Optimizing Process Control and Data Systems

Teamwork is necessary for any plant to operate at its optimum; maintenance, operations, and engineering must work together.

L.A. Pebworth
Farmland Industries, Inc.
Dodge City, Kans.

J.R. Wickes
Honeywell, Inc.
Dodge City, Kans.

Optimizing plant process controls is a continuing objective and requires confidence and teamwork by all parties involved. After the initial installation, the controls are thoroughly analyzed, then they are coordinated and tuned. The modifications and improvements incorporated over a six-year period are included in this report. The process chromatograph and data systems are the first steps toward computer control after all controls are on "automatic." The process controls must be retuned after computer control installation.

Are your control loops and data equipment doing what you need them to do?

Does someone review vibration analysis? Are the records kept where they are available for ready reference?

If you feel that you have equipment that is not utilized to its maximum, put your heads together and make it do what you need.

Are your control loops on automatic? This is a must for optimizing your operations. With the evolution of the computer you are going to have to have your plant on automatic before the computer has a chance.

Start at the front of your process and put them on automatic, one at a time, tuning each controller as you go. If you get part way through and find that the dog is chasing its tail, stop and analyze your problem. Check those loops which are on automatic and find what is causing the problem before you go on.

Are you expending minimum energy to accomplish the needed work? We have installed pneumatic flow and pressure controllers throughout the plant on console oil and reflux turbines so they will produce improved requirements on some oil and water systems.

Flow controls have been installed on the turbines on the 101-J, 105-J and the 103-J lube oil seal oil control systems. A pressure controller was tried on the 101-J lube oil system and was not satisfactory and the flow control system was installed and proved satisfactory.

Pressure controllers were installed on the turbines on the clarified water booster pumps and demineralized water pumps.

Are you using the simplest system to accomplish the end result? On the fuel gas system PIC-3 the controller and control valve were removed and a pressure regulator was installed.

Feed forward control system

The feed forward control system on the steam, involving the speed control on the 103-J, PRC 12, and the auxiliary boiler firing PRC 17, was valved out, because when the steam pressure transmitter, PRC 12, which controls the 103-J, was taken out of service to check the calibration, the firing on the auxiliary boiler went to maximum and could not be brought back under control until the transmitter was put back into service. At Dodge City the let-down controller on the 103-J, PRC 12 is the only board instrument which is run on manual and the package boilers are used to control the 545 lb. steam system.

The controller on the PRC 12 was moved to PR 33 and we are now using it to control the loop pressure automatically.

104D shift converters temperature control

TRC 10 was originally only a 3-15 lb. butterfly control valve controlling inlet temperature to the high temperature shift converter, Figure 1.

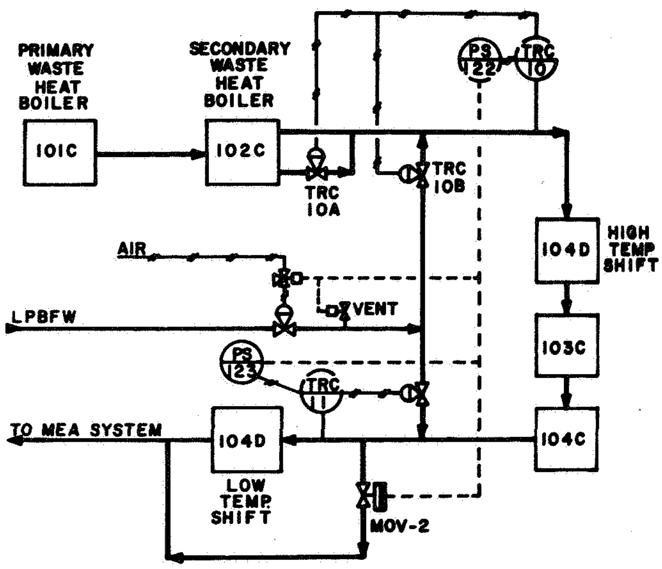


Figure 1. Shift converters temperature control.

3 to 9 lb. spring was installed in the positioner and a 9 to 15 lb. control valve was added to feed boiler feed water quench to the process gas on the outlet of the secondary waste heat boiler. The quench allows additional cooling after the bypass valve is opened.

The low temperature shift converter also has a quench control system. We took TRC 11 out of its original service bypassing 136C and removed the butterfly control valve.

A control valve was installed on the outlet of the 104-C to feed boiler feed water quench to the process gas entering the low shift. The control point is just above the first bed.

The low temperature alarms of both converters are paralleled through relays which trips two solenoids. One solenoid VS-5 activates a quick opening pneumatic control valve V-5, which will cut off boiler feed water to both TRC 10B and TRC 11. The second solenoid, VS-6 vents the boiler feed water valve between the trip valve and the quench control valves.

Operation of MOV2 low temperature shift bypass will also trip the quench shut-off valve V-5.

Are your systems safe?

Does your system protect personnel and hardware as well as it could? If you feel that you could protect the hardware equipment or people better, contact the manufacturer. There may also be some new ideas coming out of other plants.

102-B startup heater

A low flow of synthesis gas through the startup heater will cut off the fuel to the startup heater. We are using a North American shut-off valve which takes power to hold in the open position. In the event of trouble the board man can step behind the control board and shut off the power to the fuel gas valve, shutting down the startup heater. Soon we plan to install a complete FM approved flame safeguard system. This includes a push-to-start which would ignite the pilots, prove them and then allow the main burners to be lit. All this is remote of the heater.

101-J air machine trip system

We have added two 3-way solenoids to the air control system, Figure 2. When air to the secondary reformer, MOV-3 closes, VS-19 vents. The FIC-4 control valve diaphragm to atmosphere venting 101-J to atmosphere, at the same time VS-20 vents the controlled air signal to 101-J governor allowing the machine to go back to minimum governor.

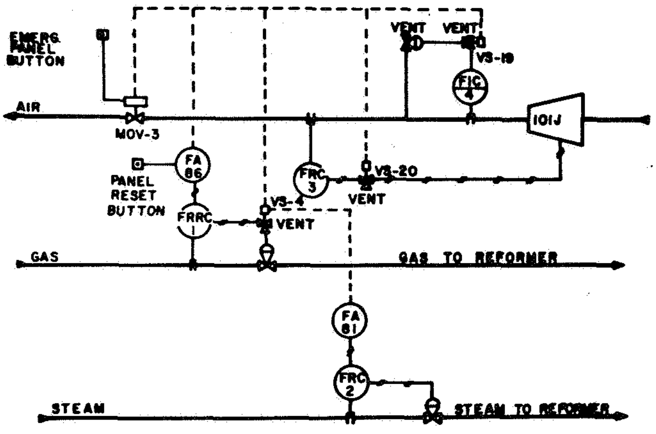


Figure 2. Reformer trip system.

105-J refrigeration machine trip system

The shutdown was removed from the Delta P switch and put on the seal oil supply to the seals downstream of the flow control valve. This has significantly reduced nuisance trip-outs of the refrigeration machine. Also during previous startups the Delta P switch was blocked in order to bring the machine up which leaves the machine unprotected. Since the installation of the pressure switch we have not had to block the trips to start this machine.

PICA-19 primary reformer draft transmitters

The draft transmitter was moved from ground level to the reformer penthouse. We had problems with the process variable line filling with condensate and oil from the transmitter. There was no reference line from the transmitter to the penthouse. After the penthouse was enclosed we received false readings and had to run a reference line.

The transmitter was moved to the penthouse, above the draft tube. This eliminated steam tracing. Now the transmitter is located within the reference area, and we no longer need reference piping.

V-1 stack steam ring trip

We have installed a MIC on the low draft trip on the reformer which in case of a low draft condition the steam ring will trip and the board man gets an alarm, but the valve opening is controlled from the control board and is set at 13.7 lb./sq.in. gauge air loading which allows 10,000 lb./hr. to flow through the steam ring. If not controlled in this manner it has been our experience that the design 45,000 lb./hr. flow will drain our steam system dry before anything can be done. In windy Western Kansas when on startup or low rates a false alarm due to sudden wind changes is possible. If no precautions are taken it could cause a shutdown due to low steam pressure.

Instrument air compressor

We have installed a pressure controller which in the event the air dryers do not make a complete switch, air will bypass the dryers and prevent a shutdown. Also we have a N_2 line from our liquid nitrogen storage tank complex which can be hooked into the instrument air system with a short quick connecting hose, downstream of the dryers, in the event of a failure of any component of the instrument air system.

LIC-1 steam drum level control

The steam drum level control system has been modified by removing the zero to 100 lb. Delta P controller. The valve now operates 3 lb. to 9 lb., from 9 to 15 lb. The signal is changed to 3 to 15 with a transducer to operate the high pressure boiler feedwater pump. A remote feedwater gauge is mounted so operators can see it while switching pumps.

The auxiliary level indication on the steam drum is an "Eye-Hi". This system uses conductivity probes to indicate the level with lights and has proven very satisfactory.

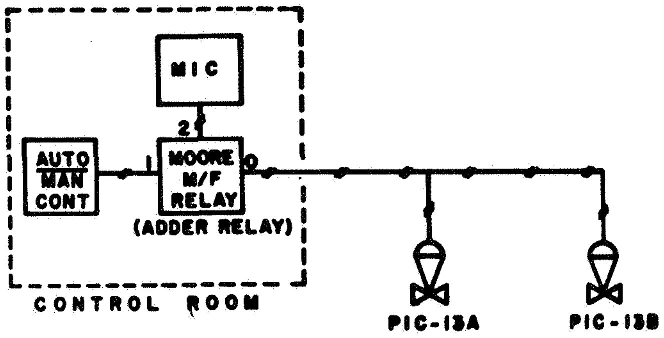


Figure 3. Steam letdown: 1500 lb.–545 lb.

PICA-13 1,500 lb. to 545 lb. steam let-down

We have taken the control air signal from a PIC-13 and a signal from a manual loader into a multi-function relay using the relay as an adder, Figure 3. This allows the board man to control the steam let-down of the automatic system to prevent overpressuring the low pressure system. The manual loader allows one to hold a constant pressure on the 1,500 lb. system while bringing up the synthesis gas machine by manually controlling the 1,500 lb. steam flow when switching from PIC-13 to the synthesis gas topping turbine.

Shutdown equipment inspections

During shutdowns our maintenance and engineering people use check lists for performing equipment inspections, Figure 4. This approach provides a record of work performed as well as assuring a complete inspection.

During a turnaround after compressor switch settings are made, car seals are installed and numbers are recorded. This reminds a person to open the valves after checking the switch. By comparing with the last check we can tell if a switch has drifted. The sheet shown is part of the synthesis gas machine check list. We have sheets for all alarms and trip switches in the plant.

After a turnaround these settings are reviewed to see if there needs to be a change made to warn of a possible malfunction early enough to prevent damage or excessive wear.

These check sheets become part of the shutdown report.

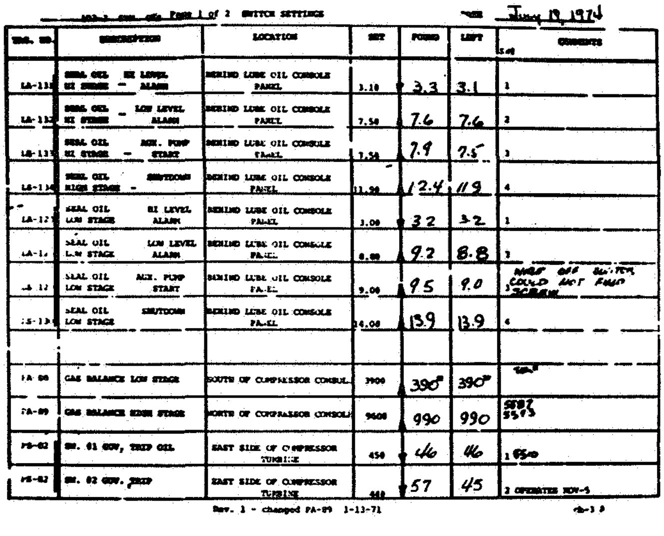


Figure 4. Check lists used for inspection.

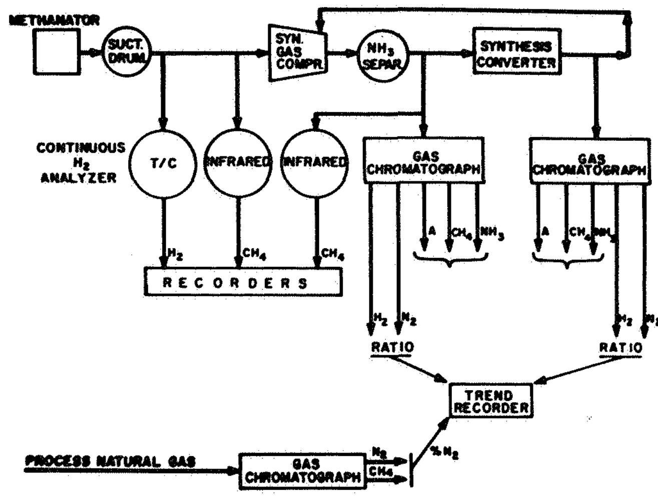


Figure 5. Synthesis H/N ratio control.

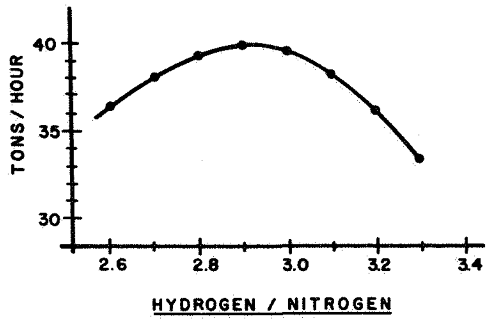
The reports are made available to operating personnel for their use. By seeing these reports it helps in their understanding of overall operations.

Dodge City has no automatic vibration and temperature recording on the compressors. Compressor operators have been trained to understand basic vibration analysis. The readings are taken every two hours. Temperatures are recorded on the log sheet. Vibrations are plotted on a graph. The operating personnel know if high readings are significant. We feel that operator involvement and judgement in this area is more valuable in diagnosing troubles than a simple set of alarm equipment.

Hydrogen-to-nitrogen ratio

In daily operation of today's ammonia plants the deviation from the proper H/N ratio will prevent maximum production. Many plants have installed "on stream" process chromatographs with ratio trend recorders in an effort to maximize production, Figure 5. Tom Stout of Profimatics, Inc. has published some information on the effect of reduced variability on ammonia production.

As an additional handicap, our natural gas feedstock



HYDROGEN-TO-NITROGEN RATIO		AVERAGE PRODUCTION RATE	
AVERAGE	STANDARD DEVIATION	TONS/ HOUR	TONS / DAY
3.0	0.15	37.4	879.6
2.9	0.15	38.2	916.8
2.9	0.05	39.8	955.2
2.9	0.00	40.0	960.0

BY DR. TOM STOUT PROFIMATICS, INC.

Figure 6. Effect of reduced variability on ammonia production.

varies from 12% to 17% nitrogen so 11% to 16% of the required nitrogen is introduced into the primary reformer, Figure 6. We have a three-stream chromatograph and our three pen trend recorder monitors (1) the nitrogen in the feed gas, (2) the ratio into the ammonia converter and (3) the ratio out of the converter.

We are conducting our own study on the best ratio into and out of our ammonia converters with our plant conditions. After we have completed our studies we will move one of the sample streams to the fresh gas feed to the loop.

Next year we plan to use computer control to control the H/N ratio. We will use feed forward control from the nitrogen in the natural gas feedstock and cascade control from the ratio of the fresh gas feed to the loop and the ratio either into or out of our ammonia converters.

In order for any plant to operate at its optimum, teamwork is necessary. The instrument people must have the confidence of operations and vice versa. Maintenance, operations and engineering must work together with a common goal, insight . . . to make "their plant" run better than any other.

What causes shutdowns

Instrument failures cause about 10% of the total shutdowns but account for only 3% of the total downtime according to a survey made in 1971 of 23 plants.

General — *8 shutdowns (13%)*

(2) Malfunction of automatic demineralizer controls.
(1) Natural gas feed compressor vent valve opened.
(1) Natural gas pressure controller (PIC-1) failed.
(1) Fuel gas control valve (PIC-3) malfunctioned, resulting upset blew 1500 psig superheater RV which did not reset.
(1) Gasket failed at TRC-10 control valve up stream of the HT shift with resulting fire.
(1) Air controller to secondary reformer FRC 3 sensing line froze.
(1) Methanator inlet valve tripped close due to instrument malfunction.

Steam systems — *11 shutdowns (17%)*

(2) 1500 lb./sq.in. gauge steam pressure controller PRC 17 froze or malfunctioned, blowing relief valves.
(1) Auxiliary boiler (1500 lb./sq.in. gauge) tripped because of bad relay contacts.
(1) Auxiliary boiler (1500 lb./sq.in. gauge) tripped because of plugged pressure sensing line.
(4) Steam control to synthesis gas compressor failed.
(1) 1500 lb./sq.in. gauge steam bypass valve tripped open due to vibration.
(2) Package boiler instrument failure.

CO_2 removal system — *5 shutdowns (8%)*

(4) Failure of absorber ΔP controller with MEA carryover into methanator.
(1) Absorber let down control valve stem came loose from plug.

Air compressor — *9 shutdowns (14%)*

(4) Anti-surge protection malfunction
(2) Governor malfunction
(2) Overspeed trip malfunction
(1) Auxiliary lube oil pump too slow

Synthesis gas compressor — *21 shutdowns (33%)*

(6) Governor malfunction
(5) Overspeed trip malfunction
(6) Auxiliary lube oil pump too slow
(1) Auxiliary seal oil pump too slow
(3) Lube oil system—faulty or corroded switches

Refrigeration compressor — *4 shutdowns (6%)*

(1) Governor malfunction
(2) Seal oil pressure switch corroded contacts
(1) Auxiliary lube oil pump too slow

Ammonia loop — *6 shutdowns (10%)*

(6) Ammonia separator level control failure. High ammonia concentration causes loss of reaction in ammonia convertor.

Summary of Dodge City modifications

1. PIC-3 fuel gas controller changed to a gas pressure regulator.
2. 2105-F sphere level indicator changed from a float type to a motor driven weight.
3. 2000 lb./day chlorinator replaced by a 500 lb./day cylinder mount.
4. Ferrous sulfate feeder replaced by liquid sulfur dioxide.
5. Modified acid and caustic day tank level indicator.
6. Additional utility alarms were added to D.I. train regeneration panel.
7. D.I. train auto regeneration modified to run acid and caustic regeneration simultaneously.
8. Loading scale trips changed from photo cell to proximity switch.
9. MEA letdown changed to double seated cage valve with a special stem and bonnet.
10. Primary reformer draft controller moved to reformer penthouse.
11. 105-J seal oil trip moved from ΔP's to a pressure switch.
12. Thermowells on transfer line between the primary and secondary reformers were capped.
13. Stainless steel tubing has been installed in place of copper on valve bonnets. Also in high vibration areas where the copper tubing showed signs of cracking.
14. A filter was installed on the process line going to pressure switch for the fuel gas trip on the auxiliary boiler. Earlier this year the line filled with a carbon deposit. A slight leak in the piping between the fuel gas line and the switch caused the auxiliary to trip out.
    NOTE: Every turnaround we wash out this line with hot boiler feed water and other fuel gas lines which show up with these heavy deposits. We have experienced this with all natural gas valves and have been washing them out as part of preventive maintenance.

15. Process analyzer systems: sample coolers and regulators were moved to the side of the analyzer building and a bleed set-up so we could get a fresh sample every 2 to 3 minutes.

Summary of Dodge City control additions

1. PR-33—loop pressure recorded—now purge controller.
2. Plant nitrogen, a liquid system, piped to analyzer building for process analyzer purge.
3. Lo-level alarm, 103-J lube oil console.
4. Eye-Hi level indicator on the steam drum.
5. Recording flow meter on cooling water to cooling tower.
6. Recording flow meter on fuel gas to arch burners, tunnel burners and auxiliary boilers.
7. Temperature controlled air conditioning of process analyzer building.
8. Pressure controller on 107-F.
9. Governor on clarified water booster pump and "DI" pump were changed to pneumatic pressure control.
10. Compressor lube oil governors changed to pneumatic flow control.
11. High and low temperature shift quench control. #

WICKES, J. R.

PEBWORTH, L. A.

DISCUSSION

JAN BLANKEN, UKF Holland: I would like to mention an incident we had in one of our plants. On a certain winter morning the plant was running fine. Both the firing of the auxiliary boiler and the induced draught fan were on automatic control.

The problem started when the fuel to the primary reformer was lost, because as was found out later, the natural gas line to the fuel pressure controller had frozen, which caused the fuel to trip on low pressure.

What happened then was, that the premix burners stopped bringing about 50% of the combustion air into the primary reformer. Therefore the induced draught fan had to take care of less flue gas and went down in speed as it was automatically controlled. Because the steam generation was on automatic control the auxiliary boiler went up and fired to the maximum with the result that the draft at the point where the auxiliary boiler is connected to the convection was not sufficient to take care of the flue gas of the auxiliary boiler.

This resulted in black smoke coming from the primary reformer stack. We thought we had been lucky that the natural gas decomposed instead of ignited in the convection section.

We installed an override in the control of the induced draught fan such that normally it is on automatic control but if anything happens it does not go to minimum speed automatically but is stopped by the override and the operator has to adjust the override before the speed is further decreased.