
CHAPTER 12

LIQUID FUEL STORAGE AND DISPENSING SYSTEMS

This chapter will describe the design, selection, and installation requirements for atmospheric storage, distribution, and dispensing of new or replacement systems for liquid-petroleum-based fuels used, for example, in automobiles and other internal combustion motors such as emergency generators and fire pumps. Typical systems have a volume of product storage limited to approximately 6000 gal (22,500 L). Gasoline tanks are installed for commercial purposes and at facility sites primarily intended to serve the public or company-owned vehicles. Similar installations include liquids such as kerosene, motor lubrication oil, and waste oil.

Fuel oil systems for boilers and other heat-producing apparatus and chemical storage facilities are outside the scope of this handbook. Other system aspects not discussed concern existing tanks such as investigation, closure, removal, and repairs of leaking systems.

DEFINITIONS AND LIQUID FUEL CLASSIFICATIONS

A *storage tank for liquid fuel* is any stationary receptacle designed to contain an accumulation of regulated substances. Tanks can be constructed of materials such as steel, concrete, plastic, or various combinations that provide structural support.

A storage tank is considered *underground* if the sum of the total tank volume of single or multiple tanks, including all of the associated and interconnecting piping, is 10 percent or more below grade or covered with earth.

A *regulated substance* is any designated chemical that includes hydrocarbons derived from crude oil such as motor fuels, distillate fuel oils, residual fuels, lubricants, used oils, and petroleum solvents. Kerosene is also a regulated substance. Hydrocarbons are measured in parts per million (ppm) of total petroleum hydrocarbons (TPH). In future discussions, all of these will be called *product*.

OSHA (29 CFR 1926) further defines storage tanks according to the following operating pressure ratings:

1. *Atmospheric tanks*. Atmospheric pressure to 0.5 psig
2. *Low-pressure tanks*. Greater than 0.5 to 15 psig
3. *Pressure tanks*. Greater than 15 psig

Liquid fuels are governed by the requirements of NFPA-30. In this standard, liquids are classified as either flammable or combustible based on their flash points. The *flash point* of a liquid is the temperature at which the liquid could give off vapor in sufficient concentration to form an ignitable mixture with air at or near the surface. In short, the flash point is the minimum temperature at which a fire or explosion could occur. The following definitions are applicable only for the purpose of fire protection.

Liquids are classified by the NFPA as either flammable or combustible and are divided into class I, II, and III. All *flammable liquids* are considered class I. They have a flash point below 100°F (37.8°C) and a vapor pressure no higher than 40 psia (2086 mmHg) at 100°F. Class I liquids are further subdivided into class IA, IB, and IC. Class IA (which includes gasoline and gasoline blends) liquids have a flash point below 73°F (22.8°C) and a boiling point below 100°F (37.8°C).

All combustible liquids are considered class II and III liquids. They have a flash point at or above 100°F (37.8°C). Diesel fuel, light heating oil, and kerosene are class II flammable liquids with a flash point at or above 100°F (37.8°C) but below 140°F (60°C). Class III liquids are further subdivided into class IIIA and IIIB. Class III liquids include motor lubrication and waste oil.

Liquid petroleum or petroleum products are defined as any hydrocarbon that is a liquid at atmospheric pressure and at temperatures between 20 and 120°F (-29 and 49°C), or discharged as a liquid at temperatures in excess of 120°F (49°C).

The products discussed in this handbook will be gasoline, gasoline blends, or diesel oil used as fuel for motor vehicles or internal combustion engines. These fuels are classified as hydrocarbons. They are also considered flammable liquids.

Specific gravity is the direct ratio of a liquid's weight to the weight of water at 62°F.

Viscosity is a measure of the internal friction between particles in a liquid that resists any force tending to produce flow. The higher the viscosity, the slower the liquid will flow under gravity conditions. Viscosity is obtained by measuring the amount of time a given quantity of liquid at a specified temperature takes to flow through an orifice. Viscosity is expressed in Seconds Saybolt Universal (SSU) for pump work and also kinematic viscosity centistokes (centipoises, cP), Seconds Saybolt Furoil, and Seconds Redwood. Conversion between these various units and others are given in Table 12.1. A table listing the viscosity and specific gravity of various liquid fuels is given in Table 12.2.

The vapor produced by the evaporation of hydrocarbons are in a category known as *volatile organic hydrocarbons (VOC)*. Vapor produced by gasoline and gasoline blends are required by code to be recovered. The vapor density of common fuels are given in Table 12.3. *Stage I systems* refer only to storage tanks where vapor is displaced when the tank is filled with product. The recovered vapor is returned to the delivery truck. *Stage II systems* refer only to vapor recovery from automobiles when the tank is filled with product. The recovered vapor is returned to the storage tank. Kerosene and diesel oil storage and dispensing systems do not require vapor recovery.

CODES AND STANDARDS

The U.S. Environmental Protection Agency (EPA) has written basic, minimum regulations to protect the environment and people's health from the leakage of hydro-

TABLE 12.1 Approximate Viscosity Conversions

Seconds Saybolt Universal, SSU	Kinematic viscosity		Seconds Saybolt Furol, SSF	Seconds	Seconds	Degrees Engler	Degrees Barbey
	cP	ft ² /s		Red- wood 1 Stan- dard	Red- wood 2 Ad- miralty		
31	1.0	0.00001076		29		1.00	6200
31.5	1.13	0.00001216		29.4		1.01	5486
32	1.81	0.00001948		29.8		1.08	3425
32.6	2.00	0.00002153		30.2		1.10	3100
33	2.11	0.00002271		30.6		1.11	2938
34	2.40	0.00002583		31.3		1.14	2583
35	2.71	0.00002917		32.1		1.17	2287
36	3.00	0.00003229		32.9		1.20	2066
38	3.64	0.00003918		33.7		1.26	1703
39.2	4.00	0.00004306		35.5		1.30	1550
40	4.25	0.00004575		36.2	5.10	1.32	1459
42	4.88	0.00005253		38.2	5.25	1.36	1270
42.4	5.00	0.00005382		38.6	5.28	1.37	1240
44	5.50	0.00005920		40.6	5.39	1.40	1127
45.6	6.00	0.00006458		41.8	5.51	1.43	1033
46	6.13	0.00006598		42.3	5.54	1.44	1011
46.8	7.00	0.00007535		43.1	5.60	1.48	885
50	7.36	0.00007922		44.3	5.83	1.58	842
52.1	8.00	0.00008611		46.0	6.03	1.64	775
55	8.88	0.00009558		48.3	6.30	1.73	698
55.4	9.00	0.00009688		48.6	6.34	1.74	689
58.8	10.00	0.0001076		51.3	6.66	1.83	620
60	10.32	0.0001111		52.3	6.77	1.87	601
65	11.72	0.0001262		56.7	7.19	2.01	529
70	13.08	0.0001408		60.9	7.60	2.16	474
75	14.38	0.0001548		65.1	8.02	2.37	431
80	15.66	0.0001686		69.2	8.44	2.45	396
85	16.90	0.0001819		73.4	8.87	2.59	367
90	18.12	0.0001950		77.6	9.30	2.73	342
95	19.32	0.0002080		81.6	9.71	2.88	321
100	20.52	0.0002209		85.6	10.12	3.02	302
120	25.15	0.0002707		102	11.88	3.57	246
140	29.65	0.0003191		119	13.63	4.11	209
160	34.10	0.0003670		136	15.39	4.64	182
180	38.52	0.0004146		153	17.14	5.12	161
200	42.95	0.0004623		170	18.90	5.92	144
300	64.6	0.0006953	32.7	253	28.0	8.79	96
400	86.2	0.0009278	42.4	338	37.1	11.70	71.9
500	108.0	0.001163	52.3	423	46.2	14.60	57.4
600	129.4	0.001393	62.0	507	55.3	17.50	47.9
700	151.0	0.001625	72.0	592	64.6	20.44	41.0
800	172.6	0.001858	82.0	677	73.8	23.36	35.9
900	194.2	0.002099	92.1	762	83.0	26.28	31.9
1000	215.8	0.002323	102.1	846	92.3	29.20	28.7

(Continued)

TABLE 12.1 Approximate Viscosity Conversions (*Continued*)

Seconds Saybolt Universal, SSU	Kinematic viscosity		Seconds Saybolt Furoi, SSF	Seconds	Seconds	Degrees Engler	Degrees Barbey
	cP	ft ² /s		Red-	Red-		
				wood 1 Stan- dard	wood 2 Ad- miralty		
1200	259.0	0.002786	122	1016	111	35.1	23.9
1400	302.3	0.003254	143	1185	129	40.9	20.5
1600	345.3	0.003717	163	1354	148	46.7	18.0
1800	388.5	0.004182	183	1524	166	52.6	15.6
2000	431.7	0.004647	204	1693	185	58.4	14.4
2500	539.4	0.005806	254	2115	231	73.0	11.5
3000	647.3	0.006967	305	2538	277	87.6	9.6
3500	755.2	0.008129	356	2961	323	102	8.21
4000	863.1	0.009290	408	3385	369	117	7.18
4500	970.9	0.01045	458	3807	415	131	6.39
5000	1078.8	0.01161	509	4230	461	146	5.75
6000	1294.6	0.01393	610	5077	553	175	4.78
7000	1510.3	0.01626	712	5922	646	204	4.11
8000	1726.1	0.01858	814	6769	738	234	3.59
9000	1941.9	0.02092	916	7615	830	263	3.19
10000	2157.6	0.02322	1018	8461	922	292	2.87
15000	3236.5	0.03483	1526	12692		438	1.92
20000	4315.3	0.04645	2035	16923		584	1.44

Source: Cameron hydraulic data.

TABLE 12.2 Viscosity and Specific Gravity of Various Hydrocarbons

Liquid	Specific gravity	Viscosity, SSU						
		40°F	60°F	80°F	100°F	120°F	140°F	160°F
Miscellaneous liquids								
Water	1.0	31.5	31.5	31.5	31.5	31.5	31.5	31.5
Gasoline	0.68–0.74	30	30	30	30	30	30	30
Jet fuel	0.74–0.85	35	35	35	35	35	35	35
Kerosene	0.78–0.82	42	38	34	33	31	30	30
Turpentine	0.86–0.87	34	33	32.8	32.6	32.4	32	32
Gasahol 15% gas, 85% alcohol	0.70–0.72	30	30	30	30	30	30	30
Fuel oil and diesel oil								
No. 1 fuel oil	0.82–0.95	40	38	35	33	31	30	30
No. 2 fuel oil	0.82–0.95	70	50	45	40	—	—	—
No. 3 fuel oil	0.82–0.95	90	68	53	45	40	—	—
No. 5A fuel oil	0.82–0.95	1,000	400	200	100	75	60	40
No. 5B fuel oil	0.82–0.95	1,300	600	490	400	330	290	240
No. 6 fuel oil	0.82–0.95	—	70,000	20,000	90,000	1,900	900	500
No. 2D diesel fuel oil	0.82–0.95	100	68	53	45	40	36	35
No. 3D diesel fuel oil	0.82–0.95	200	120	80	60	50	44	40
No. 4D diesel fuel oil	0.82–0.95	1,600	600	280	140	90	68	54
No. 5D diesel fuel oil	0.82–0.95	15,000	5,000	2,000	900	400	260	160

TABLE 12.3 Specific Gravity of Common Vapors

Air	Diesel fuel	Gasoline	Methanol, 100%	85% methanol, 15% gasoline	Natural gas
1.0	5.5	3.4	1.1	2.0	0.6

carbons and VOCs from USTs, ASTs, and associated piping. The basic purpose of these regulations is to assure proper installation of the various system components, prevent leaks or spills from occurring, and, if a leak or spill does occur, to assure that the leak is quickly found and annunciated. Other organizations regulate component testing and general provisions for system components and installation with regard to fire prevention.

In almost all jurisdictions where these systems are installed, there exist specific requirements mandated by the local and state agencies. These requirements govern permits, registration, fees, and recordkeeping, as well as specific technical rules and regulations concerning system installation, materials, and leak detection. Very often, they may be more stringent than the federal EPA regulations cited here. A thorough code search will be necessary to assure complete compliance with all applicable federal, state, and local regulations.

The following is a list of commonly used codes, regulations, and guidelines. This list is not complete and must be verified in the locality where the project is constructed.

1. NFPA 30 and 30A
2. 40 CFR 112 Spill Containment Control and Countermeasures
3. Regional fire codes such as BOCA and UFC
4. Underwriters Laboratories UL-142 Standard for Safety and UL-2085 Fire Resistance
5. Resource Conservation and Recovery Act (RCRA), Subtitle 1 & C
6. Steel Tank Institute (STI)
7. Public Law (PL) 98 and 616
8. Clear Air Act Amendments (CAAA)
9. SARA, Title III, 1986

SYSTEM DESCRIPTION

The liquid fuel storage and dispensing system is intended to store and dispense liquid fuel used to power internal combustion engines. Other required ancillary functions include systems and devices to recover vapor evaporated from product, measure the level of liquid inside the storage tank, and detect any leakage from the storage tank and piping distribution system.

SYSTEM COMPONENTS

Liquid fuel storage and dispensing, whether in an above-ground storage tank (AST) or underground storage tank (UST), require many interrelated subsystems and components for proper operation and compliance with applicable codes and standards. They are:

1. A storage tank, including:
 - a. Tank filling and accidental spill containment
 - b. Atmospheric tank venting
 - c. Overfill protection
2. Leak detection and system monitoring
3. Vapor recovery systems to prevent the vapor produced by gasoline and gasoline blends from storage tanks and fuel tanks of motor vehicles from escaping into the atmosphere
4. A pump and piping system for dispensing and distributing product from the storage tank into motor vehicles or directly to engines

Because there are significant differences in the materials and the installation and operation of a UST and an AST, they will be discussed in separate sections. In addition, fire pump and emergency generator fuel systems are included in a separate section.

UNDERGROUND STORAGE AND DISTRIBUTION SYSTEMS

STORAGE TANKS

General

Storage tanks are designed and fabricated to prevent product releases due to structural failure and corrosion of the tank from the time of installation to the end of the expected useful life of the system. This requires that the tank manufacturer fabricate the tank in conformance with applicable codes and nationally recognized standards for structural strength and corrosion resistance. Since the tank must be installed in a manner that will prevent distortion and stress, the installation of the specific tank must be done by contractors trained and approved by the manufacturer. The tank foundation, bedding, and backfill shall be done only with material and methods approved by the manufacturer.

The structural integrity of any tank requires manufacturing methods capable of passing an internal pressure and vacuum test. This assures that the tank is capable of resisting a higher internal pressure than would be expected during operation. USTs conforming to codes from ASTM, UL, and STI produce a tank capable of resisting external pressure. The corrosion resistance for USTs is determined by industry consensus codes that provide detailed performance requirements. The corrosion resistance for ASTs is determined by the quality of the protection of the tank exterior. These requirements must be accepted by the implementing agency responsible for the approval of the installation.

Tank Materials

The materials used to manufacture primary and secondary tanks are:

1. Steel, with thin coating or thick cladding based on corrosion protection method selected by the manufacturer. Cathodic protection may be required.
2. Fiberglass reinforced plastic (FRP). No corrosion protection required.
3. Steel and fiberglass reinforced plastic composite.
4. Preengineered, cathodically protected steel. This option is rarely used.

Clad steel is manufactured by applying a layer of plastic, usually FRP, over the exterior surface of the steel tank. This offers the strength of steel with the corrosion protection of plastic. Great care must be taken to prevent damage to the cladding during shipping and installation. Some authorities require the installation of sacrificial anodes.

FRP tanks are manufactured by several proprietary processes from thermoset plastic reinforced by fiberglass. Reinforcing ribs are built into the tank for increased structural strength. Generally, there is a resin-rich layer that contacts the product. The specific plastic materials are listed by the implementing agency as being suitable for the intended product. These tanks are completely resistant to corrosion, but they are more susceptible to damage by mishandling and distortion during installation.

The composite tank is manufactured by having the steel tank “wrapped” in a jacket of high-density polyethylene that is not bonded to the tank itself. This provides a very thin interstitial space that can be monitored. Experience has shown that the jacket is the portion of the assembly that fails most often.

Preengineered steel tanks are constructed by having an insulating coating on a steel tank with sacrificial anodes welded to the tank side. The coating is usually of coal tar epoxy, although FRP and polyurethane are also used. If steel piping is used, it must be isolated from the tank by special bushings. This is the least costly of all materials, but it requires the cathodic protection to be constantly monitored.

Tank Construction

Typical tanks are cylindrical with a round cross section. They are available in either single-wall or double-wall construction. For double-wall construction, the inner tank containing the product is called the *primary tank*. The outer tank is called the *secondary containment tank*. This system of double wall tanks is often referred to as *double contained*. The outer tank could be manufactured from the same material as the primary tank or a different material as approved by the implementing agency.

A space between the primary and secondary tank is called an *interstitial space*. The width of the space varies between different manufacturers and types of construction. It is this space that is monitored for leakage of the primary tank.

Steel primary tanks with steel secondary tanks are available in different configurations. The steel secondary tank could extend partly around the primary tank (300°) with a small interstitial space, extend fully around the primary tank (360°) with a small interstitial space, or extend fully around the primary tank with a larger interstitial space. This last method usually consists of two full tanks, one inside the other.

There are several proprietary methods used to construct the secondary tank around the primary tank. The choice between single- and secondary-contained tank systems as well as the tank material depends on the proposed method of leak detection and corrosion protection. The double-wall tank is the most often used. Typical fiberglass double-contained tank dimensions are listed in Table 12.4. Steel double-contained tanks are comparable in size.

Corrosion Protection

All tanks not manufactured throughout from noncorrosive materials, such as steel, must be protected against corrosion. This also includes distribution pipe of a material subject to corrosion. A bare steel tank can be dialectically coated with a thin material but must also be cathodically protected by means of impressed current or sacrificial anodes. It could also be coated with a thick, noncorrodible cladding that prevents corrosion, and no cathodic protection is necessary. Another type of protection is an exterior wrapping with a noncorrosive material, usually polyethylene. The most often used cladding material is FRP. Both methods are factory applied. There are industry standards detailing performance requirements such as STI-P3 and UL Standard 1746.

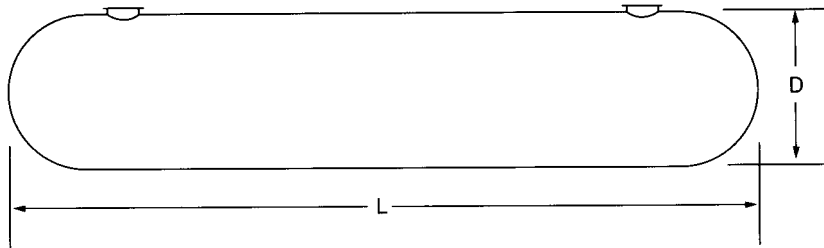


TABLE 12.4 Typical Fiberglass Double-Wall Tank Dimensions

Nominal capacity, gal	Actual capacity, gal	D, nominal diameter, ft	L, overall length	Number of 22-in manways	Number of 4-in NPT service fittings	Number of 4-in NPT monitor fittings	Interstitial volume, gal	Shipping weight, lb
550	553	4	6'-9 ¹ / ₄ "	1	4	1	85	1,100
750	750	4	8'-11"	1	4	1	127	1,250
1,000	1,009	4	11'-7 ¹ / ₈ "	1	4	1	181	1,400
2,500	2,319	6	13'-5 ³ / ₄ "	1	4	1	48	1,570
3,000	2,900	6	16'-4 ¹ / ₄ "	2	6	2	59	1,950
4,000	3,782	6	20'-8"	2	6	2	76	2,250
6,000	5,562	6	29'-5"	2	6	2	110	3,010
6,000	5,998	8	20'-6 ¹ / ₂ "	2	6	2	114	2,745
8,000	7,841	8	26'-0 ¹ / ₂ "	2	6	2	152	3,460
10,000	9,684	8	31'-6 ¹ / ₂ "	2	6	2	189	4,085
12,000	11,527	8	37'-0 ¹ / ₂ "	2	6	2	227	4,650
10,000	10,369	10	21'-5 ¹ / ₄ "	2	6	2	144	4,170
12,000	11,849	10	24'-0 ¹ / ₄ "	2	6	2	167	4,950
15,000	14,976	10	29'-5 ³ / ₄ "	2	6	2	213	6,110
20,000	19,703	10	37'-8 ³ / ₄ "	2	6	2	280	8,210
25,000	25,587	10	48'-0"	—	—	2	1,540	16,000
30,000	30,352	10	56'-3"	—	—	2	1,802	18,500

Source: Courtesy Xerxes.

Tank Connections and Access

There must be a convenient and leakproof method of providing connections directly into the primary tank to allow for filling, venting, product dispensing, gauging, and leak detection. For larger tanks, access directly into the tank for personnel may also be desired. This is done by means of a *manway*, also called a *manhole*. It is formed at the factory during manufacture and provides a large circular opening into the primary tank. The manway is provided with a bolted and gasketed cover.

Two methods are used to connect piping: single connections directly installed in the tank wall and multiple connections in the cover of a manway. Typical manways of 22, 30, and 36 in (53, 72, and 86 cm) diameter are available. This manhole may be a full-size opening for tank access or may have several pipe connections in the manhole cover. A *manway riser* is used to extend the manway to grade. This is also called a *manway extension*.

Standard threaded single connections into steel tanks consist of NPT half couplings welded onto the tank. For FRP tanks, they are cast into the wall of the tank. For double-wall tanks there is a connection from the primary tank to the coupling on the wall of the secondary tank. Connections are available for single- and double-contained piping. Connections for flanged pipe are also available. Sizes range from 2 to 8 in (50 to 200 mm) for most tanks, with the most common sizes being 3 and 4 in. It is generally not practical to have the larger-size pipe connections in smaller tanks. There are standard locations on each tank provided by each manufacturer, but they can be located at custom intervals at extra cost.

If the manway will be used for installing equipment and several piping connections, a manway cover with multiple piping connections in a variety of sizes can be provided. Standard fittings are 3 and 4 in NPT. Standard I.D. of manway openings are generally 22, 30, and 36 in, depending on the size of the tanks. A typical manway into an FRP tank and arrangement of multiple connections is illustrated in Fig. 12.1. These connections could be arranged either in a straight line or circular configuration. Typical manways into a single-wall and double-containment steel tank are illustrated in Fig. 12.2.

In order to extend the manway to grade and provide space and access for pipe fittings and equipment connections, a manway riser, or extension, must be attached to the manway. Manway risers are available in a variety of standard sizes ranging from the manway diameter to larger sizes up to 48 in. The manway riser must have an additional waterproof top that is flush with grade. Several methods of accessing extensions from grade are used. Connection to the manway from the manway riser should be waterproof to guard against the entrance of groundwater or rainwater. Various methods are utilized by different manufacturers including collars around the manway and direct bolted and gasketed connections. For steel tanks, the reverse flange type of manway connection is recommended. Typical manway risers are illustrated in Fig. 12.3.

In cases where only piping connections are provided, an enclosure connected to all connections and including an extension to grade will be installed to allow leakage monitoring and access to the connections themselves for maintenance. This arrangement is commonly called a *containment sump* because there is no direct connection of the sump to the wall of the tank. A containment sump is illustrated in Fig. 12.4.

Tank Filling and Spill Prevention

Tank Filling. USTs are filled by gravity from delivery trucks using a hose connected to the truck and to a fill connection into the tank called a *port*. This operation

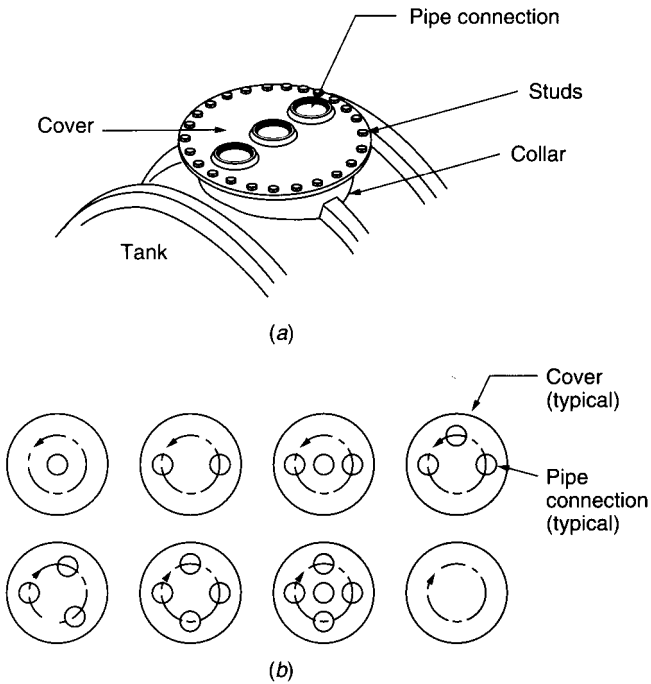


FIGURE 12.1 (a) Typical manway into FRP tank with multiple piping connections. (b) Typical manway cover fitting configurations. (Courtesy Xerxes.)

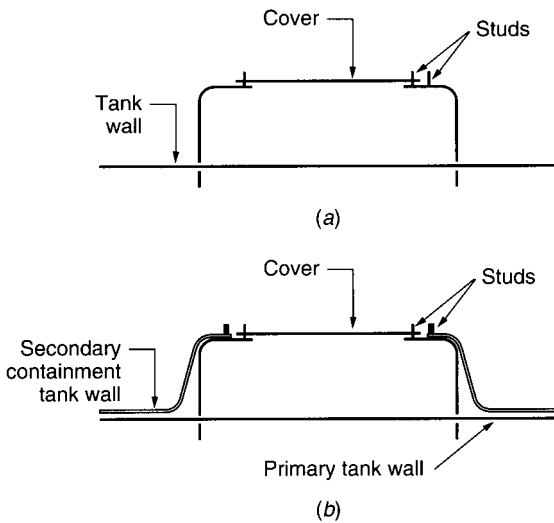


FIGURE 12.2 Typical manway in steel tank. (a) Double ring for single-wall tanks. (b) Jacketed double ring for total containment tanks. (Courtesy Highland Tank and Manufacturing Company.)

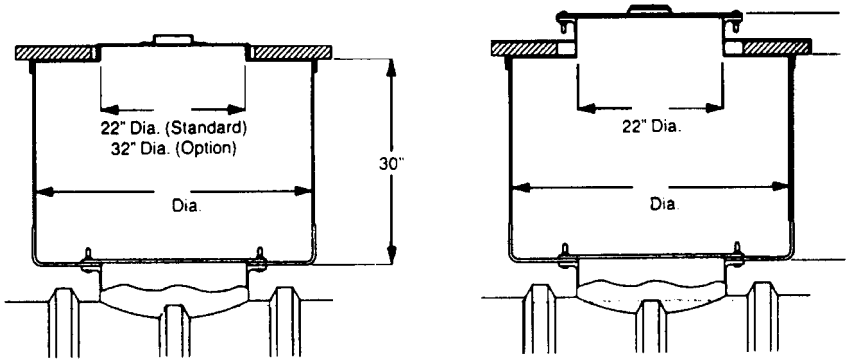


FIGURE 12.3 Typical manway extension.

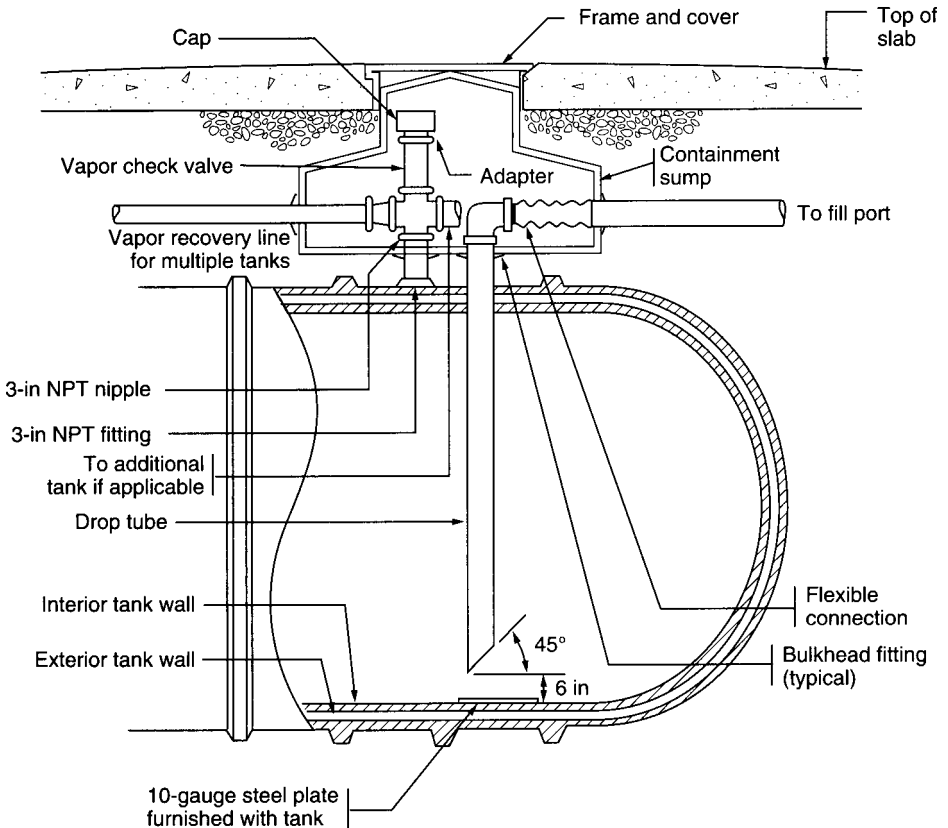


FIGURE 12.4 Typical containment sump, drop tube, and vapor recovery connection.

is commonly called a *gravity drop* or simply a *drop*. When gravity filling is not possible, truck-mounted pumps are used. If the fill port is located directly over the UST, the assembly is called a *direct fill port*. If there is any horizontal piping from the fill port to the tank, it is considered a *remote fill port*. The fill port covers shall be watertight. Where multiple tanks containing different products are installed, the fill port covers shall be painted different colors to distinguish between the various product ports and also the vapor recovery port if used. Installing the cover plates 1 in (25 mm) above slab level will minimize the possibility of storm water entering the port. A typical fill port assembly is illustrated in Fig. 12.5.

Another integral part of the filling system is the drop tube inside the tank being filled directly connected to the fill line. The drop tube, illustrated in Fig. 12.4, provides a submerged inlet for product during filling. This produces a minimum of turbulence inside the tank, compared to having the product spill directly onto the surface of liquid.

It is common practice for manufacturers to install a wear plate inside the tank under the fill tube outlet to limit internal erosion of the tank bottom by the product stream over the years. Another type of device (not shown) used to divert the product stream for retrofit of existing tanks is a “bottom shield” attached to the bottom of the fill pipe and consisting of four thin rods attached on one end to a horizontal circular plate and the other end to the fill pipe.

Spill Prevention. The purpose of spill prevention is to provide a safe filling method capable of catching spills from delivery hose disconnections. A typical 20 ft, 0 in length of 4-in delivery hose holds 15 gal. Product spilled must be prevented from entering the soil adjacent to the fill port by providing safeguards that are code mandated and recommended by good practice.

This is accomplished by installing a below-grade catchment basin with a capacity of from 3.5 to 15 gal (13.5 to 57 L) to catch spillage of product from truck delivery hose. An optional device that could be included as part of the sump is a drain valve that when opened, will empty product in the sump into the fill line. Water in the sump will be removed manually. Installing a drain valve inside the catchment sump could allow a smaller sump. The containment sump is shown in Fig. 12.5.

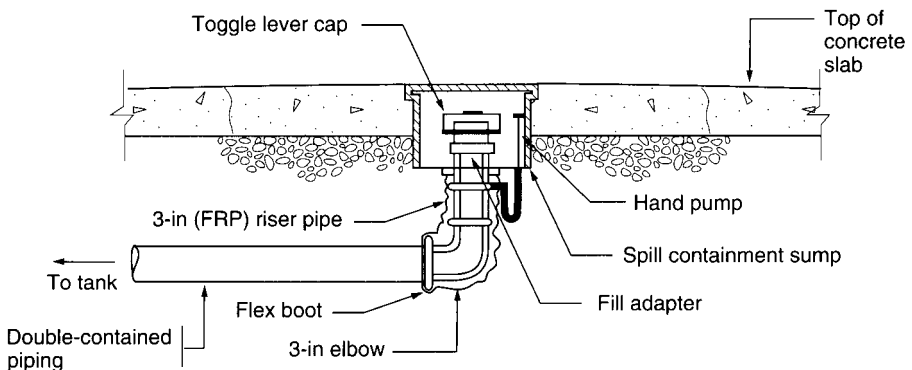


FIGURE 12.5 Typical fill port.

The fill port assembly is designed to accomplish the following:

1. Provide a watertight grade cover, allowing access to the fill hose connection.
2. Provide a fill hose connection for the tanker truck delivery hose. The truck hose end has a standard end connection. This requires that an adapter be installed on the fill pipe leading to the tank. The gravity drop delivers about 200 gpm (750 Lpm). The flow rate of a truck-mounted pump is generally 50 gpm (190 Lpm).
3. Allow any fuel spillage from the fill hose to be contained and returned to the tank and any water to be removed. This is usually accomplished by installing a spill container around the fill port capable of containing from 5 to 15 gal of product. A hand pump removes spilled fuel from the port bottom and returns the fuel into the fill line.

A dry disconnect coupling on the delivery truck hose could also be used to prevent spills.

Another, less commonly used fill method uses a coaxial hose to both fill the tank and recover vapor. This requires only one connection from the truck to the tank fill port and requires a different type of adapter than that used for a fill connection alone.

Atmospheric Tank Venting

The USTs are at atmospheric pressure and require continuous tank venting to assure that no pressure or vacuum is built up inside the tank. This is not to be confused with vapor recovery vents, which serve a different purpose.

Since all of the vapors produced from products are heavier than air, the vapors will not normally escape. Release of vapor can occur as the tank is being filled or as product is removed, or from a buildup of vapor pressure resulting from evaporation of product at times of high temperature. Each tank is vented by means of a dedicated 2-in (50-mm) vent pipe (typical size).

The vent pipe is directly connected to the top of each primary tank and shall be extended to a safe location above the highest level of an adjacent building or a minimum of 12 ft above grade. The vent discharge shall be directed either vertically or horizontally away from other buildings or tanks.

When not in conflict with other regulations, general practice is to have the vent terminate in a pressure-vacuum cap that protects against the entrance of rain and will only open when the pressure exceeds 2 to 15 oz/in² or a vacuum pressure of 1 oz/in² is exceeded. If the cap is not provided, a flame arrestor should be installed if permitted by regulations.

Overfill Prevention

All UST systems must be provided with overfill protection by installing one or more of the following devices or other methods accepted by the local authorities. The specific individual or combination of devices and methods accepted in any specific location shall be obtained from the local authorities.

1. A device that will alert the operator when the product level in the tank reaches 90 percent full by restricting the flow of product into the tank or alerting the operator by means of an audible alarm actuated by a high-level alarm probe

2. A device to shut down flow into the tank when the product level reaches 95 percent full
3. Equivalent devices or methods accepted and approved by the local implementing authority

The best method is the installation of an automatic device on the fill tube that will reduce flow into the tank when it becomes 90 percent full and stop it entirely when the tank becomes about 95 percent full. There are a number of approved mechanical devices from different manufacturers that perform this function. One such device is illustrated in Fig. 12.6.

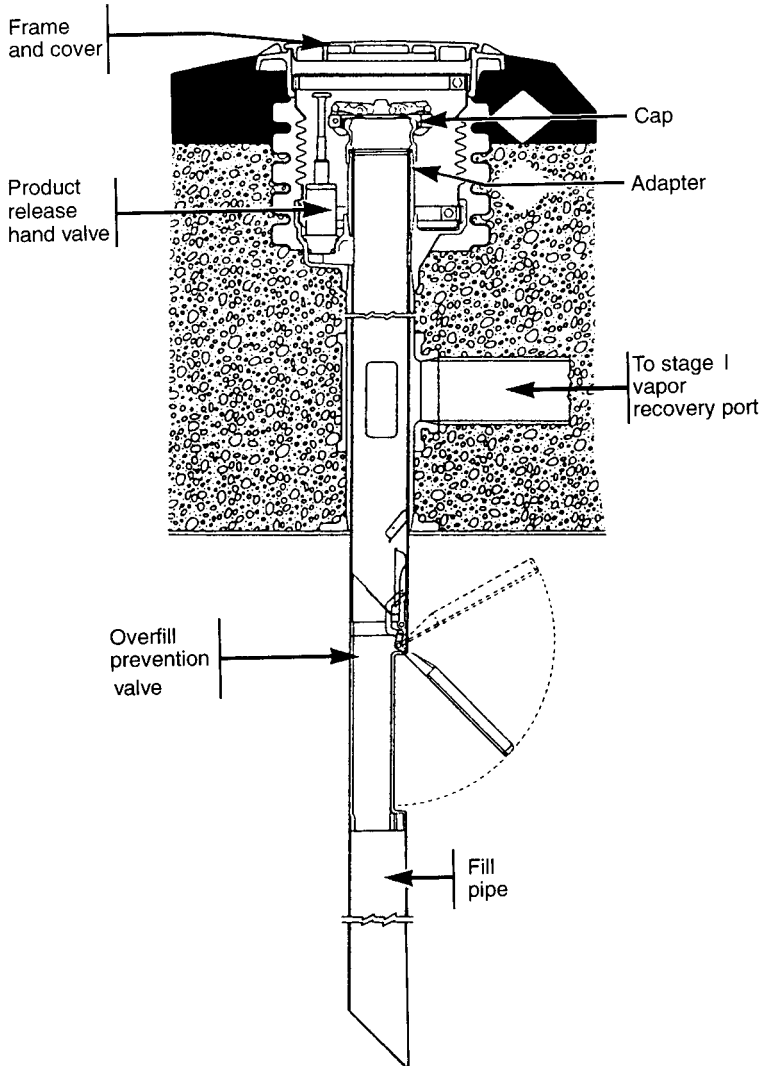


FIGURE 12.6 Automatic overfill protection valve.

Another method is to install an audible alarm actuated by the level gauge that automatically sounds when the liquid level in the tank reaches 90 percent full. Often a visible alarm is included. This alarm must be located in clear sight of the fill port.

In addition, tanks that do not require a vapor recovery system could have a floating ball device installed on the atmospheric vent line that will close the vent when product reaches a predetermined point (usually at the 90 percent full level) when additional filling may cause a spill. By closing, the air pressure will increase inside the tank and restrict the inflow, alerting the operator that the tank is approaching full. An extractor fitting is required that allows access into the line for removal of the float assembly. The float assembly is illustrated in Fig. 12.7.

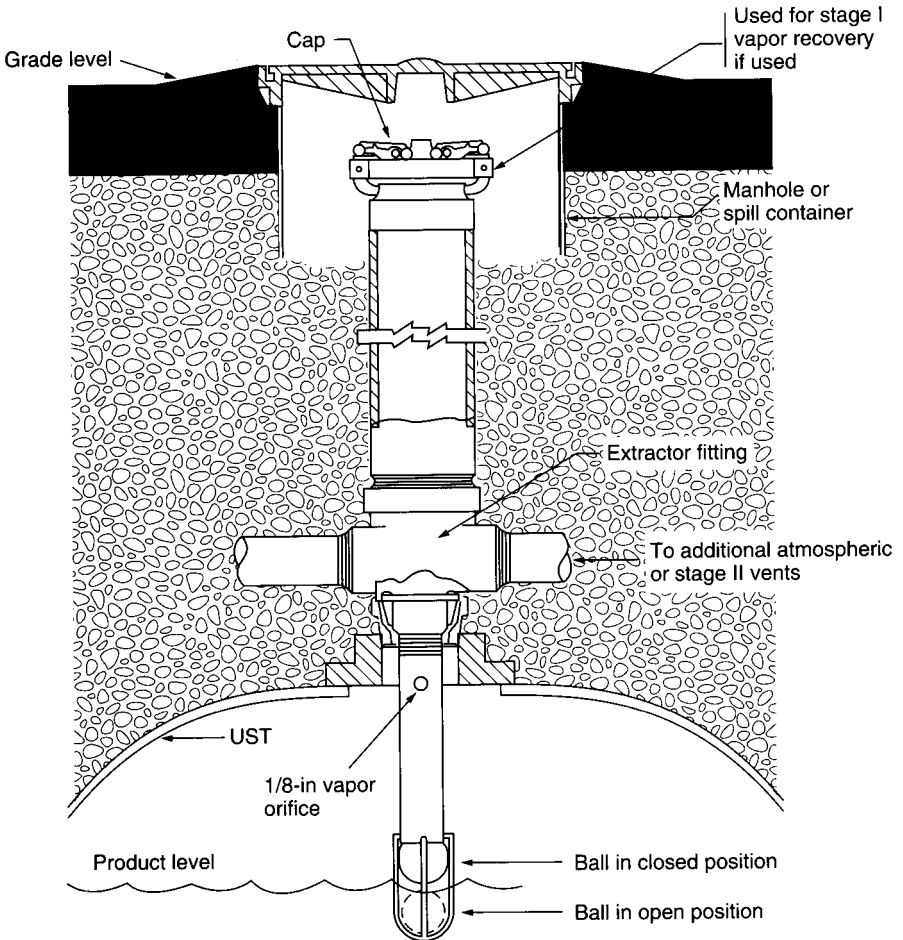


FIGURE 12.7 Ball float overfill protection valve. Stage I vapor recovery vent on UST.

LEAK DETECTION AND SYSTEM MONITORING

General

Leak detection is required by code. The three basic requirements for leak detection are:

1. Leakage must be capable of being detected from any portion of the tank or piping that routinely contains petroleum.
2. The leak detection equipment must meet performance requirements described in Federal Regulations, Sections 280.43 and 280.44.
3. Leak detection equipment must be installed, calibrated, operated, and maintained in accordance with the manufacturer's instructions.

The EPA has established various options, combinations of which must be used depending on project conditions, initial or long-term costs, and product. In addition, state and local requirements may differ in the number and application of these options. A schematic diagram indicating the leak detection methods from tanks and piping is illustrated in Fig. 12.8. These options are:

1. Leakage from tanks
 - a. Manual tank gauging
 - b. Automatic tank gauging

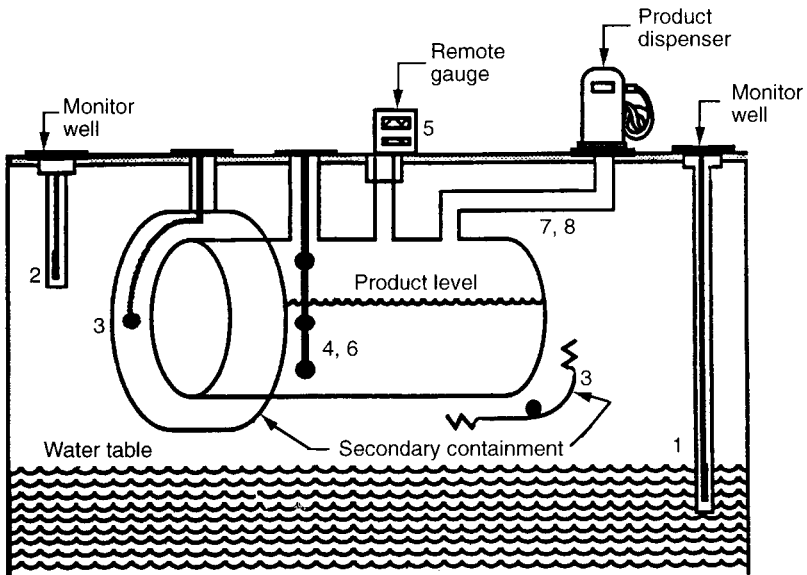


FIGURE 12.8 Leak detection methods for tanks and piping. (1) Groundwater monitoring. (2) Vapor monitoring. (3) Secondary containment with interstitial monitoring. (4) Automatic tank gauging. (5) Tank tightness testing with inventory control. (6) Manual tank gauging. (7) Leak detection for suction piping. (8) Leak detection for pressurized piping.

- c. Tank secondary containment interstitial monitoring
 - (1) Vapor monitoring
 - (2) Liquid monitoring
 - (3) Hydrostatic monitoring
 - (4) Pressure monitoring
2. Leakage outside of tanks
 - a. Groundwater monitoring
 - b. Piping leak detection
3. Tank tightness testing with inventory control

Leakage from Tanks

Measuring leakage from tanks is accomplished by gauging the level of product in a tank and metering the amount of product dispensed and the amount of product delivered. If the dispensed and remaining product figures agree with the amount of product delivered, there is no leakage.

Manual Tank Gauging. Referred to as *sticking*, manual gauging uses a long gauge stick calibrated to $\frac{1}{8}$ in (3 mm) lowered directly into the tank until it rests on the bottom. This requires that a straight, direct access into the tank be provided. The wetted level leaves a mark on the stick that is read by the operator after removal from the tank. This method is generally limited to tanks of 2000 gal (7560 L) and smaller, and only in conjunction with tightness testing for tanks with a capacity larger than 550 gal (2080 L).

When using this method, the tank being measured must be completely idle for at least 36 h. Two separate readings shall be taken at the beginning and at the end of that period and must be performed once per week. If the reading exceeds weekly or monthly standards, the tank is leaking.

It is common to provide manual tank gauging as a check against the mechanical or electronic methods and to allow measurement if electrical power is out or there is a failure of the automatic devices.

Automatic Tank Gauging. Automatic tank gauging is accomplished by permanently installing a special probe, or monitor, into the storage tank. The probe could be mechanical, pneumatic, or electronic.

Mechanical Tank Gauging. The least costly tank gauging is a mechanical device, such as a float, that rides on the surface of the liquid. The movement of the float transmits the liquid level through a mechanical or other linkage to a remote indicator. General accuracy is about 2 percent.

Another, more accurate method is a pneumatic tank gauge that uses a bubbler pipe extending down into the liquid. A permanent source of compressed air or a hand-operated air pump forces air out of the bubbler pipe. The operating principle is to measure the pressure required to force air out of the bubbler pipe. The more pressure required to produce the bubbles, the deeper the depth of liquid.

Electronic Tank Gauging. The electronic tank gauging system consists of a probe mounted in a tank opening extending to the bottom of a tank and a remote panel that is microprocessor controlled and could be programmable. The probe is capable of monitoring many parameters and extends from the primary tank bottom to a termination above the tank that both anchors the probe and acts as a junction box for the wiring. For USTs this point is below grade or the slab above the tank.

Access to the box is through a small manhole in the slab. For ASTs, it terminates in a junction box on top of the tank.

The advantage to the electronic gauging system is that it is capable of being programmed to automatically record many items. The probe will monitor such parameters as product and water level inside the tank and product temperature. In addition, probes extending from various locations can be electronically linked together to monitor vapor and liquid leakage from many sources such as monitoring wells, piping, containment sumps, and tank interstitial spaces. Probes from multiple tanks can be linked to a single panel. Overfill and low product levels are also capable of being monitored. The installation of one type of electronic probe is illustrated in Fig. 12.9.

The commonly available types of electronic probes are the magnetostrictive and ultrasonic. The magnetostrictive type uses a change in the magnetic field produced by movable product sensor floats, one for water and one for product. Each float has an integral magnet and is free to ride on the probe shaft as the product (and water) level changes. Signals are sent from a wire in the probe shaft and returned to a device on the top of the probe to gauge levels. The ultrasonic devices use

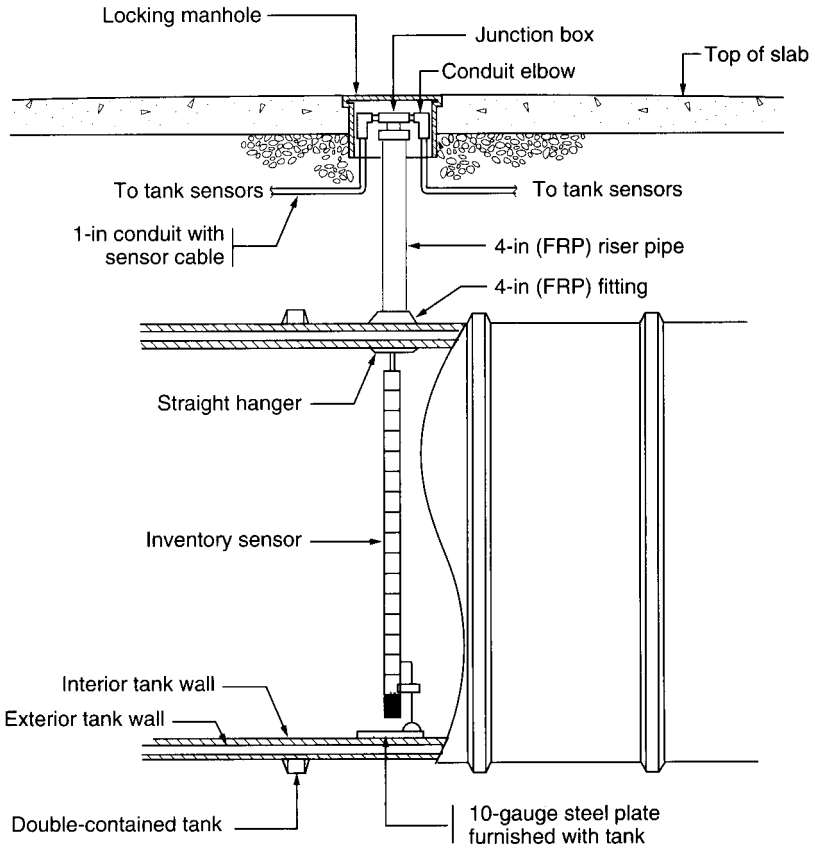


FIGURE 12.9 Electronic fuel gauging detail.

ultrasound waves from the probe on the shaft to a receiver on the top of the probe to signal a change in product level. Capacitance probes are no longer recommended, having been replaced by less expensive and more accurate electronic probes.

Interstitial Monitoring. The interstitial space between the tanks is used to contain and detect any leakage from the primary tank. Monitoring the interstitial space is divided into two general categories: wet and dry. With dry methods, vapor is monitored for the presence of hydrocarbon vapors; with wet methods, liquid is monitored for the presence of liquid product. Wet methods are also used in pressurized systems using either air pressure or vacuum. Typical locations for dry monitoring devices are shown in Fig. 12.10. The wet system uses hydrostatic monitoring, as illustrated in Fig. 12.11.

Vapor Monitoring. Vapor monitoring is achieved by placing a probe sensitive to product vapor into the dry interstitial space from a special tank opening. The probe is generally placed one-half the distance into the tank. If leakage occurs, the vapor produced by the product is detected by the probe, and a signal is given that leakage is present. This method has the advantage of not being affected by condensed water.

Liquid Monitoring. Liquid monitoring is achieved by placing a probe at the bottom of the dry interstitial space that is capable of detecting liquid. If leakage occurs, it is detected by the probe and a signal is produced. A shortcoming of this method is that water condensation into the interstitial space is also detected as leakage.

Hydrostatic Monitoring System. This is the most costly and the most accurate method of interstitial monitoring. This is a wet system that uses a liquid, usually brine, installed at the factory that completely fills the interstitial space. The system is at atmospheric pressure with the liquid level carried above the tank into a reservoir that contains a level probe. Since normal product temperature differences will cause the liquid level to fluctuate, the level probe will annunciate only unacceptable changes. This system is illustrated in Fig. 12.11.

Water from a high water table leaking into the interstitial space from a hole in the secondary tank will cause the level to rise. Product leaking out of the primary

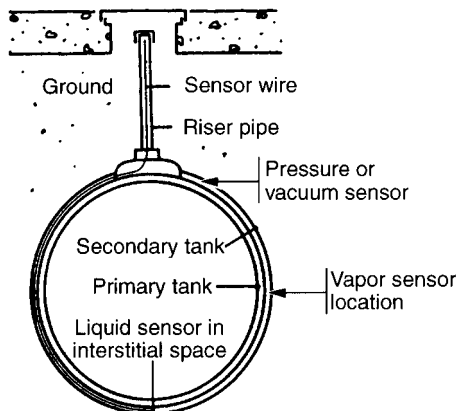


FIGURE 12.10 Dry interstitial monitoring device locations.

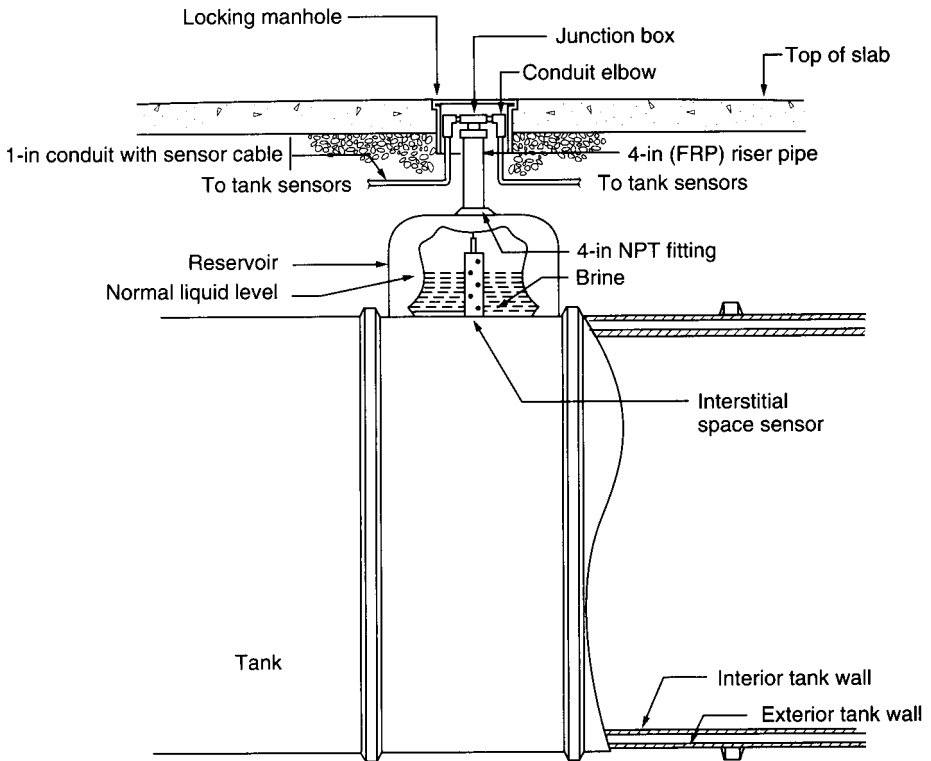


FIGURE 12.11 Detail of hydrostatic interstitial monitoring.

tank into the interstitial space will also cause a rise in level. Conversely, a hole in the secondary tank will allow the brine to leak out of the system.

In order to maintain atmospheric pressure, holes must be made in the standpipe cap. If there is a possibility of a high water table that will allow water to enter the holes, a separate vent line extended to a point safely above grade must be installed.

Pressure Monitoring. Pressure monitoring of the interstitial is accomplished by injecting light air pressure (1.5 psig) or creating a vacuum in the space. Any increase or reduction of pressure or vacuum indicates a leak that is sent to a remote panel for annunciation. Pressure systems are rarely used due to the increased maintenance required.

Leakage Remote from Tanks

Groundwater Monitoring. Groundwater monitoring senses the presence of product floating on the surface of groundwater. It can be used only where the products to be measured are immiscible. This method requires the installation of monitoring wells at strategic locations into the groundwater at several locations near the tank. The wells must be properly designed and sealed to eliminate contamination.

They can be checked either manually or by automatic, electronic methods. Manual methods require the use of a “bailer” to collect liquid samples from inside the well and bring them to the surface. They must be sent for analysis once each month. Electronic methods use probes suspended in the well to continuously monitor for the presence of contamination in the groundwater. An alarm is annunciated at a remote panel. Monitor wells are limited to sites where the groundwater level is 20 ft (6.2 m) or less below the surface, with best results obtained from depths of between 2 to 10 ft (0.60 m to 3 m).

In-Ground Vapor Monitoring. In-ground vapor monitoring measures “fumes” in the soil around a storage tank to determine the presence of spilled product. This method requires the installation of monitoring wells similar to those used for groundwater monitoring. The wells can be checked by either manual or automatic, electronic methods. Manual methods require air sample gathering and submission to a laboratory for analysis once a month. Electronic equipment uses a probe suspended in the well and a remote, highly calibrated analyzer. Vapor monitoring should be considered only where backfill is sand, gravel, or other similar material through which vapor will readily move from the tank to the monitor. It is not recommended where a high groundwater level and excessive precipitation would interfere with the operation of this system for more than 30 days.

Leakage from Piping

Underground Pressurized Delivery Systems. Pressurized piping shall have one automatic leak detection method and one additional method, as follows.

1. Automatic leak detection consists of a permanently installed automatic flow restrictor or automatic flow shutoff device installed in the product discharge piping or a continuous alarm system. The continuous alarm could be a probe installed in the secondary pipe continuously monitoring liquid or vapor release of the secondary containment piping system. If the secondary containment terminates in a manway or containment sump, the lower end of the secondary containment pipe shall be open to the sump and allow any leaking liquid to spill into the sump to be detected.

2. Additional methods include one of the following monthly requirements: groundwater monitoring, secondary pipe vapor monitoring, secondary pipe liquid monitoring, or annual pipe tightness testing. A continuous alarm to detect spillage as described above complies with this requirement as an additional method if installed in addition to an automatic detection method.

The following accuracy must be provided for automatic detection: A pressurized shutdown monitoring device that prevents flow of produce when a line tightness test indicates a minimum leakage of 0.10 gph (0.016 Lps) is detected. In addition, the device shall be capable of shutting down the system when a leak of 3 gpm (19 Lps) at 10 psi (68 kPa) is detected. One type of device commonly used is installed on the discharge of the submersible pump in the manway. It must act independently of any other pressurized shutdown monitoring device.

Underground Suction Delivery Systems. Underground suction piping leak detection is not required if the piping is both sloped back to the tank from the dispenser and if a check valve is installed in the dispenser as close as possible to the vacuum

pump. Because of the anticipated increased use of alcohol additives to gasoline, it is general practice to provide double-contained suction piping for gasoline systems. Double-contained piping is not required for diesel fuel, but it is highly recommended.

When the tank is higher than the dispenser, it is necessary to use double-contained piping. A sump is installed at the low point of the piping, and a probe is installed to detect leakage from the secondary pipe.

Tank Tightness with Inventory Control

This is a combination method using periodic tank tightness testing and a monthly inventory control. It is allowed only for the first 10 years of operation. Tank tightness requires that the tank be taken out of service and temporary equipment be installed. One method uses a volumetric test to exactly measure the change of level of product over a period of several hours. Another method uses ultrasound or tracer gas detection techniques to discover a leak in the tank wall. The monthly inventory requires that exact measurement be taken each month of the amount of product delivered compared to the amount stored in the tank and the amount dispensed. If the two figures do not balance, there is a leak.

Leakage into Sumps, Pans, and Other Secondary Containments

Any product leaking from the primary pipe will spill into the secondary containment pipe and flow by gravity to the low point. The piping is pitched downward to a bulkhead, sump, or manway. Double-contained piping penetrates the side of the bulkhead using special fittings called *bulkhead fittings*. These fittings are used to terminate double-contained piping so that the secondary containment is open and free to have liquid spill into the sump to be detected.

Leakage within containment sumps and manways is monitored by means of probes sensitive to liquid or vapor. They are suspended in or attached to the sides of the containment. The liquid probe level is adjusted to signal the presence of liquid. Probes are available to discriminate between water and petroleum products. They are connected by wires to a remote panel for annunciation. A typical containment probe is illustrated in Fig. 12.13.

Inductive sensors are also available that do not require penetration of the secondary containment pipe. This type of sensor is attached directly to the outside of the secondary pipe to detect leakage by interrupting the inductive path of the sensor.

VAPOR RECOVERY SYSTEMS

It is a code requirement that VOC vapors resulting from the displacement of gasoline and gasoline-blended products be prevented from entering the atmosphere. This occurs when storage tanks and motor vehicles are being filled. Diesel fuel, kerosene, waste and motor oil, and heating oil do not require vapor recovery.

Vapor recovery is divided into two phases. Phase I is recovery from gasoline storage tanks, and phase II is recovery from gasoline dispensers.

Phase I Vapor Recovery

Phase I vapor recovery is a separate and independent closed system installed at the storage tank for use only when filling the storage tank. The purpose of phase I vapor recovery is to prevent the escape of VOCs into the atmosphere from the UST. It is used only when filling storage tanks. This can be achieved by means of either a two-point, or coaxial, system.

Two-Point System. The two-point vapor recovery system is a separate and independent closed system. It consists of a separate vent from the UST piped directly to the tanker truck. A separate hose from the truck is connected to an outlet accessed through a vapor recovery fill port adjacent to the product fill port. A typical vapor recovery port is illustrated in Fig. 12.12.

If the vapor recovery connection to the UST is remote, the piping shall pitch back to the tank so that any condensed product will drain back into the tank. The pitch is generally $\frac{1}{4}$ in by 10 ft (3 m). This piping need not be double contained. If there are multiple USTs, the vapor recovery piping could be manifolded. Connection to the phase II vapor recovery system may be allowed by the responsible code officials.

It is common practice to have the vapor recovery pipe size the same as the fill line. Typically, this size is 3 in (75 mm) and does not require double-contained pipe.

Coaxial Vapor Recovery. This system is a combination system with a single connection point. It is similar in principle to phase II vapor recovery used in dispensers. It consists of a drop tube having a pipe within a pipe and a delivery hose of the same construction. Product is delivered through the center pipe of the delivery hose, and the vapor passes through the outer pipe of the drop tube and continues to the delivery truck through the coaxial delivery hose as the product fills the tank.

Phase II Vapor Recovery

Phase II vapor recovery is a separate and independent closed system installed at the dispenser for use only when dispensing gasoline. Its purpose is to prevent the

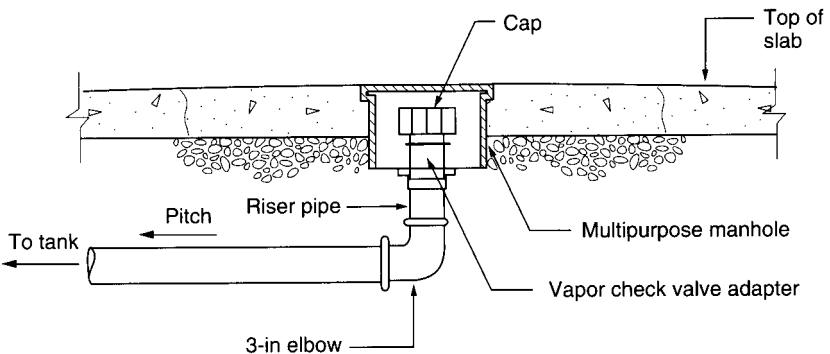


FIGURE 12.12 Typical vapor recovery port.

escape of VOCs from the motor vehicle tank into the atmosphere during tank filling. Phase II vapor recovery can be achieved by either a balanced or vacuum system.

Balanced Vapor Recovery System. A balanced system, which has no moving parts, is used when the tank is lower than the dispenser. The system consists of a coaxial hose from the nozzle to the dispenser, a separate fitting in the dispenser that separates the outer vapor line from the inner product hose and a separate vent pipe from the dispenser routed directly to the UST. The pressure developed by the displacement of air in the vehicle fuel tank is used to force the vapor into the hose. Special coaxial dispensing hoses and a nozzle shroud are ancillary requirements. The dispenser selected for gasoline service should be “vapor recovery ready.”

If there are multiple dispensers, the vapor recovery pipe from each dispenser to the UST could be manifolded together. In addition, connection to the phase I vapor recovery system may be allowed by the responsible code officials.

Vacuum Vapor Recovery System. A vacuum system is required when the tank is higher than the dispenser. The system uses a vacuum pump in the dispenser enclosure to draw the vapor from the coaxial dispenser hose and nozzle and provides the pressure necessary to force the vapor and condensed liquid back into the UST.

PRODUCT DISPENSING SYSTEMS

Product dispensing refers only to the transferring of product from the storage tank into the fuel tank of motor vehicles. Other motors, such as those for fire pumps and emergency generators, have integral fuel pumps that supply the engine and often recirculate product from a storage tank.

There are two types of systems used to transfer product from the UST to the motor vehicle: pressure and vacuum. The pressure system uses a pump submerged in the UST to create the pressure needed to transfer the product from the UST to the vehicle. The vacuum system uses a pump installed in the dispenser enclosure to create a suction pressure needed to draw the product from the UST into the vehicle.

For USTs, the pressure system is preferred for the following reasons:

1. Maintenance is much lower compared to vacuum systems.
2. The initial cost is lower.
3. With a vacuum system, there is a practical limit of 10 ft (3 m) suction lift possible from the UST bottom to the highest point of the dispensing system.
4. A submersible pump will supply multiple dispensers. Vacuum pumps must be installed in each individual dispenser.
5. Submersible pumps can deliver much higher flow rates than vacuum pumps.
6. Vapor lock is not possible with a submersible pressure pump system.

Pressure Dispensing System

The pressure system consists of a small-diameter submersible pump installed in the product storage tank that provides the required flow rate and pressure. The submersible pump is sized to fit inside a 4-in (100-mm) tank connection.

Piping extends from the top of the pump directly to the dispenser. Since the pump is screwed into the tank connection, the orientation of the pump outlet is not always in line with the piping connection to the dispenser. A length of flexible hose, usually metallic, is required for the final connection. Larger pumps will fit inside a 6-in (150-mm) tank connection. The assembly shall be enclosed within a manway that will allow access to the electrical work, leak detection options, and the piping connections for future testing and repair. A simplified detail of a typical installation is illustrated in Fig. 12.13.

The system starts operation when the dispenser calls for product. The pump is started, and the product flows to the dispenser nozzle. When the nozzle shuts off, the pump stops. A check valve on the discharge of the pump at the tank prevents product in the piping system from draining back into the tank.

Vacuum Dispensing System

The vacuum dispensing system consists of a drop tube inside the storage tank, a vacuum pump for product installed inside the dispenser housing, piping from the storage tank, and check valves to keep product from draining back into the tank and the dispenser. The primary use of the vacuum dispensing system is for situations in which there is no pitch of the product line from the dispenser to the storage tank.

The system starts operation when the dispenser calls for product. The pump in the dispenser is started, and the product is drawn to the dispenser nozzle. When the nozzle shuts off, the pump stops. A practical limit of 10 ft (3 m) suction lift must not be exceeded from the bottom of the tank to the highest point of the dispenser hose.

A check valve in the product line prevents product in the piping system from draining back into the tank. There are three locations for the check valve: at the base of the product suction line inside the tank (called a *foot valve*), an angle check valve in the suction line mounted above the tank, and a check valve in the dispenser at the vacuum pump. The angle check valve is often used because of its reliability. It is accessible through a manhole installed for accessibility. The foot valve is prone to clogging, and its removal must be made through an extractor filling. It is being used to a lesser extent because clogging is common and removal for servicing is difficult. The check valve in the dispenser enclosure is acceptable by the EPA and is cited as one method that if used, will not require additional leak detection methods if slope back to the tank is possible. It is the most accessible. When used for gasoline, the dispenser-mounted check valve allows product vaporization and resulting vapor lock.

Product Dispenser

Dispensers are commonly available for two flow rates, standard speed for cars, which delivers a flow rate in the range between 7 and 15 gpm, and high speed for trucks which delivers as much as 45 gpm. For passenger cars, the average dispenser discharges approximately 10 gpm (65 Lps) and requires approximately 30 psi (200 kPa). The size hose from the dispenser to the nozzle could be either $\frac{5}{8}$ or $\frac{3}{4}$ in, with $\frac{3}{4}$ in most often used. High flow rates for large fuel tanks require a 1-in (25-mm) size hose.

A wide variety of features can be selected for dispensers. The following are the major components generally found in a dispenser:

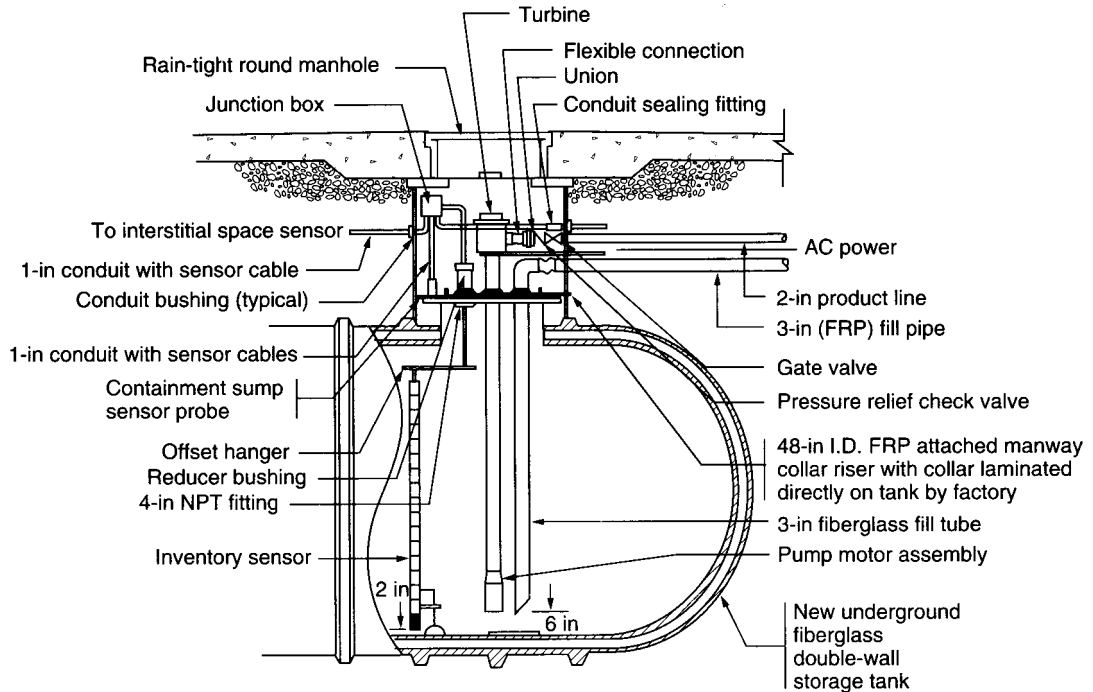


FIGURE 12.13 Containment sump with pressure pump and other connections to UST.

1. *The register.* Used to display the amount of product.
2. *A meter.* Used to register the total gallons.
3. *Location of the hose outlet.* Available in side or front locations.
4. *Hose.* Coaxial type for stage II vapor recovery. A length of 12 ft is average, but 15 ft is available, with breakaway fitting.
5. *A high hose retriever.* Used to keep the hose off the floor.
6. *A high-capacity product filter.*
7. *An emergency shutoff.* Used to stop the flow in the event of a supply or dispenser hose line break.
8. *A dispenser containment mounting pan.* Used when installing the dispenser.
9. *A nozzle with vapor recovery feature where required and automatic shutoff feature.* Two sizes are generally available: $\frac{5}{8}$ in and the more common $\frac{3}{4}$ -in.

Dispenser Pan

A dispenser pan is required to attach the dispenser onto a concrete pad or island. The pan provides a liquid-tight entry for both single- and double-wall product piping and electrical conduit and is designed to collect and monitor spills and prevent product leaking from below the dispenser into the environment.

ABOVE-GROUND STORAGE AND DISTRIBUTION SYSTEMS

STORAGE TANKS

Tank Materials

The most often used primary tank is factory constructed of steel and intended for atmospheric pressure conditions. They shall conform to UL-142, Standard for Safety. Other materials, such as FRP, reinforced concrete, and FRP clad steel are seldom used for smaller tanks. Stairs are generally provided to allow inspection and delivery truck operators to reach connections located on top of the tank.

Tank Construction

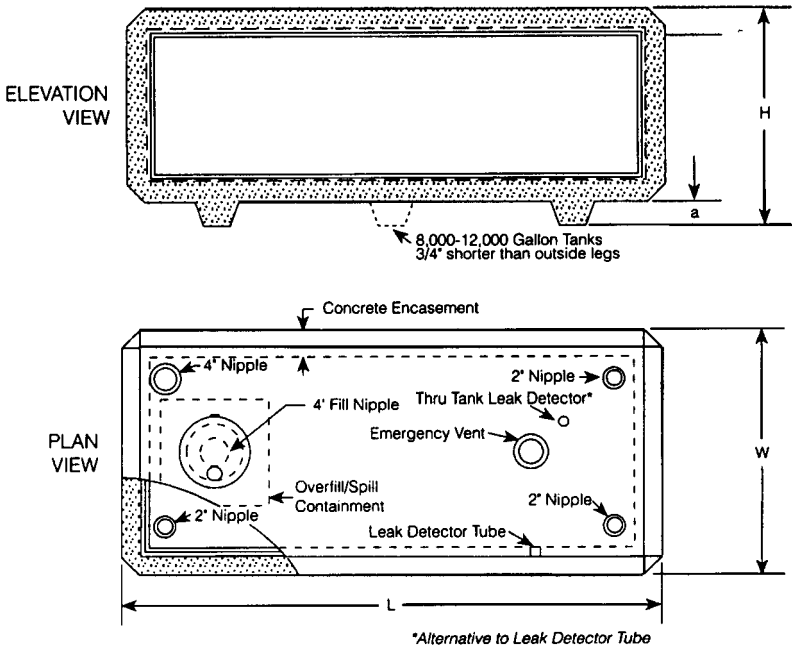
ASTs are factory fabricated in both round and rectangular configurations. Primary tanks are often manufactured with compartments capable of storing different products. NFPA-30 limits motor fuel AST capacity to 6000 gal (22,680 L). All ASTs must be provided with some form of product leakage and overflow containment conforming to Spill Prevention Containment and Countermeasures (SPCC) regulations. This containment shall be either a dike or impoundment capable of holding 110 percent of tank contents or with integral secondary containment of the primary tank.

Most smaller tanks are provided with an integral secondary containment and an interstitial space. The width of the space varies between different manufacturers. There are several proprietary methods used to construct the secondary containment vault around the primary tank. An often used material is lined concrete, which provides a 2-h fire rating required by UL-2085 if sufficiently thick. Plastic-lined concrete with a wall thickness capable of providing a 2-h fire rating, as required by UL-2085, is generally used for an integral secondary containment. It is a code requirement that the outside of the concrete vault be protected against corrosion, weather, and sunlight. An external secondary containment vault of steel is also used. Insulation between the primary and secondary tank is provided by some manufacturers to protect the primary tank from temperature extremes. This may also be used to meet fire safety requirements for a 2-h rating.

The dimensions of a typical tank with integral secondary containment with 2-h fire rating are given in Fig. 12.14. The dimensions of a typical steel tank with external secondary containment are given in Fig. 12.15. Weight and dimensions are similar to those found accompanying Fig. 12.14.

Corrosion Protection

Since the tank is above ground, the only corrosion protection required for the tank is weather resistance of the tank exterior. This is a code requirement, and each manufacturer has a proprietary method of protecting the outside of the AST. The exposed piping shall be either corrosion-resistant material such as FRP (which must



Tank Size	L	W	H	a	wt.
250	7'-8"	3'-9"	3'-3"	0'-4"	8,000
500	11'-0"	4'-6"	3'-4"	0'-4"	12,000
1,000	11'-0"	5'-8"	4'-4"	0'-4"	18,000
2,000	11'-3"	8'-0"	5'-6"	0'-6"	30,000
4,000 ^{max}	12'-2"	8'-0"	8'-9"	0'-6"	40,000
4,000 ^{min}	17'-7"	8'-0"	6'-6"	0'-6"	45,000
5,200 ^{max}	15'-6"	8'-0"	8'-9"	0'-6"	50,000
5,200 ^{min}	13'-2"	11'-11"	7'-0"	0'-6"	53,000
6,000	17'-7"	8'-0"	8'-10"	0'-6"	57,000
8,000	23'-1"	8'-0"	8'-10"	0'-6"	72,000
10,000	28'-7"	8'-0"	8'-10"	0'-6"	87,500
12,000	34'-1"	8'-0"	8'-10"	0'-6"	101,000

FIGURE 12.14 AST tank weights and dimensions with integral secondary containment. (Courtesy Convault.)

also be impervious to UV light), stainless steel, or protected (painted or coated) black steel pipe.

Tank Connection and Access

Connections are located only on top of the tank, and they extend through the vault or secondary containment into the primary tank. There is usually no direct access

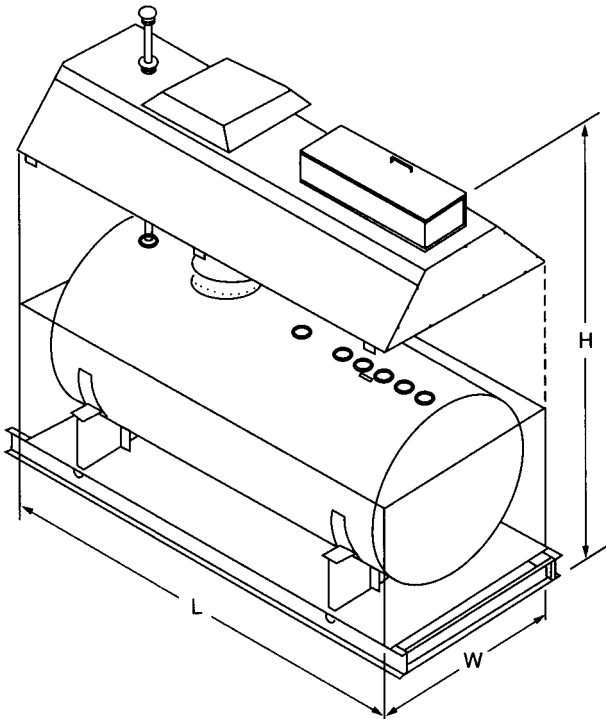


FIGURE 12.15 AST tank with external secondary containment.

for personnel entry into the primary tank except for larger tanks. Standard connections include:

1. Tank vent
2. Emergency vent
3. Product dispenser outlet
4. Product fill (either coaxial or single as required)
5. Phase I vapor recovery (if necessary)
6. Tank gauging
7. Leak detection

Tank Filling and Spill Prevention

Tank Fill. The tank is filled using a fill port assembly built into the tank enclosure or containment at the top of the tank. The delivery truck must have a pump, and the operator is required to climb stairs to make the connection. The fill port cover could be locked if desired. In order to reach the top-mounted connection with the hose, stairs are provided as part of the installed tank. If a coaxial vapor recovery system is used, only one connection to the tank is required. If a two-point system

is used, two connections are required. An optional, ground-level remote tank filling station is usually available as a separate piece of equipment to allow convenient filling without having to connect to the top of the tank. The remote fill station could have a self-contained pump or use the built-in fuel truck pump.

Spill Containment. For tanks with integral secondary containment, there is a containment sump surrounding the fill pipe. The size of the sump ranges from 5 to 15 gal (19 to 57 L). For tanks with external secondary containment, spills will enter the containment and be manually removed. The remote fill station could be provided with an integral spill containment sump to catch any hose spills. A small hand or electric pump could be provided to empty the containment sump back into the primary tank.

Atmospheric Tank Venting

An AST requires two vents. One is the standard atmospheric vent used to keep the tank at atmospheric pressure. This is commonly a 2-in size and shall extend to a point 12 ft, 0 in, above grade. The end typically terminates in a pressure-vacuum cap. The second is an emergency vent required to depressurize a tank if there is a fire close to or under the tank that raises the temperature to a point where the amount of product vapor is generated faster than the atmospheric vent is capable of passing. These vents are commonly a 6 or 8 in size, depending on the tank size and number of gallons stored. The tank manufacturer will provide the required emergency vent with a size based on API standards.

Overfill Prevention

Overfilling is prevented by automatic or manual means installed directly on the tank. Automatic overfill prevention uses an overfill preventing valve similar to that previously described in the UST subsection. Manual methods include a direct reading level gauge installed in sight of the operator or an audible high-level alarm activated by a separate probe installed inside the tank. Alarms shall operate when the product level reaches 90 percent of capacity and stopped when the level reaches 95 percent.

LEAK DETECTION AND SYSTEM MONITORING

Leakage from Tanks

Above-ground tanks require a method of containing any possible product release and preventing contamination of the adjacent environment. Releases can result from small leakage from the tank or catastrophic failure of the tank. Required containment methods include providing either a dike completely around the tank, remote secondary containment, or integral secondary containment.

For ASTs without secondary containment, a dike shall be provided. Dikes are required to contain 110 percent of tank capacity and to be constructed of materials such as concrete, steel, or impermeable soil designed to resist the full head of water.

They must be constructed in conformance with NFPA-30. Discharge from the dikes must have a separator along with the necessary control valves that may have to be self-actuating to conform with local codes. It is recommended that an additional impoundment basin be constructed at least 50 ft (16 m) from the AST and at a safe distance from other buildings or tanks. The purpose is to capture and isolate any flammable liquids released during a fire or tank failure and remove it to a safe distance away from the AST. For ASTs, dikes are seldom used because remote and integral secondary containment have a far less initial cost.

Remote secondary enclosures are usually made of steel. They are of the totally enclosed type and are sealed in a manner so as to prevent the entrance of rainwater. They are required by code to provide 110 percent nominal capacity of the primary tank.

Tank integral secondary containment is achieved by enclosing the primary tank with an integral containment, usually steel or reinforced concrete. This type of tank has an interstitial space that is monitored for leakage in the same manner as the USTs discussed previously.

System Monitoring

System monitoring consists of product-level gauging and leakage annunciating. The AST systems can be monitored either manually or electronically.

Product-level gauging in the tank could be achieved by the use of a visual level gauge or an electrical gauge either mounted on or immediately adjacent to the tank or at a remote location. Level gauges similar to those installed in USTs can be used. Remotely mounted electronic gauges capable of recording and placing in memory many functions using probes similar to those installed in USTs are commonly used.

Leak detection for ASTs is much easier than for USTs because leakage from the tank can easily be observed manually. Automatic means of system monitoring include a stand-alone alarm panel or an alarm integral to an electronic panel used for product-level indication.

VAPOR RECOVERY

Stage I and II vapor recovery for gasoline and gasoline blends is required. For stage I recovery, either coaxial or two connections from a delivery truck are necessary during the filling operation. Stage II vapor recovery for tank-mounted dispensers are usually integral. For remote dispensers, a separate vapor recovery line is required, connecting from the dispenser to the tank.

PRODUCT DISPENSING SYSTEMS

For ASTs, the dispenser is usually directly connected to the tank or is located a very short distance away. The vacuum system is usually preferred for these installations because it is lower in initial cost, and due to the short piping runs and single

dispenser, most of the objections discussed in the UST subsection do not apply. It is important to include an antisiphon valve to all AST dispensing systems.

For ASTs, the dispenser could be mounted either on the tank or as a separate, remote dispenser (similar to those used for a UST), and available with vacuum or pressure systems (Fig. 12.16*a*).

The tank-mounted dispensing system consists of a submersible pump, the complete dispenser (nozzle, hose, integral vapor II recovery system, base mounting method, and safety features), product pump, and interconnecting piping. A detail of a typical tank-mounted installation is illustrated in Fig. 12.16*b*.

TANK PROTECTION

All ASTs located adjacent to a road or subject to a possible collision shall be adequately protected. Accepted means are concrete barriers or bollards. Bollards are the most often used and are similar to those used to protect fire hydrants. Bollards are illustrated in Fig. 6.47.

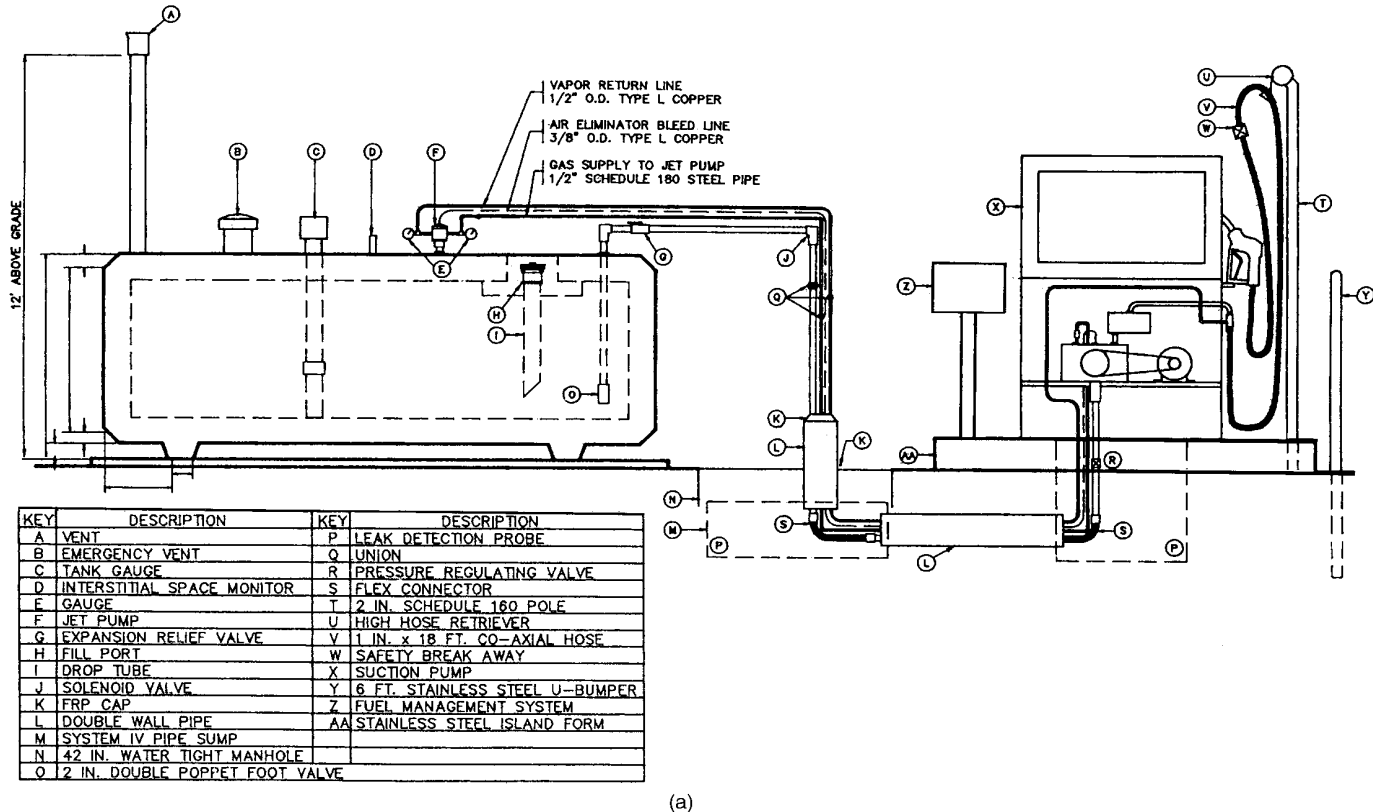
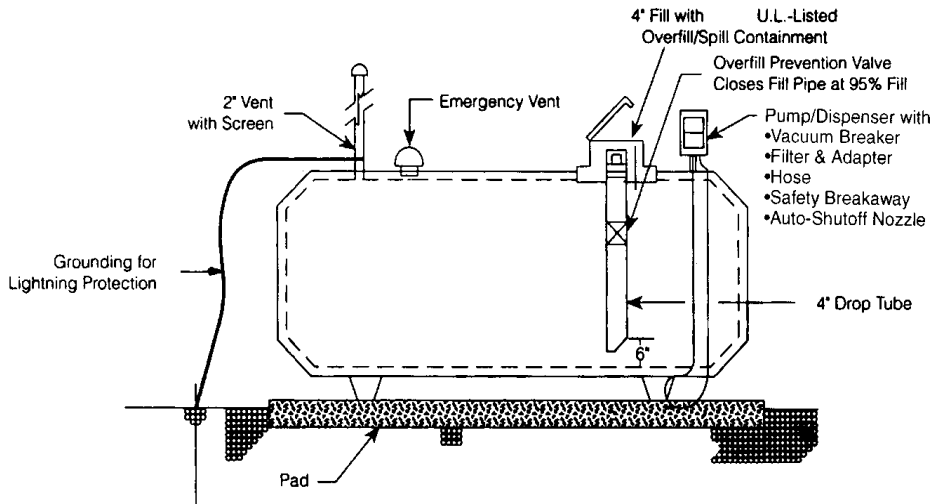


FIGURE 12.16 (a) Typical remote dispensing from an AST. (Courtesy Ten Hoeve Brothers.)



(b)

FIGURE 12.16 (b) Typical tank mounted above-ground dispenser. (Courtesy Convault.)

MISCELLANEOUS MOTOR FUEL STORAGE

FIRE PUMP FUEL STORAGE

General

Diesel fuel is often used to supply fire pumps and emergency generator motors. This section will discuss storage facilities for these purposes. The driver most often used to power fire pumps other than an electric motor is a diesel fueled engine. This section will discuss the storage of diesel fuel for that purpose.

Codes and Standards

The principal code is NFPA-20, Fire Pumps. In future discussions, this will be referred to as "code." Other codes may be local fire and building codes, as well as other local regulations governing the storage of diesel fuel.

General Design Considerations

The diesel fuel is stored in a tank whose bottom is elevated about 3 ft, 0 in, above the floor. The fuel is fed by gravity to the diesel engine that has an integral fuel pump as part of the engine assembly.

The code recommends that diesel fuel be stored indoors adjacent to the fire pump if allowed by local regulations. The following discussions concern only an indoor tank. If the storage containment is a remote underground or above-ground tank, the requirements are the same as previously discussed for AST or UST installations. The above-ground tank shall be UL approved.

The minimum amount of actual storage mandated is 1 gallon per pump horsepower. Approximately 10 percent additional tank capacity should be added to the calculated storage to allow for freeboard.

The tank should be placed on legs to elevate it as high as reasonable to provide static height for gravity feed to the engine. A generally accepted distance is about 3 ft, 0 in, above the floor. The entire tank shall be protected by a dike high enough to contain the entire contents with an additional allowance of several inches freeboard. It is recommended that a fire extinguisher be placed nearby for safety.

A fill line connection is factory installed at the top of the tank. Since the fill line shall extend outside the building to allow the pumper delivery truck to connect to it, the connection point will be placed lower than the top of the tank. Because of this, an antisiphon valve shall be placed on the high point of the pipe run to the fill line to prevent accidental emptying of the tank. A special "quick disconnect" connection shall be provided. If the fill line is in-ground, a check valve connection on the fill line shall be installed.

Other connections on top of the tank are for the vent and gauge. The vent, usually with 2 in size, must extend from the tank to a point 12 ft, 0 in, above grade and in a safe location. A fuel-level gauge connection is provided that will permit a visual gauge to be mounted directly onto this connection. In this location the gauge must be read directly in front of the tank. If a more convenient gauge location

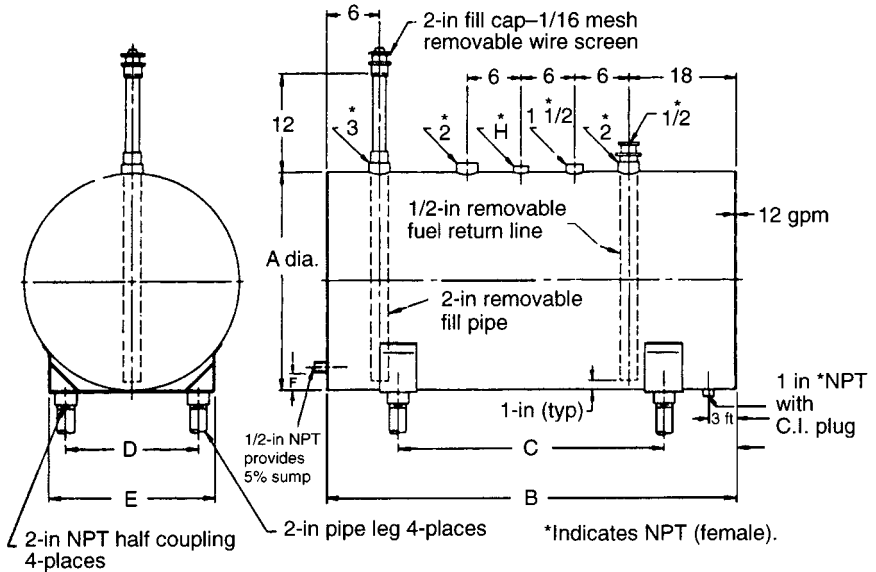
is desired, a remote gauge can be placed on an adjacent wall near the fill line if conditions allow. Interconnection tubing must be installed from the tank connection to the gauge. Although having a higher cost, the remote gauge, located at the fill connection if possible, will allow the delivery person to accurately observe the level of fuel in the tank to avoid overfilling.

Interconnecting fuel supply and return piping from the tank to the engine is generally made of copper tube.

Storage tank dimensions for one manufacturer are given in Fig. 12.17. A diesel fuel storage system for fire pumps from one manufacturer is shown in Fig. 12.18.

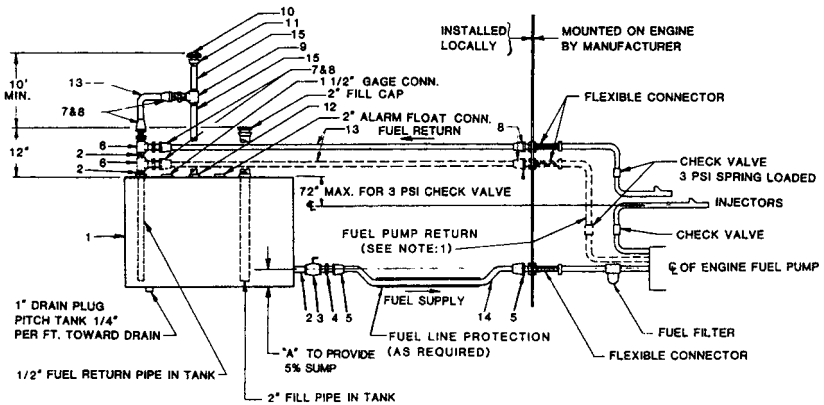
EMERGENCY GENERATOR FUEL STORAGE

Emergency generators could have fuel stored either in AST or UST systems. When stored inside buildings, the capacity of the tank is limited to a maximum of 660 gal. This amount of fuel shall be stored in a double-contained tank either remotely or as an integral part of the base of the generator. It is common practice for integral tanks to have an interstitial space capable of containing 110 to 140 percent of the tank capacity. When a remote storage tank is used, it is a good practice to provide



Capacity (gallon)	Dimensions							
	A	B	C	D	E	F	G	H
105	24	61	37	14	18	3	12	2
165	30	61	37	16	20	3	12	3
270	38	61	37	23	27	3 3/4	12	3
320	38	73	44	23	27	3 3/4	14 1/2	3
515	48	73	44	30	34	4 3/4	14 1/2	4

FIGURE 12.17 Typical fire pump fuel storage tank. (Courtesy Fairbanks Morse.)



FURNISHED BY FAIRBANKS MORSE	
ITEM QTY.	DESCRIPTION
1	1 FUEL STORAGE TANK
2	2 1/2" CLOSE NIPPLE
3	1 1/2" STOP COCK (LOCK TYPE)
4	1 5/8" TUBE x 1/2" PIPE THREAD CONNECTOR
5	2 5/8" TUBE NUT
6	1 1/2" PIPE TEE
7	3 1/2" TUBE x 1/2" PIPE THREAD CONNECTOR
8	4 1/2" TUBE NUT
9	1 1 1/4" x 1 1/4" x 1/2" PIPE TEE
10	1 FLAME ARRESTOR
11	1 1 1/4" x 2" PIPE BUSHING
12	1 1 1/4" x "B" PIPE BUSHING
FUEL PUMP RETURN (SEE NOTE:1)	
2	1 1/2" CLOSE NIPPLE
6	1 1/2" PIPE TEE
7	1 1/2" TUBE X 1/2" PIPE THREAD CONNECT
8	2 1/2" TUBE NUT

FURNISHED BY CUSTOMER	
ITEM	DESCRIPTION
13	1/2" O.D. COPPER TUBING
14	5/8" O.D. COPPER TUBING
15	1 1/4" VENT PIPE
FUEL RETURN LINE (SEE NOTE:1)	
13	1/2" O.D. COPPER TUBING

TANK SIZE	"A"	"B"
105 GAL.	3"	2"
165 GAL.	3"	2"
270 GAL.	3 3/4"	3"
320 GAL.	3 3/4"	3"
515 GAL.	4 3/4"	4"

NOTE 1: fuel pump return line is not required for all installations.

FIGURE 12.18 Typical diesel fire pump fuel system.

a day tank containing 2 h fuel supply immediately adjacent to the generator. The installation must conform to all local rules and regulations previously discussed.

The fill port could be mounted at the generator or remotely. For a remote fill, the inlet should be in a locked box so that the public or a casual passer-by could not have access to the inlet. On a private site, this will avoid tampering by employees. Another method is to place the fill port about 9 ft (3 m) above grade in an adjacent wall. Although this makes it difficult for delivery personnel to gain access, it also makes it much more difficult for the public to try to gain access to the inlet.

Spillage onto grade due to overfilling is prevented by installing visual and audible alarms adjacent to the fill port that signal at the 90 and 95 percent fill levels. The alarms are usually separate to have redundancy, but a single, dual alarm is available. Secondary protection is obtained by providing the nozzle on the delivery hose with an automatic shutoff similar to that on a gasoline dispensing nozzle. Leakage into the interstitial space of integral storage tanks is usually signaled by a float arrangement or probes similar to the previously discussed alarms. The tank vent is routed away from the storage tank, 12 ft (4 m) above grade, either above the generator set or on an adjacent wall.

The fill pipe and other fuel-containing interconnecting pipe should be double contained to eliminate potential leaks. The line should be pitched to a low point. A tee at the low point, with a probe connected to an alarm, will detect any primary pipe leakage. Vent piping is not required to be double contained. The end of the vent should be covered with a mesh screen to prevent entry of bugs and debris.

SYSTEMS DESIGN

PIPING MATERIALS

Piping above ground from an AST is for the vent, product delivery, and for tank fill from a remote location. The most common material is A-53 steel with threaded joints and factory-applied corrosion protection. The pipe shall be coated at the factory with an accepted and proven corrosion paint or coating. A common practice is to use a baked-on powder. Another material used is stainless steel where corrosion protection and strength is required. FRP with ultraviolet protection added to the pipe is another often-used material. Galvanized steel pipe is not considered acceptable. Adapters are used to connect steel pipe to FRP if an underground run to a remote dispenser is necessary.

Because of the requirement to cathodically protect underground steel pipe, interconnecting piping installed for new and replacement USTs is almost exclusively plastic or FRP piping with secondary containment. Requirements of the implementing authority must be verified regarding approval of the specific piping material selected.

Plastic piping could be divided into two general types, flexible and rigid. Flexible pipe is generally manufactured from proprietary materials. If it is approved by UL and/or FM, it is generally acceptable. Flexible piping materials have found limited use and acceptance. In addition, the joints and connection methods should also be closely examined for strength, ease of installation, and corrosion resistance.

Rigid FRP piping with an epoxy interior lining has been widely used and accepted and is considered the piping material of choice. The primary pipe is assembled with socket type fittings and epoxy cement. The outer (secondary containment) pipe is the same material as the primary pipe manufactured in two half sections with a longitudinal flange. It is assembled after the primary pipe is tested using cement placed on the adjacent flanges with nuts and bolts installed to hold the two half sections together until the cement dries. The secondary containment pipe is shown in Fig. 12.19.

Flexible pipe connectors are used to connect piping runs to sumps and manways to allow for settlement. In addition, because submersible pumps are screwed into a tank connection, the product discharge will not always face the direction of the

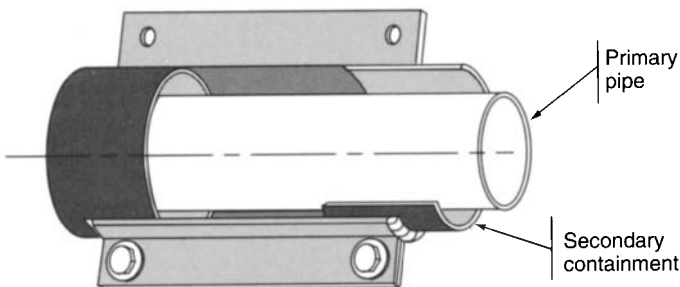


FIGURE 12.19 Secondary containment for FRP piping.

piping run to the dispenser when tightened. Flexible connectors are necessary inside manways to connect submersible pump discharge to the dispenser supply piping.

Because leakage is visible, double-contained piping is not required for ASTs if they are located within a dike or inside a remote containment. If the pipe run is underground, it shall be double contained with leak detection capability.

PIPE SIZING

Pipe sizing is based on the flow rate of the product, the allowable friction loss of the fluid through the system, and fluid velocity. This is an iterative procedure done in conjunction with selecting the size of the product pump.

Information Required

The procedure for sizing the dispensing system involves determining the following before the actual pipe is sized:

1. The dispenser location and type and ancillary devices
2. The pipe material
3. The layout of the piping system
4. The storage tank size and location
5. The type of product pump system, either suction or pressure

Flow Rate

For ordinary applications, the typical discharge flow rate to motor vehicle from average dispensers is 8 to 10 gpm (30 to 38 Lpm). High-rate dispensers for buses and trucks are available with a discharge of up to 45 gpm (285 Lpm).

Simultaneous-Use Factor

The number of dispensers likely to be used at once is usually provided by experience. When no experience exists, multiple dispensers of up to four is normally considered a 100 percent use factor. For more than four, a 75 percent simultaneous-use factor is used.

Velocity

For FRP piping, the recommended maximum velocity is less than 7.5 fps. Maintaining a velocity below this rate keeps the pressure rise from water hammer to a safe level of 150 percent of design pressure. This is necessary due to the quick closing of the dispenser valve. For steel pipe, a velocity of 8 fps has been found acceptable.

Piping Friction Loss

Friction loss of product through piping with 1¼ to 2½ in (125 to 250 mm) size is found from Table 12.5. Using the established flow rate, select the allowable friction loss based on pipe size and the selected product.

For preliminary sizing purposes only and if specific tables are not available, most products are close enough in viscosity to that of water to use standard water charts to obtain a sufficiently accurate friction loss figure. For FRP pipe, decrease the friction loss by 10 percent to obtain a more accurate figure.

TABLE 12.5 Friction Loss of Product through 100 ft Steel Pipe

Pipe size, in	Velocity, ft/s	gpm	Friction loss*		Pipe size, in	Velocity, ft/s	gpm	Friction loss*	
			Gasoline	Diesel				Gasoline	Diesel
1½	0.84	6	0.3	0.5	2½	3.92	60	3.1	5.0
	1.26	8	0.7	1.1		4.56	70	4.1	6.6
	1.57	10	0.9	1.5		5.23	80	5.4	8.4
	1.80	12	1.4	2.3		5.80	90	6.5	10.3
	2.36	15	2.1	4.0		6.54	100	8.3	12.4
	3.15	20	3.3	5.7		7.10	110	9.9	14.5
	3.80	25	5.2	8.5		7.84	120	11.7	17.1
	4.72	30	7.2	14.7		8.48	130	13.6	19.7
	6.30	40	12.4	19.2		9.15	140	15.6	22.5
	7.67	50	18.9	28.4		9.51	150	17.8	25.4
	8.44	60	24.7	39.4		11.76	180	25.2	35.3
	11.02	70	36.9	52.5		13.07	200	30.9	42.6
	12.50	80	44.3	63.0		15.69	240	43.8	53.1
14.71	90	56.5	81.3	16.95	260	59.0	61.1		
15.74	100	71.5	91.0	19.61	300	67.4	86.5		
2	2.5	25	1.5	2.6	3	4.5	100	2.6	4.46
	3.0	30	2.1	3.6		5.4	120	3.9	6.18
	3.6	35	2.8	5.2		6.3	140	5.3	8.04
	4.0	40	3.6	5.8		7.2	160	6.7	10.06
	5.1	50	5.4	8.6		8.1	180	8.4	12.44
	6.1	60	7.6	11.9		9.0	200	10.2	15.0
	7.1	70	10.2	15.6		10.2	225	12.9	18.4
	8.2	80	13.1	19.8		11.3	250	15.5	22.3
	9.2	90	16.3	24.4		12.5	275	18.9	26.8
	10.2	100	20.0	29.2		13.6	300	22.2	31.0
	11.2	110	24.3	34.7		14.8	325	25.9	35.6
	12.2	120	28.6	40.7		17.0	375	34.3	41.0
	13.2	130	33.4	46.9		18.2	400	39.0	52.0
14.3	140	39.5	53.5	19.3	425	43.5	58.0		
15.3	150	43.9	60.6	21.6	475	54.4	71.0		
20.4	200	76.6	101.3	22.7	500	60.3	78.0		

*For FRP pipe, reduce friction loss figure by 10 percent.

SUBMERSIBLE PUMP SIZING

The submersible pump is suspended in the product storage tank with the impeller near the bottom of the tank and the motor, piping connections, and electrical work exposed in a manway at the tank top. The pump is sized according to the flow rate of the product and the total head required.

To find the flow rate: Calculate the total gallons per minute from each section of the product line. This is done using the flow rate from the selected dispensers and the simultaneous-use factor for the number of dispensers that may be used at the same time. This will give the gallons per minute (liters per minute) requirement for the pump.

To find the total pump head required:

1. Calculate the height from the bottom of the storage tank to the high point of the dispenser hose, including the elevation of the high hose dispenser.
2. Find the friction loss of the product flow through the distribution piping up to the dispenser, based on the flow rate calculated. This figure must include the equivalent length of run and other losses through fittings and all other connected devices. Most figures are obtained from manufacturers. To find the pressure loss through a submersible pump leak detector, refer to Table 12.6. To find the pressure loss through the dispenser assembly, refer to Table 12.7. To find the pressure loss through the dispenser hose, refer to Table 12.8.
3. Obtain the recommended pressure required for proper operation of the selected dispenser. A typical figure used is 25 to 30 psi (170 to 205 kPa). This figure includes losses through the nozzle, hose, strainer, and so on.
4. Add all of the above figures together to calculate the total head required.
5. For a system head loss calculation sheet containing a checklist of all fittings and devices, refer to Fig. 12.20. This checklist contains items that may not be used for all installations.

From the manufacturer of the selected pump, obtain the pump curves, and select the pump based on the calculated head and flow rate.

Vacuum Pump Sizing. The vacuum pump size is an integral part of the dispenser, installed inside the dispenser above ground level. Since this system serves only one dispenser, the gallons per minute (liters per minute) flow rate and the highest al-

TABLE 12.6 Pressure Loss through Submersible Pump Leak Detector

Flow rate, gpm	Head loss, ft
10	2
20	5
30	6
40	13
50	18
60	22
70	28

Source: Courtesy Marley Pump Co.

TABLE 12.7 Pressure Loss through Typical Dispenser Assembly

Flow rate, gpm	Head loss, ft
3	15
5	23
7	32
9	42
11	53
13	64

Source: Courtesy Marley Pump Co.

TABLE 12.8 Pressure Loss through Dispenser Hose (Friction Loss in Feet Head per 100 ft of Smooth-Bore Rubber Hose)

gpm	Actual inside diameter, in							
	¾	1	1¼	1½	2	2½	3	4
15	70	23	5.5	2.5	0.9	0.2		
20	122	32		4.2	1.6	0.5		
25	182	51	15	6.7	2.3	0.7		
30	259	72	21.2	9.3	3.2	0.9	0.2	
40		132	23	15.5	5.9	1.4	0.7	
50		185	55	23	8.3	2.3	1.2	
60		233	81	32	11.8	3.2	1.4	
70			104	44	15.2	4.2	1.8	
80			134	55	19.6	5.3	2.5	
90			164	70	23.0	7	3.5	0.7
100			203	83	29	9.1	4	0.9
125			305	127	46	12.2	5.5	1.4
150			422	180	62	17.3	8.1	1.6
175				230	85	23.1	10.6	2.5
200				304	106	30	13.6	3.2
250					162	44	21	4.9
300					219	62	28	6.7
350					252	83	39	9.3
400						106	48	11.8
500						163	74	17.1

Project _____	Specific gravity _____	Temp. _____
Liquid _____	gpm Range _____	Viscosity _____
A. Static Losses (ft)		
Tank Diameter	_____	
Bury Depth	_____	
Height High Hose Reel	_____	
Total Static Height	_____	ft
B. Run of Pipe. Pipe Size _____		
Measured Run	_____	ft
Fittings	_____	
Valves	_____	
Reducers and Enlargements	_____	
Total Equivalent Run	_____	ft
C. Pipe Friction Loss = Equiv. Run _____ × friction loss/100 ft		
D. Equipment Loss (in feet head)		
Meter	_____	
Dispenser	_____	
Filter and Leak Detector	_____	
Hose and Nozzle	_____	
Strainer	_____	
Total Equipment Losses	_____	ft
E. Total Head Loss (A + C + D) _____		

FIGURE 12.20 System head loss checklist.

lowable suction lift figure must be obtained from the manufacturer of the dispenser selected. Based on the flow rate and pipe size, the suction lift calculated must be below the maximum allowed.

GENERAL DESIGN CONSIDERATIONS

For pressurized product pipe, it is common practice to use a minimum of a 2-in (100-mm) size, increasing it only if the system under design requires a larger size based on a higher flow rate or if the difference in friction loss will allow the selection of a lower horsepower submersible pump. It is generally accepted practice to not use pipe sizes smaller than 1¼ in (30 mm) in size. A larger-size product pipe is generally used in order to lower the head requirements of the pump selected.

For vacuum pump systems, the vacuum pump manufacturer will recommend a pipe size for a specific installation. This is required in order to limit the total static lift plus friction loss figure below that required by the specific vacuum dispenser pump selected.

TESTS

Testing of all piping and the UST at the time of installation is critical to assure that no leakage of product could occur and to check the integrity of the pressure-bearing components. In addition, tests of the UST for deformation after installation and corrosive coating damage are also necessary.

Testing of the Storage Tank

The UST shall be pressure tested prior to placing the tank into the excavation and again after backfilling is complete. If a factory-installed hydrostatic interstitial monitoring system is used, a test before installation is not required since a visual check of the leak detection system will disclose any problem.

The pressure test prior to installation consists of maintaining 5 psig of air pressure for 2 h with no lowering of pressure permitted. For this test all tank openings shall be sealed and a soapy water solution applied to all connections to observe for bubbles, which would indicate leakage. If the tank has a coating for corrosion protection, this shall be checked with an electronic device that will disclose imperfections in the coating, called *holidays*, that must be repaired.

After installation, a hydrostatic test of the tank shall be performed with water at a pressure of 5 psig for a period of 30 min, with all piping isolated so that only the tank is under pressure. It is important to remove all traces of water prior to filling with product.

Testing of the Piping Network

All piping containing product shall be tested hydrostatically at a pressure of 100 psig for a period of 30 min with no leakage allowed. Containment piping shall be tested with air at 10 psig for 30 min with no leakage permitted.

Vent and vapor recovery piping shall be tested hydrostatically at a pressure of 30 psig for 30 min with no leakage permitted.

Tightness Testing

Tightness testing is a general term used for testing and evaluating existing tanks and piping systems that contain product. Tightness testing is performed periodically, as required by local authorities. Generally, periodic tightness testing is not required for the following:

1. Tanks and piping containing No. 5 and No. 6 fuel oil
2. Tanks and piping with a capacity of 1100 gal or less unless the authorities have a reason to believe leakage is occurring
3. Tanks and piping that are corrosion resistant and have an approved leak detection system
4. Tanks and piping installed in conformance with requirements for new construction
5. Tanks larger than 50,000 gal and/or for tanks for which it is technically impossible to perform a meaningful series of tests. An alternative test or inspection approved by authorities shall then be conducted

All tests must conform to EPA and local requirements, and the technicians performing such tests must be trained and qualified by the test equipment manufacturer.

The tightness test shall detect a leak of 0.1 gph from the system with a detection probability of 95 percent, and a false alarm probability of 5 percent. Acceptable leakage amounts vary, depending on those values established by the local implementing authorities.

There are many types of tests capable of achieving this precision, and various manufacturers make testing equipment. The type of test chosen must take into consideration the following:

1. Vapor pockets
2. Thermal expansion of product
3. Temperature and temperature stratification
4. Groundwater level
5. Evaporation
6. Tank end deflection
7. Pressure

EVALUATION OF AST OR UST INSTALLATION

For smaller tanks, the decision on whether to install an above-ground or underground tank is based on many other factors in addition to the initial cost. Since the general useful life of any tank system is 20 to 30 years, all of the factors should be included in the calculations to find the actual cost for any specific installation. The following considerations are important to determining which type of installation is better for any specific facility.

AST

Advantages:

1. Easier to visually detect leakage, contain spills, and repair tank
2. Less initial installation cost
3. Easily removed and relocated
4. Fewer regulatory compliance requirements
5. Usually less piping cost if dispenser is integral part of tank

Disadvantages:

1. Occupies space on property, which may be an aesthetic problem
2. Must be protected against physical damage and vandalism
3. More vulnerable to fire damage which would mean higher insurance costs
4. Higher level of maintenance
5. Higher tank initial cost
6. Requires separation from other structures, roads, and property lines
7. May not be accepted by local authorities
8. May require reliable source of water to fight potential fire

UST

Advantages:

1. Superior protection against fire
2. Lower level of maintenance
3. Narrow range of temperature fluctuations, which limits vapor production
4. Buried tank, which allows the use of the ground surface above the tank
5. Not prone to vandalism, which means that physical protection is not required for the tank

Disadvantages:

1. Close supervision and training of installer required for proper installation
2. Cost of repair of tank higher than for an AST
3. Higher leak detection and instrumentation costs
4. Requires separation from well water supply sources
5. Must rely on instruments to detect leakage

Evaluation of New UST Tank Containment System

A primary consideration in selecting a tank containment system is whether to use a single tank or one with secondary containment. Federal rules and most states allow either. The basic advantage to the double-contained option is that it enhances the capability of the leak detection system. For typical installations, the use of a double-contained tank has proven cost effective over the useful life of the system.

SYSTEM DESIGN CONSIDERATIONS

Tank Installation

The installation of the tank is critical to the proper and long-lasting functioning of the system and the prevention of leakage in the later years of its operational life. It is a requirement that the contractor or installer be trained and authorized by the specific tank manufacturer as qualified to install any tank manufactured by that manufacturer only.

FRP underground tanks rely on the quality of the backfill for long-term support to resist elongation and resulting failure. Experience has shown that washed pea gravel, free from any organic matter and having no sharp edges, is the best backfill material. The gravel must be very carefully compacted. FRP tanks should be installed in conformance with API 1615. If there is a remote possibility of the tank's floating, such as in areas subject to flooding or an abnormally high water table, the tanks must be installed over a reinforced concrete ballast pad heavier than the buoyant force and anchored to that pad by means of hold-down straps. The weight of backfill over the pad, which also resists floating, should not be added, and it is used as a safety factor. It is recommended that the calculated load on each hold-down strap be increased by a safety factor of 5. The exact buoyant force shall be obtained for the selected storage tanks from the manufacturer. For preliminary planning purposes, Table 12.9 gives buoyant force values for typical size tanks.

Steel UST tanks are structurally stronger and do not depend as much on backfill for support. The backfill must prevent all but very minor shifting or settling of the tank in the future. The USTs shall be installed in conformance with NFPA-30 and NFPA-31. The requirement for ballast pad and hold down is the same as for FRP tanks.

When steel tanks are used, they are protected from corrosion with a special coating. This coating must be tested for faults (called *holidays*) both on the truck and after initial placement in the excavation. All defects found must be repaired in strict conformity to the manufacturer's recommendations. FRP tanks do not require corrosion protection.

Tanks shall not be stored on the site prior to installation due to the possibility of damage. Arrangements shall be made to deliver the tank on the day installation is to be made. If delays require that the tank not be installed, the tank shall be shipped back to the manufacturer and another, new tank delivered to the site. A detail of a typical UST installation is shown in Fig. 12.21.

The AST shall be placed on a concrete pad of sufficient thickness to adequately support the tank and product. Bollards shall be placed around the tank to protect it from vehicle damage.

TABLE 12.9 Approximate Buoyant Force of Empty Storage Tanks

Tank capacity, gal	Tank diameter	Tank length	Tank weight, lb ¹	Wall thickness	Net upward force (net buoyancy) in pounds totally submerged in water*
560	4'0"	6'0"	480	12 gauge	4,190
560	4'0"	6'0"	828	7 gauge	3,842
1,000	5'4"	6'0"	875	10 gauge	7,475
1,000	4'0"	11'0"	968	10 gauge	7,382
1,000	5'4"	6'0"	1,180	7 gauge	7,459
1,500	5'4"	9'0"	1,575	7 gauge	11,200
2,000	5'4"	12'0"	1,980	7 gauge	14,720
2,500	5'4"	15'0"	2,375	7 gauge	18,479
3,000	5'4"	18'0"	2,765	7 gauge	22,235
3,000	6'0"	14'0"	2,565	7 gauge	22,150
4,000	5'4"	24'0"	3,560	7 gauge	29,790
4,000	6'0"	19'0"	3,310	7 gauge	30,040
4,000	7'0"	14'0"	3,150	7 gauge	30,200
5,000	6'0"	24'0"	5,400	1/4 in	36,300
5,000	8'0"	13'6"	4,775	1/4 in	36,925
6,000	6'0"	29'0"	6,380	1/4 in	43,720
6,000	8'0"	16'0"	5,370	1/4 in	44,630
7,500	8'0"	20'0"	6,500	1/4 in	56,238
8,000	8'0"	21'6"	7,000	1/4 in	59,750
8,000	10'6"	12'5"	6,470	1/4 in	60,980
10,000	8'0"	27'0"	8,360	1/4 in	74,356
10,000	10'6"	15'6"	7,600	1/4 in	75,019
12,000	10'6"	18'6"	8,400	1/4 in	91,440
15,000	10'6"	23'3"	12,600	5/16 in	112,833
20,000	10'6"	13'0"	15,900	5/16 in	151,345
25,000	12'0"	30'0"	20,875	3/8 in	190,509
30,000	10'6"	46'3"	27,000	3/8 in	222,518
30,000	12'0"	36'0"	24,294	3/8 in	229,392

*Lb \times 2.2 = Kg

Source: Courtesy ASPE.

Piping Installation

Pipe should be installed in a trench, far enough underground to prevent damage. Initial backfill should be pea gravel, clean sand, or other acceptable material. A generally accepted minimum depth from grade surface to the top of the pipe where there is no slab is 18 in (45 cm), 12 in (30 cm) below asphalt slabs and 6 in (15 cm) under concrete slabs. It is also accepted practice where electrical conduit is installed in the same trench as piping to protect the conduit with a concrete encasement and to provide 4 in separation.

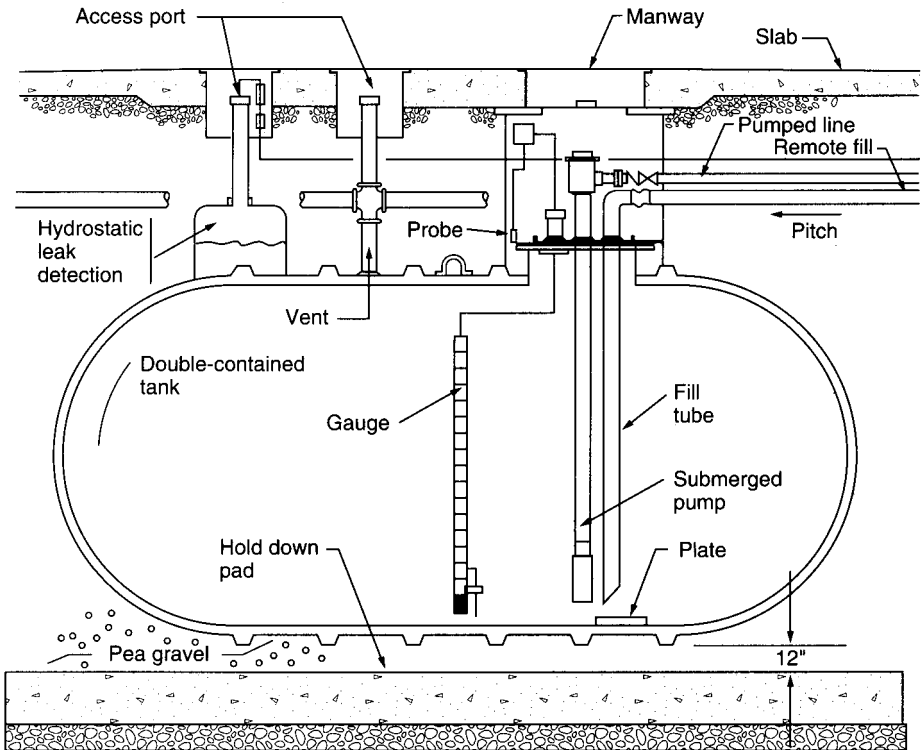


FIGURE 12.21 A typical UST installation.

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