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I. PROJECT OBJECTIVES

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.

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II. MAJOR ACCOMPLISHMENTS DURING FISCAL YEAR 1976

Permeation of oxygen through Parker Seal N741-75 nitrile and Minnesota Rubber FX 522 urethane elastomers was measured as a function of temperature on slabs previously measured for argon, krypton, xenon, and hydrogen.

All testing has been completed on the CRBRP rotating plug inflatable seal. Two 1600-hour, 150F (339 K) dwells were performed. Breakaway drag, for a nominal seal speed of 15 ft/min (7.6 E-2 m/s), was 87.8 lb/ft (1458 N/m) following the first dwell and was 54 lb/ft (983 N/m) for a slow start speed of 2 ft/min (1.0 E-2 m/s) following the second dwell. A breakaway drag of 63.9 lb/ft (1061 N/m) was measured after a 100-hour dwell with no lubrication on the seals. Drag and leakage tests were conducted on the seals with a worst case horizontal offset of 0.25 inch TIR (6.35 mm). Drag was ~ 40% above nominal values and although no massive buffer cavity leakage was measure, 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 months 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 gas film. The blade was wetted by a 600F (588K) thermal soak and the surface film eliminated.

Leakage tests were completed on dynamic, spring-assisted EPDM and nitrile seals at 150F (339K). Static tests were similarly run on indium-plated EPDM and nitrile O-rings and gasketed metal E-seals.

Permeation measurements were completed on carborane siloxane and phosphazene slabs. Sodium vapor/aerosol exposure tests were run on O-rings of silicone and EPDM to 300F (422K), and nitrile and urethane to 220F (378 K).

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

III. PROGRESS DURING THE REPORTING PERIOD

A. CRBRP ROTATING PLUG INFLATABLE SEAL

All scheduled testing on the CRBRP inflatable seals has been successfully concluded during the reporting period. The seals are currently being stored in-place on the test assembly under argon pressure. During the last quarter, the following tests were conducted.

1. Slow Start, 1600-Hour Interim Dwell Test

The slow start, 1600-hour dwell-breakaway test was conducted to study the effect of seal startup speed on post-dwell breakaway drag. All dwell and post-dwell drag test parameters duplicated those of the first interim dwell (AI-ERDA-13165), except seal speed was set at 2 ft/min (1.0 E-2 m/s) instead of the nominal 15 ft/min (7.6 E-2 m/s).

Initial plans were to perform the breakaway at a seal speed of 6 in/min (2.5 E-3 m/s) which approximates the minimum attainable CRBRP rotating plug speed, but the 2 ft/min (1.0 E-2 m/s) was the minimum speed possible without modifying the test fixture.

Breakaway drag after 1584 hours at 150F (339 K) was 54 lb/ft (898 N/m) of double seal with dynamic drag decreasing to 34.1 lb/ft (583 N/m) after 1/4 revolution. Seal speed was slowly increased to the nominal 15 ft/min (7.6 E-2 m/s) with no effect on drag and after two hours of continuous cycling drag was stable at about 21 lb/ft (349 N/m). Table I summarizes the comparative results of the nominal and slow start breakaway-dwell tests.

TABLE I
INTERIM DWELL TEST SUMMARY

ACTIVITY	NOMINAL TEST	SLOW START TEST
Dwell Time: Hr (s)	1608 (5.8 E+6)	1584 (5.7 E+6)
Temperature: °F (K)	150 ± 5 (339 ± 3)	150 ± 5 (339 ± 3)
Seal Speed: ft/min (m/s)	15 (7.6 E-2)	2 (1.0 E-2)
Breakaway Drag: lb/ft (N/m)	87.8 (1458)	54 (898)
Drag after 1/4 revolution	37.6 (624)	35.1 (583)
Drag after 2 Hr (at 15 ft/min)	22 (365)	21 (349)
Breakaway: Avg. Drag	4:1	2.6:1

Assuming the same effect of speed on breakaway drag, the 132 lb/ft (2191 N/m) drag measured following the 3500-hour dwell could be reduced to approximately 82 lb/ft (1361 N/m) and significantly reduce the potential short-term overload on the CRBRP rotating plug drive system. The system is currently designed for a maximum continuous load of 75 lb/ft

(1245 N/m) with the capability for short term (~ 30 sec) overload periods.

Following breakaway tests, drag vs speed vs inflation pressure parametric tests were performed at 150F (339 K) and closely duplicated those run prior to the dwell and during the nominal speed interim dwell. Figure 1 shows post-dwell data for both dwell tests.

Dynamic leakage tests were performed by rotating the seal and measuring cross-seal gas leakage from the buffer cavity for a variety of seal inflation and buffer cavity pressures. Results were unchanged from previous tests. Based on the results of the 150F (339 K) parametric drag and leakage tests, the seal was determined to be operating normally and ambient temperature tests were deleted.

2. No-lube, Breakaway Test

A no-lube breakaway drag test with all traces of grease removed from the seal was run to simulate conditions where grease had been lost through aging or evaporation at the end of seal life. After interim dwell testing, the test fixture was disassembled, all visible traces of the DC-55M grease removed from the seal, the track and the seal were wiped grease-free using cloths moistened with MEK, and then allowed to dry overnight to fully dissipate the MEK vapors. The seal fixture was reassembled, heated to 150F (339 K), and dwelled for 100 hours. Breakaway drag, at the nominal 15 ft/min (7.6 E-2 m/s) speed, 7.5 psig (1.53 E+5 Pa) inflation pressure conditions was 63.9 lb/ft (1061 N/m). Under lubricated conditions (AI-ERDA-13154), a breakaway drag of about 48 lb/ft (797 N/m) would be expected. Removal of the grease resulted in a drag increase by a factor of ~ 1.33 . After 1/4 revolution, the drag decreased to about 22 lb/ft (365 N/m), but steadily increased to ~ 55 lb/ft (913 N/m) during 2 hours of continuous cycling in a clockwise-counterclockwise mode.

CRBRP ROTATING PLUG INFLATABLE SEAL
POST DWELL DRAG vs INFLATION PRESSURE

FIGURE 1

The drag vs speed vs inflation pressure parametric tests were repeated and results are included in Figure 1. Drag was ~ 70 lb/ft (1162 N/m) at 15 ft/min (7.6 E-2 m/s) speed and 7.5 psig (1.53 E+5 Pa) nominal conditions, showed no effect of speed between nominal speed and 5 ft/min (2.5 E-2 m/s) and no effect of inflation pressure until it was decreased to 3 psig (1.2 E+5 Pa) where buffer cavity pressure could not be maintained due to cross seal leakage. Normally, drag decreases with decreasing speed and/or inflation pressure.

Dynamic leakage test results were consistent with similar tests on the lubricated seal. The seal was cooled to ambient temperature and drag measurements at a speed of 15 ft/min (7.6 E-2 m/s) initiated. During a 20-minute run, drag increased from 83 lb/ft (1378 N/m) to > 130 lb/ft (2160 N/m) where the test fixture drive system stalled. Repeated efforts to rotate the seal resulted in stalling of the system in ~ 1/4 revolution. Seal speed was reduced to 5 ft/min (2.5 E-2 m/s) with no effect and inflation pressure was decreased to 3 psig (1.25 E+5 Pa) before continuous rotation could be maintained at a drag of ~ 80 lb/ft (1328 N/m). Under these conditions, drag is greater than the 75 lb/ft (1245 N/m) CRBRP continuous capacity and a buffer cavity gas seal cannot be maintained. The fixture was disassembled and a visual examination showed the seal to be in excellent condition.

3. Seal Off-set Test - 0.25 in (6.35mm) TIR

The seal blade assembly was relocated to provide a 0.25 in (6.35mm) TIR eccentricity between the elastomer seal and the 304 SSTL seal blade. Drag and leakage tests have previously been run at horizontal eccentricities of 0.10 (2.52) and 0.18 in (4.58mm) TIR, (Ref. AI-ERDA-13154) and this test, rescheduled to preclude possible damage to the seal before all testing was completed, was run under maximum test fixture offset capabilities.

Drag vs inflation pressure results for the 0.25 in (6.35mm) TIR test are included on Figure 1. For all inflation pressures, drag is approximately a factor of 1.3 greater than that for nominal offset conditions. Figure 2, which includes data from previously run offset tests, shows the effect of horizontal offset on running drag for various inflation pressures. Up to a TIR of ~ 0.12 in (3.05mm), drag is relatively independent of offset, but increasing the offset beyond that results in an increasingly sharp rise in drag and eventually the inability to maintain zero buffer gas leakage.

Under nominal offset 0.04 in (1.02 mm) TIR , a buffer cavity gas seal is maintained at inflation pressure > 5 psig ($1.36 \text{ E}+5$ Pa) for a 1 psig ($1.09 \text{ E}+5$ Pa) buffer pressure and > 10 psig ($1.7 \text{ E}+5$ Pa) for a 5 psig ($1.36 \text{ E}+5$ Pa) buffer pressure. Also, when the inflation pressure is reduced to the point where leakage can be detected, any additional reduction in inflation pressure will result in massive leakage. For the 0.25 in (6.35 mm) TIR test condition, all combinations of inflation pressure, buffer cavity pressure, and seal rotating speed (including static conditions) resulted in low level gas leakage from the buffer cavity. As with nominal offset, the leakage varied with the angular position of the seal and reached a maximum of ~ 15 cc (Std)/min when the points of maximum vertical and horizontal offset coincided. It appears that while the excessive horizontal offset does not permit a gas-tight seal to be maintained, the blade is forced against the seal side wall such that the rigidity of the seal body supported by the gland provides a mechanical seal independent of any inflation pressure.

Following completion of the 0.25 in (6.35 mm) offset test, the test fixture cover was removed and the seals visually inspected. Figure 3 shows the seals in the region of maximum offset. Note that the grease was forced out of the seal wear strip trough due to the blade side load.

EFFECT OF HORIZONTAL OFFSET ON RUNNING DRAG
FOR 3 SEAL INFLATION PRESSURES
FIGURE 2

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Figure 3. CRBRP Rotating Plug Seals; Area of Maximum Offset, 0.25 in TIR Test

A thin film of grease remained on the seal wear strip, however, and was sufficient to provide adequate lubrication. Some slight darkening of the grease was found due to trace amounts of the elastomer being abraded off, and collected in the grease. Figure 4 shows an adjacent section of the seals following removal of the grease. Both seals are in excellent condition, and no signs of deterioration or damage to the seals were found during a detailed visual inspection. Based on the condition of the seals after ~ 200,000 ft (60,960 m) of travel, it is expected that the seals could run another 200,000 ft with little additional wear.

4. Adhesive-Grease Compatibility Tests

All adhesive-grease compatibility tests for the FFTF-IVHM, CRBRP rotating plug nitrile inflatable seals have been completed. Test specimens, thermally soaked at 150F (339 K) for up to 18 months, have been pulled to failure and the bond strengths of the Chemlok 304 and 140 RTV adhesives established. Results of the Chemlok 304 series are given in Table II.

TABLE II

CHEMLOK 304 ADHESIVE-GREASE BOND STRENGTH RESULTS			
Soak Time Months	No. of Specimens	Avg. Shear Stress at Failure:psi (Pa)	
		DC 55 M Grease	Exxon 5182 Grease
1	2	151 (1.04 E+6)	139 (0.96 E+6)
2	3	133 (0.92 E+6)	135 (0.93 E+6)
4	2	158 (1.09 E+6)	166 (1.14 E+6)
8	1	149 (1.03 E+6)	179 (1.23 E+6)
16	2	134 (0.92 E+6)	144 (0.99 E+6)
Avg.	10	143 (0.99 E+6)	148 (1.02 E+6)

Figure 4. CRBRP Rotating Plug Seals: Post Test Condition

TABLE III

EFFECT OF METAL, GREASE ON SHEAR STRENGTH

Grease	Metal	No. of Specimens	Avg. Shear Stress psi (Pa)
DC 55 M	304 SSTL	4	143 (0.99 E+6)
	Carbon Steel	6	144 (0.99 E+6)
5182	304 SSTL	4	141 (0.97 E+6)
	Carbon Steel	6	153 (1.05 E+6)
DC 55M 5182	Either	10	143 (0.99 E+6)
	Either	10	148 (1.02 E+6)
Either Either	304 SSTL	8	142 (0.98 E+6)
	Carbon Steel	12	149 (1.03 E+6)
Avg. of all 20 specimens			146 (1.01 E+6)

Based on these data, the Chemlok strength is shown to be independent of all variables, including exposure time. Nominal seal operating drag of ~ 40 lb/ft (664 N/m) and worst case breakaway drag of 132 lb/ft (2192 N/m) represent shear stresses of 1.6 psi (1.10 E+4 Pa) and 5.5 psi (3.79 E+4 Pa) respectively. The lowest bond strength measured, ~125 psi (0.86 E+6 Pa), represents a safety factor of 77 and 22 for the nominal and worst case drag.

The specimens tested with the original FFTF IVHM adhesive, 140 RTV, were all bonded to 304 SSTL and coated with DC 55M grease. Table IV summarizes results of those tests.

TABLE IV

140 RTV ADHESIVE-DC55M GREASE BOND STRENGTH RESULTS

Soak Time Months	No. of Specimens	Shear Stress at Failure: Psi (Pa)	
		Actual	Avg.
5	2	15.0(1.03 E+5), 27.7 (1.91 E+5)	21.4(1.47 E+5)
9	2	13.1(0.90 E+5), 24.4 (1.68 E+5)	18.8(1.30 E+5)
14	2	17.1(1.18 E+5), 19.8 (1.36 E+5)	18.5(1.27 E+5)
18	2	13.5(0.93 E+5), 13.5	13.5(0.93 E+5)
	8		18.1(1.25 E+5)

Although the minimum shear was measured on a 9-month coupon, the average data indicate a decrease in bond strength with time. Extrapolating a curve generated from the minimum stress at failure for each time period, the adhesive would provide a safety factor of 7 for the nominal drag and 2 for worst case drag after 10 years operation.

FFTF Instrument Tree adhesive-grease compatibility tests have been terminated after 11 months of the scheduled 18-month test period. Segments of the silicone Instrument Tree seal were bonded to 304 SSTL tabs using the seal-supplier recommended 731 RTV adhesive and coated with Exxon 5182 grease. Pull (shear) and peel (tensile) specimens were thermally soaked at 150°F (339 K) and pulled to failure in tests similar to the IVHM adhesive tests. As a result of bond failure on specimens pulled after 11 months thermal soak, specimens scheduled for 16 months were also pulled. Table V summarizes test results.

TABLE V
FFTF-INSTRUMENT TREE ADHESIVE-GREASE BOND STRENGTH TESTS

Soak Time	Pull Specimens Shear stress:Psi (Pa)	Peel Specimens Force: lb/in (N/m)
1	31.9 (2.19 E+5) 43.1 (2.97 E+5)	3.6 (6.31 E+2) 0 ①
2	19.8 (1.36 E+5) 45.2 (3.11 E+5)	5.6 (9.81 E+2) 10.6 (1.86 E+3)
4	38.0 (2.62 E+5) 12.2 (0.84 E+5)	7.6 (1.33 E+3) 3.3 (5.80 E+2) ②
11	7.2 (0.49 E+5) ③ 0 ② 0 ② 79.9 (5.50 E+5)	0.3 (0.53 E+2) ③ 5.9 (1.03 E+3) 0 ① 3.3 (5.80 E+2)

- ① Separated during loading in tensile machine
- ② Separated during removal from oven
- ③ Partial separation of bond during thermal soak

Visual observation of the specimens shows a probable weakening of the adhesive bond due to adsorption of the grease by the adhesive. Based on the Instrument Tree test results (AI-ERDA-13154), the test seals were subjected to a maximum load of 0.8 lb/in (140.2 N/m) or 1.6 psi (1.10 E+4 Pa) shear stress at the bond area. Since the actual seals have a large total bond area and the amount of grease used is substantially less than used with the adhesive bond strength tests, failure of the bond is less likely in actual use. However, loss of bond strength on several of the test specimens should be cause to initiate investigations for an alternate adhesive.

5. Seal Procurement Specification

The Westinghouse Engineering Specification for purchase of the CRBRP inflatable seal was reviewed, and recommendations based on AI inflatable seal experience were forwarded to Westinghouse.

B. TOP SHIELD DIP SEAL CONFIGURATION CHARACTERISTICS

During the first quarter of FY '76, gas attenuation measurements showed excessive leakage of helium across the dip seal blade. Non-wetting of the blade was identified as the problem, the sodium was heated to 600F (589 K) to wet the blade, and subsequent attenuation tests resulted in an acceptable helium leak rate (AI-ERDA-13165).

Two additional gas attenuation runs were made at 420F (489 K) and 590F (583 K). Table VI shows the helium leak rate across the dip seal blade for the various test conditions and compares those results to acceptable limits and the calculated diffusion rate through sodium.

TABLE VI
EFFECT OF WETTING OF DIP SEAL BLADE SURFACE
HELIUM LEAK RATE FOR 5 in. OF SODIUM

Condition	Temp. °F(K)	Helium Leak Rate scc/sec-cm
1. Dip Seal Blade: Pre-wetted	400 (478)	4.5×10^{-6}
2. Dip Seal Blade: After wetting	420 (489)	0.8×10^{-8}
3. Permissible Leak Rate*	400 (478)	4.9×10^{-8}
4. Calculated rate: diffusion through quiescent sodium	400 (478)	3.2×10^{-12}
* For decontamination factor of 3×10^{-4}		

Tests on the dip seal test article have been suspended and procedures will be investigated to ensure wetting of the dip seal under CRBRP conditions. An inert atmosphere glovebox has been set up (Figure 5) and will be used to establish conditions necessary for sodium wetting on small tabs of the SA 508 dip seal blade material. The dip seal blade will be processed accordingly, and the process verified by resumption of the dip seal tests.

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Figure 5. Sodium Wetting Test Glove Box

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C. ADVANCED SEALS AND GEOMETRY

The nitrile and EPDM jacketed helical spring seal reciprocating test has been disassembled after 2000 hours at 150F (339 K). Inspection of the fixture showed the test shaft was in contact with one side of the housing on the EPDM seal end during test. This resulted in a non-uniform loading of the seals with ~ 20% compression on one side and ~0% on the opposite side. A single groove ~ 5 mils (12.7 E-5 m) in depth and 1 mil (2.5 E-5 m) wide was cut in the shaft and very slight wear was visible in the EPDM seal's rubbing surface. Gas leakage rates (reported in AI-ERDA 13165) were generally less than those of similar reciprocating O-ring tests and any effects due to the shaft offset were not measurable. The EPDM test seals are shown in Figure 6 and, except for the small wear area, are in excellent condition.

The 150F nitrile and EPDM jacketed U-shaped spring seal reciprocating test has also been disassembled. All conditions were nominal and the seals were in excellent condition (Figure 7). A 250F (394 K) nitrile and EPDM jacketed U-shaped spring seal reciprocating test has been initiated. All other test conditions duplicate those of the previous 150F (339 K) test to study effects of temperature on seal leakage and compression set.

The rigid polyester thermoset and EPDM jacketed reciprocating test planned for 300F (422 K) was set up, but checkout of the system showed the polyester seals could not prevent gas leakage at the nominal installed 10% compression. The test setup will be modified to increase the seal compression to 20% and the test restarted.

A purchase order has been placed with Electroless to plate nickel films on slabs and O-ring specimens of nitrile, urethane, EPDM, and silicone elastomers. These will be available for permeation (slab) and static leakage (O-ring) testing in early April. Leakage rates are expected to be less than those obtained on preliminary tests with indium coated specimens

EPDM JACKETED HELICAL SPRING SEALS
2000 HOURS AT 150°F

INNER SEAL

MIDDLE SEAL

OUTER SEAL

Figure 6.

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EDPM JACKETED U-SHAPED SPRING SEALS
2000 HOURS AT 150°F

INNER SEAL

MIDDLE SEAL

OUTER SEAL

Figure 7.

9006-40620

due to better uniformity of coating surfaces and greater coating density.

D. ADVANCED MATERIALS

The evaluation of carborane siloxane, which appears to have great promise as a high temperature seal material, will be interrupted for approximately six months. During the past few months Union Carbide, the developer of the polymer, has made significant advances in the processing sequence and has produced a polymer chain with a molecular weight of about 5 million. The polymer under test at AI currently has a molecular weight of about 250,000. This increase in molecular weight should provide a substantial increase in the number of cure sites and, consequently, greatly increase the high temperature properties and stability of the polymer. By changing the cure mechanism from methyl vinyl to methyl sites, varying the peroxide initiator amounts, and altering the cure cycle of the new polymer, Union Carbide expects to produce a material capable of continuous use above 500F (533 K). Production of the currently-used low molecular weight polymer has been stopped and a pilot plant is being constructed to produce the new raw polymer which Union Carbide expects to have available in about six months.

A request for quotation (RFQ) was issued to Horizons Inc., and Parker Seal Co. to conduct a study for optimizing the properties, principally compression set and gas permeation resistance, of the polyphosphazene elastomer. Parker Seal No-bid the proposal, but Horizons responded with a program encompassing a nine-month's effort. Horizon's response is based on optimizing the basic polymer and then the elastomer product compounding variables such as curing agents and conditions, reinforcing fillers, activators, and process additives. Technical review of the proposal is in progress.

The phosphazene O-ring test fixture was assembled, seal welded, leak checked, and measured for internal cavity volumes. A 250F (394 K), 2000-hour leakage test has been initiated.

The second 1000-hour sodium vapor/aerosol exposure test of silicone, EPDM, nitrile and urethane O-rings has been completed and evaluation of the O-rings is in progress. The silicone and EPDM O-rings were maintained at 300F (422 K) and the nitrile and urethane O-rings at ~ 220F (378 K). Aerosol/vapor deposits were heavy on both the urethane and EPDM, smaller amounts were present on the silicone, and negligible amounts on the nitrile seals. Changes in properties, hardness and weight, of the elastomers due to the aerosol exposure are shown in Table VII.

TABLE VII
EFFECTS OF 2ND 1000-HOUR SODIUM VAPOR EXPOSURE

PROPERTY	TEST GROUP	AVG. PERCENT CHANGE IN PROPERTY			
		URETHANE	NITRILE	EPDM	SILICONE
HARDNESS	Na Exposed	+ 3.7	0	+ 2.6	+ 1.0
	Control	+ 1.7	1.6	+ 4.6	+ 1.6
	Effect of Na	+ 2.0	-1.6	- 2.0	- 0.6
WEIGHT	Na Exposed	- 1.1	- 1.5	- 2.4	- 0.5
	Control	- 1.2	- 0.7	- 2.4	- 0.3
	Effect of Na	+ 0.1	- 0.8	0	- 0.2

Test Conditions: 220F : Urethane, Nitrile
300F : EPDM, Silicone

These results and those of the first low temperature test (AI-ERDA-13165) run at 150F (nitrile and urethane) and 180F (EPDM and silicone) show that the effects of the aerosols on the indicated properties are minimal under the above test conditions. Data scatter is of the same order of magnitude as the changes noted. Tests are in progress to determine any effect on elastomer tensile strength from the two exposures.

Results from ongoing compression set tests on plied-up disks from advanced elastomer slabs are shown in Figure 8. These tests indicate that carborane siloxane exhibits greater set resistance than silicone at the test conditions. The tests also show that forms of polyphosphazene have set resistance comparable to silicone. This is significant, since the phosphazene was not compounded to its optimum performance, and its permeability is considerably less than silicone.

COMPRESSION SET OF ADVANCED MATERIALS-SLABS

FIGURE 8

E. GAMMA IRRADIATION

The O-ring test fixtures were assembled, installed in the test cart, and flux maps were run. Uniform dose rates to the test specimens were established at ~ 0.9 megarad/day (2.5 J/kg-sec) and 1.2 megarad/day (3.3 J/kg-sec) for the low and high intensity sources. The O-ring test specimens were loaded in the test fixtures, seal welds were made and leak checked, and the test fixtures were installed in the gamma cell.

The gas chromatograph and residual gas analyzers were checked out and calibrated for quantitative measurement of gas leakage across the seal and evolution of gases from the seals due to irradiation. Low level irradiation tests at 10^7 rad (1.0 E+5 J/kg) have been completed and leakage data are being analyzed.

Restart of the 5×10^7 (5.0 E+5 J/kg) and 10^8 rad (1.0 E+6 J/kg) total dose tests will be delayed ~ one month for gamma cell maintenance.

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 REPORTING PERIOD ACTIVITIES

The sodium wetting tests will be completed and a recommended procedure established to ensure wetting of the CRBRP dip seal blade.

The 250F (394 K) nitrile and EPDM jacketed U-shaped spring seals reciprocating leakage test will be completed. Static leakage tests on polyphosphazene will be completed. Interim level, 5×10^7 rad (5.0 E+5 J/kg) total dose, gamma irradiation tests on O-ring specimens will be completed provided gamma cell maintenance is completed as scheduled.

The currently scheduled activities for the seal program in FY 1976 are shown in Figure 9.

Figure 9. Schedule and Milestones