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General Electric Company
KNOLLS ATOMIC POWER LABORATORY
Schenectady, New York

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EXAMINATION OF SLG SODIUM STOP VALVE BELLOWS

by

J. M. Gerken

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H. B. Roopman
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Introduction

Two 8-inch sodium stop valve bellows Nos. RP115T and RP116T which had been endurance tested in sodium at Mine Safety Appliance Co. were received by Welding Metallurgy and Development for evaluation of the bellows welds.

In addition, a 2-inch sodium stop valve bellows which leaked at a point on one of the outer welds was received for determination of the cause of leaking.

This 2-inch valve had been in test at Mine Safety Appliance Co. in a loop constructed to simulate the S2G drain system. The draining procedure was performed three times after which the valve was removed from the system. A mass spectrometer leak check of the valve bellows at MSF showed the bellows still to be leak tight. The valve was shipped to West Milton for the purpose of connecting into the S1G system. However, it was mass spectrometer leak checked again and this time was found to leak at one of the outer bellows welds. The standard procedure at KAPL is to work a bellows in and out a number of times before leak checking to remove any deposits of dirt or oxide which might plug a leak. It is likely that this final working could have opened up any cracks which were already present. The material used in all bellows was type 347 stainless steel.

Conclusions

8-inch-Stop Valve Bellows

1. Both 8-inch sodium stop valve bellows were mass-spectrometer leak tight after mechanical cycling tests in 850°F sodium.
2. Visual inspection of the bellows edge welds indicated some variation in the thickness of the weld bead.
3. The minimum weld throat was at least equal to the thickness of the discs comprising the bellows.
4. Examination of representative sections of the inner and outer edge welds showed no evidence of the crevice between the discs progressing into the root of the weld.

2-inch-Stop Valve Bellows

5. The weld in the region of the leak in the 2-inch bellows was found to be severely oxidized internally. This was an indication that the flow of inert shielding gas failed momentarily during welding.

Procedure

Initially, all three bellows were mass spectrometer leak checked to determine the presence and location of any leaks.

Each bellows section was severed from the test assembly, then cut longitudinally into two halves. All inside the outside bellows weld beads were examined visually for lack of fusion, cracking, variation in weld thickness and eccentricity. Representative bellows halves were cut up into smaller pieces so that cross sections of a number of welds could be examined.

Sections from the vicinity of the leak in the 2-inch bellows were prepared for metallographic examination.

Results

Mass spectrometer leak testing of bellows Nos. RP115T and RP116T indicated that both bellows were leak tight after the cycling treatment listed in Table I. Visual examination of inside and outside welds on both bellows revealed some irregularity in the width and thickness depth of the weld beads. However, examination of several macro sections of the welds indicated that the minimum throat depth was never less than the thickness of a bellows disc. The relative variation in weld cross section is shown in Figure 1.

Leak check of the 2-inch bellows showed one leak in an outside weld. This valve was intended for service as a sodium drain in the SLC system at West Milton but was not used on account of the leak.

Visual examination of the welds showed a greater variation in thickness than was noticed on either of the 8-inch valve bellows. The quality of the welds was generally poorer than that of the 8-inch valve bellows. A few instances were found in which the weld throat was somewhat less than the disc thickness.

Metallographic examination of several weld sections taken in the region of the leak indicated that the weld metal was spongy and cracked. Figure 2 is a section at the root of a weld showing the spongy condition at the outer edge and just under the crevice between the two discs. Cracking occurred only in the area of the spongy weld metal. It can be seen that the root crevice did not propagate through to the weld crack near it. Other weld sections in this area exposed similar spongy conditions and cracking in the weld, as shown in Figures 3 and 4.

The spongy area was concluded to be a highly oxidized or burned area caused by momentary failure of the inert gas flow from the welding torch. These areas were weakened by this condition and finally cracked completely through the weld as a result of repeated operation of the valve.

It can be seen from Figure 2 that no stress corrosion cracking or fatigue cracking occurred outward from the root of the weld but that the failure resulted from a defect in the weld metal.

Table I

Mechanical Cycling History of 3-Inch Sodium Stop Valve Bellows

Bellows No. RP116T

1. Cycled 90,000 times with 4 min. time delay between strokes (8 min. cycles)
2. 12,819 hours immersion time.

Bellows No. RP115T

1. Cycled 9,720 times with a 4 min. time delay between strokes (8 min. cycles)
2. 1521 hours immersion time.
3. Also, cycled 430 times, in compressed position (open) 8 hours, and in extended (closed) position 16 hours (24 hour cycles) except over weekends when kept extended for 53 hours.
4. 11,115 hours immersion time.

Total cycles 10,150

Total immersion time 12,639 hours

References:

1. Letter: RT Flickinger to JM Gerken dated October 19, 1956 - Subject: Cycling Tests of S2G Bellows No. RP116T and RP115 Performed at Mine Safety Appliance Co.
2. Memo Report 107 Two-Inch Stop Valve Test With Sodium - CE Kennedy and EC King - Mine Safety Appliance Co. - March 5, 1956

Figure 1 - Typical cross section of 8-inch stop valve bellows - Magnification 6X

Figure 2 - Section at junction of weld and discs on 2-inch stop valve bellows.
Note that cracks occur only in spongy areas - Magnification 250X

Figure 3 - Section from cracked area of 2-inch valve bellows - Magnification 100X

Figure 4 - Section from cracked area of 2-inch stop valve bellows - Magnification 100X

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Schenectady, New York

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P.O. Box 62
Oak Ridge, Tennessee

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Mary Jane Sears, Supervisor
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