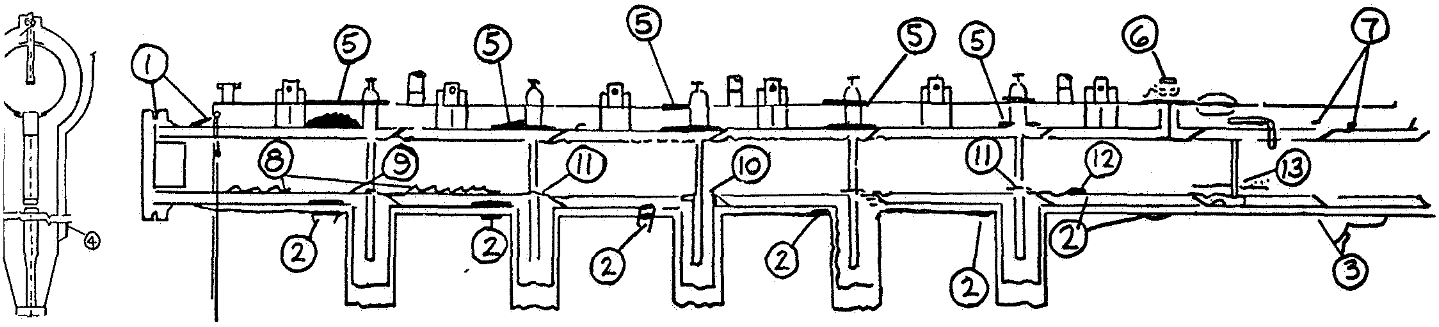

Numbered areas indicate cutouts for inspection and repairs.

Figure 1. Outline of transfer area.

Transfer Line Failure

When problems with transfer line insulation or liners are discovered, new ones should be installed since they are very costly to repair or fabricate when in place.

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FARMLAND INDUSTRIES OPERATES 600 TON/DAY TURbine drive, centrifugal compressor type ammonia plants at Fort Dodge, Iowa and Dodge City, Kansas. At each, synthesis gas is made at high pressure in a down fired reformer using several rows of HK-40 alloy tubes delivering to bottom incoloy headers attached by riser tubes to an internally insulated, water jacketed header. This header is welded directly to the secondary reformer. The Dodge City plant, with bubbled alumina insulation in the transfer line, was put in operation the fall of 1968 and has had no transfer line or serious operating and mechanical problems with major equipment. The Fort Dodge plant, using insulag insulation, was put in operation the fall of 1966 and did not experience known insulation and transfer line problems until early 1969 following prolonged startup difficulties while the weather was unusually cold. Visual inspection of the liner and insulation as late as last fall did not reveal serious impending trouble.

Insulation failure

From the start of operations, water boil-off from the jacketed systems appeared higher than anticipated and slowly increased with time until a rapid rise occurred a few days before line failure. During this last stage, it was periodically necessary to supply additional condensate through a hose to the transfer line jacket. The level was erratic and steam production increased threefold. A short time prior to failure, the reformer was operated for several hours at low process gas rate and low pressure while repairs were made on a frozen flange at the far end of the empty water jacket. This operation may have accelerated the insulation failure. Over the years, the indicated riser outlet and the transfer line temperatures dropped from about 1,500° F to 1,200° F, a decline that was largely attributed to faulty thermocouples rather than to deteriorating insulation around the couples and in the transfer line itself.

Despite lack of accurate and definite boil-off data collected over a period of time, and evident faulty thermocouples in the risers, there were sufficiently reliable indications immediately prior to the failure to have warranted a shutdown. In fact, even with sub-zero weather conditions, maintenance repairs were being planned the morning of the failure. The line ruptured about 10 a.m. on January 30, 1969 during otherwise

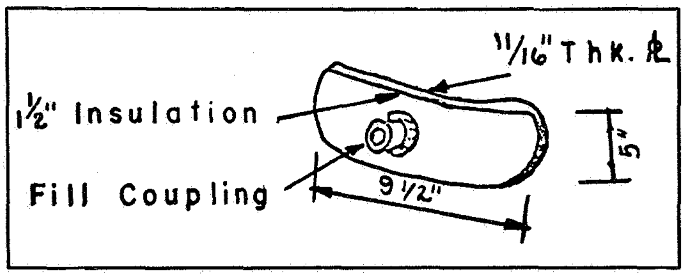


Figure 3. Typical bottom cut-out.

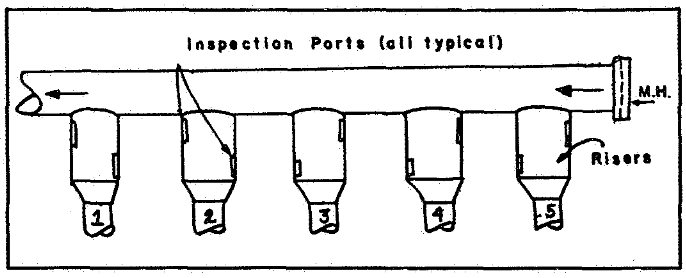


Figure 4. Water jacketed risers.

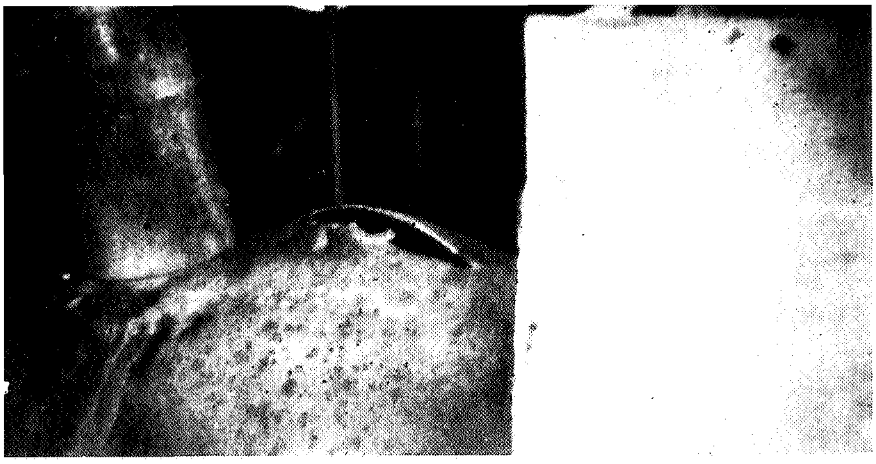


Figure 2. The transfer line rupture.

normal design operations. The mixture of gas and steam vented mostly through 6 in. vents with turn-down elbows above the roof, although some gas escaped and burned for a short time from openings around the transfer line thermocouples. There were no injuries to personnel and only minor damage to structural steel, instrument wiring, etc., in the penthouse, but considerable damage resulted to a part of the roof covering under the vents. There was a sudden, violent movement of the inlet process gas and fuel headers, but no failures or leaks developed at that time and none were found during subsequent inspection and tests.

During previous yearly routine inspections of the liner and insulation in the transfer line, there was only minor evidence of liner buckling or of soft or missing insulation. It was difficult to thoroughly inspect the entire liner and riser areas because of close clearances and interference from the thermocouples which, at this plant, could not be removed because of overhead structural steel.

Following the transfer line rupture it was considered prudent to inspect the other major equipment suspected to have been adversely affected by emergency shutdown, or which could be developing insulation problems similar or related to the actual failure.

During the emergency shutdown prior to the transfer line rupture, it had been necessary to repair the welds on the bottom tees of #1 and #3 headers and to replace a damaged section of #5 collector header. After the transfer line rupture, all of the tees were again x-rayed and found satisfactory, and all riser welds under the stainless steel protective cans were again x-rayed. Repairs were required to cracked welds on #3, #4, and #5 risers. Other repairs included build-up of a corroded section of #1 collector header and cut-off of eleven reformer tubes on #1 collector header to remove bubbled alumina inadvertently spilled into that riser and which found its way up to the reformer tube catalyst supports. Nine of the eleven tubes were rewelded to the bottom incoloy tees without unusual difficulty, but eventually it was necessary to replace short sections of two tubes and #5 riser in order to secure good welds. In making these repairs we used all of the usual procedures plus the following special precautions which we recommend for the success of such an undertaking:

1. Completely eliminate the porosity on the inside of tubes by grinding back about 1 in. to increase the reformer tube diameters by about 0.2 in.

2. Prepare the levels for a near perfect match with 1/16 in. flats and a 1/16 in. space for the TIG weld.

3. Preheat the tubes to 175-200° F and use 82 or 310 HC 0.3% to 0.5% C rod.

4. Dye check and x-ray the filler pass to insure that there are no cracks and x-ray the final welds.

Primary reformer transfer line

Removal of the top sections of the water jacketing for inspection of the pressure line revealed a 16 in. rupture near the #5 east riser and several bulged areas which are described further with reference to marked areas on Figure 1. A photograph of the rupture is shown in Figure 2.

1. The manhole cover, cerafelt insulation on the east end of the transfer header, was removed revealing the insulation retaining ring around the shroud. The ring was pulled loose from the inside diameter of the manhole flange. The ring was rewelded, including a small crack in the water jacket on the north side, and behind the manhole above where a recent repair had been made to the water jacket.

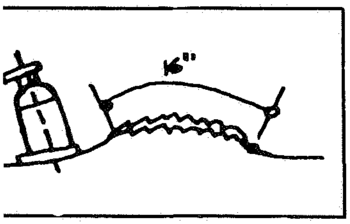


Figure 5. Rupture area.

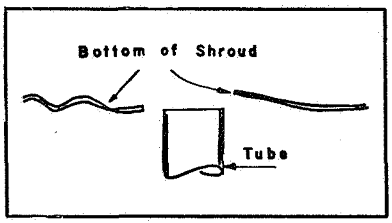


Figure 6. Shroud at tube near rupture.

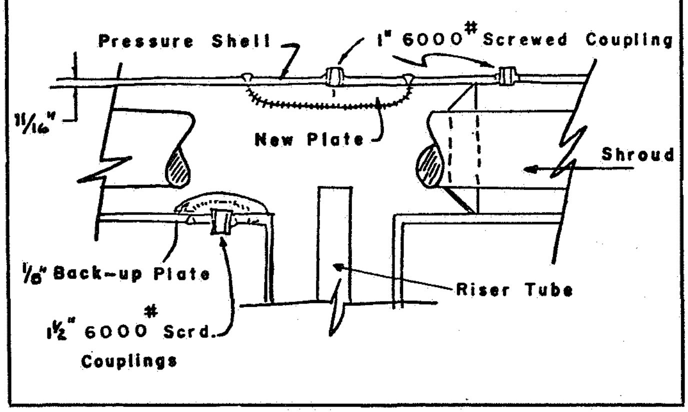


Figure 7. Pressure shell area.

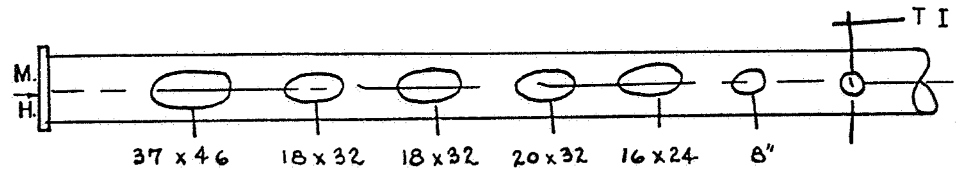


Figure 8. Top pressure shell cut-outs.

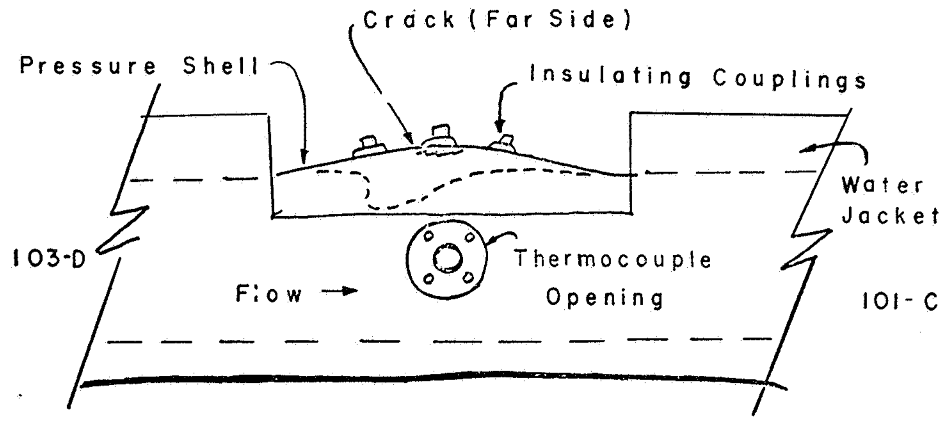


Figure 9. Side view of transfer line between secondary reformer and boiler.

2. On the bottom of the header, inspection and insulation removal plates were cut out from the water jacket and pressure shell. The size of pressure shell plates are approximately 9½ in. x 5 in. and each plate received a 1½ in. 6000# screwed coupling as shown in Figure 3. New plates were welded in the bottom of the header as shown on Figure 1. Each has a ⅛ in. thick back-up plate. All welds were x-rayed and dye checked, but pressure testing was not required.

3. A pressure coupling was installed directly in the pressure shell to facilitate filling the line with insulation between the last riser and the secondary reformer.

4. All riser water jacketed areas and pressure shells were inspected, as indicated on Figure 4. Each riser pressure shell had two 8 in. round holes cut out to inspect the insulation. All risers were found in good condition and no insulation was required except on risers #2 and #4 where the insulation had been partially removed for inspection. This insulation was replaced with dry packed, shredded asbestos chips and the ½ in. thick ports were replaced with a full penetration weld. The water jackets were cleaned and the 3/16 in. plates were rewelded in place.

5. The pressure shell ruptured at this point on the top north side leaving a gash approximately 16 in. long and 2 in. wide at the most open point. A measurement of the steel at the rupture opening showed only 11/32 in. thickness. The rupture was east of the thermocouple and, viewed from the side, it resembled the contour shown on Figure 5. The tube opening was clear, but the shroud was flared up at the bottom near the tube and had buckles in the shroud on one side of the tube, Figure 6. The shroud was pushed back into place by heating and jacking. The thermowell was removed and the pressure shell was repaired with a 37 in. x 46 in. oval piece. A 1 in. 6000# screwed inspection coupling was installed in this piece directly above the tube opening.

The repairs to the pressure shell above the other risers were basically the same except for size. Each had a 1 in. 6000# screwed coupling welded nearly over the riser tube. There were bulges on the pressure shell on the top side east of the thermowells on all risers except the riser closest to the secondary reformer. Figure 7 illustrates the method used in repairing the pressure shell over the other risers and Figure 8 shows the top pressure shell repair plate sizes.

6. The complete thermocouple assembly was removed from the pressure shell and the insulation appeared to be in fairly good condition. Two couplings were welded on the thermocouple cap and the insulation was removed from the dome and the assembly rewelded to the header.

7. Screwed couplings (1 in. 6000#) were welded into the pressure shell at this location for insulating ports.

8. The bottom of the shroud was buckled at two points. They were left in the shroud.

9. The shroud around the tube, bent up at this point, was pushed back in place by jacking.

10. A crack, found to the side of the tube on the bottom side of the shroud, was repaired by welding.

11. The shroud had moved and pushed the side wall of the tube in slightly. The shroud was cut back to reestablish specified clearances.

12. A large hump in the bottom of the shroud was removed and repaired with a ⅛ in. thick stainless steel patch.

13. A crack found on the bottom of the shroud was rewelded.

Despite the fact that the insulation had been badly softened and partly washed out, it was still very difficult and time consuming to remove all of it through relatively small openings during sub-zero weather. Finally, 11,000 lbs. of insulation of the following composition was pumped into the heated line during about 16 hours total pumping time:

Alumina Al_2O_3 ....94.6%

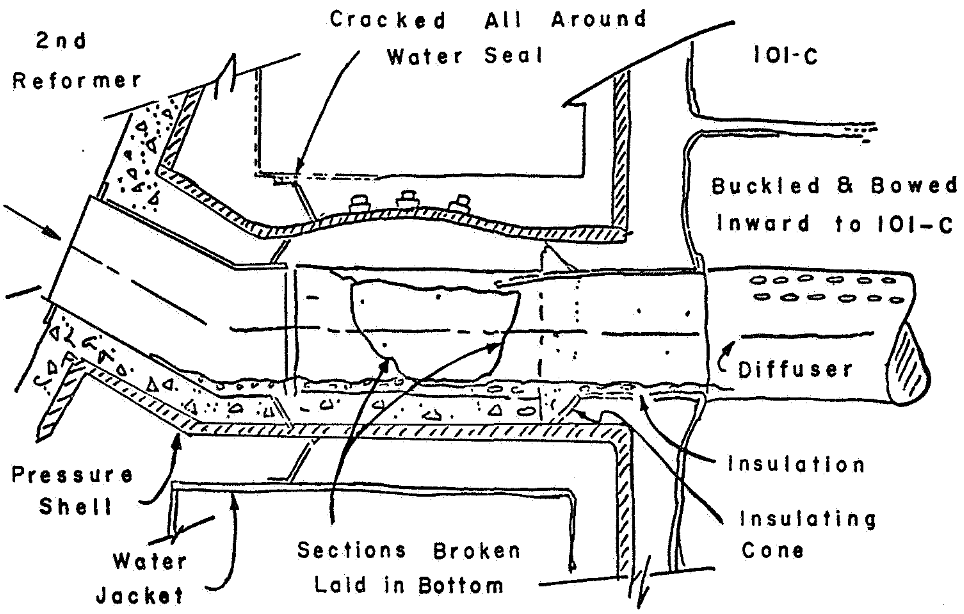


Figure 10. Half section view of transfer header between secondary reformer and boiler.

Silica SiO_2 .... 0.5%
Iron Oxide Fe_2O_3 .... 0.2%
Sodium Oxide Na_2O 0.4%
Calcium Oxide CaO 4.2%
Magnesium Oxide MgO 0.1%
Bulk Density–Dry .. 75 lbs./cu. ft.
Porosity ..68.0%
Thermal Conductivity B.T.U. @ 2,200 degrees 4.7°F.
Modulus of Rupture–300 to 400 psi cold
Cold Crushing Strength–1,300 to 1,400 psi

Stronger end hanger springs were installed to compensate for the 30% heavier insulation used in the reformer transfer line.

Following inspection of a similar reformer gas boiler producing 1,500 psig steam and with knowledge of a thermocouple-sample line failure between two vessels at another plant, it was decided to inspect this equipment at Fort Dodge. Necessary cut-outs were completed during the prolonged reformer repairs. The 4 in. crack, critical lining and insulation failures were revealed as indicated in Figures 9 and 10. A very hazardous rupture was imminent at this point and possibly along the lower shell of the boiler.

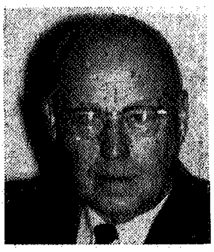
Again, it is very difficult to pump insulation during sub-zero weather and it is almost impossible to keep the primary transfer line and stainless steel liner reasonably warm except by using a fired blower type heater delivering hot flue gas into the transfer line. In our case, this precluded continuous inspection of the liner and riser during the actual pumping and eventually led to the spill which plugged several reformer tubes. This short section of high temperature insulated and jacket transfer line was repaired using the methods and materials described for the reformer transfer line. Simultaneously, it was necessary to repair the liner and to replace the insulag insulation in the boiler using bubbled alumina. This again is a very costly and time consuming job, especially during winter weather.

Recent inspection of the pressure piping, liner and insulation repairs indicates that the bubbled alumina pumped into the wrinkled liner during sub-zero weather and without use of cardboard filler materials remains satisfactory after six months operation.

Suggested improvements

The insulation and liner problems described emphasize the need for the following improvements:

1. Provide improved insulation (probably bubbled alumina) and improve the liners used in jacketed piping and vessels. Ceramic or heavier 25-20 material is suggested for lining boilers.
2. Eliminate the thermocouples in risers to reformer transfer lines. These thermocouples are unreliable and make inspection of such lines very difficult.
3. Maintain a record of boil-off from jacketed piping and vessels. This information will indicate the average condition of the insulation, although it cannot reveal hot spots where the insulation is missing.
4. Provide level alarm at the far end of the reformer transfer line. This is necessary since the jacket water is fed from the secondary reformer and low level may occur at the far end when water usage is above normal.
5. Make careful, periodic inspections of the liner and insulation in jacketed equipment. This can be accomplished by visual inspection, hammer tests, cutouts of the lining, and possibly by x-ray methods.
6. When insulation or liner problems are developing, make plans immediately to purchase or fabricate new liners and for insulation to be installed during normal, mild weather inspection-maintenance periods. From our experience, it is far too costly and time consuming to repair or fabricate liners of any type when they are in place. Field repairs will double or even triple the costs for a patch job over use of new prefabricated materials. #



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