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 SUBJECT: Bellows Failure in Solids Separation
 Loop of the HRT Mockup

TO: P. H. Harley

FROM: T. M. Kegley, Jr. and J. P. Hammond

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Introduction:

Two type 347SS bellows from the Solids Separation Loop of the HRT Mockup were received for metallographic examination. The loop, in which the two bellows were located, was circulating 10 gm u/l uranyl sulfate solution containing about 100 ppm oxygen at 300°C. The bellows which failed had operated 183 hours before failure. The two bellows were also exposed to oxide solids which were placed in the system for studying the efficiency of the solids separator.

There was a possibility that the bellows were also exposed to fluoride and chloride, since deposits found in pitted areas elsewhere in the Mockup system were shown to contain 2000 ppm fluoride and 25 ppm chloride. It was suggested that the fluoride was introduced through the use of impure solids.

Solids were injected adjacent to the block valve containing the failed bellows. The two bellows operated probably at a somewhat lower temperature than the loop temperature of 300°C.

The failed bellows was sealed in the block valve by means of a gold gasket which was seated on the base of the bellows.

Procedure:

A section was taken through the break in the wall of the failed bellows shown in Fig. 1. The second bellows assembly from the solids separation loop was sectioned at E, as shown in Fig. 8. The two sections were then polished and examined metallographically.

Results:

The severest attack of the failed bellows assembly occurred on the uranyl sulfate side in the base to which the bellows was joined and in the portion of the wall of the bellows nearest the base. The break in the wall of the failed bellows is shown in Fig. 1b and at A in Fig. 2. The corrosion attack at the break was general in nature in that the attack did not follow an intergranular path. However, there was transgranular cracking in a region adjacent to the break-through (B, Fig. 2). This transgranular cracking is shown in Figs. 3 and 4.

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Portions of the surface of the outer ply of the wall of the failed bellows were covered with an oxide layer on the side adjacent to the uranyl sulfate solution. This oxide layer is shown in Fig. 5.

A serious cracking situation existed at one end of the weld juncture between the failed bellows and the base. The cracking had progressed almost through the base, as seen at C in Fig. 2. This cracking, shown in Fig. 6, was transgranular.

Severe corrosion was evident on the surface of the base, as shown at D in Fig. 2. Also, numerous transgranular cracks in addition to the crevice attack were found in the crater at D (see Fig. 7).

Two specimens taken from the base of the failed bellows assembly passed the 65% boiling nitric acid test with an average penetration rate of 1.0 and 0.8 mils per month, respectively.

Transgranular cracks also appeared in the second bellows, although these were not as severe. These transgranular cracks occurred at F as located in Fig. 9 and are shown in Fig. 10. The maximum depth observed for these cracks was about 4 mils. Cracks also occurred in the weld which joined the second bellows to the base as shown in Fig. 11.

Conclusion:

The failure of the valve bellows would appear to be due to a combination of stress corrosion and crevice corrosion. Stress corrosion occurred as evidenced by the transgranular branched cracking found in the bellows and in the base which was joined to the bellows. It seems probable that chlorides were present, which, along with the residual stresses present in the bellows assembly, created the necessary conditions for stress corrosion to occur. Crevice corrosion occurred probably due to heavy deposits of solids at the base of the bellows, which created a condition of oxygen impoverishment. While the crater in the base may have been related to a galvanic effect created by the gold gasket, the contour of the crater (D in Fig. 2) would suggest that the cause of the crater was due more to crevice corrosion.

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T10829 (a)

T10827 (b)

Fig. 1. Failed Block Valve Bellows From Solids Separation Loop.

(a) Bellows and Plug Assembly (b) Break in Bellows Wall

T10847

4.5X

Fig. 2. Section Taken Through Break in Bellows.

Fig. 3. General Corrosion and Cracking at B.
As Polished.

250X
Fig. 2,

Fig. 4. Transgranular Cracking at B, Fig. 2. Specimen Etched
With Glyceregia.

T10850 250X

Fig. 5. Oxide Layer on Outer Ply of Bellows. Specimen Etched With Glyceregia.

T10848 50X

Fig. 6. Transgranular Cracking in Base Near Juncture Between Bellows and Base. Location at C in Fig. 2.

Fig. 7 T10853 150X
Transgranular Cracks in Pit in Base at D in Fig. 2.
Etched With Glyceregia.

Fig. 8. T10830
Second Bellows and Plug Assembly from Solids Separation
Loop. Section for Metallographic Examination Taken at D.

T11201

Fig. 9. Section Taken at E, see Fig. 8. Second Bellows from Solids Separation Loop.

T11200

Fig. 10. Transgranular Surface Cracks at F, See Fig. 9.

T11199

Fig. 11. Second Bellows from Solids Separation Loop. Cracks
in Weld at G, Fig. 9.