Lease and Battery Automation, Fullerton Clearfork Unit

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ABSTRACT

To date, there have been two major automation projects in the Fullerton Clearfork Unit. The first was completed in 1956 and included 57 wells. It consisted of complete automation from the wellhead to the storage tanks with no custody transfer facilities. This, being a pioneer installation, required some changes and revisions before satisfactory operation was obtained; however, once completed it has operated satisfactory.

The second project, including 51 wells, was completed in 1958. The essential difference between these two projects is that the first was designed to handle intermittent flowing wells, while the second was designed to handle pumping water flood production and includes "LACT" facilities.

This paper is concerned, primarily, with a discussion of these automation projects and the types of equipment used. It discusses briefly the operational and economic criteria for the application of automation.

INTRODUCTION

Automation is a relative new comer to the petroleum production industry, although it has been used for years in related industries. Genuine progress toward getting it accepted in the production branch of the industry has been made only in the past several years. The momentum of old accepted practices and the natural resistance to change are frequently posed as the reasons for the lag in acceptance of automation by the petroleum industry.

While this is undoubtedly true, other factors have contributed substantially to this delay, namely, regulatory bodies, diverse interests, indeterminate size of a field prior to complete development, complications inherent in processing a multi-phase fluid, and economics.

Unitization eliminates some and simplifies other problems which tend to complicate lease operations. Therefore, units lend themselves more readily to automation than most other production operations. A fully unitized operation will usually be operated as one lease by one operator company with the only division of interest being according to a predetermined percentage of ownership. Such operations lend themselves most readily to physical consolidation of production facilities and equipment, which is very often essential to an economically attractive automation project.

Some of the factors to be considered when justifying a consolidation, automation project are: crude oil gravity and volume conservation, replacement and repair of worn and/or obsolete equipment, need for more and better treating and testing facilities, reduction in lease maintenance, and reduction in and/or better utilization of labor.

Automation equipment as presently developed and available permits a high degree of automation, i.e., from the wellhead to the pipe line. Available data recording and transmission equipment make it possible to have the data immediately available at remote offices. The completeness of the system installed depends upon the economics involved, which vary greatly from one operation to another and depend on field conditions.

DISCUSSION

General

The Fullerton Clearfork Field was discovered in

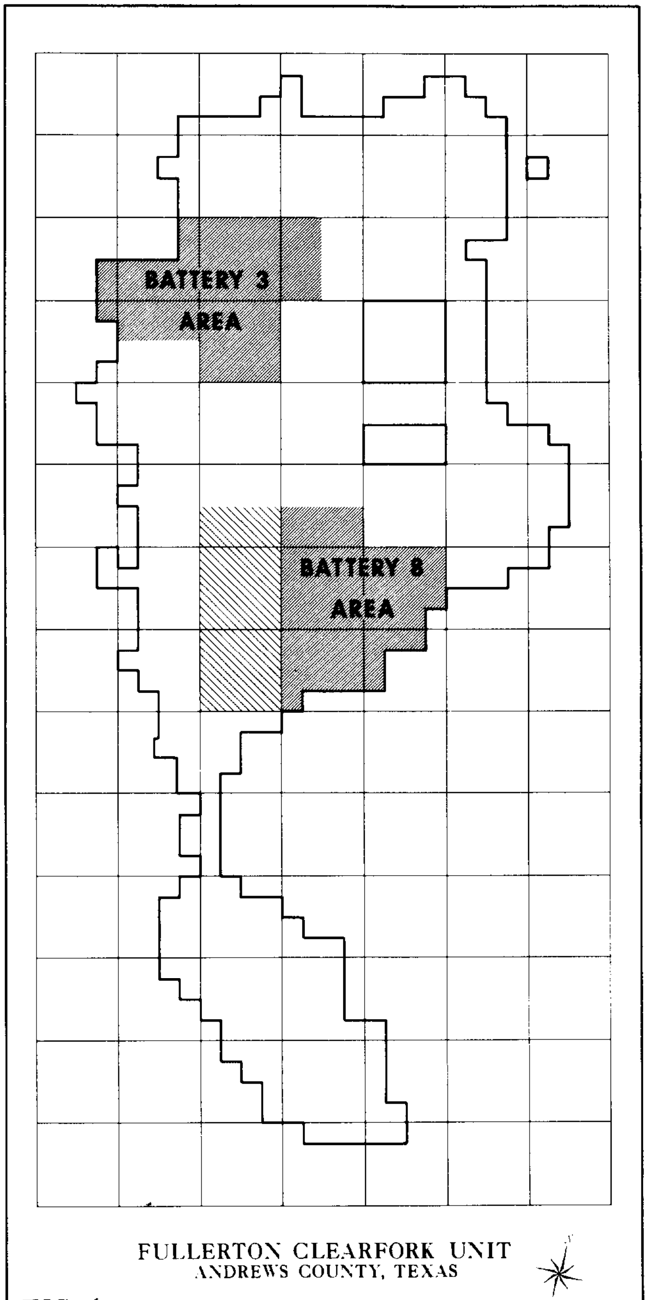


FIG. 1

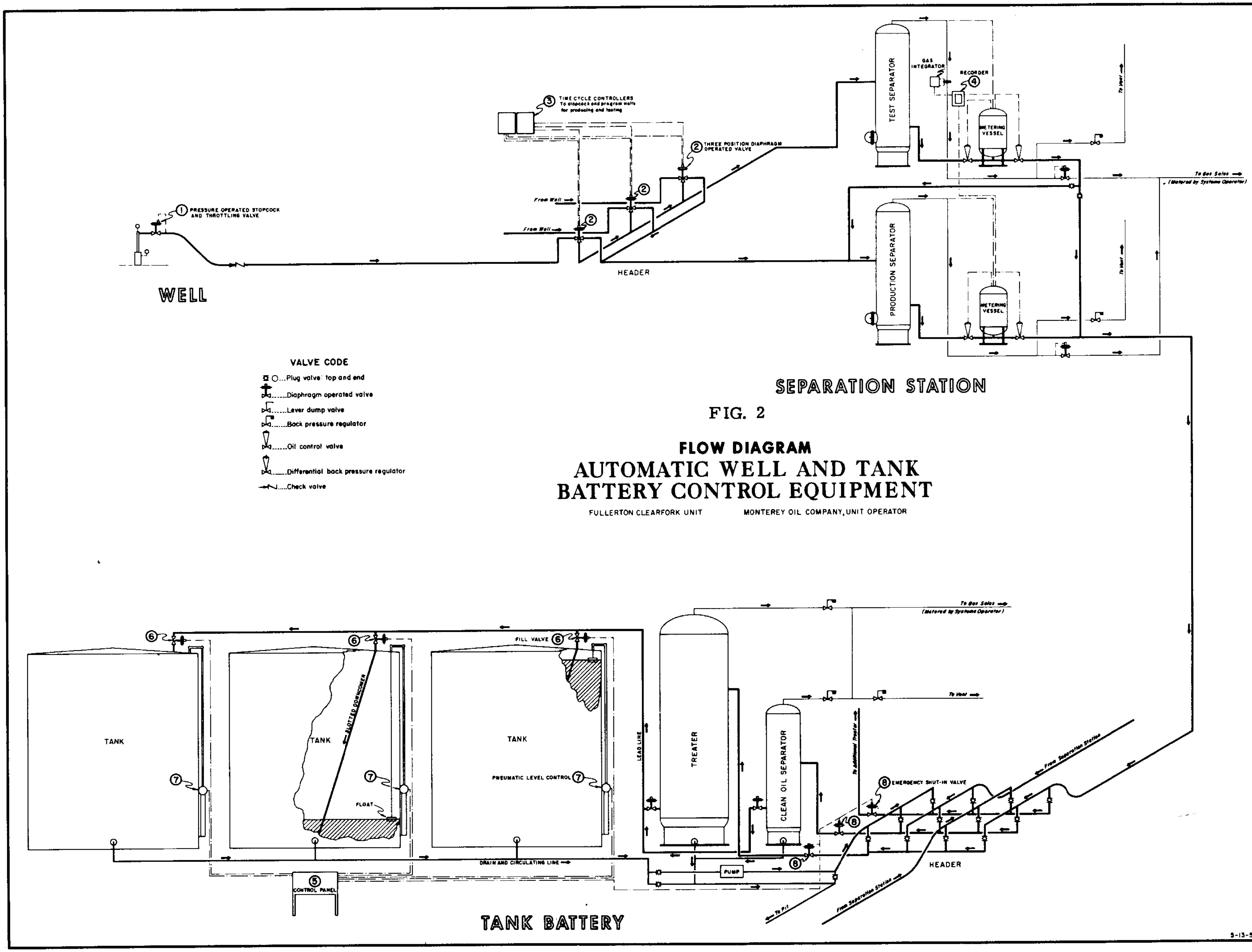
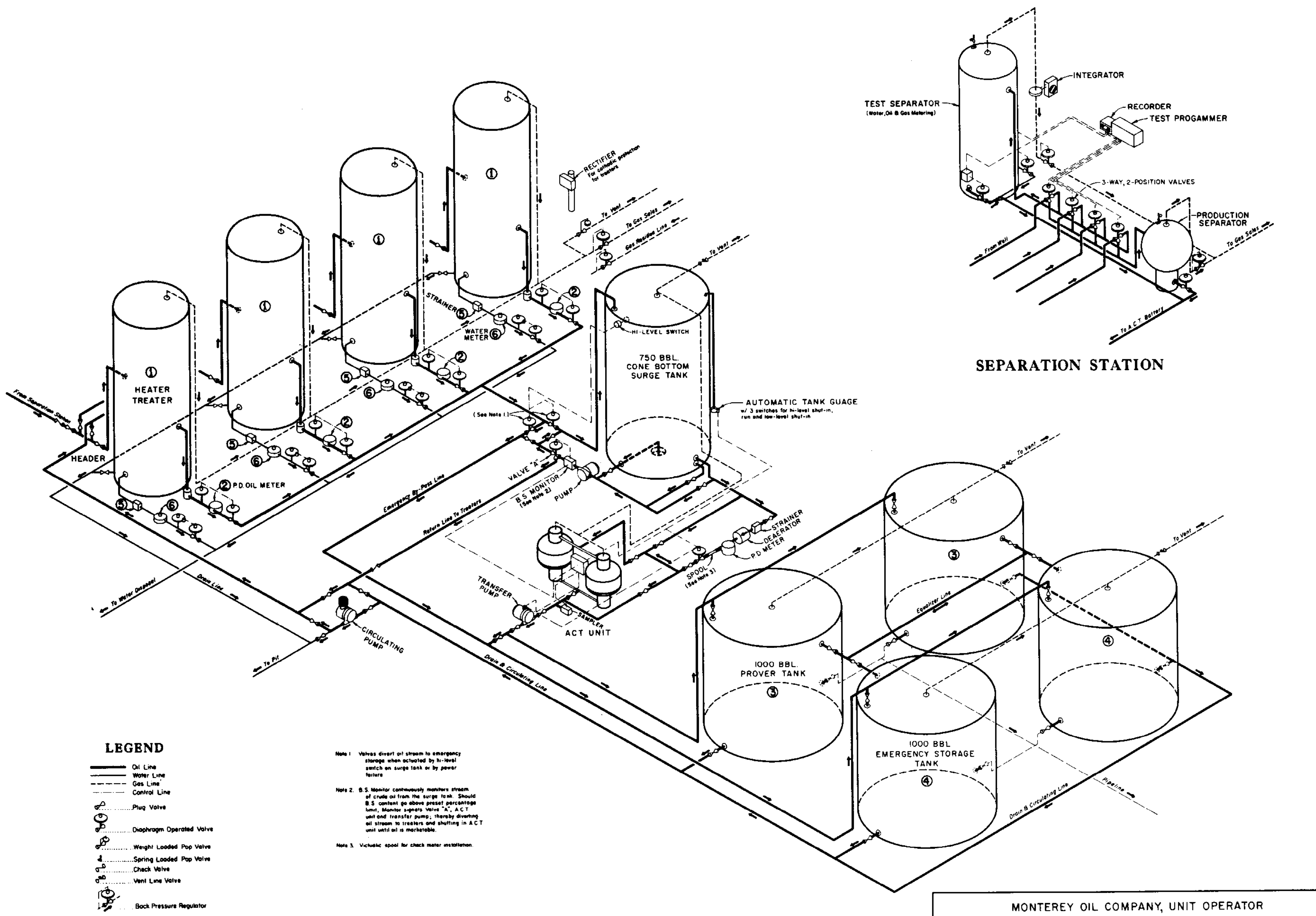


FIG. 2

FLOW DIAGRAM

AUTOMATIC WELL AND TANK BATTERY CONTROL EQUIPMENT

FULLERTON CLEARFORK UNIT MONTEREY OIL COMPANY, UNIT OPERATOR



Note 1 Valves divert oil stream to emergency storage when actuated by hi-level switch on surge tank or by power failure

Note 2. B.S. Monitor continuously monitors stream of crude oil from the surge tank. Should B.S. content go above preset percentage limit, Monitor signals Valve "A", A.C.T. unit and transfer pump; thereby diverting oil stream to treaters and shutting in A.C.T. unit until oil is marketable.

Note 3. Victaulic spool for check meter installation.

FIG. 3

MONTEREY OIL COMPANY, UNIT OPERATOR

FLOW DIAGRAM

CONSOLIDATED BATTERY 8

WITH TYPICAL SEPARATION STATION

DRAWN BY R. E. RODGERS

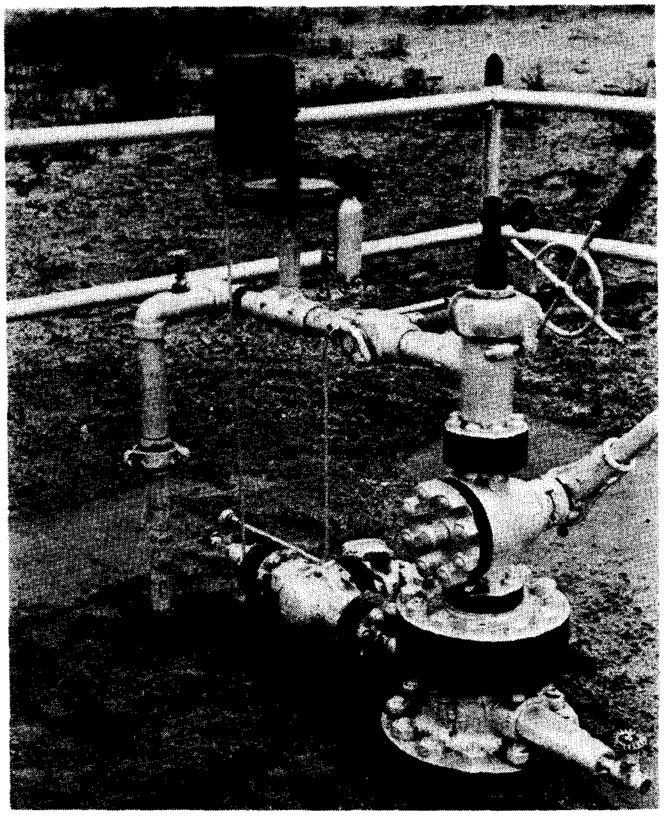


FIG. 4

February, 1942 and unitized in February, 1954. Tankage, separation and treating equipment has been in service in a corrosive atmosphere and has deteriorated to the extent that a substantial amount of repair and replacement is required. This, along with unitization and proposed secondary recovery, make the field a good candidate for automation and consolidation.

Presently there are two automatic consolidated batteries in the Fullerton Clearfork Unit. The first, designated "Battery 3" on the Index Map and flow diagram, was installed early in 1956 and was somewhat of a pioneer project in that much of the automation equipment was field tested for the first time. This project includes 56 wells formerly served by 10 manual batteries. The production from this area is from intermittent flowing wells which produce considerable gas and negligible amounts of water.

The wells are consolidated into six automatic separation stations from which the production is routed to one automatic consolidated battery. With the exception of automatic custody transfer of crude oil to the pipe line, this is a completely automatic project including automatic well control, testing, production and test programming, tank gauging and switching, and lease shut-in.

The second battery, designated "Battery 8" on the Index Map and flow diagram, was completed in the latter part of 1958 and includes 51 wells formerly served by 12 manual batteries. All production is routed to four automatic separation stations and thence to one automatic battery. It is located in the pilot water flood area and designed to handle water flood production, current and future. There is a planned 40 well extension which will make a total of 91 wells going to this battery. The areas included in the existing and proposed extension to this battery are shown on Fig. 1.

The differences between these batteries are due to the different types of production they were designed to handle and the equipment available when they were installed. The intermittent flowing wells in the first project required production programmers and lease and well shut-in equipment, whereas these facilities were not required in the second project.

The second project, in the water flood area, required water and oil separation and testing equipment which was not needed in the first project since water production was negligible. The second battery has custody transfer facilities which eliminate the need for the automatic tank gauging and switching that was included in the first battery. Schematic flow diagrams of the two installations are shown on Figs. 2 and 3.

BATTERY NO. 3

It was necessary that lease and well shut-in equipment be installed in this area since wells are produced intermittently. Automatic equipment at each well includes pressure operated throttling valves adjusted to shut-in the wells at a preset flow line pressure. An increase in flow line pressure occurs when the well is shut-in at the separation station header according to its schedule, or a pressure increase can occur when the lease is shut-in either intentionally or due to malfunction of equipment. When this occurs, the valve closes and shuts in the well. Fig. 4 shows a typical wellhead installation.

Each well is routed to a header at a separation station, as shown by Fig. 5. These headers consist of a production and test line and a three-way three-position diaphragm operated motor valve to route the flow from each well. The motor valves are operated either by an electric solenoid valve or a pneumatic pilot valve which is sequenced by the production and test programmers located in the control building. Each station has a test and production separator with one barrel-dump-type metering vessels for metering test and total produced liquid. Since there is no separation of oil and water at these stations, samplers were installed downstream of the metering vessels to permit a determination of water-oil ratio.

Test gas is measured by an integrating orifice meter and then commingled with total lease gas, which is metered to sales at the separation station. From the separation station lease production, oil and water is routed to the central battery. Flow line header valves are closed by a signal from a high level float installed in the production separator. This causes a pressure increase on individual well flow lines and actuates the well shut-in valves.

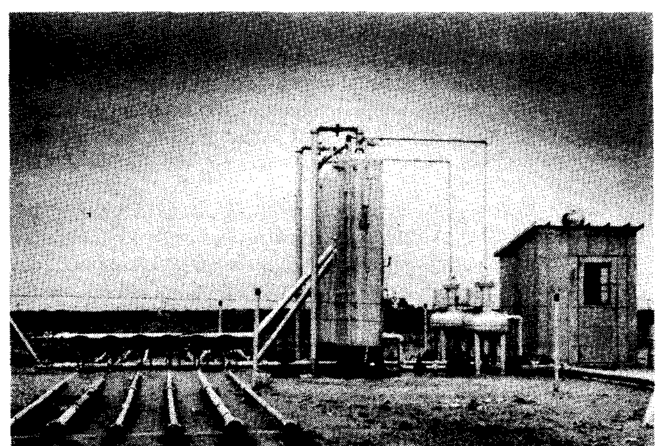


FIG. 5

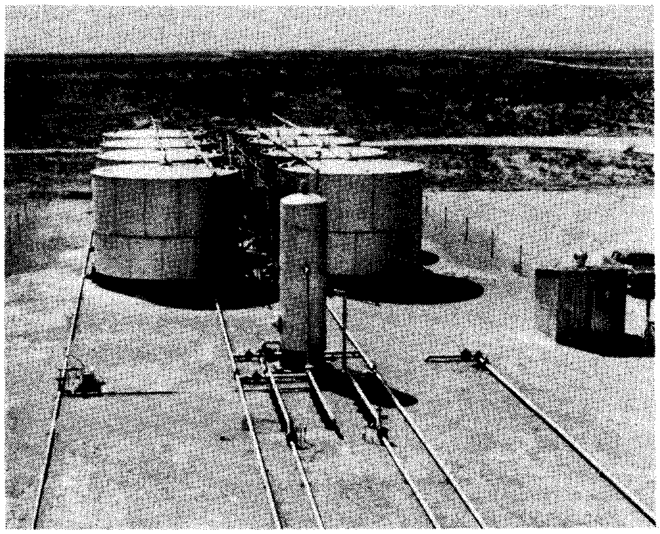


FIG. 6

Production and test programming panels and strip chart data recorders are installed at each station. Test programmers are equipped so that wells can be tested automatically, according to a preset sequence. The test period for any well can be varied from 15 minutes to 24 hours in multiples of 15 minutes. Production programmers permit the same flexibility for adjusting flow patterns.

Panels are equipped with manual overriding switches which are used when it is necessary to deviate from the automatic sequence. Indicator lights on the panels identify the wells and the sequence at any given time. The strip chart records test oil and gas and total lease production in units of one and multiples of ten. The decade counters make one blip for each ten units of production and thereby permit a quick determination of this data.

Automatic Features

The automatic features incorporated in the separation stations were dictated by the functions essential to handling the lease production. With this equipment at each station it is possible to program the production for each well, test the wells and shut-in the lease without visiting the wells or initiating any manual operation. All production and test data are quickly available from the strip chart and can be forwarded to the field office for processing with little delay.

The central battery, shown in Fig. 6, is similar to any consolidated battery except for the automatic gauging and switching equipment. It has a production separator, two treaters and eight 1,000 barrel tanks. The production separator processes oil which does not require treating.

Stock tanks are equipped with automatic ground level gauges and diaphragm operated motor valves for switching tanks. These valves are operated by solenoid pilots that receive signals from the control panel in the doghouse. This electric panel is equipped with automatic and manual sequencing switches and panel lights to regulate the filling sequence and indicate what operations are in progress.

It was desirable to try several types and makes of equipment in this battery so that the most suitable could be selected for future installations. Pneumatic production and test panels were installed at two stations and electro-pneumatic at the others. Several makes of valves, pilots and programmers were used. It was apparent that much of this equipment could be improved.

In general, the programmers were too complex and bulky and it was obvious that they could be simplified and assembled into a more compact package. Experience indicated the electro-pneumatic equipment, utilizing solenoid valves, to be less complex, more dependable and easier to install and repair than the pneumatic pilot operated equipment.

The samplers had very little utility since they did not take a composite sample and were completely unreliable when the water cut was more than a few per cent. Since only negligible amounts of water are produced in this battery, the unreliability of these samplers did not detract from the overall operation.

Economically and operationally the installation is a success. Once the initial problems were solved it has operated satisfactorily. A substantial reduction in battery maintenance, and tank and equipment repair have been realized. The chief economic benefit is from gravity conservation. The crude oil gravity was increased approximately 2.5 , for a gravity bonus of 1 and a volume increase of approximately 5 per cent. Treating and chemical costs were reduced very substantially. Frequent and more reliable well tests, efficient flow patterns and conservation are some of the intangible benefits.

BATTERY NO. 8

This battery is located in the pilot water flood area and was designed to handle large volumes of oil and water, which required some additional features not necessary in the first battery, i.e., separation and metering of both oil and water. An emergency method for shutting in wells or handling production is essential in a completely automatic system. In this instance it was decided to install emergency storage at the battery rather than lease and well shut-in equipment. When the allowable has been run or there is a malfunction of equipment, the production is routed to emergency storage at the central battery which is adequate to handle 24 hours production.

This emergency storage feature simplified the system and was less expensive because it eliminated the need for lease and well shut-in equipment and production programmers, and permitted the substitution of three-way, two-position valves for three-way, three-position valves at separation station headers. On-hand tankage was available for storage, which minimized the cost of the system. Pumping water flood production, where

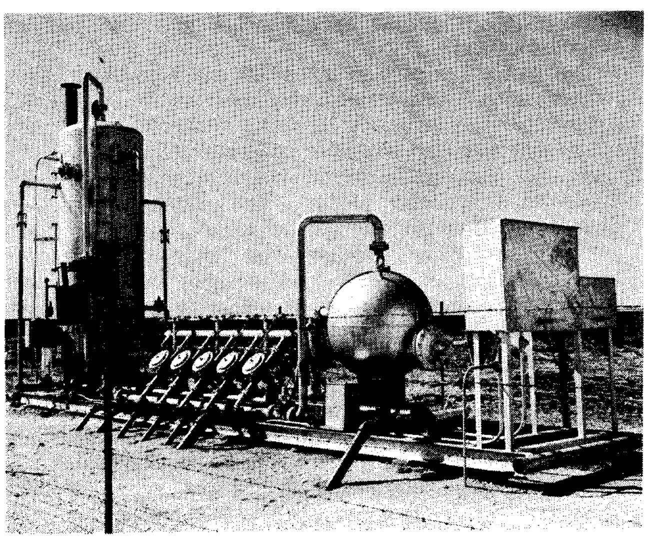


FIG. 7

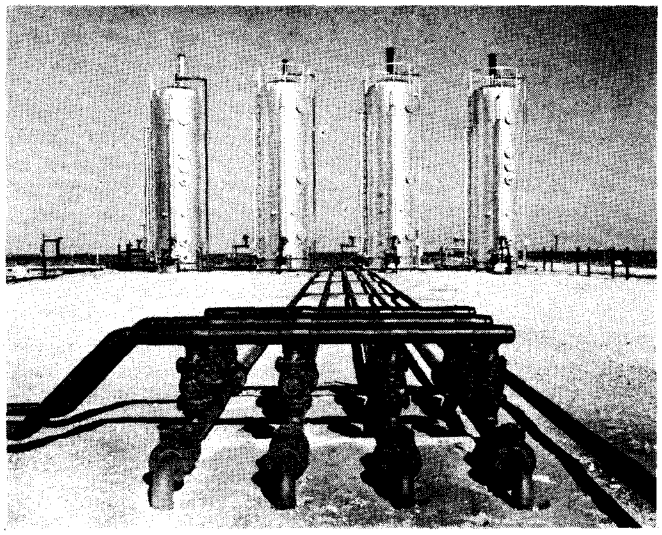


FIG. 8

wells produce 24 hours a day, can be handled satisfactorily by emergency storage; however, it is not feasible to handle intermittent flowing wells in this manner.

In this manner, production is routed from each well through individual lead lines to separation station headers. Separation stations are equipped with three-way, two-position routing valves, a test and a production header, a three phase metering test treater, spherical production separator, a test programming panel and data print recorder. All equipment is compactly mounted on a skid.

Test production is processed through the test treater which separates and meters the oil and water. Test gas is measured through an integrating orifice meter and then commingled with total produced gas and metered to sales. The data is recorded on the print recorder which records the well number, the date, the hour, the oil and water in barrels and the gas in MCF. This data is accumulated and recorded each hour. The test programmer is simplified so that wells can be tested only for equal periods of time; however, manual control switches are provided which permit special testing of wells. Fig. 7 shows a typical separation station.

Produced fluid from each station goes to a separate heater-treater at the central battery which is equipped with positive displacement (PD) meters for metering the oil and water production; see Fig. 8. A treater installation with PD meters is shown on Fig. 9. From the treater, the oil goes to a surge tank then through custody transfer metering equipment to prover tanks.

Meters

The oil and water meters at each treater record the total production of these fluids from each separation station, which gives the pumper a quick check on lease production. These meters are calibrated but are not compensated for temperature variation. Snap acting dump valves are installed upstream of the PD meters to stabilize rate of flow, which is necessary for accuracy. The surge tank is equipped with a ground level gauge and three float-switches.

The bottom float-switch is a low level controller which closes a motor valve and stops the flow of oil through the custody transfer meters. The intermediate switch opens the valve and permits flow through the metering equipment, and the top switch is a high level shut-down which operates a motor valve and diverts oil from the surge tank to emergency storage. An additional high level shut-down float is installed to divert the oil to emergency storage in event of failure of the gauging equipment. This valve is fail-safe and diverts to emergency storage when there is a power failure or any malfunction in the system.

A BS&W monitor is installed for quality control. This monitor is installed so that a side stream can be taken either from just beneath the pipe line connection or from the pipe line stream. It closes the pipe line valve when the BS&W content reaches a predetermined high and opens the valve when clean oil is available for the pipe line; thus, it prevents nonmerchantable oil from going to the pipe line.

A PD meter and a dump meter are used to meter the oil to the pipe line. Both types of meters were installed so that an evaluation of each can be made to determine which type is the more suitable. Fig. 10 shows the PD meter, the dump meter, and accessory custody transfer equipment. Both meters are skid mounted along with their accessory equipment.

The PD meter, strainer, deaerator, back-pressure valve, and master meter header are mounted on one skid. The meter is equipped with a temperature compensator, master cumulative counter, reset counter and ticket printer. A proportioning sampler, sample container and centrifugal pipe line pump are installed downstream of the PD meter skid. Oil from the surge tank flows through the strainer, deaerator, meter, back-pressure valve, and to the pipe line pump.

It is essential that no entrained gas go through the meter since it will register the same as oil and destroy the metering accuracy. For this reason, the deaerator is installed to remove entrained gas and the back-pressure valve is installed downstream of the meter to hold a back-pressure on the oil and prevent gas from breaking out.

The PD meter compensates for temperature automatically; however, gravity and BS&W must be determined, which is the reason for the sampler and sample container. To obtain the net oil through the meter, it is necessary to take the temperature compensated meter reading, multiply this by the meter factor and deduct for BS&W, which is determined in the usual manner from the oil in the sample container.

PD meters can be calibrated and adjusted to record net temperature compensated oil; however, the usual procedure is to calibrate and determine a factor which the meter reading must be multiplied by to determine net temperature compensated oil. PD meters wear and must

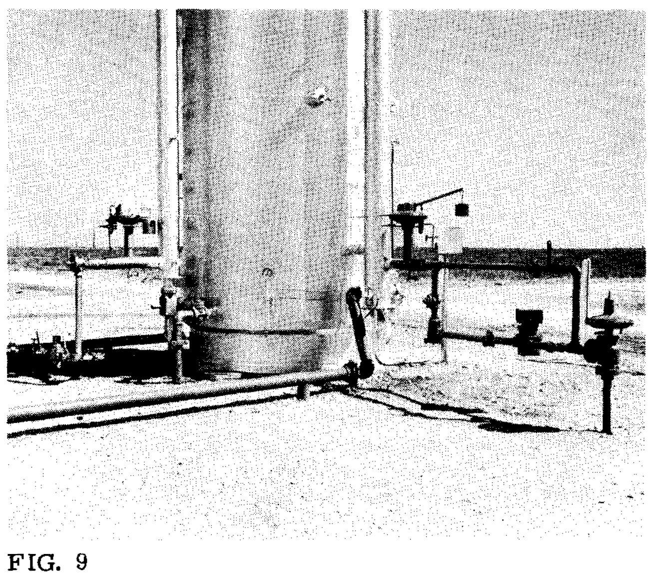


FIG. 9

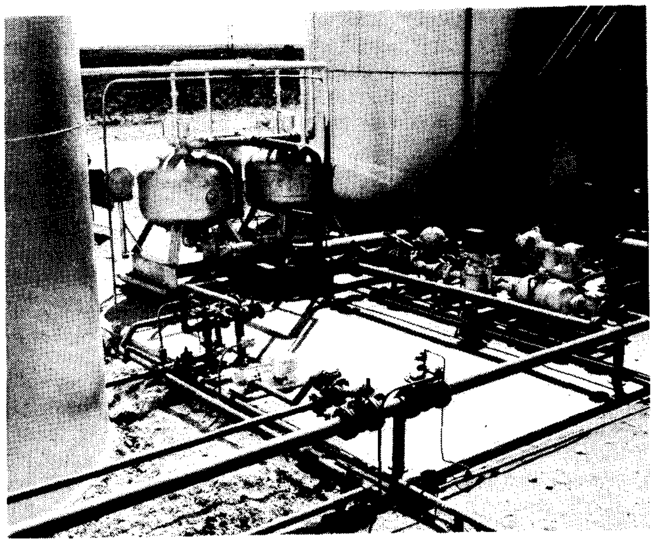


FIG. 10

be calibrated from time to time. This is a simple operation and can be done with either a master PD meter or prover vessel. In this installation, a master meter header was installed to facilitate calibration.

The PD and dump meters are installed so that they can be used separately or in series. The dump meter consists of two five barrel vessels, temperature compensator, unit counters for each vessel, and a master counter with ticket printer. Each vessel is equipped with a continuous temperature recorder for checking the temperature compensator. The metered oil is contained between a top and bottom valve in each vessel.

These valves are interlocked so that when a vessel is filling the dump valve cannot open until the vessel is filled and the fill valve has closed; conversely, when a vessel is dumping, the fill valve cannot open until all the oil has been dumped and the dump valve has closed.

The valving is interlocked between the two vessels so that only one vessel can be filling and one vessel dumping at the same time. Each vessel is accurately calibrated according to United States Bureau of Standards specifications. The master counter records net temperature compensated oil and requires only a correction for BS&W to arrive at net oil. The dump meter and accessories are pneumatically operated. Constant residue gas pressure is carried on the surge tank and the metering vessels to minimize flashing of gas.

The dump meter vessels are lined with baked-on plastic, which has prevented any accumulation of paraffin. The lines between the surge tank and pipe line pump are not plastic lined and paraffin accumulation has caused some problems, particularly in small lines and tubing. Plastic lining is planned and should solve this problem. The produced water is corrosive; for this reason, all water lines are plastic lined and cathodic protection equipment is installed at the treaters.

This battery has just been completed and proving of the custody transfer equipment is in progress. Proving is done in four 1,000 barrel stock tanks downstream from the pipe line pump. To date, sufficient data are not available to make a comparison or evaluation of the two meters.

CONCLUSION

A comparison of the projects discussed in this paper shows the rapid progress that has and is being made in developing suitable and reliable automation equipment. Lease automation is now generally accepted by the industry. Where properly applied to a suitable operation, the economic and conservation benefits are most gratifying.

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