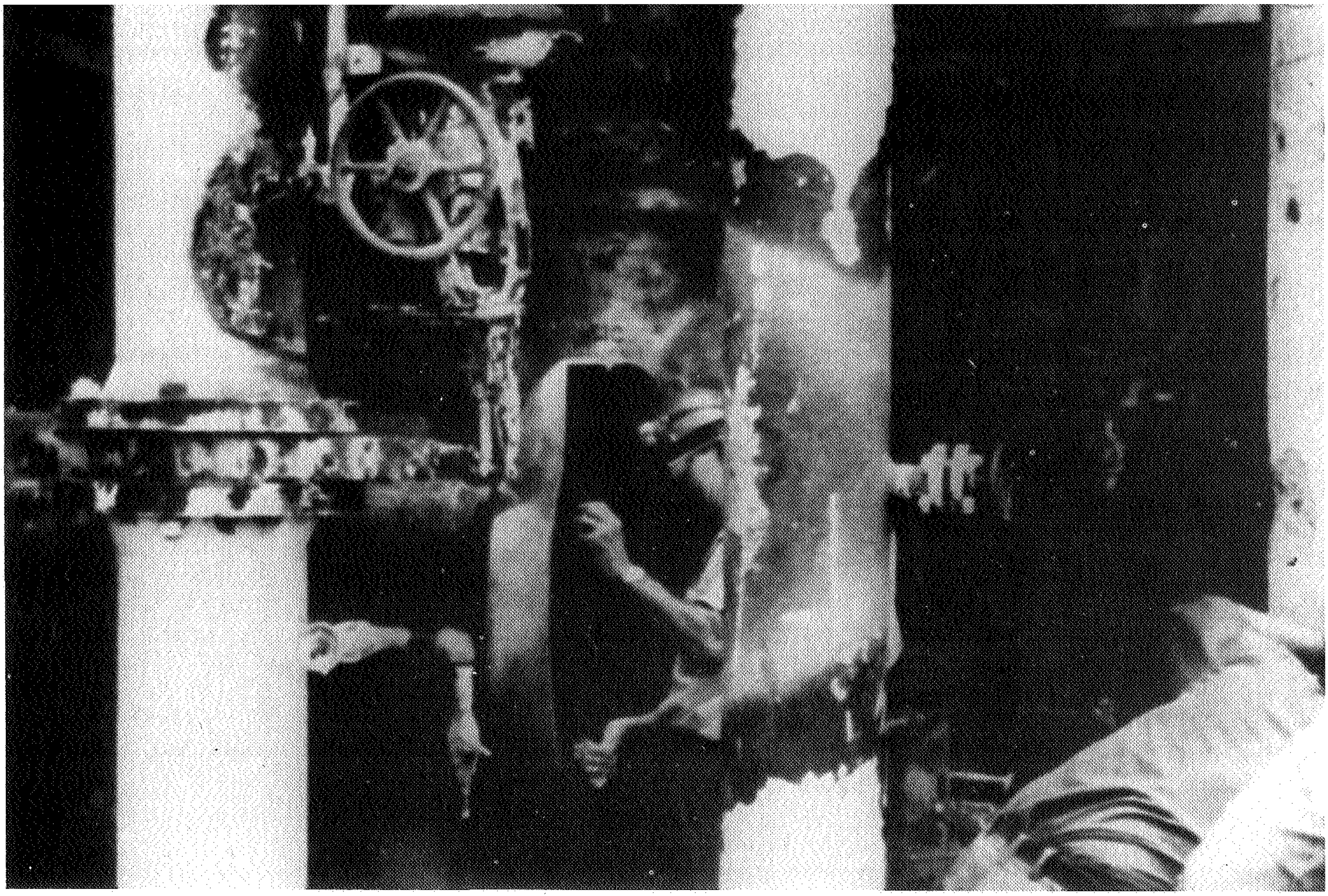

Figure 1. Damage to adjacent equipment caused by butterfly valve flange fire.

Vol. 11 Safety in air and ammonia plants 1968.

Preventing Ammonia Plant Fires

Operating tips show how to prevent and contain the possibility of flange fires and protect equipment and personnel from such incidents.

R. A. Watkins, Beaumont Works, E. I. DuPont de Nemours & Co., Beaumont, Tex.

PRESENT DAY AMMONIA PLANTS ARE so compact and interlaced with process pipelines that protection from fires is of major importance. At the Beaumont works ammonia plant there were two flange fires in the past six months. Both situations required immediate plant shutdown, isolation of equipment at the location of the fire, and several days for repair. These fires and those encountered on other plants indicate that preventive measures are needed. Here is a review of what is being done to minimize the possibility of flange fires and to protect equipment and personnel from such fires should they occur.

Butterfly valves involved

The two incidents involved butterfly valves in process lines under 400 psig pressure. In one case, the line was in cold service with asbestos sheet gaskets; in the other case, the line was in hot service with spiral wound, asbestos filled, metal gaskets. Both leaks were initially small but flame impingement caused the bolts to relax, allowing more gas to escape, increasing the size of the fire. Investigation revealed that the flange bolts were elongated, the asbestos gasket blew out of the flange, the spiral wound metal gasket asbestos filler blew out and the centering ring was deformed.

Figure 1 is a photograph taken after the first butterfly valve fire. It shows the effects of the fire on adjacent equipment which included a heat exchanger, steam lines and the adjacent compressor platform. The head has been removed from the heat exchanger for repairs as it was slightly deformed. The heat exchanger shell flange is being examined by a mechanic. The butterfly valve installation is typical. Note how the bolts extend across both flange faces and are exposed to any flange fires. The effect of the flame impinging on the adjacent pipe and on the concrete column can also be seen.

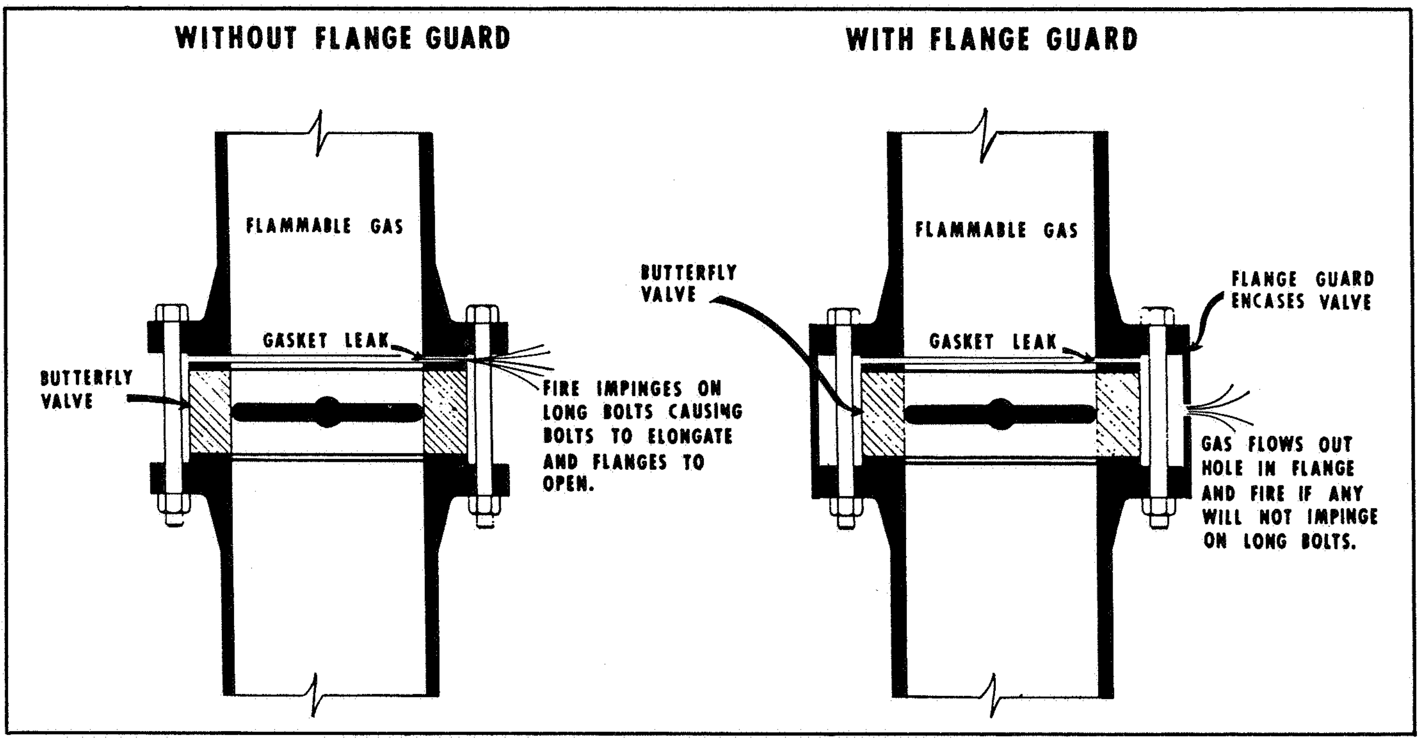

Figure 2. Cross section of butterfly valve.

Figure 2 shows a cross section of a typical butterfly valve. The left figure shows the valve without a flange guard. The bolts, 10-12 in. in length and 1½ in. in diameter, are exposed in the area between the two pipe flanges. These long bolts are used at all double gasket joints and are a weak link in the piping system. They occur not only at butterfly valves but also at "spectacle" blinds and "dutchman" flanges. In the case of a gas leak and fire, the fire impinges on the long bolts causing the bolts to elongate and the flange joint to open. Protection of the bolts from flame impingement would have reduced the bolt elongation and severity of the fire.

For this reason, flange guards were designed to protect the bolts from flame impingement. The right illustration shows a butterfly valve with flange guard in place. Each guard has a leak-off line or vent hole punched through the guard. A gas leak inside the flange cover would displace the air from within the enclosure and leak out the vent. Due to the lack of oxygen, ignition of the gas should occur outside the enclosure and fire, if any, and will not impinge on the long bolts. Thus, the long bolts are protected from flame impingement and bolt elongation should be minimized.

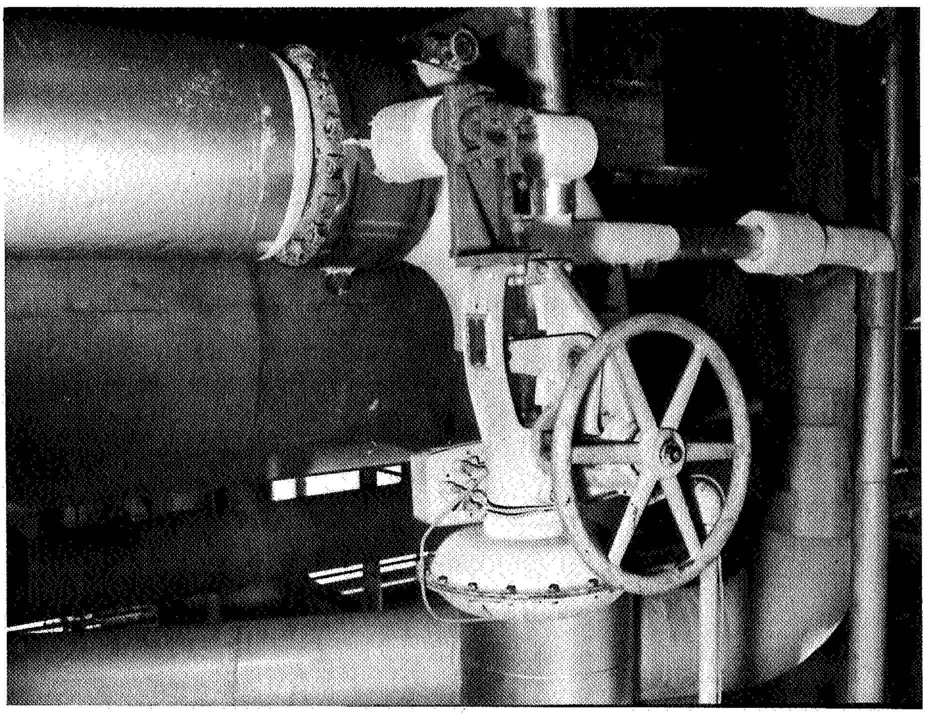

Figure 3. Butterfly valve installation with flange guard in place.

Where the flanges were fully insulated, there was already a material barrier and only leak-off lines or vent tubes were added to direct the gas away from critical areas.

Figure 3 shows a typical butterfly valve installation with the guard in place. The metal guard is sealed both circumferentially and at the yoke intersections using a heat resistant caulking compound. Where gas leaks occur at the valve packing glands, a metal guard and leak-off line was formed to direct the flow of gas away from equipment.

Figure 4 shows a horizontal pipeline flange opening directly into the pathway of conduit and cable tray carrying all thermocouple and instrument air control lines from the central control room to the ammonia converters. Protection of the flange with a guard will assist in directing any leaking gases away from the cable tray and should the gases fire, the flange guard will reduce the hazard to plant instrument control at this point.

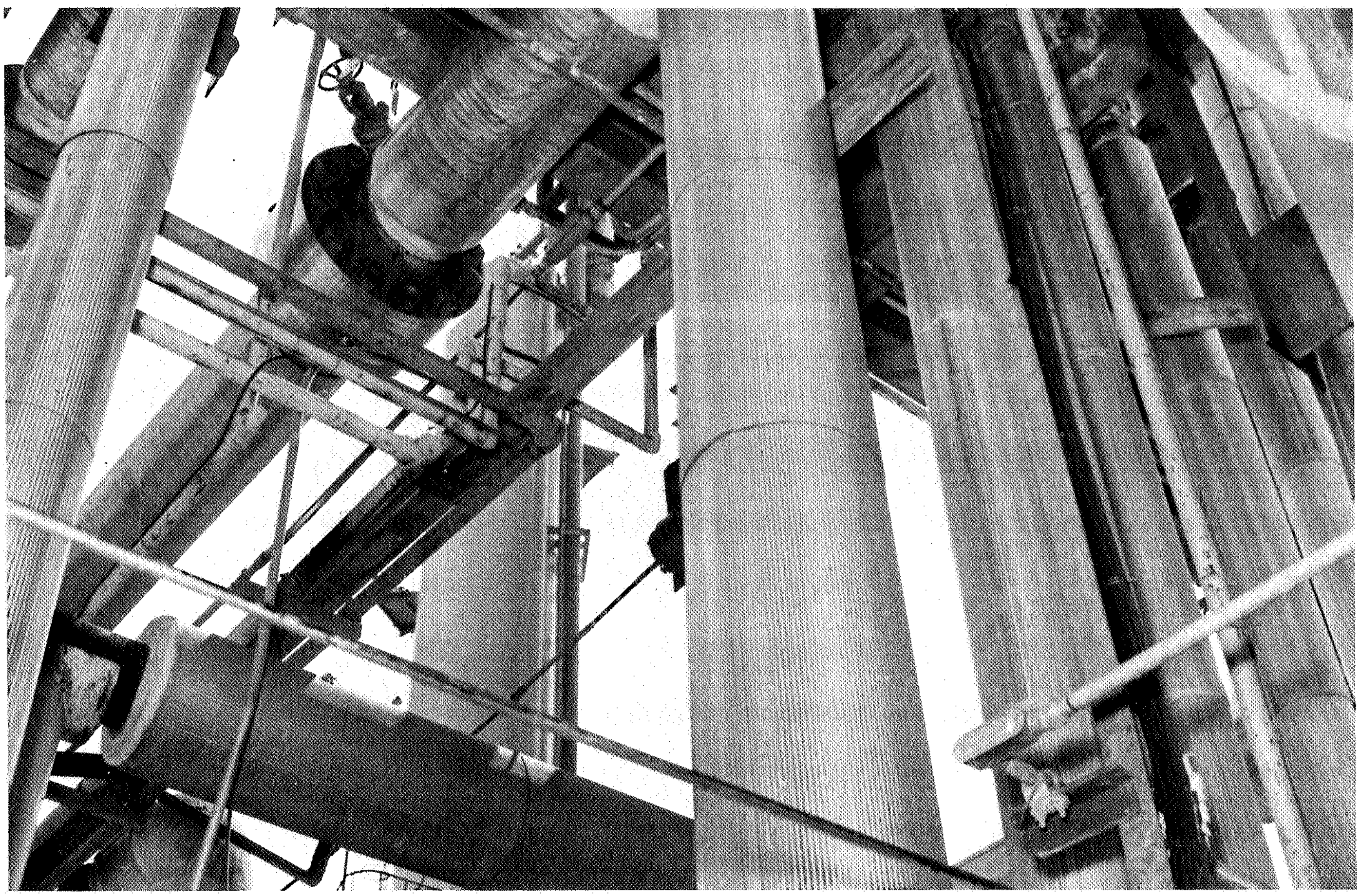

Figure 4. Location of pipeline flange with respect to adjacent piping and instrument tubing.

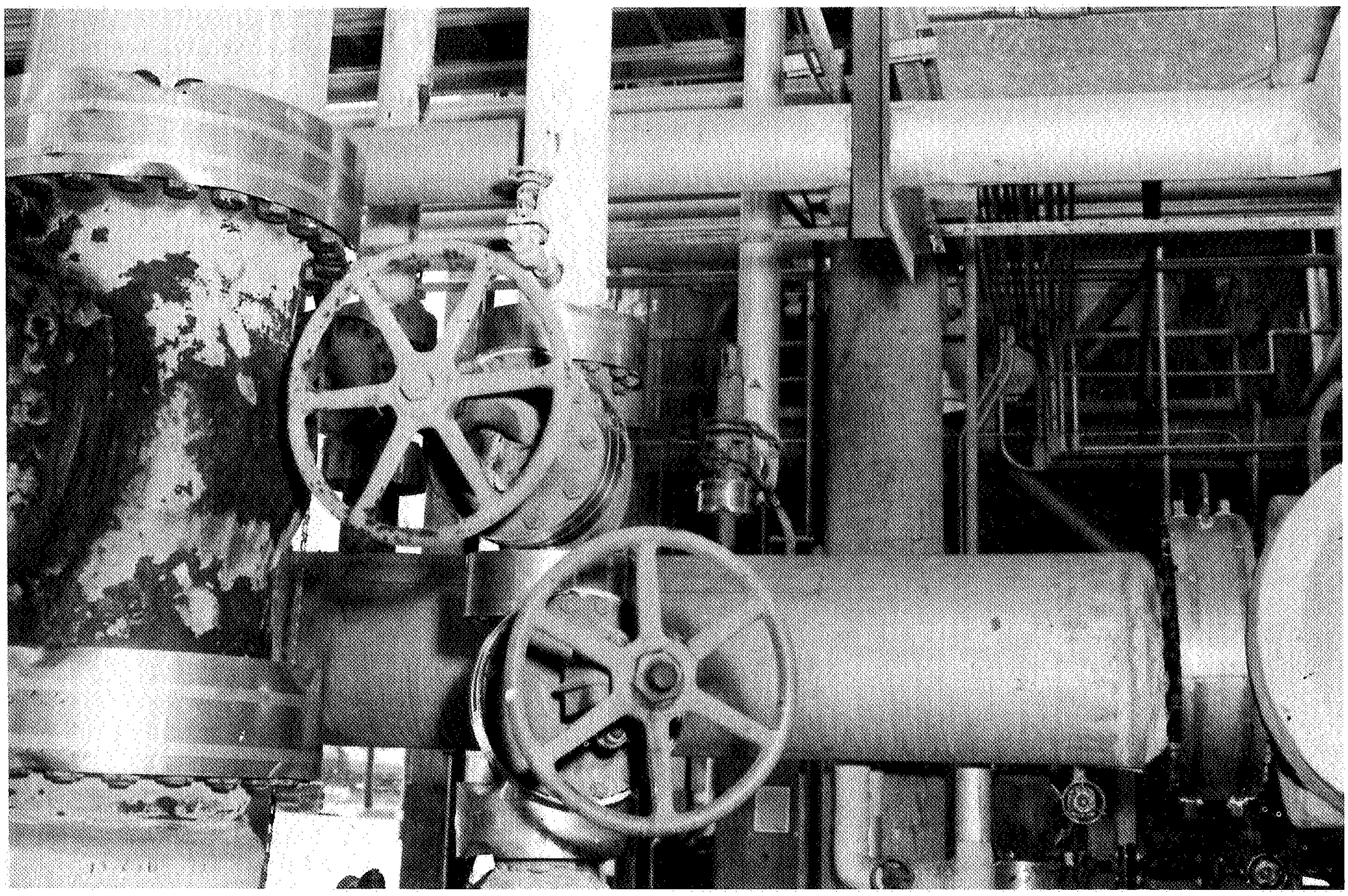

Figure 5. Multiple flange locations expose major electrical wiring and overhead instrument tubing to damage in event of fire.

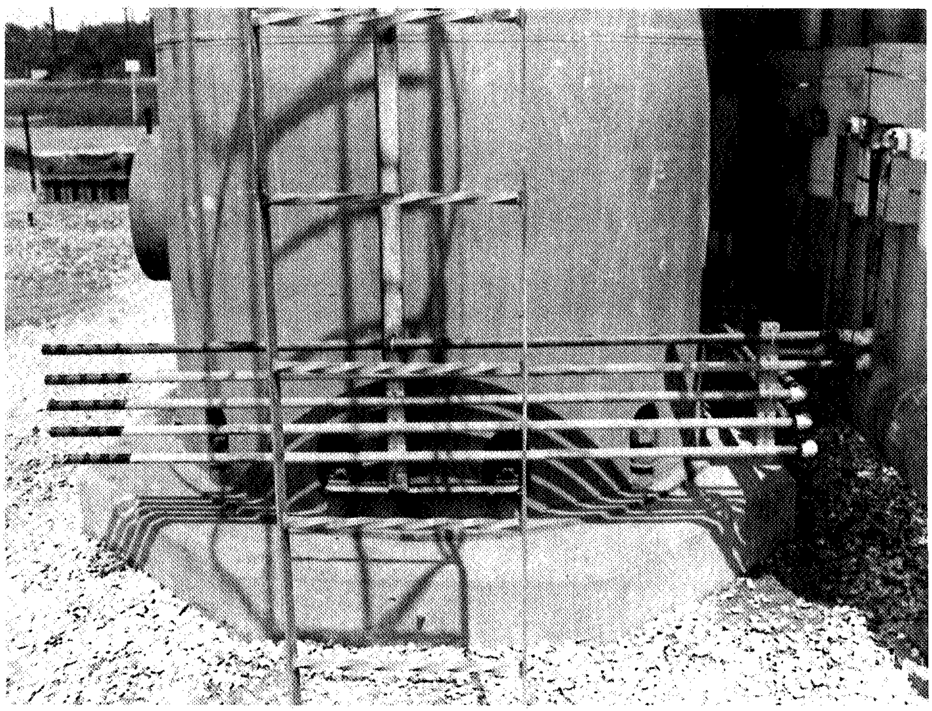

Figure 6. Insulated flange vent lines improve ability to detect leaks.

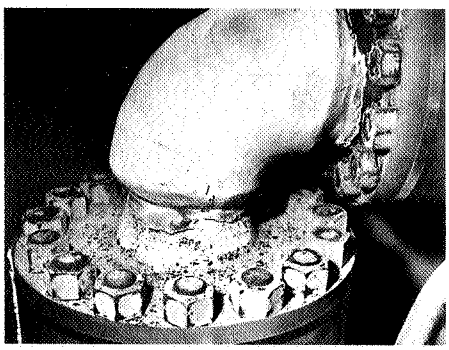

Figure 7. Large nozzle flanges with flange covers in enclosed areas reduce hazards of flame impingement on vessel supports.

Figure 5 shows multiple flange locations including a large horizontal pipeline flange. A flange fire at this point could impinge on the major instrument cables and cause loss of the plant instrument control. Guarding the flange will again reduce the hazard. Here also can be seen the extent of the guarding program with 11 flanges guarded.

As mentioned previously, insulated flanges give a natural barrier and need only to be vented. Figure 6 illustrates the use of leak-off vents from insulated quench valves on one of the ammonia converters. The close spacing and insulation made detection of leaks difficult. With the new leak-off system, using 1 in. pipe arranged for easy access, detection of leaks has become relatively simple and exact.

Flange guards help

The installation of flange guards on process piping has increased awareness of flange leaks and the particular problems they would present to the operating plant. Where a flange guard may help control bolt elongation, it would not stop heat degradation of asbestos gaskets. A review of process piping indicated asbestos gaskets in 300 psig service would be most susceptible to degradation by heat and cause failure at the flanges. To prevent this type of failure, there is a program to replace all asbestos sheet gaskets in process service over 150 psig with spiral wound, asbestos filled metal gaskets. The spiral wound metal gaskets will take more temperature than the asbestos sheet.

Figure 7 shows another area of concern in preventing major damage from process flange fires; a nozzle flange located inside the supporting skirt on a major vessel. A flange fire at this location would impinge on the skirt and possibly buckle the supporting steel and topple the vessel. An external fire could have the same affect on steel structures and skirts supporting other major vessels. The use of fireproof insulation to protect the supporting steel on major vessels from flame impingement and/or heat is being considered.

The measures taken are only a beginning in the prevention program. Two additional followup steps are required: checking all flanges on a routine basis for leaks with tightening during operation and use of a tightening procedure for all flanges during a shutdown.

Flanges are checked once a week. This has been accomplished by providing checklists that are part of each operator's daily patrol of the plant. Using a MSA explosimeter, the operator checks at each flange guard vent hole for explosive atmospheres. Those showing positive tests are checked with a bubble tube to determine pressure. If a positive pressure is ascertained, the flanges are hot tightened. In the absence of positive pressure, the flange is marked for shutdown repair. This weekly inspection procedure and reporting of leaks has improved plant tightness and given control of existing leaks. Maintenance forces now have the knowledge of flanges needing shutdown repair to give a plant with no flange leaks. It also has helped improve field welding safety procedures by giving knowledge of leaks previously unknown and undetected.

On shutdown, all flanges in hot service (above 200°C) are tightened when the flanges are cold. Any flange that is broken during the shutdown will also be hot tightened after startup. These steps add to shutdown work load but it is felt that they will reduce flange leaks during operation.

To sum up

In summary, it is believed that this program will eliminate serious flange fires and that with advance knowledge of leaks, repairs can be made during planned shutdowns. The elimination of fires and emergency shutdowns will go a long way to improve safety and building operator morale. #

R. A. Watkins is senior supervisor, Manufacturing Div., Explosives Department, DuPont Co. He is a member of the supervisory group responsible for the production of ammonia in the 1,000 ton per day plant built for DuPont by M. W. Kellogg Co. at Beaumont, Tex. He has held various technical and production positions in New Jersey, West Virginia and Texas during seventeen years service with DuPont. Watkins graduated from Bucknell University.

Discussion

Q. One of the problems with hydrogen fires, at least on a theoretical basis, is that you sometimes don't know if you have them, until—well, for quite a while. Were these where you showed the damage immediately apparent or had they perhaps been buring for some time before they were found, do you know?

WATKINS: In both instances, the fires were found immediately. In each case we had a report and a harmonic sound that existed throughout the plant to warn the operator that a problem existed. Since that time we have been successful in detecting flange fires using our flange guards. We had known that the particular flanges involved in these fires had 100% explosimeter rating and that by keeping the operators aware of this on their patrols, they discovered a fire occurring at one flange and were able to add steam underneath the flange and actually control it.

We have found since that time that it's very necessary to keep the air out of these particular covers, and have underway a program of rechecking the leaking flanges each week to determine that the circumferential seal is tight and that all of the seals around the various intersections of the pipelines and the cover have the caulking compound in place.

Q. You mentioned in connection with the degradation of asbestos jointing material that you were replacing these with re-enforced gaskets in services above 150 lbs./sq. in. Is there any temperature limitation of this too?

WATKINS: Actually what we're saying is that we have no temperature limitation because what we're concerned with is the external fires. In the event of the external fire we have heat, and this heat tends to cause the degradation of asbestos, not the process temperature. Replacement of gaskets was for protection from external fires not process pressure and temperature.

Q. I gather that this weekly tightening that you do is a normal practice for your maintenance people, and I wondered what precautions you took before tightening under pressure, since there are many types of flange joints or many types of connections which can leak. We've had many discussions with our safety department and they are dead against tightening under pressure. We do it at times, but we take each individual leak and consider the various merits of tightening or not tightening without a shutdown at the time. Could you give us your general policy on this?

WATKINS: I think we tend to agree with your safety department's attitude on this. We consider each individual flange leak on its own merits as to the degree of explosimeter reading that we have, the degree of pressure involved and the location of the leak. In addition we look very carefully at the access to and from the particular area in which the men work. We are also using "Nomex*" nylon fibre hot suits for this type of work in the event that we do have fire at that point. Thus, the men are protected. These "Nomex*" nylon fibre suits have been used very effectively by automobile race drivers for fire protection during crashes. We feel that these procedures have helped our people feel more secure under these circumstancs.

Q. Do your maintenance people make use of torque wrenches during this typing procedure?

WATKINS: Yes sir, they do. In 100% explosive atmospheres we would not use anything but torque wrenches. We do not use hammer wrenches or impact wrenches in hazardous flanges.

E. W. OWEN, Humphreys & Glasgow, Ltd., London, England: We have built over 120 reforming units, most of which are based on naphtha feedstock. I would like to make one or two observations from our experiences with leakage of hot flanges on naphtha hydrodesulphurisation equipment.

In view of the relatively low fluid flows in relation to equipment size, it was considered necessary at the design stage to lag flanges to maintain temperatures. On the early plants, fires occurred at several of these flanges. In some cases the fire was at some distance from the flange, and was traced to naphtha from a leaking flange spreading behind adjacent lagging. To prevent such spreading, stopper plates were considered for fitting close to the flange. As far as the insulation on the flange itself was concerned, the normal commissioning practice was to remove the lagging and leave the flange exposed to atmosphere.

From an analysis of several sites it became clear that the flanges which caused fires were probably leaking before insulation was applied. The application of lagging resulted in the leak becoming sufficiently hot for auto-ignition to occur. Providing the flange was not leaking in the unlagged condition, however, lagging could safely be applied and has been applied satisfactorily in many instances. It is, therefore, now practice to pay greater attention to leak testing of such flanges before lagging application.

The quality of construction work has clearly been a factor effecting flange fires. Where construction quality has been good, flange fires have been rare, but where construction has been generally difficult, flange leakage has been more prevalent.

Once satisfactory lagging has been achieved, this appears to have been a benefit and resulted in little subsequent trouble or fire—possible related to the point which Mr. McFarland made, namely that on start up lagged equipment is less prone to differential temperature stresses with less consequent risk of leakage.

---

* Reg. U.S. Patent Office, E. I. du Pont de Nemours & Co., Inc.