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POST TEST VALVE EXAMINATION
OF SARGENT GLOBE VALVE

by

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1.0 INTRODUCTION

1.1 OBJECTIVES

The purpose of this examination was to observe and record any abnormalities caused by verification testing in liquid sodium that would be significant to valve performance in the FFTF and future LMFBRs. The examination was intended to verify that the valve performed its intended design functions satisfactorily during testing to simulate 20 years of reactor service.

The test program consisted of gas leakage measurements before and after a series of closing and opening actuations and thermal transient cycle exposures. Exposure included fully opened, fully closed and partially open positions. External loads were intentionally applied to the assembly to simulate service loading of flow induced vibration.

Specific malfunctions to be looked for and recorded included (a) bellows failure, (b) gross seal leakage without line loads, (c) external leakage, (d) gross changes in valve assembly operation, and (e) binding or other mechanical or chemical corrosion problems.

1.2 SCOPE

The examination was initiated with the availability of the sodium filled assembly at room temperature. The exterior was visually examined for evidence of sodium leakage and distortion. The sodium was removed from the valve. The leak rates of the empty valve and bellows were measured. The assembly was dimensionally inspected concurrently with sectioning to disassemble the valve. The surfaces of the interior components were examined and photographed to record artifacts of contact and wear. Macrophotographs were assembled to display the location of the artifacts. Optical and electron scan micrographs were prepared to identify the mechanisms of the alteration of the contacting surfaces. Chemical analyses were made to identify the composition of the materials and establish their conformance with design.

2.0 SUMMARY

2.1 CONCLUSIONS

1. Valve leakage after hot sodium testing was caused by deterioration of the sealing interface between the plug and the seat, which was caused by roughening of the contact surface. Roughening was caused by repeated contact of the plug and seat surface in high temperature (1050°F) sodium, which transferred material across the interface and resulted in fissures between grains that are typical of self-welding.

Self welding is caused by the reduction of protective oxide films by hot sodium and the application of contact loads approaching the deformation strength of the materials at elevated temperature resulting in micro-adhesion. The significance of self-welding is that additional forces are required to separate contacting surfaces such as opening a closed valve plug. The progressive roughening of the contact surface by debris of transferred material caught on the contact surface is a secondary mechanism of leakage generation.

2. A fissure found at the lower edge of the contact surface of the seat insert suggests that loading may have exceeded the high temperature strength of the cast Stoddy 6 brazed insert. However, surface cracks reported in Stoddy 6 castings prior to brazing reduces the significance of the discovered fissure.

Parallel stria found on the fracture surface of the plug suggest interrupted fatigue type loading of the fracture front resulting from the 8000 closure cycles.

3. Plug guide fingers sliding on the ID of the seat insert were found to be burnished, galled, exhibited transferred metal and generated metallic debris. These artifacts were more pronounced on the outlet or down-gravity side of the mounted "Y" configuration.

The greater magnitude of the artifacts suggest that the dead weight of the included stem assembly may have combined with the pressure of the hydraulic flow of sodium to increase the contact load.

The material transferred to the surface of the fingers was 0.010 in. thick, which approached the tolerance for diametral clearance between the fingers and the seat ID of 0.010 to 0.015 in. Although the thickness of the buildup in this test did not exceed the available clearance, continuation of debris could contribute to misalignment and even potential binding of the guide fingers in the seat.

Although dimensional eccentricity was measured on the alignment of the bellows shield, it did not contribute to misalignment because the shield did not directly affect plug to seat alignment.

4. The braze joint of the seat insert was dimensionally unaffected by the service testing. Although the joint was not corroded, the silicon and nickel content decreased from the original composition and from the center of the joint progressively toward the sodium-exposed edge, because of high temperature diffusion. The contribution of the furnace brazing operation or sodium exposure to the alteration of the composition could not be distinguished.

The braze joint of the back-stem seat was porous on the surface and unfilled to a depth of 0.01 in. This was because of the gap (0.026 in.) that is beyond the gap bridgable by most braze alloys. The cause of this excessive gap may have been poor assembly fit or movement of the insert during brazing.

5. The valve bellows were leak tight, dimensionally unchanged, and uncorroded. However, the convolution was distorted. The loss of symmetry may have been introduced during forming, installation, or post-disassembly handling.

The microstructure of both the Inconel 718 and Type 316 ply contained a duplex grain texture localized in both the inner and outer maximum curvature of the convolution where flexing would be expected to be a maximum. The large grains extend more than half the thickness of the ply (0.0044 in. for 316 and 0.0066 in. for Inconel 718). This grain texture suggests

that cold work was followed by recrystallization and grain growth at high temperatures of heat treating the Inconel 718. There was no evidence of deformation caused by the differential expansion differences between 316 and Inconel 718.

6. There was no measurable deformation of the crotch angle of the "Y" pattern valve body forging. This indicates that the mounting loads on the external nozzle were insufficient to induce distortion at high temperature.

The microstructure of the crotch was equiaxial uniform ASTM #2 grain size. This indicated recrystallization that eliminated forging flow lines probably by the ~2000°F furnace brazing operation of the seat insert.

7. Ethanol effectively removed sodium for purposes of further disassembly. Although all metallic sodium had been reacted, a white film of sodium salts was observed on the interior surface of the valve body and the exterior of the bellows.

2.2 RECOMMENDATIONS

Although it may not be possible to modify the design and material of valves to be used in the FFTF, recommendations have been developed to apply these valves to future sodium systems.

1. The effects of self-welding could be minimized by applying more self-weld resistant materials for the plug and seat contact surfaces. The current self-welding program at WARD⁽¹⁾ suggest TRIBALLOY -800 to itself or high carbon STELLITE-1 to itself could improve resistance to self welding of stainless to itself or STELLITE-6 to itself.
2. Wear and galling on the sliding surfaces of the plug-guide fingers could be reduced by reducing lateral loads of the stem weight on the seat ID in the inclined "Y" mounting configuration or improving stem guideway.
3. A fissure in the seat insert might be reduced by using more fatigue-resistant seat materials than Stooddy 6.

4. Effective sodium removal rinsing and drying operations should be conducted with bellow assemblies in the vertical position to avoid local salt deposits. Rinsing operations using alcohol should use more than two rinses to minimize the white film deposit.

3.0 BACKGROUND

3.1 COMPONENT DESCRIPTION

The component under investigation was a Sargent 1-in. "Y" Globe valve, serial number 001 (TV-10) per Westinghouse P/N H4-3027-5031, Sargent P/N 750010-31. A simplified sketch of the valve is shown in Figure 3.1. The valve was a bellows seal design, fabricated to meet the RDT E1-18T and HWS 1045 criteria. It is a nuclear small class I valve, according to Section III of the ASME Boiler Code. This specific valve is intended to be normally open with a fail-safe mode as opened. The design is intended for service between ambient and 1200°F. The valve was operated by a pneumatic Masoneilan operator with a response time of 2 to 20 seconds opening time and 2 to 20 seconds closing time.

3.2 FABRICATION

The valve body and most components were fabricated from Type 316 HSS. The plug is hard-faced with TIG weld-deposited STELLITE-6. The seat was hard surfaced with a brazed insert of STELLITE-6. The analyzed composition of alloys and their nominal composition was presented in the Chemical Analysis Section of this report. The seat was furnace brazed with alloy BNI-4. The body of the valve was fabricated from Type 316 HSS forgings. Details of fabrication requirements are available in References 2, 3, and 4.

3.3 SERVICE AND TEST CONDITIONS

Prior to Phase I Verification Testing the 1-in. valve was subjected to gas seat leakage calibration. After verification testing, as a measure of performance degradation, the valve was subjective to static liquid sodium and gas seat leakage tests.

The test pressures and temperatures for the liquid sodium seat leakage testing are as follows:

- Differential pressure: 5, 50, 200 and 300 psid (forward direction)
- Differential Pressure: 5, 20, and 50 psid (reverse direction)

- Fluid Temperature: 350, 800, 1000 and 1200°F
- Three leakage rates at each temperature/pressure condition.

Review of test logs indicate the total duration of 1000°F Na exposure was 1150 hr in the closed condition. Of this 19.9 hr was in Na leak testing, and 357.3 hr was Phase I actuation testing.

The maximum allowable leakage per HWS 1045 was 0.3 to 1.0 ml/min of liquid sodium at 350°F to 1200°F. Prior to testing the leakage ranged from 0.001 to 0.03 ml/min. After verification testing this leak rate at 300 psi increased to 100 ml/min at 350°F

35 ml/min at 800

10 ml/min at 1000, and

0.7 ml/min at 1200.

The Phase I Verification Test Program was as follows:

• Functional and Sealing Performance	• Seven Performance Checks
• Flow Characteristics	• Complete
• Bonnet Heater Performance	• Complete
• Life Cycle (Mechanical Endurance)	• 8000 full open-close-open cycles at 1200°F, 200 psig and rated flow
• Thermal Transient and Soak	• 250 Transients 1200 to 800°F @ -7°F/sec
	25 Transients 800 to 1200°F @ +10°F/sec
• Flow-Induced Vibrations	• Qualitative Only

3.4 SODIUM REMOVAL

A process avoiding the use of water was selected to remove sodium to avoid rusting or contamination of the interior of the valve, or any residues that could be found. The details of this procedure are reported in Appendix A. The sodium removal liquor and rinse solution were filtered for possible significant debris. Analysis of this residue is shown in the chemical section of Table 3.2 and the appearance of the residue is shown in Figure 4.1. From

the above observations it was concluded that the debris consisted chiefly of metal chips from cutting open the pipe in which the valve had been installed rather than wear-fragments from the seat or plug.

Radiography of the sodiums filled valve revealed sodium pockets; these are not apparent in Figure 3.3. Subsequent examination of the radiograph indicated that the surface of the plug was not parallel with the bellows protective flow shield. Closed examination indicated that the thickness of the weld bead was thicker on the inlet side than on the outlet side of the valve and contact line. This was not believed to have contributed to plug misalignment.

Details of testing are available in References 5 through 11.

4.0 EXAMINATION

4.1 EXTERNAL

A white deposit located as shown in Figure 3.2 was observed on the exterior surface of the operator casting yoke that fits over the valve stem. This deposit was sampled and analyzed as shown in Table 3.2 to identify the composition of the deposit and possibly to establish its source. The material could not be identified, although the lack of solubility suggests the absence of sodium compounds. A possible source of the deposit was suggested to be a residue from lubricant used in the operator. Surplus grease and sealing compound were observed on the surfaces of the operator. The body of the sodium-filled valve body and piping are heat-tinted to a dark brown, indicating extended exposure of the stainless steel above 1000°F. An area of blue marking dye was observed on the support frame of the operator, but this was not significant to the valve examination.

4.2 SODIUM RESIDUES

The sodium was drained from the pipe and valve body per the procedure outlined in Appendix A. The alcohol solutions used to react the residual sodium in the pipes and valve body were filtered, and particulates were found on filters through which the sodium rinse solution had been filtered. These were microscopically observed to be metallic chips shown in Figure 4.1 which was confirmed by fluorescent x-ray analysis shown in Figure 4.2. This leads to the recommendation of additional care when cutting out valves from lines, so metal debris is not ingested into the sodium circuit.

4.3 NON-DESTRUCTIVE TESTING

A preliminary radiograph shown in Figure 3.3 for sodium removal processing indicated that the alignment of the plug was not concentric relative to the supporting bellows protective shield. This was also supported by a thickening of the weld bead shown in Figure 3.3 on one side of the stem. Dimensions after sectioning indicated that the surfaces of the bellows shield was eccentric by 0.011 in., but this did not contribute to plug-seat misalignment.

4.4 VALVE BODY

The exterior surface of the body was oxidized with a brown discoloration indicative of prolonged air exposure of over 1000°F. No misalignments were found of the body exterior. The angle of the crotch at the outlet line and stem housing was measured by several methods to show repeatable results of 44.8 to 45.2 degrees in Figure 4.3. Since the drawing was dimensioned to be 45°, no change in this angle is apparent from the service testing exposure. The microstructure of the forging showed no flow line deformation of equi-axial grains (ASTM grain size #2). This grain texture was probably introduced during brazing of the insert. The interior of the body contained white deposits that produce a pH greater than 10 by a litmus test. This indicated that all sodium salts had not been removed by the prescribed alcohol-water rinse. Consequently, a process change was recommended to apply an additional alcohol rinse for removing sodium from future valves.

4.5 PACKING

The packing gaskets were examined and found (Figure 4.4) to be a gray-white color in contrast to the black usually found on graphite-asbestos type packing. The material was CRM-187-1 asbestos woven with inconel wire. The surfaces of the gaskets in contact with the packing rings exhibited a burnished surface suggesting sliding at the metal to non-metallic interface. No abnormal conditions were observed other than the splitting of each gasket for disassembly.

4.6 GUIDE FINGERS

Rubbing contact of the exterior surfaces of the fingers was apparent as bright, smeared, and galled surfaces of transferred metal as shown in Figure 4.5. Most of this rubbing contact appears to be on the downstream outlet and gravity downside of the valve. Electron scan micrographs were prepared to amplify the examination of these surfaces to be followed by analysis if required as shown in Figure 4.2.

4.7 PLUG

The spherical surface of the male plug was bright, uncorroded, and unaffected except for the contact line with the seat. The contact line was about 25% of the distance up the plug surface from the bottom. The width of the contact line was eccentric and wider on the outlet side or downstream side, which corresponds to 6 o'clock in Figure 4.6. Examination of the contact line at higher magnification in Figure 4.7 shows that the roughening of the surface corresponds to metal transfer or pull-out such as is normally found in self-welded surfaces under sodium. A metallographic section of the plug shown in Figure 4.8 shows an indentation to a depth of 0.0004 in. and pileup of material adjacent to the indentation of 0.0002 in. in addition to possible pullout of metal grains.

The plug was TIG weld deposited Stellite 6 diluted by 316 Type SS of the parent material as confirmed by analysis shown in Figure 4.9 and Table B-1 in Appendix B. Metallography showed nine separate layers of weld deposit which contribute to thermal stress and shrinkage. The process specification specified three weld bead passes.

A 0.01 in. long fissure was found in the parent metal-fusion zone interface at the top of the deposit as shown in Figure 4.8. Although this fissure was probably caused by shrinkage from over-heating during welding, the fissure had not contributed to malfunction of the valve in this test. Such a fissure does introduce a stress riser and is a potential initiation site of future fatigue crack propagation.

The hardness of the weld-deposited Stellite 6 ranged from DPH 463 (R_C 46) at the edge to DPH 316 (R_C 32) in the core of the weld deposit. Hardness details are available in Table 4.1.

4.8 SEAT

The surface of the seat was bright and uncorroded. The seat was a brazed insert of Stoddy 6. The contact line of the seat in Figure 4.10 exhibited a roughened surface similar to that of the contact line of the

plug and typical of self-welding and metal transfer. The width of the roughening appeared in Figure 4.10 to be greater on the outlet end (6 o'clock in plan view) which also corresponds to the lower side that supports the weight of the stem. Although some loose debris and markings were found on the surface of the seat, it was not determined if these were the result of valve operation or artifacts due to post-test handling. Distinct rub marks found on the ID of the seat in Figure 4.10 conform to the galling marks on the guide fingers. Ink marks showing in the photographs were applied intentionally to maintain orientation of the hardware.

Composition of the Stoddy 6 insert was confirmed by analysis in Table 4.2. The hardness of the insert ranged from R_C 53 to 46 at the edge. In the stainless steel parent metal core was found to be R_b 84. The as-manufactured hardness is specified to be R_C 49 maximum; details of hardness data are available in Table 4.2. The curvature radius of the seat contact line was measured by a profilimeter and metallography to be 0.025 and 0.030 in. radius on the inlet side and 0.060 on the outlet side as shown in Figure 4.11.

An intergranular fissure in the brazed insert parent metal was found in Figure 4.12 to be 0.001 in. deep at the lower edge of the contact surface. The fissure suggests that the seat may have been overloaded in static or cyclic loading. The location and direction of the fracture also suggests that the direction of the load application was near parallel to plug motion causing a shear load in the radial direction. A series of near parallel stria at high magnification in Figure 4.13 suggests a fatigue type of failure mechanism, which could correspond to interrupted fracture due to cyclic loading during opening and closing the valve.

The brazing joint of the seat insert was found (see Figure 4.14) to be intact and free of mechanical damage or chemical corrosion. The filler metal was a high nickel alloy, BNI-4, of a composition shown in Table 4.2. The variation of silicon content of the alloy, originally 3.5%, was found to be reduced by diffusion by microprobe analysis described in additional detail in Appendix C.

4.9 BACK SEAT

The surface of the back seat was examined and surface roughness was found above the brazed insect, see Figure 4.15. Metallographic sections (Figure 4.16) revealed a joint gap of 0.026 in. unfilled by braze filler material. This suggests the back-seat insert was not positioned tightly enough for good braze joint practice.

4.10 BELLOWS

A white deposit was also found between the convolutions of the bellows as shown in Figure 4.17. The bellows had been demonstrated to be leak tight to 10^{-15} cc/sec He. The exterior surface of the bellows was bright, unscaled and not corroded, although metallographic sections show some unsymmetrical deformation of the convolutions as shown in Figure 4.18. This deformation is not considered significant to performance. Higher power magnification showed no evidence of corrosion or section thinning. The microstructure of the two Inconel 718 and the one 316 ply is shown in Figure 4.18.

4.11 STEM

The surface of the stem after removal of the bellows exhibited certain artifacts as shown in Figure 4.19. Although these markings may have occurred in handling from lathe chuck marks, rubbing from the bellows ID is a possible explanation. A ring of chatter-type markings were evident in Figure 4.20 on the reduced section of the stem that corresponds to the zone below the packing opposite the pressure probe. This may suggest that debris in the cavity intermittently contacted the stem as it rotated. Under the bellows, circumferential rub marks are apparent suggesting contact with the ID of the bellows. An indentation originally believed to have been a hardness indentation was found to be a blind drill hole. Examination of the back seat showed no abnormal marking or contact after the bellows was cut from the stem.

5.0 ACKNOWLEDGMENT

The author recognizes the guidance provided by G. Bazinett of the FFTF Component Group; R. Johnson, who interpreted the self-welding features in the fractographs; and K. Gustafson, who validated the normality of the braze microstructure and analysis. Recognition is also directed to D. McCauley for consistency of follow-up with inspection and machining operations.

6.0 REFERENCES

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2. Hanford Works Standard HWS-1045, Revision 1, Addenda 3 and 5, "Specification for Small Class 1, Liquid Metal Valves," dated January 1972.
3. Weld Procedure, HEDL-W-GS-5G1, dated March 8, 1975.
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6. SDD-335A, "System Design Description for the Transient Test Loop," dated September 30, 1975.
7. Test Request, E. A. Shearer, "Small Design Description for the Transient Test Loop," dated September 30, 1975.
8. H-3-37608, "Sodium Valve Test, Pressure Top Manifold, Transient Test Loop."
9. VTM Test Procedure 76-1
 - A. Appendix I VTM & Test Valve Preheat
 - B. Appendix III Valve Performance Checks
 - C. Appendix IV Valve Characterization 2"
 - D. Appendix V Calibrate Test Valve Positioning
 - E. Appendix VI Flowmeter Sensitivity
 - F. Appendix VII Thermal Transient Tests
 - G. Appendix VIII Bonnet Heater
 - H. -- -- Pressure Sensing
 - I. -- -- Check Valve X-ray
10. Test Plan, VTM-001, Revision 2, "Small Sodium Valve Flow Verification Testing in VTM," dated April 1975.
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TABLE 3.1. Valve Examination Data & Logic Summary
(1-in. Sargent Bellows Seal "Y" Globe Pattern)

Subassembly	Observations	Cause & Mechanism	Recommendations
Body	Exterior discolored Interior wht. deposit	Hi temp. service Direct Na alcoholate Insufficient rinse	3 cycle rinse
Bellows	Exterior discolored Exterior wht. deposit Distorted convolution Leak tight to He Duplex grain	As above Unknown Unknown Non-uniform deform. and thermal cycle grain quantity	- - - -
Guide Finger	Burnish (worst on) Galling (outlet) Mat'l Transfer	Sliding Heavy pressure sliding in hot Na Inclined and Hydraulic loading	-Hard surface guide finger -Mount stem vertically
Plug Seat Contact	Rough surface area Grain pull out Transferred Mat'd Worst on outlet side Debris Misalignment Fissure in seat Fracture stria	Push-pull contact Self-welding Wear from finger Bellow seal weld distortion Fatigue Fatigue	- -Self-weld resistant mat'l Less Load -Jig welds -Less load -More fatigue resist. mat'l
Stem	Rub marks Chatter marks opposite probe	Possible bellows ID rub ---	--- --- ---
Back Seat	Incomplete braze	Gap too wide	Jig braze

TABLE 3.2. Chemical Composition of Debris

	<u>Fe</u>	<u>Ca</u>	<u>Ti</u>	<u>Cr</u>	<u>Ni</u>	<u>Pb</u>	<u>Zn</u>	<u>Mn</u>
Filtered Residue From Na Removal Solution	48.1	29.4	6.1	3.2	1.4	1.2	1.1	1.2

White
Deposit
On
Exterior

Insoluble in water, therefore not Na compound.

White
Deposits
On
Bellows
Exterior

Soluble in water, therefore, not Na compound.
Turns filter paper blue = ph > 10

TABLE 4.1. Hardness Measurements

	<u>Seat</u>			<u>Plug</u>	
	<u>Room Temp.</u>				
	<u>DPH</u>	<u>R_c</u>	<u>R_b</u>	<u>DPH</u>	<u>R_c</u>
EDGE	565	53		463	46
	463	46.5			
	493	49			
	553	53			
	463	46.5			
	453	46			
BRAZE	115	64			
	112	63			
	201	91.5			
316 SS	167	84	316	32	

TABLE 4.2. Chemical Analysis Results

Nominal	Fe	Ni	Cr	Co	Mo	W	Mn	C	B	Si	Zn	Remarks
316 SS	bal	10-14	16-18	--	2-3	--	2 max	.04-.05	--	1 max		
Stellite 6	3.5 max	3 max	33 max	55	1.5	6	1	--	--			
Braze BN1-4	--	bal	--	--	--	--	--	.06	1.8	3.5		
<u>Analyses</u>												
Body					TBD							TBD
Plug Matrix	66	7.1	50	--	2.7	--	--	--	--	.26		316 SS
Plug Insert Weld*	10-34 18	2.4-4.4 6	58-56 25	30-10 45	.8-1.7 2	-- 2.5	-- 0	-- --	-- --			Stellite 6 Weld Dilute
Seat Matrix	--	3.0	--	--	--	--	--	--	--	0.5		TBD
Seat Insert Stoody 6	2.0	.25	26-29 Max.	bal		4-6	0.5 Max.	.9-1.6	.80-1.5	0.3		TBD
Seat Braze BN1-4	6.7-34	bal	--	0.4-1.4	--	--	--	.06	1.8	3.5		BN1-4 depleted
*Left at Na edge. Rt at weld HAZ.												
<u>White Deposit</u>												
Exterior	4.62	17.13	17.17	0	0	--	9.56	--	--	--	10	Debris with SS chips

HEDL 7701-109.1

FIGURE 3.1 Simplified Sketch of Valve in Mounted Position (Print BNL-770841-2)

FIGURE 3.2 External Appearance of Valve After Testing Prior Sodium Removal Showing White Deposit (Print BNW-770330-4)

FIGURE 3.3 Radiograph of Valve Assembly Prior to Sodium and Removal
Showing Distortion of Plug Bellows Shield by Weld (Print
BNW-770330-1)

0.2 mm
HEDL 7701-109.4

METALLIC SS PARTICLES

FIGURE 4.1 Debris Filtered From Sodium Rinse Solutions Confirmed
by Analysis to Contain Metal Chips (Print BNL-770841-4)

FIGURE 4.2 Fluorescent X-Ray Analysis of Plug-Seat Contact Surfaces

MACRO PHOTO SHOWING UNDISTORTED ANGLE OF VALVE BODY CROCH
AFTER HIGH TEMPERATURE SURVICE AND RECRYSTALISED GRAIN SIZE
ASTM #2

FIGURE 4.3 Section of Valve Body at Crotch of "Y" Showing (a) Unchanged
45° Angle, (b) Absence of Forging Flow Lines, and (c) ATSM
Grain Size #2 (Print BNL-770330-2)

PACKING
SUPPORT

1x

PACKING
GASKETS

2x

ASBESTOS
&
INCONEL
WIRE
PACKING

12x

HEDL 7701-109.3

FIGURE 4.4 Appearance of Packing (Print BNL-770841-3)

**SURFACE CONDITION OF PLUG GUIDE FINGERS AND PLUG-SEAT
CONTACT LINE SHOWING 1. BURNISHING 2. GALLING & 3. SELF-WELDING**

HEDL 7611-131.2

FIGURE 4.5 Surface Condition of Stem-Plug-Guide Fingers Showing
(a) Location of Burnishing, (b) Galling, and (c) Self-
Welding (Print BNL-7611090-1)

PLUG SURFACE CONDITION

FIGURE 4.6 Surface of the Plug Contact Line Showing Location of Grain Pull Out (Print BNL-7610640-1)

12 O'CLOCK
INLET SIDE

3 O'CLOCK

6 O'CLOCK
OUTLET

9 O'CLOCK
HEDL 7611-75.1

FIGURE 4.7 Plug Contact Line Showing Width and Roughened Surface of Contact Area
(Print BNL-7610635-2)

FIGURE 4.8 Sections of Plug Showing a) Shrinkage Void, b) Contact Line Indentation and Deformation and c) Multi Pass Weld Deposit of Land Facing Stellite 6 (Print BNW-770230-3)

PLUG -SEAT CONTACT LINE SHOWING MATERIAL PULL-OUT TYPICAL OF SELF-WELDING

FIGURE 4.9 Electron Scan Micrograph of Guide Fingers and Plug Surfaces Showing (a) Grain Pull Out, (b) Fissure or Grain Separation, (c) Burnishing, and (d) Metal Transfer or Galling (Print BNL-761169-1)

FIGURE 4.10 Views of Seat Contact Area Showing Location of Damage
(Print BNL-770841-1)

PLUG CONTACT LINE SHOWING MATERIAL TRANSFERRED BY SELF WELDING

STELITE 6
INSERT

SEAT CONTACT LINE SHOWING MATERIAL TRANSFER BY SELF WELDING AND FISSURE AT ROOT OF CONTACT LINE

8 O'CLOCK LOCATION

0.08 INCH 12X

HEDL 7612-106.1

FIGURE 4.11 Micrograph of Transverse Section of Seat at 8 o'clock showing (a) Transferred Material, (b) Corresponding Plug Locations, and (c) Intergranular Fissure in Seat Insert (Print BNL-12071-2)

HEDL 7701-99.2

FIGURE 4.12 Stereo Views of Plug Contact Area Showing Pulled Open Grains Typical of Self-Welding (Print BNW-770545-2)

LOCATION
MARK

**SEAT CONTACT
LINE AT 8 O'CLOCK
LOCATION**

STELLITE 6

**TRANSFERRED WELD
DILUTED STELLITE 6**

**POSSIBLE
FATIGUE
STRIA**

**POSSIBLE
FATIGUE
STRIA AND
PLOWMARK**

FIGURE 4.13 Scanning Electron Fractographs of Seat Contact Area Showing
a) 8 o'clock Location Mark b) Sites of X-Ray Fluorescent
Analysis, c) Grain Separation and d) Potential Fatigue Stria
(Print BNL-7612071-1)

FIGURE 4.14 Transverse Section of Stellite 6 Seat Insert at 4 to 5 o'clock Location Showing (a) Curvature of Contact Line, (b) Profile of Seat Insert, and (c) Taper of Braze Joint (Print BNW-770330-3)

HEDL 7701-99.1

FIGURE 4.15 Upper Valve Body Showing a) White Deposit, b) Surface Discoloration, c) Braze Porosity and d) Back-Stem Seat Contact (Print BNW-770511-1)

FIGURE 4.16 Braze Joint of Stem Back-Seat Showing Poor Braze Alloy Bridging Caused by Excessive Gap Clearance (0.026 inches)

VALVE BODY

1X

BELLOWS

4X

FIGURE 4.17 White Deposit of Sodium Compounds on As-rinsed Surface of Body Interior and Outer Surface of Bellows

FIGURE 4.18 Micrograph of Bellows Showing (a) Asymetric Convolution, (b) Duplex Grain Structure, (c) Single Grain Across the Ply Thickness, and (d) Absence of Corrosive Attack (Print BNW-770330-5)

INLET SIDE
12 O'CLOCK

9 O'CLOCK

OUTLET SIDE
6 O'CLOCK

3 O'CLOCK

HEDL 7611-75.3

FIGURE 4.19 Overall Views of Stem to Record Location of Artifacts (Print BNW-7610435-1)

HEDL 7611-75.2

FIGURE 4.20 Artifacts on Surface of Upper Stem Shaft Showing
a) Chatter Type Contact, b) Potential Drill Hole,
and c) Rotational Rubbing (Print BNW-7610435-3)

APPENDIX A

SODIUM REMOVAL PROCEDURE

From: Sodium Systems Development
Phone: 942-5484
Date: November 1, 1976
Subject: ONE- AND TWO-INCH SARGENT VALVE CLEANING

Hanford Engineering Development Laboratory

RECEIVED

NOV 2 1976

C. W. FUNK
RECEIVED

NOV 5 1976

C. W. FUNK

To: C. W. Funk

Copy to W. V. Cook
J. L. Ballif
D. L. McCauley

Both the one- and two-inch Sargent valves were recently cleaned according to the attached procedure. After disassembly of the one-inch, some traces of reaction product were found in the bellows area. These appeared to be residue from evaporation of the remaining solvent held in this area. Solvent in this area would be expected to be heavily loaded with reaction products because of poor circulation.

In the future, a second rinse of ethanol will be used before drying to give better reaction product removal. This second rinse will also be applied to the two-inch valve which is now in storage awaiting dissection.

It may be of some interest to note the manpower requirements for this project. About 55 manhours were used in the initial cleaning but most of this time was spent making the initial setup. Thirteen hours were used to clean the second valve.

We also found that we are not equipped to physically handle the larger valves as they are now delivered. In the future, we will require that for two-inch, or larger, the operator be detached or a support fixture be provided which will allow 100-degree rotation of the valve.

Monte Crippen

M. D. Crippen
bf

Attachment

APPENDIX B

DIMENSIONAL INSPECTION PRE AND POST TEST
MEASUREMENTS

	B/P DIMENSION OR REQUIREMENT	B/P ZONE	ACTUAL (INSPECTED) DIMENSION PRE-ASSEMBLY & TEST	POST-TEST & TEARDOWN	REMARKS
a.	.012/.007 (FINGER TO COCR OPENING)	E-8		.009	Finger Dia. Varies .007
b.	45° ± 2°	F-7		44° ^{External} 43°30'	Internal - Used Mitutoyo machinist's protractors 550-57-01-002
c.	12.72 ± .06	H-6		12.880	
d.	2.410 DIA.	E-6		2.4098	
e.	1.770 DIA.	E-6		1.774	
B-1 f.	.163/.137 DIAMETRAL CLEARANCE	E-6			
g.	.077/.068 DIAMETRAL CLEARANCE. (BACKSEAT-TO-STEM)	D-5			N/A Inaccessible
h.	.164/.130 DIAMETRAL CLEARANCE (SPACER-TO-STEM)	D-5			N/A Disassembled
i.	2.52 ± .09 NORMALLY CLOSED	G-5		N/A	
j.	.033/.025 DIAMETRAL CLEARANCE (STEM-TO-FOLLOWER)	E-4			N/A Disassembled
k.	.011/.005 DIAMETRAL CLEARANCE (FINGER-TO-STEM)	D-4			N/A Disassembled

B/P DIMENSION OR REQUIREMENT	B/P ZONE	ACTUAL (INSPECTED) DIMENSION		REMARKS				
		PRE-ASSEMBLY & TEST	POST-TEST & TEARDOWN					
0.50 ± .04 STROKE	G-4		.518	Verified during acceptance testing with operator				
.006/.002 DIAMETRAL CLEARANCE (GUIDE-TO-BONNET)	F-4			N/A Disassembled				
.006/.002 DIAMETRAL CLEARANCE (FOLLOWER-TO-BONNET)	F-4			N/A Disassembled				
<table border="1"><tr><td>⊙</td><td>B</td><td>C</td><td>.020 DIA.</td></tr></table>	⊙	B	C	.020 DIA.	G-3			N/A Disassembled
⊙	B	C	.020 DIA.					
RELAXED BELLOWS POSITION : 0.152 ± .092" PLUG OFF FRONT SEAT.	NOTE 27			NORMALLY CLOSED VALVES.				
RELAXED BELLOWS POSITION : 0.051 ± .078" STEM OFF BONNET B-SEAT.	NOTE 28	* ?	.075 - .080	NORMALLY OPEN VALVES.				

B-1

DWG is marked as 75001-1030X

	B/P DIMENSION OR REQUIREMENT	B/P ZONE	ACTUAL (INSPECTED) DIMENSION		REMARKS
			PRE-ASSEMBLY & TEST	POST-TEST & TEARDOWN	
a.	1.770 $\pm .010$ DIA.	F-7		1.775	After body sectioning ~ 1/8" above seat Tol. of meas $\pm .005$
b.	1.530 DIA.	F-5		(1.540) 1.534	
c.	1.019 DIA.	D-5		1.021 - 1.024	CHECK AT SEVERAL POINTS
d.	1.770 DIA.	E-4		1.772 - 1.776	CHECK AT SEVERAL POINTS
e.	◎ A B .010 DIA.	E-4		Does not exist as shown	CHECK AT SEVERAL POINTS
f.	1.172 DIA.	B-4		1.165	
g.	1.180 DIA.	B-2		1.184	
h.	◎ A B .010 DIA.	B-2			
i.	0 .0005	B-2		Cannot set up	
j.	1.092 $\pm .003$ DIA.	C-3		1.093	
k.	◎ H .002 DIA.	C-3		Cannot set up	
l.	32 / FINISH	C-3		32-63 RMS	inaccessible (Approximation)

	B/P DIMENSION OR REQUIREMENT	B/P ZONE	ACTUAL (INSPECTED) DIMENSION		REMARKS
			PRE-ASSEMBLY & TEST	POST-TEST & TEARDOWN	
a.	2.410 DIA.	F-7		2.391 - 2.393	
b.	1.770 DIA.	E-7		1.756	
c.	C .020 DIA.	E-7		.004	
d.	0.900 $\pm$.003 DIA.	F-6		.899	
e.	3.94	G-6		3.933	
f.	0.156	F-5		.156	
g.	0.250	F-5		.250	
h.	2.000 DIA.	E-5		1.997 - 2.001	
i.	0.568 $\pm$.005 - .000 DIA.	D-5		.571	
j.	A C .003 DIA.	D-5		.002 A)	
k.	0.876 $\pm$.002 - .000 DIA.	F-4		.877	
l.	1.747/1.744 DIA.	F-4		1.746	
m.	1.12 DIA.	E-4		1.100	

[illegible]

DWG is marked as 75001-1060X

	B/P DIMENSION OR REQUIREMENT	B/P ZONE	ACTUAL (INSPECTED) DIMENSION		REMARKS
			PRE-ASSEMBLY & TEST	POST-TEST & TEARDOWN	
a.	1.085 $\pm .000$ $-.002$ DIA.	F-7		1.079 - 1.085	
b.	$\text{G} \text{ .002 DIA.}$	F-7		2 FINGERS .000 1 Finger	-.005, 1 Finger -.010
c.	$\text{K} \text{ .010 DIA.}$	F-7		.008	
d.	1.390	G-6		1.420 Approx to center of weld	Not attainable
e.	16/ ON 0.500" DIA. ✓ FOR 1.62" LG.	G-5		Cannot determine due to usage	
B-7 f.	$\text{—} \text{ .005}$	F-5		.004	
g.	15.40	D-5		15.393	
h.	0.750 DIA.	F-5		.752	
i.	$\text{A} \text{ .010 DIA.}$	F-5		.004	
j.	16/ FINISH ON .500 DIA. (KNOB END)	F-4		Cannot determine due to usage	
k.	0.500 $\pm .000$ $-.004$ DIA.	E-4		.498	
l.	0.182 $\pm .000$ $-.003$	F-4		.179	
m.	$\text{O} \text{ .0005}$	C-4		.0005	

	B/P DIMENSION OR REQUIREMENT	B/P ZONE	ACTUAL (INSPECTED) DIMENSION		REMARKS
			PRE-ASSEMBLY & TEST	POST-TEST & TEARDOWN	
n.	⊙ A .005 DIA.	C-4		.003	
o.	34° ± 1/2°	C-4		34°	
p.	7.968 ± .005	B-4		7.974	
q.	0.688 GAGE DIA.	B-3		.694	
r.	0.759 ± .005 GAGE POINT	B-6		.763	
s.	1.180 GAGE DIA.	B-6		1.180	
t.	⊙ .0005 DIA.	B-6		.001	
B-8
			A	B	C
	Red mark indicates	0°	.714	.710	.713 12 o'clock
	Locking at seat end	90°	.715	.711	.710 3 o'clock
	part is rotated	180°	.715	.708	.716 6 o'clock
	clockwise	270°	.713	.706	.717 9 o'clock

APPENDIX C

MICROPROBE ANALYSIS RESULTS

From: Microstructural Analysis
Phone: 2-3668
Date: January 11, 1977
Subject: Sample #764051 and 764252

Hanford Engineering Development Laboratory

To: Campbell Funk

cc: WI Clark
LA Hartcorn
ED Jenson
RB Davis/file

Your sample #764051 and 764252, weld section and brazed section respectively, were examined in the microprobe. Ten determinations were made in the weld area along micro hardness indents, progressing from the weld metal to the base metal. Molybdenum, nickel, chromium, silicon, cobalt and iron were analyzed for at each indent. Table I is a summary of the results, note that at large count rates (large percentages) the error is larger, due to dead time.

In the brazed sample, the silicon composition was determined at ten positions along the braze, figure 1. Table II lists the results. The silicon is apparently depleted at the ends of the braze metal. Also plotted, are the silicon and nickel compositions across the braze metal in three areas. Shown in fig. (1).

R.B. Davis

kfn

FIGURE C-1. Micrograph of Microprobe Analysis Sites
Along & Across Braze of Plug of One Inch
SARGENT Valve

TABLE C.1

Composition Along Indents of Sample #764051 (Plug)
Element

POSITION	Mo	Ni	Cr	Si	Co	Fe
1	0.83	2.35	58.07	0.93	30.18	10.45
2	0.92	2.51	58.26	0.80	29.43	12.17
3	0.93	2.56	56.81	0.79	27.88	12.34
4	0.80	2.82	66.48	0.76	28.21	14.02
5	1.30	3.56	62.51	0.66	20.13	23.65
6	1.58	4.14	62.29	0.62	15.47	29.06
7	1.58	4.11	55.87	0.62	15.73	31.81
8	1.51	4.05	56.37	0.62	15.54	28.28
9	1.50	4.56	56.39	0.54	11.39	34.63
10	1.61	4.73	56.24	0.58	12.22	34.05
11	1.77	4.37	56.26	0.54	10.34	34.39

TABLE C.2

COMPOSITIONS OF EACH DETERMIATION SHOWN IN FIGURE 1
(Along Length of Seat - Insert Braze)

POSITION	ELEMENT COMPOSITION		
	Si	Co	Fe
1	1.49	0.44	24.49
2	1.97	0.48	11.49
3	1.97	1.35	10.08
4	1.96	1.00	8.84
5	1.96	0.93	8.64
6	0.80	0.24	33.74
7	2.05	1.14	6.74
8	1.36	1.19	7.72
9	1.89	1.25	6.82
10	1.69	1.01	13.49

FIGURE C.2 Microprobe Analysis Traverse Across Braze

FIGURE C.3 Microprobe Analysis Traverse Across Braze

LINE 3

FIGURE C.4 Microprobe Analysis Traverse Across Braze