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.

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# PIP CVC01015
## Civil Design Criteria

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1. **Scope**

This Practice describes minimum requirements for design of civil sitework of process industry facilities at onshore U.S. sites. This Practice covers all work related to preparation of site such as grading, roadways and railroads, and sewer work and related facilities, and all work related to finishing site. This Practice is intended to be used in conjunction with *PIP CVC01017* and *PIP CVC01018*, as applicable.

2. **References**

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

### 2.1 Process Industry Practices (PIP)

- PIP CVC01017 - Plant Site Data Sheet
- PIP CVC01018 - Project Data Sheet
- PIP CVE02350 - Roadway Design Guide (U.S. Customary)
- PIP CVE02350M - Roadway Design Guide (Metric)
- PIP CVI02350 - Roadway and Area Paving General Notes and Typical Details
- PIP CVS02010 - Geotechnical Engineering Investigation Specification
- PIP CVS02100 - Site Preparation, Excavation, and Backfill Specification
- PIP CVS02350 - Roadway and Area Paving Construction Specification
- PIP CVS02700 - Underground Gravity Sewers Specification
- PIP CVS02830 - Chain-Link Fence and Gates Installation Specification
- PIP PNE00003 - Process Unit and Offsites Layout Guide
- PIP STS03001 - Plain and Reinforced Concrete Specification

### 2.2 Industry Codes and Standards

- American Concrete Institute (ACI)
  - ACI 330R - Guide for the Design and Construction of Concrete Parking Lots
- American Petroleum Institute (API)
  - API 2610 - Design, Construction, Operation, Maintenance, and Inspection of Terminal & Tank Facilities
- American Railway Engineering and Maintenance-of-Way Association (AREMA)
  - AREMA Manual for Railway Engineering
- ASTM International (ASTM)
  - ASTM A746 - Standard Specification for Ductile Iron Gravity Sewer Pipe
• American Water Works Association (AWWA)
  – AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast

• National Fire Protection Association (NFPA)
  – NFPA 30 - Flammable and Combustible Liquids Code

• Portland Cement Association (PCA)
  – PCA SN298 - Guide for Roller-Compacted Concrete Pavements

2.3 Government Regulations

• U.S. Department of Justice (DOJ) / Americans with Disabilities Act (ADA)
  – 2010 ADA Standards for Accessible Design
  – Guidance on the 2010 ADA Standards for Accessible Design

• U.S. Department of Homeland Security (DHS)
  – 6 CFR Part 27 - Chemical Facility Anti-Terrorism Standards; Final Rule

• U.S. Environmental Protection Agency (EPA)
  – EPA 40 CFR - Protection of the Environment

• U.S. Department of Transportation (DOT)
  – 49 CFR Part 213 - Track Safety Standards

3. Definitions

BMPs: Best Management Practices are techniques (buffers, silt fences, detention ponds, swales, etc.), schedules of activities, prohibitions of practices, and maintenance procedures used to prevent or reduce discharge of pollutants

constructor: Party responsible for supplying materials, equipment, tools, supervision, and labor for installation of civil sitework in accordance with contract documents. The term constructor applies also to constructor’s subcontractor(s) and vendor(s).

contract documents: Any and all documents, including codes, studies, design drawings, specifications, sketches, practices, and data sheets, that purchaser or engineer of record has transmitted or otherwise communicated, either by incorporation or reference, and made part of the legal contract agreement or purchase order between purchaser and constructor.

covered facility (or covered chemical facility): A chemical facility determined by the Assistant Secretary to present high levels of security risk, or a facility that Assistant Secretary has determined is presumptively high risk under U.S. Department of Homeland Security 6 CFR Part 27 Section 27.200. Assistant Secretary shall mean the Assistant Secretary for Infrastructure Protection, U.S. Department of Homeland Security or his designee.

DOT: Department of Transportation or equivalent government organization for state, province, or country in which project site is located

engineer of record: Purchaser’s authorized representative with overall authority and responsibility for engineering design, quality, and performance of civil works, structures, foundations, materials,
and appurtenances described in contract documents. Engineer of record is licensed as defined by laws of the locality in which the work is to be constructed, and is qualified to practice in the specialty discipline required for the work described in contract documents.

g**eotechnical engineer:** Professional engineer responsible for performing geotechnical investigation and/or geotechnical consulting during construction of civil works

**noncontact cooling water:** Cooling water that does not have direct contact with process fluids or materials. Cooling water may be recirculated or used only once and conveyed through gravity drainage systems.

**operator:** Entity (generally company, corporation, etc) that has: (1) operational control of construction project plans and specifications, including the ability to make modifications to those plans, or (2) day-to-day operational control of stormwater compliance activities

**owner:** Party who has authority through ownership, lease, or other legal agreement over facility wherein sitework will be used.

**process sewers:** Any waste collection/drainage system carrying materials (exclusive of sanitary waste) requiring treatment before discharge

**purchaser:** Party who awards contract to constructor. Purchaser may be owner or owner’s authorized agent

**SWPPP:** Stormwater Pollution Prevention Plan is a document that describes pollution prevention practices and activities that will be implemented on the site. It includes information on the site and of each major phase of the planned activity, roles and responsibilities of contractors, and inspection schedules and logs. The SWPPP also serves to document weather events and modifications to construction plans and stormwater pollution prevention activities.

## 4. Requirements

### 4.1 General

Owner or owner’s representative shall provide PIP CVC01017 and PIP CVC01018 Data Sheets that document site specific data and design basis for the project.

### 4.2 Environmental Protection

#### 4.2.1 Storage facilities and process infrastructure (e.g., process loading/unloading, petroleum storage, and hazardous material storage) shall be designed to protect against soil, groundwater and surface water contamination in accordance with *EPA 40 CFR*, state, and local regulations. Examples of protection methods include drip pans, paving, impervious layers or membranes and concrete containment.

#### 4.2.2 Diked areas shall be designed to contain 100% of largest tank volume.

   **Comment:** To allow for volume occupied by tanks, capacity of diked area enclosing more than one tank shall be calculated after deducting volume of tanks, other than the largest tank, below the height of the dike.
Comment: It should be noted that some owners and local jurisdictions may require the dike to provide “freeboard” for foam application and runoff from fire-fighting operations and precipitation requirements.

Comment: See API 2610 for guidance on design of terminal and tank facilities.

4.2.3 Facilities for storage, handling, and use of flammable and combustible liquids shall be in accordance with NFPA 30.

4.2.4 Sewers that carry water that is not normally subject to contamination (noncontact cooling water or stormwater) and that have potential to receive spills (e.g., potentially contaminated water) shall be designed to include monitoring and diversion capabilities.

Comment: Stormwater from process, storage, and loading areas should be segregated from stormwater from undeveloped and non-process areas to minimize volume of water requiring treatment.

4.2.5 Building floor and roof drains and other areas not subject to process spills shall connect to stormwater drainage system.

4.2.6 Additional Requirements for Toe Wall Enclosures, Dikes and Pits

4.2.6.1 Tops and sides of dikes shall be protected from erosion.

4.2.6.2 Tank pits and dikes shall be made resistant to percolation with a hydraulic conductivity no greater than $3.9 \times 10^{-7}$ inches/s ($10^{-6}$ cm/s) as determined by ASTM D6391, using methods approved by engineer of record.

4.2.6.3 Diked or toe wall enclosures, including tank dike areas, shall be drained with at least one catch basin or pipe through the enclosure discharging to a drainage system outside the dike or toe wall. For dike areas with combustible storage tank dike areas, all discharges shall be provided with a valve according to Section 4.10.8 below, located such that it is accessible for operation from outside the enclosure.

4.3 Geotechnical Engineering Investigations

4.3.1 If sufficient geotechnical information is not available, geotechnical engineering investigations shall be performed in accordance with PIP CVS02010.

4.3.2 If available and appropriate, the following technical information shall be provided to geotechnical engineer:

a. Site plan showing proposed facilities and adjacent existing facilities

b. Topographic plan or relative elevations of existing grades and facilities to planned grades of proposed facilities

c. Descriptions of proposed and existing facilities, including the following:

1) Types of structures

2) Anticipated design loads for various design cases including static compression, uplift, horizontal shear, vibratory, dynamic, and blast

3) Any settlement sensitivity of structures or equipment
4) Any sensitivity to vibration from external sources of both proposed and existing facilities
5) Special or unusual conditions such as pits, basements, elevator shafts, reciprocating compressors, retaining walls, etc.
6) Elevations such as building ground floor, bottom of pits, basements, elevator shafts, walls, tanks, etc.
7) Proposed finish grade elevation adjacent to facilities
8) For tanks, load condition (empty, full, test, and operating weights); normal operating level ranges, durations, and settlement tolerances
9) Pavement loading and traffic data if pavement recommendations are needed
10) Information regarding any known or potential soil/groundwater contamination at the site
11) Drawings and other information for adjacent or on-site existing facilities, including underground utilities and structures

4.4 Site Preparation and Grading

4.4.1 Site preparation activities, including clearing and grubbing, stripping, and general site grading, shall be in accordance with PIP CVS02100.

4.4.2 Excavation, fill, stockpile and disposal areas, and extent of clearing and grubbing areas shall be defined in contract documents.

*Comment:* Consideration shall be given to balancing cut and fill for earthwork.

4.4.3 All demolition and disposal methods shall be defined in contract documents.

4.4.4 Vehicular traffic detours shall be designed to provide a safe routing and a satisfactory means of controlling traffic.

4.4.5 All graded surfaces shall be sloped to provide positive drainage and to avoid ponding.

4.4.6 Final grade shall take into consideration the existing drainage from surrounding areas if applicable.

4.5 Excavation and Backfill

4.5.1 Excavation and backfill shall be in accordance with PIP CVS02100.

4.5.2 Areas requiring differing levels of compaction shall be noted on design drawings. These areas include structure areas, roadways, railroad subgrades, paved area subgrades, utility trenches, embankments and dikes, and general graded areas outside process or work areas.

4.6 Erosion and Sediment Control

4.6.1 Erosion and sedimentation controls shall be in accordance with local, state, and federal regulations, including EPA, US Army Corps of Engineers, and project specific permits. Soil erosion control shall be designed to comply with federal, state, and local regulations and shall be in accordance with PIP CVS02100.
4.6.2 Operator(s) shall develop and implement a Stormwater Pollution Prevention Plan (SWPPP) and maintain all Best Management Practices (BMPs) during each stage of the project in accordance with applicable regulations. SWPPP must be available on-site for review during inspection.

4.6.3 Construction activities that expose soil due to clearing, grading, excavating, etc., affecting one or more acres, including smaller sites in a larger common plan of development, require coverage under a National Pollutant Discharge Elimination System (NPDES) permit for stormwater discharges. Operator(s) shall complete the following steps, as applicable under the governing jurisdiction:

a. Develop and implement a Stormwater Pollution Prevention Plan (SWPPP). Submittal is required in some states. SWPPP must be completed prior to submitting the Notice of Intent.

b. Submit a Notice of Intent (NOI) to governing authority.

c. Submit a Notice of Termination (NOT) to governing authority.

4.6.4 Where required, erosion control permitting documentation shall be submitted to owner.

4.7 Railroad Work

4.7.1 Railroad design shall be in accordance with AREMA Manual for Railway Engineering and local operating railroad requirements.

*Comment:* See 49 CFR Part 213 Track Safety Standards for additional general information.

4.7.2 Railroads shall be standard gauge and shall meet design, condition, and maintenance requirements for yards and terminals track systems as defined by AREMA.

4.7.3 Loading, unloading, and scale stations shall be designed to be level.

4.7.4 Rail unit weight and rail type shall be selected to be compatible with existing rail system and to provide desired design life according to intended service and availability.

4.7.5 A drainage system shall be designed to drain ballast and subgrade. Flooding of grades between parallel tracks shall be prevented.

4.7.6 A geosynthetic material shall be installed between subgrade and ballast if recommended by geotechnical engineer to prevent fouling of ballast.

4.7.7 Ballast section shall remain level with top of tie between adjacent tracks to provide level walking surface area.

4.7.8 Unless otherwise specified in PIP CVC01015 and PIP CVC01018, railroads shall be designed in accordance with the following:

a. Railroad clearances shall be in accordance with PIP PNE00003.

b. Rail shall be AREMA Class 1 relay.

c. Unless otherwise required by the local operating railroad, turnouts on tracks shall be No. 8 minimum.

d. Maximum grade, unless otherwise required by local topography, shall be 2%. 
e. Maximum degree of curvature shall be 10 degrees.

f. Ballast shall be size AREMA No. 5 material with properties meeting AREMA limiting values.

g. Ballast depth shall be a minimum of 8 inches (200 mm) from bottom of tie.

h. Sub-ballast shall be in accordance with AREMA and geotechnical engineer’s recommendations.

### 4.8 Roadways, Area Paving, and Surfacing

4.8.1 Roadways and area paving shall be in accordance with PIP PNE00003.

4.8.2 ADA accessible parking spaces shall be designed in accordance with 2010 ADA Standards for Accessible Design.

*Comment:* Engineer can also refer to Guidance on the 2010 ADA Standards for Accessible Design document for more information.

4.8.3 Roadways and Area paving shall be designed using materials and methods specified in PIP CVC01017 and/or PIP CVC01018.

4.8.4 Surfacing for the following areas shall be as specified in PIP CVC01017 and/or PIP CVC01018 data sheets or as otherwise designated by owner. See PIP CVE02350, PIP CVE02350M and PIP CVI02350 for information on various surfacing options.

- a. Sidewalks
- b. Roadways, streets, or drives
- c. Process equipment areas
- d. Maintenance areas
- e. Loading or unloading areas
- f. Parking or storage areas

4.8.5 Final grading and paving around plant buildings shall direct liquids away from the buildings.

*Comment:* Directing drainage so that liquids flow away from buildings reduces the risk of building involvement in a plant fire.

### 4.8.6 Roadways

4.8.6.1 Unless otherwise specified by owner, roads shall be designed in accordance with PIP CVE02350 or PIP CVE02350M.

4.8.6.2 Design drawings shall show all pavement and road requirements including location, width, thickness of base course and pavement, pavement type, grades, geometry, joint types and locations, shoulder details, curbs, signage, drainage features, and materials.

### 4.8.7 Concrete Area Paving

4.8.7.1 For concrete materials and construction, see PIP CVS02350 and PIP STS03001. Unless specified otherwise in PIP CVC01017 and/or
PIP CVC01018, roadways and paving shall be designed in accordance with the following requirements:

a. Concrete area paving may be of the following types:
   1) Jointed plain concrete paving (JPCP) (Section 4.8.7.2)
   2) Jointed reinforced concrete paving (JRCP) (Section 4.8.7.3)
   3) Roller-compacted concrete paving (RCCP) (Section 4.8.7.4)

b. Rigid pavement shall be designed based on the modulus of subgrade reaction \( (k) \) determined or calculated at top of base course.

c. See PIP CVE02350 or PIP CVE02350M for design procedures for concrete pavements.

d. See PIP CVI02350 for pavement thicknesses and joint construction and spacing information.

e. Area paving shall be curbed where needed to contain chemicals or hydrocarbons. Containment curbs shall be a minimum of 6 inches (150 mm) wide and as tall as required to contain the material.

f. Pavement shall be divided into sections or catchment areas. Catchment areas shall be sloped to sewer inlets to provide rapid removal of stormwater, firewater, or hydrocarbon spills. One catch basin shall be provided for each 3000 ft\(^2\) (280 m\(^2\)) of paved area and 5000 ft\(^2\) (465 m\(^2\)) of unpaved area. Maximum surface runoff travel distance to catch basins shall be 100 ft (30 m) in process areas.

g. Minimum slope for area paving shall be 1% unless otherwise specified. Consider 2% for areas that are constantly wet.

*Comment:* For sewer system to provide adequate drainage during a storm or fire event, limitations are placed on maximum runoff travel distance, area and ground slope.

h. Pavement subject to chemical attack shall be designed with an appropriate protective coating or special concrete mix design.

i. For additional information on area paving and parking lots, see ACI 330R.

4.8.7.2 Jointed Plain Concrete Paving (JPCP)

JPCP is unreinforced and shall be designed according to methods and procedures of PIP CVE02350 or PIP CVE02350M. Provisions of Section 4.8.3 shall be applied to the design.

4.8.7.3 Jointed Reinforced Concrete Paving (JRCP)

JRCP is reinforced and shall be designed according to methods and procedures of PIP CVE02350 or PIP CVE02350M. Provisions of Section 4.8.3 shall be applied to the design.
4.8.7.4 Roller-Compacted Concrete Paving (RCCP)

1. RCCP may be used for most of the applications listed in the previous section for JPCP at owner’s option. RCCP should be considered for area paving where heavy forklifts greater than 15,000-lb (6,800-kg) capacity or other heavy equipment operate, such as in container yards.

2. RCCP shall be designed according to methods and procedures described in PCA SN298.

4.8.8 Gravel or Crushed Stone Surfacing

1. For area paving around exterior electrical equipment enclosures and at other locations that are not subject to leaks or spills, crushed stone or similar locally available material may be used.

2. Gravel or crushed stone surfacing shall be placed to a minimum finished thickness of 3 inches (75 mm).

3. Gravel or crushed stone surfacing shall be suitable for pedestrian traffic.

4.8.9 Asphalitic Concrete Roadway and Area Paving

Asphalitic Concrete shall be designed according to methods and procedures of *PIP CVE02350* or *PIP CVE02350M*. Provisions of Section 4.8.3 shall be applied to the design.

4.9 Curbs, Gutters, and Walkways

4.9.1 Walkways and roadway crossings shall be provided to connect parking lot, gatehouse, administration building, cafeteria, process buildings, etc., for safe pedestrian travel. Accessible routes including curbs, gutters, walkways, and roadway crossings shall be designed to comply with *2010 ADA Standards for Accessible Design*. Engineer can also refer to *Guidance on the 2010 ADA Standards for Accessible Design* document for more information.

4.9.2 Walkway subbase shall be in accordance with *PIP CVS02100*.

4.9.3 Walkway grades without steps shall not exceed 6%.

4.9.4 Finished grades shall be shown on design drawings.

4.10 Sewers and Drainage Systems

This section covers design and installation of stormwater, sanitary and process sewer wastewater collection systems. See also *PIP CVS02700* for specifications related to underground gravity sewers that are relevant to the design and installation of sewer systems.

*Comment:* This section uses partial flows depth, seals and vents for safety to prevent vapor buildup and transmission. Other systems in use by petrochemical companies are flooded systems using weirs to prevent vapor buildup or transmission.

4.10.1 General

4.10.1.1 Sewers and drainage systems shall be designed to protect atmosphere, soil, surface water, and groundwater from contamination and to
provide safe, economical collection and flow of all sewage to treatment and/or holding facilities and subsequently to approved disposal. Sewers and drainage systems shall prevent the spread of fire from one drainage area to another.

*Comment:* Site drainage is designed to prevent the spread of fire from one area to another in order to minimize hazards to personnel and equipment and maximize effectiveness of emergency response.

4.10.1.2 If specified by owner, open channel ditches and basins that potentially convey or retain groundwater contaminants (e.g., potentially contaminated flows, firewater runoff) shall be lined. Lining material shall meet owner-specified permeability requirements.

4.10.1.3 If specified by owner, each sewer system shall be designed for increased flow from future sewer extension or from changes in surfaces that change runoff coefficients.

4.10.1.4 Unless owner has provided written notice that downstream system can accommodate the additional flow, existing systems to which new systems will connect shall be reviewed to verify service compatibility and to ensure that sufficient capacity is available to accept the additional flow.

4.10.1.5 Sewer system shall provide access for inspection and repair.

4.10.1.6 Sewer line inverts shall slope continuously downstream throughout the system such that no low points or traps are created in sewer lines.

*Comment:* Low points or traps in sewer lines allow for collection of hydrocarbons that can either initiate or contribute to a plant fire.

4.10.1.7 Sanitary sewers shall be designed to keep solids suspended and transported to the treatment facility without stagnant pockets where solids can settle out and collect.

4.10.1.8 Process and stormwater sewers shall be designed to settle and trap solids as close to their source as possible.

4.10.1.9 A closed system (e.g., pipe) with seals and vents shall be used for all wastewater collection in process areas:

1) that are normally subject to hydrocarbon/oil or chemical contamination or:

2) from process equipment contains potentially hazardous or flammable vapors or liquids or:

3) that are subject to rainwater runoff from areas subject to contamination.

*Comment:* Hydraulic seals prevent potentially hazardous or flammable vapors from back flowing from sewer system through the process drains. Proper venting of sewer system prevents loss of hydraulic seals by either a pressure
buildup or siphoning during normal sewer operations and allows vapors to be safely discharged.

4.10.1.10 Open ditches are acceptable for stormwater drainage outside process areas that are not normally subject to hydrocarbon/oil or chemical contamination and not subject to rainwater runoff from areas subject to contamination.

4.10.1.11 Natural sheet runoff is acceptable from unused plant areas that are not contaminated.

4.10.1.12 Process sewers shall be segregated from stormwater sewer as specified in contract documents.

4.10.1.13 Pipe material, strength selection, and installation shall be based on the following:

1. Minimum earth cover shall be at least 1 ft (300 mm) below frost line and not less than the smaller of 3 ft (900 mm) or one nominal pipe diameter below finished grade.

2. Superimposed wheel load shall be a minimum of 16,000 lbs (7260 kg), and a 50% load increase for impact shall be applied.

3. For rigid pipe, a bedding factor based on the method and class of bedding selected, pipe crushing strength based on the three edge method, and a safety factor of 1.5 for the applicable ASTM pipe material standard shall be used to establish the safe supporting strength (design load) of the pipe.

4. For flexible pipe other than ductile iron, a bedding constant and modulus of soil reaction based on the method and class of bedding, a pipe stiffness based on a parallel-plate loading test, and a safety factor of 2 applied to the critical deflection limit for the applicable ASTM pipe material standard shall be used to establish the design deflection limit of the pipe.

5. For ductile iron pipe, minimum pipe thickness/strength shall be in accordance with ASTM A746 or AWWA C151/A21.51 for the laying condition selected or shall be based on a maximum design deflection of 3% and design ring bending stress of 48 ksi (330 MPa), using the modulus of soil reaction and deflection and bending coefficients based on the method and class of bedding selected.

6. High density polyethylene (HDPE) sewers may be used in areas where maximum process stream operating temperature is less than manufacturer’s limits.

Comment: Sustained high temperatures may damage or collapse an HDPE pipe and ultimately reduce the effectiveness of the sewer to drain away firewater. For HDPE sewer lines exposed to constant elevated temperatures, temperature limits should be as specified by Piping Manufacturer.
4.10.1.14 Pipe joints shall be specified on drawings and shall be suitable for the service and wastewater properties. Where zero leakage over the life of the sewer is required, welded/fused or flanged/mechanically locked gasketed joints shall be used compatible with the type of pipe selected. Where nominal infiltration/exfiltration over the life of the sewer is permissible, push-on compression gasket joints may be used.

4.10.1.15 Sewer Proximity

1. Sanitary and process sewers shall be designed to cross under potable water lines.

2. Unless otherwise required by local codes, a minimum of 24-inches (600-mm) vertical clearance above the sewer and 48-inches (1,200-mm) horizontal clearance shall be provided if sanitary or process sewers parallel a potable water line.

3. If a potable water line crosses a sanitary or process sewer line, one segment of the potable water line pipe shall be centered over sanitary or process sewer line such that joints of the potable water line pipe are equidistant and at least 9 ft (2.7 m) horizontally from the sanitary or process sewer line. Potable water line shall cross at least 24 inches (600 mm) above the sanitary or process sewer line.

4.10.1.16 Minimum pipe sizes shall be 4 inches (100 mm) for sewers that do not receive surface runoff and have length of run less than 75 feet (20 m). Minimum pipe size shall be 8 inches (200 mm) for all other lines. Smaller sizes may be acceptable for condensate drains, equipment drains, etc.

4.10.1.17 Cleanout plugs shall be threaded to piping. In vehicle traffic area, cleanout plugs shall be recessed below grade and have a removable cover suitable for traffic loads.

4.10.2 Surface and Stormwater Drainage

4.10.2.1 Stormwater sewers and drainage structures shall be designed to carry normal daily process flow and runoff from the larger of a rain event or firewater discharge as specified in PIP CVC01017 and PIP CVC01018 provided by owner or in contract documents.

4.10.2.2 Unless otherwise specified, maximum inlet times shall be taken as 15 minutes for process areas with catch basin spacing of approximately 100 ft (30 m).

4.10.2.3 Inlet times for large undeveloped areas shall be determined for each project with special consideration for future development but shall not exceed 30 minutes unless otherwise specified by owner.

4.10.2.4 Piping design flow depth shall not exceed 2/3 of pipe diameter.

4.10.2.5 Minimum closed system design velocity shall be 3 fps (0.9 m/s) at average daily flowrate. When daily rate is negligible, minimum closed system design velocity shall be 2.5 fps (0.75 m/s) at 20 % of design capacity.
4.10.2.6 Flow velocity for closed sections shall not be more than 10 fps (3 m/s) for the maximum design flow rate.

4.10.2.7 Unlined ditches shall be designed for a maximum velocity of 2 fps (0.6 m/s). In lined ditches, there are no restrictions on maximum velocity.

4.10.2.8 Freeboard for open channels or ditches shall be a minimum of one velocity head \( (\sqrt{V^2/2g}) \).

4.10.2.9 Runoff coefficients shall be determined for each area. Unpaved areas designated for future development shall be considered paved unless otherwise specified by owner.

4.10.2.10 Where deferred stormwater runoff is specified, it shall be excluded from cumulative stormwater quantities where release is through a fully closed outlet. Where release is through an open flow restriction outlet, the maximum discharge of the outlet shall be included in cumulative flows in sizing the system.

4.10.2.11 Firewater for sewer branches collecting effluent from individual inlets such as drains and catch basins shall be a minimum of 500 gpm (110 m³/h).

4.10.2.12 Firewater for lines collecting effluent from two or more inlets discharging to manholes on mains within process and loading areas shall be the cumulative firewater flow from the catch basins served. The cumulative flow shall be based on the specified firewater application rate, which may be less than 500 gpm (110 m³/h) per catch basin, or 1000 gpm (230 m³/h), whichever is greater.

4.10.2.13 Sewers outside process units receiving combined flow from tank areas, process units, street drains, etc. shall be designed for the largest single quantity of firewater discharging into the main from any one facility or process unit, but not less than 2000 gpm (450 m³/h). Process and/or stormwater flow in combined mains may be greater than the design firewater flow and could therefore set the sizing.

4.10.2.14 Firewater flows for tank area shall be 500 gpm (110 m³/hr) for tank diameters less than 40 ft (12 m), 750 gpm (170 m³/hr) for tank diameters between 40 ft (12 m) and 65 feet (20 m) and 1000 gpm (230 m³/hr) for all tank diameters greater than 65 ft (20 m).

### 4.10.3 Sanitary Sewers

4.10.3.1 Sanitary waste from toilet facilities, lavatories, floor drains in wash rooms and rest rooms, etc., shall discharge to sanitary sewers. Effluent from floor drains shall discharge to the sanitary sewer downstream of the septic tank, if used.

4.10.3.2 Sanitary sewers shall form a separate system into which no hydrocarbons/oil or other process waste may be discharged.

*Comment:* Risk associated with process waste should be isolated to only process sewers to minimize the effect of sewer fires and explosions on occupied buildings. Discharging hydrocarbons or process wastes into sanitary sewers prior to
treatment can reduce effectiveness of sanitary waste treatment. If biological treatment is not included in the treatment system, sanitary wastes would not receive adequate treatment prior to discharge.

4.10.3.3 If facilities for treatment of raw sanitary waste are not available in a plant or municipal sewer system, then sanitary sewers shall discharge into septic tanks, meeting local codes and the following:

1. Tanks shall be designed for the anticipated structural loads, including adjacent service by a vacuum or septic pump-out truck.
2. Tanks may be constructed of concrete block, precast or cast-in-place concrete, polyethylene, or "fiberglass."
3. Capacity shall be based on 50 gallons (0.2 m³) of sewage per person per day with a minimum capacity of 500 gallons (1.9 m³).
4. Tanks shall operate at a minimum level of 4 ft (1200 mm).

4.10.3.4 If septic tanks are used, then absorption beds shall be provided to handle discharge from the septic tanks.

4.10.3.5 If an adequate absorption bed cannot be provided for a septic tank, then effluent may be discharged to the process sewer if approved by engineer of record and provided the following requirements are met:

1. All regulatory requirements for sanitary wastewater handling, disinfection, and conveyance shall be met.
2. Outlet from septic tank shall be hydraulically sealed
3. A vent shall be provided on septic tank or on the line between septic tank and house trap.
4. Septic tank effluent shall discharge downstream of the oil/water separation part of the process wastewater treatment plant but upstream of the secondary (biological) treatment facilities.

Comment: Installation of a hydraulic seal prevents the transmission of flammable vapor from the process sewer into the sanitary system. Proper venting prevents loss of hydraulic seals by either a pressure buildup or siphoning during normal sewer operations. Connecting the sanitary system downstream of the separation facility reduces risk of involvement in a process sewer system fire or explosion.

4.10.3.6 Minimum design velocity shall be 2 fps (0.6 m/s) with pipe flowing half full at maximum flow rate.

4.10.4 Process Sewers

4.10.4.1 Underground process sewers shall be designed to protect against groundwater contamination.
4.10.4.2 Underground process sewers shall be designed to prevent potential leakage caused by anticipated corrosion, surface loads, shifting soils, water tables, etc., for owner’s specified design life.

4.10.4.3 Underground process sewer joining systems shall be welded, fused, or glued unless otherwise specified.

4.10.4.4 Underground process sewers shall be designed in accordance with owner’s Process Safety Management (PSM), environmental, and health requirements.

4.10.4.5 Process sewer designs shall be in accordance with regulations in *EPA 40 CFR*.

4.10.4.6 Acidic or caustic waste lines shall in no case be connected to stormwater or sanitary sewers.

4.10.4.7 Acidic or caustic waste lines shall not discharge to process sewers unless waste has first been neutralized or treated to be compatible with the process sewer materials and non-reactive with the process waste. Method of neutralization or treatment is as specified.

*Comment:* Method of neutralization is dependent on the type of waste present and must be specified on a case-by-case basis. Acids and caustics can impact the treatability of certain wastewaters and can also result in the evolution of hazardous materials (e.g., sulfides) in the sewer and wastewater treatment units, with potential air quality and / or personnel exposure issues. pH extremes can impact the integrity of sewer pipes, thereby increasing risk of sewer pipe leakage to soil/groundwater.

4.10.4.8 Corrosive chemical floor drains and catch basins shall be piped to a chemically resistant sump or chemical sewer. Floor drains and catch basins shall have acid-resistant slotted covers or grates. Floor drains shall have a strainer composed of acid-resisting material to prevent refuse from clogging the drains. See Section 4.10.7 for requirements to neutralize or treat acidic or caustic waste before discharge to process sewers.

4.10.4.9 Design flow depth of gravity process sewers shall not exceed 2/3 of the pipe diameter with a minimum velocity of 3 fps (0.9 m/s).

4.10.4.10 Materials for drain system piping from refrigerated and pressurized storage vessels, including valves outside the enclosure, shall be suitable for the lowest temperature that may be encountered during a spill.

**4.10.5 Seals and Vents**

*Comment:* Hydraulic seals prevent potentially hazardous or flammable vapors from back flowing from the sewer system into the drained area. Proper venting of sewer system prevents loss of hydraulic seals by either a pressure buildup or siphoning during normal sewer operations and allows vapors to be safely discharged.
4.10.5.1 Hydraulic seals and sediment traps shall be at catch basins, manholes, or similar structures to provide direct access for cleanout.

4.10.5.2 Catch basin seals, where applicable, shall be as follows:

1. Seals shall provide a minimum 6-inch (150-mm) hydraulic seal at zero flow level.
2. Seals shall be gas tight and accessible for cleaning.
3. Seals shall be bolted in place or otherwise installed so as to be replaceable without demolition of the drain or catch basin.
4. Material shall be equal to or better than the sewer line, resistant to atmospheric conditions and the wastewater constituents, and owner-approved.
5. Seals shall include provisions for clear, easy opening to allow direct, full diameter in-line access to the sewer line for periodic cleaning.
6. Seal shall be at either the outlet of the catch basin or the inlet to the manhole, and shall preferably be located consistently throughout the plant.

*Comment:* Detail requirements for seals are provided to ensure that they remain effective in prevention of vapor transmission from one area to another. Experience has shown that seal material can fail, resulting in vapor (reverse) migration into a catch basin.

### 4.10.5.3 Vents

1. Sewers requiring vents shall be specified by owner or shall be required on the basis of the properties of chemicals contained in the sewers or process area.
2. Collection systems shall be trapped and sealed to prevent personnel exposure to emissions.
3. Sewers and sewer vents shall be designed to comply with regulations for control of volatile organic compound (VOC) and hazardous air pollutant emissions.
4. Vents shall be located away from normal operating areas and shall be equipped for secondary VOC emission disposal (e.g., scrubbed, flared, etc.) if required. Vent discharge location and elevation shall be as follows, which may require an underground extension to a safe location and attachment to a pipe support or other structure.
   a) Vent discharge shall be at least 10 ft (3 m) above grade in a safe, open area.
   b) Vent discharge shall be at least 10 ft (3 m) above any platform, elevated road/accessway, etc., located within a horizontal distance of 25 ft (7.5 m).
   c) Vent discharge shall be above any equipment, building, or pipeway/rack located within a horizontal distance of 25 ft (7.5 m).
d) Vent discharge shall be at least 50 ft (15 m) above grade when less than 100 ft (30 m) from a fired heater, substation, switch rack, or similar ignition source, and shall in no case be less than 50 ft (15 m) from such ignition sources.

e) Vent discharge shall be at least 3 ft (1 m) from any other sewer vent of a different sealed section of sewer.

5. The highest manhole or highest point in each branch of each sealed section of the sewer system shall be vented.

6. Vent piping shall be as follows:

   a) Vent pipes shall be 4 inch (100 mm) maximum nominal pipe size.
   b) Vent pipes shall be vertical at the discharge end and cut horizontal to discharge upward.
   c) Vent pipes shall be sloped to drain back to the manhole without low points, which can trap liquid.
   d) Vent pipes shall have at least one flanged joint above and near grade to allow for cleaning access and extension/replacement without welding.
   e) Vent pipes shall be marked as specified by engineer of record for easy field identification as a sewer vent.

Comment: The vertical direction of a vent helps aid in dispersion. It also avoids flame impingement issues if ignited. During staged civil work, the flange is blinded to avoid soil/gravel falling into the vent. Caps on open 4-inch (100-mm) vents have not been successful. Vents are marked to highlight locations where potential hazardous or flammable gases may be present. Sites have different identification systems that must be specified on a case-by-case basis.

7. Vents shall be protected from damage by mobile equipment and vehicles.

Comment: Damage can render a vent ineffective. The result is a non-vented sewer/manhole. Without a vent, vapor can "blow through" and out a catch basin, resulting in a potential fire.

4.10.6 Drains

4.10.6.1 Use of open channel floor or pavement drains in process areas requires owner's approval. Such drains shall be covered with grating.

Comment: Open channel drains are a potential source of spreading a fire or creating a wall of fire. Additionally, open floor drains pose a tripping hazard to workers.

4.10.6.2 Process drains discharging to the process sewer, including open channel floor or pavement drains, shall discharge to the sewer system through a minimum 6-inch (150-mm) hydraulic seal such as a self-
sealing drain hub, "P" trap, or the line sealed (submerged) into a junction box.

*Comment:* Hydraulic seals prevent potentially hazardous or flammable vapors from backflowing from the sewer system through the process drains.

4.10.6.3 Building drains shall be as follows:

1) Floor drains shall not be installed in control houses or electrical substations except as provided for in 4.10.3.1.

2) If floor drains are used in other buildings where they will handle process wastewater, they shall be connected to the process sewer through a seal.

3) Drains for sample rooms, laboratory sinks, and similar facilities containing hydrocarbons/oils, but free of corrosive chemicals, shall discharge through a seal to an oil collection facility or sump, and then to a process (oily water) sewer system or other closed collection system.

4) A running trap with double hub vented to the atmosphere shall be installed in the sewer line at a point where the drain line leaves the building.

*Comment:* In critical buildings, floor drains are not permitted to be connected to the process sewer. This practice reduces the chance of hydrocarbon vapors collecting through a leaking or dry seal. In other buildings, where hydrocarbons are normally present, hydraulic seals are provided to prevent vapor transmission. The running trap provides a vapor seal to prevent transmission of vapors from the sump to the building.

4.10.7 Catch Basins

4.10.7.1 Catch basins shall not be located beneath equipment, pipeways/pipe racks or major piping, instrumentation or controls, structures, or stairways or ladders, including their landings.

*Comment:* Catch basins are collection points for drainage. During a fire, flammable liquid will pool at the catch basin, increasing risk to any facilities located above it.

4.10.7.2 Catch basins shall not be located within 10 ft (3 m) horizontally of air fin coolers, battery limit valve stations, or valves provided for the purposes of emergency isolation, emergency shutoff, activation of snuffing steam, activation of water spray/deluge systems, etc.,

4.10.7.3 Catch basins in process area or process service shall:

1) One catch basin shall not be connected to or flow through another catch basin.

2) Discharge to the sewer through a minimum 6 inch (150 mm) hydraulic seal. Where the seal is provided in the manhole, the line from the catch basin shall be individually routed to the manhole.
Comment: To prevent transmission of a flammable material from one area to another, catch basin to catch basin flow is not permitted. Hydraulic seals prevent potentially flammable vapors from being emitted from the sewer system through the catch basin.

4.10.7.4 Catch basins in segregated stormwater sewer service may be connected in series with engineer of record approval.

4.10.8 Valves

4.10.8.1 Valves shall be of an end-of-pipe style that is attached on only one side and completely free on the opposite side (see Figure 1).

Figure 1. Example of Enclosed Area Drainage

4.10.8.2 For in-line service, valves shall be installed in a manhole or similar structure, as approved by owner, which provides the means for continuation of flow and that, provides access for maintenance and replacement (see Figure 2).
4.10.8.3 Valves installed in manholes or other structures shall have a position indicator visible from outside the manhole or structure.

4.10.8.4 Valves shall be bolted in place and shall be removable without cutting or burning.

4.10.8.5 Valve components shall be of corrosion-resistant materials such as cast iron, stainless steel, and galvanized steel.

4.10.8.6 Moving parts shall be designed to be non-binding and made of materials, such as brass, that do not require frequent lubrication.

4.10.8.7 Valve stems shall have a suitable closure and packing to prevent vapor from escaping at penetrations through lids or covers in closed sewer systems.

4.10.8.8 Valves that may be subject to an unseating pressure shall be capable of resisting that pressure.

4.10.9 Manholes

4.10.9.1 Manholes shall be located as follows:
1. Manholes shall be located at spacing intervals to facilitate maintenance, inspection, and cleaning.
2. Manholes or cleanouts shall be provided at changes in horizontal direction.
3. Maximum spacing of manholes shall be 200 ft (60 m) for sewers less than or equal to 12 inches (300 mm) in diameter and shall be 500 ft (150 m) for sewers larger than 12 inches (300 mm) in diameter.
4. Manholes shall not be located beneath equipment, pipeways/rack or major piping, instrumentation or controls, structures, or stairways or ladders, including their landings.

Comment: During a sewer explosion, it is possible for the manhole lid to be launched and cause damage to any facility.
above it. The subsequent fire may also increase risk to any facilities located above it.

5. Manholes shall be installed where a sewer line from a process unit connects to a sewer outside the unit.

*Comment:* Addition of a manhole provides additional isolation of two process areas during a sewer explosion.

6. Manholes serving more than one integrated process unit or integrated plant area shall not be located inside a process unit.

7. Manholes shall not be located inside tank dike areas except when they receive drainage only from the tank and dike area within which they are located.

4.10.9.2 The top of the outlet line shall be no higher than top of the lowest inlet line, except for inlet lines submerged to form a seal.

*Comment:* The top of the outlet pipe must not be higher than the top of the inlet pipe so that during a high flow situation the system remains adequately vented.

4.10.9.3 Sealed manholes shall be provided as follows:

1. All sewers from process areas, storage areas, loading/unloading, pumping, or other areas where hydrocarbons/oil or chemicals are handled shall pass through sealed and vented manholes when tying into a main plant sewer.

2. Integrated plants or large process areas shall be subdivided into process areas of not more than 60,000 ft² (5,600 m²) each separated by a sealed manhole.

3. The sewer for an individual process unit or part of a unit located within an integrated plant but designed to operate separately from the entire plant shall be separated by a sealed manhole from other units and shall discharge to a main that is isolated from other process units by seals (see Figure 3).

4. The plant main sewer shall pass through a sealed manhole before entering a separator to prevent a separator fire from traveling back up the sewer into the plant.

*Comment:* Requirements for sealed manholes are provided to ensure an adequate vapor separation between process areas. Additionally, area limits are provided to reduce the size of facilities that may be involved in plant fires.

4.10.9.4 Manhole vents shall be as follows:

1. All sealed sections of a sewer system shall be vented on both sides of the seal to prevent blowing of seals by pressure buildup, as follows:
   
a) Manholes with baffle-type seals shall be vented on both sides of the seal by separate vent pipes discharging to locations at least 3 ft (1 m) apart.
b) Where manhole seals are established by submerging inlet connections, a vent shall be provided on both the sealed manhole and the next manhole upstream.

![Diagram of Integrated Plant Area with Manholes and Seals]

**Figure 3: Example Location of Sealed Manholes to Isolate Units in an Integrated Plant**

### 4.11 Fencing and Security

4.11.1 Chain-link fencing shall be in accordance with *PIP CVS02830*.

4.11.2 If a facility is deemed a “Covered Facility”, refer to Site Security Plan and implement appropriately risk-based measures designed to satisfy performance standards of *Part III, U.S. Department of Homeland Security 6 CFR Part 27*.

### 4.12 Landscaping, Seeding, and Sodding

4.12.1 Surface treatments shall be shown on final earthwork drawings.

4.12.2 Seeding and sodding shall comply with local DOT specifications.