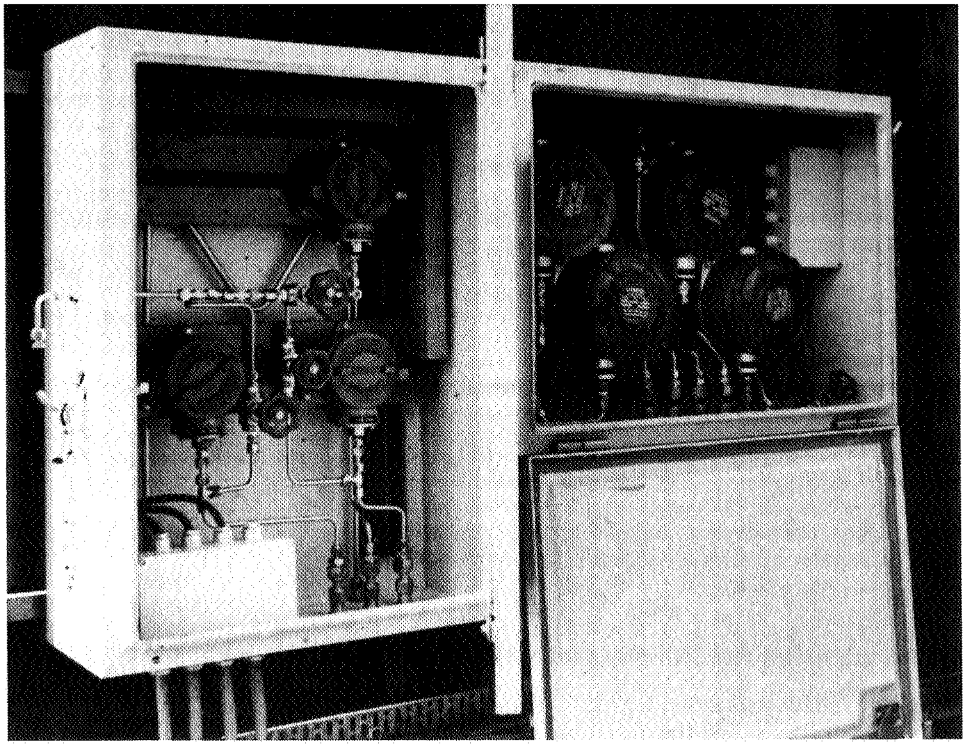

Figure 1. Typical watertight box used for plant instruments.

Instrument Trip System Maintenance & Improvement Program

A multi-trip circuit system, coupled with high design and maintenance standards, have eliminated unnecessary outages in this Dutch ammonia plant.

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Practically everyone in the ammonia industry is familiar with the damage and loss of production that usually results from a plant trip. If the trip is in response to an unsafe condition, the trip action is financially justified, but when the outage is due to an internal fault the losses are clearly unacceptable, especially for larger ammonia facilities.

Several years ago, Esso Chemicals' 1,500 ton ammonia unit in Rotterdam suffered many so-called "nuisance trips." As a result, an action group was set up to improve the reliability of the instrumentation. This article discusses how Esso approached the problem, gives examples of the reasoning and actions taken, and outlines the steps we would now take if confronted with a similar situation.

A number of factors were directly responsible for the troubles we experienced:

a. Poor construction with unsafe, inaccessible transmitters.
b. Many transmitters were found shorting to ground.
c. Wrong instrument and thermocouple compensation cables were used.
d. Many junction boxes were open or not watertight, with many trips and malfunctions as a result.
e. Some drawings and equipment information were inaccurate or unavailable.
f. Many copper tubing and junction box connectors corroded due to the aggressive atmosphere.
g. Leadlines were hooked-up improperly and shoddy materials were used.
h. Unreliable instrument power supply.

Eliminating unnecessary trip actions

A Trip Review Committee was set up to investigate how many of the trip actions were really required to protect the plant, and how many were unnecessary. The Committee consisted of representatives of the site process, mechanical, and technical divisions together with outside consultants. The basis for eliminating a trip was either:

1. The protection was not necessary because it was already covered by a trip circuit upstream or downstream in the system.
2. The operator had adequate time to respond to an alarm.
3. The trip circuit was so unreliable that the probability of a nuisance trip was higher than the probability of damage from the variable being controlled. For example, trips were removed from the Bently vibration probes on the compressors.

All changes recommended by the Committee were approved by the plant manager before implementation. In this way, 26 trip actions of the original 71 were removed or bypassed. As a further aid to reliability, all work on the plant trip system was forbidden unless expressly approved by the plant manager.

Improve quality of the instrumentation

The original installation had pressure switches in which an alarm and trip action were activated by one bellows. The alarm action could not be checked without tripping the plant. We now use separate reliable switches —Barksdate and Ashcroft.

We have standardized on Foxboro D.P. cells with as many parts as possible fabricated from stainless steel or Teflon. As a general rule, we avoid copper components in the field instrumentation.

The original field installation suffered from such problems as water in junction boxes, corrosion of terminal connectors, corrosion of copper tubing by ammonia, etc. Consequently, an improved standard of installation was applied in the plant.

General rules for field installation

1. Put the instruments, e.g., ΔP transmitters, pressure transmitters for the two out of three system, together in watertight boxes, Figure 1.
2. Use Weidmuller Kupradur connectors. Kupradur is resistant against chemical attack from NH_3, etc.
3. Use one uninterrupted cable from instrument boxes in the field to the main control room as follows:
   a. Electronic loop → junction box in field → M.C.R., or,
   b. Pneumatic switch → M.C.R.
4. All cabling from tripswitches in the field to main control room, and all cabling to solenoid valves in the field must go via a main junction box in the M.C.R. From there the wiring must go directly to the relay-cabinets or to the field.
5. Bring all field instruments to safe locations which are easy to reach and to work on.
6. All instrument air tubing must be stainless steel.
7. Where high pressures are involved and a leak in an impulse line could lead to its becoming overheated, autoclave tubing should be used.
8. Use General Electric RTV-108 sealant for all junction boxes and inputs. This plastic will provide adequate protection for many years.

The two from two and two from three trip systems

Although the actions described above reduced the number of nuisance trips somewhat, it soon became clear that, even with the most reliable instrumentation available, the probability that one of the remaining trip circuits would cause a plant shutdown was unacceptably high.

Consequently, the Trip Committee was again convened to review sections of the plant for the installation of double, parallel trip circuits on a two from three system. In principle, the best possible material was chosen for the installation with the provision that the trips could be by-passed to enable maintenance work to be done on the run. Run checks with the old system had caused so many nuisance trips that work on the trip systems was forbidden while the plant was in operation.

The Committee soon found that there were certain areas where, without waiting for the delivery of new equipment, a circuit could be doubled and made into a two from two system. For example, on the grounds that it was impossible to get an overpressure in the A side of the firebox of the reforming furnace without having a similar rise in the B side, it was agreed to combine these two overpressure trips into a two from two trip circuit. A principle sketch of a two from three trip circuit for pressure instruments is given in Figure 2.

Primary reformer control and trip system

The most important control loop is the steam-gas-air ratio loop. This loop is always on automatic control to protect the plant in undesired or unexpected situations, e.g., while fluctuations occur in the steam-system, the gas- and airflow will be adjusted automatically via the ratio controller so that safe temperatures and/or safe flows will be maintained, Figure 3.

The steam and feed gas flows both have a low flow cut out. Interruptions of the steam flow, even for short

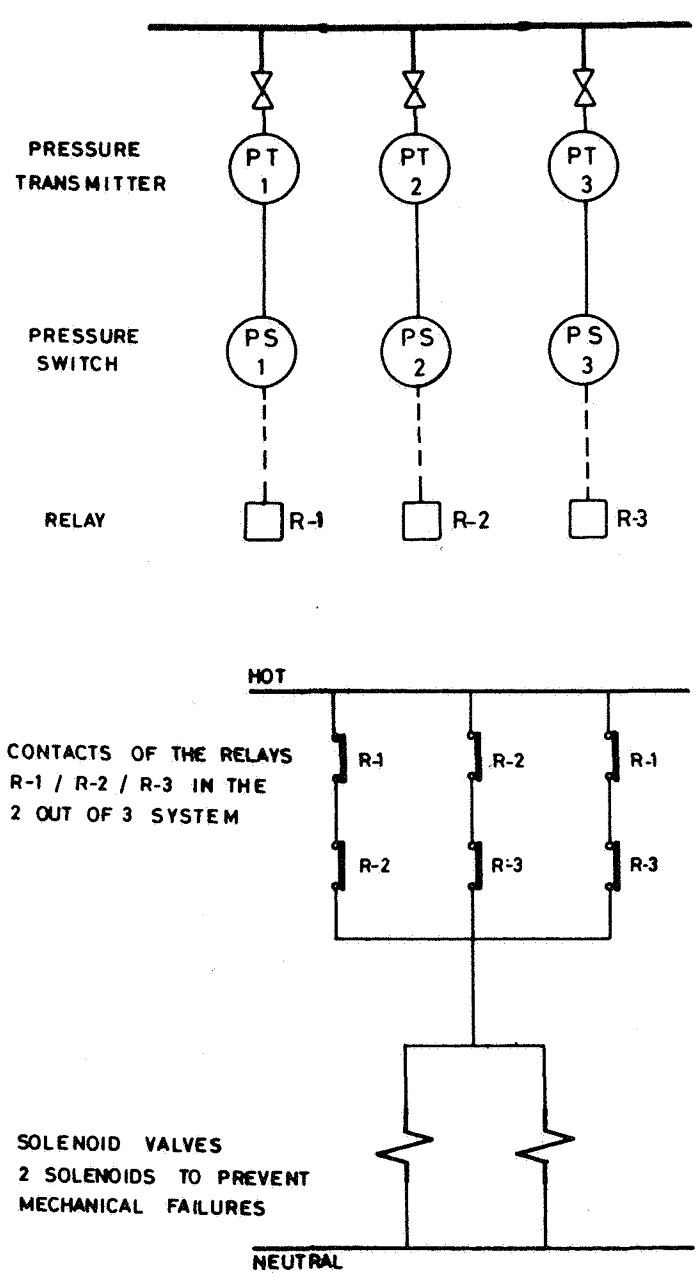


Figure 2. Example of a two out three system (majority trip system).

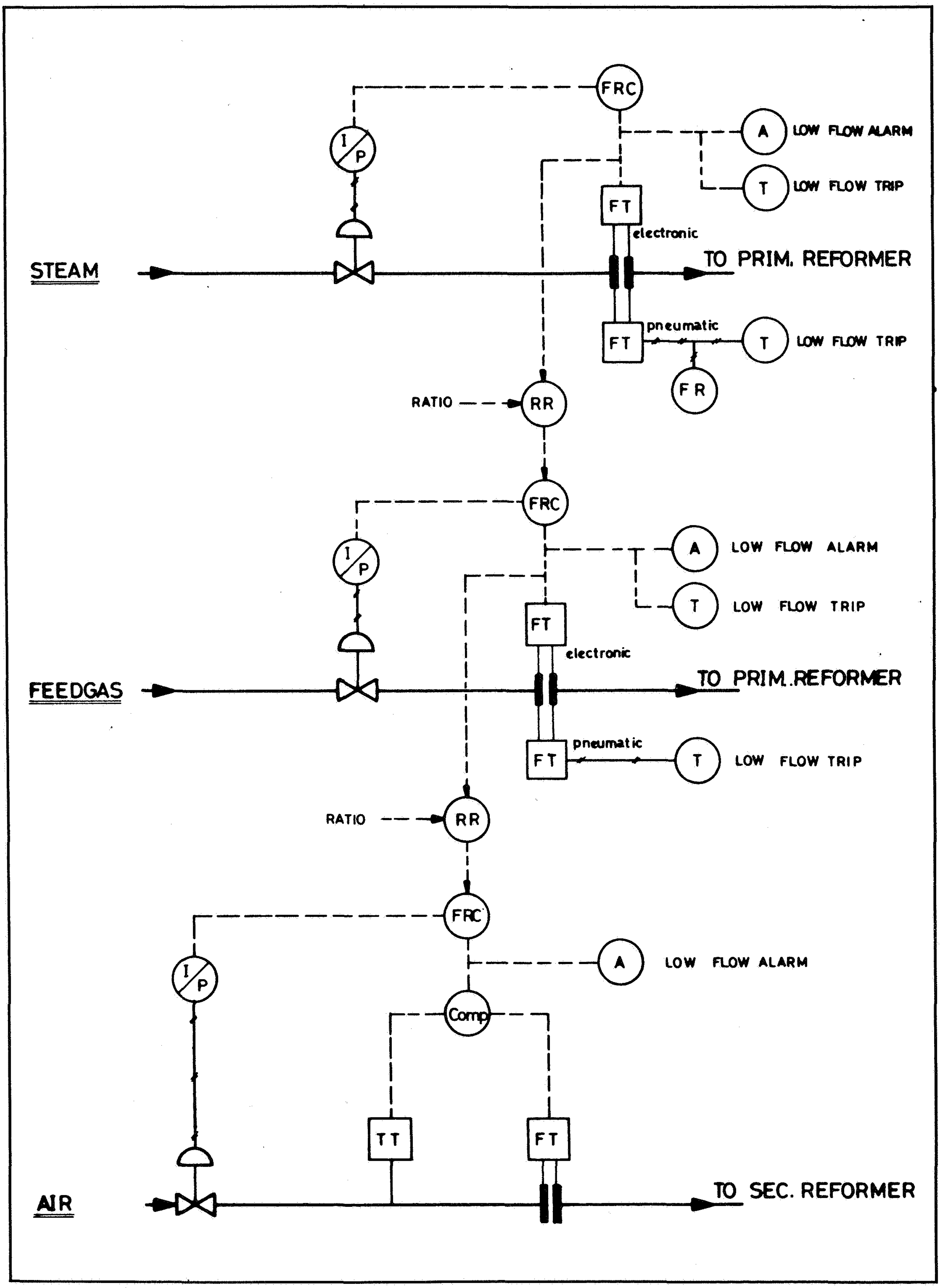


Figure 3. Steam-air-gas ratio loop—the most important in plant.

periods, can coke up the primary reformer catalyst if the gas flow still remains in the furnace. A low flow of the feed gas, however, will burn up the secondary reformer if the air flow stays in. Therefore automatic control of the ratio loop steam- gas- air flow is very important and should be set as soon as possible after the plant is started.

A good working shutdown system is of high importance to protect personnel, mechanical equipment, and catalysts. The ratio loop is hooked up as shown in Figure 4.

The steam- and feed gas flow control loops now consist of a single orifice with two sets of impulse lines each connected to a ΔP cell.

The original design was an electronic control loop, consisting of transmitter, controller, recorder, low flow alarm, low flow trip, and ratio controller. These are hooked together by a so called two wire system as shown in Figure 5.

The trip signal travels via six instruments and a power supply which are each potentially capable of giving a nuisance trip. The risk of accidentally causing a trip while doing preventive maintenance on this system was so high that the Trip Committee decided that work ought never be undertaken on a trip circuit while the plant was in operation.

A completely independent pneumatic ΔP cell transmitter was installed to make the trip system a two from two system. This means that the electronic, as well as the pneumatic flow transmitter, have to give a trip signal before the plant would come down.

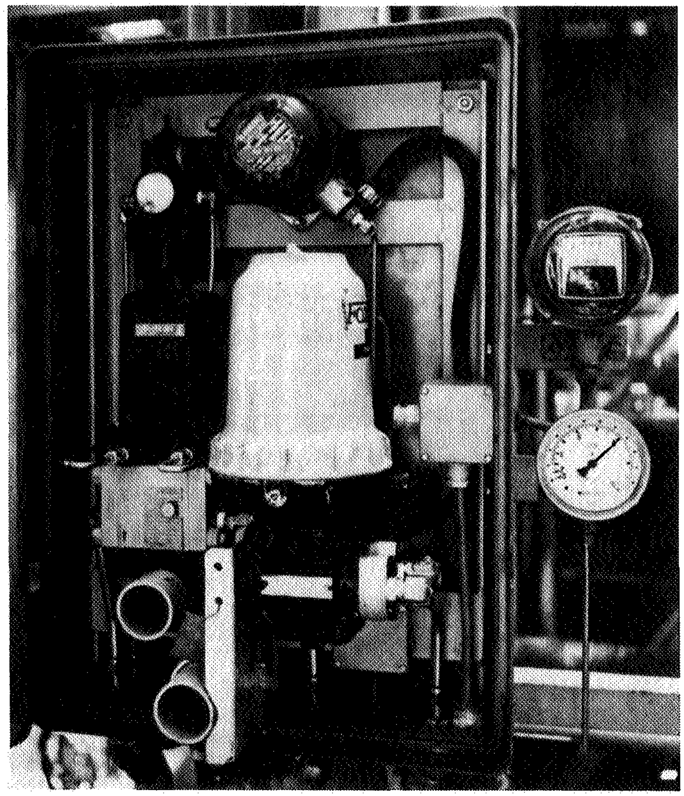


Figure 4. The ratio loop instrumentation box.

Improvement of instrument panels

The original installation was not systematically designed and was altered so much during commissioning that it was no longer worthwhile to risk trying to make improvements piece by piece. Consequently, many of the panels were entirely renewed with the wearing and outgoing leads systematically arranged and labeled to avoid mistakes during onstream checks. These panels were constructed so that the trips circuits could be bridged for continuity and component checking.

Figure 6 shows the systematic set-up of the trip relay panel for the feed gas compressor. The cables from the field enter the cabinet from the left-hand side and extend to incoming terminal strips which are situated in the second from the bottom compartment. The internal cabling runs from this terminal strip to the relays which are situated in the top compartment. The returning cables run via the left hand side of the cabinet to the outgoing terminal strip in the bottom compartment. Above the main door of the cabinet, and thus visible to the process operators, are the main power switch, and indicator lamps corresponding with the position of the signal being sent to the panel from the field.

The relays and terminal blocks are clearly labelled and a book of up-to-date drawings are kept in the cabinet. With this set-up it is easy to convince the process supervisor that work can be done safely, and virtually eliminates the risk that the wrong circuit will be worked on.

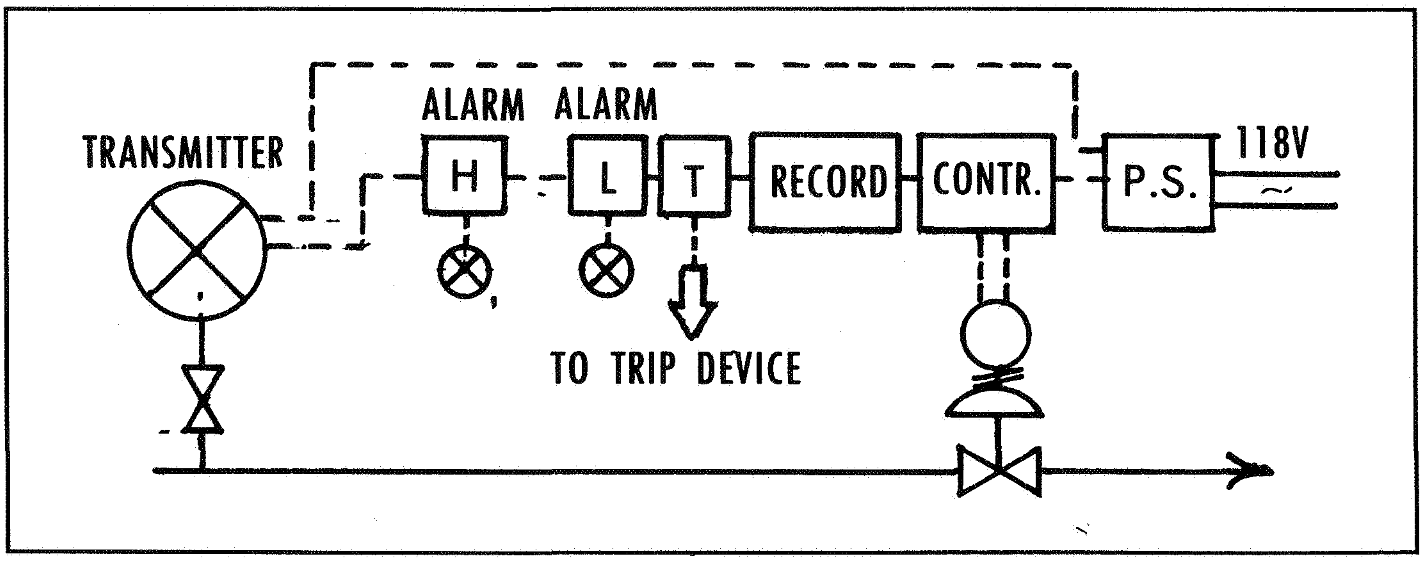


Figure 5. Original control loop was this two-wire system.

Preventive maintenance

Having physically established a system which makes it possible to maintain and check safely on the run, it is essential to support it with a reliable preventive maintenance scheme. There are 187 control loops in the ammonia plant and about 1,000 instruments. This means that, even on a once-a-year basis, an average four control loops and 40 instruments have to receive preventive maintenance each week. The work is done with the close cooperation and approval of the process operators. Often a control loop is checked in sections, one section per day, because the process operators prefer not to run more than four to six hours with a trip by-passed.

For each instrument we developed a card, on which most of the preventive maintenance activities are preprinted. On the card is an indication of where the instrument is located, which service it has, and the instrument man who has to do the work.

As an example, we will consider a control valve card, Figure 7. When the work permit is issued, the instrument man asks production to take the valve on by-pass. If this is not possible, the valve is placed on hand-jack. Now he can check the transducer and positioner of the valve. He will cross off which items are completed, note his comments on the back of the card, and indicate what further work has to be done.

When the preventive maintenance is done, the card will be checked by the foreman who will indicate on the standard form what has been done, Figure 8. There are several codes used to indicate completed work:

1. Leave small circle open means: No P.M. done.
2. Make the small circle black means: P.M. done—O.K.
3. Make the small circle red means: Turnaround item.
4. Make the small circle green means: No permit given.
5. Make the small circle blue means: Still something to do.

This makes it easy, during unexpected plant shutdowns, to make a shutdown list of preventive mainte-

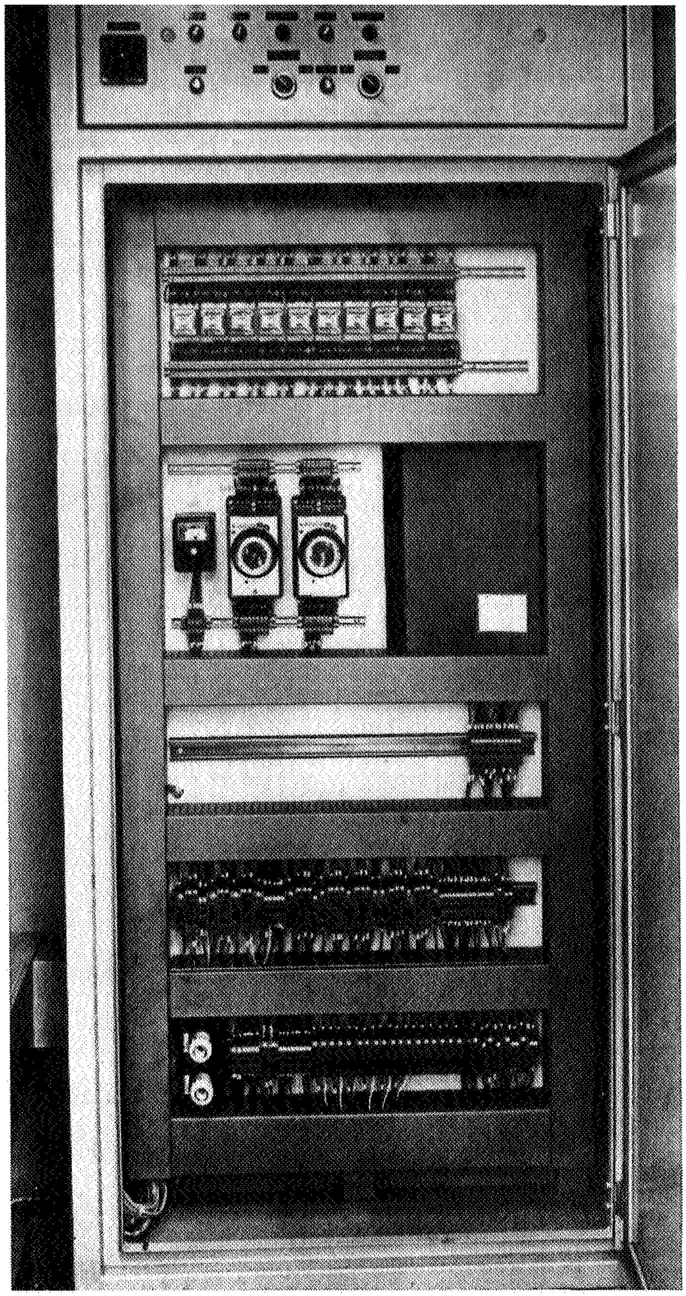


Figure 6. Systematic set-up of trip relay panel for feed gas compressor.

Date:		Technician:	
Loop nr:	Loop instr.: Transmitter		Code:
Location:	Type:	Process cond.	
P.M.		Range: mm WK	
Zero check	▭		
Calibrate	▭	Check indicator	▭
Renew coil feedback	▭	Clean flapper/nozzle	▭
Renew detectorblock	▭	Steam trace	▭
Renew capsule	▭	Manifold	▭
Clean capsule	▭	Overhaul complete transm.	▭
Renew force bar	▭	Check float	▭
Renew amplifier	▭	Renew gaskets	▭
Change range	▭	Check pilot	▭
Change converter	▭	Check wiring	▭
Cleane transmitter	▭	Check tagging	▭

Figure 7. Preventive maintenance activities are pre-printed on this card.

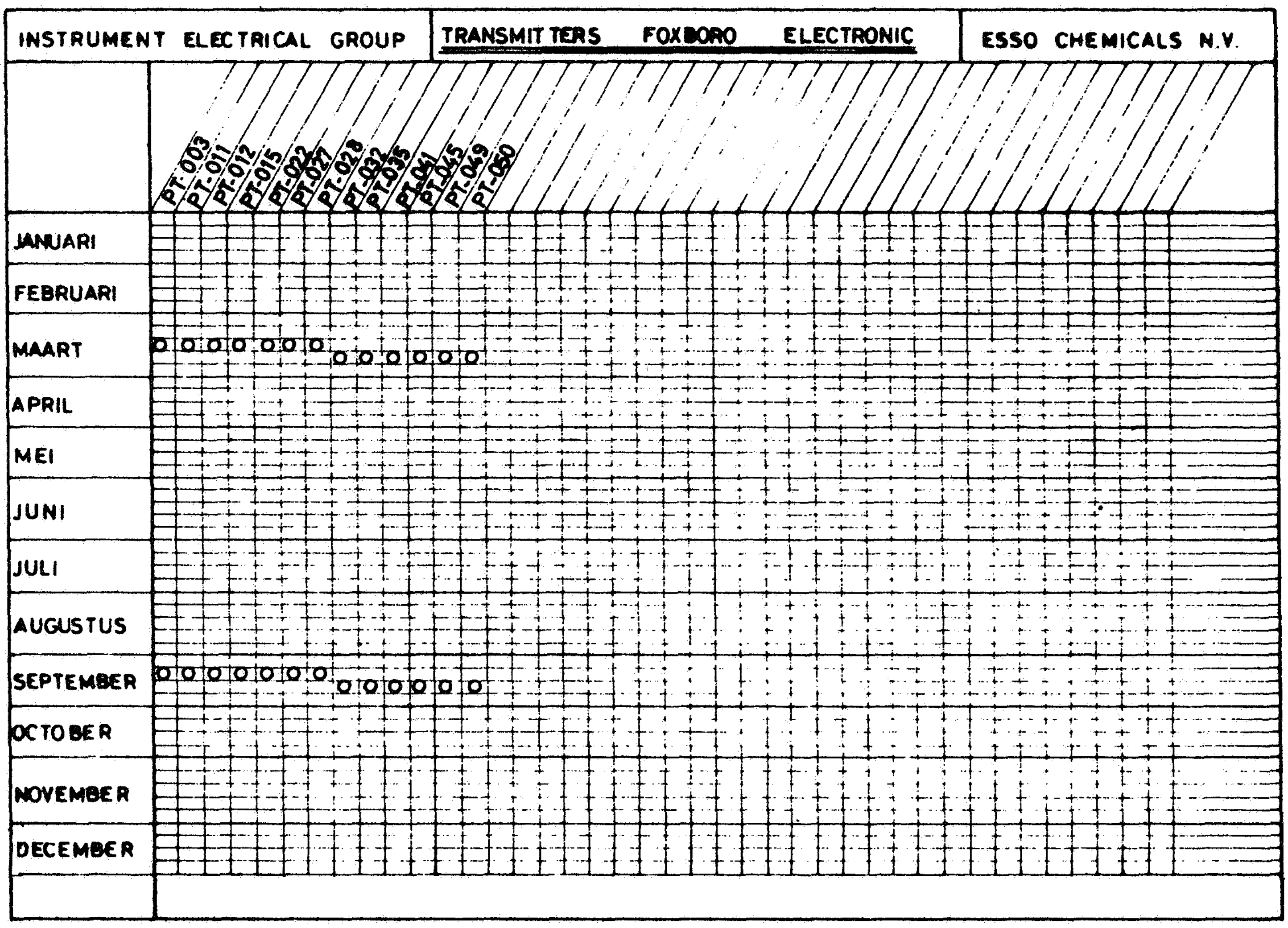


Figure 8. Form used to indicate what work has been done.

nance work by just noting the red spots of the standard forms.

From the time we have used this system, the reliability of instrumentation has improved remarkably. This is shown by the fact, that since 1973, when we started to change the trip and alarm systems and instrumentation preventive maintenance had proved to be working, no trips caused by malfunctions of instruments have occurred.

As far as possible, the plant's trip circuits are checked during scheduled shutdowns. These lists have shown that the instrumentation works well and exactly on the settings for which it is calibrated.

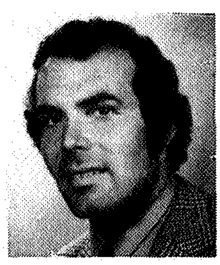
Approaching a future problem

The main lessons which we have learned in designs installing and achieving a high standard of reliability in the instrumentation in the ammonia unit are:

1. Always review the necessity for trip actions and use where operator response is acceptable.
2. Do not rely on being able to solve the problem with good quality instrumentation alone. In critical areas this must be duplicated or triplicated depending upon the severity of the consequences of a nuisance trip.
3. Combine field instrumentation in watertight boxes and minimize the number of junction boxes by using continuous cables.
4. Use a systematic set-up by which it is easy to determine faults and to avoid working on the wrong circuit.
5. Ensure that adequate time is planned to thoroughly train technicians, before they are allowed to work on the circuits.

As the complexity and scale of modern chemical plants increase, an ever increasing demand is placed on the instrument designers to improve the reliability and safety of the instrumentation. However, the improvements in the design must be supported by a systematic and workable preventive maintenance system.

We believe that, at the present state-of-the-art, a multi-trip circuit approach must be applied in critical areas with a high standard of design and maintenance such as described here. #



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