DOE/SF/71011--T7

SA-007

Program: Cover-Gas Seals

ERDA Task: 11 - FFTF-LMFBR Seal-Test Program

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I. PROJECT OBJECTIVES

DE82 005385

The objectives of the general seal test program are to: (1) conduct static and dynamic tests to demonstrate or determine the performance of full-size (cross section) FFTF fuel transfer machine and reactor vessel head seals, (2) demonstrate that these FFTF seals or new seal configurations provide acceptable performance at Clinch River Breeder Reactor Plant (CRBRP) operating environmental conditions other than radiation, (3) develop improved seals and seal technology for LMFBR applications and (4) publish and periodically update a Design Guide for reactor seals.

Current activities include providing CRBRP design information based on tests of the IVHM Inflatable Seal to CRBRP conditions, testing the CRBRP dip seal configuration to determine its performance characteristics, and delineating the effects of sodium and radiation environments on the efficiencies of various seal materials.

The primary direction of the general seal effort is to develop advanced seal geometries and materials to overcome deficiencies of commercially available seals, permeation rate, compression set, and high temperature operation, which restrict their use in LMFBR applications.

II. MAJOR ACCOMPLISHMENTS DURING FISCAL YEAR 1976

Testing of the CRBRP rotating plug inflatable seal was completed. Break-away drag, after two 1600-h, 150°F (66°C) dwells, was 87.8 lb/ft (1458 N/M) for a nominal seal speed of 15 ft/min (76 mm/s) and 54 lb/ft (983 N/M) for a slow start speed of 2 ft/min (10 mm/s). With no lubrication on the seals,

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breakaway drag was 63.9 lb/ft (1061 N/M) after a 100-h dwell. For a worst case horizontal offset of 0.25 in. TIR (6.35 mm), drag was ~40% above nominal and although no massive buffer cavity leakage was measured, zero leakage could not be maintained.

Adhesive-grease compatibility tests were completed on the FFTF IVHM/CRBRP nitrile inflatable seals. Through 18 months, the original DC 140 RTV adhesive showed slight deterioration of bond strength, but appears adequate for a five-year seal life. The new reference Chemlok 304 showed superior strength and no deterioration through 16 months.

FFTF-Instrument Tree adhesive-grease compatibility tests were terminated after 11 mo due to severe loss of adhesive bond strength.

The sodium dip seal test article was assembled, checked out and charged with sodium. Pressure recovery margin and convection tests were completed. Gas attenuation tests revealed migration of gas across the dip seal blade through a thin surface film. The blade was wetted by a 600°F (588 K) thermal soak and the surface film eliminated.

Techniques are being studied to depress the wetting temperature of the dip seal blade. Test specimens ("brushless" electroplated with tin) have been repeatedly wet at 390°F (199°C).

Tests completed at 150°F (66°C) on dynamic U-shaped spring-assisted EPDM and nitrile seals had lower or equivalent leakage rates than the solid cross section seals. Tests at 250°F (121°C) show the seals to have good elevated temperature performance.

Sodium vapor-aerosol exposure tests were run on O-rings of silicone and EPDM to 300°F (149°C) and, nitrile and urethane to 220°F (104°C) without measurable effects.

Gamma irradiation tests on silicone, nitrile, EPDM and urethane elastomers under installed, compressed conditions have been completed through a total dose of 10^7 rad.

III. PROGRESS DURING REPORT PERIOD

A. TOP SHIELD DIP SEAL CONFIGURATION CHARACTERISTICS

Tests have been initiated to establish conditions necessary to depress the wetting temperature of the SA508, Class II, dip seal blade to between 375 and 450°F (190 to 232°C). An inert atmosphere glove box, Figure 1, has been modified by adding an external sodium supply vessel and a sodium feed line plumbed into the box interior. The argon atmosphere is controlled to maintain 10 ppm or less of oxygen and hydrogen while working with liquid sodium.

Test specimens, 0.25 by 1.0 by 2.0 in. (0.64 by 2.54 by 5.08 cm) were cut and serialized from SA508, Class II steel, 1020 carbon steel, and Type 304 stainless steel. Type 1020 and 304 stainless steel specimens are being used primarily for system setup and checkout. Wetting of the test coupons is being studied as a function of specimen cleaning technique, surface finish, sodium purity, specimen temperature, and time to wet.

A review of current literature indicates that the probability of wetting at low temperatures, <500°F (260°C), is enhanced by the following cleaning techniques:

- 1) Degreasing in refluxing trichloroethylene or acetone at 100°F (38°C)
- 2) Scrubbing with a trisodium phosphate solution
- 3) Immersion in 50% sodium hydroxide at 150 to 165°F (66 to 74°C)
- 4) Immersion in aqua regia (3HCl, 1 HNO₃) at 70°F (21°C)

Several SA508, II coupons were treated by the various techniques as shown in Table 1, heated to 450°F (232°C) and exposed to sodium droplets for 2 h minimum, without significant wetting. At about 750°F (399°C), wetting was instantaneous, however.

Figure 2 shows a typical unwetted coupon with the sodium droplet at a contact angle in excess of 90°. In the simplest form, wetting occurs where the contact angle between the sodium and metal is < 90°. This is illustrated in Figure 3.

Figure 1. Dip Seal Wetting Test Glove Box

9006-40626A

Figure 2. Typical Unwetted Coupon With Sodium Droplet Test Temperature: 450°F (232°C) 9006-40632A

Figure 3. Contact Angles for Sodium Wetting 9006-40527

TABLE 1
SODIUM WETTING TEST RESULTS - DROPLET TECHNIQUE

Material S/N	Cleaning Treatment	Temper- ature °F(°C)	Time (h)	Results (contact angle)
SA-508-01	Acetone rinse	450(232)	>3	no wet (>90°)
-03	Immerse in aqua regia	450(232)	>1	no wet (>90°)
-04	Immerse in aqua regia	450(232)	>1	no wet (>90°)
-05	Hand polish, acetone rinse	450(232)	>1	no wet (>90°)
-06	Scrub with trisodium phosphate	450(232)	>1	no wet (>90°)
-08	Hand polish, acetone rinse	825(441)	1 min	wet (~30°)
-11	Hand polish, acetone rinse	770(410)	1 min	wet (~30°)

The droplet technique for measuring wetting has several disadvantages. The principal one is the inability to maintain a uniform temperature between the sodium droplet and the large exposed specimen surface. Secondly, the coupon is exposed to surface oxidation.

Subsequent coupons tested were either fully or half immersed in a sodium bath and wetting was measured by viewing the sodium adhering to the surface as the coupon was removed from the bath or observing the sodium contact angle on the partially submerged specimen. These techniques more closely duplicate actual use conditions of the submerged dip seal blade, allowing for more accurate temperature control, while preventing oxidation of the test surface.

Three other coupons were cleaned by: (1) acetone rinse (S/N 19), (2) immersion in aqua regia (S/N 25), and (3) immersion in NaOH, (S/N 26). These coupons were immersed in sodium at 450°F (232°C) during which time a 15-min excursion to 500°F (260°C) occurred, and after 44 h ~70% of the surface areas were wet. Each coupon, however, had several small unwetted areas. These results, and those of all coupons tested using the immersion technique, are summarized in Table 2. The tests were rerun on a second set of coupons. After 28 h, the acetone rinsed coupon was fully wet and after 80 and 100 h respectively, the coupons immersed in NaOH and aqua regia were about 90% wet with some small unwetted areas remaining. Tests will be repeated at 413°F (212°C) to study effects of temperature.

Two additional wetting techniques are being investigated: (1) mechanical cleaning by ultrasonic agitation of sodium in contact with the dip seal blade, and (2) grip blasting of the surface.

TABLE 2
SODIUM WETTING RESULTS - IMMERSION TECHNIQUE

Material S/N	Cleaning Treatment	Temperature °F(°C)	Time (h)	Results
A19	Acetone rinse	450(232)	28	Completely wet
A29	Acetone rinse	450(232)*	44	Spotty wetting
A28	Immersion in aqua regia	450(232)	100	~90% surface wet
A25	Immersion in aqua regia	450(232)*	44	Spotty wetting
A27	Immersion in NaOH	450(232)	80	~90% surface wet
A26	Immersion in NaOH	450(232)*	44	Spotty wetting
A15	Acetone rinse-ultrasonic run for >3 min	260(127)	100	No wetting (>90°)
A13	Tin plate (30 x 10 ⁻⁶ in.)	340(171)	15 min	100% wet on tinned side
A14	Tin plate (50 x 10 ⁻⁶ in.) plus ~15 min ultrasonic	270(132)	1	100% wet on tinned side
A17	Tin plate (30 x 10 ⁻⁶ in.) front face; 60 x 10 ⁻⁶ in. back) plus ~3h ultrasonic	270(132)	24	~90% wet
A18	Tin plate (100 x 10 ⁻⁶ in. front face; 200 x 10 ⁻⁶ in. back)	390(199)	1	Fully wet
	Oxidized 6 days at 70°F rewet	450(232)	4.5	Fully wet

*15 min at 500°F (260°C)

Initial attempts to wet test specimens using an ultrasonically agitated sodium bath were unsuccessful. The 150-W generator and bath were limited to 270°F (132°C) due to the 300°F (149°C) breakdown temperature of the ultrasonic drivers and wetting of the sodium tank and sample coupons could not be accomplished. A 350-W magnetostrictive driver capable of 400°F (204°C) operation has been ordered.

Tin plating and low power (150 W) ultrasonics were evaluated together and proved to be more effective than either technique alone. The tinned side coupon (S/N A 14) was wet after 1 h at 270°F (132°C) maximum. Figure 4 shows the coupon prior to wetting in the sodium bath with a depressed sodium meniscus (contact angle $>90^\circ$). Figure 5 shows the coupon following wetting with a contact angle of $\sim 20^\circ$. Type 304 stainless steel tank material is unwetted in both figures.

9006-40637A

Figure 4. Test Coupon (S/N A14) Prior to Wetting

9006-40634A

Figure 5. Tin Plated (SA508, II) Test Coupon After Wetting

Two additional coupons were plated to study the effect of tin plate thickness. Coating thicknesses were 30, 60, 10, and 200×10^{-6} in. (76, 152, 254, 508 μm). As noted in Table 2, no effect on thicknesses was observed. Figure 6 shows Specimen A 18, which wet after 1 h at 390°F (199°C) after being removed from the sodium bath. The top of the coupon, not immersed in the sodium, shows a dark grey area which may be an alloy of tin and sodium, $\alpha\text{Na-Sn}_2$, as noted on the sodium-tin phase diagram of Figure 7.

9006-40641A

Figure 6. Tin Plated (SA508, II) Test Coupon Following Wetting at 390°F (199°C)

9006-40528

Figure 7. Sodium-Tin Phase Diagram

Tests were also conducted to demonstrate that the tin plate could be rewet after exposure to an oxidizing atmosphere. Rewetting was accomplished at 450°F (232°C) in 4 h after exposure to the glovebox atmosphere for 1 week.

B. ADVANCED SEALS

The 250°F (121°C) nitrile and EPDM jacketed U-shaped spring seal reciprocating test has accumulated ~2850 h at temperature. Current leakage rates are shown in Table 3 and are compared with results of the identical test run at 150°F (66°C). Also included are comparative rates for a similar test run at 150°F (66°C) with Q-rings. Although the elastomer compounds are not identical, the performances of the jacketed spring seals are superior to the solid elastomers. Tests will continue to evaluate long term effects of elevated temperature, particularly for the nitrile.

TABLE 3
SUMMARY OF RECIPROCATING LEAKAGE TESTS –
JACKETED U-SHAPED SPRING SEALS

Elastomer	Temperature °F(°C)	Time (h)	Test Gas	Leakage Rate (scc/s-in. -atm $\Delta P \times 10^{-8}$)	
				Jacketed Spring Seal	Q-ring
Nitrile	150 (66)	1994	Kr	16	28
			Xe	21	23
			H ₂	44	80
	250 (121)	2848	Kr	37	} 2800 h
			Xe	20	
			H ₂	204	
EPDM	150 (66)	1994	Kr	38	118
			Xe	33	445
			H ₂	204	954
	250 (121)	2848	Kr	15	} 2800 h
			Xe	43	
			H ₂	550	

C. ADVANCED MATERIALS

The 250°F (121°C) polyphosphazene static leakage test has accumulated 2000 h at temperature. After 1300 h, a small gas reservoir was added to the system to improve gas chromatograph analyses. At this time the fixture cavities were evacuated and recharged with the test gases. Leakage rates after recharging the system are consistent with those measured before evacuation and are considerably lower than calculated rates based on slab permeation data. Figures 8 and 9 show the krypton and hydrogen leakage rates, 36.7×10^{-8} and 391×10^{-8} scc/s-in. -atm ΔP , respectively, overplotted on the theoretical leakage curves based on the permeation data.

A 250°F (121°C), 50% initial deflection compression set test was initiated on a phosphazene O-ring from the same series as those used for the static leakage test. After one week, the O-ring was found to have a series of splits around the entire circumference (Figure 10). It is postulated that the cause is volatilizing of gases, probably peroxides used in the curing cycle, from within the elastomer. A second O-ring was put on test at 150°F (66°C) at the 50% deflection. After two weeks, splitting of the O-ring surface was again observed.

The phosphazene polymer was obtained from Firestone and was molded by Parker Seal Co. on a best-effort-basis as to curing initiators, cure time, and temperature. Optimization of the curing cycle will be required and is one of the program tasks which will be studied under the compounding study to be initiated in GFY 77.

Work is continuing at Union Carbide Co. on development of a high molecular weight carborane siloxane polymer and recent advances have been significant. It is estimated that initial specimens of the improved material will be available in late July for initiation of gas permeation and compression set resistance tests.

D. GAMMA IRRADIATION

Gas leakage rates for the four elastomers undergoing irradiation tests are presented in Table 4. Values are for the completed 10^7 rad (10^5 J/kg) tests, the ongoing 10^8 rad (10^6 J/kg) tests through $\sim 7 \times 10^7$ rad (7×10^5 J/kg), and typical data from similar nonirradiated static leakage tests previously run (AI-AEC-13154). There are no indications of any significant effect of

Figure 8. Polyphosphazene-Parker/Firestone O-Ring Static Leakage (L_{KR}) - Calculated From Measured Permeability and Estimated h/t 9006-40529

Figure 9. Polyphosphazene-Parker/Firestone O-Ring Static Leakage (L_{H_2}) - Calculated From Measured Permeability and Estimated h/t 9006-40530

Figure 10. Polyphosphazene O-Ring — 1 Week at 250°F (121°C)
Under 50% Deflection

9006-40631A

TABLE 4

ELASTOMER IRRADIATION TEST RESULTS

Elastomer	Test Temperature °F(°C)	Dose (rad)		Total Time at Temperature (h)	Leak Rate†		Hardness	Compression Set (%)	Weight Change (%)
		Current	Total Required		Xenon	Krypton	Pre / Post		
Silicone Parker S684	300 (149)	1.22×10^7	10^7	866	224.1	199	77/84	78.9	-0.1
		7.0×10^7	10^8	2785	272	279			
		—	—		N/A	165	76/74		
EPDM Parker E692	150 (66)	$1.3 \times 10^{7*}$	10^7	866	118.1	78	78/83	42.9	-0.1
		7.0×10^7	10^8	2785	115.9	81.7			
		—	—		N/A	60	74/74		
Nitrile Parker N741	150 (66)	$1.15 \times 10^{7*}$	10^7	866	14.8	12.1	83/86	27.5	-0.1
		7.0×10^7	10^8	2785	17.4	16.1			
		—	—		N/A	16	77/77		
Urethane Parker B642	150 (66)	$1.4 \times 10^{7*}$	10^7	866	43	144.8**	74/75	64.1	-0.1
		7×10^7	10^8	2785	43	37.8			
		—	—		N/A	17	72/71		

*Test complete

†L = cc/s/in. /ΔP atm at STP

§Weight increase due to absorbed grease — radiation test
elastomers nonlubricated

** Potential fixture leak

irradiation on the leakage rates. Variations in leakage rates between irradiated and nonirradiated tests are comparable to variations between individual variations for nonirradiated tests. Leakage rates for one silicone and one urethane test are higher than expected and indicate potential fixture leaks. This will be identified at the conclusion of the test phase.

Also included in Table 4 are hardness, weight change, and compression set results for the completed 10^7 rad (10^5 J/kg) tests. Typical of crosslinking type polymers, there appears to be some effect of irradiation on increasing the hardness of the elastomers. Figure 11 shows the relative compression set for the nitrile seal after the 10^7 rad (10^5 J/kg) irradiation test and for a similar nonirradiated test run in air.

Fixtures used for the 10^7 rad (10^5 J/kg) irradiation tests were reloaded with new O-rings, seal welded, and leak checked for use in conducting the 5×10^7 rad (5×10^5 J/kg) tests. Seals in two fixtures were exposed to excessive heat during the seal welding sequence and are being replaced. The remaining two fixtures have been satisfactorily checked, but will be held until all fixtures can be placed into the cell together to ensure a uniform total dose.

E. CELL PENETRATION SEALANT TEST

A new activity was initiated in May to select a material suitable for use as a sealant in LMFBFR equipment cell penetrations, piping, and cable conduits. The reference material must withstand molten sodium at 1000°F (538°C) for 1 h and a radiation dose of 10^9 rad (10^7 J/kg) gamma and still retain its sealing capability.

A test plan, N707TP810013, "Test Plan for the Selection of a Sodium and Radiation-Resistant Sealant for Penetrations, Conduits, etc. in LMFBFR Equipment Cells" was prepared. The three-phase test consists of screening tests on 1-in. dia by 2-in. long (2.54 cm by 5.08 cm) cylinders of sealant material geometry tests on samples cast in 2-in. dia pipe, and a prototype test of single cell penetration.

Table 5 shows 16 materials, and their published properties, selected for initial evaluation. Additional candidates may include materials selected for Table 5 with various fillers such as vermiculite, NaX, dry sand, and glass beads.

Three 1-in. dia by 2-in. long (2.54 cm by 5.08 cm) specimens for initial sodium and irradiation testing, plus a 2-in. dia by 0.55-in. thick (5.08 cm by 1.40 cm) specimen for resiliancy tests have been mixed from the Dow Corning Sylgard 186 and 187, and the Eccosil 4553, 4712, 4952, 4966, and TP50. Viscosity of the TP50 is very high and it is difficult to fill all voids. Large scale pours would probably have to be made with a caulking gun. Figure 12 shows three typical test specimens. Fabrication of the sodium test vessel for the initial test is complete and ready for filling with sodium.

F. MATERIALS HANDBOOK

Permeation, compression set, physical and mechanical properties data have been compiled for all elastomers evaluated at AI and submitted to the Nuclear Systems Materials Handbook (NSMH) review committee. The data covers approximately 25 individual elastomers including nitrile, silicone, urethane, ethylene propylene, polyacrylic, neoprene, fluorocarbon, Buna S, and butyl for several manufacturers, including Parker Seal Co., Minnesota Rubber, Greene-Tweede and Co., and B. F. Goodrich. The permeation and

TABLE 5
SEALANTS TO BE TESTED IN THE CELL PENETRATION SEALANT TEST
(Sheet 1 of 3)

Manufacturer and Trade Name	Dow Corning Sylgard 186	Dow Corning Sylgard 187	Dow Corning RTV 3110	Dow Corning RTV 3112	Dow Corning ⁽²⁾ RTV 3140	Dow Corning ⁽²⁾ RTV 3145	Dow Corning 93-104
Type Material	Two-part RTV silicone rubber	Two-part RTV silicone rubber	Two-part RTV silicone rubber	Two-part RTV silicone rubber	One-part solventless silicone rubber	One-part vulcanizing silicon rubber	Two-part silicone ablative material
Form	Pourable	Pourable	Pourable	Pourable	Ready-to-use viscous liquid	Nonslumping paste	
Viscosity, Poise ⁽¹⁾ (see notes)	450 (with 10 pph curing agent added) may be lowered with 1330 thinner	500 - May be lowered with 1330 thinner	130 ± 50	300 ± 100	350		2250 (with catalyst); may be diluted to spraying consistency
Color	Clear	Black and opaque	White	White	Clear	Gray	Dark gray
Specific Gravity	1.12	1.12	1.17	1.38	1.05	1.12	1.46
Hardness Shore A	32	32	45	55	22	33	75
Service Temperature [°F(°C)] Short Time	480 (249)	480 (249)	480 (249)	480 (249)	480 (249)	570 (299)	6000 (6) (3315)
Tensile Strength (psi)	700	700	300	550	300	700	300
Elongation (%)	420	420	150	100	350	675	60
Thermal Conductivity (Btu-ft/ft ² -h-°F)			0.18	0.14	0.07	0.10	
Mix Preparation	Add 186 curing agent	Add 187 curing agent	Add catalyst S	Add catalyst S			Add 93-104 catalyst
Cure Temperature (°F)	RTV or elevation	RTV or elevation	RTV or up to 60°C	RTV or up to 60°C	⁽³⁾ Room temperature only	⁽³⁾ Room temperature only	RTV or elevation
Radiation Resistance (megarads) ⁽⁴⁾	200	250	100	100	100		

NOTES: (1) Viscosity values right after mixing with curing agent
(2) Normally used as thin coatings. Cure time excessive for thicknesses greater than 1/8 in
(3) Requires >30% relative humidity in air to cure at room temperature
(4) Useful after exposure to this megarad dose
(5) Elastomeric properties retained
(6) As ablative material

TABLE 5
SEALANTS TO BE TESTED IN THE CELL
PENETRATION SEALANT TEST
(Sheet 2 of 3)

Manufacturer and Trade Name	Eccosil 4553	Eccosil 4712	Eccosil 4952	Eccosil 4966	Eccosil TP 50
Type Material	Fiber-reinforced RTV silicone rubber	Epoxy/silicone	RTV silicone rubber	RTV silicone rubber	silicone rubber
Form	Liquid	Liquid	Liquid	Liquid	Paste
Viscosity, Poise ⁽¹⁾ (See Notes)	360	1200	300	500	Thixotropic
Color	White	Red	Red	Red	Reddish
Specific Gravity	1.60	1.20	2.28	1.50	1.55
Hardness Shore A	72	68	70	60	56
Service Temperature [°F (°C)] Short Time	500 (260)	500 (260)	600 (316)	625 (329)	550 (288)
Tensile Strength (psi)	550	500	650	850	700
Elongation (%)	>100	60	>100	130	150
Thermal Conductivity (Btu-ft/ft ² -h-°F)	0.20	0.20	0.62	0.20	0.42
Mix Preparation	Add catalyst 50	Mix A + B + C + D	Add catalyst 50	Add catalyst 50	Mix A + B
Cure Temperature (°F)	RTV or elevation	250° F for 2 h	RTV or elevation	RTV or elevation	RTV or elevation
Radiation Resistance (megarads) ⁽⁴⁾					

NOTES: (1) Viscosity values right after mixing with cure agent
(2) Normally used as thin coatings. Cure time excessive for thicknesses greater than 1/8 in.
(3) Requires >30% relative humidity in air to cure at room temperature
(4) Useful after exposure to this megarad dose
(5) Elastomeric properties retained
(6) As ablative material

TABLE 5
SEALANTS TO BE TESTED IN THE CELL
PENETRATION SEALANT TEST
(Sheet 3 of 3)

Manufacturer and Trade Name	GE RTV 511	GE RTV 560	GE RTV 577	PR1750
Type Material	Two-part RTV silicone rubber	Two-part RTV silicone rubber	Two-part RTV silicone rubber	Two-part polysulfide RTV rubber
Form	Pourable	Pourable	Thixotropic paste	Pourable
Viscosity, Poise ⁽¹⁾ (See Notes)	200	400	6000	300
Color	White	Red	White	Dark gray
Specific Gravity	1.18	1.42	1.35	1.58
Hardness Shore A	45	60	50	50(Rex)
Service Temperature [^o F(^o C)] Short Time	600(316) ⁽⁵⁾ up to 9000(4982) ⁽⁶⁾	600(316) ⁽⁵⁾ up to 9000(4982) ⁽⁶⁾	600(316) ⁽⁵⁾ up to 9000(4982) ⁽⁶⁾	360(182)
Tensile Strength (psi)	350	800	480	400
Elongation (%)	180	160	180	200
Thermal Conductivity (Btu-ft/ft ² -h- ^o F)	0.15 at 200 ^o F	0.18 at 200 ^o F	0.18 at 200 ^o F	
Mix Preparation	Add catalyst 9811	Add catalyst 9811	Add catalyst 9811	Add accelerator
Cure Temperature (^o F)	RTV	RTV	RTV	RTV
Radiation Resistance (megarads) ⁽⁴⁾				

NOTES: (1) Viscosity values right after mixing with curing agent
 (2) Normally used as thin coatings. Cure time excessive for thicknesses greater than 1/8 in.
 (3) Requires >30% relative humidity in air to cure at room temperature
 (4) Useful after exposure to this megarad dose
 (5) Elastomeric properties retained
 (6) As ablative material

9006-40491A

Figure 12. Resiliancy Test Specimens

compression set data were generated at AI, while most of the physical property data were supplied by the manufacturers. Typical data sheets are shown in Figures 13 and 14, and Table 6. Following acceptance of the data package by the NSMH review committee, the material will be published as enclosures for Volumes 1 and 2 of the Handbook.

G. CRBRP INFLATABLE SEAL VENDOR QUALIFICATION

In support of the CRBRP rotating plug inflatable seal vendor qualification effort, visits were made to three inflatable seal suppliers: (1) Kirkhill Rubber, (2) Presray Rubber Corporation, and (3) Seal Masters Corporation. The suppliers were evaluated on experience and capability for supplying the 20-ft (6.1 m) diameter CRBRP seals and it was judged that all suppliers should be capable of supplying the seals if they wished to.

9006-401118

Figure 13. Log $\bar{P}$ vs $1/T(K)$ for H_2 , Ar, Kr, and Xe for Silicone Rubber, Parker Seal Co., Compound S684

9006-4098A

Figure 14. Compression Set of Parker Seal O-Ring Seals, Silicone, Compound S684

TABLE 6
SAMPLE ELASTOMER PROPERTIES DATA

Property Code	Property	ASTM Test	S684-70 ^a Batch 16349 ⁽¹⁾	S684-70 ^a	S684-70 ^a (1)	S604-70 ^a (1)	S627-70 ^a (1)	S650-70 ^a (1)	71417 ^b (1)
2101	Tensile Strength (psi)	D412, Die C	1200	1226	1029	1075	1366	1308	685
	Pascal, N/m ² x 10 ⁴		825	845	710	740	942	902	470
2109	Hardness, Shore A, pts	D2240	73	68	71	68	65	73	70
2503	Elongation (%)	D412, Die C	232	232	203	174	300	375	135
	Tear Resistance (ppi)	D624, Die B	87	122 ⁽³⁾	—	—	—	—	77
	N/m		9.8	13.8	—	—	—	—	8.7
3304	Specific Gravity		1.23	1.19	—	—	—	—	1.44
4102	Air Aging, 70 h	D573							
	Temperature (°C)		175	225	—	—	—	—	200
	Hardness Change(pts)		+2	+3	—	—	—	—	+9
	Tensile Strength Change (%)		+8	-12.2	—	—	—	—	+18.1
	Elongation Change (%)		+8	-21.1	—	—	—	—	-3.8
2207	Compression Set, Method B	D395							
	Temperature (°C)	(25% Compression	70	150 ⁽²⁾ 150 ⁽²⁾	—	—	—	—	70
	Hours		22	70, 1000	—	—	—	—	22
	% Original Deflection		4.4	11.7, 33.8	—	—	—	—	3.2
	% Original Thickness		—	—	—	—	—	—	—
2120	Abrasion Resistance, Labor	D1044							
	Weight Loss, mg per 1000 cycles		10.0	—	—	—	—	—	—
2120	Abrasion Index	D2228	—	—	—	—	—	—	58
	Resiliency, Bashore (% Rebound)	D2632	52	—	—	—	—	—	—
	Resiliency (%)	D945	—	—	—	—	—	—	51
	Reference		1	1(S)	1(S)	1(S)	1(S)	1(S)	2

a — Parker Seal Co. b — Minnesota Rubber Co. c — Greene, Tween & Co.

(1) Slab (2) O-ring (3) Die C

IV. IMPACT ON LMFBR PROGRAMS

The initial phases of this program have guided selection of materials and seals for the FFTF and CRBRP from information on permeability, compression set, and gland design published in progress and technical reports. Designs of the FFTF-IVHM inflatable and primary seals were verified. Other phases have verified the instrument tree inflatable seal design and are evaluating the use of inflatable seals for CRBRP. Effects of sodium vapors and aerosols, and radiation on the sealing efficiency of elastomers will be delineated. Advanced seal geometries and materials will be developed to overcome the commercial seal deficiencies of excessive compression set (short maintenance cycle) and permeation. Specifications and a design guide for use in the LMFBR industry will become available and will be updated as new information is generated.

V. NEXT REPORT PERIOD ACTIVITIES

During the next reporting period it is expected that the sodium wetting tests will be completed and a recommended procedure established to ensure wetting of the CRBRP dip seal blade. Effort will be initiated to verify the technique on the dip seal blade test model.

The 10^8 rad (10^6 J/kg) gamma irradiation tests will be completed on the O-ring specimens and the 5×10^7 rad (5×10^5 J/kg) tests will be initiated.

The cell penetration sealant material selection should be narrowed to four candidates which will be tested for selection of the prime material.