REFORMING SYSTEM FAILURE

Failures of flexible hoses and expansion bellows due to stress corrosion cracking. Potential for trouble exists when chlorides are present

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During the month of February, 1966, we experienced a series of failures in our reforming system. On February 4 we developed a 3-in. crack in the stainless steel expansion bellows on the shell of our exchanger, E-101, exchanging heat from process gas out of the methanator to natural gas from the desulfurizers. At the time we thought this was a failure of mechanical origin and came down just long enough to pull the bundle out of the line and pipe a bypass on both sides of the system. We continued to operate while a new expansion joint of more rugged construction was fabricated.

About two weeks later when swinging desulfurizers, we had an immediate rise in primary reformer outlet temperature, from about 1,325 F. to 1,500 . We continued to operate at high steam-gas ratio to relieve the obvious poisoning of reformer catalyst while we went about determining what happened.

Flexible hoses ruptured

The next afternoon we observed two of the flexible stainless steel hoses on the primary reformer inlet to the radiant tubes leaking slightly. Our reformer actually is two cells, so we have two feed headers and each of these hoses was at an end of one of the header runs.

About four hours later one of these flexible hoses ruptured. There was no fire or damage except to the hose itself and an orderly shut-down was conducted.

The presence of excessive quantities of carbon in the area of the failure gave us confirming information that the basic trouble was in a desulfurizer carbon bed. Investigation showed the bottom screen of the south desulfurizer had failed. Carbon was found in the bottom of the desulfurizer vessel and at each end of the two horizontal runs of the primary reformer feed header. The last flexible hose at each of the four ends of the headers was full of carbon, including the top of the reforming tubes. Those were the only places where we found carbon. No other hoses, tubes or equipment had any carbon particles.

On removal of the desulfurizer screen, which is 30-mesh, it was found to be corroded through in spots and completely plugged in other areas, with a mass which included carbon particles, carbon fines, metallic copper, and copper salts.

The cause of the trouble

What happened? Well, we knew that the carbon contained quantities of a copper chloride salt to enhance its sulpher removal capacity and we are familiar with the procedure to be followed to avoid corrosion. During the early phases of the startup and shakedown of the plant, however, these procedures, although followed, were not adequate to assure we stayed alkaline during the regeneration cycle and were completely dry before concluding the regeneration procedure.

The result – corrosion, deterioration and pluggage of the screens and subsequent chloride carry-over to downstream stainless equipment.

A number of corrective actions were taken:

1. Procedures were changed to assure we were always alkaline during regeneration and were blown dry before concluding the regeneration procedure.
2. The drain system was improved on the desulfurizers.
3. Inspection ports were installed underneath the beds to permit periodic inspection of the screen and supports.
4. The catalyst support system was revised.

A subsequent investigation of the E-101 expansion bellows and the flexible hoses on the reformer indicated that these failures were due to stress corrosion cracking.

On talking with associates in the industry, it is apparent that most everyone is aware of the presence of chloride in their desulfurization carbon where appropriate. Many, however, are not fully appreciative of the potential for trouble that exists unless adequate protection is provided in the mechanical design and close operational attention is paid to the procedure involved.

Piping failure on reboiler

Another piping failure occurred on March 9, 1966, at the elbows coming out of the MEA regenerator reboilers on the synthesis gas side. In our plant the raw synthesis gas after leaving the first shift converter exchanges with gas going to the second shift, cooling to about 625 F. This gas is then direct contact quenched to 343 F. and from there it is used to reboil. This gas leaves the reboilers at 270 to 280 F. and 190 pound gauge.

Coming out of the reboilers we have carbon steel short radius elbows combining at a tee for a short horizontal run before rising to the overhead pipe rack. The failure occurred on the outside of one of these short radius elbows, laying open a hole about 3 in. long and about 1 in. wide. The plant in depressuring itself through this opening blew a hole in the ground about 4 ft. deep and about 6 ft. in diameter.

On examination, this elbow was paper thin on its outside radius. When we hammer-tested the corresponding elbow on the other reboiler, the hammer penetrated the pipe.

We were aware of the possibilities for failure in this section of the piping system from previous experiences of others, including those written up in earlier symposium notes. Because of this, we had inspected these elbows and the horizontal piping runs visually and with instruments during a period of downtime about six months earlier.

It is our feeling that this failure was caused by the erosive action of the two-phase mixture aggravated perhaps by the piping configuration including the short-radius elbows. At the time we also had a comparatively high level of solids in the synthesis gas stream due to problems with refractory in the secondary waste-heat boiler.

For a fast repair, we replaced both elbows and the tee with carbon steel as this was immediately available. In July of this year we installed stainless elbows and tee and put a flange in the line.