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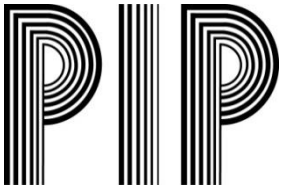

Process Industry Practices
Piping

PIP PNE00003
Process Unit and Offsites Layout Guide

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

PUBLISHING HISTORY

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Table of Contents

1. Introduction

1.1 Purpose

This Practice provides guidance for the design and layout of process units and offsites. This guide should be used as a starting point for the development of plans, electronic models, and working drawings for process units and offsites. This Practice should be coordinated with the overall site and offsites layout for geotechnical, grading, zoning, building codes, life safety code, fire codes, other regulatory requirements, and owner's and insurer's risk assessment requirements.

1.2 Scope

This Practice describes the guidelines for the layout of plot areas, equipment, pipe racks, piping, platforms, roadways, and other miscellaneous items.

Layout includes equipment location, access and egress for personnel safety, access for operations and maintenance, and provisions for operational housekeeping and constructability.

This Practice does not cover requirements for owner safety and property protection needs (e.g., loss prevention, vapor cloud explosions, or environmental or flare/vent stack requirements). Spacings shown in the "Recommended Equipment Spacing Charts" in this Practice are based on industry experience predominantly from a fire exposure/asset loss stand point and are generally applicable for facilities processing flammable and combustible gases and liquids.

This Practice should be used by persons knowledgeable in the governing laws, codes and regulations applicable to the specific facility to ensure that minimum access/egress and equipment spacing is provided to permit compliance with safety regulations. This Practice does not cover the requirements of laws, codes, and regulations in detail, it only provides general guidance or as a pointer for more information.

2. References

Applicable parts of the following Practices, industry codes and standards, and references should be considered an integral part of this Practice. The edition in effect on the date of contract award should be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP CVE02350 – *Roadway Design Guide*
- PIP CVE02350M – *Roadway Design Guide (Metric)*
- PIP PCCGN002 – *General Instrument Installation Criteria*
- PIP STE01100 – *Constructability Design Guide*

2.2 Industry Codes and Standards

- American Concrete Institute
  - ACI 376 – *Code Requirements for the Design and Construction of Concrete Structures for the Containment of Refrigerated Liquid Gases and Commentary*
- American Petroleum Institute (API)
  - API RP500 – *Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1 Division 1 and Division 2*
  - API RP505 – *Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1 Zone 0, Zone 1, and Zone 2*
  - API RP521 – *Guide for Pressure – Relieving and Depressurizing Systems*
  - API RP752 – *Management of Hazards Associated with Location of Process Plant Buildings*
  - API 625 – *Tank Systems for Refrigerated Liquid Gas Storage*
  - API RP753 – *Management of Hazards Associated with Location of Process Plant Portable Buildings*
  - API 2510 – *Design and Construction of Liquefied Petroleum Gas Installations (LPG)*
- International Code Council (ICC)
  - International Fire Code (IFC)
- National Fire Protection Association (NFPA)
  - NFPA 1 – *Uniform Fire Code (UFC)*
  - NFPA 30 – *Flammable and Combustible Liquids Code*
  - NFPA 58 – *Liquefied Petroleum Gas Code*
  - NFPA 59 – *Utility LP-Gas Plant Code*
  - NFPA 59A – *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*
  - NFPA 70 – *National Electrical Code (NEC)*
  - NFPA 101 – *Life Safety Code*
  - NFPA 497 – *Recommended Practice for Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*
- Society of International Gas Tanker and Terminal Operators (SIGTTO)
  - *A Guide to Contingency Planning for Marine Terminal Handling Liquefied Gases*
- The Institute of Electrical and Electronic Engineers (IEEE)
  - *National Electrical Safety Code (NESC)*

2.3 Government Regulations

- Environmental Protection Agency (EPA)
  - 40 CFR 112 – *Oil Pollution Prevention*
  - 40 CFR 264 – *Resource Conservation and Recovery Act (RCRA)*
- Occupational Safety and Health Administration (OSHA)
  - 29 CFR 1910 Subpart D – *Walking and Working Surfaces*
- US Department of Defense (DoD), Unified Facilities Criteria (UFC)
  - UFC-4-020-01 – *Security Engineering Facility Planning Manual*
- US Department of Justice (DOJ-ADA)
  - 28 CFR Part 36 – *ADA Standards for Accessible Design*

3. Definitions

accessways: Travel ways that provide occasional access to equipment or congested areas of a facility for maintenance, security, and firefighting vehicles. Also known as tertiary roadways.
constructability: Optimum use of construction knowledge and experience in planning, design/engineering, procurement, and field operations to achieve overall project objectives

dirty service: Contains fluids that may contain particulates which can plug passages or cause erosion or has materials for which containment must be provided in the event of a spill

fixed industrial stairs: This classification includes interior and exterior stairs around machinery, tanks, and other equipment, and stairs leading to or from floors, platforms, or pits. *(OSHA 29 CFR 1910.24.a)*

fixed ladders: A fixed ladder is a ladder permanently attached to a structure, building, or equipment. *(OSHA 29 CFR 1910.21.e.2)*

main operating levels: Areas which, during plant operation, require plant personnel to be continuously present or to be scheduled for presence at least once every shift

means of egress: A continuous and unobstructed way of travel from any point in a building or structure to a public way consisting of three separate and distinct parts: (1) the exit access, (2) the exit, and (3) the exit discharge. Public way is considered as beyond the battery and/or unit limit.

offsites: Equipment grouped outside a process unit battery limits (e.g., tanks, loading/unloading facilities, cooling towers, flares, etc.)

primary roadways: Main traffic routes. Primary roadways provide access to product shipping and receiving points and sufficient space for major maintenance vehicles to pass. Primary roadways include all roadways typically used by large trucks and cranes.

process unit: A group of equipment performing a predetermined process operation as defined by the enclosing battery limit lines. Battery limits are as shown on the plot plan.

secondary roadways: Secondary roadways provide access to equipment within plant areas by maintenance vehicles (except cranes) and personnel vehicles. Secondary roadways are not subject to high traffic loads.

4. General

4.1 Prevailing weather and site conditions should be considered in the development of general plant arrangements.

4.2 Site topography, soil conditions and geology should be considered and used to minimize earthmoving and foundation requirements. Multiple ground elevations may be used in a plant to avoid extensive cut and fill.

4.3 Grade elevation should be referenced to a datum (e.g., Elevation = 100 feet) for convenience in design and to establish a consistent elevation relationship between design disciplines. Reference point or reference coordinates are necessary for locating the plant relative to its surroundings.

4.4 The Process Flow Diagram, equipment list, and additional process information show how the pieces of process equipment are interconnected and provide special required elevation requirements.

4.5 Plant equipment should be located far enough from public areas and thoroughfares to minimize risk to or from the public.

4.6 Applicable local zoning, building codes, and regulations for specific setback, type of facilities permitted, and type of construction permitted should be obtained and applied.

4.7 The process unit should be integrated within a common plant site such that independent operating and shutdown requirements for maintenance of other process units are not affected.

4.8 If independent operation and shutdown is required for maintenance of a process unit, facilities should be provided for the isolation of the process unit.

4.9 Plant and equipment layout should ensure that a safe means of egress is provided for personnel evacuation in the event of an emergency. Egress routes should be continuous (not necessarily in a straight line), unobstructed, clearly marked, and lighted.

4.10 Any future plot needs, as required by the owner for process and supporting equipment, should be considered early.

4.11 Process lines, utility headers, power and instrumentation services should be supported on overhead pipe racks at elevations designated for each fluid service.

4.12 Fire and safety equipment should be located to maximize accessibility and minimize exposure to fires, explosions, or releases.

4.13 Equipment noise levels should be considered during process unit location and layout.

4.14 Equipment that handles flammable liquids (e.g., light hydrocarbons) should be located downwind, with respect to prevailing wind direction, of fired heaters, boilers, and other equipment that may cause ignition.

4.15 Layout should permit full utilization of plant mobile handling equipment for construction, servicing, and maintenance from roadways through or adjacent to the unit.

4.16 Permanent handling equipment should be limited to specific items that cannot be serviced manually or by plant mobile equipment.

4.17 If cost effective, equipment that shares common service should be grouped together.

4.18 Equipment containing hazardous materials should be grouped within a paved and curbed area that is drained or transferred to waste neutralizing.

4.19 All special process requirements (e.g., gravity flow, self-draining, critical Net Positive Suction Head, etc.) should be considered.

4.20 If possible, catch basins, floor drains, and other flammable fluid spill collection points should not be located under fixed ladders, fixed industrial stairs, low platforms, or flammable/heat-sensitive fluid storage equipment or close to egress points. Consideration should be given to the location of drains with relation to fired equipment.

4.21 Offsites and process units equipment spacing requirements should be in accordance with Tables 1 and 2, respectively, of this Practice.

4.22 Constructability considerations for facilities should be in accordance with the guidelines of *PIP STE01100*.

4.23 ADA considerations for facilities should be in accordance with *DOJ-ADA 28 CFR Part 36.*

5. Site Plan Development

For preparing plot plans, the following information should be considered:

a. Prevailing wind direction and meteorology

b. True North as related to Plant North

c. Location and elevation of railroads

d. Location and extent of fencing

e. Location of gates

f. Location of wells

g. Existing and original grade elevations

h. Emergency response requirements

i. Legal boundaries

j. Adjacent land usage

k. Nearby public facilities

l. Location and elevation of public roadways

m. Location and elevation of public utilities

n. Local regulations (e.g., noise, visual, sediment control, etc.)

o. Location and elevation of waterways both drainage and navigable

p. Site data (e.g., contaminated soil, seismic, wetlands, etc.)

q. Topography

r. Future development

s. Risk assessment findings

6. Accessways, Platforms, Fixed Industrial Stairs, Fixed Ladders

6.1 Access and Egress

6.1.1 Means of egress including fixed ladders, fixed industrial stairs, platforms, and railings, should be designed in accordance with applicable federal standards and instructions of the Occupational Safety and Health Administration (OSHA), *NFPA 101*, Life Safety Code.

6.1.2 Clearance information is shown in Table 4 of this Practice.

6.1.3 Requirements for number, location, and arrangement of means of egress from industrial occupancies are provided in *NFPA 101,* Chapter 40 with references to Chapter 7. Chapter 7 has requirements for public occupancies.

6.1.4 *OSHA 29 CFR 1910.36* governs the design and construction of exit routes. This regulation is mostly applicable to enclosed exit routes; however, portions of the regulation are applicable to outdoor exit routes.

6.1.5 Doors in accordance with *NFPA 101* requirements for means of egress are permitted.

6.1.6 Obstructions to means of egress should not be permitted.

6.1.7 The width of fixed industrial stairs, walkways, and landings should be evaluated for rescue purposes. *DOJ-ADA* requires a minimum clear width of 36 inches along routes which may be accessed by disabled persons.

6.1.8 If disabled persons may access the facility, local regulations should be checked for more restrictive requirements than *DOJ-ADA*.

6.1.9 Personnel accessways should be provided where plant personnel are likely to pass through while carrying out routine duties.

6.1.10 In accordance with *OSHA 29 CFR 1910.22.b.1,* aisles and passageways including stairs and ladders are to be kept clear and in good repair, without obstructions across or in aisles that could create a hazard.

6.1.11 In accordance with *NFPA 101,* means of egress are to be continuously maintained free of all obstructions or impediments to full instant use in the case of fire or other emergency.

6.1.12 In accordance with the *IBC*, obstructions are not to be placed in the required width of a means of egress except projections permitted by code. The required capacity of a means of egress system are not to be diminished along the path of egress travel.

6.1.13 Elevators may be considered for maintenance and operations in tall structures for moving small numbers of personnel and equipment. Elevators should not be considered as a means of egress for emergency use.

6.2 Platforms

6.2.1 Platforms serving vertical and horizontal exchangers should not interfere with removal of the channel end or bundle.

6.2.2 Platforms around furnaces should permit unobstructed access for plant personnel at and around piping manifolds, instruments, and furnace appurtenances.

6.2.3 The distance between the edge of equipment and the pipe rack should be set to permit operator access to equipment and grade level instruments.

6.3 Fixed Industrial Stairs

6.3.1 Fixed industrial stairs should serve as the primary access and egress to main operating levels in structures, industrial buildings, and furnaces for operation or maintenance services if the maximum occupancy is expected to be more than three persons at any time.

6.3.2 The number of fixed industrial stairs provided depends on the number of occupants and the length of the egress route in accordance with *NFPA 101*.

6.3.3 Fixed industrial stairs should have sufficient clearance to permit unobstructed passage for plant personnel. See Table 4 of this Practice for clearances.

6.3.4 Fixed industrial stairs or fixed ladders should be considered for access to electrical equipment and instrumentation not installed at grade.

6.4 Fixed Ladders

6.4.1 Fixed ladders may be used as the means of access and egress to vessel platforms, air cooler walkways, relief valves platforms, and all other areas not defined as main operating levels provided the maximum occupancy is expected to be not more than three persons at any time.

6.4.2 Fixed ladders may also be used as a secondary egress for not more than three persons where fixed industrial stairs serve as primary egress for other occupants. See *NFPA 101* for more information.

6.4.3 Fixed ladders should not be used as work platforms for operating, reading or maintaining instruments or other items unless three-point contact on the ladder can be maintained.

7. Roadways and Area Paving

7.1 Design and layout of roadways should be in accordance with the guidelines in *PIP CVE02350* or *PIP CVE02350M*.

7.2 Primary roadways should have sufficient horizontal and vertical clearance to permit unobstructed access to shipping and receiving points, and travel of major maintenance vehicles including cranes.

7.3 Table 4 of this Practice describes minimum horizontal and vertical clearances to be provided for roadways. Clearances required for the actual vehicles expected to use the roadways should also be considered.

7.4 Access clearances and roadway geometry should be provided as follows:

a. Under pipe racks as required to permit access for routine maintenance and removal of equipment

b. To reactors as required to permit catalyst transfer vehicles to reach the area near catalyst unloading nozzles

c. At compressors as required to permit vehicles such as flatbed trucks to enter a dropout area and remove components using mobile equipment or permanent handling facilities

d. Around other equipment as required by owner

7.5 Concrete and area paving should extend as follows:

a. To the outside edge of the supporting column piers of equipment such as bottom oil-fired or combustible-liquid-containing furnaces or elevated structures supporting coke drums

b. Around catalyst-containing vessels

c. Around groups of two or more pumps located outdoors

d. Around compressors and related servicing equipment (e.g., lube oil consoles)

e. Around equipment in dirty service that requires frequent turnaround maintenance

f. Around equipment handling materials detrimental to the environment (i.e., hazardous gas/liquid/solid materials) to control spills

7.6 Containment curbs required to retain spilled materials should be specified to contain the required spill volume but not less than 150 mm (6 inches) wide. Curb height should be specified to contain the required spill volume of a single container: 100% of container plus 10%.

7.7 Secondary containment requirements are addressed by *EPA. RCRA* requires secondary containment in two different areas as follows:

a. Portable storage containers (e.g., 55-gallon drums) for hazardous waste (see *EPA 40 CFR 264.175)*

b. Large stationary containers (e.g., tank systems) for hazardous waste (see *EPA 40 CFR 264.193)*

7.8 Facilities that store hazardous materials may also be required to be in accordance with either *NFPA 1,* UFC-06 60.3.2.8.3 or *ICC,* IFC-06 2704.2 depending on the applicable code.

7.9 Strategies and plot plan areas for managing and containing contaminated fire water volumes should be considered.

8. Piping

8.1 All piping should be routed considering the following:

a. Provide the shortest possible run while avoiding pockets and permitting thermal expansion.

b. Group piping together to present a neat appearance, permit orderly branching to various users, and use common supports.

8.2 Provision of a centralized pipe rack should be considered. Equipment can be located on both sides of the pipe rack. The area under the pipe rack can be used to provide access to properly maintain adjacent equipment.

8.3 Specific elevations for pipe running north-south and other specific elevations for east-west piping should be selected.

8.4 Piping at ground level should be located a minimum of 30 cm (12 inches) off the ground, and supported. Runs of lines located at ground level should not obstruct any maintenance, operational accessways, and emergency egress/access. If crossing of walkways is unavoidable, stiles should be provided.

8.5 Steam, instrument air, plant air, nitrogen, gas and vapor branch lines to/from main headers should be connected at the top of the headers.

8.6 Discharge piping for relief valves should be connected into top of the relief header.

8.7 Steam and condensate piping should be arranged to permit expansion by using vertical and horizontal offsets, loops, or expansion joints. The support system can require anchors at certain places to control the direction and effect of expansion. Hot lines requiring expansion loops should be grouped at one side of the pipe rack for ease of support.

8.8 For a two level pipe rack, utility lines and service piping should be placed on the upper level.

8.9 Space should be provided in pipe racks for instrument piping and electrical conduit.

8.10 Requirements for piping spacing around equipment should be considered in the layout.

8.11 Additional insulation thickness should be considered in the requirements for piping spacing.

8.12 Process piping should be located above ground.

8.13 Firewater mains, process sewer, sanitary sewer, and storm water drainage piping should be located below grade.

8.14 Underground piping should have a minimum horizontal clearance from structures to provide room for maintenance. Depth of piping burial should be determined based on the following factors:

a. Commodity being carried

b. Whether flow depends on pressure or gravity

c. Traffic loads

d. Weight of cover loads

e. Depth of frost line

8.15 Underground piping should be located above the bottom of spread footings or mat foundations or beyond a line sloping downward at 45 degrees from the base of the foundation.

8.16 Underground piping can require room for massive thrust blocks for piping restraint at bends and elbows. Large pipelines, especially water supply or cooling lines, typically require thrust blocks.

9. Buildings

9.1 Buildings should be located in accordance with applicable zoning, building regulations, *API RP752,* and the results of risk assessment analyses.

9.2 If feasible, buildings should be located upwind (based on prevailing wind direction) of process units, or storage tank areas containing combustible or flammable gases, liquids or solids.

9.3 Buildings should be located upwind or cross wind from cooling towers.

9.4 All drainage should be directed away from buildings.

9.5 Emergency evacuation and egress routes should be considered.

9.6 Portable occupied buildings should be located in accordance with *API RP753*.

10. Instrument and Electrical Equipment

10.1 Electrical power distribution equipment should be located in an unclassified area and to minimize the length of power distribution conductors.

10.2 Minimizing exposure of electrical equipment to damage from heat sources and chemical and particulate contamination should be considered.

10.3 Electrical equipment installation should be in accordance with *NFPA 70* and should be suitable for the area classification established in accordance with *NFPA 497*, *API RP500*, or *API RP505*, and local codes if applicable.

10.4 Consideration should be given for the location of instrument I/O buildings to minimize the exposure potential with regards to fire or corrosive atmosphere.

10.5 Clearances for electrical lines over roadways, walkways, rail, water, and open land should be in accordance with Table 4 of this Practice. The clearances shown in Table 4 are in accordance with *NFPA 70,* Table 225.60. See the *IEEE NESC* for additional electrical clearance information.

10.6 Clearances for electrical lines over buildings and other structures should be in accordance with Table 4 of this Practice. The clearances shown in Table 4 are in accordance with *NFPA 70,* Table 225.61.

10.7 Maximum underground electrical duct bank or cable depth of burial should be in accordance with Table 4 of this Practice. The depths shown in Table 4 are in accordance with *NFPA 70,* Table 310.60.

10.8 Detailed minimum cover requirements for cables, conduits and duct bands should be in accordance with *NFPA 70,* Table 300.50. See the *IEEE NESC* requirements for additional information.

11. Equipment and Instrument Access

11.1 General

11.1.1 Equipment and instruments should have minimum access provisions and minimum clearance dimensions in accordance with Tables 3 and 4 and the other spacing requirements in this Practice.

11.1.2 Instrumentation access and clearances should also be in accordance with *PIP PCCGN002*.

11.1.3 Unless located at grade, service platforms should be provided for orifices or meter runs requiring certified calibration, as specified by owner.

11.1.4 Equipment for which permanent access is not provided should be located so that temporary access can be provided.

11.1.5 Reserved space should be provided for routine maintenance activities (e.g., filter cartridge removal, catalyst handling, tray removal, relief valve removal, etc.).

11.1.6 Access and clearances for operation and maintenance on proprietary equipment or parts of proprietary equipment should be in accordance with the equipment manufacturer's standards.

11.2 Fired Heaters and Furnaces

11.2.1 Space should be provided for tube replacement for heaters and furnaces.

11.2.2 Sufficient access and clearance should be provided for removal of sootblowers, air preheaters, burners, fans etc. and for operation of pressure relief doors.

11.2.3 Heater stacks should be extended or heaters should be located so that stack gases cannot drift into tall structures and columns where maintenance or operating personnel can be present.

11.3 Towers and Drums

Sufficient drop space, free of obstructions, should be provided for removal of tower/drum internals and relief valves.

11.4 Heat Exchangers

11.4.1 Clearance should be provided for tube bundle removal and channel or bonnet removal.

11.4.2 Access to air cooled exchangers should be provided for cooler removal, cooler maintenance, fan motor maintenance, and header box access.

11.4.3 Heat exchangers, other than air cooled exchangers, should be located at grade and grouped. Consideration should be given for vapor cloud explosion risks as identified in the results of a risk assessment analysis.

11.4.4 Air cooled heat exchangers may be located on the top level of pipe racks provided that the pumps are located in accordance with Section 11.5.5.

11.4.5 Tubular heat exchangers should not be stacked higher than 4 m (12 feet) to the top unit centerline.

11.4.6 If locating exchangers beneath other facilities cannot be avoided, the channel should be clear of overhead obstructions and readily accessible for removal.

11.4.7 Access should be provided for exchanger cleaning and/or disassembly.

11.4.8 Bundle pulling methodology and equipment should be considered (e.g., bundle extractors or external anchorage).

11.5 Pumps

11.5.1 Access should be provided to pump auxiliaries (e.g., seal pots, starter button stations, motor conduit connections, etc.)

11.5.2 Clearances and access should be provided for removal of pump, drivers, pump rods, impellers, and other parts.

11.5.3 Access should be provided around and between pumps.

11.5.4 Vertical pumps should have appropriate overhead clearances for removal of drivers, shafts, impellers and other parts.

11.5.5 For location of pumps relative to pipe racks, pumps should be located such that the wet end is located outside the pipe rack and the driver should not extend more than 0.76 m (2 ft-6 in) inside the center line of the pipe rack column.

11.5.6 Pumps should be located close to and below their point of suction.

11.5.7 Pumps should be grouped for convenient operation and maintenance.

11.6 Compressors and Auxiliaries

11.6.1 Clearance should be provided so that compressors and associated auxiliaries (e.g., lube oil consoles, large castings, rotating elements, and valves) are readily accessible for maintenance.

11.6.2 Clearance and adequate laydown areas should be provided for maintenance activity equipment (e.g., lifts for large compressor cylinders and pistons, casing and impellers for centrifugal compressors, and rotors for large motors).

11.6.3 All air compressor intakes should be located to avoid intake of contaminants.

11.6.4 Adequate space should be provided for personnel on compressor decks and around compressor auxiliaries.

11.6.5 Lay down areas on compressor decks should be provided on elevated structures.

11.7 Reactor and Dryers

Adequate space should be provided for handling drums and/or tote bags at dryers, reactors, etc. that require frequent catalyst changes or raw material charging.

11.8 Pressure Reliefs and De-pressurizing Systems

Pressure reliefs and de-pressurizing systems should be located in accordance with *API-RP521.*

12. Cooling Towers

Cooling towers should be located downwind or crosswind (based on prevailing wind direction) of buildings, process units, and electrical substations and equipment.

13. Storage Tanks

13.1 Tank spacing and location should be in accordance with NFPA 30, NFPA 58, and API 2510 as appropriate.

13.2 Equipment such as pumps and exchangers should be located outside of diked storage areas.

13.3 Equipment inside dikes should be placed at an elevation above the top of the dikes or above the elevation of the design storm water event.

13.4 Adequate space should be provided for containment dikes to avoid unnecessary expenses for dike construction. Typically an economically and properly constructed earthen dike is 2.4 m (8 ft) wide at the top and has side slopes of three horizontal to one vertical. Therefore, the plot plan space for an earthen dike is six times the height required plus 2.4m (8 ft).

13.5 If there are constraints on plot plan space, other types of containment dike construction may be considered in lieu of an earthen dike.

13.6 A ditch or other drainage at the bottom of a dike is typically required.

13.7 Secondary containment of hazardous materials should be specified to contain the required spill volume as follows:

a. Single container: 100% of container plus 10%

b. Multiple containers: greater of 150% of largest container volume or 10% of total volume

c. Additional allowance of 135 mm (4.5 inches) of precipitation

d. Additional volume to contain a minimum of 20 minutes duration of fire sprinkler output on the containment area

14. Gas Processing, Storage and Terminal Facilities

14.1 Liquefied petroleum gases (LP-Gases) are gases at normal room temperature and atmospheric pressure. LP-Gases liquefy under moderate pressure and readily vaporize upon release of the pressure.

14.2 Storage, handling, transportation, and use of LP-Gas facilities should be in accordance with *NFPA-58.*

14.3 Design, construction, location, installation, operation and maintenance of refrigerated and non-refrigerated LP-Gas plants should be in accordance with *NFPA 59*.

14.4 Coverage of LP-Gas systems at utility gas plants extends to the point where LP-Gas or a mixture of LP-Gas and air is introduced into the utility distribution system.

14.5 *NFPA 59A* should apply to the following:

a. Facilities that liquefy natural gas

b. Facilities that store, vaporize, transfer, and handle liquefied natural gas (LNG)

c. The training of all personnel involved with LNG

d. The design, location, construction, maintenance, and operation of all LNG

14.6 LNG storage facilities should be in accordance with *NFPA 59, ACI 376* and *API 625.*

14.7 Marine terminals handling liquefied gases should be in accordance with the contingency planning described in the *SIGTTO* publication *A Guide to Contingency Planning for Marine Terminal Handling Liquefied Gases.*

15. Miscellaneous Considerations

15.1 The following code issues should be considered:

a. Occupancy requirements: normal, turnarounds

b. Removable handrails and grating

c. Potential blast pressures, blast resistance

d. Access/egress for emergency response vehicles

e. Evacuation routes to egress and plant evacuation

f. Environmental issues

15.2 The following utility issues should be considered:

a. Transformer containment complexity, trenches, grating

b. Power delivery & distribution; sub-stations, transmission lines

c. Water supply and fire protection

d. Trash, sewage and hazardous waste disposal

e. Storm water runoff, detention ponds, and sediment control

15.3 The following construction issues should be considered:

a. Construction lay down and office, location, remote, blast resistant

b. Crane pads

c. Heavy haul and modular delivery

d. Large erection equipment such as heavy lift cranes or transporters

e. Revamp; adding levels to existing structures, tight clearances

f. Underground obstructions

15.4 The following operational issues should be considered:

a. Monorails and davits, clearances, lifting

b. Fencing, security issues

c. *DoD Manual UFC-4-020-01*

d. Plant entry and exit control, truck inspection

e. Maintenance shops, warehouses, operator shelters

Table 1 - Recommended Offsites Equipment Spacing

ROW	1 BLOWDOWN FACILITIES (DRUMS, PUMPS, STACKS)	2 FIRED BOILERS	3 BLDG HIGH OCCUPANCE (> 15 PERSONS)	4 BLDG LOW OCCUPANCY (15 PERSONS OR LESS)	5 BUILDINGS UTILITY	6 COOLING TOWER	7 ELECTRICAL OVERHEAD POLE LINES	8 ELECTRICAL MAIN SUBSTATIONS	9 ELECTRICAL CONTROL AND DISTRIBUTION CENTERS (SEE NOTE 8)	10 FIRE STATIONS, FIRE PUMPS	11 FLARE STACKS	12 HIGHWAYS, ROADS & PUBLIC AREAS	13 LOADING AND/OR UNLOADING RACKS	14 NATURAL GAS METERING STATIONS (MAIN PLT)	15 PIPEWAYS (MAJOR)	16 PUMPS (FLAMMABLE)	17 PUMPS (NONFLAMMABLE)	18 RAILROADS (MAIN LINES -R/W)	19 RAILROADS (SPURS-CENTER LINE)	20 OIL-WATER SEPARATORS (API-CPI)	21 SEWER MAINS (FLAMMABLE)	22 PLANT ROADS (EDGE)	23 PROPERTY LINES (OTHER THAN ROADS & RAILROADS)	24 PRESSURE STORAGE VESSELS, 500,000 GAL OR LESS	25 SPHERES AND SPHEROIDS (OVER 500,000 GAL)	26 NFPA CLASS III LIQUID STORAGE	27 ATMOSPHERIC, LOW & INTER VAPOR PRESS STORAGE)	28 PROCESS UNITS
A	A																												
B	30 (100)	A																											
C	A	A	A																										
D	A	A	A	A																									
E	30 (100)	A	A	A	A																								
F	15 (50)	30 (100)	A	A	30 (100)	A																							
G	15 (50)	15 (50)	A	A	6 (20)	30 (100)	A																						
H	30 (100)	30 (100)	A	A	0	30 (100)	A	A																					
I	15 (50)	8 (25)	A	A	0	6 (20)	A	A	A																				
J	61 (200)	30 (100)	A	A	15 (50)	30 (100)	8 (25)	15 (50)	A	A																			
K	A	A	A	A	A	A	A	A	A	A	A																		
L	61 (200)	30 (100)	A	A	15 (50)	30 (100)	6 (20)	0	0	15 (50)	A	A																	
M	30 (100)	61 (200)	A	A	46 (150)	30 (100)	15 (50)	30 (100)	15 (50)	61 (200)	A	30 (100)	A																
N	15 (50)	30 (100)	A	A	30 (100)	30 (100)	8 (25)	30 (100)	30 (100)	30 (100)	A	30 (100)	30 (100)	3 (10)															
O	6 (20)	6 (20)	A	A	6 (20)	8 (25)	0	6 (20)	0	6 (20)	A	0	6 (20)	3 (10)	A														
P	15 (50)	15 (50)	A	A	15 (50)	15 (50)	5 (15)	30 (100)	8 (25)	30 (100)	A	30 (100)	30 (100)	15 (50)	5 (15)	1 (3)													
Q	8 (25)	2 (5)	A	A	0	A	5 (15)	5 (15)	5 (15)	0	A	5 (15)	5 (15)	3 (10)	0	1 (3)	1 (3)												
R	61 (200)	30 (100)	A	A	0	30 (100)	8 (25)	8 (25)	0	15 (50)	A	A	61 (200)	8 (25)	0	30 (100)	15 (50)	N/A											
S	15 (50)	8 (25)	A	A	A	11 (35)	A	A	A	15(50)	A	A	A	8 (25)	A	5 (15)	A	A	A										
T	30 (100)	61 (200)	A	A	46 (150)	30 (100)	15 (50)	30 (100)	15 (50)	61 (200)	A	30 (100)	30 (100)	30 (100)	6 (20)	3 (10)	5 (15)	30 (100)	30 (100)	8 (25)									
U	8 (25)	15 (50)	A	A	6 (20)	6 (20)	6 (20)	6 (20)	6 (20)	6 (20)	A	3 (10)	3 (10)	3 (10)	A	3 (10)	3 (10)	3 (10)	3 (10)	3 (10)	A								
V	5 (15)	5 (15)	A	A	5 (15)	8 (25)	1 (4)	5 (15)	5 (15)	12 (40)	A	A	6 (20)	5 (15)	1 (3)	3 (10)	3 (10)	3 (10)	A	5 (15)	A	A							
W	61 (200)	30 (100)	A	A	8 (25)	8 (25)	8 (25)	0	A	8 (25)	A	A	30 (100)	8 (25)	8 (25)	30 (100)	15 (50)	N/A	A	30 (100)	3 (10)	A	N/A						
X	61 (200)	61 (200)	A	A	46 (150)	15 (50)	C, D	30 (100)	15 (50)	61 (200)	A	61 (200)	30 (100)	30 (100)	8 (25)	C, D	8 (25)	61 (200)	30 (100)	61 (200)	8 (25)	A	B, C, D	B, C, D					
Y	61 (200)	91 (300)	A	A	76 (250)	30 (100)	C, D	61 (200)	30 (100)	91 (300)	A	91 (300)	30 (100)	30 (100)	15 (50)	C, D	8 (25)	61 (200)	30 (100)	61 (200)	15 (50)	A	B, C, D	B, C, D	B, C, D				
Z	B	B	A	A	B	B	8 (25)	B	B	61 (200)	A	B	B	B	B	B	B	B	A	B	A	A	B, C, D	B, C, D	B, C, D	B, C, D			
AA	61 (200)	61 (200)	A	A	61 (200)	61 (200)	8 (25)	61 (200)	A	76 (250)	A	61 (200)	46 (150)	A	3 (10)	A	A	61 (200)	A	61 (200)	A	A	B, C, D	B, C, D	B, C, D	B, C, D	B, C, D		
BB	30 (100)	30 (100)	A	A	15 (50)	15 (50)	3 (10)	30 (100)	15 (50)	61 (200)	A	30 (100)	61 (200)	30 (100)	5 (15)	A	A	30 (100)	A	61 (200)	6 (20)	5 (15)	30 (100)	61 (200)	61 (200)	A	46 (150)	15 (50)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	COLUMN

Notes:
1. This table does not account for vapor cloud explosions, customer safety and property protection, environmental or flare vent/stack dispersal requirements.
2. Distances are in meters (feet).
3. Distances are from PIP Member Company input.
4. "A" indicates that an engineering/ safety decision is required. For location of buildings, refer to Section 9.1.
5. "B" Indicates refer to NFPA 30.
6. "C" Indicates refer to NFPA 58.
7. "D" Indicates refer to API 2510.
8. Greater spacing may be required if control or distribution center serves more than one

Table 2 - Recommended Process Unit Equipment Spacing

ROW	BLOWDOWN FACILITIES (DRUMS, PUMPS, STACKS)	COMPRESSORS GAS (NO IGNITION SOURCE)	CONTROL HOUSES (FOR SINGLE UNIT)	CENTRAL CONTROL HOUSES (2 OR MORE UNITS)	COOLERS, AIR FIN-FAN	COOLING TOWERS	DRUMS - CONTAINING FLAMMABLES	ELECTRICAL CONTROL AND DISTRIBUTION CENTERS	ELECTRICAL SWITCH RACKS, CRITICAL	EXCH'RS CONTAINING FLAM/COMB LIQ	FURNACES (PROCESS FIRED EQUIPMENT)	PIPEWAYS (BETWEEN UNITS)	PIPEWAYS (WITHIN UNITS)	PUMPS (FLAMMABLE)	PUMPS (NONFLAMMABLE)	REACTORS (INTERNALLY LINED & EXTERNALLY INS)	SEPARATOR UNIT(S) (LIGHT ENDS)	SNUFFING STEAM OPERATING VALVE FOR FURNACES	STRUCTURES (EQUIPMENT & PROCESS)	TOWERS (FLAMMABLE)	WATER SPRAY DELUGE VALVES
A	A																				
B	15(50)	3 (10)																			
C	A	A	A																		
D	A	A	A	A																	
E	15 (50)	8 (25)	A	A	A																
F	15 (50)	15 (50)	A	A	15 (50)	A															
G	15 (50)	8 (25)	A	A	2 (8)	15 (50)	2 (5)														
H	15 (50)	15 (50)	A	A	15 (50)	15 (50)	15 (50)	1 (4)													
I	15 (50)	8 (25)	A	A	5 (15)	5 (15)	5 (15)	A	A												
J	15 (50)	8 (25)	A	A	2 (8)	15 (50)	2 (5)	15 (50)	5 (15)	A											
K	30 (100)	30 (100)	A	A	15 (50)	30 (100)	8 (25)	15 (50)	12 (40)	15 (50)	8 (25)										
L	6 (20)	5 (15)	A	A	A	8 (25)	2 (5)	3 (10)	0	1 (3)	8 (25)	A									
M	2 (5)	A	A	A	A	1 (3)	1 (3)	3 (10)	0	1 (3)	1 (3)	A	A								
N	15 (50)	8 (25)	A	A	8 (25)	15 (50)	2 (5)	15 (50)	8 (25)	2 (5)	15 (50)	1 (3)	0	1 (3)							
O	8 (25)	2 (8)	A	A	A	A	1 (3)	8 (25)	2 (8)	1 (3)	8 (25)	1 (3)	0	1 (3)	1 (3)						
P	15 (50)	8 (25)	A	A	3 (10)	15 (50)	3 (10)	15 (50)	5 (15)	3 (10)	8 (25)	3 (10)	2 (5)	3 (10)	2 (8)	3 (10)					
Q	15 (50)	8 (25)	A	A	15 (50)	15 (50)	6 (20)	15 (50)	5 (15)	8 (25)	15 (50)	5 (15)	A	3 (10)	1 (3)	15 (50)	A				
R	15 (50)	15 (50)	A	A	6 (20)	15 (50)	6 (20)	1 (4)	1 (4)	6 (20)	15 (50)	0	0	6 (20)	1 (3)	15 (50)	9 (30)	0			
S	15 (50)	8 (25)	A	A	A	15 (50)	1 (3)	15 (50)	5 (15)	1 (3)	15 (50)	0	0	2 (5)	1 (3)	6(20)	15 (50)	5 (15)	0		
T	15 (50)	8 (25)	A	A	2 (8)	15 (50)	2 (8)	15 (50)	5 (15)	2 (8)	15 (50)	2 (8)	2 (5)	2 (5)	2 (5)	3 (10)	6 (20)	8 (25)	2 (5)	2 (8)	
U	15 (50)	15 (50)	A	A	8 (25)	5 (15)	8 (25)	1 (4)	1 (4)	5 (15)	15 (50)	0	0	8 (25)	1 (3)	15 (50)	6 (20)	0	0	8 (25)	0
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

COLUMN

Notes:
1. This table does not account for vapor cloud explosions, customer safety and property protection, environmental or flare vent/stack dispersal requirements.
2. Distances are in meters (feet).
3. Distances are from PIP Member Company input.
4. "A" indicates that an engineering/ safety decision is required. For location of buildings, refer to Section 9.1.

Table 3 - Minimum Access Provisions

Minimum Access	Type of Item to be Accessed
Platform - Items Located Over Platform	Elevated heat exchangers Elevated control valves (all sizes) Manholes (higher than 3660 mm (12 ft) above grade) Relief valves (NPS 100 mm (4 inches) inlet and larger on vertical vessel) Process blinds (higher than 3660 mm (12 ft) above grade) Furnace soot blowers Furnace burners (when not accessible from grade) Furnace observation doors and sample ports (higher than 3660 mm (12 ft) above grade) Elevated cleanouts
Platform - Items Located at Edge of Platform	NPS 100 mm (4 inches) and larger gate and globe valves at vessels Battery limit valves in elevated pipe racks Elevated motor operated valves Relief valves - NPS 75 mm (3 inches) inlet and smaller on vertical vessels Relief valves - All sizes on horizontal vessels Sampling devices on vessels (higher than 3660 mm (12 ft) above grade)
Fixed Ladder	All sizes of check valves at vessels NPS 75 mm (3 inches) and smaller gate and globe valves at vessels Level gauges and valves Furnace observation ports between 2130-3660 mm (7-12 ft) above grade Instruments requiring routine access Handholes Elevated electrical substations and equipment
Mobile Stair	All servicing between 2130-3660 mm (7-12 ft) above grade except as noted in this Table
No Permanent Access	Block valves in pipe racks (except at battery limit) Elevated orifices or meter runs Nozzles on vessels (without process blinds or valves) Check valves not at vessels Temperature connections in piping Pressure connections in piping Silencers or exhaust heads Metal temperature measuring points on vessels Instrument connections on furnaces

Table 4 - Minimum Clearance Dimensions

Item	Description	Dimension
Roadways	Clearance over primary access roadways where major maintenance vehicles are expected to pass	5.5 m (18 ft)
	Clearance over roadways to electrical transmission and distribution lines	See section for electrical clearances below
	Width of primary access roadways including shoulders	8.2 m (27 ft)
	Clearance over secondary access roadways and pump access roadways	4.1 m (13.5 ft)
	Width of secondary roadways including shoulders (single lane)	4.1 m (13.5 ft)
	Width of accessways and pump access roadways w/shoulders (single lane)	4.9 m (16 ft)
	Clearance to equipment	4.0 m (13 ft)
Railroads	Clearance over through-railroads (from top of rail)	6.7 m (22 ft) (check local regulations)
	Clearance over dead ends and sidings (from top of rail)	4.9 m (16 ft) (check local regulations)
	Horizontal clearance from track centerline to obstructions	2.6 m (8.5 ft)
	Clearance over railroads (from top of rail) to electrical lines	See section for electrical clearances below
Access Walkways and Fixed industrial stairs	Clearance height for projections over platforms, working areas, walkways (exit access routes)	2290 mm (7.5 ft); 2030 mm (6.75 ft) for bottom of valve handwheels or other projections from ceiling
	Minimum head room over stairs	2030 mm (6.75 ft)
	Projections into stairs below handrail height	115 mm (4-1/2 inch)
	Width of stairs serving < 50 persons	915 mm (36 inches)
	Width of stairs serving > 50 and < 2000 persons	1120 mm (44 inchest)
	Width of landings in direction of stairs, minimum	Width of the stair
	Length of landings in a straight run, maximum	1220 mm (48 inches)
	Minimum Width of walkways (should be the width of the required stair)	915 mm (36 inches)
	Width of walkways for industrial equipment access < 20 persons	560 mm (22 inches)
	Maximum vertical rise of one flight of stairs	3660 mm (12 ft)
	Maximum horizontal distance from any point on platform to an emergency exit	22 m (75 ft)
	Maximum length of outdoor dead-end platforms and exit routes (depends on occupancy class)	6100 mm (20 ft)
Fixed ladders	Maximum vertical rise of fixed ladders in a single run	9 m (30 ft)
	Maximum allowable slope of fixed ladders from vertical	15 degrees
	Minimum toe clearance from centerline of rung to obstruction	180 mm (7 inches)

Platforms	Maximum variance in platform elevations without an intermediate step	305 mm (1 ft)
	Minimum unobstructed width of platforms	760 mm (2.5 ft)
	Occasional obstructions (level glass, transmitter, etc.)	460 mm (1.5 ft)
	Minimum width of manhole platforms on vertical vessels	1070 mm (3.5 ft)
	Minimum platform extension beyond centerline of manhole flange on vertical vessels	760 mm (2.5 ft)
	Minimum width of platform from three sides of manhole on vessel top head platforms	760 mm (2.5 ft)
	Minimum width of platforms at ends of horizontal tube furnaces	1070 mm (3.5 ft)
Operation & Maintenance	Minimum clearance in front of channel end of horizontal exchanger for tube removal or cleaning	Tube bundle length plus 1525 mm (5 ft)
	Minimum clearance around exchanger body flanges	460 mm (1.5 ft)
	Vertical exchangers	Unobstructed vertical access
Electrical <22KV	Roadway, driveways, parking, and open land clearance under electrical transmission and distribution lines	5.6 m (18.5 ft)
	Railroad clearance under electrical lines (to top of rail)	8.1 m (26.5 ft)
	Walkway clearance under electrical lines	4.1 m (13.5 ft)
	Over roofs accessible to trucks	5.6 m (18.5 ft)
	Over roofs accessible to vehicles but not trucks	4.1 m (13.5 ft)
	Balconies, catwalks, etc. accessible to people	4.1 m (13.5 ft)
	Over or under roofs, etc not accessible to people	3.8 m (12.5 ft)
	Horizontal clearance to buildings, structure, catwalks, balconies	2.3 m (7.5 ft)
Electrical >22KV	For clearances listed above, for voltages >22KV per *NFPA 70 (NEC)*	Increase clearances by 10 mm (0.4 inch) per KV
Electrical Duct Banks & Cables	Maximum depth of bury to top of electrical duct banks	750 mm (30 inches)
	Maximum depth of bury to top of direct bury electrical cables	900 mm (35 inches)