Lease Automatic Custody Transfer

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In everyday language the term "Custody Transfer" means simply a "sale," and the Lease Automatic Custody Transfer may be defined as the unattended sale of oil by the producer from the lease tanks to the pipe line. Under this method, all the operations of gauging and thiefing the tank, of determining the BS&W content, the temperature and the gravity of oil, and finally of placing the tank on the line, normally done manually, are being performed automatically.

The question could be asked, Why discuss the automatic custody transfer of oil during a course devoted to methods of artificial lifting of oil? The answer lies in the fact that full benefits of LACT may be realized only if other lease operations are also automatic. These include the automatic control of oil-lifting installations. With the present interest in and trend toward LACT, those concerned with artificial lifting of oil should become familiar with the method, at least in its general aspects, because acceptance of LACT may make more general the acceptance of automatic oil-lifting installations.

HISTORICAL BACKGROUND

Attempts at automatic operation of an oil lease were started quite early. Thirty-two years ago in the Salt Creek Field in Wyoming electric clocks were used for part-time pumping of wells. Automatic switchers for tank batteries were introduced just after World War II, and automatic scheduling of well tests was generally accepted several years ago. The combination of the three -- the automatic part-time pumping, the tank switching and gauging, and the well testing -- represented a nearly complete automatic operation of the lease. The only operation left was the automatic sale of oil to the pipe line. There is a good reason why this development was the last to be taken into consideration.

In general in the automatic control of pumping installation, or of switching the tanks, or of testing the wells, only the interests of the operator are involved. Except in very special cases, he is the only judge who determines whether or not the automatic equipment is to the economic advantage of his operations. This situation is, however, not true in the operation of selling of oil because at this point interests of many different persons are involved. These interests and the persons involved include the following:

1. The producer wants to be sure that he is paid for every barrel of oil he is transferring to the pipe line.
2. The pipe line company, which pays the producer, but acts actually as a transfer agent between the producer and the refinery, wants to be sure that it receives the oil in the same amount and of the same quality that it will sell to the refinery at the other end of its system.
3. The royalty owner is paid on the basis of the run tickets, and he obviously wants to have the assurance that a proper record is kept of the oil sold from the lease.
4. The State Regulatory Bodies depend on run tickets from the lease for a check on compliance with state-imposed production restrictions.
5. The taxes levied on crude oil are based on the records of the transfer of oil from the producer to the pipe line.

Because of the importance of the transaction, many rules, promulgated by the State Regulatory Bodies, govern the methods of selling of oil by the producer to the pipe line. Also, on the books of many oil-producing states definite statutes cover this transaction. What is surprising, therefore, is not the fact that the question of possibilities of automatic custody transfer were not considered until only in the last few years, but the fact that these possibilities were considered at all and that once they were considered, the acceptance by the industry became so rapid and widespread.

The Shell Oil Company was the first to install an experimental LACT battery in the Antelope Field, North Central Texas, in February, 1948. The same company installed a much larger and elaborate experimental automatic LACT battery in the Wasson Field in West Texas in 1953. During 1953 Sinclair Oil and Gas Company started experimenting with a LACT unit in Wertz Dome Field in Wyoming. In 1954, the Gulf Oil Corporation in the Glen Pool, Oklahoma, the Texas Company in the Wilson Creek Field, Colorado, and the Humble Oil and Refining Company in the Anahuac, Webster and Conroe Fields of Texas installed experimental LACT units. Early in 1955, Stanolind Oil and Gas Company (now Pan American Petroleum Corporation) in the Southwest Sholem Alechem Field, Oklahoma, and Imperial Oil Co. in Red Water Field in Canada began testing of their LACT units. Other companies followed.

The first actual automatic custody transfer of oil in this country, not a test, but a routine sale of lease oil was made by the Gulf Oil Corporation's LACT unit in Bloomer, Kansas, to the Kaw Pipe Line Company on December 22, 1955. This was the same unit which was extensively tested in the Glen Pool, as previously mentioned.

Considerable contribution toward rapid development of the LACT method was made by a Study Group formed within the American Petroleum Institute's Committee on Crude Oil Measurements. This Study Group was formed during the Annual API Meeting in Chicago in November, 1952. It consisted originally of four members. The objective of the Group was to determine the accuracy and the reliability of the equipment and of the methods involved in automatic custody transfer and to work out eventually a standard for precision and installation of the acceptable devices. The Group grew very rapidly, held a series of meetings, coordinated the work of different companies performing the tests on the different LACT units by furnishing a forum for exchange of information, and released in 1956 a Bulletin of Information on the method. A good indication of the rapidity of the development in this field is the fact that this Bulletin, published only a few months ago, is already obsolete, and its second edition is being prepared.

ADVANTAGES

The method of automatic custody transfer offers decided advantages both to the producer and to the pipe line.

To the Producer

From the producer's point of view these advantages are as follows:

1. Reduction of the required lease storage.
2. Prevention of evaporation losses.
3. Better utilization of personnel time.

Storage. In the designing of tank batteries, customarily tank capacity sufficient for two or three days' storage is provided. In the LACT method what is needed in addition to the unit itself is only a small emergency storage. This saving in tank investment may be quite substantial. For instance, at our LACT installation on one of the leases in the Hastings Field now being tested, the lease has at present a storage capacity of 7000 bbl. When the unit is in actual routine operation only 1000 bbl storage capacity will be provided, representing a saving in tankage investment of around $20,000. From the above figures, apparently installation of LACT is particularly advantageous to the operator when he begins a new lease or when replacement of the tankage becomes necessary.

Evaporation Losses. The LACT unit is a "closed" system which eliminates the filling and the evaporation losses. In some of the designs of LACT units it is possible to maintain a pressure on the system over and above the pressure conventionally used on tanks. If and when the time comes that pipe line systems will operate under pressure, very substantial increases in oil recoveries will be effected by the saving of lighter components of oil now lost in handling by evaporation.

Personnel. A large portion of the pumper's time is devoted to stopping and switching the tanks and to working with the operation of the sale of oil to the pipe line. With this portion of his function taken over by the LACT unit, the pumper can devote more of his time to other work on the lease. There is a wide field of opportunity for increasing the efficiency and, what follows, for decreasing the operating cost, of artificial lift installations by closer attention of the field personnel to the manner or operation and to the performance of these installations.

The LACT unit offers also opportunities for saving clerical and accounting work. Each run ticket made out on a lease starts a chain reaction of clerical and accounting work as the ticket moves through different offices. The LACT reduces this work by reducing the number of the tickets needed. For instance, at our LACT unit, now being tested in the Elk Basin Field, Wyoming, around 4000 bbl of oil per day are being run from the lease in question and 1000 bbl tanks are used, necessitating around 120 run tickets per month. With the LACT unit only two tickets per month will be needed.

To the Pipe Lines

The principal advantages of LACT to the pipe lines are (1) increased accuracy, (2) improvement of the so-called "load factor" and (3) better utilization of gaugers' and clerical time.

Accuracy. In the last few years the pipe lines have become acutely aware of losses that they sustain as a result of the so-called "incrustation" of lease tanks. The tank tables are prepared from strapping of a clean tank. As the tank is used, an accumulation of paraffin, sometimes of BS&W, and of corrosion products gradually forms on the walls of the tank. This "incrustation" decreases the volume of the tank. The producer and the royalty owner are still paid on the basis of the volume of a clean tank, but the pipe line sustains a loss. This loss may not be large for only one tank, but it is substantial for a large number of tanks over a long period of time. As discussed later, the LACT systems make provisions for elimination of this inaccuracy.

Increased Load Factor. The load factor is a measure of degree of loading of pipe line facilities, that is, lines, pumps, and so on. As a general rule in a pipe line system connected to a number of producing leases, this loading starts increasing each morning, remains high through the day, starts declining in the evening, and is low through the night. The facilities have to be designed for the peak day demand, yet their capacity is not utilized during the night. In a system connected to leases equipped with LACT units, the runs from the individual leases could be so scheduled that the load on the facilities would be uniform throughout the 24-hour period, in many cases permitting use of smaller lines and pumps.

Utilization of Personnel. As it saves clerical time for the producer, by reduction in the number of trips to the lease batteries and in the amount of the records involved, the LACT method also offers an excellent opportunity for better utilization of the time of the pipe line personnel.

LACT SYSTEMS

In all of the LACT systems now on test or in actual operation the determination of oil's gravity and BS&W content is made, in general, by the same methods. There are, however, two basically different methods of determining the volume, and from this point of view all the LACT systems may be divided into two large groups: (1) those using the dump-type metering tanks and (2) those using the positive-displacement meters. The temperature is determined differently in each of the two methods.

From the standpoint of operation of the controls, the LACT units may be divided into four groups:

1. All-electric units, in which both the signals are transmitted and the controls are operated electrically.
2. Electro-pneumatic units, in which the signals are transmitted electrically and the controls are operated by compressed gas
3. Electro-hydraulic units, in which signals are transmitted electrically and the controls are operated hydraulically
4. All-pneumatic units, in which both the signals are transmitted and the controls are operated by compressed gas.

VOLUME DETERMINATION

Because the method of determining the volume is distinctly different in the two different types of LACT units, it must be considered in more detail.

Dump-type Metering Tanks

The method of metering dump tanks is old in the oil field practice. It has been used for many years for production tests of wells. Under this method a small tank of a known volume is filled with produced fluid. When full, the tank is dumped, and the filling starts again. Each dump is registered by a counter. The number of dumps multiplied by the known volume of the tank gives the total amount of the fluid measured during any given period of time.

In the application of this method to LACT, only the assurance of the accuracy of repeated filling of the tank to the exact same volume on each dump was necessary. The ways in which this is done is illustrated in Figure 1.

Part A shows the method of floats. When the fluid reaches the upper float, the fill valve closes, the pipe line valve opens, and the tank is "on the line." When the fluid level reaches the lower valve, the pipe line valve closes, the filling valve opens, and the cycle begins again.

Refinement of the method is shown in B. The float is placed in a restricted dome, the so-called "Seraphin Neck." Because the volume of the dome is so small compared to the volume of the tank even considerable error in the movement of the float, which closes the filling valve, results in an extremely small error in measurement of the volume of the tank. For instance, in a horizontal tank 6 ft in diam by 18.5 ft in length with 100-bbl capacity and with a dome of 18-in. diam, the error in movement of the float of as much as 2 in. would result in error of measurement of only 0.03%. In the method illustrated in A, if the tank were 8 ft in diam by 11 ft in length with 100-bbl capacity, the error of 2 in. in movement of the float would result in measurement error of 1.5%.

Under this method, it is necessary to slow down the rate of filling or emptying the tank when the fluid enters the upper or the lower dome to assure precise level control. This is done by placement of a restriction at the entrance of the upper

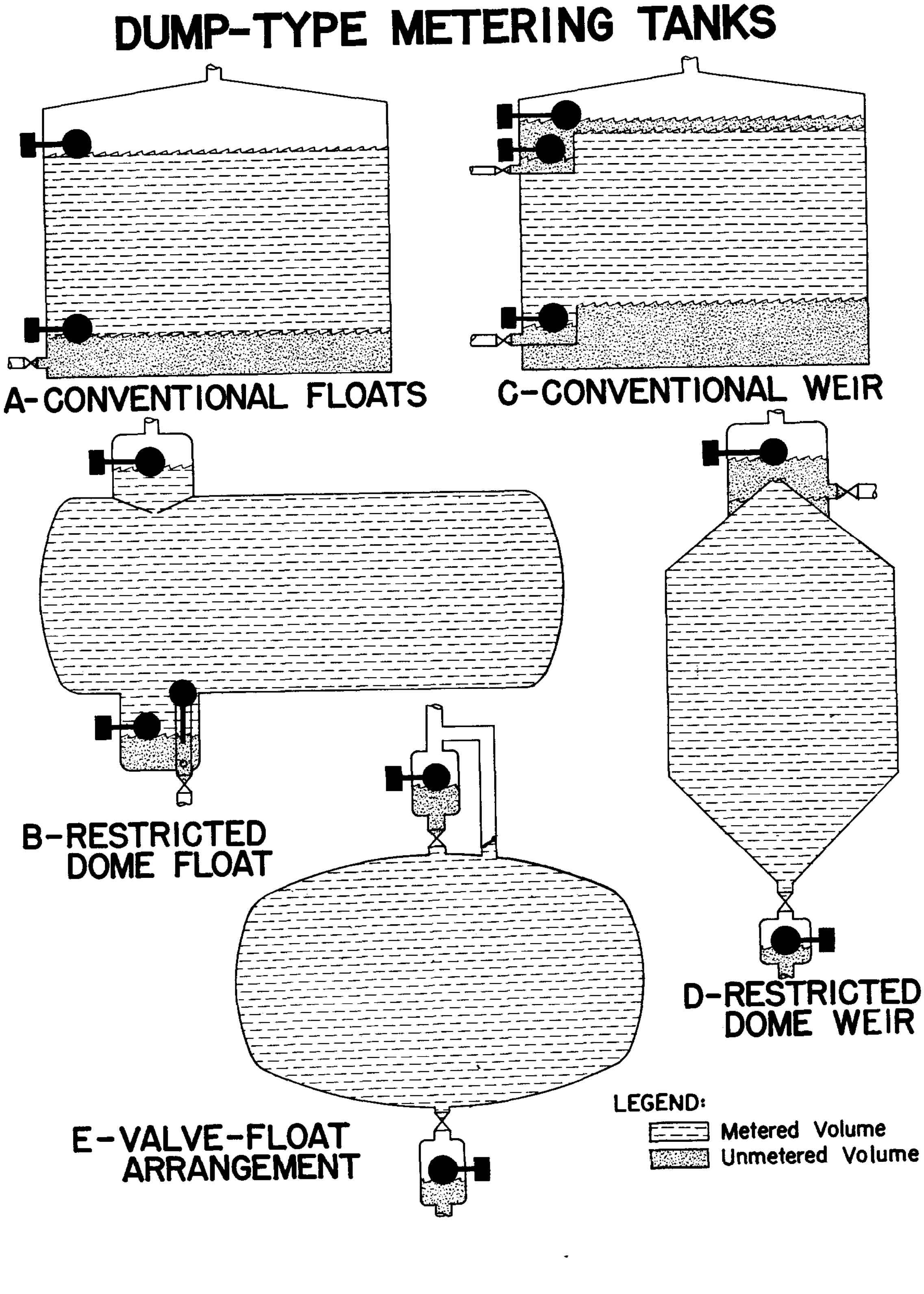
DUMP-TYPE METERING TANKS
A-CONVENTIONAL FLOATS
C-CONVENTIONAL WEIR
B-RESTRICTED
DOME FLOAT
D-RESTRICTED
DOME WEIR
E-VALVE-FLOAT
ARRANGEMENT
LEGEND:
Metered Volume
Unmetered Volume

Figure 1

dome and by a special arrangement which permits draining of the lower dome through a small opening.

Sketch C illustrates the so-called "weir method." A weir in this case is a box placed on the inside wall of the tank. The weir has an outlet, controlled by a valve, and is equipped with a float. Two weirs are in the metering tank. During the filling of the tank, both weir valves are closed. When the fluid level reaches the float above the upper weir, the fill valve closes, and the oil is directed into another tank. After a specified time delay, the valve of the upper weir opens, and the oil is drained from above the weir into the other tank now being filled. When the fluid reaches the upper edge of the upper weir, the draining of the tank stops, and the weir itself is being emptied. This actuates the weir float, which closes the upper weir valve and opens the pipe line valve located in the lower weir. When the fluid level reaches the upper edge of the lower weir, the emptying of the tank stops. When the lower weir drains, the weir float closes the pipe line valve, and the tank is ready for the next filling.

The weir method is quite accurate. Each time the tank is filled, exactly the same volume is measured, that is, the volume between the upper edges of the two weirs.

A variation of the method is shown in D. The upper weir, conical in shape, is placed in a restricted dome on top of the tank. When the fluid reaches the float above the weir, filling of the tank stops. Only a very small amount of oil has to be drained off to bring the fluid level to the upper edge of the weir. The volume is measured between the top weir and a valve in the bottom of the tank.

In the method illustrated in E the volume is measured between the two valves operated by floats. It should be noted that in this arrangement the movement of the float is not critical as far as the accuracy of the measurement is concerned. The volume is measured always between two fixed points, the valves.

Positive-displacement Meters

A positive-displacement meter is a device placed in a flow line in such a way that the total flow stream passes through the meter, causing the measuring element of the meter to rotate, dividing the stream into segments of known volume. Through a gear train this rotation is transferred to a counting device which adds the volumes of the individual segments and shows the results on a counter, in barrels.

Several designs of positive-displacement meters are commercially available. Figure 2 shows schematically the

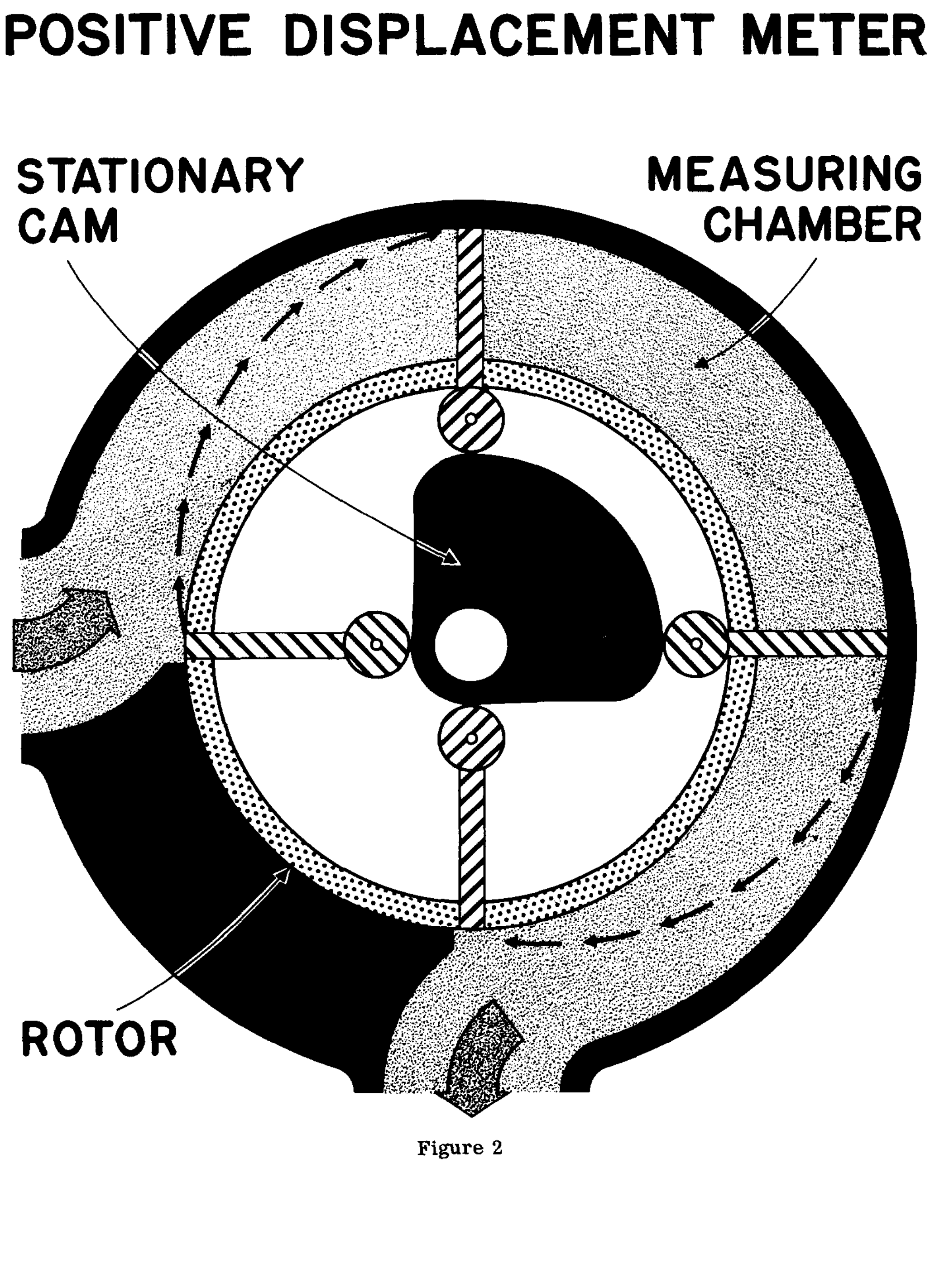

Figure 2

principle of operation of one of these designs.

In this design the housing of the meter contains a rotor equipped with vanes rotating around a stationary cam. The design of the cam is such that vanes move outward, forming a measuring chamber of known volume with the rotor, the housing, and the covers. Four such chambers are formed during each revolution of the rotor, and the volumes are registered on the counter in terms of barrels.

In this and other designs there is always some slippage of the fluid by the vanes. This slippage is determined originally by comparing the meter-measured volume against a very carefully calibrated vessel, the so-called "prover tank." The ratio of the volumes is the "meter factor" which is applied against the meter-measured volume. The meters are calibrated at least once every four weeks. Change in the meter factor indicates need for check and correction of the mechanical operation of the meter.

Comparison

The dump-type metering tank has the advantage of simplicity. No moving parts are involved except instrumentation for operation of the valves. The volume measured is always the same. No periodic calibration is necessary. The disadvantage is the cost. The LACT units now in use employing metering tanks have all been "custom built." Their cost will decrease once they are manufactured on production basis. At present, for a given size of lease production their cost is at least twice that of a positive-displacement meter unit.

The positive-displacement meters were used in the past or individual well tests. In general, the results were not entirely satisfactory. The LACT positive-displacement-meter installations, however, proved that when properly installed and maintained, the meters are capable of extremely high accuracy. Their main disadvantages are that (1) many moving parts make them susceptible to possibilities of mechanical failure, (2) they require maintenance by a qualified person, and (3) the cost of periodic calibration and of maintenance may offset to some degree the advantages expected from the LACT method. As previously stated, their main advantage is a relatively low initial cost.

It is believed that there is room for both methods in future LACT installations. Factors determining the selection will be volume and characteristics of the fluid to be handled, climatic conditions under which the units are to operate, areal concentration of the units which would determine the maintenance cost, and others.

OTHER MEASUREMENTS

As stated, the custody transfer of oil also involves the determination, in addition to volume, of temperature, gravity, and BS&W content of oil.

Temperature

In Metering-tank-type units the temperature is usually recorded on a chart by a recording thermometer. Provisions are made for periodic checking by a conventional test thermometer. An average temperature for the period covered by the unit's run ticket is used for correcting to the standard conditions of 60 F.

In case of positive-displacement meters and of some metering-tank units, the volume shown on the counter is already corrected to the standard conditions by the so-called "temperature compensation." The device which compensates for the temperature is set for the expected range of gravities of oil to be handled. In the meter illustrated, the gear ratio between the rotor of the meter and the counter is then changed automatically with temperature changes so that the counter shows the volume already corrected to 60 F.

Gravity

Instruments which give continuous record of gravity of the oil being measured are available. However, in the LACT units now in operation, the gravity of oil is being determined from the "composite sample" which is accumulated for the period covered by one run of the unit. Small samples are collected from each dump in the case of metering-tank units or continuously from the stream passing through the positive-displacement meter. The samples are deposited in a closed container so that at the end of the run an average sample is available to the pumper and the gauger.

BS&W Content

The so-called "capacitance probe" is used for determining the BS&W content of the oil. Whenever two electric conductors of different electric potential are close to each other, the so-called dielectric circuit exists. This system stores energy in the material between the two plates. The amount such a system can store, that is, its "capacitance", depends on several things, one of which is the kind of material separating the plates. In case of the LACT "capacitance probe," one of the plates is the pipe through which the oil flows; the other is a rod located centrally within the pipe, the electrode. The differences in the capacitance caused by either clean oil or oil and water flowing through the pipe are utilized to operate a relay which controls the necessary instrumentation.

The instrument is very accurate and provides continuous record of BS&W content of oil passing through it. In a majority of cases, however, the probe is used at present only as a monitor; that is, the probe is pre-set for a specific permissible value of BS&W, for instance 0.5%. If the amount of BS&W in oil exceeds this value, the unit is automatically shut down. The average amount of BS&W for calculation of the run tickets is determined from the "composite sample" mentioned above.

OTHER INSTRUMENTATION AND SAFEGUARDS

In addition to instruments needed for determination of volume, temperature, gravity, and BS&W, an LACT unit is equipped with a number of other instruments which make its operation entirely automatic and eliminate possibility of mismeasurements.

Pipe-line scheduling instruments enable the pipe line to put the unit on the line automatically at the desired hour of the day to assure uniform loading of the system connected to several units. Monthly and daily allowable shutdowns can be pre-set in advance, so that the unit shuts down each day after the day's allowable has been run and shuts down completely, until reset manually, when the month's allowable has been exhausted. Automatic ticket printers furnish a record which is used in place of run tickets now manually prepared. Ground-level recording gauges give the amount of oil in the surge tank, that is, the tank from which the oil is supplied to the dump tank or meter, to furnish data for calculation of daily production.

All these instruments, however, would be of little value unless assurance were given that they are functioning properly and that field personnel are advised promptly of any malfunction. For this assurance, many safety features and checks have been built into the LACT unit.

All the valves are fail-proof. They are kept closed by a spring and are opened by the power operating the unit, whether electricity, compressed gas or liquid pressure. In case of power failure, all of the valves close, and an alarm, visual or audible, is given.

A system of interlocks is provided. For instance, the pipe line valve of the metering tank cannot open if the filling valve is fully or partly open.

Some units have indicators showing that the unit has been tampered with. In general, all the instruments are sealed at the beginning of the run. The seal is broken at the end of the run.

The metering tanks are glass-or-plastic lined to minimize paraffin deposition. Provisions are made for spraying the inside of tanks with hot oil to remove any accumulated incrustation. The bottoms of the surge tank are automatically re-circulated through the treating system.

If the metering unit is shut down for one of several possible reasons, the production enters the surge tank. When this tank is full one of two possible arrangements can be provided for. Either the lease is shut down and an alarm is given, or the production is diverted into an emergency tank and the alarm is given.

If the BS&W monitor shuts down the unit, two arrangements can be made. Either the production is re-circulated through the treating system until the oil is clean and the monitor starts the unit, or the unit remains shut down and the alarm is given when the surge tank is full.

Since positive-displacement meters are calibrated once a month, situations could arise under which the meter could be found considerably out of calibration. The question then would be over what period of time did this error occur. Therefore, two meters, connected in series are used. A device compares the volumes registered by the two meters. If the difference between the two volumes exceeds a predetermined amount, the unit is shut down. The possibility of the two meters' having the same error is extremely remote.

A system of checks is provided in dump-tank-type units. The printed ticket must check with the visual counter. The temperature of oil is taken by the recording thermometer for each filling of the metering tank; therefore, the number of "kicks" on the temperature chart provides another check on the number of dumps. Also, the metering tank is equipped with a recording gauge which shows changes of the head in the tank during its filling and emptying. Therefore, the chart of this gauge also shows the number of the dumps.

Any mechanical device is subject to failure. However, failure of human error, or of mechanical nature, also occurs in present conventional methods of custody transfer. It is believed that LACT units have had built into them a sufficient number of safety features to make them as reliable as the methods now used, if not more reliable.

ACCURACIES

The accuracies of LACT units when they are compared with manual gauging cannot be questioned. They have been reported at the hearings of State Regulatory Bodies and in the technical literature. They are based on exhaustive tests covering long periods of time and involving large volumes of oil handled.

As far as volumetric accuracies are concerned, differences of 0.037 of 1% have been reported in checks between dump-type-tank LACT unit and conventional measurements. Accuracies of similar magnitude have been reported for the positive-displacement meters.

Comparison of data from LACT units' composite samples with averages from manually taken individual samples shows the differences of around 0.2 of 1 F for temperature and 0.1 of 1% for gravity and BS&W content.

THE FUTURE

Certain factors will tend to slow down in the future the acceptance of the Lease Automatic Custody Transfer method:

1. Not every oil-producing lease is a candidate for the LACT method. Many factors, most of them economical, have to be weighed before a change to the LACT is made, reducing the sphere of application of the method.
2. Certain companies and individuals will be reluctant to adapt the LACT quickly.
3. In some of the oil-producing states certain laws will have to be changed by the legislature before LACT can be applied on a routine basis.
4. The systems now in operation are still in the process of development. New equipment is being brought out every day. Until the actual field experience reduces the systems to those which are the least expensive, the simplest, and the most accurate and until the designs are frozen for mass production, the acceptance of LACT will be limited primarily to a number of large companies who are particularly interested in the subject and are doing their own experimenting with the method.

Despite these limiting factors, there is no question that acceptance of LACT will be growing in the future at an ever-increasing rate. This statement is justified on the basis of the experience of the past few years during which the growth of LACT has been phenomenal, considering the fact that the inertia and the initial prejudices had to be overcome.

As an example of the growth of LACT, in the case of our company, by the end of 1956 we were selling automatically to the pipe line the amount of about 120 barrels per day. If the tests on all the LACT units we are now installing are completed by the end of 1957, we should be selling then to the pipe line, automatically, around 15,000 barrels a day. These are, of course, the plans of one company only and should not be interpreted as indicating industry-wide trend. Nevertheless, the optimism toward the growth progress of LACT is well founded.