2004. *American National Standard, Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors.* La Grange Park, Illinois: American Nuclear Society. TIC: 258161.
[DIRS 179998]
ICC (International Code Council) 2006. *2006 International Mechanical Code.* 1st Printing. Country Club Hills, Illinois: International Code Council. TIC: 259251.
[DIRS 180319]
10 CFR 63. 2007. Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Internet Accessible.
[DIRS 180437]
ASME NUM-1-2004. 2005. *Rules for Construction of Cranes, Monorails, and Hoists (with Bridge or Trolley or Hoist of the Underhung Type).* New York, New York: American Society of Mechanical Engineers. TIC: 259317.
[DIRS 180457]
ACGIH (American Conference of Governmental Industrial Hygienists) 2006. TLVs® and BEIs®, *Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices*. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists. TIC: 258915.
[DIRS 180651]
IEEE Std C57.12.01-2005. 2006. *IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin-Encapsulated Windings.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 259338.
[DIRS 180653]
IEEE Std C57.12.00-2006. 2007. *IEEE Standard for Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 259340.
[DIRS 181218]
ANSI/ANS-58.21-2007. 2007. *American National Standard, External-Events PRA Methodology.* La Grange Park, Illinois: American Nuclear Society. TIC: 259266.
[DIRS 181664]
Regulatory Guide 1.68.3, Rev 0. 1982. *Preoperational Testing of Instrument and Control Air Systems.* Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 2714. Internet Accessible.
[DIRS 181669]
ANSI/ANS-6.4-2006. 2006. *American National Standard, Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants.* La Grange Park, Illinois: American Nuclear Society. TIC: 259189.
[DIRS 181670]
ACI 349-01/349R-01. 2001. *Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01) and Commentary (ACI 349R-01).* Farmington Hills, Michigan: American Concrete Institute. TIC: 252732.
[DIRS 181833]
10 CFR 433. 2007. Energy: Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High Rise Residential Buildings. Internet Accessible.
[DIRS 181834]
DOE O 413.3A. 2006. *Program and Project Management for the Acquisition of Capital Assets.* Washington, D.C.: U.S. Department of Energy. Internet Accessible.

[DIRS 181942]
NRC (U.S. Nuclear Regulatory Commission) 2006. *Interim Staff Guidance HLWRS-ISG-02, Preclosure Safety Analysis - Level of Information and Reliability Estimation, Draft.* HLWRS-ISG-02. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: RPM.20071015.0012.
[DIRS 181945]
Regulatory Guide 1.23, Rev. 1. 2007. *Meteorological Monitoring Programs for Nuclear Power Plants.* Washington, D.C.: U. S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 181962]
10 CFR 20. 2007. Energy: Standards for Protection Against Radiation. Internet Accessible.
[DIRS 181963]
10 CFR 436. 2007. Energy: Federal Energy Management and Planning Programs. Internet Accessible.
[DIRS 181964]
10 CFR 50. 2007. Energy: Domestic Licensing of Production and Utilization Facilities. Internet Accessible.
[DIRS 181966]
10 CFR 61. 2007. Energy: Licensing Requirements for Land Disposal of Radioactive Waste. Internet Accessible.
[DIRS 181967]
10 CFR 71. 2007. Energy: Packaging and Transportation of Radioactive Material. Internet Accessible.
[DIRS 181969]
10 CFR 73. 2007. Energy: Physical Protection of Plants and Materials. Internet Accessible.
[DIRS 181970]
40 CFR 273. 2006. Protection of Environment: Standards for Universal Waste Management. Internet Accessible.
[DIRS 181971]
40 CFR 279. 2006. Protection of Environment: Standards for the Management of Used Oil. Internet Accessible.
[DIRS 181972]
40 CFR 280. 2006. Protection of Environment: Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST). Internet Accessible.
[DIRS 181973]
47 CFR 15. 2006. Telecommunication: Radio Frequency Devices. Internet Accessible.
[DIRS 181974]
49 CFR 172. 2006. Transportation: Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements. Internet Accessible.
[DIRS 181975]
49 CFR 173. 2006. Transportation: Shippers--General Requirements for Shipments and Packagings. Internet Accessible.
[DIRS 181978]
10 CFR 430. 2007. Energy: Energy Conservation Program for Consumer Products. Internet Accessible.
[DIRS 181979]
10 CFR 1041. 2007. Energy: Enforcement of Nondiscrimination on the Basis of Handicap in Programs or Activities Conducted by the Department of Energy. Internet Accessible.
[DIRS 181980]
40 CFR 110. 2006. Protection of Environment: Discharge of Oil. Internet Accessible.
[DIRS 181981]
40 CFR 112. 2006. Protection of Environment: Oil Pollution Prevention. Internet Accessible.
[DIRS 181982]
40 CFR 122. 2006. Protection of Environment: EPA Administered Permit Programs: The National Pollutant Discharge Elimination System. Internet Accessible.
[DIRS 181983]
40 CFR 125. 2006. Protection of Environment: Criteria and Standards for the National Pollutant Discharge Elimination System. Internet Accessible.
[DIRS 181984]
40 CFR 133. 2006. Protection of Environment: Secondary Treatment Regulation. Internet Accessible.
[DIRS 181985]
40 CFR 136. 2006. Protection of Environment: Guidelines Establishing Test Procedures for the Analysis of Pollutants. Internet Accessible.
[DIRS 181986]
40 CFR 141. 2006. Protection of Environment: National Primary Drinking Water Regulations. Internet Accessible.
[DIRS 181987]
40 CFR 143. 2006. Protection of Environment: National Secondary Drinking Water Regulations. Internet Accessible.

[DIRS 182003]
Regulatory Guide 1.61, Rev 1. 2007. *Damping Values for Seismic Design of Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 182350]
Regulatory Guide 1.54, Rev. 1. 2000. *Service Level I, II, and III Protective Coatings Applied To Nuclear Power Plants.* Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 182445]
NAC (Nevada Administrative Code) 477. 2006. State Fire Marshal. TIC: 258954.
[DIRS 182588]
NRC (Nuclear Regulatory Commission) 2007. *Preclosure Safety Analysis - Dose Performance Objectives and Radiation Protection Program.* HLWRS-ISG-03. Washington, D.C.: Nuclear Regulatory Commission. ACC: MOL.20070918.0096.
[DIRS 182650]
NDOT (Nevada Department of Transportation) 2007. *Standard Plans for Road and Bridge Construction*. Carson City, Nevada: Nevada Department of Transportation.
[DIRS 182707]
USDOT (US Department of Transportation) 1996. *Standard Specification for Construction of Roads and Bridges on Federal Highway Projects.* FP-96. Washington D.C.*;* U.S. Department of Transportation.
[DIRS 182845]
NFPA 68. 2006. *Standard on Explosion Protection by Deflagration Venting.* 2007 Edition. Quincy, MA: National Fire Protection Association.
[DIRS 182857]
ASTM E 84-07. 2007. *Standard Test Method for Surface Burning Characteristics for Building Materials.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 259765.
[DIRS 182858]
ANSI C84.1-2006. 2006. *Electric Power Systems and Equipment - Voltage Ratings (60 Hertz).* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 259766.
[DIRS 182861]
NEMA WC 74-2006. 2007. *5-46kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 259767.
[DIRS 182862]
NEMA MG 10-2001 (R2007). 2007. *Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel - Cage Polyphase Induction Motors.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 259768.
[DIRS 182868]
10 CFR 851. 2007. Energy: Worker Safety and Health Program (Eff 02/09/07): Internet Accessible.
[DIRS 182870]
IEEE Std 1205-2000 (R2007). 2007. *IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 259769.
[DIRS 182871]
IEEE Std 572-2006. 2006. *IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations.* New York, New York: Institute of Electrical and Electronics Engineers. TIC: 259770.
[DIRS 182873]
ANSI/AWS A5.32/A5.32M-97 (R2007). 2007. *Specification for Welding Shielding Gases.* Miami, Florida: American Welding Society. TIC: 259771.
[DIRS 182875]
NSF/ANSI 60-2005 Addendum 1. 2006. *Drinking Water Treatment Chemicals - Health Effects.* Ann Arbor, Michigan: NSF International Standard/American National Standard. TIC: 259772 .
[DIRS 182876]
NSF/ANSI 61-2007a. 2007. *NSF International Standard/American National Standard for Drinking Water Additives - Drinking Water System Components - Health Effects.* Ann Arbor, Michigan: NSF International. TIC: 259724.
[DIRS 182880]
Interim Staff Guidance No. 1, Rev 2. 5/11/07. *Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation Based on Function.* Washington, D.C.: U.S. Nuclear Regulatory Commission Internet Accessible.
[DIRS 182890]
36 CFR 1191. 2006. Parks, Forests, and Public Property: Americans with Disabilities Act (ADA) Accessibility

Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines. ACC: Internet Accessible.
[DIRS 182892]
ISO/IEC 13818-1:2000/Amd.1:2003(E). 2003. *Information Technology -- Generic Coding of Moving Pictures and Associated Audio Information: Systems, Amendment 1: Carriage of Metadata Over ISO/IEC 13818-1 Streams.* 2nd Edition. Geneva, Switzerland: International Organization for Standardization. TIC: 254395; 255747.
[DIRS 182893]
AREMA (American Railway Engineering and Maintenance-of-Way Association). 2007. *Manual for Railway Engineering.* Four Volumes. Lanham, Maryland: American Railway Engineering and Maintenance-of-Way Association.
[DIRS 182903]
ASHRAE (American Society of Heating, Refrigerating & Air-Conditioning Engineers). 2007. *2007 ASHRAE® Handbook, Heating, Ventilating, and Air-Conditioning Applications.* Inch-Pound Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
[DIRS 182922]
ANSI/AWS A2.4-98. 2007. *Standard Symbols for Welding, Brazing, and Nondestructive Examination.* New York, New York: American National Standards Institute/American Welding Society (ANSI/AWS). TIC: 259774.
[DIRS 183013]
DOT (U.S. Department of Transportation) 1995. *Airport Pavement Design and Evaluation.* Advisory Circular 150/5320-6D. Washington, D.C.: U.S. Government Printing Office. TIC: 255501.
[183058]
ASTM D 5139-90. (Reapproved 1996). *Standard Specification for Sample Preparation for Qualification Testing of Coatings to be Used in Nuclear Power Plants.* West Conshohocken, PA: American Society for Testing and Materials. TIC: 257415.
[DIRS 183066]
ASTM D 3911-95. *Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions.* West Conshohocken, PA: American Society for Testing and Materials. TIC: 257407.
[DIRS 183067]
ASTM D 4082-95. *Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Light-Water Nuclear Power Plants.* West Conshohocken, PA: American Society for Testing and Materials. TIC: 257409.
[DIRS 183087]
NFPA 16. 2006. *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association.
[DIRS 183088]
Regulatory Guide 1.13, Revision 2. 2007. *Spent Fuel Storage Facility Design Basis..* Washington, D.C: U.S. Nuclear Regulatory Commission. Internet Accessible.
[DIRS 183091]
NFPA 2001. 2007. *Standard for Clean Agent Fire Extinguishing Systems.* 2008 Edition. Quincy, Massachusetts: National Fire Protection Association.
[DIRS 183094]
NFPA 385. 2006. *Standard for Tank Vehicles for Flammable and Combustible Liquids.* 2007 Edition. Quincy, Massachusetts: National Fire Protection Association.
[DIRS 183364]
NUREG/CR-5042 Supplement 1. 1988. *Evaluation of External Hazards to Nuclear Power Plants in the United States : Seismic Hazard.* Washington, DC: U.S. Nuclear Regulatory Commission (NRC). TIC: 234504.
[DIRS 183396]
UL 50. 2007. *UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations.* -Twelfth Edition. Northbrook, Illinois: Underwriters Laboratories.
[DIRS 183402]
ANSI/ITSDF B56.8-2006. 2006. *Safety Standard for Personnel and Burden Carriers.* Washington, DC: Industrial Truck Standards Development Foundation.
[DIRS 183403]
ANSI/ITSDF B56.9-2006. 2006. *Safety Standard for Operator Controlled Industrial Tow Tractors.* Washington, DC: Industrial Truck Standards Development Foundation.
[DIRS 183449]
ASTM D 4286-90 (Reapproved 1999). 1999. *Standard Practice for Determining Coating Contractor Qualifications for Nuclear Powered Electric Generation Facilities.* West Conshohocken, Pennsylvania: American Society for Testing and Materials.

[DIRS 183467]
72 FR 13534. Preclosure Safety Analysis - Level of Information and Reliability Estimation; Availability of Final Interim Staff Guidance Document. Internet Accessible.

8.3 Source Data

[DIRS 161983]
MO0211HISTMPEX.000. Summary of Ambient Temperature Extremes at Amargosa Farms, Beatty, and Desert Rock WSMO, Nevada. Submittal date: 11/13/2002.
[DIRS 162490]
MO0303SGPM9502.000. Storage Gauge Precipitation Measurements, Yucca Mountain 1995-2002. Submittal date: 03/11/2003.
[DIRS 165395]
MO0307MWDAC8MV.000. Analytical-La-Coarse-800M Ventilation. Submittal date: 07/15/2003.
[DIRS 166163]
MO0305SEP02MET.002. Meteorological Monitoring Data for 2002. Submittal date: 05/21/2003.
[DIRS 166164]
MO0305SEP01MET.002. Meteorological Monitoring Data for 2001. Submittal date: 05/21/2003.
[DIRS 166165]
MO0302METMON99.001. Meteorological Monitoring Data for 1999, Sites 1-9, Hourly and Ten Minute. Submittal date: 02/13/2003.
[DIRS 166730]
MO0209SEPQ2000.001. Meteorological Monitoring Data for 2000. Submittal date: 09/09/2002.
[DIRS 166731]
MO0206SEPQ1998.001. Meteorological Monitoring Data for 1998. Submittal date: 06/26/2002.
[DIRS 166735]
GS030808312231.004. Moisture Monitoring in the Exploratory Studies Facility (ESF) from August 2000 to July 2002. Submittal date: 09/26/2003.
[DIRS 169194]
MO0403SEPPRFQE.000. Hourly and Daily Precipitation Return Frequency Estimates at Yucca Mountain Meteorological Tower, Site 1. Submittal date: 03/17/2004.
[DIRS 169326]
MO0405XTMP9802.000. Extreme Temperature Values For Meteorological Monitoring Sites From 1998-2002. Submittal date: 05/10/2004.
[DIRS 170462]
MO0405SEPRHVMM.000. Mean Relative Humidity Values for Meteorological Monitoring Site 1 from 1998-2002. Submittal date: 05/25/2004.
[DIRS 171885]
MO0409SEPNOAPD.000. NOAA Extreme Annual Precipitation Data. Submittal date: 09/30/2004.
[DIRS 173394]
MO0504DSRKSNOW.001. Climatological Snow Data For Desert Rock WSMO, Nevada, 01/01/1983 TO 02/28/2005. Submittal date: 04/07/2005.
[DIRS 176097]
MO0503SEPMMD03.001, Meteorological Monitoring Data for 2003. Submittal date: 03/03/2005.
[DIRS 178311]
MO0607SEPMMD04.001, Meteorological Monitoring Data for 2004. Submittal date: 07/18/2006.
[DIRS 178663]
MO0605SEPSGP05.000 Storage Gauge Precipitation 2005.
[DIRS 178864]
MO0412SEPSGP03.000 Storage Gauge Precipitation 2003. Submittal date: 12/16/2004.
[DIRS 178865]
MO0607SEPSGP04.001 Storage Gauge Precipitation 2004. Submittal date: 07/25/2006.
[DIRS 181421]
MO0706DSDR1E4A.001. Seismic Design Spectra for the Surface Facilities Area at 1E-4 APE for Multiple Dampings. Submittal date: 06/14/07.
[DIRS 181422]
MO0706DSDR5E4A.001. Seismic Design Spectra for the Surface Facilities Area at 5E-4 APE for Multiple Dampings. Submittal date: 06/14/07.
[DIRS 181423]
MO0706DSDR1E3A.000. Seismic Design Spectra for the Surface Facilities Area at 1E-3 APE for Multiple

Dampings. Submittal date: 06/15/2007.
[DIRS 181960]
MO0706TH1E4APE.001. Time Histories for the Surface Facilities Area at 1E-4 Annual Probability of Exceedence. Submittal date: 05/29/2007.
[DIRS 181961]
MO0706TH5E4APE.001. Time Histories for the Surface Facilities Area at 5E-4 Annual Probability of Exceedence. Submittal date: 05/29/2007.
[DIRS 182460]
MO0706TH1E3APE.000. Time Histories for the Surface Facilities Area at 1E-3 APE. Submittal date: 11/01/2006.
[DIRS 182647]
MO0610METMND05.001 Meteorological Monitoring Data for 2005. Submittal date: 08/22/2007.
[DIRS 183128]
MO0707DSRB1E3A.000. 5%-damped Seismic Design Spectra for the Repository Block at 1E-3 APE. Submittal date: 07/23/2007.
[DIRS 183129]
MO0707DSRB1E4A.000. 5%-damped Seismic Design Spectra for the Repository Block at 1E-4 APE. Submittal date: 07/24/2007.
[DIRS 183130]
MO0707DSRB5E4A.000. 5%-damped Seismic Design Spectra for the Repository Block at 5E-4 APE. Submittal date: 07/24/2007.

8.4 Output Constraints

This section includes output constraints that may be acceptable for use, such as material or citing specifications. These constraints identify a version, where the project has determined that the latest version shall be used. Although the DIRS numbers provided in this section were previously used in the text, the DIRS numbers are not required to be tracked for the following:

[DIRS 158601]
NEMA WC 8-1988. 1996. *Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 252691.
[DIRS 158834]
ANSI Z535.3-2002. 2002. *Criteria for Safety Symbols.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 252735.
[DIRS 174875]
ASTM A 392-03. 2003. *Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 257190.
[DIRS 175561]
NEMA 250-2003. 2003. *Enclosures for Electrical Equipment (1000 Volts Maximum).* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 257762.
[DIRS 176249]
ASTM A 36/A 36M-05. 2005. *Standard Specification for Carbon Structural Steel.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258055.
[DIRS 176256]
AWS D1.1/D1.1M:2006. 2006. *Structural Welding Code - Steel (with Errata).* 20th Edition. Miami, Florida: American Welding Society. TIC: 258433.
[DIRS 176280]
UL 437. 2004. *Standard for Key Locks.* 7th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258046.
[DIRS 176290]
UL 768. 2006. *Standard for Combination Locks.* Eighth Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258033.
[DIRS 176311]
ANSI Z535.1-2002. 2002. *American National Standard for Safety Color Code.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258651.
[DIRS 176312]
ANSI Z535.2-2002. 2002. *American National Standard for Environmental and Facility Safety Signs.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258652.
[DIRS 176313]
ANSI Z535.4-2002. 2002. *American National Standard for Product Safety Signs and Labels.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258653.

[DIRS 176314]
ANSI Z535.5-2002. 2002. *American National Standard, Safety Tags and Barricade Tapes (for Temporary Hazards).* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258654.
[DIRS 176348]
UL 467. 2004. *UL Standard for Safety for Grounding and Bonding Equipment.* 8th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258595.
[DIRS 176403]
ASTM A 108-03. 2005. *Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258679.
[DIRS 176429]
ASTM F 1554-04. 2004. *Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258689.
[DIRS 177883]
ASTM A 185/A 185M-06. 2006. *Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258700.
[DIRS 177889]
ASTM A 307-04. 2004. *Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258703.
[DIRS 177894]
ASTM A 53/A 53M-06. 2006. *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258712.
[DIRS 177895]
ASTM A 653/A 653M-06. 2006. *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258717.
[DIRS 177898]
ASTM A 992/A 992M-06a. 2006. *Standard Specification for Structural Steel Shapes.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258723.
[DIRS 178043]
UL 1581. 2006. *Reference Standard for Electrical Wires, Cables, and Flexible Cords.* 4th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258756.
[DIRS 178048]
UL 96A. 2005. *Installation Requirements for Lightning Protection Systems.* 11th Edition. Northbrook, Illinois: Underwriters Laboratories. TIC: 258761.
[DIRS 178106]
ASTM D 1784-06. 2006. *Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258754.
[DIRS 178107]
ASTM D 3034-06. 2006. *Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 258755.
[DIRS 178298]
NEMA WC 72-1999 (R2004). 2004. *Continuity of Coating Testing for Electrical Conductors.* Rosslyn, Virginia: National Electrical Manufacturers Association. TIC: 258876.

8.5 Procedures

[DIRS 179695]
BSC (Bechtel SAIC Company) 2007. *Application of ALARA in the YMP Design Process.* EG-DSK-3701. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070312.0021.
[DIRS 180474]
BSC (Bechtel SAIC Company) 2007. *Quality Management Directive.* QA-DIR-10, Rev. 1. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070330.0001.
[DIRS 182372]
RQ-DIR-10, Rev. 3. *Requirements Management Program.* Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070510.0016.
[DIRS 183132]
EG-PRO-3DP-G04B-00001, Rev. 009. *Design Criteria.* Las Vegas, NV: Bechtel SAIC Company, LLC (BSC). ACC: ENG.20070627.0007.

LS-PRO-0201, Rev.4 *Preclosure Safety Analyses Process.* Las Vegas, NV: Bechtel SAIC Company, LLC (BSC). ACC: ENG.20070918.0002.
LS-PRO-3005, Rev. 1. *REGULATORY GUIDANCE AGREEMENTS.* Las Vegas, Nevada: Bechtel SAIC Company, LLC. ACC: DOC.20070802.0002.