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EVALUATION OF ELASTOMERS AS GASKET MATERIALS IN PNEUMATIC AND HYDRAULIC SYSTEMS

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16. Abstract

In the search for superior materials from which to make gaskets for pneumatic and hydraulic systems at the Kennedy Space Center, promising materials were selected from a number of vendors, and then tested. The testing was conducted in two phases. Those materials that passed the tests of Phase I were tested in Phase II and categorized in the order of their preference.

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LOX	Phase II	
RP-1		
MIL-H-5606 Hydraulic Fluid		

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EVALUATION OF ELASTOMERS AS GASKET MATERIALS IN PNEUMATIC & HYDRAULIC SYSTEMS

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INTRODUCTION

This report summarizes a testing program which was conducted by the Materials Testing Branch for the Design Directorate, Mechanical Design Division, to evaluate the performance of various types of elastomers for pneumatic and hydraulic systems. The program was initiated in June 1969, by a request from Mr. A. Zeiler, and the testing was completed in August 1970.

The wide use of gasket materials, especially in RP-1, MIL-H-5606 Hydraulic Fluid and Oxygen systems at the John F. Kennedy Space Center, created the interest for this study program of new elastomers. The purpose of the program was to identify one or more materials of superior quality in service life, performance, and aging over materials currently in use.

A similar program (reference MAB 1991-67) was conducted in 1967 in which eight materials were evaluated for use in ultra-clean RP-1 fuel systems. However, that program primarily dealt with the nitrile type elastomers. The present program was directed toward the more exotic type of elastomers that are capable of greater service life and improved performance, e.g., the silicones and the fluorinated, acrylate, urethane, and acrylonitrile rubbers.

This program required the cooperation of vendors who could furnish the necessary materials for tests, as specified by the Materials Testing Branch. Contacts were made with vendors supplying materials believed suitable for the requirements. Those vendors indicating an interest in the program provided the necessary samples for the tests.

MATERIALS

Eighteen different materials were supplied by seven vendors. A listing of these materials and their sources are given in Table 1.

Samples for the test were supplied in 6-inch by 6-inch by 0.075-inch (15.24 cm by 15.24 cm by 0.19 cm) sheets and 0.500-inch by 1.29-inch (1.27 cm by 3.277 cm) diameter discs. The sheets were used for tensile dumbells and weather exposure samples; the discs were used for the compression set tests.

Table 1. Evaluation of Elastomers as Gasket Materials in Pneumatic & Hydraulic Systems

Vendor	Sample Description	Type
American Cynamid	9068-TIPA	Urethane
American Cynamid	8168-M	Urethane
Thiokol	E-109325-1	Acrylate
3M Co.	E-2141	Fluorel
3M Co.	E-2160	Fluorel
Dow Corning	LSX31243	Fluorosilicone
Goodrich Chemical Co.	245-13-159-1	Epichlorohydrin
Goodrich Chemical Co.	245-13-159-2	Epichlorohydrin
Goodrich Chemical Co.	210-21-124-1	Nitrile
Goodrich Chemical Co.	210-21-124-2	Nitrile
Goodrich Chemical Co.	210-21-124-3	Nitrile
Goodrich Chemical Co.	210-21-124-4	Nitrile
Goodrich Chemical Co.	210-21-124-5	Nitrile
Goodyear Tire & Rubber Co.	MA-442	Chloroprene
Goodyear Tire & Rubber Co.	D2-104D276	Chloroprene
Goodyear Tire & Rubber Co.	D2-70D552	Ethylene Propylene
Goodyear Tire & Rubber Co.	D2-70D553	Ethylene Propylene
Pelmor Laboratories	PLV-5010-B	Viton

TEST PROCEDURE

The testing program was conducted in two phases. Phase I, which involved testing of all eighteen materials, screened out those materials having weaknesses in some of the major performance parameters. Phase II involved additional testing of those materials found to be satisfactory in all major test categories during Phase I testing.

The Phase I program included room temperature exposures to both RP-1 and MIL-H-5606 Hydraulic Fluid for periods of up to 28 days. Physical properties such as ultimate elongation and hardness were determined after each exposure period and compared to data obtained prior to exposure in the test fluids. Accelerated oxygen aging, resistance to surface cracking and several other tests were conducted during this testing phase. All test procedures were taken from ASTM* standards, and the equipment used during the tests are shown in Figures 1 through 10. A brief summary of each test method used during this phase of the program is described as follows.

*American Society for Testing and Materials

ASTM D 395-61, "Compression Set of Vulcanized Rubber," is intended to measure the ability of rubber compounds to retain elastic properties during prolonged action of compression stresses. Method B was used where specimens were compressed between flat steel plates and steel spacers to give the required percentage of compression. Figure 1 displays a typical compression set test in progress.

ASTM D 412-64T, "Tension Testing of Vulcanized Rubber," covers the determination of the effect of the application of a tension load to vulcanized rubber and similar rubber-like materials at room temperature and elevated temperatures. Covered are tests for tensile strength and ultimate elongation. Figure 2 shows a sample being tensile tested.

ASTM D 471-64, "Change in Properties of Elastomeric Vulcanizates Resulting from Immersion in Liquids," is a procedure for exposing test specimens to the influence of liquids under definite conditions of temperature and time for the purpose of measuring the resulting deterioration. The deterioration is measured by the changes in physical properties before and after immersion in the test liquid. The deterioration was measured by tension testing, durometer hardness, and weight change. Figure 3 shows a specimen being readied for immersion in aging media.

ASTM D 518-61, "Resistance to Surface Cracking of Stretched Rubber Compounds," consists of continuously exposing rubber test specimens, held under strain to normal outdoor weather conditions. Procedure B was used whereby specimens 1 inch by 3-3/4 inches (2.54 cm by 9.525 cm) in length were looped and inserted between wooden strips and clamped to hold firm. The looped specimens were exposed to the weather at a 45-degree angle facing south and examined every 48 hours for deterioration. Figure 4 shows actual test samples after aging.

ASTM D 572-61, "Accelerated Aging of Vulcanized Rubber by the Oxygen-Pressure Method," consists of subjecting test specimens having previously determined physical properties to controlled deteriorating influences for known periods, after which the physical properties are again measured and the changes noted. In this method, the test involves exposure of specimens to an elevated temperature and elevated oxygen pressure. The physical properties used to measure the deterioration of the rubber, in addition to visual inspection, are tensile strength, ultimate elongation, and durometer hardness. Figure 5 shows the apparatus that was used to perform this type of test. Tension testing was measured as outlined per ASTM D 412-64T.

ASTM D 573-53, "Accelerated Aging of Vulcanized Rubber by the Oven Method," consists of subjecting test specimens having previously determined physical properties to controlled deteriorating influences for known periods, after which the physical properties are again measured and the changes noted. The physical properties used to measure the deterioration of the rubber, in addition to visual inspection, are tensile strength, ultimate elongation, and durometer hardness. Figure 1 shows specimens being oven aged as outlined above. Tension testing was measured as outlined per ASTM D 412-64T.

ASTM D 2240-64T, "Indentation of Rubber by Means of a Durometer," measures a given degree of hardness of the rubber specimen within limitations, and also indicates a state of cure. The durometer consists of a pressure foot, indentor point, indicating device and calibrated spring. Figure 6 shows the durometer with a specimen in place.

ASTM D 746-64T, "Brittleness Temperature of Plastics and Elastomers by Impact." This method of test is a procedure for determining the temperature at which plastics and elastomers exhibit brittle failure under specified conditions. Low temperature brittle failure is that temperature at which 50 percent of the specimens would fail in a specified test. This method has been found useful for specification purposes, but does not necessarily measure the lowest temperature at which the material may be used. Test specimens are mounted in the apparatus and immersed in the heat-transfer fluid for 3.0 ± 0.5 minutes at the test temperature. After immersion for the specified time, the temperature is recorded and a single impact is delivered to the specimens. Figure 10 displays the Brittleness Tester.

ASTM D 792-64-T, "Specific Gravity and Density of Plastics by Displacement," of a liquid and determination of the change in weight. The specific gravity or density of a solid is a property that can be measured conveniently to identify a material, to follow physical changes in a sample, to indicate degree of uniformity among different sampling units on specimens or to indicate the average density of a large item. Method A-1 was used by weighing the specimen in air then weighing in water and the resulting difference used to calculate the specific gravity.

Seven of the initial eighteen materials were selected for the Phase II program. During this phase the seven materials were again exposed to both the RP-1 and MIL-H-5606 hydraulic fluid, but for a period of 112 days, rather than 28 days. The physical properties were again determined before and after exposure. In addition, LOX impact compatibility tests were conducted by the method defined in KSC Procedure, MAB-SO-TSD-3-0001 and MSFC-SPEC-106B**. In order to comply with acceptance criteria of these documents, twenty separate samples of the material, submerged in LOX, are subjected to 10 Kg-M (72 ft.-lbs.) impact energy delivered through a 1/2-inch (1.27 cm) diameter area. More than one indication of sensitivity is cause for immediate rejection. A single explosion, flash, or other indication of sensitivity during the initial series of twenty tests requires that an additional forty samples be tested without incident to insure acceptability of the material. See Figure 9 (LOX test apparatus).

TEST RESULTS

Test results of the Phase I testing program are shown in Table 2.

Seven materials were selected for the Phase II testing program. Test results of this phase are shown in Table 3.

**MAB-SO-TSD-3-0001 - Kennedy Space Center LOX Test Procedure
MSFC-SPEC-106B - Marshall Space Flight Center LOX Test Specification

CONCLUSIONS

The following materials were found to be satisfactory in practically all categories for use in RP-1 and MIL-H-5606 hydraulic systems. They are listed in order of preference based on their overall performance in this testing program. Although the Goodrich 245-13-159-1 and 245-13-159-2 materials discolored the MIL-H-5606 hydraulic fluid, this is not uncommon and believed not to be detrimental to either the hydraulic fluid or the elastomer.

3M-2160
Dow-Corning LSX31243
Thiokol E-103325-1
Goodrich 210-21-124-4
Pelmor Labs. PLV-5010-B
Goodrich 245-13-159-2
Goodrich 245-13-159-1

3M-2160 is the only material of the seven tested which meets the batch test requirement for LOX compatibility if the material is to be used in the configuration of an "O" ring. This decision takes into consideration findings in test results obtained between disks and strips cut from the same sheet of material. Tests performed on several types of elastomers have shown that strips cut from sheet stock (to simulate "O" rings) react, while 11/16-inch (1.746 cm) diameter disks cut from the same sheet do not. This may be due to a greater concentration of impact energy on the smaller sample.

3M-2160, THIOKOL E-103325-1, Goodrich 210-21-124-4 and Pelmor Labs PLV-5010-B were found suitable for use in LOX and GOX systems on a batch test basis when used in sheet configuration.

This report lists seven materials in order of preference based on their overall performance in this particular testing program. However, it is suggested that the data tables be thoroughly evaluated before making a selection, since a material may have ranked poorly in overall performance but excelled in the specific characteristics for a particular end use. For example, the Goodrich 245-13-159-1 material was rated seventh primarily because it discolored the test fluids during exposure. However, it excelled in the low temperature brittle point test and would function better in low temperature systems where discoloration of the fluids is not a factor.

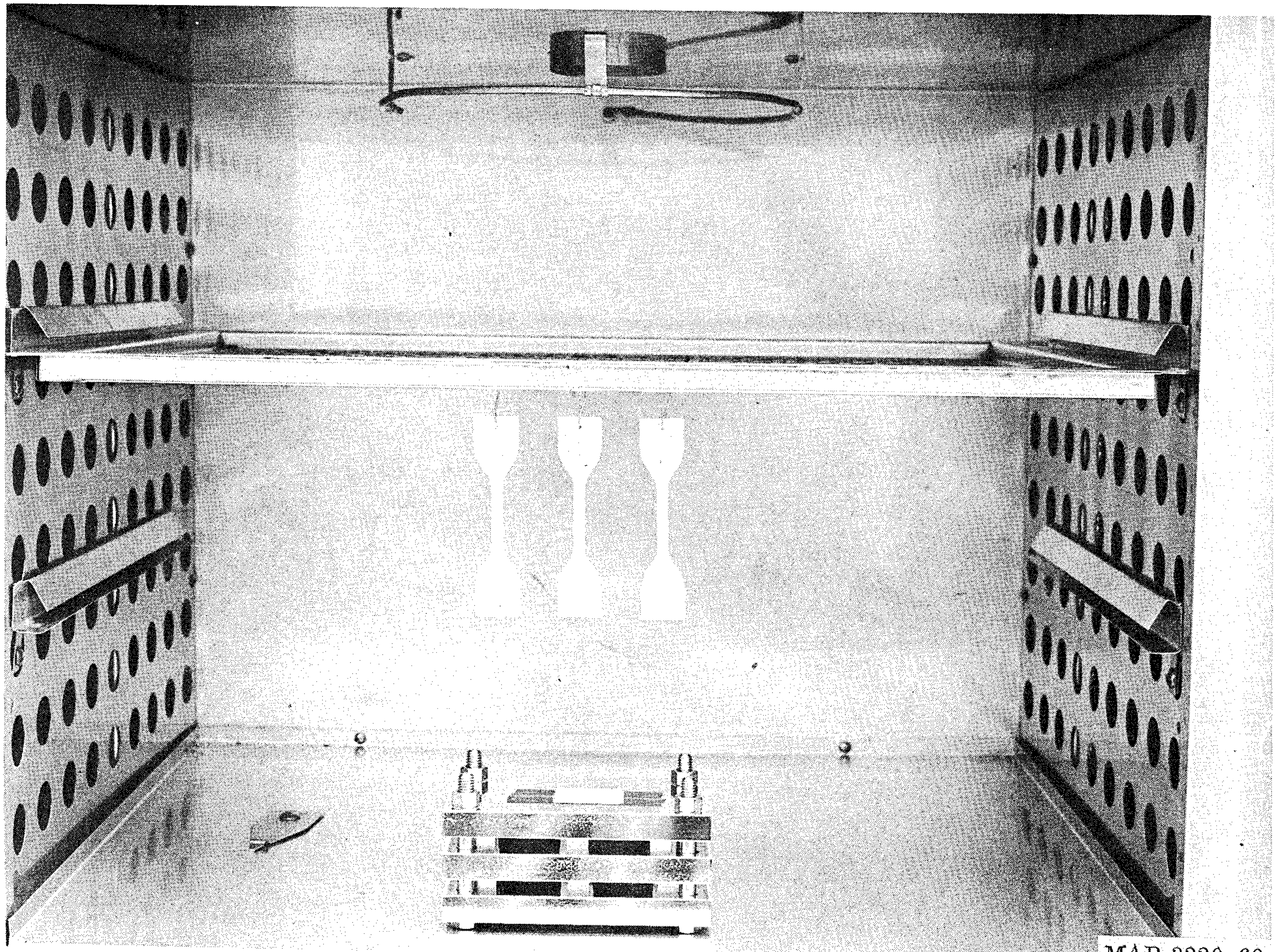

MAB 3220-69

Figure 1. Compression Set Test

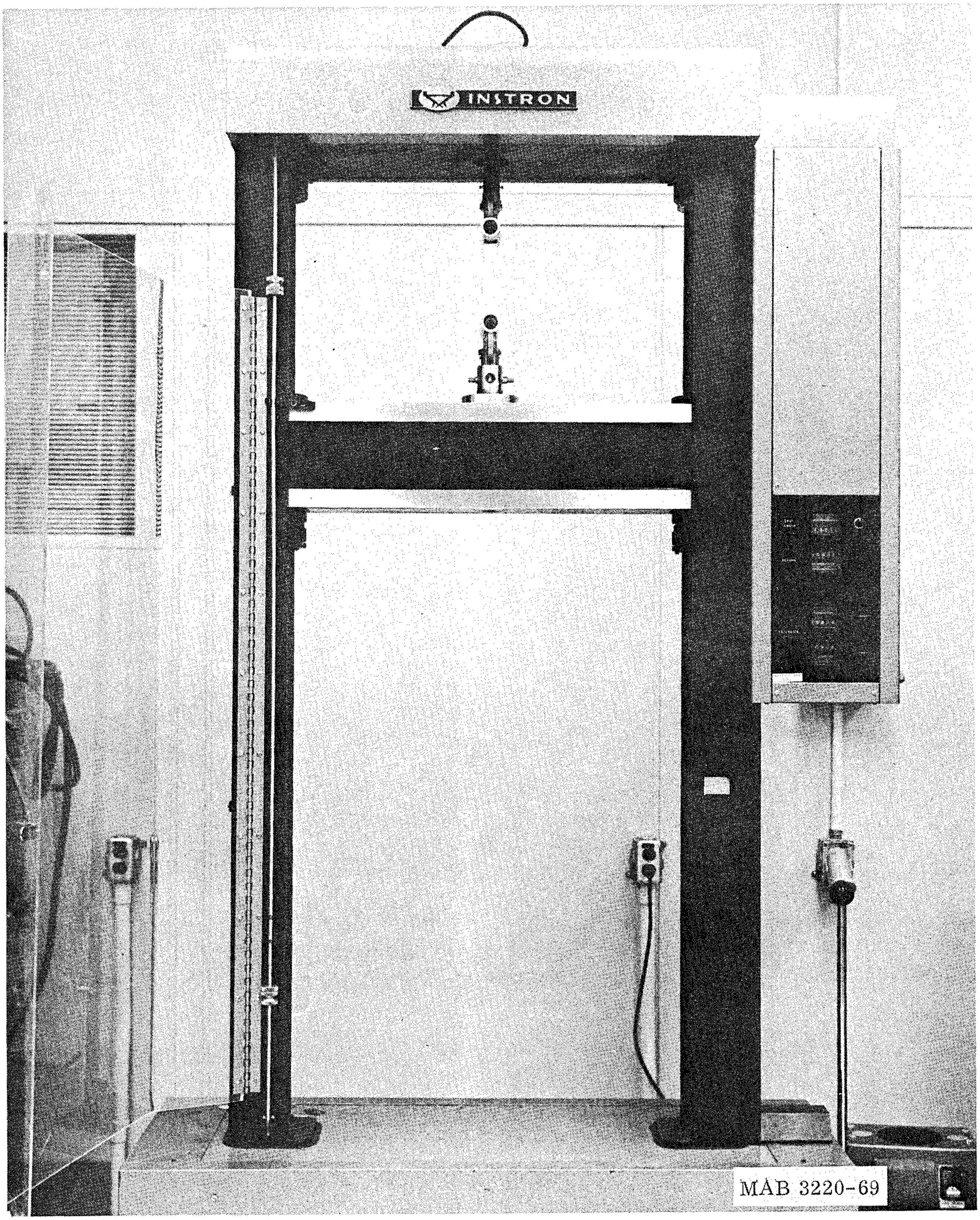


Figure 2. Tension Test

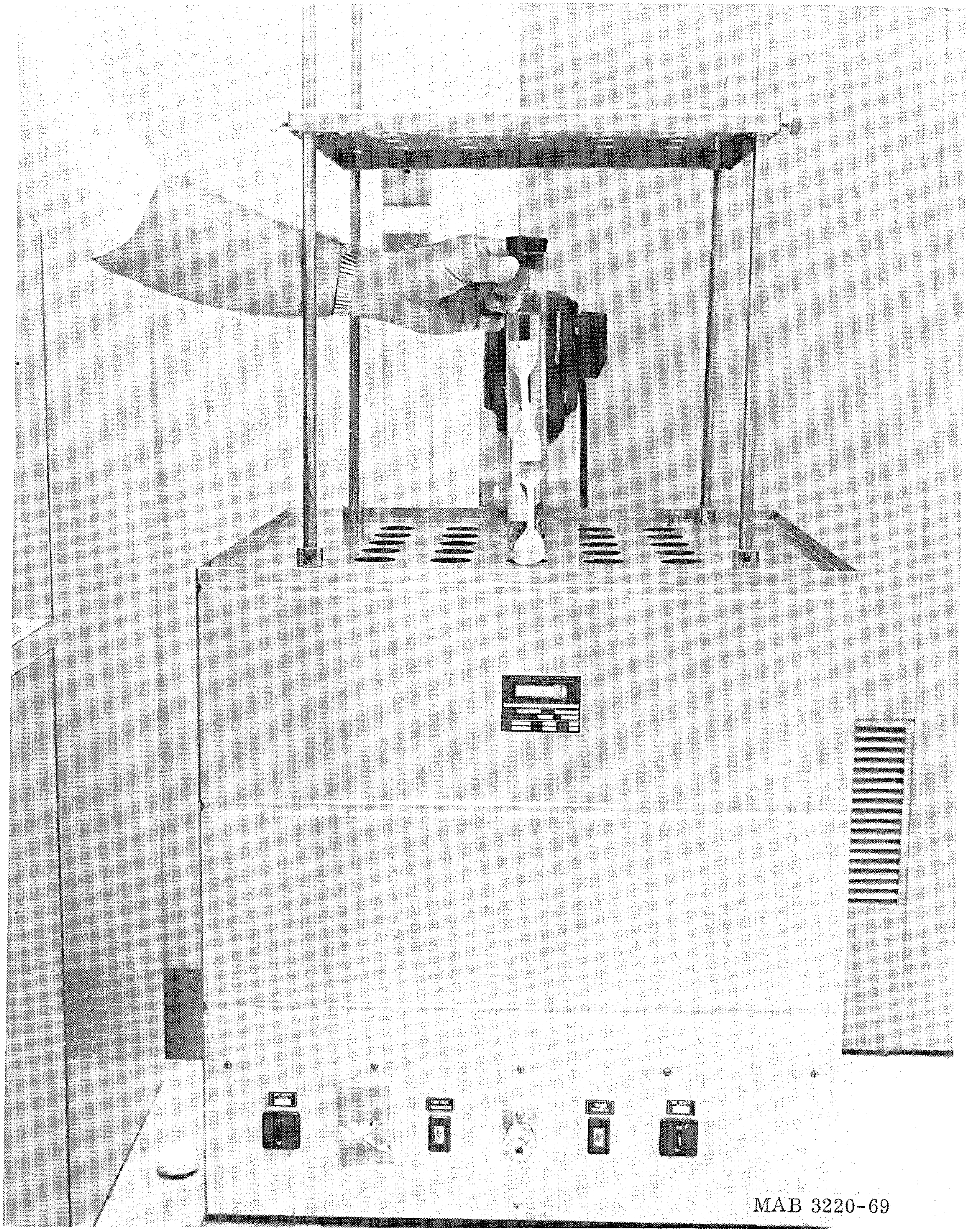
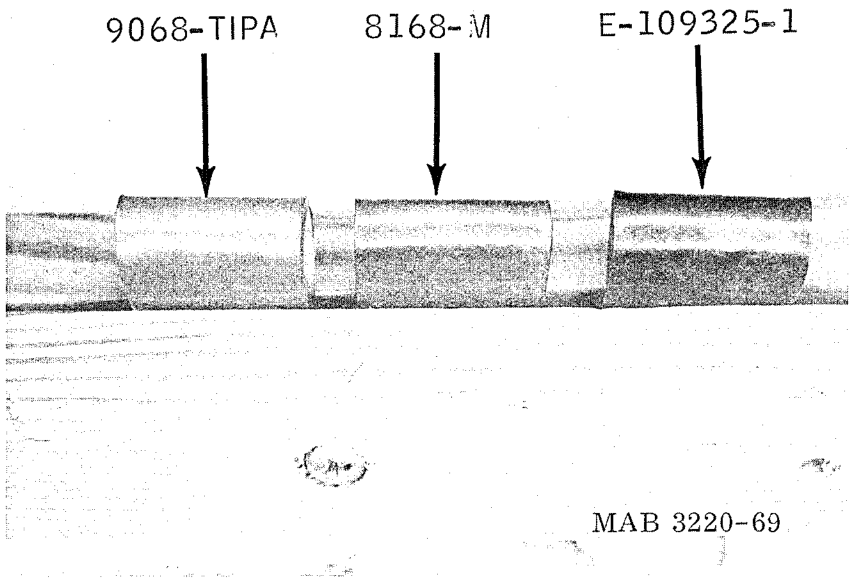
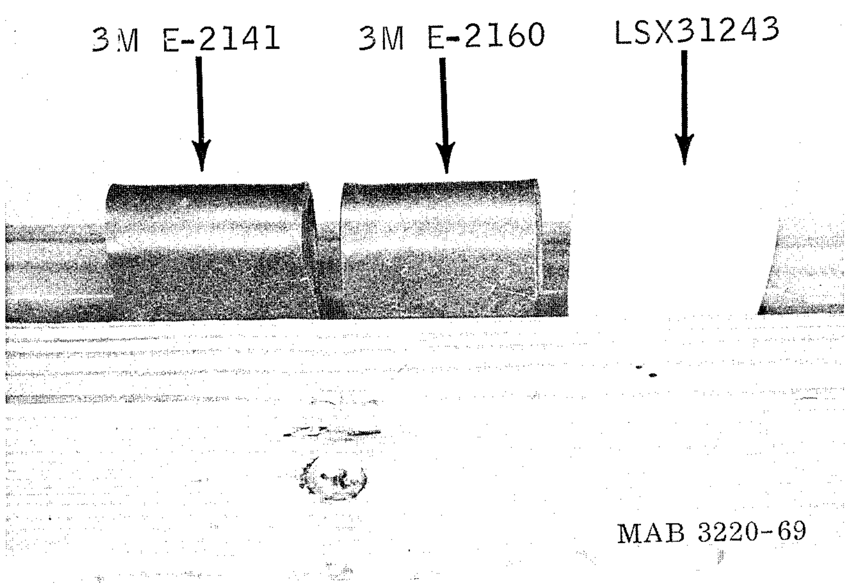


Figure 3. Immersion Test

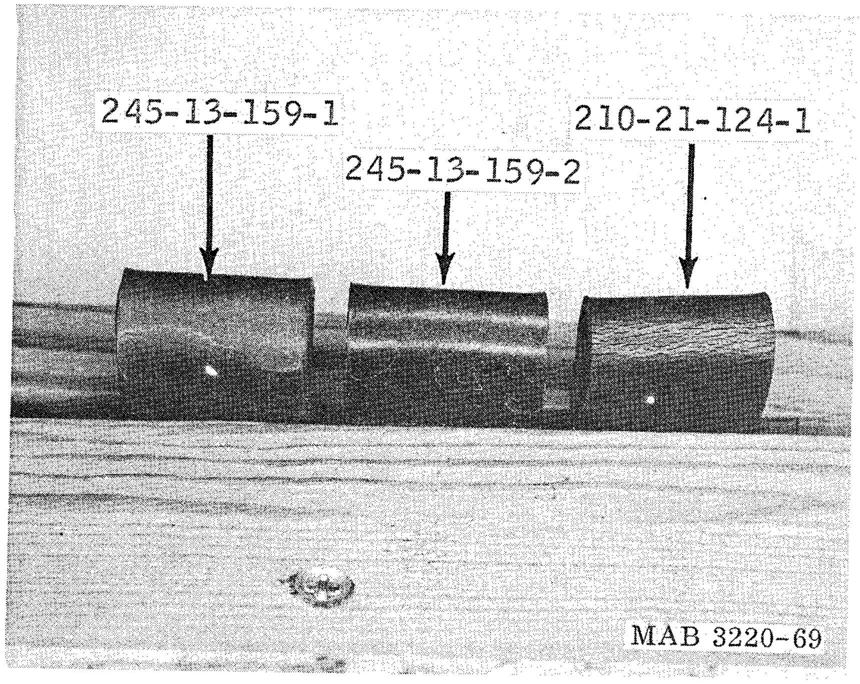


View A

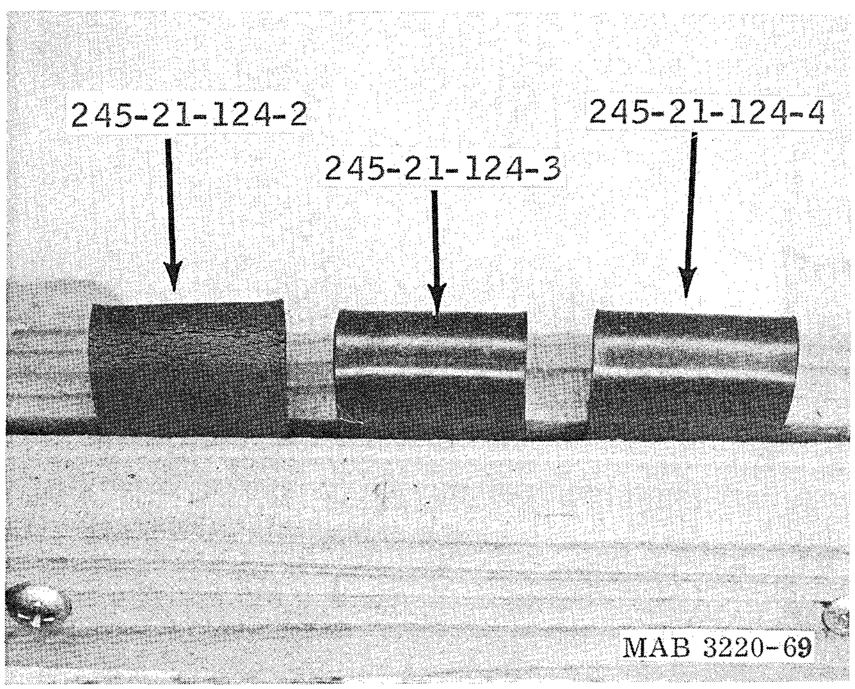


View B

Figure 4. Weather Age Test (Sheet 1 of 3)

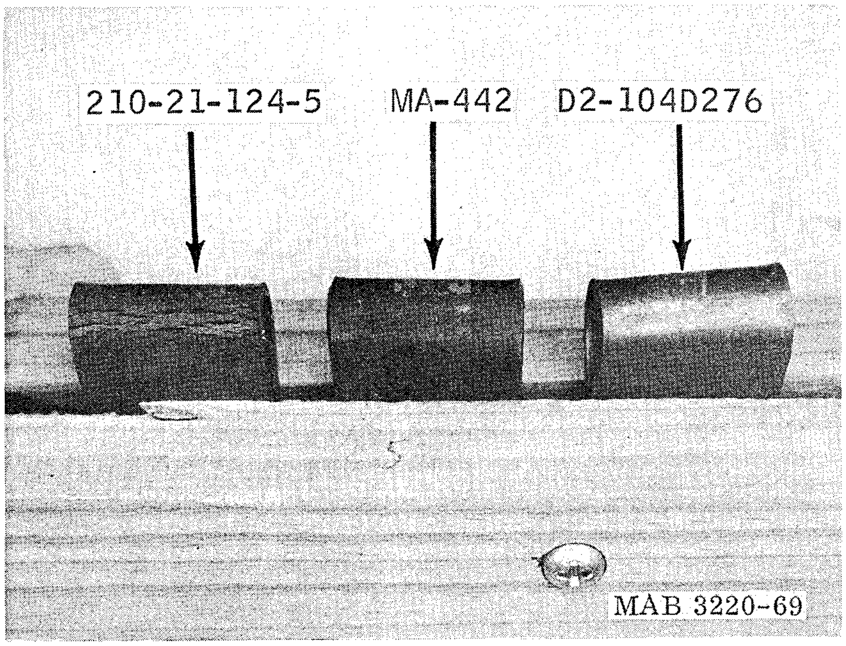


View C

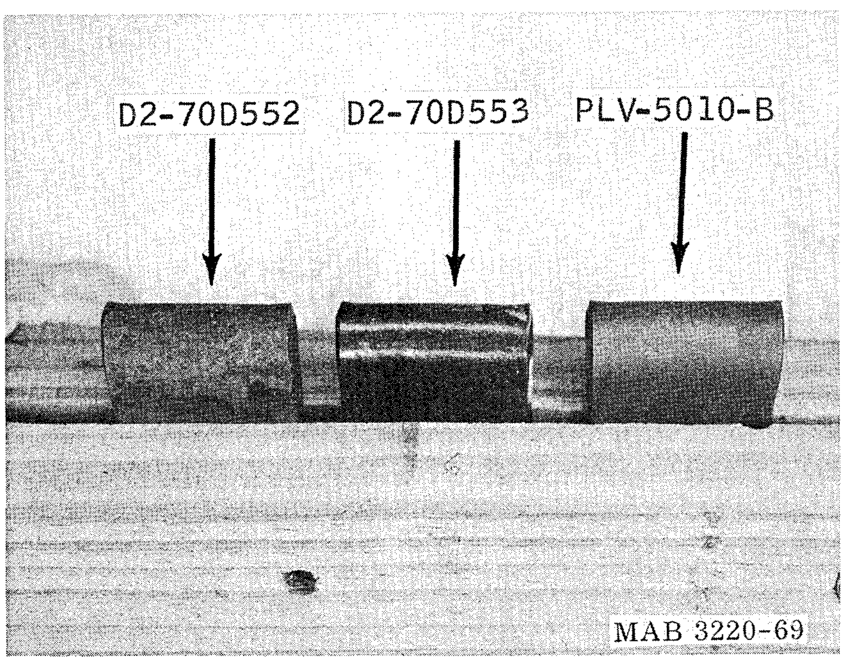


View D

Figure 4. Weather Age Test (Sheet 2 of 3)



View E



View F

Figure 4. Weather Age Test (Sheet 3 of 3)

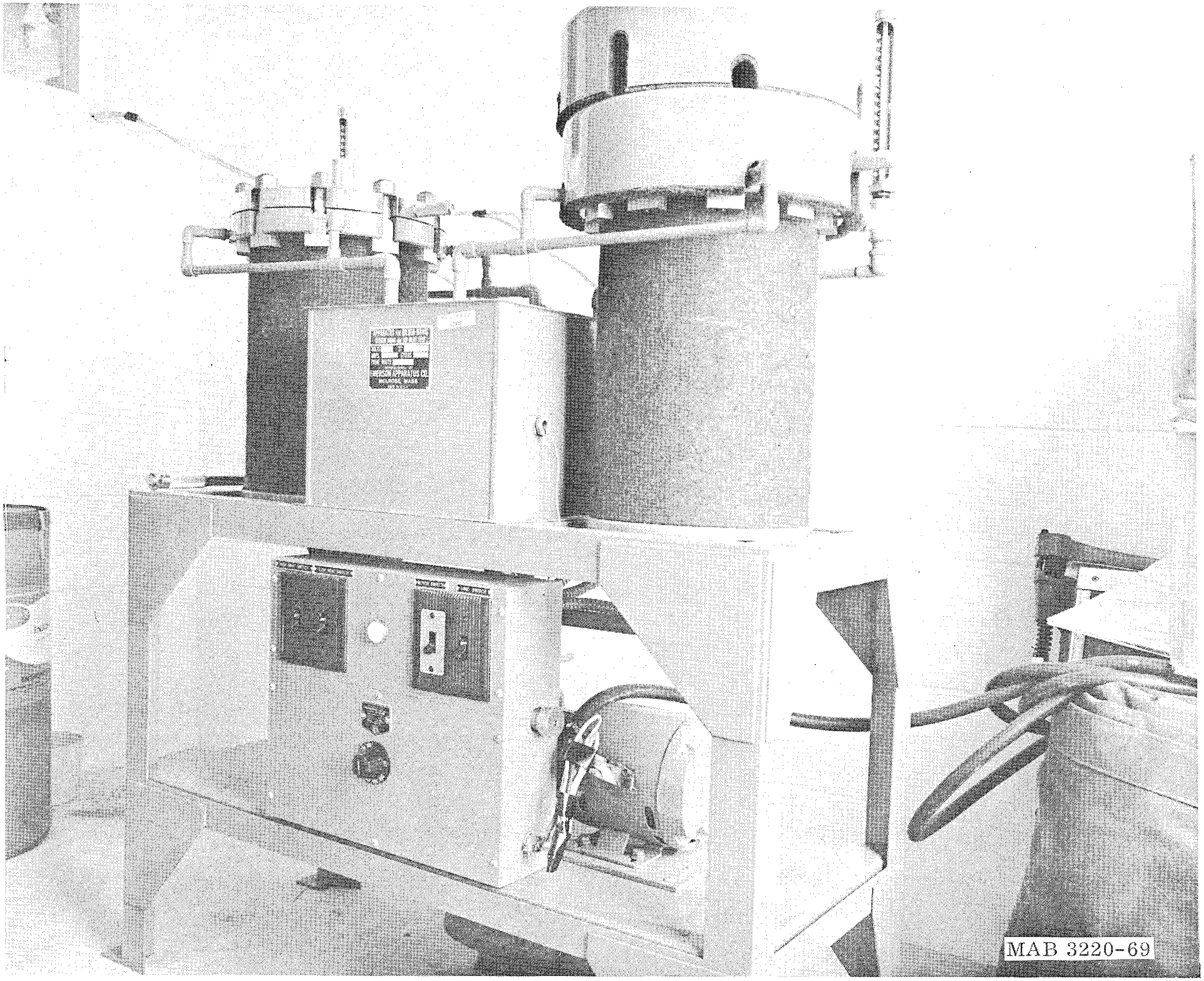


Figure 5. Oxygen Aging Apparatus

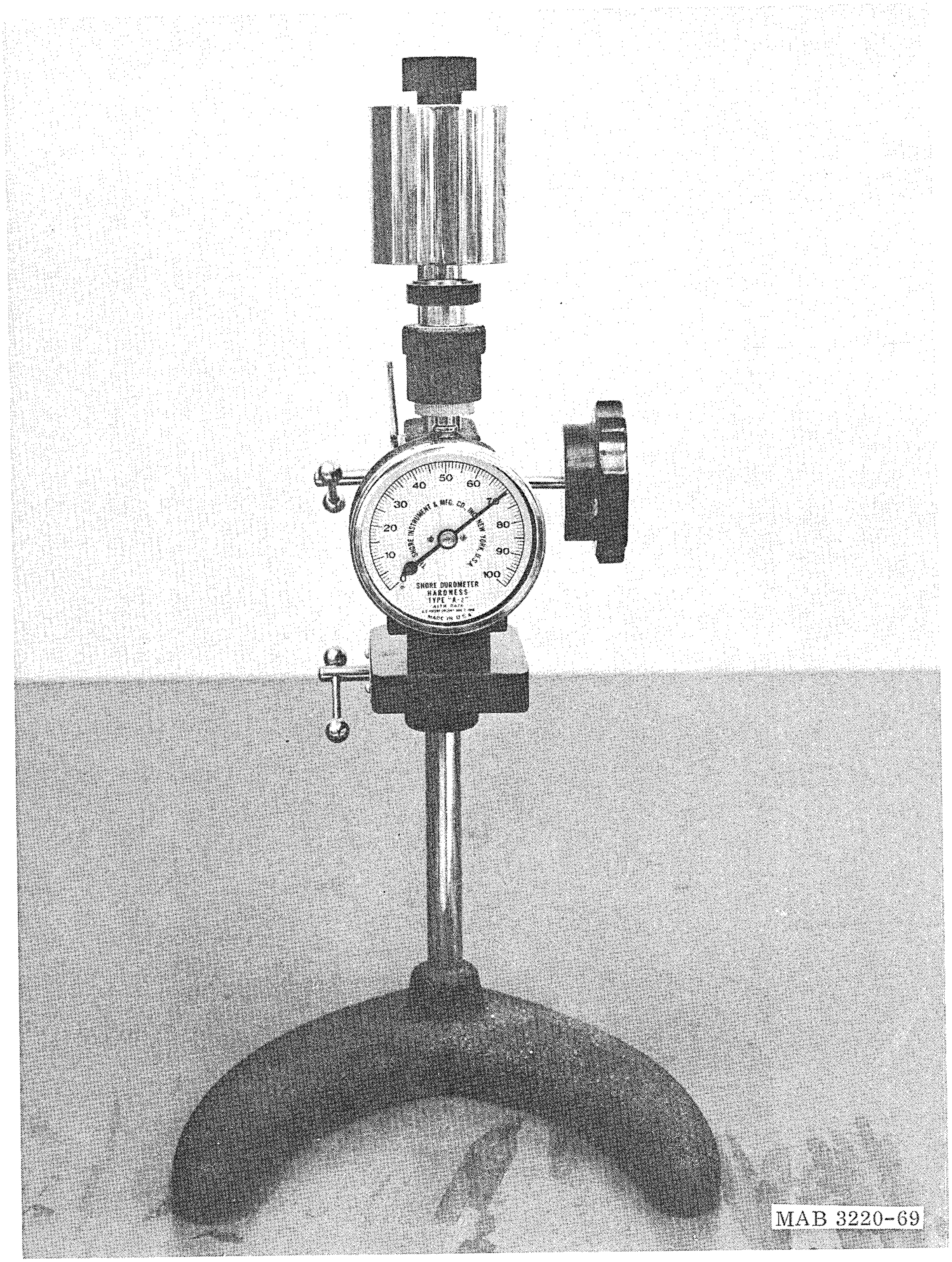


Figure 6. Durometer Test

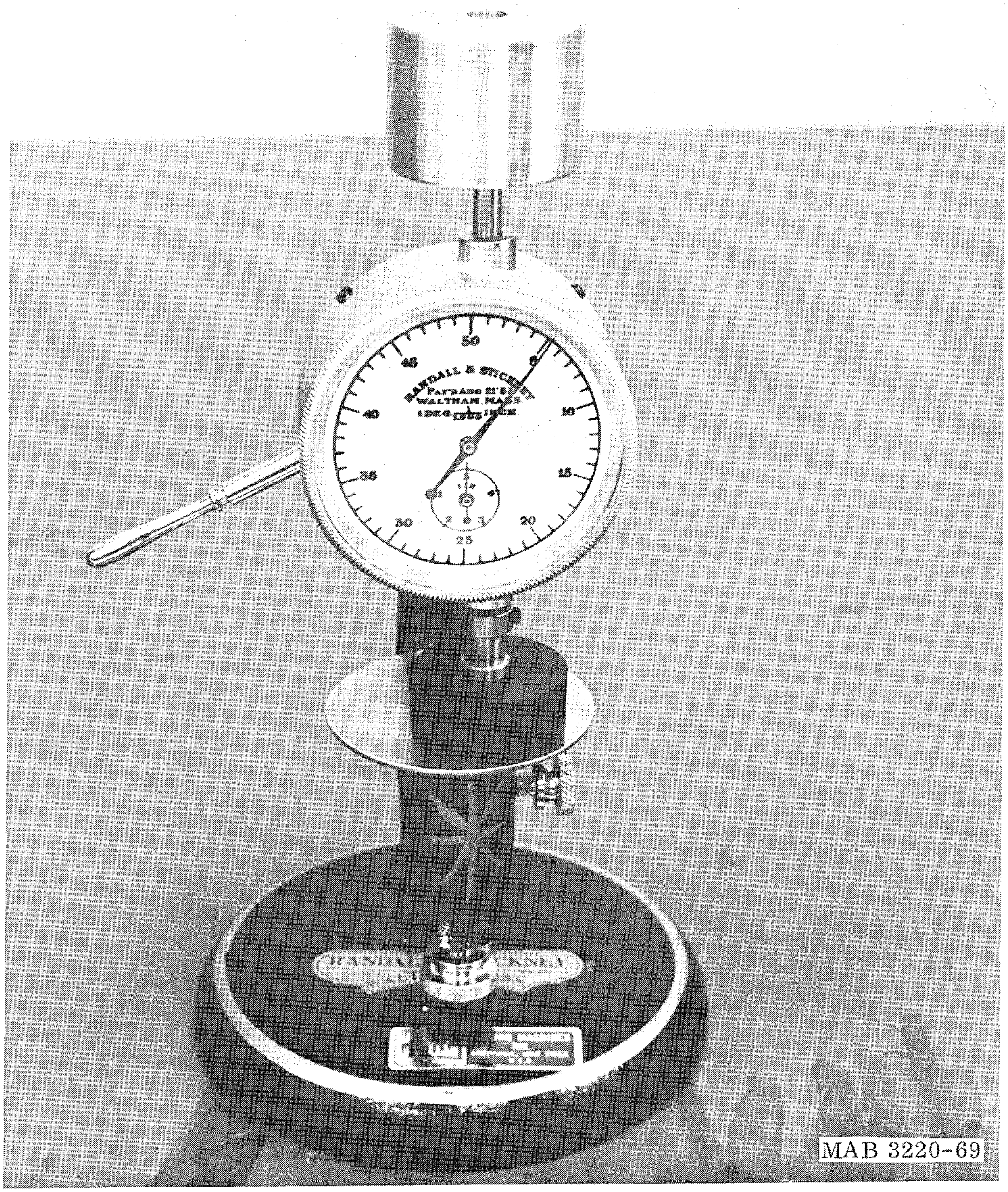


Figure 7. Thickness Gauge

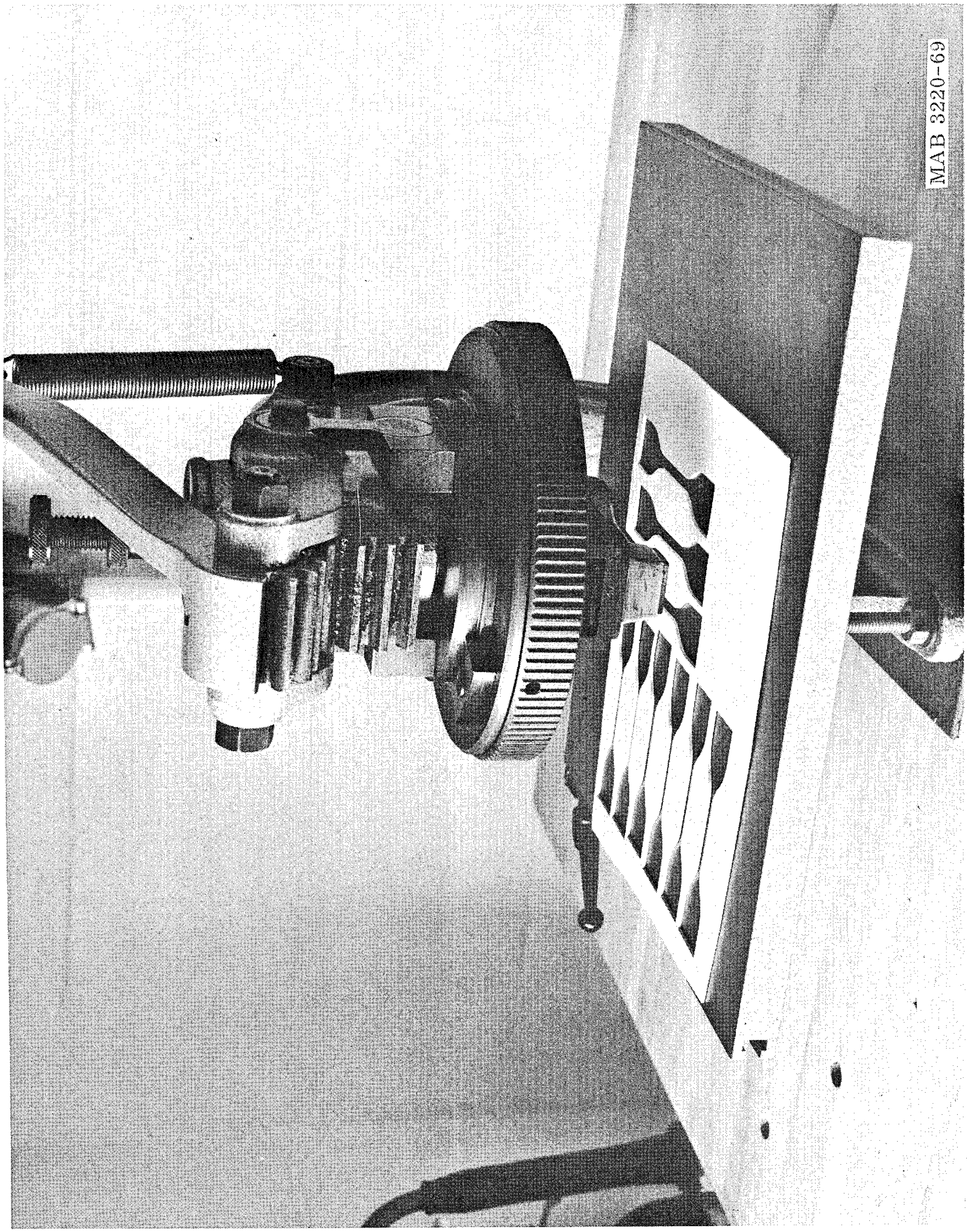


Figure 8. Tensile Dumbell Cutter

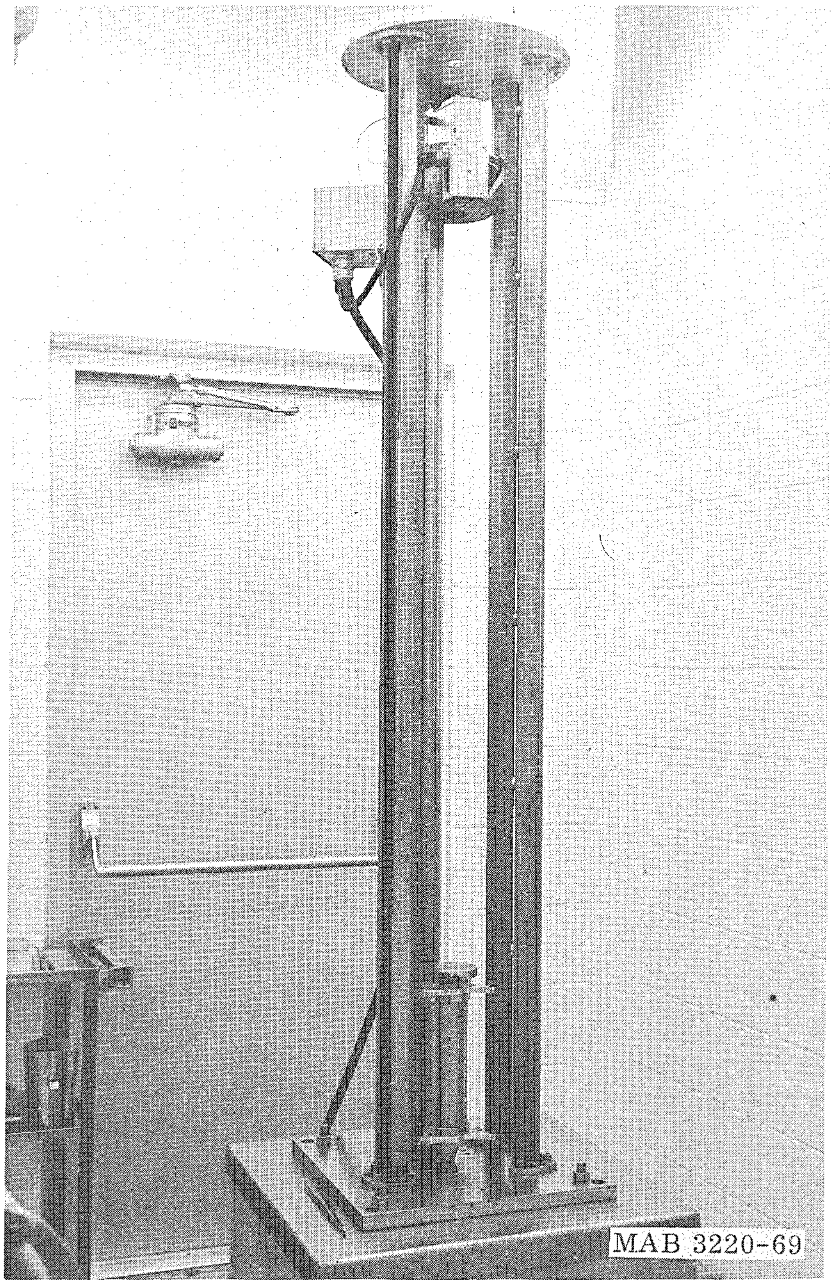


Figure 9. Liquid Oxygen (LOX) Impact Tester

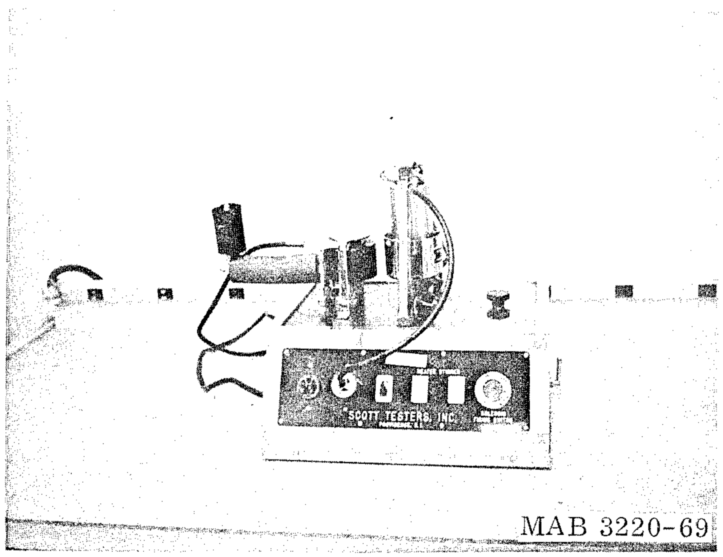


Figure 10. Low Temperature Brittleness Tester

Table 2. Test Results of Phase I Testing Program

	American Cyanamid 9068-TIPA	American Cyanamid 8168-M	Thiokol E-109325-1	3M E-2141	3M E-2160	Dow-Corning LSX31243
ORIGINAL PROPERTIES						
Ultimate Tensile Strength (PSI)	not uniform 2350	7640	2160	2120	1760	1130
Ultimate Elongation (%)	406	592	170	195	142	225
Hardness (Shore A) ****	60	81	65	64	69	62
Specific Gravity	1.27	1.25	1.30	1.96	1.85	1.50
96 Hours @ 70°C in Air Oven						
Ultimate Tensile Strength (PSI)	not uniform 3380	7150	1990	2010	1730	1270
Ultimate Elongation (%)	408	582	142	230	197	225
Hardness (Shore A)	60	80	68	65	70	64
14 Days @ 70°C in Air Oven						
Ultimate Tensile Strength (PSI)	not uniform 3660	7250	2170	1870	1900	1410
Ultimate Elongation (%)	422	600	125	268	153	223
Hardness (Shore A)	62	81	72	66	74	65
IMMERSIONS						
70 Hours @ Room Temp in RP-1						
Ultimate Tensile Strength (PSI)	not uniform 3430	7210	1800	1690	1600	1070
Ultimate Elongation (%)	413	587	138	167	137	230
Hardness (Shore A)	62	82	67	72	77	58
Weight Change (%)	+0.06	+0.65	+1.07	+0.10	+0.11	+1.5
28 Days @ Room Temp in RP-1						
Ultimate Tensile Strength (PSI)	700	8100	1920	1880	1610	1190
Ultimate Elongation (%)	270	613	125	228	132	238
Hardness (Shore A)	59	82	69	69	79	58
Weight Change (%)	+1.10	-1.55	+1.16	+0.13	+0.07	+2.6
OXYGEN AGING						
48 Hours O_2 Aging @ 70°C & 300 PSI						
Ultimate Tensile Strength (PSI)	not uniform 3010	7210	2060	2070	1820	1230
Ultimate Elongation (%)	432	592	143	258	175	225
Hardness (Shore A)	60	80	71	66	74	65
96 Hours O_2 Aging @ 70° & 300 PSI						
Ultimate Tensile Strength (PSI)	not uniform 3290	7070	2200	1960	1660	1250
Ultimate Elongation (%)	427	582	150	265	178	228
Hardness (Shore A)	59	80	69	67	73	64
70 Hours @ Room Temp in Hydraulic Fluid						
Ultimate Tensile Strength (PSI)	2870	7280	1560	1780	1590	1150
Ultimate Elongation (%)	400	580	130	218	142	242
Hardness (Shore A)	58	80	63	65	76	58
Weight Change (%)	+0.15	+1.18	+1.03	+0.09	+0.07	+1.08
28 Days @ Room Temp in Hydraulic Fluid						
Ultimate Tensile Strength (PSI)	508	7740	1800	2100	1610	1130
Ultimate Elongation (%)	252	578	123	224	130	237
Hardness (Shore A)	56	72	66	67	76	57
Weight Change (%)	+1.40	+0.76	+1.26	+0.16	+0.15	+2.6

**** 3 Dumbell Specimens

Goodrich							Goodyear				Pelmor Labs
245-13-159-1	245-13-159-2	210-21-124-1	210-21-124-2	210-21-124-3	210-21-124-4	210-21-124-5	MA-442	D2-104D276	D2-70D552	D2-70D553	PLV-5010-B
2140	2030	2920	2380	2450	2000	1860	2460	1910	1120	3440	1740
250	267	418	523	543	242	353	582	218	498	350	252
75	73	64	58	64	55	57	49	66	50	79	74
1.45	1.45	1.24	1.21	1.21	1.28	1.17	1.33	1.44	1.08	1.19	1.87
2250	2080	2810	2410	2440	1900	1980	2730	2010	1250	3480	1730
247	250	348	452	470	242	352	592	212	517	307	240
72	73	66	61	62	60	59	51	74	52	81	75
2330	2190	2880	2510	2480	1980	2130	2630	2250	1340	3580	1790
243	245	293	397	437	250	343	545	222	533	277	240
73	74	68	63	67	61	62	53	77	52	84	75
2120	1970	2860	2300	2220	1940	1360	1090	1820	***	***	1540
255	247	372	480	482	242	268	383	203	***	***	247
72	74	64	57	64	58	50	38	62	20	42	74
+0.82	+0.7	-0.21	-0.03	-0.02	+0.51	+10.8	+17.4	+5.3	+227.0	+97.5	+1.43
2050	1960	2700	2250	2150	1740	1820	1050	1800	***	***	1600
237	257	330	477	467	232	273	372	213	***	***	243
73	72	64	59	63	56	47	38	61	20	42	74
+1.16	+0.68	+2.5	+0.05	-2.7	+2.8	+8.8	+17.8	+3.8	+219.0	+99.0	+0.98
2070	1970	2690	2230	2250	1820	1820	2570	2290	1560	3310	1770
258	265	350	477	478	250	353	587	247	545	297	253
70	70	66	60	67	60	59	50	68	50	79	75
1990	1910	2830	2300	2270	1870	1840	2500	2210	1250	3620	1750
255	265	362	470	457	253	343	605	258	527	305	240
71	72	67	62	67	63	59	51	70	48	80	76
2050	1940	2660	2340	2280	1770	1310	1030	1940	***	***	1540
260	260	353	465	503	218	272	390	217	***	***	243
70	70	64	54	59	56	45	37	60	19	.44	74
+1.02	+0.74	+0.47	+1.01	+0.88	+1.34	+13.5	+16.1	+6.2	+227.0	+103.0	+1.35
1970	1930	2610	2310	2280	1710	1380	970	2030	***	***	1590
247	235	345	487	490	230	258	347	220	***	***	240
71	72	66	55	64	58	45	35	62	19	43	74
+1.92	+0.95	+0.11	+0.94	-0.10	+1.98	+14.3	+24.0	+7.2	+222.0	+104.0	+1.08

Table 2. Test Results of Phase I Testing Program (Continued)

AFTER IMMERSION	American Cynamid 9068-TIPA	American Cynamid 8168-M	Thiokol E-109325-1	3M E-2141	3M E-2160	Dow-Corning LSX31243
10 Minutes in LCX						
Ultimate Tensile Strength (PSI)	4010	7110	2040	1870	1580	1290
Ultimate Elongation (%)	432	575	126	222	170	254
Hardness (Shore A)	61	80	65	63	71	64
Resistance to Surface Cracking (test started 1-29-70)	*	*	*	*	*	*
COMPRESSION SET (ASTM D-395, Method B)						
22 Hours at 70°C	1.4%	20.4	6.4	23.5	6.3	2.6
Hardness (Shore A)	61	80	65	64	69	60
70 Hours at 100°C	20.4%	57.2	14.8	19.3	4.5	7.9
Hardness (Shore A)	59	75	67	67	72	62
In RP-1 70Hrs, then 22 Hrs @ 70°C	0.71%	20.3	3.1	31.9	6.8	3.3
Hardness (Shore A)	61	78	67	66	72	59
In RP-1 28 Days, then 22 Hrs @ 70°C	0.71%	17.1	6.5	31.3	7.3	1.0
Hardness (Shore A)	61	79	67	64	74	58
In RP-1 70 Hrs, then 70 Hrs @ 100°C	19.5%	10.4	17.0	25.0	6.4	8.0
Hardness (Shore A)	61	77	71	64	71	61
In RP-1 28 Days, then 70 Hrs @ 100°C	25.5	106.0	17.0	26.9	5.5	6.2
Hardness (Shore A)	61	72	67	63	70	58
In Hydraulic fluid 70 hrs, then 22 hrs @ 70°C	1.4%	20.7	3.3	27.4	6.3	2.6
Hardness (Shore A)	61	78	66	65	72	59
In Hydraulic fluid 28 days, then 22 hrs @ 70°C	0.70	19.7	5.4	21.3	6.3	2.6
Hardness (Shore A)	62	79	67	65	71	58
In Hydraulic fluid 70 hrs, then 70 hrs@ 100°C	25.8	104.0	17.9	34.6	6.4	13.2
Hardness (Shore A)	56	73	66	61	71	59
In Hydraulic fluid 28 days, then 70 hrs@ 100°C	25.0	104.0	16.6	27.0	9.2	7.2
Hardness (Shore A)	59	74	69	63	74	58

Notes:
- * No craze or crack after 188 days
- ** Start to craze 2-2-70; Start to crack on 2-4-70
- *** Test not performed because of sample swelling
- √ Swell

Goodrich							Goodyear				Pelmor Labs
245-13-159-1	245-13-159-2	210-21-124-1	210-21-124-2	210-21-124-3	210-21-124-4	210-21-124-5	MA-442	D2-104D276	D2-70D552	D2-70D553	PLV-5010-B
2000	1990	2720	2320	2330	1840	1740	2380	2210	1230	1710	
250	257	368	510	523	240	363	573	228	520	260	
72	74	63	55	66	61	56	49	66	50	75	
*	*	**	**	*	*	**	*	*	*	*	
8.4	13.4	8.9	11.5	30.5	8.8	12.4	16.6	5.5	14.8	24.6	17.0
73	71	65	57	62	55	54	48	68	49	78	77
21.6	22.2	25.1	34.9	42.3	14.1	34.7	53.8	13.7	18.5	73.0	17.2
70	69	65	59	62	55	57	52	71	51	80	75
7.8	13.5	8.8	10.8	29.6	11.2	7.3	12.4	2.7	***	***	17.4
72	71	64	57	62	54	53	45	67	30	70	76
7.4	11.9	28.8	11.9	28.8	10.6	4.5 √	7.2	3.1 √	***	***	17.6
72	71	65	57	62	53	48	40	63	32	54	79
20.6	22.2	24.6	35.1	40.1	13.9	30.9	50.7	10.9	***	***	21.2
72	71	65	58	62	56	57	50	68	47	84	77
20.9	22.6	25.3	35.2	41.7	15.8	24.4	48.0	5.5	***	***	19.2
70	70	64	58	60	54	52	50	68	48	79	76
8.0	12.3	7.5	9.8	31.0	9.1	8.9	17.4	5.2	***	***	18.9
71	72	65	57	63	54	55	48	67	38	63	76
6.2	10.9	9.7	11.4	27.6	10.1	+0.9	9.0	1.0	***	***	20.6
71	71	64	56	61	54	49	42	64	29	50	76
21.0	23.8	24.7	36.0	40.2	14.6	30.4	52.0	10.6	***	***	21.6
71	71	65	57	61	54	56	51	67	45	74	76
21.5	22.5	26.6	36.2	43.1	14.1	31.8	50.6	7.0	***	***	22.5
70	68	64	57	59	53	53	47	68	46	75	78

Table 3. Test Results of Phase II Testing Program

	Thiokol E-109325-1	3M E-2160	Dow-Corning LSX31243
112 DAYS in RP-1			
Ultimate Tensile Strength (PSI)	1930	1520	1040
Ultimate Elongation (%)	120	180	205
Hardness (Shore A)	64	71	59
Weight Change (%)	+2.14	+.086	+1.8
112 DAYS in HYDRAULIC FLUID			
Ultimate Tensile Strength (PSI)	1890	1590	1030
Ultimate Elongation (%)	133	210	210
Hardness (Shore A)	65	70	60
Weight Change (%)	+2.7	+.089	+1.20
COMPRESSION SET %			
112 Days in RP-1, then 70 Hrs @ 100°C	13.0	15.2	10.4
Hardness (Shore A)	65	68	57
112 Days in Hydr, then 70 Hrs @ 100°C	14.3	5.7	9.9
Hardness (Shore A)	66	75	58
LOX IMPACT			
LOX Impact (11/16-inch disc)	0 for 20	0 for 20	3 for 60
LOX Impact (Simulated "O" Rings)	19 for 20	0 for 20	****
BRITTLE POINT °C			
Brittle Point (°C)	-15.4	-16.6	-58.1

NOTES:
- * 7 for 40 + 3 burned odors- rust like coating on sheets
- ** 0 for 40, except 5 burned odors
- *** 0 for 20- unusual smell
- **** No test performed, failed initial LOX Test

Goodrich			Pelmor Labs
245-13-159-1	245-13-159-2	210-21-124-4	PLV-5010-B
discolored RP-1	discolored RP-1		
1790	1930	1730	1560
258	263	228	263
71	71	55	75
+0.63	+0.32	+2.17	+0.71
1880	1800	1600	1440
290	268	240	238
71	72	57	76
+1.44	+0.60	+2.8	+0.75
17.6	20.2	12.8	21.2
70	70	55	77
18.0	19.1	13.2	22.7
69	69	54	76
*	**	***	0 for 20
****	****	17 for 20	2 for 20
-43.0	-23.2	-14.8	-16.8

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