Procurement Specification for CO_2 Removal System at ETF

Prepared by
Paul Townson
Amentum LLC

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1.0 SCOPE

This procurement specification is for an in-line system to remove dissolved and free CO_2 from the Effluent Treatment Facility (ETF) influent stream after it leaves the surge tank (60A-TK-1) and immediately upstream of the ultraviolet/oxidation (UV/OX) process. The reason for this is that WTP EMF feeds contain high levels of carbonate, and carbonate in the process stream scavenges free hydroxyl radicals reducing the efficiency of the UV/OX process. Influent to ETF will be adjusted to pH 5.5 by the addition of sulfuric acid, and this shifts the equilibrium from carbonate to bicarbonate and (predominantly) carbon dioxide. Gas phase carbon dioxide also causes problems in the UV/OX system, so this requires removal. The CO_2 membrane contactor system will remove insoluble carbon dioxide gas and much of the dissolved carbon dioxide from the pH adjusted WTP EMF effluent. The design flow rate of the system is 170 gpm, with a minimum flow capability of 40 gpm, and the required removal of CO_2 is such that the equivalent carbonate concentration is reduced from approximately 3000 to <300 mg/l, which will be required to support Hanford Waste Treatment Plant (WTP) operations when it comes on line. The **SELLER** shall provide the CO_2 removal system in accordance to the requirements of this specification.

Unless noted otherwise, the new system shall be designed as a skid mounted package that contains all equipment and components such as CO_2 membrane contactors, manual and automatic valves, measurement devices, on-skid piping, tubing, wiring, conduit, instruments, and control systems (if required) for fully operational unit. The CO_2 membrane contactors shall be 3M™ Liqui-Cel™[1] EXF-10x28 in stainless steel.

Liqui-Cel Membrane Contactors make it possible to transfer gas to or from an aqueous stream without dispersion. A membrane contactor can contain thousands of microporous polypropylene hollow fibers knitted into an array that is wound around a center tube. Because the hollow fiber membrane is hydrophobic, liquids will not penetrate the membrane pores. A higher pressure is applied to the liquid stream relative to the gas stream. Although Liqui-Cel Membrane Contactors utilize a microporous membrane, the separation principle differs substantially from other membrane separations such as filtration and gas separation. With Liqui-Cel Membrane Contactors there is no convective flow through the pores. Instead, the membrane acts as an inert support that brings the liquid and gas phases into direct contact without dispersion. The transfer between the liquid and gas phases is primarily governed by the partial pressure difference of the target gas species between the two phases.

The following is a summary of the **SELLER's** responsibilities described in this specification:

Design and fabricate the CO_2 removal system in accordance with this specification, American Society of Mechanical Engineers (ASME®) ASME B31.3, *Process Piping,* Normal Fluid Service, ASME Section VIII, other referenced documents, the **SELLER's BUYER** approved drawings, and other referenced documents.

[1] 3M and LiquiCel are registered trademarks of 3M Industrial Business Group, Membranes Business Unit, 13840 South Lakes Drive, Charlotte, North Carolina 28273, USA

Furnish design data required by this specification to document design of the CO_2 removal system.

Procure equipment, materials, or supplies to complete the work, unless otherwise stated.

Test and inspect as required by this specification and ASME® B31.3, Normal Fluid Service.

Perform a factory acceptance test of the CO_2 removal system by using clean water.

Furnish the data required by this specification to document that required tests and inspections have been performed.

Package, ship, and deliver CO_2 removal system and related equipment.

Provide the **BUYER** full access to the facility for performing random or scheduled inspections and/or surveillance of work performed.

2.0 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of the basis of design to the extent specified in the applicable sections of this document and establish the Code of Record. In the event of a conflict between documents referenced herein and the requirements of this specification, the requirements of this specification shall take precedence over requirements in documents listed in Table 2-1 and Table 2-2 only when the specification requirements are more stringent or conservative.

2.1 GOVERNMENT DOCUMENTS

Documents listed in Table 2-1 constitute a part of this specification to the extent specified herein and establishes the Code of Record. The most current version of the documents shall be used, unless otherwise specified. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

Table 2-1. Government Documents.

Document Number	Title
(DOE) U.S. Department of Energy	
DOE/RL-92-36, Rev. 1, Release 84	*Hanford Site Hoisting and Rigging Manual*
(WAC) Washington State Administrative Code	
WAC 173-303-640	*Dangerous Waste Tank Systems*

2.2 NON-GOVERNMENT DOCUMENTS

The following documents of the exact issue shown in Table 2-2 form a part of this specification to the extent specified herein and establishes the Code of Record. In the event of conflict between the documents referenced herein and contents of this specification, the contents of this specification shall be considered a superseding requirement.

Table 2-2. Non-Government Documents. (2 sheets)

Document Number	Title
(ASME®) American Society of Mechanical Engineers	
ASME B&PVC.II.C-2017	*ASME Boiler and Pressure Vessel Code, Section II: Materials, Part C, Specifications for Welding Rods, Electrodes, and Filler Metals*
ASME B&PVC.III-2017	*ASME Boiler & Pressure Vessel Code, Section III: Rules for Construction of Nuclear Power Plant Components*
ASME B&PVC.IX-2017	*ASME Boiler and Pressure Vessel Code, Section IX: Welding, Brazing, and Fusing Qualifications*
ASME B16.5-2017	*Pipe Flanges and Flanged Fittings*
ASME B16.9-2018	*Factory-Made Wrought Buttwelding Fittings*
ASME B16.20-2017	*Metallic Gaskets for Pipe Flanges*
ASME B31.3-2018	*Process Piping*
(ASNT) American Society Nondestructive Testing	
ASNT CP-189-2016	*ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*
ASNT SNT-TC-1A-2016	*Standard Topical Outlines for Qualification of Nondestructive Testing Personnel*
(ASTM®) American Society of Testing and Materials	
ASTM A36/A36M-19	*Standard Specification for Carbon Structural Steel*
ASTM A182/A182M-20	*Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service*
ASTM A193/A193M-19	*Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*
ASTM A194/A194M-20	*Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*
ASTM A213/A213M-18b	*Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes.*
ASTM A240/A240M-19	*Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General applications.*
ASTM A269/A269M-15a	*Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.*
ASTM A276-17	*Standard Specification for Stainless Steel Bars and Shapes*

Table 2-2. Non-Government Documents. (2 sheets)

Document Number	Title
ASTM A312/A312M-19	*Standard Specification for Seamless, Welded, and Heavily Cold worked Austenitic Stainless Steel Pipes*
ASTM A403/A403M-20	*Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings*
ASTM A479/A479M-19	*Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and other Pressure Vessels*
ASTM A500/A500M-18	*Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes*
ASTM A992/A992M-11(Reapproved 2015)	*Standard Specification for Structural Steel Shapes*
(AWS®) American Welding Society	
AWS B2.1/B2.1M-BMG:2014	*Base Metal Grouping for Welding Procedure and Performance Qualification*
AWS D1.1/D1.1M:2015	*Structural Welding Code — Steel*
AWS D1.3/D1.3M:2018	*Structural Welding Code — Sheet Steel*
AWS D1.6/D1.6M:2017	*Structural Welding Code — Stainless Steel*
AWS D9.1M/D9.1:2018	*Sheet Metal Welding Code*
AWS QC1:2016	*Specification for AWS Certification of Welding Inspectors*
(NFPA) National Fire Protection Association	
NFPA 70-2020	*National Electrical Code (NEC)*
NFPA 70E, 2018	*Standard for Electrical Safety in the Workplace*
(UL) Underwriters Laboratories	
UL 508A, 2018	*Standard for Industrial Control Panels*
(WRC) Welding Research Council	
WRC-297, 1984	*Local Stresses in Cylindrical Shells Due to External Loadings on Nozzles-Supplement to WRC Bulletin 107*
WRC-537, 2010	*Precision Equations and Enhanced Diagrams for Local Stresses in Spherical & Cylindrical Shells due to External Loadings for Implementation of WRC Bulletin 107*

2.3 NON-CODE OF RECORD DOCUMENTS

The **SELLER** shall draft a Request for Information (RFI) to inquire about specific Tank Operations Contractor (TOC) standards, procedures, and documents. The following documents (Table 2-3) are used in or referenced by this specification, but are not considered Code of Record. Unless otherwise shown or noted, the latest edition and addenda are applicable.

Table 2-3. Non-Code of Record Documents. (2 sheet)

Document Number	Title
QA-AVS B13	"Fabrication/Inspection/Test Plan"

Table 2-3. Non-Code of Record Documents. (2 sheet)

Document Number	Title
QA-AVS B16	"Source Inspection"
QA-AVS B22	"Nonconformance Documentation and Reporting"
QA-AVS B25	"Certified Welding Inspector (CWI)"
QA-AVS B28	"Welding Procedures and Qualifications"
QA-AVS B31	"Nondestructive Examination Process"
QA-AVS B46	"Liquid Penetrant Material Certification"
QA-AVS B49	"Certified Material Test Report"
QA-AVS B52	"Inspection and Test Report"
QA-AVS B61	"Certification of Calibration Services"
QA-AVS B76	"Procurement of Potentially Suspect or Counterfeit Items"
QA-AVS B79	"Certificate of Conformance"
QA-AVS B85	"Packaging/Shipping Procedures"
HNF-27957, Rev 3	"200 Area ETF, Load-In, and LERF Pipe Class Specification"
RPP-8360, Rev. 6	"Lifting Attachment and Lifted Item Evaluation"
RPP-36610, Rev. 7	"Tank Farm Monitor and Control System Software Requirements Specification & Software Design Description"
TFC-BSM-IRM_DC-C-02, Rev F-24	"Records Management"
TFC-BSM-IRM_DC-C-07, Rev A-13	"Vendor Processes"
TFC-BSM-AD-STD-02, Rev. D-12	*"Editorial Standards for Technical Documents"*
TFC-ENG-DESIGN-C-06, Rev. L-5	*"Engineering Change Control"*
TFC-ENG-DESIGN-C-09, Rev. E-10	*"Engineering Drawings"*
TFC-ENG-DESIGN-C-10, Rev. B-16	*"Engineering Calculations"*
TFC-ENG-DESIGN-C-25, Rev. G-5	*"Technical Document Control"*
TFC-ENG-DESIGN-C-34, Rev. C-3	*"Development of Technical Requirements for Procurements"*
TFC-ENG-DESIGN-C-42, Rev. A-8	*"Design Requirements Compliance Matrix"*
TFC-ENG-DESIGN-D-13.2, Rev. A-29	*"Guidance for Applying Engineering Codes and Standards to Design"*
TFC-ENG-DESIGN-D-51, Rev. A-5	*"ECN Preparation and Work Completion Walkdown"*
TFC-ENG-DESIGN-P-12, Rev. G-11	*"Plant Installed Software"*
TFC-ENG-DESIGN-P-54, Rev. A-11	*"Checking of Engineering Documents"*
TFC-ENG-DESIGN-P-59, Rev. B-4	*"Plant Installed Software Quality Assurance"*
TFC-ENG-FACSUP-C-23, Rev. G-2	*"Equipment Identification and Data Management"*
TFC-ENG-FACSUP-C-25, Rev E-0	"Hoisting and Rigging"
TFC-ENG-STD-01, Rev. A-7	"Human Factors in Design"
TFC-ENG-STD-02, Rev. B-0	"Environmental/Seasonal Requirements for TOC Systems, Structures, and Components"
TFC-ENG-STD-06, Rev. D-2	"Design Loads for Tank Farm Facilities"
TFC-ENG-STD-07, Rev. D-2	"Ventilation System Design"

Table 2-3. Non-Code of Record Documents. (2 sheet)

Document Number	Title
TFC-ENG-STD-12, Rev. E-4	"TOC Equipment Identification Numbering and Labeling Standard"
TFC-ENG-STD-15, Rev. C-7	"Standard for Raceway Systems and Flexible Cords & Cables"
TFC-ENG-STD-23, Rev. A-9	"Human-Machine Interface for Process Control Systems"
TFC-ENG-STD-36, Rev. B-4	"Hardware for ABB Process Control Systems"
TFC-ENG-STD-40, Rev. B-1	"Alarm Management and Annunciator Panel for Process Control Systems"
TFC-ENG-STD-41, Rev. A-11	"Electrical Installations"
TFC-ENG-STD-51, Rev A-1	"Vendor Calculation Standard"
RPP-8360, Rev 6	*Lifting Point Evaluation Process*
TFC-PLN-118, Rev. B-1	"Strategic Plan for Hanford Waste Feed Delivery and Treatment Process Control Systems"
H-2-88970, Sheet 1, Rev 6	"Process Flow Diagram"
H-2-88973, Sheet 1, Rev 2	"Material Balance DB3"
H-2-88975, Sheet 1, Rev 14	"Piping & Instrumentation Diagram Rough Filter System"
H-2-88993, Sheet 1, Rev 15	"Piping & Instm Diag Vessel Ventilation System"
RPP-PLAN-62157, Rev 3	"Effluent Treatment Facility Excel Based Flowsheet"

2.4 HIERARCHY OF CODE

Except in those instances where Washington State has been granted regulatory authority by the Federal Government, the hierarchical relationship among requirements specified in Section 3.0 is as follows:

1. Federal requirements (e.g., *Code of Federal Regulations*);
2. Washington State requirements (e.g., *Washington Administrative Code*);
3. Local ordinances;
4. DOE orders and standards;
5. National consensus codes and standards; and
6. Hanford Site-specific codes and standards.

This hierarchy establishes the order of precedence of requirements levied in this specification. In the event of a conflict between two requirements, the **SELLER** shall submit a RFI for clarifications prior to use.

3.0 SYSTEM, STRUCTURE, AND COMPONENT CHARACTERISTICS AND REQUIREMENTS

3.1 SYSTEM, STRUCTURE, AND COMPONENT FUNCTIONS AND FUNCTIONAL PERFORMANCE REQUIREMENTS

3.1.1 General Design Requirements

NOTE: The CO_2 removal system will be installed indoors, with an ambient temperature range of 50 °F to 90 °F, <95% Relative Humidity.

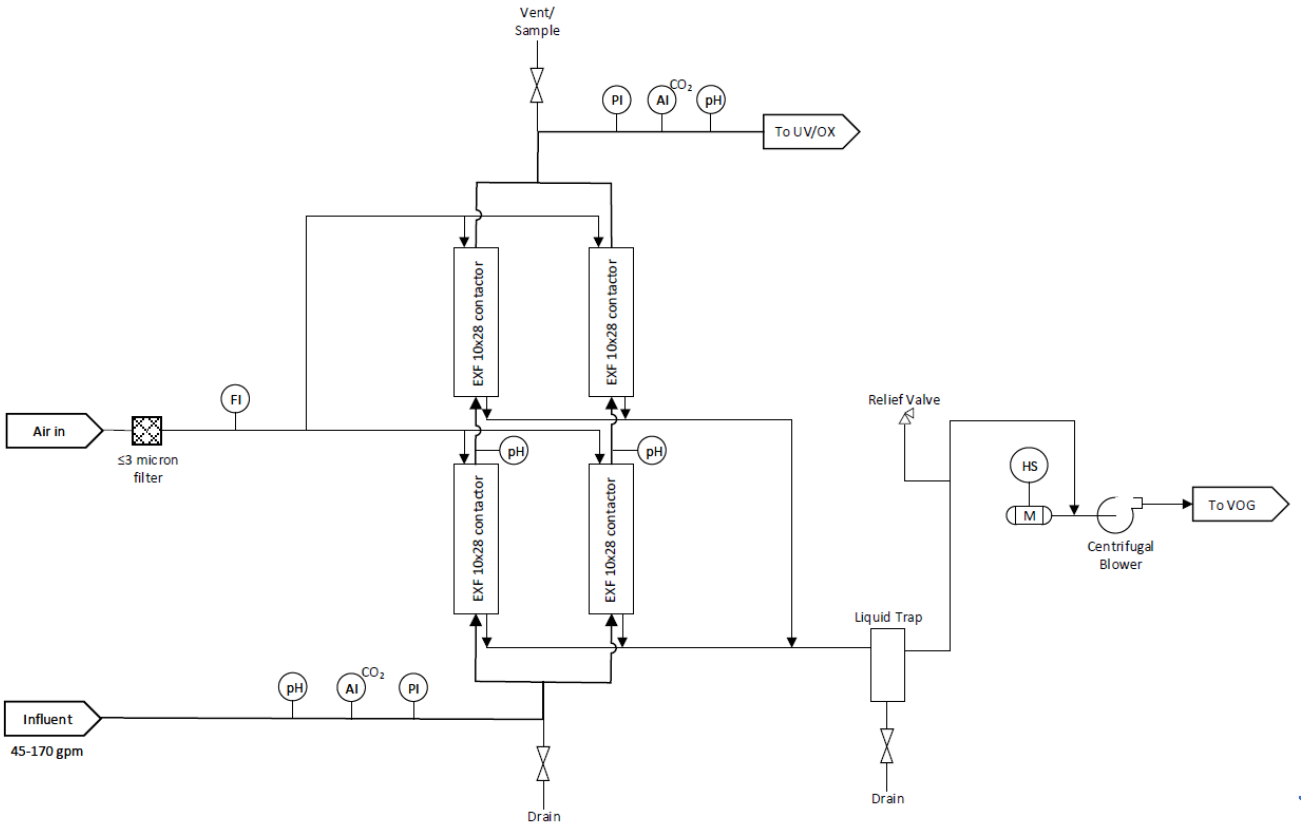
1. For the CO_2 removal system operating conditions and design data, refer to Section 3.3.
2. Design, fabricate, test, and label the CO_2 removal system in accordance with:
   a. this specification,
   b. the **SELLER's BUYER**-approved drawings, and
   c. applicable regulations.
3. If there is a conflict among the above listed requirements, applicable regulations will take precedence. Bring any conflicts to the **BUYER's** attention for resolution.
4. The **BUYER** will review and comment on design calculations and drawings. The **BUYER** review does not release the **SELLER** from responsibility to design and fabricate the CO_2 removal system in accordance with applicable regulations, and this specification.

3.1.2 Performance Criteria

1. The CO_2 removal system shall be sized for a maximum design flow of 170 gpm, with the ability to run at flow rates as low as 40 gpm. The removal system skid shall comprise four total 3M™ Liqui-Cel™ EXF-10x28 contactors in stainless steel, containing X50 fibers, in two parallel trains each containing two contactors in series mounted vertically. See *3M Design & Operating Guidelines for Liqui-Cel Extra-Flow Membrane Contactors* for further design information.
2. The system shall operate in sweep gas mode. Sweep gas mode is a process by which a gas in the lumen side of the contactor flows counter-current to the water flow. By choosing a sweep gas (air) that is different from the gas targeted for removal (CO_2), a partial pressure gradient is created between the liquid phase (shell side) and the gas phase (lumen side). This forces the target gas to transfer to the lumen side and be swept away. Filtered and oil free atmospheric air is suitable for use as the sweep gas. The air sweep flowrate for the EXF-10x28 contactor is in the range 5-30 scfm. The sweep gas shall discharge directly into the ETF vessel offgas (VOG) system via a skid mounted blower.
3. The system shall have pressure and CO_2 measurement at the inlet and at the outlet to the skid.
4. The skid shall also provide connections for acid and caustic chemical cleaning reagents to clean the contactors if they become fouled. See *3M™ Liqui-Cel™ EXF Series Membrane Contactors Cleaning and Storage Guidelines* for additional guidelines. Cleaning reagents will be delivered to the skid by the **BUYER**.

5. The maximum available footprint for the CO_2 removal system skid is 2’-0” by 6’-0”. SELLER to inform BUYER immediately if this is not achievable.
6. See section 3.2 for BUYER provided interfaces for all inlet and outlet connections.
7. Network Communication: The pressure, CO_2 values, blower status, alarms and faults will need to be relayed to the main control room.

Figure 3-1 Conceptual ETF CO_2 Removal System Process Flow Diagram



3.2 SYSTEM, STRUCTURE, AND COMPONENT INTERFACES

8. Process inlet point from surge tank pump, 3” Class 150 raised face flange.
9. Process outlet point feeding to UV/OX system, 3” Class 150 raised face flange.
10. Sweep air outlet to VOG system, 3” Class 150 raised face flange.
11. Acid cleaning connection ¾” class Class 150 raised face flange
12. Sodium Hydroxide cleaning connection, ¾” Class 150 raised face flange
13. Drain lines, 1” Class 150 flat face flange.
14. Main circuit breaker 120-V 1-phase overcurrent protective devices.
15. Provide own overcurrent protection.
16. Discrete 24Vdc instrumentation connections for hardwired analogue output signals.

3.3 SYSTEM, STRUCTURE, AND COMPONENT CHARACTERISTICS

3.3.1 Functional Characteristics

The CO_2 removal system shall be used to remove CO_2 from the ETF influent liquid feeding forward to the main treatment train from the surge tank. Additional information regarding the interfaces to the CO_2 removal system to the interfacing piping systems is provided in Paragraph 3.2.

3.3.1.1 System Design Life. The CO_2 removal system and accessories shall have a design life of 30 years except for wear parts and consumables such as the membrane contactors (expected life 10 years).

3.3.1.2 Design and Operating Conditions. The CO_2 removal system's operating profile is 7 days per week 24 hours per day (52 weeks per year).

3.3.1.3 Process Stream Piping

1. Flow rate: 170 gpm max, 45 gpm min, average flow rate 100 gpm.
2. Design pressure: 150 psig
3. Design Temperature: 200 °F.
4. Design Code ASME® B31.3, Category D Fluid Service

3.3.1.4 Sweep Air

1. Design Pressure Piping:15 psig.
2. Design Temperature 50-90 °F.
3. Maximum operating flowrate 120 scfm (30 scfm per contactor)
4. Blower discharge design pressure to VOG 1 in. H20 STD
5. Design Code ASME® B31.3, Category D

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3.3.1.5 Chemical Cleaning Design and Operating conditions

1. Design Pressure 120 psig.
2. Design Temperature 120 °F.
3. Design Code ASME® B31.3, Normal Fluid Service

3.3.1.6 4% Sulfuric Acid Design and Operating conditions:

1. Design Pressure 75 psig.
2. Design Temperature 120 °F.
3. Design Code ASME® B31.3, Normal Fluid Service

3.3.1.7 4%Sodium Hydroxide Design and Operating conditions:

1. Design Pressure 75 psig.

2. Design Temperature 120 °F.
3. Design Code ASME® B31.3, Normal Fluid Service

3.3.2 Physical Characteristics

This section provides the physical characteristics for the CO_2 removal system, and any accessories.

3.3.2.1 Environmental Conditions. Design the CO_2 removal system and accessories to operate indoors per Paragraph 3.1.1 and package for dry storage outdoors in the environmental conditions specified in TFC-ENG-STD-02.

3.3.2.2 Design Loads. Design loads shall comply with TFC-ENG-STD-06, Natural Phenomena Hazard Design Category NDC-2, Limit State C.

3.3.2.3 Packaging, Storing, Shipping, and Load Handling. When the **SELLER** has requirements for packaging, storage, shipping, and handling (PSSH), the **SELLER's** PSSH requirements must be approved by the **BUYER**. Otherwise, the **SELLER** shall use the requirements in Section 7.0.

3.3.3 System Monitoring Design Features

System Design and Construction shall include the following minimum monitoring requirements.

A. Reserved.

3.4 DESIGN AND CONSTRUCTION REQUIREMENTS

3.4.1 Safety

1. The CO_2 removal system and accessories shall be designed for safe installation, operation, and maintenance, including failure modes.
2. Design shall allow easy membrane contactor cleaning and replacement.
3. The CO_2 removal system will be located on mezzanine flooring at the 27'2" level in ETF. Access to this area in limited to stairs and a temporary hoist. Design shall allow for dismantling skid into smaller parts to facilitate installation.
4. Design shall separate power and instrumentation to allow maintenance of the instrumentation without the need to shutdown power. All electrical terminals shall be finger safe.

3.4.2 Major Components

1. Configure for minimum space requirements while maintaining serviceability and for ease of upgrade for future expansion.

3.4.2.1 Containment Boundary Design Requirements.

2. Proposed weld joint configurations are to be approved by the **BUYER** prior to fabrication, unless the **BUYER** chooses to waive this requirement.
3. Provide containment basin for skid.

3.4.2.2 Nozzle Requirements.

1. Provide sufficient projection of flanged nozzles to allow removal of flange bolts from either side.
2. External nozzle connections shall be within containment basin boundary.
3. External nozzle loads shall be designed to meet requirements below:

Size (NPS)	Force (lbs_f)			Moment (lb-ft)		
	$F_{(Axial)}$	$F_{(Lateral)}$	$F_{(Horizontal)}$	$M_{(Axial)}$	$M_{(Lateral)}$	$M_{(Horizontal)}$
3/4	25	25	50	100	200	200
1	50	50	100	100	200	200
1-1/2	100	100	200	200	400	400
2	100	100	200	200	400	400
3	100	100	200	200	400	400

4. Unless specified otherwise, external nozzle flanges are to conform to ASME® B16.5.
5. Refer to Section 4.1.4 for nondestructive examination (NDE) requirements.
6. **SELLER** shall design nozzles in accordance with the methods of WRC-297 and WRC-537, or **BUYER** approved analysis.

3.4.2.3 Cyclic loads.

1. The cycles will be fewer than 7,000 for the design life of the system.

3.4.2.4 Corrosion of Parts.

1. Design of in-line CO_2 removal system shall include a corrosion allowance of 0.0002 in/yr over the design life of 30 years for the piping.

3.4.2.5 Supports.

1. Unless otherwise specified by the **BUYER**, design CO_2 removal system as self-supporting, including legs, etc. Consider seismic loadings in support design, depending on installation method and location. CO_2 removal system will be located indoors; wind, snow, and volcanic loadings are not applicable.
2. Allow for thermal expansion and thermal expansion loads during support design.
3. Assume that a field hydrostatic test will occur where the CO_2 removal system will be filled completely full of water, and account for this weight in the support design.
4. Design supports to meet NDC-2, Limit State C.
5. CO_2 removal system shall provide mounting holes to accommodate anchoring to mezzanine floor per TFC-ENG-STD-06, “Design Loads for Tank Farms Facilities.”. Provide reaction forces at the anchorage locations.

3.4.3 Piping and Structural Materials

Certified Material Test Reports (CMTR) shall be submitted to the **BUYER** for all pressure boundary and structural materials. All other materials used in construction shall be provided with a Certificate of Conformance, in accordance with QA-AVS B49. Certificates of Conformance shall be traceable to the material used in the fabrication and conform to the requirements in Section 6.4.4. Material CMTRs are also acceptable, and if supplied, shall contain the test results from all testing specified by the referenced material code or standard, and be traceable to the material used in the fabrication.

3.4.3.1 Influent Process and 4% Caustic Piping (Based on ETF Pipe Class 163LS, HNF-27957)

3.4.3.1.1 Piping

1. 2” and smaller ASTM® A312/A312M, Grade TP316/316L, seamless, Schedule 40S.
2. 2-1/2” and larger ASTM® A312/A312M, Grade TP316/316L, seamless, Schedule 10S.

3.4.3.1.2 Fittings

1. ASTM® A403/A403M, Class S (seamless), Grade WP316/316L, seamless, butt welding in accordance with ASME® B16.9, wall thickness to match pipe.

3.4.3.1.3 Flanges.

1. Weldneck, slip on, Class 150, raised face, forged stainless steel, ASTM® A182/A182M, Grade F316/316L, ASME B16.5. Bore weldneck flanges to match pipe internal diameter. Slip-on flanges to be double welded.

3.4.3.1.4 Threaded Couplings.

1. Class 3000, threaded, forged stainless steel, ASTM® A182/A182M, Grade F316/316L.

3.4.3.1.5 Fasteners.

1. Flanges: Stud bolts with two nuts, continuously threaded alloy steel studs, ASTM® A193/A193M, Grade B7 steel, and heavy hex nuts, ASTM® A194/A194M, Grade 2H.
2. Bolts: Threaded alloy steel bolts, ASTM® A193/A193M, Grade B7 steel.
3. Nuts: Heavy hex nuts ASTM® A194/A194M, Grade 2H.

3.4.3.1.6 Gaskets.

1. Flange Gaskets: Gaskets for chemical lines will be compatible with the chemicals expected in the line.
2. General use Flange Gaskets: Flexitallic®-style “LS” spiral wound gasket, Class 150, Flexicarb® flexible graphite, Type 304 stainless-steel outer ring manufactured to ASME® B16.20.

3.4.3.2 Sulfuric Acid Piping (Based on ETF Pipe Class 152, HNF-27957)

BUYER has Alloy 20 in specification for sulfuric acid piping but would be like vendor's recommendation of a more suitable material if they have one.

3.4.3.2.1 Piping

3. 2" and smaller ASTM® B729, Alloy 20Cb-3 (UNS N08020), seamless, Schedule 40S.
4. 2-1/2" thru 10" ASTM® B729, Alloy 20Cb-3 (UNS N08020), seamless, Schedule 10S.

3.4.3.2.2 Fittings

5. ASTM® B366, Alloy 20Cb-3 (UNS N08020), seamless, butt welding in accordance with ASME® B16.9, wall thickness to match pipe.

3.4.3.2.3 Flanges.

6. Weldneck, Class 150, raised face, forged stainless steel, ASTM® B462, B463 or B473, ASME B16.5. Bore weldneck flanges to match pipe internal diameter. Slip-on flanges may be used in lieu of weldneck for space restrictions. Slip-on to be double welded.

3.4.3.2.4 Threaded Couplings.

7. 2" and smaller Class 3000, threaded, forged stainless steel, ASTM® B366, Alloy 20Cb-3 (UNS N08020).

3.4.3.2.5 Flange Fasteners.

8. Stud bolts with two nuts, continuously threaded alloy steel studs, ASTM® A193/A193M, Grade B7 steel, and heavy hex nuts, ASTM® A194/A194M, Grade 2H ASME B1.1 and ASME B18.2.2.

3.4.3.2.6 Gaskets.

1. Flange Gaskets: Flexitallic®-style "LS" spiral wound gasket, Class 150, Flexicarb® flexible graphite, Type 316 stainless-steel outer ring manufactured to ASME® B16.20.

3.4.3.3 Sweep Air (Based on ETF Pipe Class 153S, HNF-27957)

3.4.3.3.1 Piping

9. 2" and smaller: ASTM® A312/A312M, Grade TP304/304L, seamless, Schedule 40S.
10. ASTM® A403/A403M, Class S (seamless), Grade WP304/304L, seamless, butt welding in accordance with ASME® B16.9, wall thickness to match pipe.

3.4.3.3.2 Fittings

11. 2” and smaller: ASTM® A182, Grade F304/304L, Class 3000, forged socket weld ends in accordance with ASME® B16.11.

3.4.3.3.3 Flanges.

12. Weldneck, slip on, Class 150, raised face, forged stainless steel, ASTM® A182/A182M, Grade F304/304L, ASME B16.5. Bore weldneck flanges to match pipe internal diameter. Slip-on flanges to be double welded.

3.4.3.3.4 Threaded Couplings.

13. Class 3000, threaded, forged stainless steel, ASTM® A182/A182M, Grade F304/304L.

3.4.3.3.5 Flange Fasteners.

14. Stud bolts with two nuts, continuously threaded alloy steel studs, ASTM® A193/A193M, Grade B7 steel, and heavy hex nuts, ASTM® A194/A194M, Grade 2H ASME B1.1 and ASME B18.2.2.

3.4.3.3.6 Gaskets.

15. Flange Gaskets: Flexitallic®-style “LS” spiral wound gasket, Class 150, Flexicarb® flexible graphite, Type 304 stainless-steel outer ring manufactured to ASME® B16.20.

3.4.3.4 Chemical Cleaning and Drain Piping (Based on ETF Pipe Class 155, HNF-27957)

3.4.3.4.1 Piping

1. 8” and smaller ASTM® D1784/ASTMF441, Schedule 80.

3.4.3.4.2 Fittings

2. ASTM® D1784/F439, socket weld.

3.4.3.4.3 Flanges.

3. ASTM® ASTM D1784/F439, socket flat faced Class 150 drilling, ASME B16.5.

3.4.3.4.4 Flange Fasteners.

4. Flanges: Stud bolts with two nuts, continuously threaded alloy steel studs, ASTM® A193/A193M, Grade B7 steel, and heavy hex nuts, ASTM® A194/A194M, Grade 2H ASME B1.1 and ASME B18.2.2, Zinc Plated Flat Washer.

3.4.3.4.5 Gaskets

5. Flange Gaskets: Full Face, 1/8" Thick, Durometer Rating of 60-70, Hypalon™ Or Full Face, 1/8" Thick, Durometer Rating of 70-80, Viton™.

3.4.3.5 Compressed Air (Based on ETF Pipe Class 153 and 153T, HNF-27957)

3.4.3.5.1 Piping

6. 2" and smaller: ASTM® A312/A312M, Grade TP304/304L, seamless, Schedule 40S.

3.4.3.5.2 Fittings

7. 2" and smaller: ASTM® A182, Grade F304/304L, Class 3000, forged socket weld ends in accordance with ASME® B16.11.

3.4.3.5.3 Flanges.

8. Socket weld or slip-on Class 150, raised face, forged stainless steel, ASTM® A182/A182M, Grade F304/304L, ASME B16.5. Bore flanges to match pipe internal diameter.

3.4.3.5.4 Threaded Couplings.

9. Class 3000, threaded, forged stainless steel, ASTM® A182/A182M, Grade F304/304L.

3.4.3.5.5 Flange Fasteners.

10. Stud bolts with two nuts, continuously threaded alloy steel studs, ASTM® A193/A193M, Grade B7 steel, and heavy hex nuts, ASTM® A194/A194M, Grade 2H ASME B1.1 and ASME B18.2.2.

3.4.3.5.6 Gaskets.

11. Flange Gaskets: Flexitallic®-style "LS" spiral wound gasket, Class 150, Flexicarb® flexible graphite, Type 304 stainless-steel outer ring manufactured to ASME® B16.20.

3.4.3.5.7 Tubing

12. Tubing less than 1": Tubing and fittings shall meet the requirements of ASME® B31.1 and HNF-27957 Pipe Class 153T specification. Tubing shall be ASTM® A213/A269 seamless TP316 stainless steel, minimum wall thickness, 0.035" for 3/8" OD and smaller, 0.049" for ½" OD, and 0.065" for 5/8" and ¾" OD. Fittings shall be Swagelok® stainless steel compression tube fittings and adapters.

3.4.3.6 Contactor Vessel

13. Designed, stamped and National Board Inspection Code (NBIC) registered to ASME Boiler and Pressure Vessel Code (B&PVC), Section VIII, Division 1 or Division 2.

14. Shall provide an unlisted component evaluation for review if qualifications cannot be met above.

3.4.3.7 Backing Rings.

15. Backing rings are not to be used.

3.4.4 Structural Materials

1. Carbon Steel plate and shapes shall be in accordance with ASTM® A36, wide flange sections shall be in accordance with ASTM® A36 or ASTM® A992, hollow structural shapes shall be in accordance with ASTM® A500 Grade B.
2. All carbon steel shall have two coats of either epoxy or powder coat. The paint type and color shall be approved by **BUYER**. The epoxy coating, primer and primer preparation shall be in accordance with the paint manufacture's recommendation.

3.4.5 Cleaning System

1. CO_2 removal system shall be designed so the membrane contactors and piping can be drained when the contactors are to be removed for replacement.
2. CO_2 removal system shall be designed to accommodate cleaning cycles as described in *3M™ Liqui-Cel™ EXF Series Membrane Contactors Cleaning and Storage Guidelines*. **BUYER** will provide caustic and acid feed and return lines, and drain lines to skid boundary.

3.4.6 Electrical

3.4.6.1 Electrical Interface

1. Power available 3-phase 480 VAC or 1-phase 120 VAC.
2. All electrical devices and instrumentation shall be wired to a junction box located at the edge of the skid. The junction box shall be located on the skid to allow for operator accessibility with appropriate National Electric Code (NEC) required working clearances. A master control panel shall also be provided.
3. Individual power and control panels shall be Listed and certified in accordance with UL 508A, Standard for Industrial Control Panels.
4. Power and low power (120V and less) shall be separated to allow maintenance. All terminals shall be finger safe.
5. Wire management within control panels shall be routed through wireways using a professionally neat, organized and workmanlike manner.
6. Internal panel wiring and wiring between power and control modules shall have wire labels cross-referenced to design drawings.
7. Electrical components shall be provided in accordance with UL and NFPA 70 requirements. The overall assembly shall be UL listed and labeled, or listed/certified and labeled by a Nationally Recognized Testing Laboratory (NRTL), for example Canadian Standards Association (CSA), for the application, installation condition, and the environment in which installed.

8. The CO_2 removal system shall operate based on a hardwired permissive/inhibit signal start up and send back and maintain a running status bit when it is ready. The permissive shall not over-ride the CO_2 removal system's internal permissive signals and self-protecting features (if applicable).

3.4.7 Instrumentation Interface

1. The **SELLER** shall provide a recommended list of analog and digital instrumentation to measure dissolved CO_2, pressure, air flow, blower current, and valve positions. Provide a summary list of discrete status and alarm indications for various component conditions and faults such as for valve status, breaker shunt trip, etc. This list shall be submitted for approval prior to purchase of the instrumentation and control system.
2. Alarms shall be provided to indicate to plant operators to indicate an abnormal operating condition in which the CO_2 removal performance may be jeopardized. Provide a data table of status and alarm points available to the **BUYER's** control system. IO will be wired directly to the MCS LCU E or 4 panels (by **BUYER**), whichever is the closest and easiest to access.
3. As the minimum the CO_2 removal system shall include remote indication to ETF control system of the following conditions & alarms:
   a. Low air flow alarm
   b. High inlet pressure alarm
   c. High CO_2 in outlet to UV/OX alarm
   d. System pressures
   e. High differential pressure across contactors
   f. System pH readings
   g. System CO_2 readings
4. Provide documentation of National Institute of Standards and Technology (NIST) certified calibration for each instrument in the CO_2 removal system.
5. Perform factory tests at the **SELLER's** location to confirm that purchased items perform as specified. Test functional requirements of the CO_2 removal system during the factory acceptance testing (FAT). Completely validate each specific process and control requirements and control functionality and requirements compliance during the FAT.
6. Acceptance testing is split into two parts; a) Part I being in a test environment separate from the operational environment; and b) Part II being the actual operational environment with end user testing integrated with the ETF monitoring and control system (MCS). Part I types of tests include: Unit Testing, Integration Testing, System Testing and Acceptance Testing. The first three testing types may be part of a repeated cycle of coding and testing, while acceptance testing verifies requirements compliance. Part II tests consists of Operations Testing and verifies the communication between the CO_2 removal system and the facility meet the Specification.
7. Provide test reports generated during acceptance testing that contains: hardware tested, test equipment and calibrations, date of test, indication of tester or data recorder, simulation models used, where applicable, test exceptions and problems, test results and applicability, and actions and resolution with any exceptions and/or problems noted.

8. For final CO_2 removal system acceptance, provide or append current suite of system documents to include:
   a. Operation Manual;
   b. Maintenance Manual;
   c. Calibration Instructions;
   d. Recommended spare parts list.

3.4.8 Lifting

DOE/RL-92-36, RPP-8360, and TFC-ENG-STD-06 shall be used where applicable to the design of any equipment or items requiring load handling requirements.

NOTE: All equipment that is designed to be mechanically lifted shall have lifting points, the center of gravity, and the lifting weight marked. All specialized lifting devices shall be marked in accordance with DOE/RL-92-36.

3.4.9 Nameplates and Product Marking

Attach an identification nameplate to the skid and component containing the **BUYER** identification information. Nameplates shall not be removable without destruction of the nameplate.

CO_2 contactors will require an Equipment Identification Number (EIN) label and bar code in accordance with TFC-ENG-STD-12, label design ID NK, and NL and be labelled to meet the dangerous waste labelling requirements in accordance with WAC 173-303-640.

The EIN label and bar code shall be installed to the skid and each component.

1. The EIN label shall be constructed of 6 to 16 gauge 300 series stainless steel. The label shall use either stainless steel (plain/natural) text on a black background or black text on a stainless steel (plain/natural) background. Label size, format and content shall be as described below:
   a. LINE 1 = EIN; (FIT-60B-023 etc.)
   b. LINES 2 & 3 = Equipment Description; (Flow Transmitter, etc.)
   c. LINE 5 = Barcode Number; and
   d. LINE 6 = Barcode Pattern. (LINES 4 & 7 are not used)
2. Font – USE ALL CAPITAL SIMPLE BLOCK TYPE FONT. Spacing between words shall be at least one full character width.
3. The EIN label shall be installed with adhesive, cable, or other means so that the label cannot be removed without destruction of the label.
4. The EIN and Equipment Description, will be provided by the **BUYER**; prepare and send the **BUYER** an RFI to request EINs and Equipment Descriptions.
5. The Barcode number will be provided by the **BUYER**; prepare and send the **BUYER** an RFI to request the Barcode number.

NK Label Coding

DESIGN ID: NK	LABEL SIZE CODE: E4	WIDTH: 13.75”	BORDER: 0.438”	HEIGHT: 4.00”

LINE	BARCODE REF DEN	MAX CHAR	ROW HGT	JUST C/L/R	START SIDE TOP	FONT
1		23	0.70	C	6.75 0.20	R-HEL-BOLD
2		32	0.45	C	6.75 0.85	R-HEL-BOLD
3		32	0.45	C	6.75 1.38	R-HEL-BOLD
4		18	0.25	R	-0.10 2.40	R-HEL-BOLD
5		09	0.20	C	6.75 2.44	R-HEL-BOLD
6	5 4.0	09	0.45	C	6.93 2.25	R-HEL-BOLD
7		29	0.23	L	0.60 2.40	R-HEL-BOLD

The NK label is the largest label currently in use. It is available in one-sided format only, and is supplied with a 30 mil acrylic adhesive backing.

This label is normally used for large sized equipment, or equipment that must be viewed from a considerable distance, space permitting.

NL Label Coding

DESIGN ID: NL	LABEL SIZE CODE: CA	WIDTH: 2.00”	BORDER: 0.125”	HEIGHT: 1.00”

LINE	BARCODE REF DEN	MAX CHAR	ROW HGT	JUST C/L/R	START SIDE TOP	FONT
1		23	0.13	C	1.00 0.20	R-HEL-BOLD
2		25	0.10	C	1.00 0.40	R-HEL-BOLD
3		25	0.10	C	1.00 0.50	R-HEL-BOLD
4		09	0.10	C	1.00 0.83	R-HEL-BOLD
5	4 7.1	09	0.10	C	1.10 0.73	R-HEL-BOLD

The NL label is a polyester label designed for multiple purposes. It is available in one-sided format with an integral adhesive pad. It is also available in one or two-sided format attached to a stainless steel backing plate that can be hung with aircraft cable.

- Description fields limited to 25 characters each
- No provision for old EIN

3.5 SYSTEM MAINTAINABILITY AND SPARE PARTS

3.5.1 Maintainability

3.5.1.1 Maintenance and Repair Cycles.

1. **SELLER** shall recommend frequency requirements for maintenance of the components.

3.5.1.2 Spare Parts.

1. The **SELLER** shall furnish the following spare parts and special tools:
   a. 1 – 3M™ Liqui-Cel™ EXF-10x28 membrane contactor in stainless steel containing X50 fibers (very long lead item).
   b. 1 – set of special tools required to carry out maintenance tasks (if needed).
2. **SELLER** shall specify and furnish additional recommended spares, spare parts, and special tools if not listed above.

3.6 PREPARATION FOR DELIVERY

3.6.1 Shipping Preparation

Mode and method of transporting, and the extent of storage of the vessel assemblies are to be mutually agreed on by the **SELLER** and **BUYER** prior to fabrication and delivery of the skid. The packaging procedure submitted for prior approval by the **BUYER** shall be used. For safety considerations, a means of pressure relief is to be provided on the vessels during shipping to prevent pressure buildup and/or to equalize pressure due to elevation and/or temperature changes.

3.6.2 Package Marking

Packages shall be suitably marked on the outside to facilitate identification of the purchase order, the procurement specification, the package contents, weight, and any special handling instructions.

3.6.3 Shipping and Receiving

Provide the **BUYER** with a copy of the bill of lading concurrent with the shipment. Properly and clearly describe the shipment on the bill of lading. At final destination, the **BUYER** will inspect the shipment, as necessary, to ensure that received items have not been damaged during shipment and that required items and supporting documentation have been received. The receipt inspection constitutes final acceptance.

4.0 FABRICATION REQUIREMENTS

4.1 WELDING

Refer to TFC-ENG-STD-52, Rev. A-1, “Subcontractor Welding Standard” for information on welding requirements.

Welding qualifications shall be in accordance with applicable fabrication standards or as specified by the **BUYER**. ASME® B&PVC Section IX, may be used in lieu of these requirements.

Weld size and type shall be selected by the manufacturer based on applicable loads and system pressure requirements established within this specification and must meet all applicable codes.

Special care shall be taken to limit contamination of stainless-steel components with halides, which are common to adhesive products. If necessary, stainless-steel components shall be cleaned with neutral detergent and water.

All weld joints and seams along the pressure boundaries shall be 100 percent continuously welded. Weld joints and seams shall be wire brushed or buffed after final NDE and inspections as required to remove heat discoloration, oxidation, all burrs, and sharp edges. For stainless-steel material, the wire brush shall not be made of carbon-steel elements or a stainless-steel brush previously used on carbon steel.

4.1.1 Structural Welding

All structural welding shall meet the requirements of the following codes, as applicable, and all welds shall be visually inspected per statically loaded AWS® criteria as follows:

1. AWS® D1.1/D1.1M, *Structural Welding Code – Steel*, for structural carbon steel
2. AWS® D1.3/D1.3M, *Structural Welding Code – Sheet Steel*, for sheet steel.
3. AWS® D1.6/D1.6M, *Structural Welding Code – Stainless Steel*, for structural stainless steel and stainless steel to carbon steel.

4.1.2 Weld Materials

All welding filler materials and fluxes used in the fabrication and repair of components shall be in accordance with the requirements of ASME® B&PVC Section II.C or AWS® B2.1/B2.1M-BMG. Legible CMTRs for all weld materials shall be submitted to the **BUYER.**

4.1.3 Welding Procedure Specifications and Qualifications

All welding procedure specifications shall meet the requirements set forth in the applicable fabrication code as follows:

1. The **SELLER** shall prepare written Welding Procedures. Welding procedures and performance qualifications shall be in accordance with ASME® B&PVC Section IX for all pressure boundary welds. Welding procedures and performance qualifications for structural steel welds shall be qualified in accordance with AWS® D1.1, D1.3, or D1.6 as applicable.
2. The **SELLER** shall submit copies of all Welding Procedures, Procedure Qualification Records, and Welder Performance Qualification Records to be employed in the performance of this specification. The **SELLER** shall provide records to indicate that the Welder and/or Operator are qualified.
3. The **SELLER's** Quality Control Procedures shall include the requirement that Welders shall have in their possession no more than one type of filler metal at any one time, an exception is that Welders may have both bare wire and covered electrodes that deposit weld metal of the same A-number class. The **SELLER's** filler metal control procedure shall be submitted and approved.

4. Welder Performance Qualification Records shall be submitted for all personnel performing welding, including tacking. Welders shall be qualified in accordance with ASME® B&PVC Section IX.

4.1.4 Weld Inspection Requirements

1. Personnel performing visual weld inspections shall be a Certified-Welding Inspector (Minimum Level II) in accordance with the requirements specified in AWS® QC1. Documentation shall be submitted prior to the start of fabrication inspection per QA-AVS B25.
2. All areas from which temporary attachments have been removed shall be examined by the liquid penetrant or magnetic particle method, as applicable, after the surface has been restored.
3. NDE processes required within this purchase order shall meet the requirements in Section 5.2.2
4. Data packages and changes, thereto, shall be submitted to the **BUYER** as identified in the purchase order.
5. The **SELLER** will maintain and submit weld history data for each weld.

4.1.5 Additional Welding Requirements

1. All tools used for stainless steel shall be kept separate from any tools previously used or currently being used for cleaning carbon-steel components. Tools for stainless steel shall be used only on stainless-steel surfaces. Similarly, appropriate controls shall be put into place to ensure ferrous and non-ferrous material is properly segregated and that tools specifically used on non-ferrous material be designated.
2. Preparation for welds shall be accomplished by non-thermal methods, where practical.
3. Thermally cut surfaces shall be ground to provide slag-free metal and fit-up equivalent to machining.
4. Where welding destroys protective plating on hardware items, the weld and surrounding area shall be thoroughly cleaned, primed, and painted, as appropriate.
5. Where free-iron contamination (shows up as rust streaks on stainless steel) is observed, the surface area shall be cleaned prior to welding.

4.1.6 Workmanship

Acceptable workmanship shall be based on satisfactory completion of the inspections in Section 5.0 and those required by the Quality Assurance (QA) Clauses.

4.2 CLEANLINESS

Protect stainless steel against carbon steel contamination from tooling and fixtures during fabrication. Exercise control during stages of fabrication to minimize exposure of stainless steel to contaminants, in particular to any chloride that might cause stress-corrosion cracking. Avoid chloride-bearing compounds; however, if used, completely remove by thorough cleaning. Do not use compounds, liquids, or markers on stainless-steel surfaces that contain more than 50 ppm of chloride content by weight.

4.2.1 Material of Construction Compatibility

Selection of fasteners and interfacing components (piping, bolts, nuts, washers, unions, gaskets, etc.) shall be based on required performance (e.g., strength, fluid compatibility) and galvanic corrosion, due to contact of dissimilar metals, shall be mitigated in all cases. All carbon steel pipe supports shall be insulated with non-conductive material.

4.2.2 Surface Finishes

Exercise care to prevent scratching, abrading, nicking, and denting during receiving, storage, fabrication, and handling.

4.2.3 Cleaning

1. After fabrication is completed, and before testing and inspection, clean, de-scale, and degrease the piping and associated components. Clean exterior surfaces. Methods may include cleaning by hot water spray, etc. If a detergent is required, use a detergent that has less than 50-ppm chloride content for stainless-steel vessels.
2. Use fresh water with less than 50-ppm chloride content for wash and final rinse. After final rinse, dry inside surfaces using heat, lint-free cloth, or other means to ensure cleanliness. If de-ionized water is used for the final rinse, the piping and associated components may be allowed to evaporate to dryness. If heat is used for drying stainless steel, do not allow the metal temperature to rise above 250 °F and use de-ionized water for the final rinse before drying.
3. Ensure that the cleanliness of the CO_2 removal system meets the approval of the **BUYER** at the time of the final inspection.
4. After cleaning provide temporary plugs, covers, shields, or other devices required to close all external openings on the piping.

5.0 PRODUCT INSPECTION AND TESTING REQUIREMENTS (QUALITY ASSURANCE REQUIREMENTS)

5.1 QUALIFICATION TESTING REQUIREMENTS

5.1.1 General

1. The **SELLER** shall qualify Inspection Personnel performing acceptance inspections. In addition, the **SELLER** shall document all qualifications.
2. The results of inspections shall be documented and submitted to the **BUYER** for review and approval before acceptance. The **BUYER's** approval indicates concurrence that results verify compliance with the associated design requirements.
3. NDE Personnel shall be qualified to ASNT CP-189 or ASNT SNT-TC-1A.

5.1.2 Shop Acceptance Tests

1. Perform inspection and testing of the completed CO_2 removal system in accordance with the requirements of this specification, ASME® B31.3, Normal Fluid Service and ASME B31.1.

2. Provide the test location, equipment, instrumentation of certified accuracy, and any supplementary temporary connections and auxiliary parts necessary to fully execute the tests.
3. Provide the test location, equipment, instrumentation of certified accuracy, and any supplementary temporary connections and auxiliary parts necessary to fully execute the tests.
4. Provide test personnel qualified to conduct, record, and verify test results.
5. Provide the **BUYER** with a minimum ten (10) working day advance written notice of shop acceptance tests. (See Fabrication, Inspection, and Test Plan Section 5.2.1)
6. Submit the test results as part of the Quality Assurance Document Package.

5.1.3 Pressure Test

1. Perform hydrostatic test in accordance with ASME® B31.3, Normal Fluid Service, for all piping. Ensure that weld surfaces are free of coating materials during test. Hold hydrostatic test pressure for 10 minutes, minimum. Examine all joints and connections in accordance with ASME B31.3. Piping system shall show no visual evidence of weeping or leaking. Joints and connections previously tested in accordance with the Code do not require re-examination.
2. Perform hydrostatic test in accordance with ASME® B31.3, Category D Fluid Service, for identified piping. Ensure that weld surfaces are free of coating materials during test. Hold hydrostatic test pressure for 10 minutes, minimum.
3. Water for shop-testing austenitic stainless-steel components and piping shall be potable quality with a chloride-ion content of less than 50 ppm. After testing, drain water and dry, standing water is not allowed to evaporate to dryness, unless de-ionized water is used as a final rinse.
4. Provide test reports in accordance with QA-AVS B52.

5.1.4 Factory Acceptance Testing

1. Before performing the Factory Acceptance Test (FAT), a FAT procedure shall be submitted to the **BUYER** for review.
2. The results of the FAT shall be documented and submitted to the **BUYER**.
3. The FAT test shall include as a minimum the operation, demonstration, and testing of the following:
   a. Operation/demonstration of blower fan.
   b. Operation/demonstration of all instrumentation.
   c. Instrument signal output to be displayed in control room.
   d. Signals produced for alarms and faults to be transmitted to control room.
   e. Megger testing of all conductors shall be conducted between each phase and the ground individually. Record measured resistances. Resistance measurements shall be corrected for temperature and documented in the test results.
4. The **SELLER** shall provide qualified Inspectors per ASNT SNT-TC-1A for all NDE inspections and for functional tests in this section.

5.1.5 Electrical NEC Inspection

1. Prior to authorization for shipment and after completion of NRTL field evaluation, the **SELLER** shall provide full access to the completed CO_2 removal skid assembly for a Hanford certified NEC inspector. The NEC inspector will document a complete evaluation of the integrated assembly for NEC code compliance with a findings report. **SELLER** shall submit the findings report to **BUYER** as part of the electrical design submittals package. Provide the NEC inspector with copies of all associated wiring diagrams, elementary diagrams, vendor data sheets and user manuals as inspection reference materials.

5.2 PRODUCTION INSPECTION REQUIREMENTS

5.2.1 Fabrication, Inspection, and Test Plan

The **SELLER** shall develop a Fabrication, Inspection, and Test (FIT) Plan that sequences the operations and denotes the **SELLER's** source inspection and witness notification points. The **SELLER** shall submit the FIT Plan for **BUYER** approval prior to the start of fabrication. The FIT shall be in accordance with QA-AVS B13.

The **BUYER** reserves the right to witness all tests and inspections listed below and shall be given a minimum of ten working days written notice prior to each test date. It should be noted that third party Inspectors may be required to be present during testing as the representative for the **BUYER** or an independent representative for the **BUYER** and/or their representative for specific points in the fabrication/testing process:

1. Fabrication, Inspection, and Test Plan (Section 5.2.1)
2. Weld Inspection and Examination (Section 5.2.3 and 5.2.4)
3. Shop Acceptance Test (Section 5.1.2)
4. Pressure Test (Section 5.1.3)
5. Factory Acceptance Testing (Section 5.1.4)

5.2.2 Inspection procedures and qualifications

NDE processes required within this purchase order shall require review and approval of the **SELLER** as follows:

1. Personnel certification procedure;
2. NDE operational procedures; and
3. Personnel certifications, including current and valid visual acuity examinations (less than 1 year old). **NOTE:** The examination must be performed annually.

Per QA-AVS B31, the personnel certification procedure and certification package for NDE personnel shall accurately reflect the requirements embodied in the applicable issue of ASNT SNT-TC-1A, plus any other requirements of the **SELLER**.

The NDE operational procedures shall contain all applicable requirements of the documentation referenced in the purchase order including:

1. Reference standard or image quality indicator information;
2. Chemical purity requirements per QA-AVS B46;
3. Calibration requirements per QA-AVS B61; and
4. Report forms, as a minimum per QA-AVS B52.

Data packages and changes, thereto, shall be submitted to the **BUYER** as identified in the purchase order.

In-process examination to be performed in accordance with ASME B31.3, paragraph 344.7 on final closure weld or as approved by **BUYER** on a case by case basis.

Personnel performing NDE (RT, PT, UT, or MT) shall be qualified and certified to ASNT CP-189 or ASNT SNT-TC-1A (Level II or III), current edition unless otherwise specified. The recommended practices in ASNT SNT-TC-1A are mandatory requirements for this purchase order per QA-AVS B31.

The **SELLER** will maintain and submit weld history data for each weld per QA-AVS B13.

5.2.3 Visual Inspections

Unless specified otherwise, the minimum visual inspection required is 100% of all structural welds in accordance with AWS® D1.1, D1.3, or D1 .6.

All pressure containing welds shall be visually inspected in accordance with ASME B31.1 and B31.3 Cat D and Normal Fluid Service.

5.2.4 Radiography

All pressure containing welds shall have 100% radiography in accordance with ASME BPVC.VIII.1 (UW-51) and ASME® B31.3 Normal Fluid Service piping.

Radiography is not required in accordance with ASME® B31.3, Category D Fluid Service.

5.2.5 Hold Points

SELLER shall provide required notifications of verification points and shall not proceed past the required hold points without written authorization from the **BUYER**. The minimum hold/witness points are listed below and shall be incorporated into the Fabrication, Inspection, and Test Plan:

1.	Prior to first production weld for each weld procedure:	Hold
2.	Prior to NDE Inspection	Witness
3.	Prior to Hydrostatic/Leak test	Witness
4.	Prior to the FAT	Witness
5.	Prior to Final Inspection	Hold

6. Prior to Shipping Hold

NOTE: **BUYER's** "hold/witness" points may be waived by correspondence (e.g. e:mail) from the **BUYER**, which shall be included in the work control documents.

6.0 DELIVERY, STORAGE, AND HANDLING

6.1 DELIVERY, STORAGE, & LOAD HANDLING

6.1.1 General

a) All hoisting, rigging, transport and load handling activities shall comply with DOE-RL-92-36, RPP-8360 “Lifting Attachment and Lifted Item Evaluation”, and TFC-ENG-STD-06.
b) **SELLER** shall receive, clean, package, store, preserve, handle, and ship Structures, Systems and Components to protect against physical damage, or any effect that would affect quality or cause deterioration at all times while items are located on the **SELLER**’s premises.
c) **SELLER** shall follow manufacturer’s recommendation for storage and handling of all purchased items.
d) **SELLER** shall submit a Packaging, Storage, Shipping, and Load Handling (PSSH) Plan in accordance with QA Clause B85. The PSSH plan shall include all plans, procedures, and drawings that address how items will be packaged, stored, shipped, and handled in accordance with the requirements described throughout this specification with the exception of topics covered by the Lift and Rigging Plan described in Section 6.1.4.1

6.1.2 Transportability

All transport activities shall comply with DOE-RL- 92-36, RPP-8360 “Lifting Attachment and Lifted Item Evaluation”, and TFC-ENG-STD- 06.

6.1.3 Packaging

6.1.3.1 Levels of Packaging

The packaging requirements shall be based on the protection that is necessary during shipping, handling, and storage of the item.

6.1.3.2 Cleaning Plan

Prior to packaging an item, debris/contamination shall be removed using **SELLER** documented and approved standard procedure, unless specified otherwise. Before delivery to the site, all items shall be clean to the extent that extraneous materials, such as those listed below, are not present:

- Metallic or other dusts (shop dust), chips, and turnings,
- Abrasive particles,
- Weld splatter,
- Rust and other loose corrosion products,
- Magnetic/liquid penetrant residues, dye check, etc.,
- Foreign material, such as paper, plastic, and wood,
- Cutting oils,

- Excess lubrication grease and oil,
- Marking dyes, and
- Fluid piping shall be flushed with inhibited water.

6.1.3.3 Cleaning Records

SELLER shall provide cleaning records showing the item has been cleaned as appropriate prior to packaging.

6.1.3.4 Packaging List

All activities shall comply with DOE-RL- 92-36, RPP-8360 “Lifting Attachment and Lifted Item Evaluation”, and TFC-ENG-STD- 06.

6.1.3.5 Packaging Type

Package type shall provide the level of protection as required, based on the equipment type. Containers, crates and skids shall be used as the foundation methodology for packaging.

6.1.3.6 Packaging Materials

Pressure sensitive tape should be used in lieu of adhesives in contact with bare metal.

6.1.3.7 Packaging Materials Contacting Stainless Steel and Nickel Alloy

Tapes, adhesives, desiccants, or any other packaging materials contacting austenitic stainless steel and nickel alloy surfaces:

a) Shall not be compounded from, or treated with chemical compounds containing elements in such quantities that harmful concentrations are leachable, or that they could be released by breakdown under expected environmental conditions and could contribute to intergranular cracking or stress corrosion cracking, such as those containing fluorides, chlorides, sulfur, lead, zinc, copper, and mercury.
b) Paperbacked (masking) tape shall not be used.
c) Upon removal of tape, all residual adhesive shall be removed by wiping with a reagent grade non-halogenated solvent (acetone, alcohol, or equal).
d) Starch, silicone, and epoxy tape material may be used for tape adhesive provided that the requirements of this section are met.

6.1.3.8 Seal Opening

All equipment openings shall be capped, plugged or sealed to prevent entry of foreign material and humidity and protected against corrosion and physical damage.

6.1.3.9 Protection from Corrosion

Items subject to deleterious corrosion shall be protected.

6.1.3.10 Unprotected Steel

Uncoated carbon steel (where applicable) and all stainless steel materials shall be wrapped to prevent exposure during shipment and storage.

6.1.3.11 Shipment Load Protection

All activities shall comply with DOE-RL- 92-36, RPP-8360 “Lifting Attachment and Lifted Item Evaluation”, and TFC-ENG-STD- 06.

6.1.3.12 Protection from Shock and Vibration

Cushioning, blocking, bracing and anchoring shall be used where protection from shock and vibration is required.

6.1.3.13 Other Protection

Protect equipment and finishes against impact, abrasion, and other damage

6.1.3.14 Protection of Machined Surfaces

Apply a rust preventative coating to machined carbon steel surfaces prior to shipment.

6.1.3.15 Packaging Inspection

Prior to shipment from the **SELLER**’s facilities, **BUYER** shall be provided opportunities (as appropriate) to inspect shipments to assure that products comply with all requirements, quantities are correct, products are undamaged, and packages are ready for shipment.

6.1.4 Handling

6.1.4.1 Lift and Rigging Plan

All activities shall comply with DOE-RL- 92-36, RPP-8360 “Lifting Attachment and Lifted Item Evaluation”, and TFC-ENG-STD- 06.

6.1.4.2 Lift Point Marking

Lift points shall be clearly identified on the equipment.

6.1.4.3 Lifting Attachments and Equipment

All activities shall comply with DOE-RL- 92-36, RPP-8360 “Lifting Attachment and Lifted Item Evaluation”, and TFC-ENG-STD- 06.

6.1.4.4 Rated Temperature for Custom Lifting Devices

All custom designed Hanford Site lifting devices shall be rated for cold weather temperature of 10 degrees Fahrenheit or below.

6.1.4.5 Contact with Different Metals

Any item containing or comprised of austenitic stainless steel or nickel based alloys shall be stored, handled, and constructed in a manner that prevents direct contact with materials such as carbon steel, lead, zinc, copper, mercury, halogenated material, low melting elements, and any chloride containing material.

6.1.4.6 Critical Welds

All critical welds shall be identified in the **SELLER's** design media. For the purpose of this requirement, critical welds are defined as those welds whose failure could result in loss or load or loss of load control.

- All critical welds on lifting devices should be full-penetration welds, if possible.
- Critical welds shall be verified in accordance with Section **Error! Reference source not found.**.

6.1.4.7 Shipping and Handling Drawing

Prior to shipment, the **SELLER** shall provide detailed handling instructions including a dimensioned drawing for each equipment/assembly indicating all dimensions and tools necessary for support, lift and shipment of the completed equipment. Tolerances for such dimensions shall be noted, either on the specific dimension or in general notes. Dimensions locating centers of gravity shall be generated by **SELLER** calculation and shall be noted on the drawing, and the calculations shall be submitted with the drawings. These drawings shall be provided with the PSSH plan described in Section 6.1.1.

6.1.4.8 Unpacking and Assembly Drawing

SELLER shall provide a dimensioned drawing that includes receiving instructions, offloading and unpacking instructions, and on-site assembly instructions (if equipment is shipped in a disassembled state). These drawings shall be provided with the PSSH plan described in Section 6.1.1.

6.1.4.9 Below-the-Hook Device Marking

All activities shall comply with DOE-RL- 92-36, RPP-8360 "Lifting Attachment and Lifted Item Evaluation", and TFC-ENG-STD- 06.

6.1.4.10 Offloading

Offloading at **BUYER** designated delivery site will be performed by the **BUYER** or a **BUYER** designated representative

6.1.5 Storage

Special storage instructions from the **SELLER**, if specified, shall be addressed as part of the storage process for both short and long term storage of items.

6.1.5.1.1 Care of Items

Requirements for proper maintenance during storage shall be documented in storage records described by **SELLER**'s PSSH plan. Care of items in storage (includes storage in place) shall be exercised in accordance with the following:

a. Items in storage shall have all covers, caps, plugs, or other closures intact. Methods used to seal openings shall be in accordance with Section 6.1.3.9. Covers removed for internal access shall be immediately replaced and resealed after completion of the purpose for removal.
b. Temporary preservatives shall be left intact during storage. Should reapplication of preservatives be required at the site, only those previously approved shall be used.
c. Items pressurized with inert gas shall be monitored at such a frequency as to ensure that the gas pressure is maintained within specified limits during storage. Desiccant humidity indicators shall also be monitored, and desiccants shall be changed or reprocessed when specified.
d. Space heaters enclosed in electrical items shall be energized.
e. Rotating electrical equipment shall be given insulation resistance tests on a scheduled basis.
f. The shafts of rotating equipment shall be rotated on a periodic basis. The degree of turn shall be established so that the parts receive a coating of lubrication, where applicable, and so that the shaft does not come to rest in a previous position (90 degree and 450 degree rotations are examples).
g. Other maintenance requirements specified by the manufacturer's instructions for the item shall be performed.

6.1.5.2 Environmental Storage Requirements

SELLER shall specify any additional environmental storage requirements (e.g. temperature range, humidity, range, protection from precipitation) and required maintenance during storage (e.g. pump/rotor rotation schedule)

6.1.6 Delivery

All delivery activities shall comply with DOE-RL- 92-36, RPP-8360 "Lifting Attachment and Lifted Item Evaluation", and TFC-ENG-STD- 06.

a. The delivery address for all equipment will be designated by the **BUYER** and defined in the procurement contract associated with the respective equipment.

6.1.7 Marking for Shipment

a. Prior to shipment, all packages shall be clearly and suitably tagged to identify, All transport activities shall comply with DOE-RL- 92-36, RPP-8360 “Lifting Attachment and Lifted Item Evaluation”, and TFC-ENG-STD- 06 and include the following:
    - Temporary marking of items for shipment not within a container, such as pipe, tanks, and heat exchangers, shall exhibit the above specified information in a location that is in plain unobstructed view. Marking may be applied directly to bare metal surfaces, provided it has been established that the marking material is not deleterious to the item. Stamping and etching are not allowed as temporary marking methods.
    - If any hazardous chemicals are included with shipments, the transport vehicle shall display the relevant Department of Transportation labels/placards.

b. For shipment packaging list requirements, refer to Section 6.1.3.
c. Package markings shall appear on a minimum of two sides of a container, preferably on one side and one end.
d. Package markings shall be applied with waterproof ink or paint in characters that are legible. When information relative to handling and special instructions is required, such information shall be preceded by the word CAUTION in letters that are at least 1/2 in. (12.7 mm), as permitted by package size. Alternatively, if tags or labels are used, they shall be affixed to the container using a waterproof adhesive, tacks where practical, or a corrosion-resistant wire
e. Temporary supports shall be marked (tagged or painted).
f. Clearly mark partial deliveries of component parts of equipment to identify equipment and contents to permit easy accumulation of parts and to facilitate assembly.

6.2 QUALITY ASSURANCE

Quality assurance requirements have been interspersed through this Specification, where appropriate. Regarding “Delivery, Storage, and Handling,” QA clause B85 shall be invoked, where appropriate. At a minimum, a hold point shall apply “Prior to Packaging/Shipping.” At a minimum, Quality Level (QL-3) must be used for all hoisting and rigging procurements. The **SELLER** shall provide required notifications of verification points and shall not proceed past required the hold point without written authorization from the **BUYER**.

7.0 PROJECT MANAGEMENT

7.1 WORK PLAN

A work plan covering design, fabrication, testing, and submittal schedule dates shall be provided. Any changes to the work plan will require written concurrence of the **BUYER.**

7.2 SCHEDULE

To be provided by the **SELLER** upon award.

7.3 SUBMITTALS

The **SELLER's** submittals shall be per the following subsections. All electronic submittals shall be in a suitable format per TFC-BSM-IRM_DC-C-02 and in compliance with TFC-BSM-IRM_DC-C-07.

7.3.1 Electronic Submittal Requirements

Required submittals are identified and listed on the procurement *TOC Master Submittal Register (MSR)* (Site Form A-6005-317), in addition to the submittals lists below. The MSR identifies the minimum submittals required by this specification and identifies when the submittals are required to be submitted in the procurement process. The MSR included with the purchase order will constitute the governing MSR.

Submittals shall be provided using the *Construction TOC Incoming Letter of Transmittal* (Site Form A-6005-315.1). All transmittal subject headings shall contain, at a minimum, the subcontract number, submittal number identified by the MSR, and submittal description.

All deliverable documentation shall be complete, accurate, legible, and reproducible. Before delivery, design media and documents shall be reviewed by qualified **SELLER's** personnel for technical adequacy and appropriate content in accordance with the **SELLER's** Quality Assurance procedures. The **SELLER** shall attest, in writing, to the accuracy and completeness of the information contained in the final deliverables.

The **SELLER** will not place any proprietary legend or stamp on any data produced as a result of this specification. All shop drawings or other data are the property of DOE. As-built drawings shall be required at the completion of construction.

Deliverables shall be subject to approval by the **BUYER**. Deliverables shall comply with this specification and technical basis documents and other requirements identified herein.

7.3.2 List of Submittals

This list of submittals along with relevant dates shall be kept as part of the MSR.

7.3.3 Submittals Required with Proposal

Item	Title	Description
1	Preliminary Drawing and Documentation List	List of drawings and documentation that will be provided in completion of the contract.
2	Quality Assurance Program	Copy of the **SELLER's** Quality Assurance Program.

Item	Title	Description
3	Identification of Subcontractors	List of all proposed subcontractors. The **SELLER** shall flow down all requirements to subcontractors, as applicable.
4	Preliminary Schedule	Summary of activities required to design, fabricate, test, and ship.

7.3.4 Submittals Required after Receipt of Order

Item	Title	Description
5	Configuration Drawing	Detailed drawing detailing all major components and orientation.
6	Data Sheets	The **SELLER** shall submit product data sheets for all components, equipment, and accessories.
7	Work Plan	A work plan covering design, fabrication, testing, and submittal schedule dates shall be provided.
8	Detailed Schedule	Summary of activities required to design, fabricate, test, and ship.

7.3.5 Submittals Required Prior to Fabrication (Design Phase)

The **SELLER** shall not begin fabrication until all submittals required prior to fabrication have been performed and the submittals are complete and approved by the **BUYER**.

Item	Title	Description
9	Piping and Instrument Diagrams (P&IDs)	Piping and Instrumentation Diagrams
10	Fabrication Drawings	All fabrication and assembly drawings, including manufacturer standard details, associated with the fabrication shall be submitted. Drawings shall include all piping runs, show all valves and instrumentation, dimensions, required clearances, part number callouts, associated ASTM® standards, associated ASME® standards, connection locations and sizes, welding, shipping weight, and operating weight. Drawings shall also include electrical and instrumentation wiring diagrams, including control panel drawings and details.
11	HMI interface concept if applicable	N/A
12	Preliminary Logic Diagrams	N/A
13	Piping Catalog Cut Sheets	Submit catalog cut sheets for all piping components designed in accordance with ASME® B31.3 (Process Piping) and identified within B31.3 as a listed component. Cut sheets shall list, as a minimum, component type, Manufacturer, Model Number, Maximum Allowable Working Pressure (MAWP), and size

Item	Title	Description
14	Instrumentation and Electrical Catalog Cut Sheets	Submit catalog cut sheets for all Instrumentation and electrical components, including component list and data sheets. Cut sheets shall list as a minimum, component type, manufacturer, Model Number, MAWP, NRLT listing, and size.
15	Data Sheets	Submit Completed "vendor" provided information in the Appendix A data sheets.
16	Acceptance Test Plan	Submit hardware and software acceptance test plan for approval.
17	Factory Test Procedures	Test procedures shall be submitted for review and approval per QA-AVS B52.
18	Preliminary Fabrication, Inspection and Test Plan	Preliminary Fabrication, Inspection, and Test plan shall be submitted for review and approval.
19	Welding and Welding Procedure Qualifications	All Welding and Welding Procedure Qualification Records, shall be submitted by the **SELLER** in accordance with Section 4.1 per QA-AVS B28.
20	Nondestructive examination (NDE) Procedures	All NDE Procedures shall be submitted by the **SELLER** in accordance with Section 4.1 per QA-AVS B31.
21	Authorization to Start Fabrication	The **SELLER** shall not start fabrication until written authorization has been received from the **BUYER**.
22	Packaging, Storage, Shipping, and Handling (PSSH) Plan	The **SELLER** shall submit a PSSH Plan for approval by the **BUYER**. The PSSH Plan shall be in accordance with QA-AVS B85 and include all plans, procedures, and drawings that address how items will be packaged, stored, shipped, and handled.
23	Lifting and Rigging Plan	The **SELLER** shall provide a Lift and Rigging Plan to cover the lifting and handling instructions for each lifted item. The plan shall describe the lift points, special lifting devices and/or hardware needs, and lift diagram.
24	Site Assembly Instruction	The **SELLER** shall provide site assembly instructions, including unpacking and installation drawings.
25	Calculations	Preliminary calculations shall be provided for review. Calculations may include, but are not limited to, structural and lifting calculations, vessel design calculations, and anchorage force calculations.
26	Preliminary Design Package	Preliminary design package includes Preliminary calculations for vessel, internals, external attachments, and supports including seismic calculations and fatigue analysis if required and anchorage loads. Preliminary Drawings for the CO_2 removal skid with dimensions and tolerances, weld callouts, and material callouts.

7.3.6 Submittals Required for Contract Completion

The **SELLER** shall not ship until all tests and inspections have been performed and the documentation data package is complete and approved by the **BUYER**. The **SELLER** shall notify the **BUYER** three weeks before the intended shipping date. The **SELLER** shall allow the **BUYER** one week after receiving the package and before shipment to review the data package.

Item	Title	Description
27	As-Built Drawings and Specifications	The **SELLER** shall deliver to the **BUYER** one (1) hard copy and one (1) electronic file in portable document format of the final fabrication level as-built drawings and specifications accurately depicting the product delivered. Drawings shall include: P&IDs, dimensioned layouts, dimensioned subassemblies, dimensioned component details, material and fastener size, descriptions, weld symbols, and notes. Include an Elementary Diagram for each UL 508A industrial control panel. On the Elementary Diagram show every external wiring connection to instruments or controls external to the control panel as required by TFC-ENG-STD-41 and TFC-ENG-DESIGN-D-71. Drawings shall also include control panel arrangements with terminal wiring drawings and details. The designer's name, responsible engineer's name, bills of lading, and drawing number shall appear on the index (cover sheet). Furnish a copy of all electrical drawings in native AutoCAD format.
28	Final Calculations	Reviewed and approved calculations shall be legible and prepared on 8-1/2- by 11-in. sheets with all pages numbered and bound in a hard copy binder and individual electronic files in portable document format of the final calculations.
29	Final Logic Diagrams if applicable	N/A
30	Inspection and Testing Reports	Inspections, examinations, testing, and NDE activities shall be documented and the documentation delivered before shipment of the product. Inspection reports shall provide actual inspection results, specifying what was inspected, who inspected it, the characteristics that were inspected, and the acceptance criteria. All test requirements called out in specification(s) and fabricator drawings shall be documented in the testing reports.
31	Final Fabrication, Inspection, and Test Plan	Final Fabrication, Inspection, and Test Plan documentation.
32	Completed Factory Acceptance Test Report	Completed FAT report.
33	Certified Material Test Reports (CMTRs)	CMTRs shall be provided for the production materials per QA-AVS B49.
34	Welding Inspections	Welding documentation shall meet QA-AVS B28 and be submitted in accordance with the requirements of Section 4.1, prior to shipping.

Item	Title	Description
35	NDE Inspections	NDE documentation shall meet QA-AVS B31 and be submitted in accordance with the requirements of Section 5.2 prior to shipping.
36	Spare Parts List	The **SELLER** shall provide a list of all spare parts, identifying each specific subassembly to which it applies.
37	Software and Hardware Documentation if applicable	N/A
38	Software Test Reports if applicable	N/A
39	Certificate of Conformance	The Certificate of Conformance shall identify the contract requirements met per QA-AVS B79.
40	Warranty Information	The **SELLER** shall provide their warranty offer.
41	Maintenance Manuals	Manuals shall be provided including recommended lubrication details for bearings, etc. including grease type, volume, and lubrication frequency, as well as, bolt torque requirements, and hoisting and rigging sequences.
42	Operation Manuals	Manuals shall be provided including recommended commissioning, start-up, shut-down, and normal and off-normal operational procedures, including contactor cleaning and change out. Trouble-shooting sections should also be included.
43	Final Design Package	Final design package includes Final calculations for vessels, piping, internals, external attachments, and supports, seismic calculations and fatigue analysis if required, Fluid induced loads, anchorage loads, nozzle loads, and design of attachments. Design details of each weld joint configuration, and weld maps. Final Drawings for the CO_2 removal system with dimensions and tolerances, weld callouts, and material callouts.
44	Final QA data package	Final QA data package shall include the completed Fabrication, Inspection, and Test Plan, Inspection and test reports, weld inspections, material CMTRs, Weld filler material CMTRs, and Certificates of Conformance, completed FATs, and ATPs.

7.3.7 Request for Information

Notify the BUYER, as soon as possible, in the event of conflicts among the specifications, drawings, and/or the manufacturer's recommended processes or instructions.

Requested changes shall be submitted per the RFI process described in TFC-BSM-IRM-DC-C-07.

7.3.8 Approval of Submittals

All Submittals transmitted shall include the designation in the MSR per TOC Vendor Processes stated in TFC-BSM-IRM_DC-C-07. Submittals are divided into two types: (1) those requiring

"approval" (e.g., approval data or pre-purchase evaluation data); and (2) those "not requiring approval" (e.g., vendor information data). Submittals "not requiring approval" will be reviewed to verify completeness and adequacy for their intended purposes. A submittal requiring approval that is not approved is identified as: (1) "Not Approved Revise and Resubmit" – the submittal is considered technically deficient, or incomplete, and therefore unacceptable (resubmittal is required, hence the fabrication, procurement, or performance of procedures shall not proceed); or (2) "Approved with Exception" – the fabrication, procurement, and performance may proceed (resubmittal is required to verify incorporation of the exception). Submittals "not requiring approval," that are determined to be incomplete or inadequate will be marked "Resubmit." An explanation of the deficiencies will be included for corrective action by the **SELLER**.

Approval by the **BUYER** does not relieve the **SELLER** of responsibility for accuracy or adequacy of design under this specification.

If any revision has been made to previously submitted items, the **SELLER** shall resubmit updated versions of said items for approval, in addition to the items listed above.

Certified data shall be defined to mean that the design adequacy of a given item (document, drawing, calculation, etc.) be verified by persons other than those who prepared the item. Each deliverable (drawing, calculation, etc.) shall have at least an originator's/preparer's signature and a checked-by or approved-by signature.

7.3.9 Drawings, Calculations, and Supporting Data

Submit design drawings, P&IDs, calculations, and supporting data prior to beginning CO_2 removal skid fabrication. Design drawings shall indicate the location of anchor points and reaction forces at the anchor points. The **BUYER** will review and comment on design calculations and drawings. The **BUYER** review does not release the **SELLER** from responsibility to design and fabricate theCO_2 removal system in accordance with applicable regulations, and this specification. Include assumptions and input/output data with the calculations. If computer calculations are performed, include the name of the calculation program and the version number.

Vendor calculations shall be meet the requirements of TFC-ENG-STD-51 "Vendor Calculation Standard".

After completion of the fabrication, inspection, and testing, submit as-built drawings, as-built P&IDs, calculations, and supporting data.

7.3.10 Quality Assurance/Quality Control

7.3.10.1 Quality Assurance Manual.

1. Submit an uncontrolled copy of the **SELLER's** QA manual for the **BUYER's** approval in accordance with QA-AVS B16. The **BUYER** may waive this requirement if the **SELLER's** QA Program has been previously reviewed and approved.

7.3.10.2 Quality Assurance Clauses.

1. The **SELLER** shall comply with the Procurement QA Clauses as stated in the procurement documents.

7.3.10.3 Fabrication Procedures.

If applicable, submit a copy of:

1. Welding Procedure Specifications (WPS),
2. Welding Procedure Qualification Record (WPQR),
3. Welding and NDE Personnel Listing, and

7.3.10.4 Certifications.

Submit a copy of:

1. Welder Performance Qualification Records;
2. NDE Personnel Certifications; and
3. Material certifications for steel, weld filler materials, and certify the chloride content of materials used in fabrication of stainless steel.

7.3.10.5 Inspection Reports.

Submit a copy of:

1. Weld Inspection Reports.

7.3.10.6 Test Reports.

Submit a copy of:

1. Pressure Test Report.
2. Factory Acceptance Test results.

7.3.10.7 Shipping Submittals.

Submit a copy of:

1. Bill of Lading with the CO_2 removal system shipment.

7.3.10.8 Substitutions.

1. Ensure that any substitutions are in conformance with the **BUYER's** substitution procedures.

7.3.11 Warranty

The **SELLER** is to guarantee the vessel and associated equipment at design conditions and warrant that materials and workmanship, plus apparatus supplied (if any), are in accordance with Subcontract document requirements.

7.3.12 Operation and Maintenance Manual

Provide an Operations and Maintenance Manual, with detailed instructions for performance of any required maintenance activities, including as a minimum: CO_2 contactor cleaning and/or change out, (individual or complete assembly) lubrication, refurbishment/overhaul, calibration/testing, and spare parts list. Manual shall also include sequence of operation (control narrative).

7.4 QUALITY ASSURANCE PROGRAM

The **BUYER** reserves the right to verify the quality of work at the **SELLER's** facilities, including any sub-tier facilities. Access to sub-tier facilities shall be requested through the **SELLER** and verification may be performed jointly with the **SELLER.**

The **SELLER** shall have a documented and implemented QA Program. This work is designated as Quality Level 3. The **SELLER's** QA Program shall control a combination of design, materials, preparation, fabrication, inspection, testing, cleaning, packaging, and shipping that have to be done correctly to ensure the production of an acceptable finished product.

7.4.1 Nonconformance Reports

Non-Conformance Reports identified at the **SELLER's** or lower-tier subcontractor's facility, associated with this specification, with a proposed disposition of "Accept as is" or "Repair," shall be submitted to and approved by **BUYER's** Engineering and QA before the Subcontractor takes any corrective action on the nonconformance. Submittals must conform to QA-AVS B22.

7.4.2 Inspection and Examination

The **SELLER** shall include the qualifications of the Inspectors for all critical items or features identified from the design.

7.4.3 Suspect/Counterfeit Items

Procurement of genuine, new, and unused parts shall conform to QA-AVS B76.

7.4.4 Certificate of Conformance

Objective evidence in the form of a written document for all parts procured shall be provided by the **SELLER**. Documentation shall be in the form of a Certificate of Conformance. Certificates of Conformance shall be traceable to the material used in the fabrication. Documentation shall conform to QA-AVS B79.

8.0 NOTES

8.1 DEFINITIONS

8.1.1 General Definitions

The following definitions are to be used:

May – denotes a "permissive" for a stated action, or denotes a possible outcome, depending on the context of the verbiage.

Must – denotes a requirement.

Shall – denotes a requirement.

Should – denotes a recommendation. If a "should" recommendation cannot be satisfied, justification of an alternative design solution shall be submitted to Washington River Protection *Solutions*, LLC Engineering for approval.

Will – denotes a statement of fact.

8.1.2 Other Definitions

BUYER – solicitors of purchasing proposal (i.e., Washington River Protection Solutions, LLC).

Internal Pressure – a uniformly distributed internal pressure in the vessel or piping.

SELLER – supplying contractor(s).

8.2 LIST OF TERMS

ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
ATP	Acceptance Test Plan
AWS	American Welding Society
B&PVC	*Boiler and Pressure Vessel Code*
CMTR	Certified Material Test Report
CWI	Certified Welding Inspector
DOE	U.S. Department of Energy
EIN	Equipment Identification Number
ETF	Effluent Treatment Facility
FAT	Factory Acceptance Test
°F	Degrees Fahrenheit

FIT	Fabrication, Inspection, and Test
ft	foot, feet
gpm	gallons per minute
Hz	Hertz
in.	inch, inches
in/yr	inch, inches per year
I/O	Input/Output
IP	Internet Protocol
kW	kilowatts
lb	pound
MAWP	Maximum Allowable Working Pressure
MCS	Monitoring and Control System
mm	millimeter
MSR	Master Submittal Register
NBBI	National Board of Boiler and Pressure Vessel Inspectors
NBIC	National Board Inspection Code
NDE	nondestructive examination
NDC	Natural Phenomenon Hazard Design Category
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
OIT	Operator Interface
P&ID	Piping and Instrument Diagram
PFD	Process Flow Diagram
PLC	Programmable Logic Controller
ppm	parts per million
psig	Pounds per square inch gauge
PSSH	packaging, storage, shipping, and handling
QA	Quality Assurance
RFI	Request for Information
SWRT	Secondary Waste Receiving Tank
TCP	Transmission Control Protocol
TOC	Tank Operations Contractor
UL	Underwriters Laboratory\ies
V	Volts
VAC	Volts alternating current
WAC	Washington Administrative Code

WPS	Welding Procedure Specification
WPQR	Welding Procedure Qualification Record
WRC	Welding Research Council

8.3 LIST OF TRADEMARKS

ASME	Registered trademark of the American Society of Mechanical Engineers, New York, New York.
ASTM	Registered trademark of ASTM International, West Conshohocken, Pennsylvania.
AWS	Registered trademark of the American Welding Society, Miami, Florida.
Flexicarb	Registered trademark of Flexitallic Investments, Inc., Houston, Texas.
Flexitallic	Registered trademark of Flexitallic Investments, Inc., Kingwood, Texas.
Hilti	Registered trademark of Hilti Aktiengesellschaft, Liechtenstein.
Kwik-Bolt	Registered trademark of Langford Tool & Drill Company, Minneapolis, Minnesota.
PolyFine	Registered trademark of Pall Corporation, Port Washington, New York.
Swagelok	Registered trademark of Swagelok Company, Solon, Ohio