Conroe Automation Project

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BRIEF HISTORY

Conroe Field

The Conroe Field contains 650 wells which produce primarily from the Cockfield and Main Conroe Sands. The Main Conroe Sand, encountered at about 5000 ft, yields an average oil production of 35,000 BPD. This field was discovered in 1932 and has a remaining life expectancy of more than 25 years. About 60 percent of the total wells are on gas lift. Gas production from the Cockfield zone plus oilwell residue gas from the Main Conroe Sand supply most of the gas lift gas. Two gasoline plants in the field gather the low pressure residue gas.

Getty Oil's Properties

Within the field, Getty Oil operates 10 leases that contain a total of 68 oil wells and 14 gas wells. In 1964, three ACT units were installed to serve all of these leases. During this first phase of modernization, tank storage and gauging were eliminated from each lease; but treating and separation facilities remained essentially unchanged.

In 1968, the second phase of this program was commenced to modernize existing facilities and install supervisory control equipment. This paper discusses how Getty Oil automated these leases under digital computer control. Figure 1 is a map of the Conroe Field which shows the leases automated and the location of all battery sites, remote terminal units and ACT units.

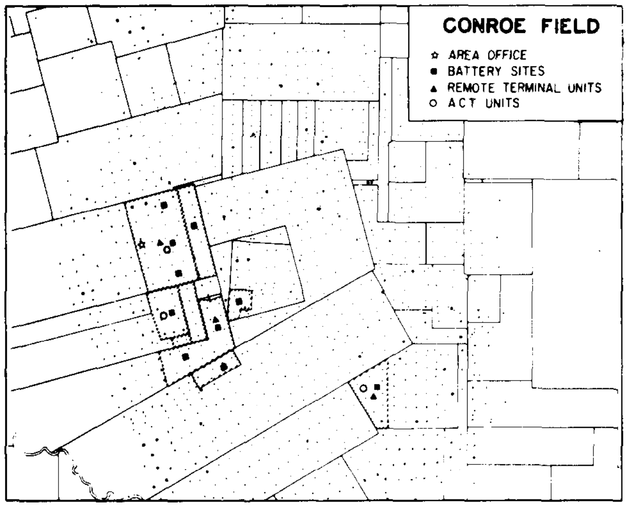

FIGURE 1

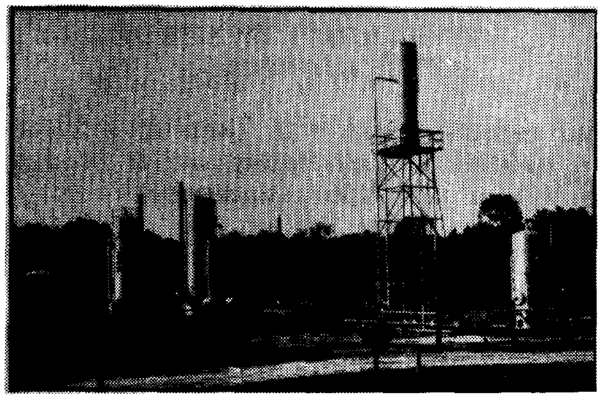

FIGURE 2
TYPICAL BATTERY SITE
BEFORE INSTALLATION

LEASE MODERNIZATION

A typical battery site in the Conroe Field before automation is shown in Fig. 2. Surface facilities consisted of a production manifold, gas lift manifold, two-phase production separator, two-phase test separator, heater treater and miscellaneous valves and meters. Water knockouts were installed at sites serving high water-cut wells. Well tests were conducted manually by measuring total fluid on test and determining water-cut with a sampler. Gas production was measured with orifice meters.

At the ACT sites, bad-oil-return heater treaters had been installed to treat nonsalable oil. All lease heater treaters were equipped with a one-barrel dump meter to measure lease production.

Gas processing facilities were located at five sites for several years and generally consisted of a production manifold, two-phase separator, dehydrator and orifice metering equipment. Three gas compressors were used to boost the pressure of the gas for use in the gas lift system.

During the second phase of modernization, most of the old surface facilities had to be replaced. A typical battery site after automation is shown in Fig. 3. The old two-phase separators were converted to sand traps with one being installed ahead of each three-phase production separator. New equipment that was installed at each battery site included: AWT production manifold, AWT gas lift manifold, three-phase production separator, three-phase test separator, time-sharing net oil detection unit, and electronic measuring and alarm detection equipment. A schematic drawing of an automated battery site is shown in Fig. 4.

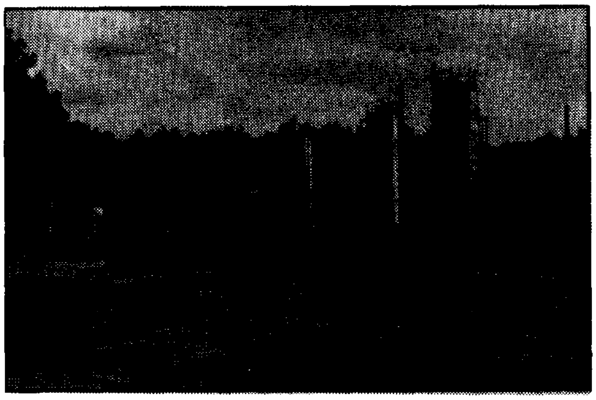

FIGURE 3
TYPICAL BATTERY SITE
AFTER AUTOMATION

Two variable chokes with electrical actuators were installed at each battery site to optimize each well on test. One variable choke was installed ahead of the gas lift gas manifold to regulate the volume of lift gas to any well on test. This is accomplished using a specially designed manifold. The second choke was installed ahead of the test separator to regulate total fluid production from the well. The choke size can be selected remotely in 1/64-in. increments for either choke. After selecting the best test based upon allowable rate, gas-oil ratio and gas lift ratio, fixed chokes are installed in the gas lift manifold and at the well head.

Gas measurement equipment was completely modernized at 59 measuring points. At 49 of these points, flow chart recorders were replaced with differential and static transmitters. Gas measurements are now being calculated and updated for these points every five minutes with a central computer. The total well test gas at each site is measured through a dual meter run. A local flow computer is used to calculate and totalize gas volumes across each dual meter run.

Five battery sites were consolidated at two locations. Testing and treating facilities are now present at ten sites. Treating facilities will be consolidated to only three sites in the near future by a further reduction in the number of lease heater treaters.

Three ACT units are geographically located to serve all ten battery sites. Each ACT facility includes 500 barrels of working storage and one bad-oil heater treater. Except for instrumentation, these facilities remained unchanged during the second phase of modernization.

INSTRUMENTATION

This system was designed to reduce operating labor to a minimum and to optimize operations at all possible locations. About 925 points were selected to be either monitored or controlled. The following instrumentation was selected at each battery site.

Manifolds

Production and gas lift gas manifolds were equipped with three-way two-position pneumatic operated valves. Two-way micro switches were installed to indicate valve position (test or production). These valves are operated with 110V AC solenoids and 30 psi supply-gas pressure. The production manifold uses 2-in valves and the gas lift manifold is equipped with 1-in. valves.

Separators

Three-phase production and test separators are each equipped with a high liquid level detector to indicate liquid carryover. Also, a low-low level switch is installed on the oil dump switch of each separator to prevent gas discharge into the oil line. This feature improves metering accuracy and prevents damage to the P.D. meter at the net oil detection unit. Total gas from the test separator is measured through a dual meter run using a local flow computer.

Net Oil Detector

The oil dump valves for the production and test separators are located on the NOD skid. These valves are equipped with two-way switches to indicate valve position (open or closed). The status of these valves is monitored frequently by the computer to make sure that only one valve is open at a time. The NOD unit displays locally the net oil, net water and total water for the lease and individual well tests. Test volumes are auto-

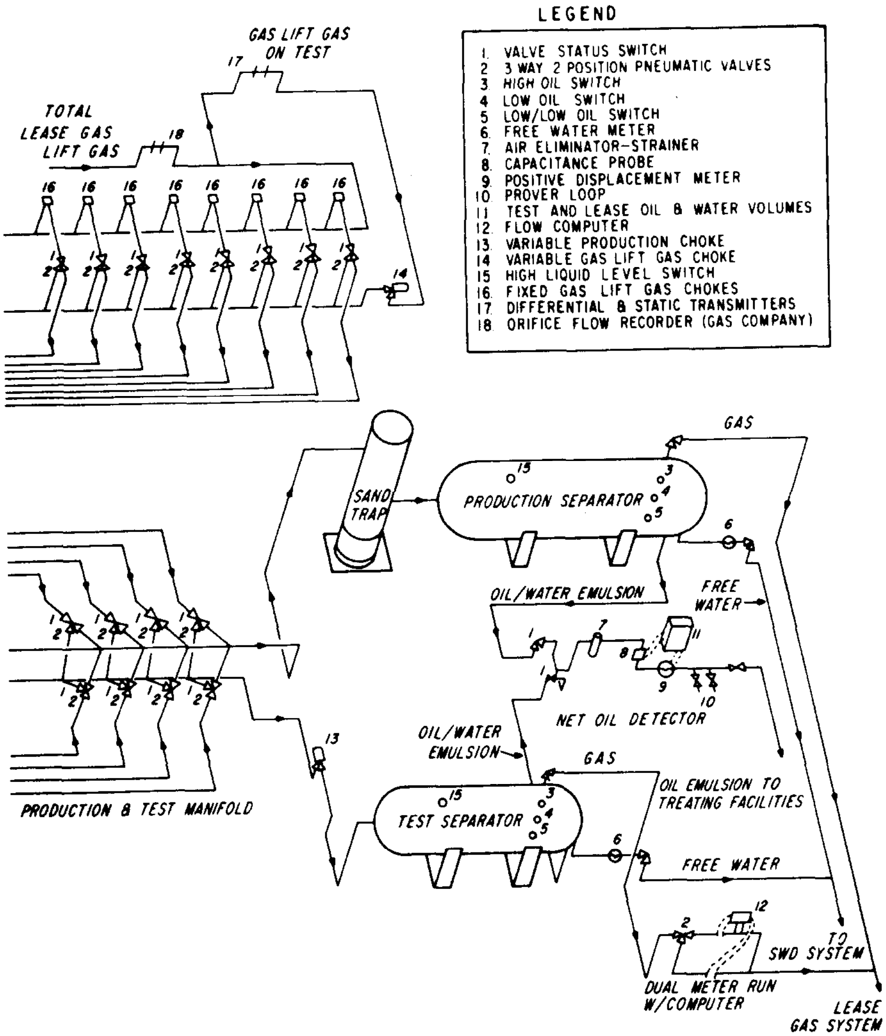

FIGURE 4
SCHEMATIC OF AUTOMATED BATTERY SITE

matically added to the lease counters. Total fluid is measured with a positive displacement meter. The capacitance probe is electronically calibrated for linearity up to 67 percent water-cut. The central computer continuously monitors all NOD units for oil and water volumes and notifies the area office when the water-cut limit is exceeded at any unit.

Treating Facilities

The central heater treaters are equipped with temperature probes. The central computer reads the temperature of each treater every five minutes and outputs an alarm based upon predetermined limits. The temperature can be read out upon request at the area office.

ACT Facilities

These facilities are monitored for bad-oil diverting, working storage tank levels, sales volumes and on/off status of ACT units. The computer outputs a message to the area office for any equipment malfunctions.

Gas Processing Facilities

Gas well gas is measured with differential and static transmitters. The central computer calculates all gas volumes every five minutes. For meters out of service, the computer automatically updates cumulative volumes based upon the previous 24-hour rate. Condensate volumes are measured for each lease and transmitted at 10 pulses per barrel to the remote terminal unit.

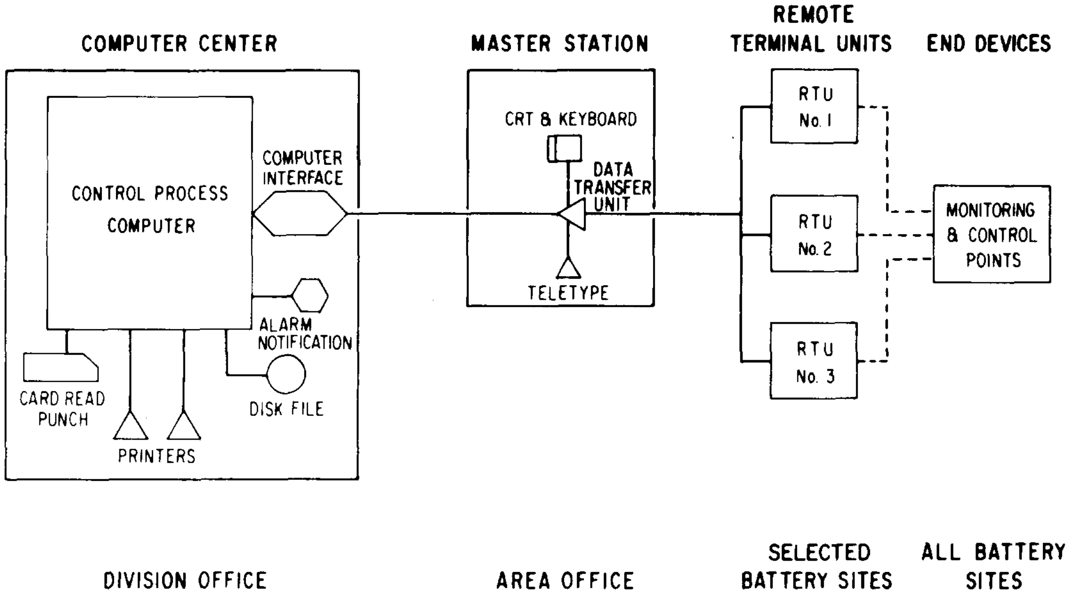

FIGURE 5
SUPERVISORY CONTROL SYSTEM

Compressor Facilities

Three compressors are operated in the field to boost low pressure gas well gas for use as gas lift gas. Two static transmitters have been installed at each compressor site to monitor high/low suction and discharge pressures and on/off status.

SUPERVISORY CONTROL SYSTEM

The central computer that monitors and controls the project is located in Houston, 40 miles away. The computer communicates via a voice grade telephone circuit at 600 bits per second with three remote terminal units (RTU) and one data transfer unit (DTU). The DTU in turn drives one cathode ray tube (CRT) and one teletype (TTY). A schematic of the communication system is shown in Fig. 5.

The three RTU's are geographically located to serve all ten battery sites and are connected to various end devices with direct burial cable. The computer supervises all status/alarm, A/D, accumulator and control points by communicating with the RTU's. Figure 6 shows the RTU hardware.

The central computer serves as a programmable master for this system. The computer configuration consists of: one central processor with 16K of core, two disk drives, two typewriters, and one card read-punch machine.

Software programs have been written and stored on disk to: poll the DTU and RTU's; run standard and optimized well tests; report status changes and alarms; read accumulators and analog to digital points; calculate gas volumes; run limit checks on data and generate comparative alarms; and output daily and monthly reports. Each program is called into core from disk on a scheduled time interval based upon assigned priority levels. All programs operate automatically and are independent of the operator demand requests.

At the area office, the operator may request certain information or initiate specific action through the keyboard of the CRT. The operator may initiate or terminate well tests; monitor any test; read temperatures, pressures, volumes, tank levels and current alarms; update data and limit check tables; and change well test parameters. Operator-demand requests can be printed out on either the CRT or teletype. Figure 7 shows the CRT and teletype at the area office.

MAIN OPERATIONAL FEATURES

The computer uses more than 100 mainline programs and 75 subprograms to supervise the project. The four major features of the system are: (1) Well Testing, (2) Gas and Liquid Measurement, (3) Alarms and (4) Reporting.

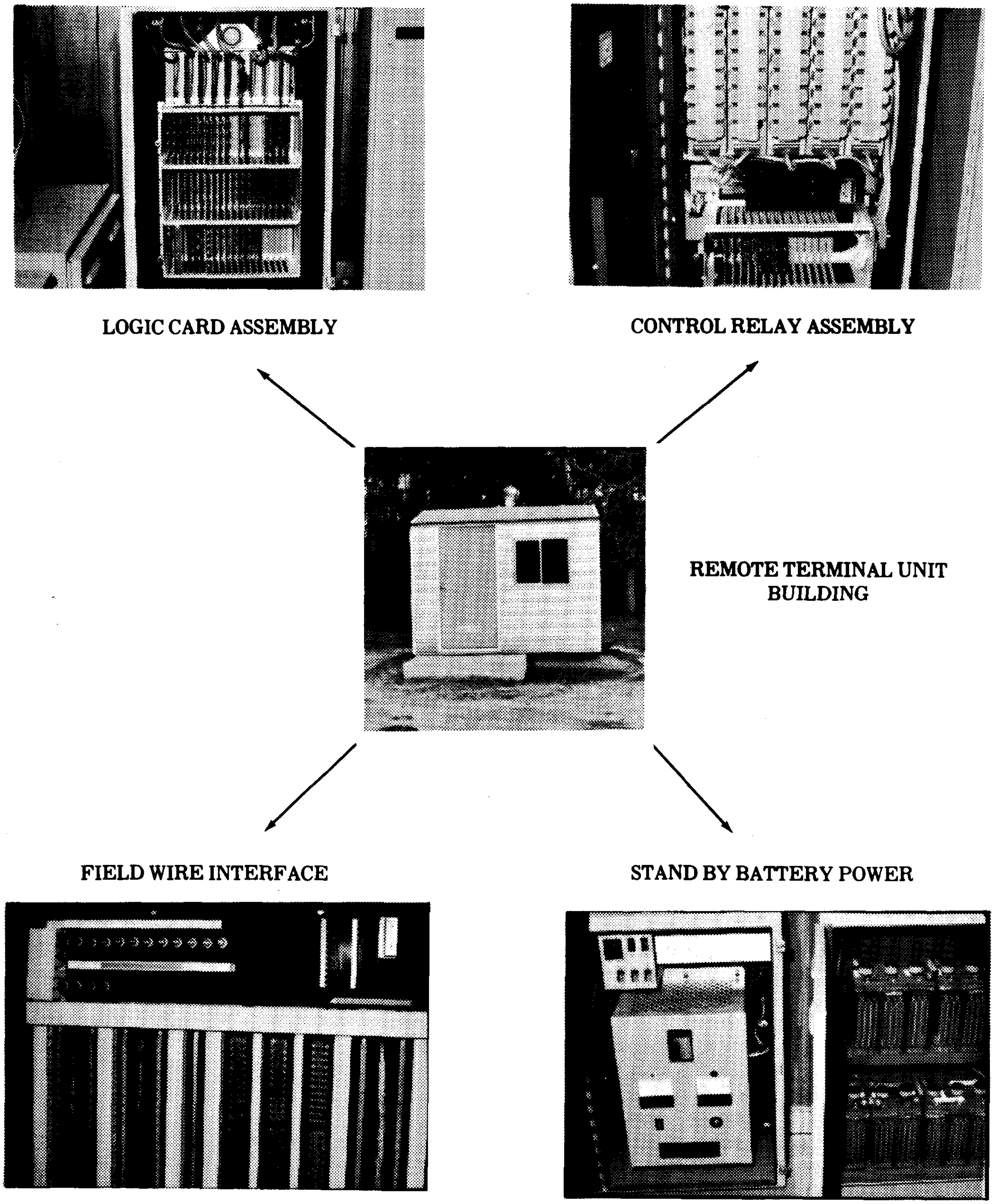

FIGURE 6
REMOTE TERMINAL UNIT

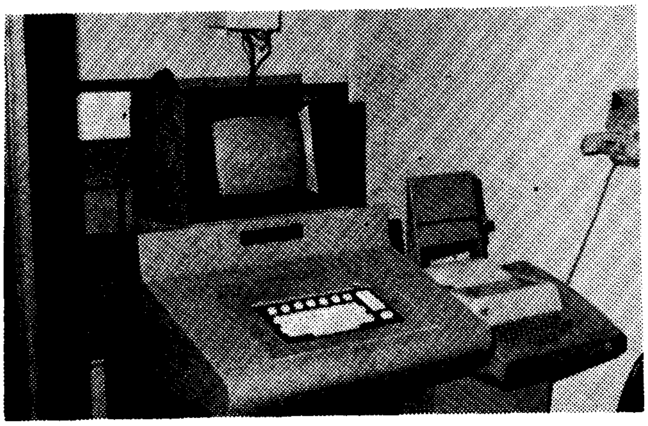

FIGURE 7
CATHODE RAY TUBE
AND TELETYPE

Well Testing

A well can be tested in regular sequence; out of sequence, such as a "one shot" test; and as an optimized test. For each well, test data may be varied for purge time, test time and for the size of gas lift gas and production chokes. All tests are monitored by the computer for acceptable production rates, gas-oil ratios and gas lift ratios. If the limit of any one parameter is exceeded, the area office is requested to retest. Up to five optimized tests can be run in sequence on one well with different choke settings. Four tests are maintained on file for each well: (1) initial, (2) optimized, (3) last accepted and (4) current.

Gas and Liquid Measurement

Each gas flow rate that is calculated by the central computer can be displayed. In addition, the following data can be shown for each gas measurement point: differential and static pressures, gas measurement constants and factors, meter run size, orifice plate size, and meter status, in or out of service. The program automatically updates cumulative volumes after a meter is returned to service. The computer monitors each point for over or underranging of each D/P and static valve. An alarm is printed out when a measuring point needs to be serviced. All oil, water and condensate volumes are accumulated at the remote terminal units as 10 pulses per barrel. In addition, the total gas on test from each battery site is stored as 100 pulses per MCF. Accumulators are read by the central computer every 45 minutes.

Alarms

This system recognizes two types of alarms. Hardware alarms are detected by a change in status of an electromechanical device; whereas, comparative alarms are generated from software checks on data limits. Both types of alarms are effective in monitoring system performance. Critical alarms are routed to an answering service during the time the field employees are off duty.

Reporting

Daily and monthly reports are automatically output at the area office. Daily reports consist of gas and oil production by well and lease, ACT unit sales, salt water disposal and condensate readings, surge tank levels, and summary of wells tested during the last 24 hours. Monthly reports show the same information with the exception of the well test summary.

Results of Testing

Since May, 1971, the supervisory control system uptime has exceeded 98 per cent of the total operating time. This includes downtime in the computer center, communication circuit and with the input and output devices at the area office. The accuracy of data recorded has generally been as follows:

1. Liquid levels: $\pm$ 1/8 in. (0-16 ft)
2. Static Pressures: $\pm$ 7 psi. (0-750 psi)
3. Differential Pressures: +-0.5 in. (0-100 in.)
4. Temperatures: $\pm$ 1^{o} F (0-160^{o} F)
5. A/D Conversion: $\pm$ 0.5% (0-100%)
6. Choke Settings: $\pm$ 1/64 in. (0-64/64 in.)
7. Accumulators: $\pm$ 0.1% (0-32,768 pulses)

The above accuracies are acceptable for the applications described herein. Additional field tests are now being made to further evaluate problems associated with gas measurement. As with most supervisory control systems, the major problems are associated with obtaining accurate and reliable measurements from all end devices.

BENEFITS

The monetary benefits from this system are now under study. The benefits ultimately expected include: (1) optimizing production, (2) better utilization of company labor, (3) less contract labor, (4) reduced treating costs, (5) reduced gas lift gas requirements, (6) savings in fuel gas and (7) fewer material replacements.

ECONOMICS

Getty Oil and the joint interest owners have invested \$750,000 in this project. About 50 percent of this investment was for modernization of surface facilities. The project is expected to pay out and provide a reasonable rate of return on the total investment.

ACKNOWLEDGMENT

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