The Lease Pumper's Handbook

CHAPTER 10

THE TANK BATTERY

A. Basic Tank Battery Systems

1. Oil Storage at the Drilling Site.
2. The Natural Production Curve for a New Well.
3. The Very First Production.
   - Gauging new production at the well location.
   - Storing oil in rectangular tanks.
   - Safety in gauging and testing oil in round vertical tanks.
   - Gauging procedures and tank charts.
   - Gauging the holding tank on the location.
4. Storing and Accounting for Produced Crude Oil and Salt Water.
5. What Is Produced from the Well?
6. Designing a Tank Battery.
   - How the tank battery works.
   - Basic tank battery components.
   - Flow lines.
   - Header lines from the wells.
   - Vessels.

B. Pressurized Vessels

1. The Flow Line.
   - Laying new flow lines.
   - Road crossings.
2. The Header.
3. Pressurized Vessels.
   - Tank battery typical operating pressures.
   - The emulsion inlet.
   - The gas outlet.
   - The drain outlet.
   - The high oil outlet.
   - The lower liquid outlet or water leg.
   - Floats.
4. The Separator.
   - Operation of the two-stage vertical separator.
   - Pressure safety devices.
5. The Heater/Treater.
   - Controlling the height of the water.
   - The fluid sight glasses.
   - Backpressure valves for pressurized vessels.

6. Interior Design of the Vertical Heater/Treater.
   - Inlet line.
   - At the bottom.
   - The oil trip upward.
   - The water leg.

C. Atmospheric Vessels

1. Major Low-Pressure Gas System Components.
2. Styles of Atmospheric Vessels.
3. Common Lines and Openings of Atmospheric Vessels.
   - The emulsion inlet.
   - The equalizer inlet or outlet (Option 1).
   - The overflow line (Option 2).
   - The gas outlet.
   - The oil outlet.
   - The side drain outlet (Option 2).
   - The bottom drain outlet.
4. The Gun Barrel or Wash Tank.
5. The Stock Tank.
   - Cone-bottomed tanks.
   - The stock tank openings.
   - The oil inlet line.
   - The drain line inside the tank.
6. The Water Disposal Tank.
7 The Pit.
8. The Dike.
9. Vessels Solve Unusual Problems.

D. Emulsion Line Systems

1. Emulsion from the Well.
2. The Flow Lines and Header.
   - The header.
3. Chemical Injection at the Header.

E Crude Oil Line Systems and Equipment

1. Lines from the Separator.
2. Lines from the Separator to the Heater/Treater.
3. Lines from the Heater/Treater to the Gun Barrel.
4. Lines from the Gun Barrel to the Stock Tanks.
5. The Equalizer Line from Stock Tank to Stock Tank.

F. Circulating and Water Disposal Systems

1. Produced Water at the Tank Battery.
2. Water Separation from the Heater/Treater and the Gun Barrel.
   - The gun barrel.
3. The Circulating System.
4. The Water Disposal Tank.

5. Solving Circulating and Disposal Problems.
- Circulating oil while removing water from the system.
- Automatic circulation from the LACT unit.
- Emptying vessels for maintenance.
- Cleaning tank bottoms.

6. The Circulating Pump.
7. Hauling the Water by Truck.
8. Water Injection.

G. The Crude Oil Sales System

1. The Oil Sales System.
2. Selling Oil by Truck Transport.
3. Selling Oil with the LACT Unit.

H. Tank Battery Design Review

1. What Does a Tank Battery Look Like?
2. No Atmospheric Vessels.
3. The Tank Battery Producing No Gas or Water.
4. The Tank Battery Requiring a Gun Barrel.
5. Tank Battery with Two Heater/Treaters and Two Stock Tanks.
6. Single Tank with Shop-Made Gun Barrel on Stand.

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Chapter 10
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Section A

BASIC TANK BATTERY SYSTEMS

A-1. Oil Storage at the Drilling Site.

The most logical place to begin studying the tank battery is at the wellhead and the drilling rig where the whole process begins.

Even before running casing, a **drill stem test** may be run on a well. This is a procedure intended to produce the well through the drill pipe. At this point, a **test tank** is normally used as a substitute for a tank battery. If the test shows that the well may have commercial potential—that is, the well will eventually pay for the drilling and operating costs and make the company a profit—the casing will be run and set.

After casing has been cemented into place and perforated and the well has been treated, production can begin. If it is a flowing well, the production may begin by simply opening a choke valve.

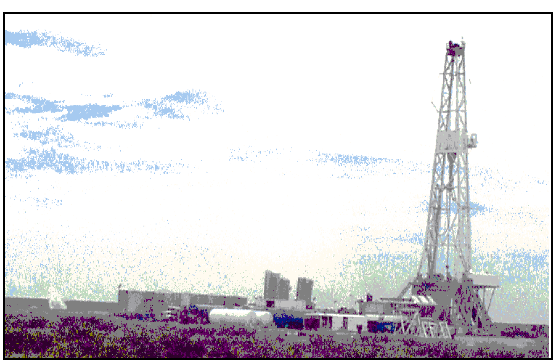


Figure 1. A drill stem test is being run at this drilling rig. Note that gas is being vented in a flare in the left side of the photograph.

With some wells, however, the lease operator must begin production by calling out a swabbing unit to swab or lift a blanket (or column) of liquid—either water or oil—out of the tubing to reduce the bottom hole pressure. This action is intended to reduce the weight of the standing column of fluid in the tubing so that it is less than the formation pressure, allowing new fluid to enter the well bore at the casing perforation. The weight generated by a column of oil is less than the weight of an identical column of salt water. By swabbing the water out and allowing the lighter oil to enter at the perforations, the reduced weight of the column may allow the bottom hole pressure to cause the well to flow. If the bottom hole pressure is higher than the weight of the column of standing fluid, the well may start flowing naturally without further stimulation.

As the well is swabbed or flowed into a vessel, the first tank gauging will usually be done or supervised by the company drilling or production supervisor or possibly by a well servicing employee. In the end, however, it will become the responsibility of the lease pumper to track production, recording the amount of gas, oil, and water produced, even if the gas is vented.

Gas will usually be lost to the atmosphere or, in some cases, burned as it is flared. A pin recorder with an orifice plate can be installed to measure the true volume.

Since the lease pumper must account for all oil and water produced, these liquids will be produced to a tank and gauged often. The fluid produced will be measured and the number of produced barrels determined several times a day until the well has been cleaned up and a rate of production for the oil, gas, and water has been determined.

A-2. The Natural Production Curve for a New Well.

When a new well is put on line or begins to produce oil, the pressure around the well bore is equal to the pressure throughout the reservoir. As production continues, the pressure in the matrix area and around the well bore decreases, while the time that it takes for the pressure to build back up to initial formation pressure increases, according to formation porosity. As this occurs, any new fluids produced must be pushed farther and farther through the formation to enter the well bore. The farther the oil must travel, the more time it takes to get to the well bore. The gas may bypass great pockets of oil unless the reservoir is very porous and good production practices are followed by the lease pumper. Pressure at the wellhead will be reduced, and the amount of oil produced will decline.

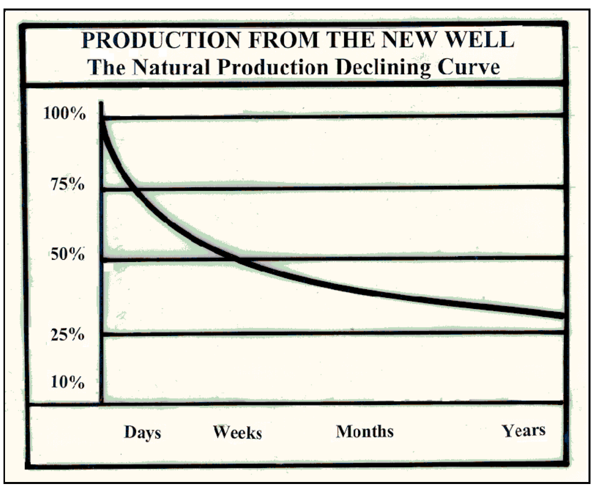


Figure 2. Oil production curve.

This is a natural flowing condition for all wells described by the curve in Figure 2. The rates of change will be controlled by formation pressure, the type of drive, thickness of the pay zone, porosity of the rock, viscosity of the oil, and many other factors.

A-3. The Very First Production.

When producing a new well or an existing well that has been worked over, chemicals or muds may initially be produced that should not be fed into the tank battery system because the mud may fill the total tank battery facilities and cut off tank operation. For this reason, an open top tank or other vessel on location may be utilized to hold the initial production.

Gauging new production at the well location. The gauging and accounting for produced oil usually begins at the well site. The use of Kolor Kut or some suitable gauge line paste will assist in determining the oil/water interface level. As the production first begins, the thief will assist the lease pumper in checking the oil/water ratio and indicate the condition of the tank bottom. The gas production can be measured with a single-pen recorder and orifice plate at the end of the gas line.

Storing oil in rectangular tanks. Rectangular storage tanks may not have a top. A set of steps will assist in allowing comfortable gauging of the vessel and checking of the produced liquids. If no steps are available, they can be constructed very economically or temporarily borrowed from another lease facility.

Safety in gauging and testing oil in round vertical tanks. Instead of a walkway, round, vertical tanks used to temporarily store oil usually have a ladder bolted to the side centered on the thief hatch. A metal hoop or band about 30 inches across installed at the top of the ladder allows the lease pumper to have both hands free for gauging the amount of liquid, using Kolor Kut paste to determine the oil/water interface level, taking a hydrometer reading to check API gravity, obtaining water samples to determine water weight, and thieving the tank to determine emulsion buildup on the bottom.

If a metal hoop is not on the tank, one can be built for only a few dollars. The hoop can be removed and stored and used again when needed. A second option is to utilize a safety belt with side snaps that can be fastened to the ladder. The safety belt is easy to carry and store.

	.00	Ft. 1	14.02	Ft. 2	28.04	Ft. 3	42.07
¼	.29	¼	14.31	¼	28.34	¼	42.36
½	.58	½	14.61	½	28.63	½	42.65
¾	.88	¾	14.90	¾	28.92	¾	42.94
1	1.17	1	15.19	1	29.21	1	43.23
¼	1.46	¼	15.48	¼	29.50	¼	43.52
½	1.75	½	15.77	½	29.80	½	43.81
¾	2.04	¾	16.07	¾	30.09	¾	44.10
2	2.34	2	16.36	2	30.38	2	44.39
¼	2.63	¼	16.65	¼	30.67	¼	44.68
½	2.92	½	16.94	½	30.96	½	44.97
¾	3.21	¾	17.24	¾	31.26	¾	45.26
3	3.51	3	17.53	3	31.55	3	45.55
¼	3.80	¼	17.82	¼	31.84	¼	45.84
½	4.09	½	18.11	½	32.13	½	46.13
¾	4.38	¾	18.40	¾	32.43	¾	46.42
4	4.67	4	18.70	4	32.72	4	46.72
¼	4.97	¼	18.99	¼	33.01	¼	47.01
½	5.26	½	19.28	½	33.30	½	47.30
¾	5.55	¾	19.57	¾	33.59	¾	47.59
5	5.84	5	19.86	5	33.89	5	47.88
¼	[illegible]	¼	[illegible]	¼	[illegible]	¼	[illegible]

Figure 3. A portion of a tank chart for a 210-barrel tank.

Gauging procedures and tank charts. As shown in the tank chart in Figure 3, tanks are usually gauged to the nearest ¼ of an inch. For a high producing well, gauging may be done to the nearest inch. On the other hand, a very low producing well may be gauged to the nearest 1/8 of an inch. This will permit better tracking of how the well is producing every day and will aid in indicating production problems. Gauging procedures are covered very extensively in Chapter 12.

Gauging the holding tank on the location. The steps for gauging the holding tank include:

1. Gauge and record the total amount of liquid in the holding tank.
2. Determine the oil/water interface level by using Kulor Kut.
3. Thief the tank if necessary to check water level, bottom emulsion build-up, and to check the API gravity.

   Note: Obtaining the gravity, temperature, and water weight may be necessary only one time or periodically to establish the quality of oil produced and to identify problems in treating.

4. Sample the oil to determine BS&W content.
5. Obtain a water sample to determine water weight per gallon.
6. Record each gauging time.
7. Compute oil and water produced.

Tank charts may not be available for temporary rectangular or a round, vertical tanks. A tank chart can be developed in a few minutes that will be accurate enough for the initial calculation of estimated production. If the oil is sold by transport direct from the location, the oil will be estimated by a chart when loaded, but accurately metered for number of barrels as it is unloaded. In Appendix F, in the math section, computations for making a tank chart are included. For round horizontal tanks, a chart is required. Companies that lease tanks have charts available.

A-4. Storing and Accounting for Produced Crude Oil and Salt Water.

The lease operator is required to give a daily, weekly, and/or monthly accounting of all oil, water, and natural gas that is produced from every well. This accounting record begins the first day that the well produces fluid and ends when the well is plugged or taken out of service. Records are maintained by regulating agencies that record cumulative lists of all oil, gas, and water that has been produced during the life of the well.

Temporary tanks are likely to be used until a decision has been made concerning the size of permanent tanks to be installed and where the tank battery will be located. This will depend upon the amount of oil being produced, how large the lease acreage is, and the immediate availability of additional drilling funds in the event that the well is a good producer.

When the fluids begin to be produced from the well, the lease pumper will become responsible for gauging the tank on a regular schedule and accounting for all fluids produced. (See Chapter 19, Record Keeping).

A-5. What Is Produced from the Well?

The goal is to produce and sell crude oil and natural gas. Along with these two fluids, the well will produce BS&W, or *basic sediment and water,* which is primarily water and a little formation sand as well as other compounds and elements. Figure 4 illustrates a small part of the byproducts. Some of these byproducts are valuable and are readily purchased by the petrochemical industry. Asphalt is used in highway construction, and natural gas can be converted to synthetic rubber and used to generate electricity. The textile and dye industries depend heavily on petroleum, and paraffin is used by many industries. Sulfur and water contribute to the formation of acids in the well and tank battery and cause corrosion.

Since all of these elements are produced in varying amounts from each well, specific vessels within the tank batteries are designed to accommodate and solve varying processing problems and procedures.

When a well produces a high level of hydrogen sulfide gas, special gauging procedures must be followed for employee safety. These precautions are in addition to the usual standards for working around natural gas. The lease pumper must be especially aware of the dangers of working with natural gas and hydrogen sulfide, since the pumper works alone most of the time.

A-6. Designing a Tank Battery.

There are many factors to be considered when a tank battery is constructed. The tank battery must be of a sufficient size to handle the amount of fluid produced but also to handle the many problems that might be caused by the quality of the fluid produced.

The wells from one reservoir have many conditions in common, such as the gravity of the oil and temperature. Each reservoir will have its own characteristics, and each tank battery is designed to accommodate whatever is produced to that tank battery only. If a reservoir is structured at an angle or on an incline, the upper wells may produce oil and gas only, while the wells at the lower zone may be water drive and produce a lot of water. Wells in the upper zone may have pressure maintenance while those in the lower zone use water drive. When a reservoir is several miles long, the wells at one side and depth vary greatly from wells at the other side and depth.

Therefore, a number of factors influence the design of the tank battery. The lease pumper must:

- Understand the purpose for the various vessels that make up a tank battery as well as what vessels are available for consideration.
- Know how each vessel is constructed on the inside.
- Know the location of each vessel within the system.
- Know how the vessels operate.
- Know problems that the vessels can solve.
- Have good problem-solving skills.

How the tank battery works. The ability of the lease pumper to understand and operate the typical tank battery begins by fully understanding the most common tank battery components and systems, the primary purpose of each part within the system, what problems that it is solving, and how each part works. This is the purpose of the information in this chapter. Additional information about tank batteries is described in Appendix C, Additional Tank Battery Information.

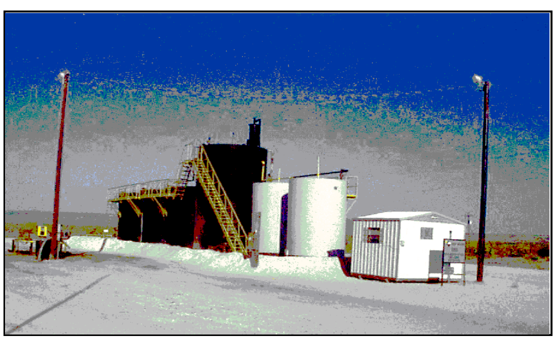


Figure 4. A tank battery with two water tanks (black), a gun barrel, and two oil stock tanks (gray).

Basic tank battery components. The most common components in the average or basic tank battery include:

Lines from the wells to the vessels:

- Flow lines from the wells.
- Headers or manifolds to connect the wells to the separators.
- Lines to connect various vessels.

The basic vessels:

- Production and the test separators.
- Heater/treater.
- Gun barrel or wash tank.
- Stock tanks.
- Water disposal tank.
- Earth pits or slush pit.
- The firewall, dike, or berm.

The equipment:

- Circulating pump.
- Chemical injection pump(s).
- Vapor recovery unit.
- LACT unit (if connected to a pipeline).
- Gas measurement and test system.
- Containers for end of sales lines (if the oil is transported by truck).

Appropriate line systems and fittings:

- Flow lines from the wells.
- Inlet header or manifold to separators.
- Crude oil lines from separators to the heater/treater, gun barrel, and stock tanks. Equalizer lines.
- The high-pressure gas system. Gas lines from the separators and heater/treaters to the sales outlet.
- The low-pressure gas system and the vapor recovery unit.
- The water collection system from the various vessels to the water disposal tank and the pit.
- The circulating and vessel emptying or filling system.
- Sales systems. LACT or truck transport.
- Water disposal systems.
- Special purpose systems.

Flow lines. Flow lines may be made of steel, plastic, or fiberglass. Steel lines may be welded, made of threaded regular line pipe, or upset tubing that has been removed from a well and downgraded. Some lines have grooved clamps instead of collars. When the line may be subjected to high pressure from the well, steel will usually be used.

Fiberglass is frequently used in extremely corrosive conditions, or polyethylene may be used for lower pressure conditions. Polyethylene has become extreme popular because of its low price, ease of use, and long life.

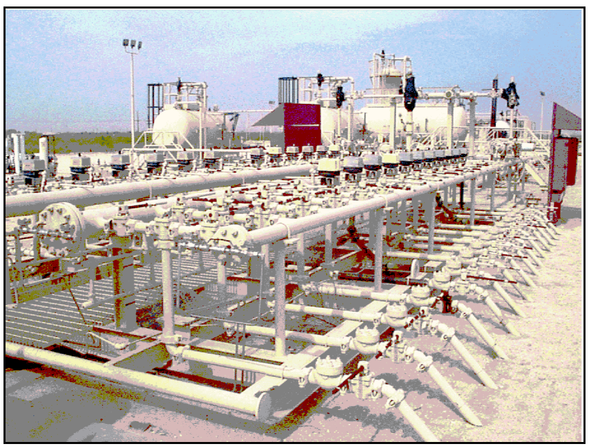


Figure 5. The header system at a large tank battery.

Header lines from the wells. As the flow lines from each well enter the tank battery, they are lined up to come in parallel to each other, and a header is constructed to receive these lines.

The header pictured in Figure 5 has the lines entering from the lower right. The fluid flows through a valve, a check valve, then turns up through an ell. As the fluid reaches the top of the header, a tee is in the line with valves to the right and to the left. The right-hand line goes to the test separator, and the left-hand line goes to the production separator. Each line has a painted number or a metal plate on it that identifies the well. Note that all of the valves are quarter-round opening. As the lease pumper walks along the header, it is clear at a glance which valves are open, which valves are closed, which wells are shut in, and which well is on test. This is a good construction practice.

As the wells leave the header to enter the processing vessels, the vessel may be bypassed or the flow may be directed through the vessel. At this point, chemical is added. By injecting the chemical after the header but before the emulsion reaches the separator, the treating process really begins. The second alternative is to inject the chemical at the wellhead. For additional information about chemical injection and treatment, see Chapter 13, Testing, Treating and Selling Crude Oil, and Appendix E, Chemical Treatment.

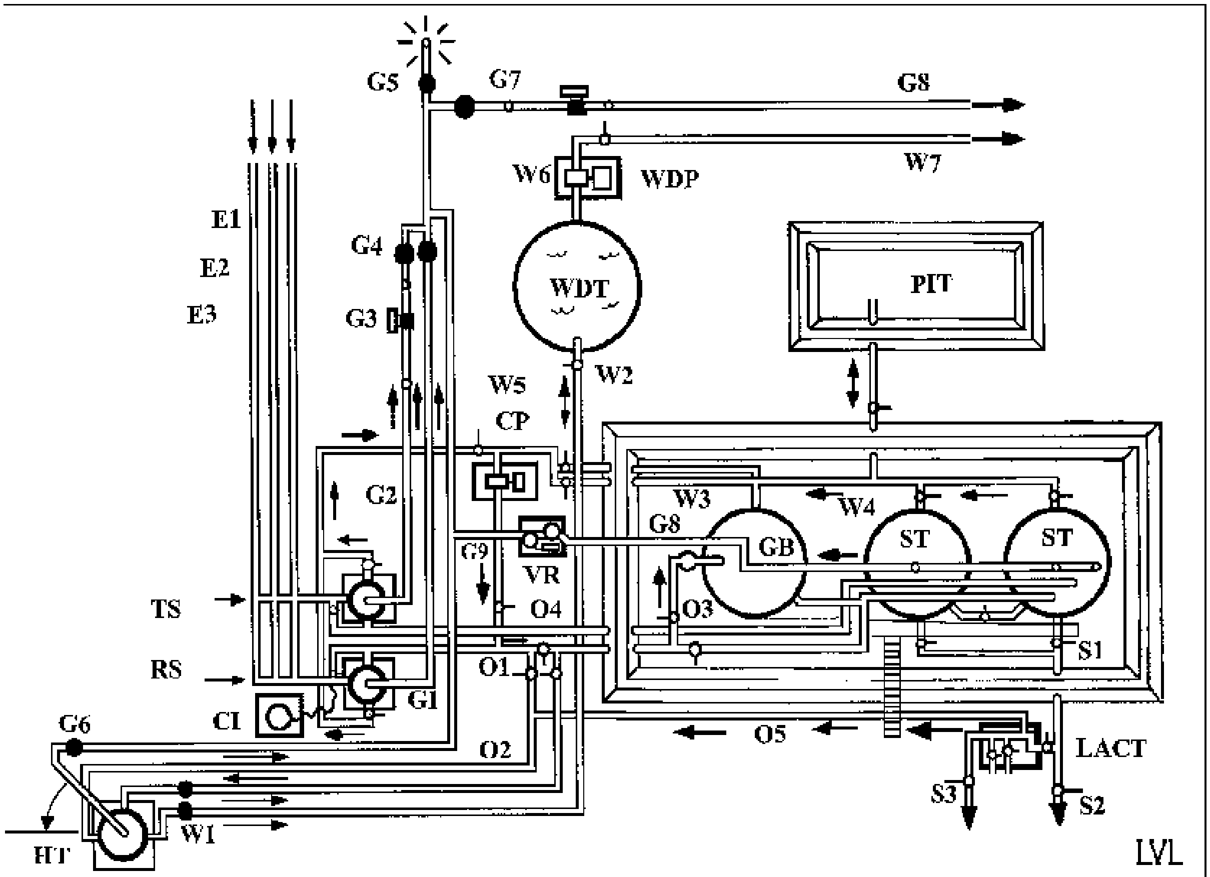
Vessels. The basic vessels are:

- **The regular and test separator.** Pressurized. Separates gas and liquid. The test separator is utilized to test individual wells and the two-phase separators are more common than three-phase.
- **The heater/treater.** May be pressurized or atmospheric. Heat treats and separates oil, water, and gas. It is a three-phase vessel.
- **The gun barrel or wash tank.** Separates oil, water, and small amounts of gas. Atmospheric. A three-phase vessel.
- **The stock tank (s).** Stores oil until sold. Atmospheric.
- **The water disposal tank.** Stores water until it is disposed of or re-injected. Atmospheric.
- **The circulating pump.** Circulates oil to remove water, clean tank bottoms, and empty and fill vessels.

- **The lined slush pit.** Stores produced water. Limited use now. An emergency overflow vessel in some situations.
- **The firewall or dike around atmospheric vessels.** Although the dike is not a formal tank, it is required around many vessels as an emergency open air tank in the event of leaks and must be capable of containing 1½ times the total capacity of all tanks.

Through most of the earlier days of the oilfields, these were the first specialized vessels and components included in a standard tank battery. Today the possibility of having a tank battery with exactly these eight components only is rather low. The rule of thumb of what components will be used is governed by the one basic rule: the components that are needed to produce and sell the oil and gas. By the end of the life of an oilfield, wells may have been produced by two or more methods of artificial lift, and the tank battery arrangement may have been altered or changed several times. The stock tanks may have been reduced to just one. As production becomes very low and if the formation gas pressure has been almost depleted, the high-pressure separator is no longer needed and is removed. As the reservoir is depleted, the expensive heater/treater may give way to a wash tank or gun barrel or even just a stock tank with a water boot attached to the side to separate the produced water. Many wash tanks are shop-made out of a piece of casing and can be very small. They are always taller than the stock tank and are easily identified. They may be set on a platform for atmospheric operation. As water flood is added to stimulate production, these new capabilities must be added, and, as a rule, water flood is the most common of most enhanced recovery operations.

Regardless of the controlling factors, the lease pumper must fully understand the operation of the basic tank battery. On the following two pages is a diagram that shows how these and other components may be connected in a typical tank battery.



Drawing Legend.

VESSELS.

GB	Gun Barrel.
HT	Heater/Treater.
PIT	Water Pit.
RS	Regular Separator.
ST	Stock Tank.
TS	Test Separator.
WDT	Water Disposal Tank.
_	Fire Wall—No Letters.

SUPPORT EQUIPMENT.

CI	Chemical Injection.
CP	Circulating Pump.
LACT	Lease Automatic Custody Transfer.
VR	Vapor Recovery.

LINES.

E.	**Emulsion.**
E-1	Flow Line # 1. Emulsion entering the tank battery from well 1.
E-2	Flow Line # 2. Emulsion entering the tank battery from well 2.
E-3	Flow Line # 3. Emulsion entering the tank battery from well 3.

O. **Oil.**

O-1. Oil line from the regular separator. May be produced to the heater/treater, gun barrel, or stock tank, according to the way the lease pumper has switched the line.

O-2. Oil line switched to flow the oil from the regular separator to the heater/treater.

O-3. Oil line switched to flow the oil to the gun barrel, then to the stock tanks.

O-4. Test separator flowing the oil directly to the stock tanks since 2nd heater/treater has not been installed. No other options are available.

O-5 Rejected oil from the LACT sales unit being diverted back to the heater/treater.

G. **Gas.**

G-1. Gas from the regular separator flows directly into the gas sales system.

G-2. Gas from the test separator flows directly to the meter run.

G-3. Gas from the test separator flows through the gas meter for cubic foot measurement.

G-4. Gas from both separators flows through independent back pressure valves.

G-5. A gas vent is provided where in an emergency the gas will vent. This pressure is set above all other back pressure valves, including the gas company sales valve.

G-6. Gas line and back pressure valve from the heater/treater toward the sales line.

G-7. Gas purchasing company meter and back pressure valve.

G-8. Gas line leaving the tank battery to enter the gas company gathering system.

W. **Water Disposal System.**

W-1. Water disposal system, beginning at the heater/treater.

W-2. The water disposal line from the heater/treater to the water disposal tank.

W-3. Water from the water disposal leg of the gun barrel to the water disposal tank.

W-4. Water from the stock tanks to the pit and to the circulating pump.

W-5. Circulating pump to the heater/treater for cleaning the oil, picking water up from the pit, and pumping fluid out of the stock tanks and heater/treater for system repairs.

W-6. Pump to automatically send accumulated water to the disposal system.

W-7 Water line from the tank battery to the water disposal or flood system.

S. **Oil Sales System.**

S-1. The oil sales line located one foot from the bottom of the front of the stock tanks.

S-2. The truck transport sales line from the front of the tank battery.

S-3. The Lease Automatic Custody Transfer (LACT), where the oil is sold and the custody of that oil is transferred to the pipeline or transportation company.

O-5 If the LACT unit rejects the oil, it will go to the heater/treater for re-treatment.