An Introduction to Petroleum Fuel Facilities: Piping Systems

J. Paul Guyer, P.E., R.A.

Paul Guyer is a registered civil engineer, mechanical engineer, fire protection engineer and architect with 35 years of experience designing buildings and related infrastructure. For an additional 9 years he was a principal staff advisor to the California Legislature on capital outlay and infrastructure issues. He is a graduate of Stanford University and has held numerous national, state and local offices with the American Society of Civil Engineers, Architectural Engineering Institute and National Society of Professional Engineers.

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1. INTRODUCTION. This publication provides guidance for the design of new piping portions of fueling systems. The criteria provided is intended to be general in scope except where specific criteria is necessary for given situations.

2. GENERAL REQUIREMENTS. Do not start design of any fueling system without first becoming completely familiar with General Design Information.

2.1 DESIGN REQUIREMENTS. Ensure that piping design, materials, fabrication, assembly, erection, inspection, and pressure tests for fuel piping systems are in accordance with ANSI/ASME B31.3. Follow appropriate guide specifications for piping design and materials selection. Use the following design criteria for piping systems:

a) Unless otherwise specified by Owner, provide underground piping systems in and around areas subject to aircraft ground movements. If approved by Owner, install piping in concrete trenches. When trenches are employed, comply with NFPA 415. The use of common trenches for more than one utility is prohibited. Fueling equipment may be aboveground where it does not interfere with aircraft or service vehicle movements. Design all clearances in accordance with DoD Standard Design AW 78-24-28.

b) In other cases, aboveground piping is preferred where it is not aesthetically objectionable or not exposed to accidental damage, vandalism, blast damage, or sabotage. \1\ Small diameter (≤4 inches (100mm)) pipe associated with the aboveground storage of fuel/oil shall be single wall aboveground piping. Exemptions may be granted by the Owner in cases where routing aboveground could result in catastrophic damage to the pipe. If an exemption is granted, double-wall piping must be installed in accordance with the paragraph titled “Double-Wall Piping”.

c) The preferred method of routing aboveground piping out of a diked area is over the top of the dike. However, avoid creating an inverted “U” on the suction side of a pump to avoid an air trap. Provide high point vents and low point drains as required, refer to Facility Plate 019.

d) Hydrostatically test new piping systems in accordance with ANSI/ASME B31.3. During testing, disconnect system components such as storage tanks or equipment which were not designed for the piping test pressure or protect them against damage by over-pressure. Hydrostatically test systems to 1.5 times the maximum allowable design pressure of the ANSI/ASME B16.5 piping system flanges at 100 degrees F (38 degrees C), see Table 1. Test hydrant and direct aircraft fueling systems and installation fuel pipelines with fuel that will be used in the pipeline or, at a minimum, a fuel with the same minimum specification flashpoint as the fuel that will be used when the piping is in service. The temperature of the fuel, and the ambient temperature, shall be at least 20 degrees F (11 degrees C) below its flashpoint during the test.

e) Testing with water requires Owner approval. When water is authorized for hydrostatic testing of fuel piping, ensure that all water is removed from the piping by either pigging the piping, air drying the line, or by vacuum extraction.

f) Lay out piping between piers and storage tanks, cross-country pipelines, and between bulk storage and operating tanks to accommodate pigging operations. Use long radius elbows, full port valves, barred tees, and provisions for the connection of temporary launchers and receivers. Give special consideration to smart pigging for single wall pipelines.

g) When laying out piping for single wall aircraft hydrant systems, consider smart pigging/pigging in the design. For systems with required piping slopes and high and low level drains, provide long radius turns, and provide spool pieces for temporary pig launchers and receivers. Ensure valves are accessible for removal and replacement with spool pieces. Where it is more economical or practical to lay hydrant piping flat (slope less than 0.2 percent), provide the capability to rapidly clean the lines with a pig or to launch a smart pig. This includes providing long radius turns, full port valves, barred tees, and pig launchers and receivers.

h) Provide thermal relief devices on all installed double block and bleed valves and other valves within the piping system. Provide drain out with non-freeze valves at all low points of pipelines.

2.1.1 HYDRAULIC DESIGN. In general, provide a hydraulic design with a velocity of 7 to 12 feet per second (2.1 to 3.7 m/s) on pump discharge and 3 to 5 feet per second (0.9 to 1.5 m/s) on pump suction at full flow. If project-specific conditions make it advisable to exceed these values, consult the appropriate Owner. Consult with appropriate Owner for outlet pressure requirements. Design suction piping to ensure that the net positive suction head required by the pumps is available under all conditions of operation. Consider the following factors in selecting pipe sizes:

a) Operating requirements of the facility to be served.
b) Capital cost of the pipe.
c) Capital cost of pumping stations and attendant facilities.
d) Operating cost of the system.
e) Harmful effects of excessive velocity of flow including hydraulic shock and static generation.
f) Fatigue failure caused by cyclic loading.

2.2 PIPING ARRANGEMENT. Wherever possible, arrange piping in parallel groups to facilitate multiple use of supports, to minimize the amount of trenching for underground piping, and to minimize the number of steps or stiles needed across pipe runs. For underground applications, consider constructability when determining amount of spacing between pipes. Use the following criteria:

a) Provide looped piping systems whenever practical. Loops add to the flexibility and reliability of the system, contribute to product cleanliness by making circulation possible, and can be used to reduce the magnitude of hydraulic shock. Sectionalize loops by double block and bleed valves to provide verifiable isolation and to facilitate pressure testing.

b) Between mains, install cross connections for flexibility of operation and as an auxiliary means of continuous operation in emergency situations. In addition, permit the use of line blinds where space limitations preclude the use of removable pipe sections or fittings. Provide a separate piping system for each grade of fuel to be handled. Do not provide cross connections between grades.

c) For short runs, provide a line slope of at least 0.2 percent. For long runs, make line slope sufficient to establish positive drainage by gravity, but without excessive bury depth. Make gradients uniform between high and low points. Traps are undesirable because they provide a place for water and sediment to accumulate. Install drains at low points to allow removal of any water from condensation. These low point drains also provide the capability to remove fuel for line maintenance. If slope is not possible, design the system to accommodate pigging by providing flange connections for pig launchers/receivers, long curvature fittings, barred tees, and full port valves. Install high point vents to remove trapped air. Low point drains are not required on interterminal pipelines.

d) As a general rule of thumb, provide spacing between piping that will allow a minimum clearance of 3 inches (75 mm) between adjacent flanges. In certain situations, such as in a piping trench or other restrictive location, it may be necessary to reduce the spacing. A minimum of 12 inches (300 mm) or one pipe diameter, whichever is greater, should still be maintained between pipe walls.

2.3 SURGE ANALYSIS. Conduct a complete surge analysis of system operation using a computer simulation program for all systems with quick closing valves and for aircraft hydrant and direct fueling systems with more than two outlets. Give full consideration to the causes and effects of hydraulic shock. This is especially important in closed fueling systems such as aircraft fueling systems where the receiving tanks or dispensing equipment may be damaged by shock pressure. Reduce the possibility of shock by limiting flow velocity and avoiding the use of quick opening/closing valves except where required for system operation such as hydrant pit valves. Do not reduce flow velocities below minimum velocity required. Every reasonable effort must be made to control hydraulic surge or shock within acceptable limits by the design of the piping system rather than by the use of surge suppressors. Surge suppressors are strictly a last resort solution and require the approval of Owner prior to designing into a system. For all aircraft direct fueling/hydrant system designs, the loop backpressure control valve is critical in preventing excessive hydraulic shock. Use the following design criteria and Table 1 for piping design pressures:

a) For all complex piping systems (main header, several laterals, mobile equipment), employ computer modeling techniques to determine if surge suppression is required. Conduct a run at steady state flow conditions to establish system flow rates for the scenario being modeled. After that, conduct a transient surge analysis imposing worst-case operating conditions on the system. For hydrant systems incorporating the use of a back pressure control valve, simulate this valve as an active modulating valve. If acceptable peak pressures are exceeded, discuss the results with the Owner fuels engineer to review parameters used and consider alternatives. If this consultation produces no workable solution, perform a second surge analysis to model the use of surge suppressors in the system. This analysis must indicate that damaging peak pressures are not exceeded. Do not use manual surge calculations, except as found under (c) below, because they do not account for dampening effects of the system and yield overly conservative results.

b) Most systems designed in accordance with this publication will have ANSI Class 150 flanges and the maximum allowable operating pressures seen in Table 1. Design the system such that the total pressure including surge, pump shutoff pressure, thermal fuel expansion effects, and static pressure in any part of the system never exceeds the maximum allowable operating pressure. Other equipment items such as tank trucks, aircraft fuel tanks, or shipboard fuel tanks which may be damaged by shock pressures may require lower maximum surge pressure. Assume a near instantaneous shut-off by the aircraft in the design of aircraft hydrant systems.

c) Do not use manual calculations instead of computer modeling when system surge pressures are crucial and the piping system is complex. However, for simple piping systems that operate under 80 psi (550 kPa) manual calculations can be used to ascertain if surge will be a problem.

	ASTM A 105	ASTM A 182 Gr. F304	ASTM A 182 Gr. F304L
Maximum Allowable Design Pressure	285 psig (1970 kPa)	275 psig (1900 kPa)	230 psig (1590 kPa)
Maximum Hydrostatic Test Pressure	450 psig (3100 kPa)	425 psig (2930 kPa)	350 psig (2400 kPa)
Minimum Hydrostatic Test Pressure	425 psig (2930 kPa)	400 psig (2760 kPa)	325 psig (2240 kPa)
Maximum Allowable Operating Pressure	285 psig (1970 kPa)	275 psig (1900 kPa)	230 psig (1590 kPa)
Maximum Allowable Surge Pressure	380 psig (2620 kPa)	366 psig (2525 kPa)	306 psig (2100 kPa)

1. All pressure values are taken from ANSI/ASME B16.5, ANSI/ASME B16.47 and ANSI/ASME B31.3 at 100 degrees F (38 degrees C).
2. Values are presented for information only. Confirm actual values with ANSI/ASME B16.5, latest edition, based on actual temperatures, bolting and gasket materials, etc.
3. For other materials, see ANSI/ASME B16.5 and ANSI/ASME B31.3.
4. For lower hydrostatic test pressures, the maximum allowable operating pressure will be lower than indicated. See ANSI/ASME B31.3.

Table 1

Allowable Pressure Table – ANSI Class 150 Flanged Joints

3. ABOVEGROUND PIPING. Support aboveground piping so that the bottom of the pipe is a minimum of 18 inches (450 mm) above the ground surface or higher if required to service valves and equipment. In areas subject to flooding, greater clearance may be desirable. At intersections with roadways, allow enough clearance for the passage of tank trucks, cranes, and similar heavy vehicles. In areas subject to seismic activity, provide the piping configuration and support in accordance with the seismic design criteria. Wherever possible, arrange piping in parallel groups to facilitate multiple uses of supports, to minimize the amount of trenching for underground piping, and to minimize the number of pipe stiles needed. Consider constructability and maintenance in spacing of piping. As a general rule of thumb, provide spacing between piping that will allow a minimum clearance of 3 inches (75 mm) between adjacent flanges. In certain situations, such as in a piping trench or other restrictive location, it may be necessary to reduce the spacing. A minimum of 12 inches (300 mm) or one pipe diameter, whichever is greater, should still be maintained between pipe walls.

3.1 IDENTIFICATION. Identify piping in accordance with Chapter 2 of this UFC. In addition, mark fuel lines at head of fueling pier near valves, and mark valve “open” and “close" positions.

3.2 PIPE SUPPORTS. Rest piping on supports, both insulated and uninsulated, on a steel shoe welded to the bottom of the pipe. Leave the shoe free to move on the support. Construct the portion of pipe supports in contact with the ground with concrete. Ensure that support material is the same as the pipe material. Other support configurations are acceptable provided the support does not contain rollers, does not allow movement of the pipe on a metal surface, and does not include hangars. Design pipe supports to meet the applicable requirements of ANSI/ASME B31.3 or ANSI/ASME B31.4.

3.3 ARRANGEMENT. Arrange pipes to provide for expansion and contraction caused by changes in ambient temperature. Where possible, accommodate expansion and contraction by changes in direction in piping runs, offsets, loops, or bends. Where expansion loops or off-sets are not possible, use flexible ball joint offsets. Provide sliding pipe supports or other method of maintaining alignment on each side of the expansion joint. Do not use expansion devices which employ packings, slip joints, friction fits, or other non-fire resistant arrangements. Use ball-type offset joints to accommodate possible settlement of heavy structures such as storage tanks, if piping design cannot provide enough flexibility. Design expansion bends, loops, and offsets within stress limitations in accordance with ANSI/ASME B31.3 and ANSI/ASME B31.4. Thermal expansion of pipes should also be calculated based on the pipe being empty to include considerations for when the pipe is being installed or drained.

3.4 ANCHORS. Anchor aboveground piping at key points so expansion will occur in the desired direction. Anchors and guides may also be required to control movement in long runs of straight pipe or near a connection to fixed equipment such as a pump or filter. See Facility Plate 021. Space anchors to provide maximum amount of straight runs of piping from expansion points to the anchors. In general, place anchors at all points of the system where only minimum piping movement can be tolerated, such as at branch connections and equipment connections. Key locations are pump houses or other buildings, manifolds, at changes of direction if not used as an expansion joint, at points where the pipe size is drastically reduced related to adjacent piping, and at all terminal points. Limit the use of anchors to the situations described above. Where an anchor is welded directly to a pipe, ensure that the anchor material is compatible with the pipe material.

3.5 THERMAL RELIEF VALVES. The coefficient of expansion of liquid petroleum in the range of 35 degrees to 60 degrees API (0.8498 to 0.7389) at 60 degrees F (16 degrees C) is 0.0005 gallon per gallon per degree F (0.0009 L per L per degree C). The total volume generated in most cases is very small, but the pressure increase resulting from this expansion can equate to as much as 75 psi for every degree rise in the fuel temperature if not relieved. For this reason, provide any section of pipe that has the potential to be isolated by a shut-off valve or other means with a thermal relief valve to relieve the isolated piping section. Provide a thermal relief of the internal cavity of valves where pressure is trapped when the valve is in the closed position (double block and bleed plug valves for example).

3.5.1 MATERIAL OF THERMAL RELIEF VALVES. The thermal relief valve should match the material of the piping in which it is installed. Provide valves used for relief of thermal expansion of not less than 3/4-inch (20 mm) nominal pipe size. It should be provided with isolation ball valves, with removable handles, on the inlet and outlet. The set pressure of the relief valve will vary, but consider a set pressure of about 10 percent above the dead-head pressure of the pump. This should keep the valve from opening during normal fueling operations. Ensure the set point is within the design limitations of the piping. Do not provide thermal relief piping with sight flow indicators.

3.5.2 DISCHARGE OF THERMAL RELIEF VALVES. Thermal relief valves should never discharge to grade or to a stormwater drainage system. Ideally, the relief valve should discharge to a header which is piped directly to an atmospheric source such as a storage tank or product recovery tank. Often, the practical alternative, is to configure the relief valves into a cascading system, where each relief valve bypass the shut-off valve that is isolating the piping section and discharges back into the main product piping. The excess volume may pass through two or more relief valves before finally making its way back to an atmospheric source. Caution must be taken to ensure that the relief valves have the capacity to handle the additive relief flows this type of system creates and that the total relief pressure does not exceed that system maximum allowable operating pressure. In a cascading system, consider using balanced type relief valves. Balanced type relief valves limit pressure buildup that is created in a cascading system, because the balanced type relief valves relieve at a point independent of downstream pressure. In some cases a small atmospheric tank may need to be placed to properly relieve a piping system. This may be the case if a system component has a lower maximum allowable pressure then the rest of the system or in a remote location where a cascading system will not work. Equip the tank with self-checking high level alarms and containment. See Facility Plates 023, 024, 025 and 026.

4. UNDERGROUND PIPING. Provide underground piping which passes under public roadways or railroad tracks in accordance with Department of Transportation regulations 49 CFR Part 195 and API RP 1102. Refer to Chapter 2 of this UFC for corrosion protection and for environmental protection. Before installing underground pipelines, review all federal, state, and local regulations for double wall pipe, leak detection, and corrosion protection requirements.

4.1 DEPTH OF COVER. Use the following criteria for depth of cover over buried fuel pipelines:

a) Locate top of lines at a minimum of 3 feet (0.9 m), except that less cover is permissible for occasional stretches where overriding conditions exist, such as the need to pass over a large culvert or beneath drainage ditches. At such locations, build sufficient slack into the line to allow for vertical and lateral movement due to frost heave. Refer to UFC 3-130 series for additional guidance. Protective measures, such as the installation of reinforced concrete slabs above the pipe, may also be required where depth is less than required under Paragraph (b) below.

b) Subject to Paragraph (a), provide minimum depths in accordance with 49 CFR Part 195 and federal, state and local regulations. Under roadways and shoulders of roadways, provide a minimum depth of 4 feet (1.2m).

4.2 PARALLEL AND CROSSING PIPES. Provide a minimum clearance of 12 inches (300 mm) between the outer wall of any buried POL pipe and the extremity of any underground structure including other underground pipe. Where pipelines cross and a minimum clearance of 12 inches (300 mm) cannot be achieved, provide an insulating mat between the pipes and centered vertically and on the point of intersection. Insulating mat shall be constructed of neoprene or butyl rubber and shall be 36 inch (900 mm) by 36 inch (900 mm) and 1/8 inch (3 mm) thick. Provide a test station with two test leads from each pipe. In areas where multiple utilities are routed in the same area (e.g., a utility corridor), make sure electrical and communication ducts/conduits are kept a minimum of 36 inches (900 mm) from all other underground utilities especially fuel, steam, and high-temperature water pipes. Refer to ANSI /IEEE C2, ANSI/ASME B31.4, and 49 CFR Part 195 for additional requirements. For pipes in concrete trenches, provide a minimum clearance of 6 inches (150 mm) between flanges and the trench wall and between adjacent flanges. If there are no flanges, provide a minimum clearance of 12 inches (300 mm) or one pipe diameter (based on largest pipe), whichever is greater, between the pipe and the trench wall and between adjacent pipes within the concrete trench.

4.3 CASING SLEEVES. Use steel casing sleeves only for those crossings where sleeves are required by authorities having jurisdiction, where it is necessary to bore under the roadway or railroad tracks to avoid interference with traffic, or where boring is the most economical construction method. When planning construction of open trench crossings, consider the economics of installing spare casing sleeves to eliminate excavating for future fuel lines. Ensure that the design isolates fuel-carrying pipes from contact with the casing pipes. Require a seal of the annular space at each end of the casing. Include a vent on the higher end of each casing. Locate crossings at a minimum depth of 36 inches (900 mm) beneath the bottom of drainage ditches. If this depth cannot be obtained, install above, but not in contact with, the casing or pipe, a 6-inch (150 mm) thick reinforced concrete slab of adequate length and width to protect the casing or pipe from damage by equipment such as ditch graders and mowers. Refer to API RP 1102 for additional information.

4.4 LINE MARKERS. Except where prohibited by national security considerations, install line markers over each buried line and allow for maintenance provisions in accordance with 49 CFR Part 195.

4.5 WARNING TAPES. Provide buried warning tape for all underground pipelines as required by the appropriate guide specification.

4.6 DOUBLE-WALL PIPING. Provide double-wall piping for Ground Vehicle Fueling Facilities and any other small diameter (≤4 inches (100 mm)) underground pipe installations. For other applications pipes >4 inches (100 mm) in diameter), do not use double-wall piping unless required by state or local regulations, and approved by Owner. Owner approval to use \1\ large diameter (>4 inches (100 mm)) /1/ double-walled pipe must be obtained at the programming level and at the 35 percent design level.

4.7 SINGLE-WALL PIPING LEAK DETECTION SYSTEMS. For all single-wall buried pipe not used in aircraft direct fueling systems, consider providing a leak detection system approved by Owner.

4.7.1 LEAK DETECTION FOR AIRCRAFT DIRECT FUELING SYSTEMS. For aircraft direct fueling systems, provide an automatic leak detection system approved by Owner, to test all buried portions of the piping system. Automatic leak detection systems measure changes in either the volume or pressure of the fuel in a fixed piping system, while accounting for variations in ambient temperature. The pressure type shall work by measuring the time rate of change of line pressure at two different pressures. The volume type shall work by measuring the amount of fuel required to maintain a constant pressure in a line, also at two different pressures. The system shall have sufficient sensitivity to detect leaks of at least 0.004 percent of line volume with a Probability of Detection = 95 percent and a Probability of False Alarm = 5 percent. All leak detection system shall be third party certified.

5. UNDERWATER PIPING. To receive fuel from offshore moorings, provide one or more underwater pipelines from the shore facility to the mooring. Limit the design of these systems to engineers with this type of experience. Coordinate offshore piping systems with Owner.

5.1 SPECIAL ARRANGEMENTS. At the mooring end of each pipeline, provide lengths of submarine fuel hose equal to 2.5 times the depth at high water. At the pipe end of the hose, provide a flanged removable section of hose 10 feet (3 m) long. At the free end of the hose, provide a steel valve with a marker buoy attached to a cable or chain which has sufficient strength and suitable fittings for the vessel to lift the hose and valve aboard.

5.2 CONNECTIONS. Lay out multiple fuel lines and connections so that they correspond to the layout of the ship's discharge manifold.

5.3 UNIQUE CONSIDERATIONS. In piping design, consider fuel characteristics as they may be affected by the sea water temperature, particularly in cold water. For diesel fuel, aviation turbine fuel, or other light fuels, small individual lines are preferable as follows:

a) Minimum nominal pipe size of 6 inches (150 mm).

b) For transfers of fuels exceeding 3,000 gpm (189 L/s), use 12-inch (300 mm) to 16-inch (400 mm) diameter pipe.

c) Instead of pipes larger than 16 inches (400 mm) in diameter, consider using two smaller diameter pipes.

d) At an accessible upland location, as close to the water entry as practical, provide a double block and bleed valve and a manually operated check valve or bypass to allow reversal of flow when required.

e) Provide a dependable means of communication between the vessel in the offshore berth and the shore facility.

5.4 CORROSION PROTECTION.

Wrap, coat, and cathodically protect underwater pipelines in accordance with requirements.

5.5 DEPTH OF BURIAL. Provide sufficient burial depth of underwater pipelines to prevent damage by dredging of the waterway, by ships' anchors, trawls, or by scouring action of the current. Specifically, ensure depth conforms to the requirements of 49 CFR Part 195. Where lines cross ship channels or anchorages, ensure the top of the pipe is at least 12 feet (3.7 m) below the theoretical, present or planned future bottom elevation, whichever is deeper. Recommended backfill in such areas is 2 feet (0.6 m) of gravel directly over the pipe, followed by stones weighing 50 to 60 pounds (23 kg to 27 kg) up to the bottom elevation.

5.6 PIPE THICKNESS AND WEIGHT. Provide sufficient pipe wall thickness to keep stresses due to maximum operating pressure and other design loads within design limits. Include full consideration to extra stresses which may occur in laying the pipe. It is common practice to use heavier wall pipe for water crossings of more than 200 feet (60 m) from bank to bank at normal water level. This affords greater stiffness and resistance to buckling during handling of the assembled crossing pipe and requires less weighting material to obtain the necessary negative buoyancy to keep the line in place while empty or containing a light product. Reinforced sprayed-on concrete is an acceptable weighting material. Hydrostatically test assembled crossing pipe before placing, unless crossing pipe is too long for prior assembly in one segment. In this case, separately test each segment as described.

6. PIPING MATERIALS.

6.1 NON-AVIATION SYSTEMS. Use carbon steel piping material for interterminal pipelines (regardless of product) and for all portions of non-aviation turbine fuel systems. FRP may be used for underground pipe (not in concrete trenches) in ground vehicle fueling facilities. FRP is not to be used in aviation turbine fuel system applications. The appropriate service guide specification includes the necessary requirements. See Facility Plate 022.

6.2 AVIATION SYSTEMS. New systems shall use stainless steel issue piping. Interior coated carbon steel may be used only with the approval of the Owner for piping downstream of the last issue filter/separator. Return piping shall be interior coated carbon steel. Give special consideration to the pressure rating of both the pipe and fittings to ensure adequacy to accommodate surge pressure. See Facility Plate 022 for piping material options.

7. WELDING CRITERIA. Ensure that the contract requires welding and welding inspections in accordance with appropriate guide specifications and/or standard design. Proper welding, done in accordance with the guide specifications, will prevent loose and adhered slag on the inside of the pipeline. Use 100 percent radiographed weld joints meeting the standards for severe cyclic service contained in ANSI/ASME B31.3 for piping downstream of the pump in hydrant systems. For all other underground steel pipes, use 100 percent radiographed weld joints meeting the requirements of ANSI/ASME B31.3.

8. PIPING CONNECTIONS.

a) For steel piping systems, use weld neck forged flanges with raised faces having a modified spiral serrated gasket surface finish.

b) Do not use cast iron flanges.

c) Do not use grooved pipe type couplings or similar fittings in permanent fixed piping systems.

d) Do not direct bury flanges, valves, mechanical couplings, threaded fittings, or any mechanical equipment. If they must be used in an underground system, enclose them in an accessible pit.

e) Use welded connections for joining steel pipe. Use flange connections for joining pipe to equipment. Use threaded connections only where unavoidable such as on differential pressure gages, pressure snubbers, and fuel sample points.

f) Use carbon steel bolts, studs, and nuts with carbon steel flanges. Use stainless steel bolts, studs, and nuts with stainless steel flanges. Stainless steel bolts may be used on carbon steel flanges in corrosive environments. Select stainless steel bolts, studs, and nuts based on seizing and elongation. Coordinate both strength with force needed to compress selected gasket. In locations where severe corrosion (typically salt air) is susceptible use flange and bolt seals, filled with grease preservative, as required to prevent and control corrosion.

g) In steel piping systems, use socket weld joints on 2-inch (50 mm) diameter nominal size and smaller pipe.

h) Make branch connections with butt welded tees except where the branch is at least two pipe sizes smaller than the run, in which case the branch connection can be made with a forged or seamless branch outlet fitting, which is designed in such a way that the connection can be radiographed.

i) Do not use wrinkle bends or mitered bends for changes in direction.

j) Except for unions and control tubing couplings, do not use threaded joints in stainless steel systems. Socket-weld stainless steel drain, vent, and pressure relief valve lines 2-inch (50 mm) in diameter or less. If aboveground, flanges may be used.

k) Join glass FRP piping by bell and spigot joints sealed with adhesive, except use FRP flanges for connections to flanged equipment such as pumps or valves. Ensure that no loading can be transferred from steel piping to FRP piping.

l) Connect all dissimilar metals with isolation flanges.

9. INTERIOR PIPE COATINGS. To protect aviation fuel quality and extend the life of the piping, minimize bare carbon steel piping (except interterminal pipeline) which comes in contact with aviation turbine fuels especially downstream of initial filtration equipment. Maximize the use of internally coated pipe. This is not intended to allow the use of lined carbon steel piping as a substitute for areas requiring non-ferrous piping. Comply with other paragraphs of this chapter for material selection. Interior pipe coating is not required on non-aviation piping except for carbon steel piping within the lower 36 inches (900 mm) of aboveground vertical storage tanks, and ballast lines on piers.

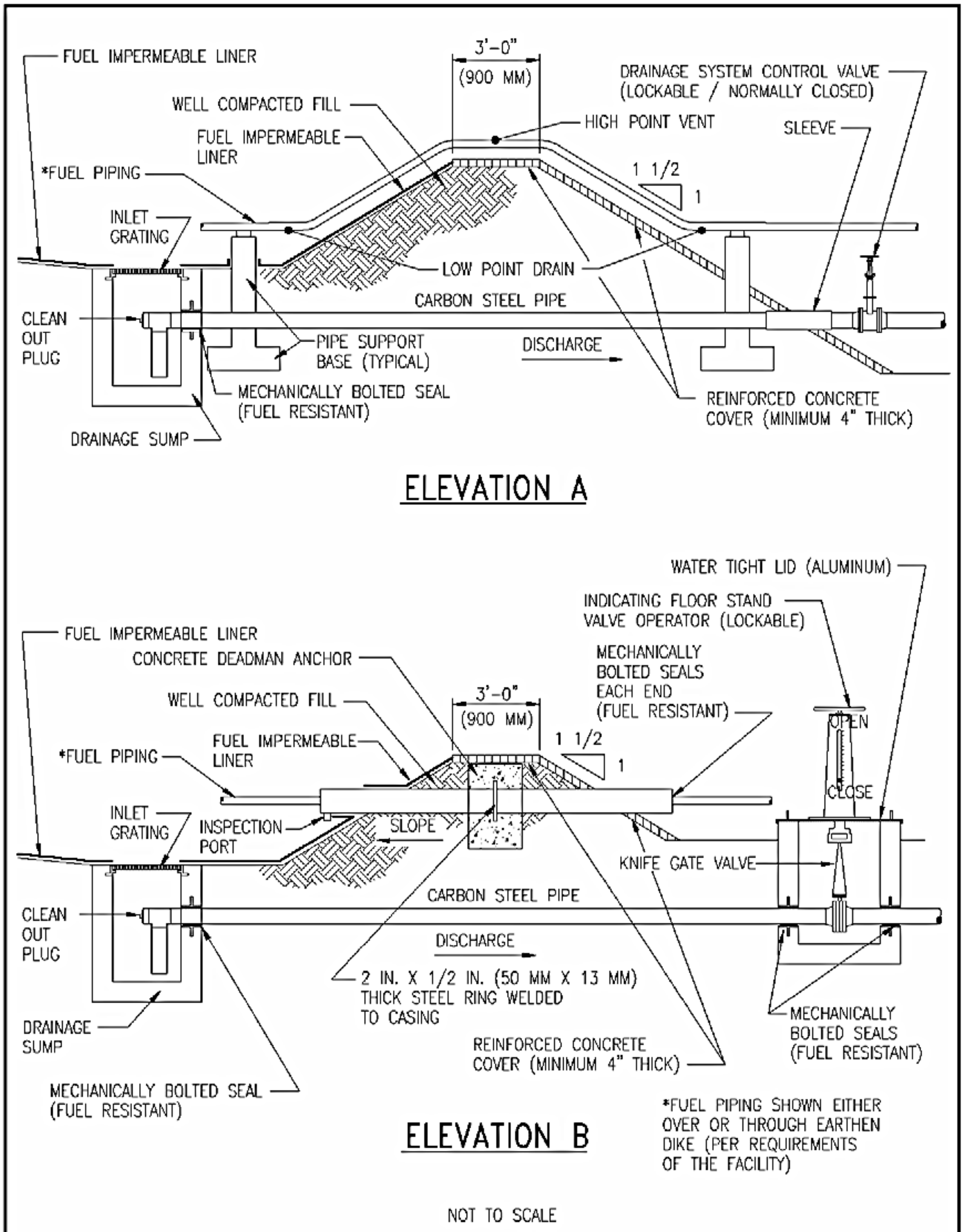
10. EXTERIOR PIPE COATINGS.

a) Protect the exterior surfaces of all underground steel piping systems with a continuously extruded polyethylene coating system or fusion bonded epoxy. Coat welded joints with a system compatible with the pipe coating.

b) Protect the exterior surfaces of all aboveground carbon steel piping systems by coating in accordance with applicable service requirement. Exterior surface of pipe shall be prepared by abrasive blasting and cleaned prior to coating application.

c) Coat underwater piping with the same materials used for underground piping. In addition, coat underwater piping with a reinforced sprayed-on concrete, or similar type material, for pipe stabilization and to provide negative buoyancy when the pipeline is empty.

11. SAMPLING FACILITIES. Provide connections for sampling fuels on each section of a fuel transfer piping system. Install sampling and testing connections at receiving points, tank outlets, inlet and outlet sides of filter/separators, all fuel dispensing points, and between isolation valves so that the remaining fuel in each portion of a fuel transfer pipeline can be sampled. Where possible, install sampling connections in vertical runs. Provide a 1/4-inch (8 mm) diameter sample point with a probe, ball valve, and quick disconnect with dust cap.



TITLE Earthen Dikes	DATE 07/08	FACILITY PLATE 019

Figure 1

Earthen Dikes

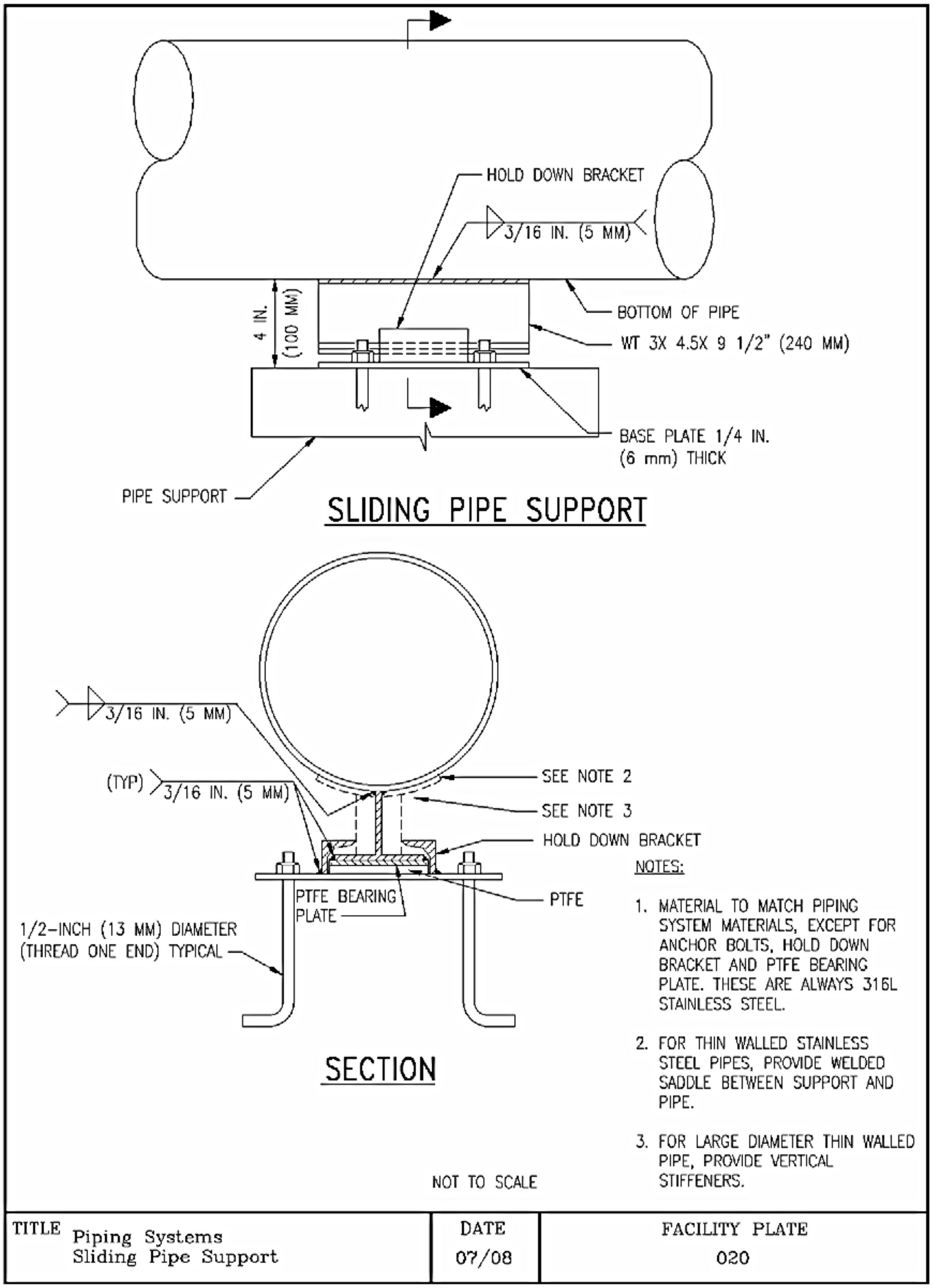


Figure 2

Piping Systems Sliding Pipe Support

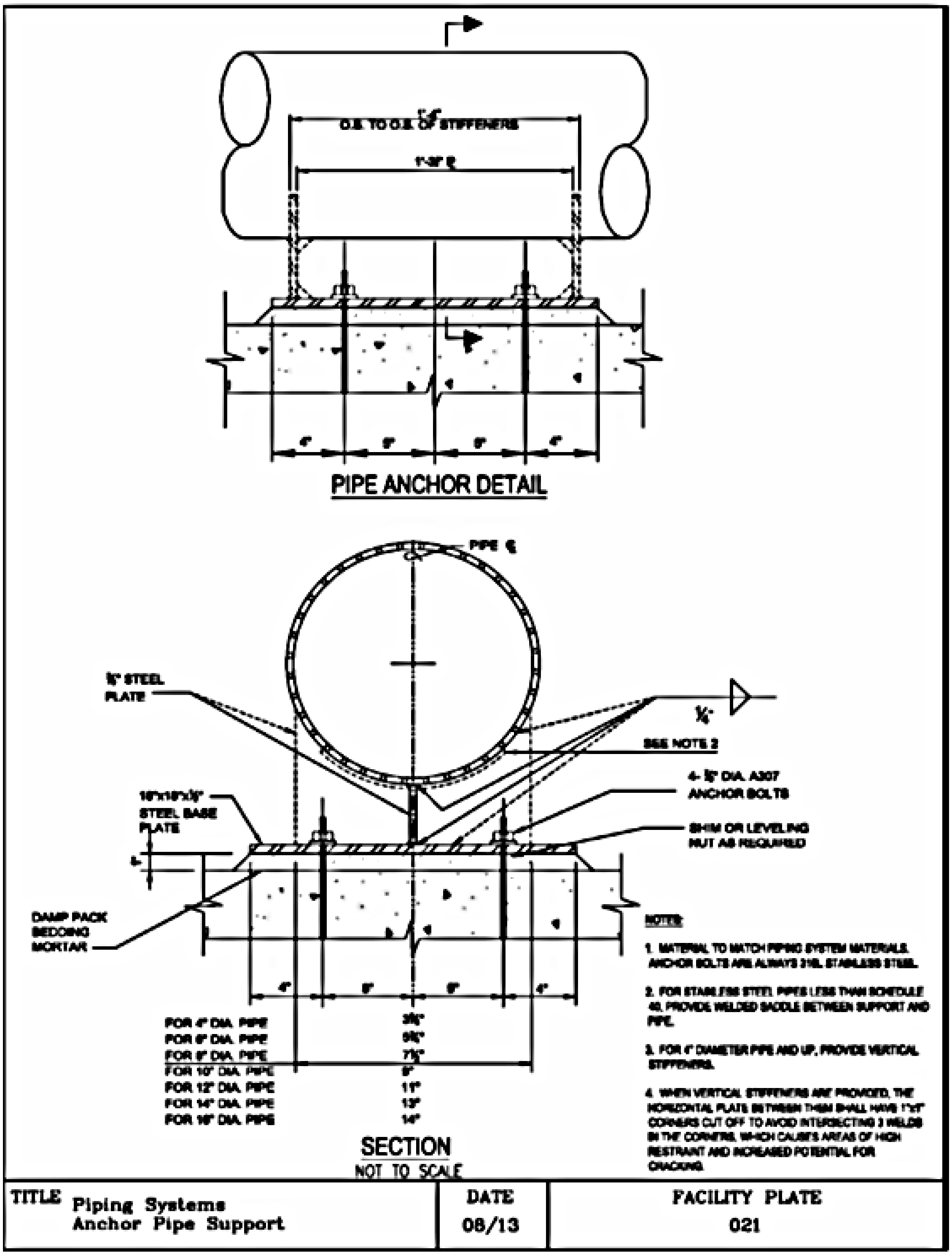


Figure 3

Piping Systems Anchor Pipe Support

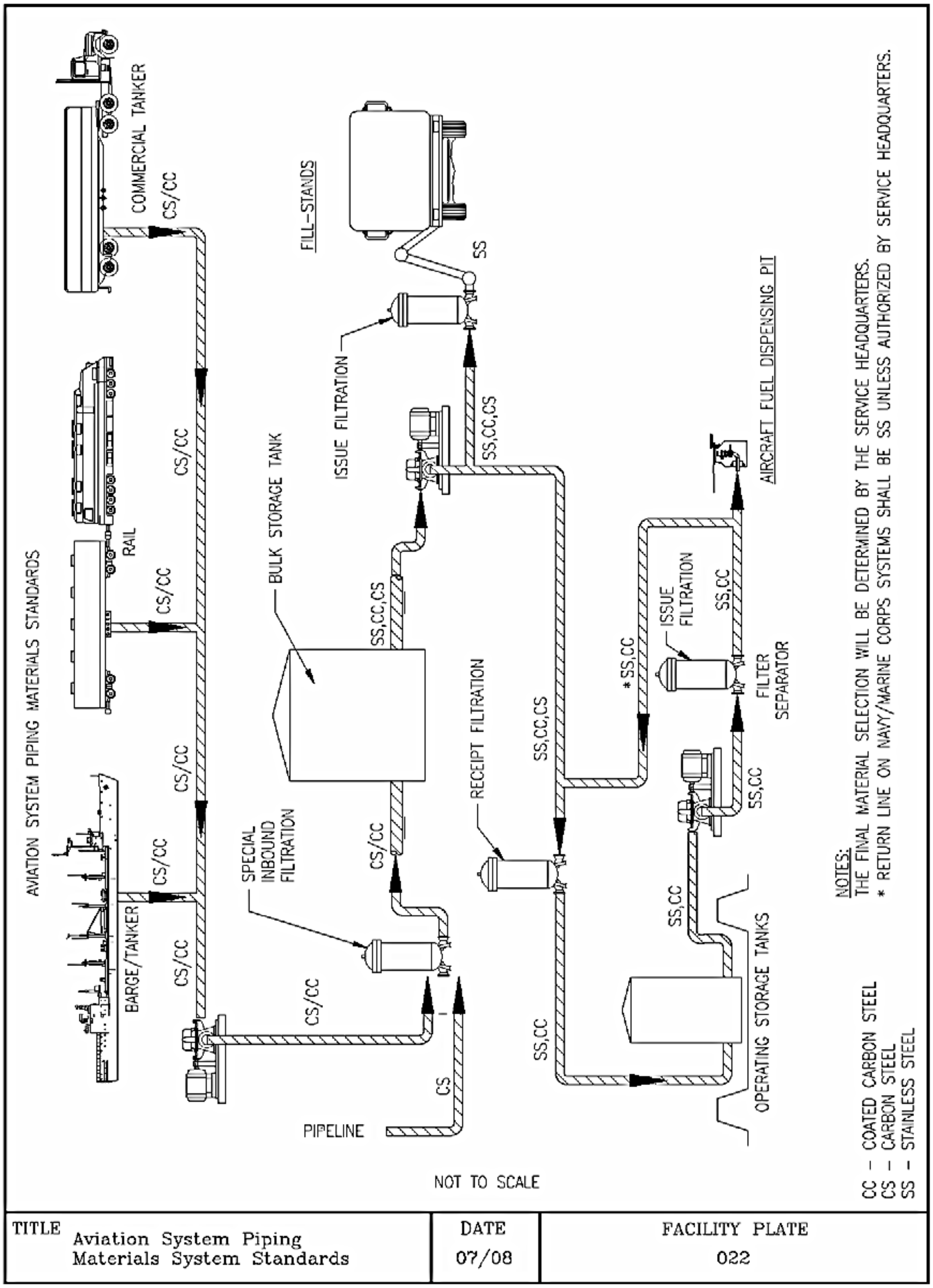


Figure 4

Aviation System Piping Materials System Standards

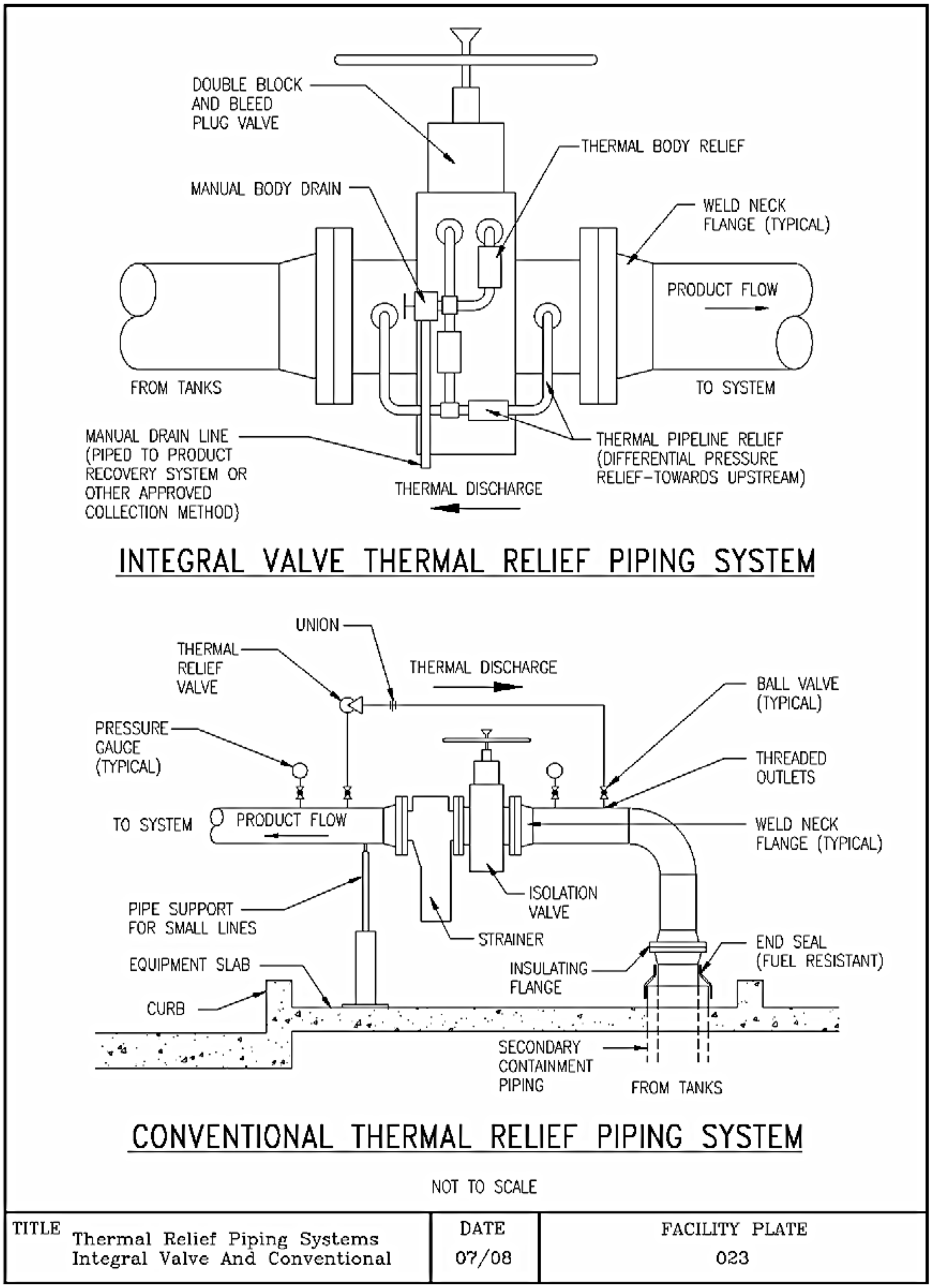
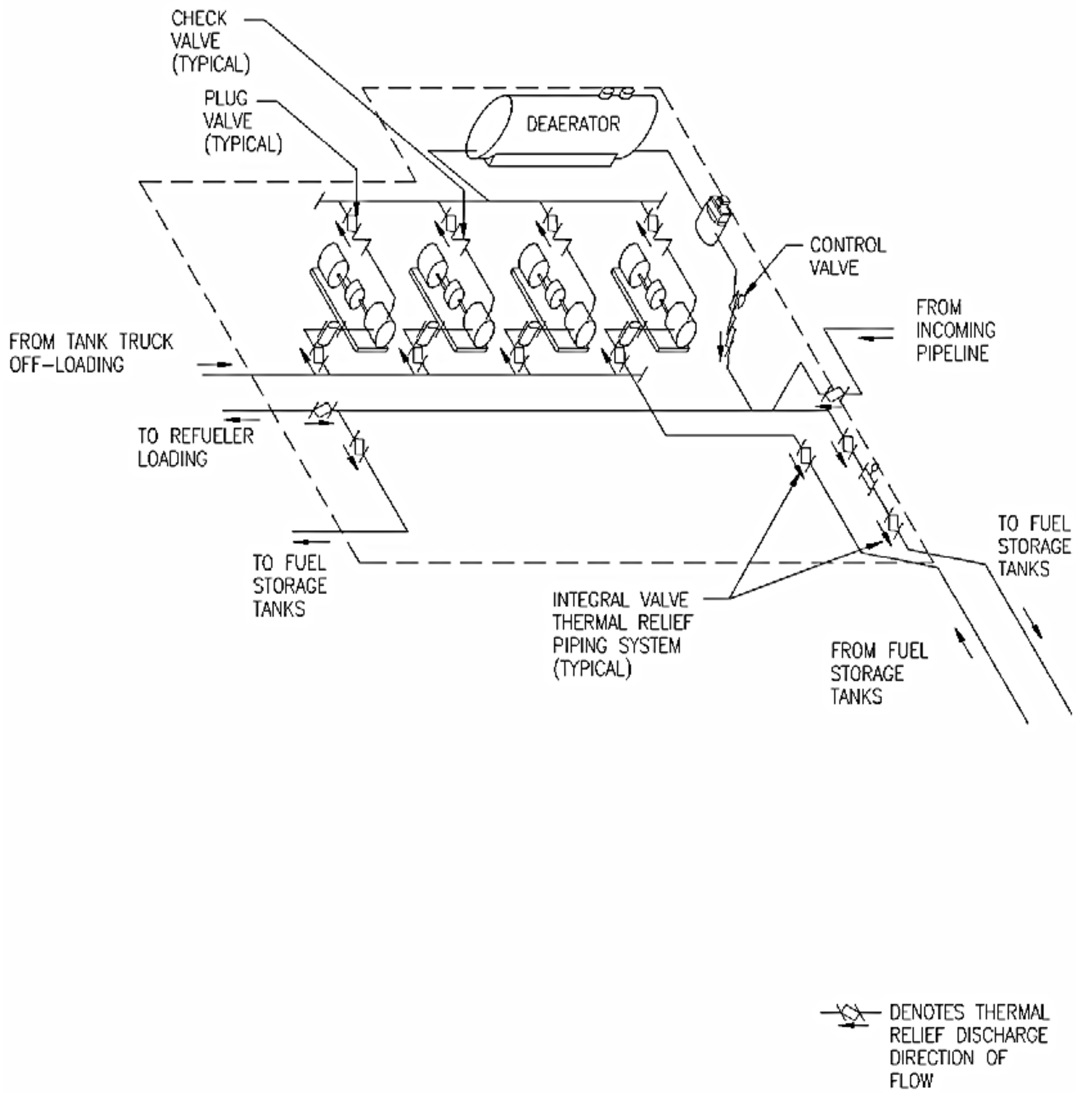


Figure 5

Thermal Relief Piping Systems Integral Valve and Conventional



EQUIPMENT PUMPHOUSE OR PADS

NOT TO SCALE

TITLE	DATE	FACILITY PLATE
Thermal Relief Piping Systems Equipment Pumphouse Or Pads	07/08	024

Figure 6

Thermal Relief Piping Systems Equipment Pump House or Pads

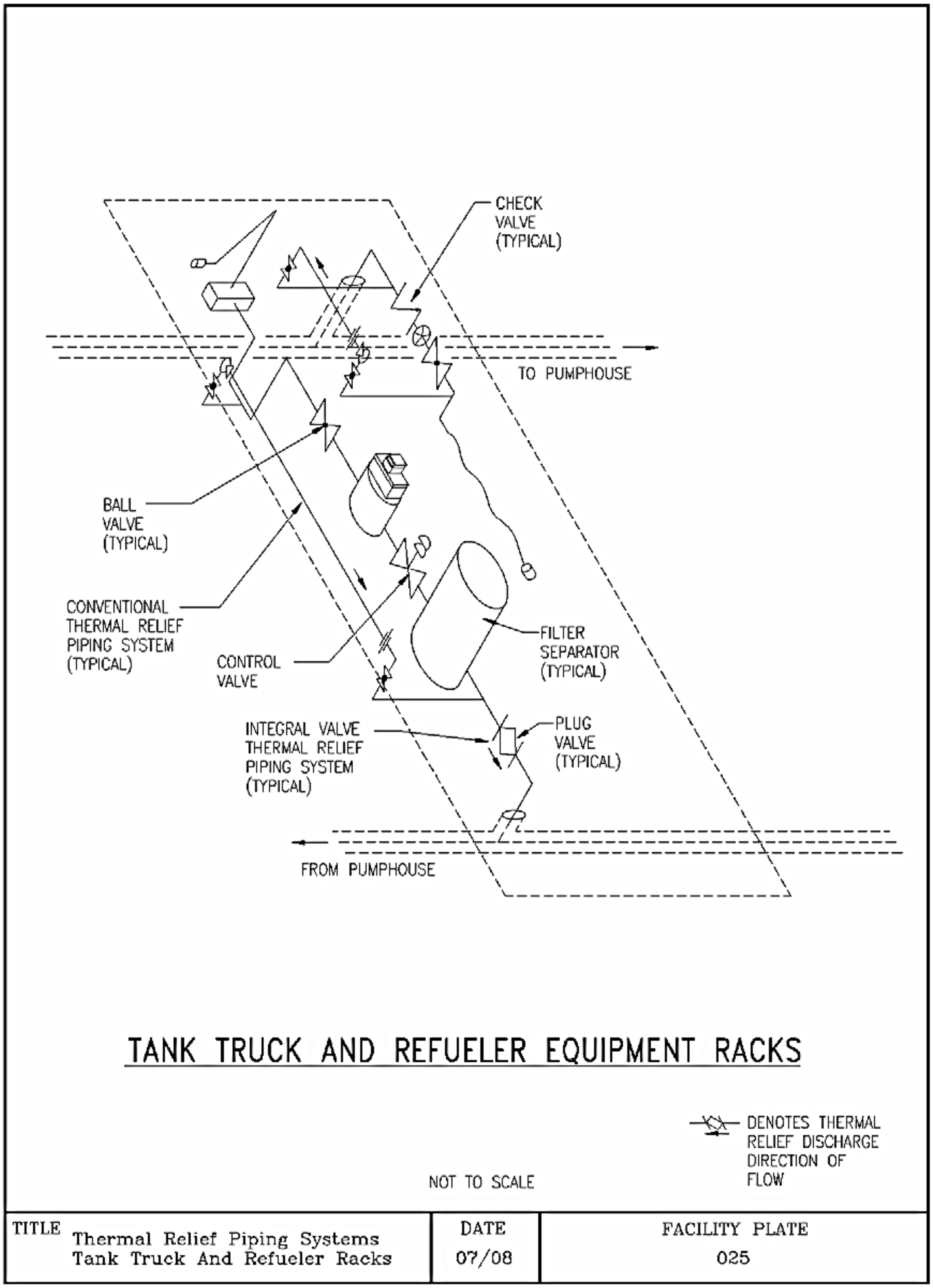


Figure 7

Thermal Relief Piping Systems Tank Truck and Refueler Racks

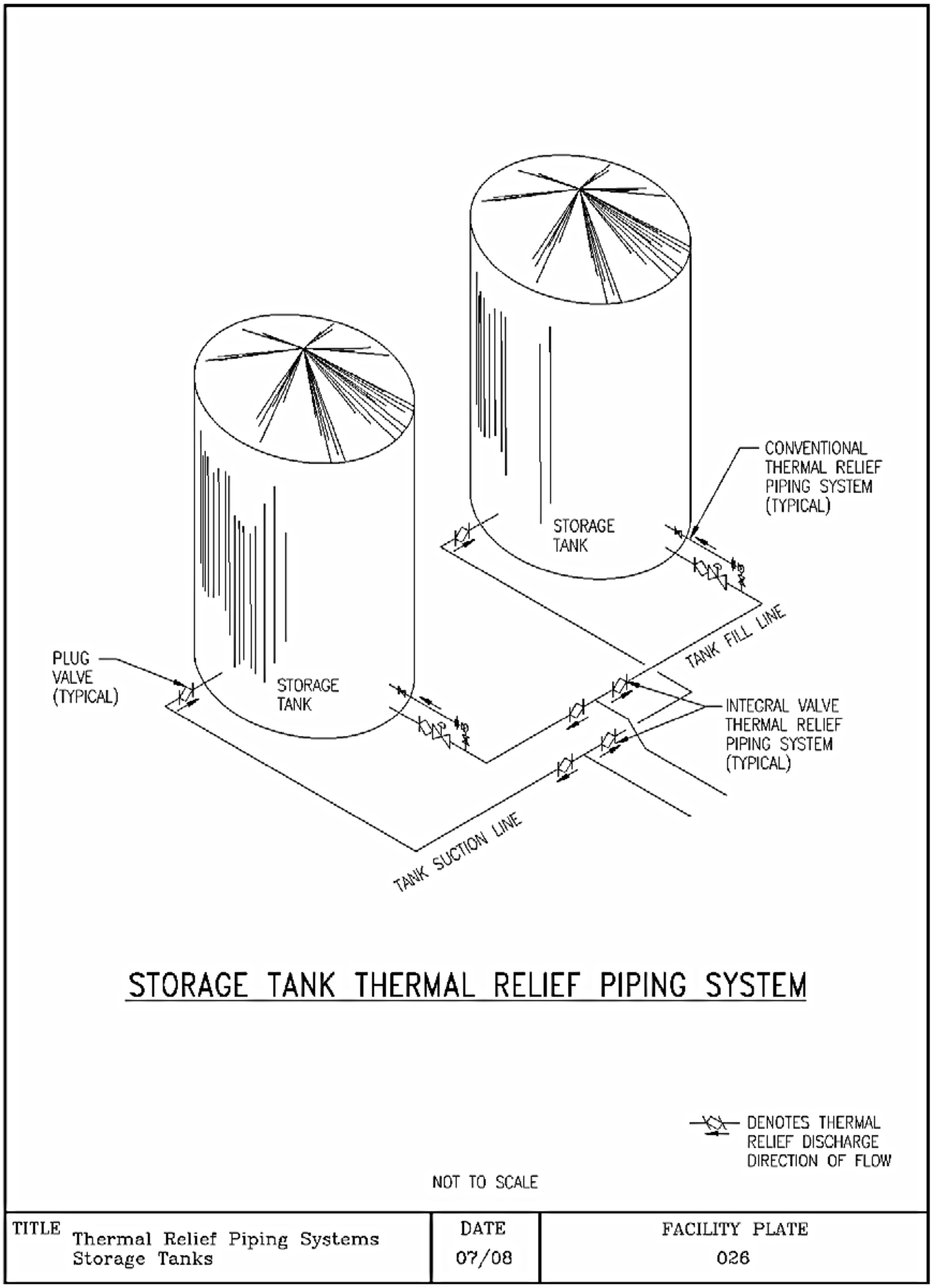


Figure 8

Thermal Relief Piping Systems Storage Tanks