Automation of Pipeline Operation

By CHARLES N. SMITH
Phillips Pipe Line Company

INTRODUCTION

The problem of increasing profits by decreasing cost has forced many innovations in all sections of the petroleum industry. The automation of its operations has been and will continue to be the major item in reducing cost.

Automation means many things to each person, and there has been numerous papers presented covering each phase of automatic equipment. This presentation will be a general description of what one pipeline company has accomplished in its operations through the use of automatic equipment.

DESCRIPTION OF OPERATION

The operations start with the gathering of crude oil in Ector and Andrews counties. The various types of crude is segregated and tanked at our terminal south of Goldsmith. The crude is then pumped in batches to either our refineries at Borger or Kansas City. The mainline is composed of two pipelines; one pumping natural gas liquids and the other crude oil.

Automation in our gathering system has been limited to consolidating and installing automatic equipment on our field pump units. All of our automatic pump units are operated electrically. The units are started and stopped by use of two float switches, installed on a volume tank. This assures the unit running to be supplied with oil at all times and reduces maintenance costs from excessive wear in the piston and liner area due to positive displacement pumps running dry. A pressure switch is used to protect the pipeline from excessively high pressure and it will hold the pump out of service only as long as the pressure is excessive. The unit will restart when line pressure drops below a predetermined pressure. Each pump unit has to be treated individually due to the different locations in the field and operating conditions. We have some locations where two P. D. pump units operate in parallel. The second pump is controlled from the holding coil of the No. 1 unit's starter and a pressure switch on the suction header or volume tank. Then, shut down of both units is actuated by the low float.

Who knows what future development will bring to the field gathering systems? The installation of ACT units has increased the demand for better cooperation between the producing and pipeline companies. New developments in metering, B. S. & W. monitors, telemetering equipment, will have a definite effect on this type of operation. In the future, field gathering systems might be operated from a central control point where all measurements, run tickets, etc., are recorded and written automatically.

Our terminal for this area south of Goldsmith is operated manually at the present time. The economics and varied operations have dictated this practice. We can receive different grades of oil from three different pipeline companies, while delivering oil to two pipeline companies, and pump oil into our own trunk line system. The oil received or pumped to other companies is metered through a P.D. type unit. The segregated oil pumped into our own trunk line system is in batches, varying from 30,000 to 100,000 barrels. We have four pump stations automatically controlled from a dispatch office in our Odessa office. Each station has two 935 HP gas engines on the crude oil pipe line and two 300 HP gas engines on the N.G.L. pipeline. All pumps are of the centrifugal type.

An all electronic, digital, pulse-code telemetering control system is used for controlling and monitoring each station. The control system operates on a four-wire, full-wave, duplex-voice grade leased telephone circuit and provides for continuous scanning made with automatic interrupt for voice communication and point command.

The control system provides for the following operation controls:

(1) Push buttons for station address and device selection.
(2) Rotary selectors for station address, command functions and digital display lamp testing.
(3) Push buttons for RPM and command message actuates.

(4) Push buttons for alarm and status reset.
(5) Push buttons for lamp test.

The digital message structure is a combination of three following types of coding:

(1) Station address and status command uses the 2/5 code.
(2) Status data is the unitary code.
(3) Quantitative data use the BCD code.

Digital message security is built into this system, in that the control to remote command is a bit by bit and message length comparison. The remote to central checks only the message length. Figure 1 shows a typical message structure and codes for this system.

MESSAGE STRUCTURE

REMOTE TO CENTRAL

MESSAGE 2 STATUS

U	U	U	U	U	U	BCD	BCD	2/5	2/5
STATUS						ZERO		IDENTITY	

MESSAGE 1 CRUDE PRESSURES

BCD	BCD	BCD	BCD	BCD	BCD	BCD	BCD	2/5	2/5
SUCTION			DISCHARGE				"O"	IDENT.	

MESSAGE 3 NGL PRESSURES

BCD	BCD	BCD	BCD	BCD	BCD	BCD	BCD	2/5	2/5
SUCTION			DISCHARGE				"O"	IDENT.	

MESSAGE 4 FLOW RATE

BCD	BCD	BCD	BCD	BCD	BCD	BCD	BCD	2/5	2/5
HOBBS			STATION				"O"	IDENT.	

MESSAGE 5 RPM

BCD	BCD	BCD	BCD	BCD	BCD	BCD	BCD	2/5	2/5
RPM			ZERO					IDENT.	

CENTRAL TO REMOTE

2/5	2/5	/////	2/5	2/5	2/5	2/5
ADD.	ADD. RPT.		COMMAND		COMMAND RPT	

FIG. 1

Different carrier frequencies are used. The central to remote is 2340 cps and the remote to central is 1860 cps with a frequency shift deviation of + 120 cps. The bit code rate is 80 cps.

The central station controls and monitors the operation of each engine at the remote station. Console lamp-displays indicate the operational status of these engines. The central station also controls the remote discharge pressure set point. The set point can be increased or decreased in increments of 10 or 100 psi. Other console controls are NGL units crash shut down, crude units crash shut down and for telephone calls.

In addition to controlling functions, the system monitors crude oil and NGL suction pressures from 000 to 999 psi, and crude oil and NGL discharge pressures from 000 to 1500 psi. Flow rate is monitored at all remote stations with a range of 000 to 1500 barrels per hour capability. In addition, the RPM select switch allows the RPM of any one of the remote engines to be monitored upon request. Pressure, flow-rate and RPM values are read out on command from the central station.

Means are also provided for automatically monitoring fire, air pressure failure, power failure, air failure, starting air, lockout, mechanical failure, hazardous atmosphere, and exhaust temperature on the two crude oil units.

The engines are started and stopped from the central control room, with provisions for starting and stopping locally. A crude oil unit may be started by pushing either the idle or run pushbutton. An idle initiated start differs from a run initiated start only in the fact that the unit will continue to run at idle speed indefinitely when started on idle. A run initiated start will automatically allow the engine to be transferred to instrument speed control and come up to run speed after five minutes, when the warm-up timer times out.

Initiating of a start will:

(1) Open suction valve (approx. 40 seconds).
(2) Start auxiliary lube oil pump.
(3) Start vacuum pump.
(4) At the end of a 40 second period with suction valve open and sufficient lube oil pressure, the fuel valve will then open and vibration holdout switch coil will become energized. At the same time, the cranking timer energizes to being a unit crank.
(5) When the engine starts, the idle relay energizes by virtue of the air output from the pneumatic speed transmitter operating a pressure switch set at 10.2 psi. The idle relay disengages the air starter, the lube oil jacket water protec-

tion holdout timer begins its timing cycle (30 seconds) and the engine warm-up timer starts its 5-minute timing cycle. The cranking timer continues to time out (25 seconds) after the engine starts and its conclusion sets up a circuit by which the speed changes control can be initiated at the end of the warm-up timing cycle.

(6) If the engine fails to start, timing out of the cranking timer will:
   (a) disengage the air starter.
   (b) close fuel valve.
   (c) close suction valve.
   (d) automatically push stop button, putting all circuitry in a normal stop status preparatory to the issuing of another start order.
   (e) lube oil auxiliary pump and vacuum pump will continue to run for three minutes and then shut down.

(7) With the engine now running as indicated in (5) above, the lube oil-jacket water hold out timer will time out in 30 seconds after the engine reaches idle speed. This disengages the vibration holdout coil and puts vibration (engine) protection in the shut down circuit. Pump vibration protection is in the protective circuit all during starting. The low lube oil pressure and high jacket water protection are now inserted in the protective circuit. The auxiliary lube oil pump is now turned off.

(8) The warm-up timer times out after 5 minutes. Locally, this timer can be bypassed by pushing the warm-up overriding push button. The warm-up timer times out, it resets the cranking timer circuit. This timer also activates the speed change relay which in conjunction with the idle run relay will, together, allow the engine to transfer to the instrument speed controls and speed up to run speed providing the idle run relay is in the "run" position. Otherwise, the unit will continue to run at idle speed until "run" pushbutton is pushed.

The crude line units are normally stopped by the central control operator. Initiation of a normal stop will initiate the cool-down time. The stop relay will begin to bleed the instrument control air from the engine controls, bringing the engine back to idle speed. At the conclusion of the 5-minute cool-down cycle, this timer will: (1) close fuel valve; (2) close suction valve; (3) disconnect lube oil and jacket water protection immediately; (4) vacuum pump will continue to run for three minutes; (5) start auxiliary lube oil pump which will run for three minutes and shut down.

The unit emergency shutdown with lock out (mechanical failure) will be initiated by one of the following protective devices:

(1) Low engine lube oil pressure.
(2) High jacket water temperature.
(3) High lube oil temperature.
(4) Low water pressure.
(5) Pump seal failure.
(6) Engine overspeed.
(7) Excess engine or pump vibration.
(8) High bearing temperature (pump or gear increaser).
(9) Loss of vacuum.

An immediate crash shut down (no cool-down period) will close the fuel valve, stopping the engine. The engine will lock out and another start cannot be initiated until the attendant goes to the station to correct the trouble and pushes the unit reset button. The shut down chain of events will follow the same pattern as those described in a normal shut down with the exception of the fact that the normal cool-down cycle is by-passed and the unit stops almost immediately.

The line shut down without lock-out, is initiated by low suction or high discharge pressure. A shut down due to high discharge pressure will crash stop all running units on the line by closing fuel valves immediately followed by the normal chain of events in a no cool-down time shut down. A low shut down due to low suction pressure will first crash stop one unit (in event two units are running) by immediately closing the fuel valve followed by the normal chain of events. If, before 7 seconds, this abnormally low pressure condition ceases, the second unit will continue to run normally. However, should the low line pressure persist in excess of 7 seconds, the second unit will then crash stop.

Line emergency shut down of units may be manually initiated. Should a condition occur whereby the dispatcher determines that the units on a line should be shut down immediately, he may push the line emergency shut down, which will immediately shut down (no cool-down cycle) all units on that line, but this will not lock them out.

In the event of instrument air pressure failure, the running units will shut down as a normal stop.

The station emergency shut down will be initiated in the event of: (1) fire; (2) a hazardous atmosphere in the pump rooms; and (3) actuation of the electrical emergency shut down. The running units will be crash shut down and all station units will be locked out.

The vacuum pump failure will be initiated if the crank case drops below one inch of water. The stop will be a normal shut down.

Starting and stopping of the NGL units is very similar to the crude units. The major difference is that the NGL units can only be started by pushing the idle button and these units do not have the auxiliary lube oil or vacuum pumps.

We have the normal maintenance problems with our engines and pumps. The major trouble is keeping the pneumatic and electrical circuits calibrated. For instance, the pneumatic speed control operates between three and 15 psi. This represents a speed range in the crude units of from 0 to 475 RPM. The electrical range of the control is from 4 to 20 milliampere flowing through a 250 ohm resistor. This is the range of all data quantity measurements in the control system. You can readily see the extreme care needed in this type of maintenance.

The major problem the pipe line companies face is maintaining the flow of oil to the refineries. This flow is important as to the type of crude oil, the amount, and time of delivery into the refinery storage. This develops into quite a problem when the refineries are 300 to 1000 miles away from the source of oil in the West Texas area.

We know that the automation of pipe line operations is still in the infant stage. The possibility of complete automatic controls from the producing property, through the crude pipe line, the refineries, the products pipe line to the customer by computers will be a reality in the near future.

ACKNOWLEDGE

The author wishes to express appreciation to Phillips Pipe Line Company for permission to prepare and publish this paper and to the many employees for their time and assistance.