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REPORT No. 10 Period 1 October to 15 October 1955

SUBJECT: Haines-Fairbanks Product Pipeline -- Station control equipment

SUMMARY:

1. The writer makes a detailed study of the control systems used at the pumping stations on the Haines-Fairbanks pipeline and reports these controls to be unsafe and unsatisfactory. Design changes are reccommended and suggestions are offered for guidance of the designer.

ANALYSIS:

2. The control system installed at the Haines pumping station has never operated satisfactorily. During the past week the writer has had an opportunity to examine the design installation and performance of this system. The following paragraphs contain a description of the survey, analysis of the findings, and reccommendations for corrective action.

3. Before we start a study of any particular control system we must understand what constitutes an ideal control system for the particular process which is to be controlled. We must fully understand the requirements of the process before we attempt to determine the merits of the control system that has been provided.

4. There are six basic requirments for a pipeline pump station control system which may be described as follows:

(a) The maximum engine speed must not be allowed to exceed the safe limit for the engine.

(b) The minimum engine speed must not be allowed to drop to the stalling point for the engine.

(c) The speed of the engine (and pipeline pump) must be modulated to prevent the pump discharge pressure from exceeding the safe maximum working pressure of the pipe and fittings in the pipeline.

(d) The speed of the engine must be modulated to prevent the minimum pump suction pressure from dropping below the flash point or vaporization point of the liquid being pumped.

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(e) The speed of response of the pneumatic control elements must be very rapid. Three to five seconds response is required to properly cope with normal pipeline upset conditions.

(f) Manual control means.
Some means must be provided to shift from Automatic Control of the engine to manual control, for engine warm-up and other purposes.

5. The six features noted above refer to the normal modulating control system. However, in addition to the regular control system we must have a number of emergency features which will accomplish a shut-down of the pump and engine in case of a failure of any part of our normal control equipment. In case of such failure we must provide most positive and reliable means to stop the pumping process to prevent damage to our pipeline or engine.

6. There are a number of features in the emergency shut-down group. The following list constitutes the proper items in this catagory for the Haines pumping station:

(a) High speed cut-out for the engine.
This device must provide positive and reliable means to force the fuel rack to the closed position in case of failure of the engine speed governor. This device will probably be set to trip at 900 RPM.

(b) High discharge line pressure shut-down.
A mercoid pressure switch is usually used for this purpose. The set point at Haines Station should be for maximum pressure of 1300 psi.

(c) Low suction line pressure shut-down.
This mercoid pressure switch should be set at 5 psi. minimum.

(d) Low engine oil pressure shut-down.
This pressure switch should be set somewhere below the normal oil pressure level.

(e) High engine jacket water shut-down.
This thermal switch should be set somewhere above the normal jacket water temperature level.

(f) Instrument air failure shut-down.
Proper "fail safe" design will provide for automatic elosing of the fuel rack on instrument air supply failure. However, a pressure switch may be provided to give a warning signal instrument air supply pressure drops below 40 psi.

(g) Electric power failure shut-down.
Proper "fail safe" design will provide for engine shut-down when the coil in the emergency air valve is de-energized by power failure.

(h) Explosive mixture shut-down.
A mine safety device located in the pump room should signal for a shut-down in case the atmosphere in the pump room reaches a condition that will support combustion.

(i) Push button shut-down.
At least two "STOP" buttons should be provided for manually breaking the circuit to de-energize the emergency air valve coil to stop the engine. One switch located at the engine and one or more located at a remote point.

7. As stated above the writer examined the design and performance characteristics of the control system at the Haines station. I wish to report that I ran into design trouble before I could get started on the examination. In order to check the performance of a pnuematic control system one must be able to observe the pressure level of the output signal from each separate control element in the system. The response rate and range from each transmitter, controller and relay must be noted and checked by observing air pressure changes on properly located pressure gauges. No such air pressure gauges were located on such vital points as the main output signal from the dual pressure controller and the fuel rack actuator diaphragm. No pressure gauges were installed at the vital points nor were any "tee" outlets available where a pressure gauge could be installed.

8. It was necessary, therefore, to change the air piping fittings and install several pressure gauges on both air supply points as well as output signals before the performance check could be started. In 35 years of experience with pnuematic controls I have never seen such poor installation practice.

9. The suction and discharge controllers were checked o.k. up to the point where the control signal was delivered to the engine room. The pressure transmitters, the receiver-controllers, the 1:1 combining relay and the inverse derivitive relay were all observed to perform satisfactorily. However, the performance of the diaphragm motor which functions as a fuel rack actuator was found very unsatisfactory.

10. The standard diaphragm motor is constructed in such a way to provide a full travel stroke with air pressure change of approximately 3 to 15 psi. The standard positioner unit functions as a booster relay; if booster service is necessary to overcome spring histeresis and reduction of effective area of the diaphragm. The diaphragm motor used at Haines takes a full travel stroke with a pressure change of 4 to 8 psi. The positioner unit acts to suppress the controller signal instead of magnifying it.

11. The attachment of the actuator stem to the fuel rack lever is normally made with a positive acting over-ride force in one direction and a free-parting non-force return. The Haines station actuator applies a spring force on the return stroke which opposes and interferes with the normal operation of the mechanical fly-ball governor.

12. The pnuematic relay which the designer specified in this control

system for the purpose of biasing the control signal and syncranizing the engine speeds is classed by this writer as worse than useless. As presently operated it serves no useful purpose. It does, however, add considerable confusion to the control system.

13. There is nothing right about the pnuematic control equipment which is attached to the engines in the Haines station. The biasing relay is a useless element. The positioner unit is improperly adjusted. The diaphragm motor has improper spring characteristics, the actuator stem has improper attachment to the fuel rack lever and the idea of applying the pnuematic control force directly to the fuel rack lever is wrong in principle.

14. This control system would work perfectly if a properly constructed diaphragm motor was installed in such a way to change the tension in the speeder spring on the mechanical fly-ball governor through the range from idle speed setting of 450 RPM to full speed setting of 750 RPM. On the other hand the writer believes that no amount of work on the present design can result in fully satisfactory control.

15. The above comments cover my observations and conclusions on the modulating section of the control system. We shall now proceed with a report on observations and conclusions resulting from a study of the emergency shut-down facilities.

16. The emergency shut-down device which is furnished by the engine manufacturer consists of a pnuematic cylinder and a solenoid operated air valve. The cylinder contains a free piston with a piston rod. The piston rod projects from one end of the piston and makes a butting contact with the engine fuel rack lever. When the coil on the solenoid valve is energized the valve opens and air is allowed to flow into the cylinder and force the piston and piston rod out to contact the fuel rack lever and force the fuel rack to close. When the solenoid coil is de-energized the valve closes the air supply port and opens the cylinder bleed port, freeing the piston and allowing the fuel rack to move toward the open position. When a shut-down signal is transmitted to this device both electric power and air supply must be available to make it operate.

17. The above device does not qualify as reliable and dependable, since failure of either electric power or air supply would render it inoperative. This device can not be classed in the "fail safe" category since failure of either electric power or air supply would leave the engine with no emergency protection. This device can be made reliable and dependable by making a slight change in design.

18. A free-moving over-riding lever should be attached to the engine fuel rack shaft which will contact the fixed fuel rack lever and force it to move to the closed position. The over-riding lever should be loaded with either a dead weight or spring which will provide sufficient force to positively close the fuel rack.

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19. The pnuematic piston, referred to above, should be rearranged to a position which allows the piston rod to contact the free lever and oppose the force of the dead weight or spring and hold the free lever away from the fixed fuel rack lever when air supply is admitted to the cylinder.

20. The electric circuits and the solenoid air valve should be arranged to provide for an energized coil and an open air supply valve all the time when the system is operating under normal conditions. On the other hand, any emergency signal will cause the coil to be de-energized, which in turn closes the air supply valve and bleeds the air pressure from the pnuematic cylinder. This action, of course, releases the force of the weight or spring and allows the over-riding lever to contact the fixed lever, and close the engine fuel rack. Electric power failure will naturally de-energize the coil and release the over-riding forces. Air failure will also result in closure of the fuel rack due to the "fail safe" nature of the design.

21. It must be noted that the coil in the emergency air valve is energized all the time the engine is in operation. This condition calls for a heavy duty coil designed for continuous service. I understand that a low voltage circuit has been provided for use in all the electro-magnetic elements in the station.

22. The engine overspeed cut-out is the first item in the above list of the various features which should signal for an emergency shut-down. Present design provides for closing a circuit and energizing the coil in an air valve which causes the valve to open. The design should be changed to provide for opening the circuit and closing the air supply valve for the over-speed emergency shut-down.

23. Both the high discharge line pressure switch and the low suction line pressure switch now sends a signal to dump the air load on the diaphragm motor. This signal should dump the air from the emergency shut-down cylinder in the new design which I have proposed.

24. Both low engine oil pressure and high engine jacket water temperature should cause the coil to be de-energized and dump the air from the emergency shut-down cylinder.

25. Failure of the instrument supply air compressor should cause a warning light and buzzer to operate from a pressure switch set at 40 psi. This pressure switch was erroneously attached to output air signal line from the pressure controllers by the constructors of the Haines station. It should be attached to the air supply system. Complete failure of air supply will automatically cause engine shut-down in the proposed revised design.

26. Electric power failure in the present design dows not shut the engine down. In the correct design, power failure de-energizes the emergency air valve and shuts the engine down.

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27. No device is presently provided to shut the engine down when the atmosphere in the pump room becomes an explosive mixture. Good design demands such a device for proper protection of both property and personnel.

28. Present push button stop means are not positive and dependable because they depend on both electric power and air supply for operation. This feature should be redesigned to conform to "fail safe" practice described above.

29. The people who furnished the Chicago Pnuematic engines for the Haines station are prepared to furnish one diaphragm motor with suitable bracket fittings for mounting on one of the engines in this station to re-position the setting of the governor speeder spring. The operators of the Haines station plan to make this change, and other changes in the control system for one engine, to conform to the design plans described above. If this trial unit works out to the satisfaction of all concerned then further steps can be taken later to re-design other units here and at other points up the line.

30. The writer hopes to be able to help revise the control equipment on the trial unit. I feel sure that the new design will result in safe and satisfactory automatic operation. I feel equally sure that nothing but unsafe and unsatisfactory operation will result from use of the present equipment.

31. While the conditions described in this report have reference to the Haines station only, it is a well known fact the design used at Haines is generally the same as that used at the other pumping stations. Therefore we can safely assume that if changes are indicated at Haines, the same changes will be needed at all stations.

RECOMMENDATIONS:

32. I recommend that all pumping stations on the Haines-Fairbanks pipeline be equipped with safe automatic control systems redesigned along the lines suggested in this report.

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