The Lease Pumper's Handbook

Chapter 10
The Tank Battery

Section C

ATMOSPHERIC VESSELS

Atmospheric vessels operate at the pressure of the surrounding air. Atmospheric pressure at sea level is 14.7 pounds per square inch or 29.92 inches of mercury. Atmospheric pressure decreases with rising elevation. Thus, air pressure on top of a mountain is less than that at sea level. This is referred to as PSIA, or pounds per square inch, absolute.

Atmospheric vessels form the *low-pressure gas system.* Every time the pressure is reduced on hydrocarbons or the liquid is placed in motion, additional gases break out. This goes on continuously. A small amount of gas is even entrained within the produced water. To reduce the loss of the light-end petroleum products from evaporation and to allow the gas to be recovered, atmospheric vessels operate with a gas backpressure of 2 to no more than 8 ounces. The thief hatch has a built-in pressure safety release. The vent line will usually have a 2-4 ounce safety back pressure release valve.

All atmospheric vessels are capable of withstanding the pressures generated by the weight of the liquid in the vessel. The weight of a column of fluid can be summarized as follows:

- **Oil.** As a rule of thumb, oil weighs 1/3 pound per square inch (psi) times the depth of the column or depth in feet. If a tank has 15 feet of oil in it and has a 2-ounce backpressure valve, the weight at the bottom of the tank is about 5 pounds, 2 ounces per square inch, thus:

  (1/3 lb/ft x 15 feet) + 2 oz. of backpressure = 5 lbs-2 oz. psi

- **Water.** As a rule of thumb, water weighs ½ pound per square inch times the depth or height of the column in feet. If a tank has 15 feet of water in it and has a 2-ounce backpressure valve, the weight at the bottom of the tank is about 7 pounds, 10 ounces per square inch.

  (½ lb/ft x 15 feet) + 2 oz. backpressure = 7½ lbs + 2 oz psi = 7 lbs.-10 oz. psi

Figure 1. Tank battery atmospheric vessels including a gun barrel, four oil storage tanks, and two water tanks.

C-1. Major Low-Pressure Gas System Components.

The major components of the low-pressure gas system (Figure 1) include:

- **Gun barrel** or **wash tank.** A large three-stage atmospheric separator designed to separate the fluid produced from the oil well into oil, gas, and water, as well as being the first vessel in the low-pressure gas system (Figure 2).
- **Stock tank.** Acts as a surge tank at the same time when a LACT unit is operating. A vessel to store produced oil until enough has been accumulated to sell to the pipeline or transport.

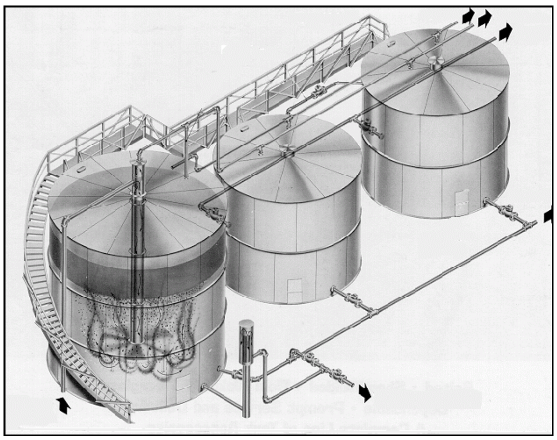

Figure 2. A common arrangement of the gun barrel and stock tanks.
(courtesy of National Tank Company)

- **Water disposal tank.** A vessel utilized to hold the produced water (usually salty) until it is re-injected into some underground formation.
- **The lined pit.** Formerly called a *slush pit* when BS&W was drained into the pit and the emulsion burned. Presently, some lined pits are still used to produce water if only a few barrels are produced daily. Under current regulations the pit still has a use as an overflow facility.
- **The dike or firewall or escarpment**. The dike is an earthen wall built around the tank battery atmospheric vessels, designed to contain liquid spills.

C-2. Styles of Atmospheric Vessels.

Atmospheric vessels were made of redwood for many years. Redwood vessels were very stable and were not greatly affected by corrosion. They did have problems, however, in maintaining a water blanket on top of them and in the grooves between the staves. Woodpeckers sometimes made holes in them. The steel bands had to be tightened periodically, and the tanks had to be re-strapped occasionally to determine the tank's capacity. The few redwood tanks that remain in the oilfields today are generally used as water tanks or gun barrels.

Bolted steel tanks—such as the stock tanks shown in Figure 2—later replaced redwood tanks, and welded tanks (Figure 3, left) have taken the place of most of the bolted tanks. Fiberglass tanks (Figure 3, right) are being widely used, but may not withstand high winds when empty. The low, wide fiberglass tank is popular for water disposal. Guy lines are placed on most of these tanks for safety. Rubber and fiberglass liners are often placed in steel tanks to combat corrosion. Some paints aid in extending tank life.

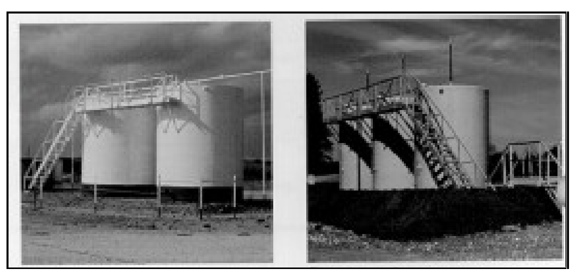

Figure 3. Examples of welded tanks (left) and fiberglass tanks (right).

Atmospheric tanks are selected on the basis of need for the site and in a size that is appropriate to the production volumes from the well. Common capacities include:

Capacity of selected standard bolted oil field tanks.

Nominal Size in Barrels		Dimensions Dia. x Height	Barrels per Foot
Low	250	15' 4-5/8 x 8' 1/2"	33.11
Low	500	21' 6-1/2" x 8' 1/2"	64.91
High	500	15' 4-5/8 x 16' 1"	33.11
High	1000	21' 6-1/2" x 16' 1"	64.91

Capacity of selected standard welded oil field tanks (Fiberglass tanks are similar in size).

Nominal Size in Barrels	Dimensions Dia. x Height	Barrels per Foot
100	8' x 10'	8.95
200	12' x 10'	20.14
210	10' x 15'	13.99
295	11' x 17.6'	16.93
400	12' x 20'	20.14

C-3. Common Lines and Openings of Atmospheric Vessels.

Figure 4 shows a diagram of an atmospheric vessel with the typical openings indicated and labeled. Each opening and common design variations are discussed in the following paragraphs.

The emulsion inlet. The emulsion inlet is usually located on the top of the tank. A walkway is usually provided and the line has a quarter-round opening valve, either a plug- or ball-type. A down-comer line is often installed inside the tank to reduce light-end evaporation and static electricity and the resulting metal loss from electrolysis. When several wells are producing to the same tank battery, there will also be a second emulsion inlet from the test three-stage vessel.

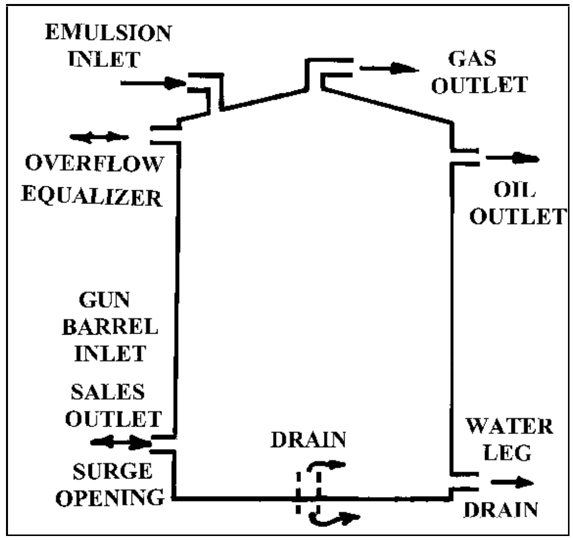

Figure 4. Line openings typically used in atmospheric vessels.

The equalizer inlet or outlet (Option 1). This is the highest opening on the side of the vessel. When it is used as an equalizer, it allows one tank to be completely filled before the fluid flows through the equalizer line and begins to fill the second tank. This usually occurs while the lease pumper is not on site, providing an easy means of topping off tanks.

The overflow line (Option 2). This is a second option for the use of the highest opening on the side of the vessel. When it is used as an overflow line, the liquids can be directed toward a lined pit or even the water disposal tank. This may be a good option when production is erratic or when automated equipment fails to function.

The gas outlet. The gas outlet line is located in the center of the top of the vessel. It is connected to the low-pressure vent system and has a 2-ounce backpressure valve to reduce light-end evaporation. Without this backpressure, some gas wells will build production up to a partially full level and then will gradually begin evaporating all of the additional liquid production. The lease records will indicate this problem, and corrective mechanical adjustments can be performed to stop this loss of production and income. The second function of the valve is to prevent the tank from filling with oxygenated air when the tank is emptied. This can result in an explosive mixture. The safe tank is one filled with natural gas.

The oil outlet. This outlet is used as an oil outlet when the vessel is used as a gun barrel and determines the liquid operating level. It is also used as an oil outlet whenever the tank is used as a skimmer tank for final oil or water removal. Skimmer tanks can be hooked up several ways to meet lease needs and resemble a wash tank in assembly.

The side drain outlet (Option 1). Side outlet. The side drain outlet is used for several important functions such as removing water accumulated from production or well testing, cleaning oil to lower the BS&W level, and cleaning heavy tank bottoms.

The side drain outlet (Option 2). Another use of the side drain outlet is for the water leg when the tank is used as a gun barrel.

The bottom drain outlet. There are three styles of tank bottoms. The most common style is flat with the drain line on the side. The two styles of cone-bottomed tanks are reviewed later in this chapter.

C-4. The Gun Barrel or Wash Tank.

An advantage of the wash tank over the gun barrel is that it slows the oil down as it goes through the vessel. The oil stays in the wash tank much longer, allowing more time for the water to drop out. The oil and water flow into the central flume or side boot, travel downward through a spreader, then work their way upward. The water falls to the bottom and is removed through the water leg. Any gas that continues to break out goes up into the low-pressure gas system.

The gun barrel washes the oil to remove as much water as possible before the oil goes through the oil line to the stock tank. Water will continue to drop out of the oil as long as it remains in the tank battery. Even though the system may treat the oil to less than one percent BS&W before it goes to the stock tank, the stock tanks will need to be circulated periodically to keep the bottoms clean. *Clean* in reference to tank bottoms indicates that there is less emulsion on the bottom than the level that the pipeline or transport company requires at the time that the oil is purchased and removed.

Figure 5. Atmospheric gun barrel made from a vertical separator and a pipe platform.

The water leg operates in the same manner as the water leg on the heater/treater. In the system shown in Figure 5, the gun barrel was shop manufactured from a used vertical separator. The operator brought the production line down through the former gas line to the bottom on the inside. The water leg is made from white PVC line, and the gas line was installed at an angle to the top center of the welded 210-barrel stock tank through the former safety pop-off opening.

The gun barrel with side boot (Figure 6) has become one of the more popular gun barrel installations. The emulsion enters the boot located high on the right side where the liquid and gas separate. The liquid falls to the bottom in the tube and enters the vessel in the bottom perforated header where the oil will begin to make its way to the upper oil area. The water remains in the water area at the bottom and goes out through the side combination outlet—that is, the drain and water leg. If the gun barrel uses a standard stock tank, it must be elevated on a mound of fill to approximately one foot higher than the stock tanks.

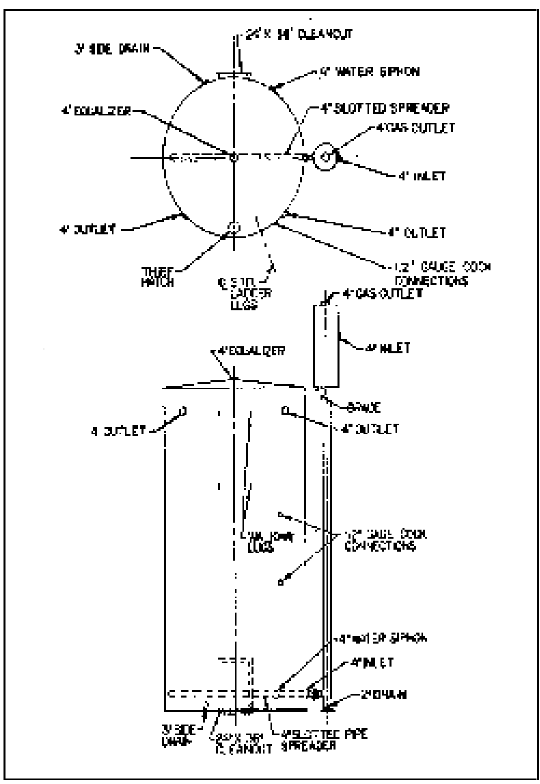

Figure 6. Diagram of a gun barrel with a side boot.

C-5. The Stock Tank.

The stock tank is similar to the gun barrel. Most stock tanks, however, have a strike plate directly under the thief hatch. This is a plate that the gauge line plumb bob will strike or bump against each time the tank is gauged. The purpose of this plate is to prevent damaging or punching holes in the bottom while gauging the tank.

There are three styles of stock tank bottoms available: a standard flat bottom and two styles of cone-bottomed tanks.

Cone-bottomed tanks. Cone-shaped bottoms are excellent for circulating and treating the *bottoms* (emulsion in the bottom of the tank) for leases with paraffin and a low API gravity oil.

To prepare the site for a cone-bottomed tank, the ground must be tapered at the correct angle and a small hole dug exactly in the center to hold the bottom projection (sump). A satisfactory layer of pea gravel or sand and a double layer of 120-pound felt (tar paper) or other suitable barrier may be placed on the ground prior to setting the tank. This is a good corrosion barrier and allows the tank to *breathe* under the bottom, allowing moisture to evaporate.

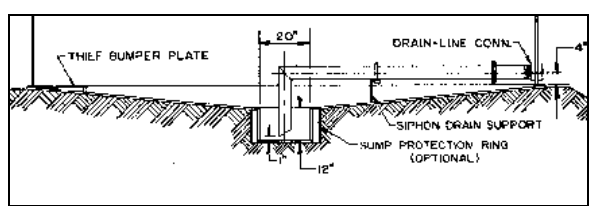

Figure 7. Style 1 cone-bottomed tank.

The style of tank shown in Figure 7 is often used, though it is not obviously a cone-bottomed tank. A check of the tank chart will show that the tank has a cone-shaped bottom because the first ¼-inch reading will contain several barrels of oil. This is because the reading must include the capacity of the cone bottom.

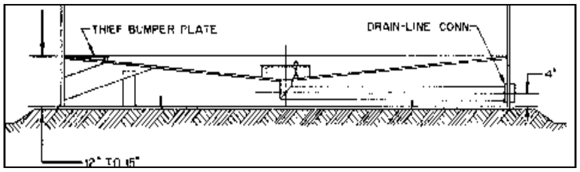

Figure 8. Style 2 cone-bottomed tank.

Figure 8 shows a cone-bottomed tank that actually has an air space under it. There is also a metal plate several inches wide that the vessel rests on to prevent it from sinking into the ground from the weight of the oil. This design is easily recognized because the pipeline connection must be elevated to allow one foot for BS&W and emulsion (Figure 9). These styles of tanks are popular with the lease pumper because of the ease they present when circulating and cleaning bad tank bottoms.

Figure 9. A Style 2 cone-bottomed tank showing how the sales outlet is raised above the BS&W level.

The stock tank openings. The stock tank is an atmospheric vessel designed to hold the crude oil until enough production has been accumulated to sell. This may be accumulated in a few days or may require many weeks. This is usually a minimum of one transport load, which requires a 210-barrel tank. This allows approximately 160-180 barrels to be sold and approaches the maximum weight allowed to be hauled on the highway. Stock tanks can be purchased as small or as large as needed.

The stock tank has four possible openings on the sides. One opening, 12 inches off the bottom, faces the front. This is the opening provided to install the oil sales line. Oil may be sold by pipeline or by the truck transport load. Illustrations of these two systems are included in Chapter 13.

On the back of the tank, approximately 4 inches from bottom, is a 4-inch drain opening. This line is connected to the drain and circulating system.

On the front near the top of the tank and at 45 degrees, there are one or two 4-inch openings provided to connect the tanks together with equalizing lines. This will allow a tank to *top out* or finish filling during the hours that the pumper is not present, and any additional oil produced will gravity feed over to the next selected tank. When the pumper comes back to the tank battery, the fill lines are switched so that the full tank of oil is isolated for final testing, treating if needed, and made ready to be sold.

The oil inlet line. Some companies install a down-comer line inside the tank on the inlet line. Since some welded tanks do not have threads on the inside of the vessel, the line is welded inside a nipple where it can be lowered inside through the top. One or two ½-inch holes are drilled into the down-comer near the top to prevent a siphon effect and to allow any free gas to escape. The line goes down to within a foot of the bottom.

There are several benefits to this line. It eliminates much of the static electricity caused by oil dumping into the tank violently and thus lessens corrosion by electrolysis. A second benefit is that it stops the high *splatter* effect of the incoming oil striking the liquid surface and reduces the amount of light-ends going out the low-pressure gas line. A third, and possibly the most important benefit, is that when oil is circulated, the high volume of liquid entering the tank sweeps up or stirs up the accumulated BS&W that piles up under the inlet area and assists greatly in keeping the bottoms clean. The rolling action stimulates treatment and water fallout.

The drain line inside the tank. The drain line opening is located on the back of the tank approximately 4 inches from the bottom. This line should extend inside the tank until it is within a foot or so of being under the thief hatch opening. Actually, a series of very small holes drilled in the bottom can be beneficial. An ell is screwed on the end or the end is turned down to place the opening within 1 inch of bottom.

When the well produces paraffin, some of it clings to the tubing and entrains a small amount of water. Eventually, the paraffin becomes heavier than oil and settles to the bottom when it enters the tank. This emulsion can build up many inches thick on bottom. When the bottom of the tank is circulated, a small amount of this emulsion is pulled up. As the less viscous upper oil channels down, it vacuums out a small pocket and most of the bottom emulsion never moves or requires hours to shift.

C-6. The Water Disposal Tank.

The disposal tank (Figure 10) is usually a short tank that holds a minimum of one transport load of water or about 200 barrels. This water will usually be pumped down a disposal or a water flood well. The tank is short to aid in water removal from the tank battery system. Some are manufactured in two matching halves for easy shipment and assembly. More extensive information about water disposal tanks is contained in Chapter 15, Enhancing Oil Recovery.

The water disposal tank has replaced the pit as a general disposal system. This has become common because of environmental regulations.

Figure 10. A water disposal tank.

C-7. The Pit.

The pit is an atmospheric open tank with earth walls to hold produced water. Many years ago it was called a slush pit. The word *slush* implies a thick emulsion or one with high paraffin content. This word is not used as often as in earlier years. Historically, the term slush pit has also been used in reference to the drilling rig pit.

The newer style pits have a plastic liner or membrane that prevents the earth from becoming contaminated by the salt and other compounds contained in the water. Frequently, pits are covered with a net mesh for wildlife safety. Pits will continue to be used in the future for both drilling and production operations because they serve as an excellent holding tank in the event of vessel overflow and may enclose emergency gas flares.

C-8. The Dike.

In some areas, an earthen dike is required around all vessels that contain fluid that might contaminate the ground. The holding capacity of these dikes is usually one and one-half times the capacity of all the vessels inside the dike. When a dike is constructed, steps should be installed over the top as walk paths to prevent people from walking across the dike at odd points. Walking across these dikes causes continuous damage to the dike so that the top edge wears away. If the walkway is high, safety hand rails should also be provided.

Figure 11. The dike around a tank battery should be able to hold a volume one-and-one-half times the capacity of all of the vessels.

C-9. Vessels Solve Unusual Problems.

Some identical vessels may be installed in two or more different locations within the battery or on the lease in order to solve completely different, unrelated processing problems. These uses are not always apparent, especially when a specific type of vessel is installed in an unusual location. Though the vessel will certainly be there to accommodate a need and solve a specific problem, but that problem may be unique to that battery. The lease pumper should never be reluctant to ask what the purpose of a vessel is and why that style of vessel was selected. Understanding these solutions may help the lease pumper to solve similar problems at a different tank battery.

Consider a few examples. A small vessel or riser may be installed ahead of a liquid meter just to prevent a slug of gas from hitting the meter. This is a solution similar to placing the gas eliminator ahead of the meter in the LACT unit. A line heater may be used to thin fluids near the wells so that thick emulsion can flow to the tank battery. A line heater may be installed between the header and the two-stage separator to prevent ice from forming in separators and causing them to overflow in cold weather. A stock tank may be utilized as a gun barrel. A separator may be used as a scrubber for cleaning firebox gas.

The list of unusual installations contains many possibilities. It is limited only by the lease pumper's imagination and knowledge of vessel performance.