Oil Storage & Storage Tanks

(Reference: Petrowiki)

Production, refining, and distribution of petroleum products require many different types and sizes of storage tanks. Small bolted or welded tanks might be ideal for production fields while larger, welded storage tanks are used in distribution terminals and refineries throughout the world. Product operating conditions, storage capacities, and specific design issues can affect the tank selection process.

Storage tanks

Types of storage tanks

Storage tanks come in all sizes and shapes. Special applications might require tanks to be rectangular, in the form of horizontal cylinders, or even spherical in shape. Horizontal cylinders and spheres are generally used for full pressure storage of hydrocarbon or chemical products. For the purpose of this page, we focus on the atmospheric or low-pressure storage tank widely used from the production fields to the refinery. The most common shape used is the vertical, cylindrical storage tank. Gross capacities can range from 100 bbl to over 1.5 MMbbl in a single storage tank. Corresponding tank sizes range from approximately 10 ft in diameter to over 412 ft in diameter for some of the largest floating-roof tanks ever constructed.

Fig. 1 shows a 312-ft diameter floating-roof storage tank for crude oil storage at a large refinery. The photograph was taken during construction and shows the single deck, pontoon-style external floating roof.

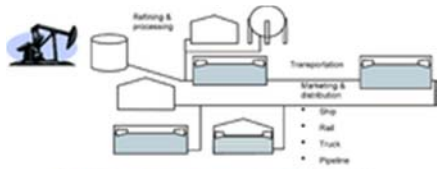

Fig. 1—312-ft diameter floating-roof tank.

Production tanks construction practices

The type of construction selected for a storage tank depends on the size of tank required and might be dependent on the type of product being stored, the location and space available for storage, prevailing weather or site-specific conditions, and local safety or environmental considerations.

Riveted, bolted, and shop welded tanks

Although the earliest storage tanks used by the petroleum industry were constructed from various types of wood, we will concern ourselves with tanks fabricated from steel or optional nonmetallic materials. Before the development and perfection of welding processes, petroleum storage tanks used either bolted or riveted construction techniques. The tanks would be designed and supplied as segmental elements for final assembly on site.

Riveted tanks dating back to the early 1900s can still be found around the world—many still in service. It is safe to say, however, that recurring maintenance costs and increased environmental and safety concerns dictate that older riveted tanks be replaced with new, state-of-the-art storage tanks.

However, bolted tanks are still used, especially in the smaller sizes typical of produced liquid storage. The fourteenth edition of American Petroleum Institute (API) *Spec. 12B, Bolted Tanks for Storage of Production Liquids* provides standard designs for capacities from 100 bbl to 10,000 bbl. Current suppliers of bolted tanks can provide capacities up to 40,000 bbl or more depending on the storage application.

Generally, bolted tanks are fabricated either from 12- or 10-gauge steel or several nonmetallic materials. If not galvanized or furnished with a protective coating for corrosion protection, bolted steel construction might not have the expected service life provided by welded-steel tanks. Welded-steel tanks are constructed of thicker plate materials that can be designed to provide some corrosion allowance.

One alternative to bolted construction is the shop welded storage tank. The size and capacities of this type of tank are limited primarily by the method of transportation used to transfer the shop built tank to the final production site. The eleventh edition of API *Spec. 12F, Shop Welded Tanks for Storage of Production Liquids* provides standard designs for capacities of 90 to 500 bbl.**Table 1** presents a partial listing of the standard sizes specified in API *Spec. 12F*. In this table, "working capacity" refers to the maximum amount of oil that can be stored between the oil outlet and the overflow connection.

TABLE 13.1—PARTIAL API SPECIFICATIONS FOR SHOP-WELDED TANKS (API SPEC. 12F)

Nominal Capacity, bbl	Design Pressure, oz./sq in.		Approximate Working Capacity*, bbl	OD, ft-in.	Height, ft
	Pressure	Vacuum			
90	16	.5	72	7'-11"	10
100	16	.5	79	9'-6"	8
150	16	.5	129	9'-6"	12
200	16	.5	166	12'-0"	10
210	16	.5	200	10'-0"	15
250	16	.5	224	11'-0"	15
300	16	.5	266	12'-0"	15
400	16	.5	366	12'-0"	20
500	8	.5	479	15'-6"	16

*Working capacities shown apply to flat-bottom tanks.

Table 1

Shop-welded storage tanks provide the production industry with tanks of adequate safety and reasonable economy for use in the storage of crude petroleum and other liquids commonly handled by the production segment of the industry. A shop-fabricated tank is tested for leaks in the shop, so it is ready for use once it arrives on site. Tanks are transferred from the truck to the final location on site; completed piping connections and the tank is then ready to be brought on line.

A second alternative for bolted construction is the shop fabricated or field assembled nonmetallic storage tank. Nonmetallic tanks customarily are constructed from plastic materials. These have the advantage of being Non-corroding, durable, low-cost, and lightweight. Probably the most common type used is the fiberglass reinforced plastic (FRP) tank. FRP tanks are suitable for outdoor as well as indoor applications. Refer to API *Spec. 12P*, *Fiberglass Reinforced Plastic Tanks* for minimum requirements for the design, fabrication, and testing of fiberglass reinforced plastic tanks.

The temperature limits of plastic tanks are approximately 40 to 150°F. Because plastic tanks are considered to degrade more quickly than metal tanks when exposed to fire, some operators prohibit the use of plastic tanks in hydrocarbon service.

Color must be added to the outer liner for protection against ultraviolet radiation. The inner liner must be selected for compatibility with the product stored. Protection from mechanical abuse such as impact loads is necessary. Good planning dictates that plastic storage should not be located next to flammable storage tanks. Special attention should be given to local codes, ordinances, and provisions for insurance relative to storing a flammable product in a flammable container.

Field welded storage tanks

Field-welded storage tanks easily meet industry needs for increased storage capacity whether at a remote production site, at the refinery, or at the marketing terminal. As noted, earlier single-tank capacities have exceeded 1.5 MMbbl of storage with tank diameters of 412 ft and shell heights exceeding 72 ft.

As with the smaller bolted storage tanks, API standards have been developed and improved over the years to ensure the tanks meet the safety and operating needs of the petroleum industry. The tenth edition of API *Spec. 12D, Field Welded Tanks for Storage of Production Liquids* provides standard sizes with nominal capacities from 500 to 10,000 bbl for the production sector.

When larger tanks are required, the industry can refer to the tenth edition of API *Standard 650, Welded Steel Tanks for Oil Storage* for material, design, fabrication, erection, and testing requirements. The standard covers open-top or fixed-roof storage tanks that generally operate at atmospheric pressures. Design pressures above atmospheric and design temperatures exceeding 200°F may be permitted when additional requirements are met. **Table 2** shows the capacity of welded storage tanks as a function of diameter and height.

TABLE 13.2—NOMINAL CAPACITY OF WELDED STORAGE TANKS

Diameter, ft	Height, 20 ft [6.1 m] Capacity		Height, 30 ft [9.1 m] Capacity		Height, 40 ft [12.2 m] Capacity		Height 50 ft [15.2 m] Capacity		Height 60 ft [18.3 m] Capacity		Diameter, m
	Mbbl*	m³**	Mbbl*	m³**	Mbbl*	m³**	Mbbl*	m³**	Mbbl*	m³**	
20	1.1	178	1.7	267	2.2	356	2.8	445	3.4	534	6.1
25	1.7	278	2.6	417	3.5	556	4.4	695	5.2	834	7.6
30	2.5	400	3.8	600	5.0	801	6.3	1,001	7.6	1,201	9.1
35	3.4	545	5.1	817	6.9	1,090	8.6	1,362	10.3	1,635	10.7
40	4.5	712	6.7	1,067	9.0	1,423	11.2	1,779	13.4	2,135	12.2
45	5.7	901	8.5	1,351	11.3	1,801	14.2	2,252	17.0	2,702	13.7
50	7.0	1,112	10.5	1,668	14.0	2,224	17.5	2,780	21.0	3,336	15.2
55	8.5	1,345	12.7	2,018	16.9	2,691	21.2	3,364	25.4	4,036	16.8
60	10.1	1,601	15.1	2,402	20.1	3,202	25.2	4,003	30.2	4,804	18.3
65	11.8	1,879	17.7	2,819	23.6	3,758	29.6	4,698	35.5	5,638	19.8
70	13.7	2,179	20.6	3,269	27.4	4,359	34.3	5,449	41.1	6,538	21.3
80	17.9	2,847	26.9	4,270	35.8	5,693	44.8	7,117	53.7	8,540	24.4
90	22.7	3,603	34.0	5,404	45.3	7,206	56.7	9,007	68.0	10,809	27.4
100	28.0	4,448	42.0	6,672	56.0	8,896	69.9	11,120	83.9	13,344	30.5
110	33.9	5,382	50.8	8,073	67.7	10,764	84.6	13,455	101.6	16,146	33.5
120	40.3	6,405	60.4	9,607	80.6	12,810	100.7	16,012	120.9	19,215	36.6
130	47.3	7,517	70.9	11,275	94.6	15,034	118.2	18,792	141.8	22,551	39.6
140	54.8	8,718	82.3	13,077	109.7	17,436	137.1	21,795	164.5	26,153	42.7
150	62.9	10,008	94.4	15,012	125.9	20,016	157.4	25,019	188.8	30,023	45.7
160	71.6	11,387	107.4	17,080	143.2	22,773	179.1	28,466	214.9	34,160	48.8
180	90.6	14,411	136.0	21,617	181.3	28,822	226.6	36,028	271.9	43,233	54.9
200	111.9	17,791	167.9	26,687	223.8	35,583	279.8	44,479	335.7	53,374	61.0
220	135.4	21,528	203.1	32,291	270.8	43,055	338.5	53,819	406.2	64,583	67.1
240	161.1	25,620	241.7	38,430	322.3	51,239	402.9	64,049	483.4	76,859	73.2
260	189.1	30,068	283.7	45,101	378.2	60,135	472.8	75,169	567.4	90,203	79.3
280	219.3	34,871	329.0	52,307	438.7	69,742	548.4	87,178	658.0	104,614	85.4
300	251.8	40,031	377.7	60,046	503.6	80,062	629.5	100,077	755.4	120,092	91.5

*Mbbl = 1,000 API bbl. **m³ = cubic meters. API bbl = 42 gal. 1 m³ = 6.29 bbl

Table 2

Current storage options

The petroleum industry has experienced significant changes in the types of products used to feed the refineries around the world. The increased use of petroleum products has prompted the industry to turn to other sources for supply. Changes in product, physical, and chemical properties impose new challenges to the storage tank industry. Environmental and safety requirements continue to be a significant factor in the selection and design of the storage tanks used by the petroleum industry.

The general types of atmospheric storage tanks (AST) in use may be open top tanks (OTT), fixed-roof tanks (FRT), external floating-roof tanks (EFRT), or internal floating-roof tanks (IFRT). Depending on the product, a closed floating-roof tank (CFRT) may even be selected.

The above ground storage tank has evolved with time. **Fig. 2** illustrates this trend, which has emphasized improved safety and improved product loss control. Production facilities generally rely on either open-top tanks or fixed-roof tanks operating at or slightly above atmospheric pressure.

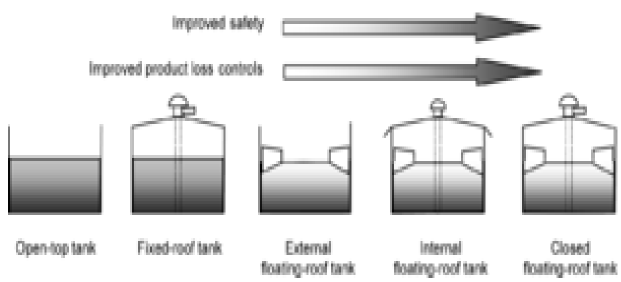

Fig. 2—Atmospheric storage tank improvements.

Open top tanks

The OTT was one of the first tanks used to store petroleum products. While it provides liquid containment, direct exposure of the liquid surface to the atmosphere assures high evaporative losses, product odors, and increased potential for fires. The OTT has only limited use, primarily for collection of contaminated run-off or wash water and wastewater processes.

Fixed roof tanks

The FRT provides improved containment of product vapors and reduces the potential for fires. The FRT still exposes the liquid surface to the tank vapor space, producing significant product evaporative losses. This increases the possibility of forming a combustible gas mixture in the vapor space for certain more volatile petroleum products. For this reason fixed roof tanks in refineries are generally used for products with vapor pressures less than 1.5 psia.

Floating roof tanks

Although not normally used in production operations, floating roof tanks are often used in pump stations or terminals where the crude oil has been stabilized to a vapor pressure of less than 11.1 psia.

Pressure vacuum valves

The evolution of hydrocarbon vapors is dependent on the product's physical characteristics, the operating pressure of upstream equipment, tank storage conditions, and tank operations. In production operations, the fluid entering a tank often comes from a higher-pressure source (separator, treater, or other production vessel). As the fluid enters the tank, a portion of the fluid will "flash" to vapor. Depending on tank design, vapors may be directed through pressure vent valves directly to a vent or lighted flare. Alternatively, a vapor recovery compressor (or blower) may be installed to direct vapors vented from storage to downstream compressors for sales or injection. Vacuum relief valves are needed to keep a vacuum from occurring because of tank breathing and pumping operations. If a vacuum develops, the tank roof will collapse. Typically, both pressure and vacuum relief are combined in a single pressure-vacuum relief valve such as that shown in **Fig. 3**.

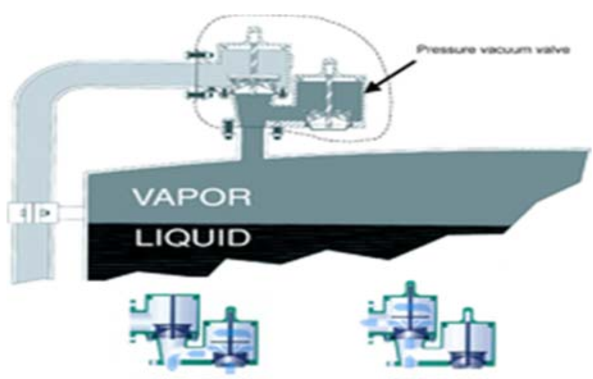

Fig. 3—Pressure vacuum valve operator.

Tank appurtenances

Tanks may include a variety of appurtenances depending on the storage application, owner requirements, and applicable design codes. In addition to normal product fill and withdrawal connections, access man-ways and various instrument or gauging connections, a tank can include shell-mounted mixers, internal heaters, platforms, ladders, and pressure/vacuum relief vents.

Floating-roof tanks require special attention to details because many can affect safe operation of the floating roof. In external floating-roof tanks, be sure that the rim seals, rolling ladder, and roof drain(s) are designed to minimize any unbalanced loads in the floating roof structure. Each floating roof should include a single anti-rotation device designed to limit the rotation of the floating roof while it is free to move up or down within the tank shell.

Some features are required for safe operation of the floating roof while others may be optional based on specific storage requirements. Many of these features affect the low operating levels of the floating roof. Optional details are available to address many of these interference issues, enabling a qualified designer to minimize the product heel while maximizing the working capacity of a floating-roof tank. **Figs. 4 and 5** identify several features that must be considered when designing the floating-roof tank.

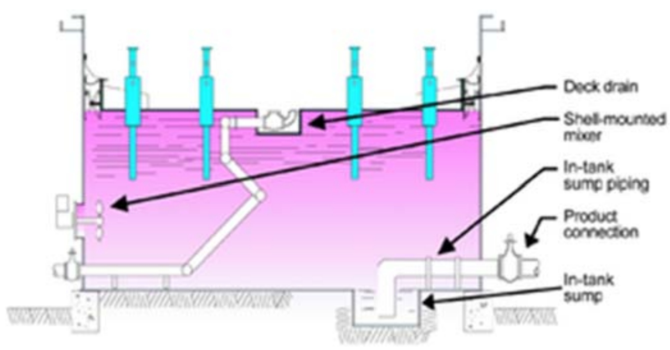

Fig. 4—Floating-roof tank appurtenances, Example A.

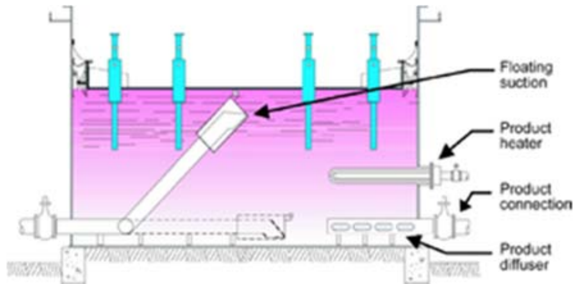

Fig. 5—Floating-roof tank appurtenances, Example B.