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EFFECT OF HYDRAULIC FLUID (MIL-H-83282) ON SELECTED COMMERCIAL O-RING COMPOUNDS

By T. E. Wood and W. P. Stone
Materials and Processes Laboratory

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16. ABSTRACT

This report presents elastomeric materials compatibility data in MIL-H-83282 synthetic hydraulic fluid. Acrylonitrile and fluorocarbon compounds were evaluated at various temperatures and time intervals in samples of the fluid obtained from three qualified suppliers.

It was concluded that both polymers can function in the MIL-H-83282 hydraulic fluids within the conditions defined by this study. Hydraulic fluid from each manufacturer was similar in its effect upon each given O-ring material, with one exception. Similarly, there were no striking differences in the resistance of O-rings of the same generic rubber type when provided by the different manufacturers.

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TECHNICAL MEMORANDUM 78154

EFFECT OF HYDRAULIC FLUID (MIL-H-83282) ON SELECTED COMMERCIAL O-RING COMPOUNDS

INTRODUCTION

The hydraulic system of the Space Shuttle will be a sealed system containing MIL-H-83282 synthetic hydrocarbon hydraulic fluid. However, very little information was available on the compatibility of elastomeric soft goods in MIL-H-83282 hydraulic fluid other than the fact that there are at least three different fluids marketed by different suppliers.

The primary objective of this study was to determine what elastomeric polymers are suitable for use as O-rings, seals, gaskets, bladders, and diaphragms under conditions simulating those of the Space Shuttle hydraulic system.

For use in this program, synthetic hydrocarbon fluids meeting the MIL-H-83282 specification were obtained from three qualified suppliers. Acrylonitrile and fluorocarbon elastomer O-rings from two suppliers were tested in each fluid.

This report describes the key property changes noted for each rubber compound as a function of fluid source, temperature, and exposure duration.

DISCUSSION AND TEST PROCEDURES

Immersion tests were run on acrylonitrile and fluorocarbon polymers in synthetic hydrocarbon fluids meeting MIL-H-83282 specifications. The rubber samples were purchased in the form of O-rings from Precision Rubber Products Company, Dayton, Ohio, and Parker Seal Company, Lexington, Kentucky. Precision Rubber Company furnished O-rings molded from acrylonitrile (Buna-N) and fluorocarbon (Viton) compounds, and the Parker Seal Company furnished O-rings molded from one of their acrylonitrile formulations. The specific formulations tested were recommended by their manufacturers for outstanding resistance and stability to hydrocarbon fluids. The three commercial rubber compounds are identified by their compound numbers as follows:

Type	Number	Source
Nitrile	737-7	Precision Rubber
Nitrile	N304-75	Parker Seal Company
Viton	19357	Precision Rubber

The synthetic hydrocarbon fluids were obtained from three qualified sources of fluids meeting the MIL-H-83282 specification. Proprietary nomenclature for each fluid is as follows:

Fluid	Batch/Lot	Manufacturer
Royco 782	Lot 10868B	Royal Lubricants Co.
Mobil RM 230A	Lot MT2X261	Mobil Oil Co.
Bray 882 (Brayco)	Nov. 228-75-C-H52	Bray Oil Co.

These fluids were used directly from the shipping containers for test purposes.

O-rings were arranged into five specimens per set, and each O-ring was numbered individually to provide traceability for individual thickness and Shore "A" hardness measurements. Multiple sets of O-rings were suspended in beakers of the different test fluids at each test temperature. A set of five individual specimens was withdrawn at each time and temperature condition. Thermostatically controlled ovens with a constant nitrogen gas purge were used for maintaining constant soak temperatures of 100°C (212°F), 150°C (302°F), and 200°C (392°F) over time intervals of 4, 8, 90, 180, and 360 days.

At the conclusion of each immersion test period, stainless steel wire holders containing five O-rings were removed from the original test fluid and transferred to containers containing fresh test fluids at ambient temperatures to cool the specimens for approximately 45 min. The specimens were quickly dipped into a solution of acetone to remove test fluid and blotted dry with an absorbent paper towel. The thickness and hardness measurements were taken and recorded. The O-rings were then tested on the Instron tester to ASTM Method D1414-65T, Procedure 7.1, to obtain tensile strength and elongation.

These properties, together with hardness and thickness changes, are shown in Figures 1 through 9 and Tables 1 through 5. Unplotted values on these graphs, denoted by the symbols + and ×, denote the effect of temperature alone, 100°C (212°F) and 150°C (302°F), respectively.

Short term (4 and 8 day) immersion tests were run at 150°C (302°F) and 200°C (392°F) on the nitrile and Viton elastomers to determine a maximum test temperature appropriate for the long range testing. The 200°C (392°F) immersion tests were deleted after 4 days. This was necessary because almost complete decombustion of the fluid media occurred. It is apparent from data obtained that both the nitrile compounds are grossly affected at 150°C (302°F), shown in Tables 1 and 2 after 4 days soaking. Tests on the nitrile specimens were continued up to 90 days, where all the nitrile test specimens were found to be hard and brittle. Consequently, the 150°C (302°F) condition was deleted on the nitrile elastomers at the end of the 90 day period.

A noticeable change in the color of the immersion fluids was apparent after exposure to 100°C (212°F) for 90 days. The Royco fluid changed from a light amber to a transparent burgundy red. The Mobil fluid changed from a light amber to a yellow transparent color, and Bray fluid changed from amber to a light reddish brown. Immersion fluids containing the Viton elastomer at 100°C (212°F) for 90 days had a more pronounced version of these colors. All three of the test fluids containing Viton samples carborized at 150°C (302°F) during the 90 day soak cycle. This exposure reduced the fluid to a dark syrupy mass containing flake-like solids which could still be wiped from the O-rings. To avoid this complication, the O-rings were suspended in fresh test fluids after 180 days exposure at 100°C (212°F) and after 18, 32, and 64 days at 150°C (302°F), with fresh fluids introduced every 30 days thereafter.

CONCLUSIONS AND RECOMMENDATIONS

This study revealed no evidence that any of the O-ring compounds evaluated would not be serviceable in MIL-H-83282A hydraulic fluid in Shuttle hydraulic systems. At temperatures above 100°C (212°F), an advantage is indicated for the Viton compound. However, testing under extreme conditions revealed one possible anomaly. The Mobil RM 230A fluid appeared somewhat more prone to decompose during elevated temperature tests and, under the same conditions, it appeared more prone to attack the Viton rubber compound. This was evidenced by more fluid decomposition or carbonization and by greater embrittlement of the Viton samples in this fluid during the 360-day Viton tests at 150°C (302°F).

TABLE 1. PRECISION 737-7 (BN) VERSUS MIL-H-83282 FLUID

	Time	Royco 782			Mobil RM 230A			Bray 882		
	Days	RT	100°C	150°C	RT	100°C	150°C	RT	100°C	150°C
Tensile (psi)	0	1328	1328	1328	1328	1328	1328	1328	1328	1328
	4			1036			1049			1177
	8			835			743			927
	90	1470	1236	*	1323	1221	*	1530	1442	*
	180	1446	1022	*	1425	990	*	1047	855	*
	360	1531	1063	*	1128	876	*	1675	978	*
Elongation (%)	0	186	186	186	186	186	186	186	186	186
	4			121			120			129
	8			91			83			100
	90	194	86	*	193	69	*	194	278	*
	180	189	60	*	190	48	*	185	76	*
	360	194	2	*	198	27	*	175	34	*
Thickness (%) Change	4			1.1			0.6			1.0
	8			0.9			0.5			0.3
	90	1.1	0.4	*	1.7	0.3	*	2.5	1.0	*
	180	0.4	0.3	*	1.6	0.2	*	1.7	0.3	*
	360	0.6	0.1	*	2.3	0.07	*	2.2	1.4	*
Hardness Shore A Point Change	4			+12			+ 9			+ 9
	8			+13			+11			+14
	90	+ 1	+14	+25	+1	+ 6	+25	+7	+13	*
	180	+10	+18	*	+3	+22	*	+8	+21	*
	360	+ 9	+20	*	+6	+26	*	+7	+23	*

TABLE 2. PARKER N304-75 (BN) VERSUS MIL-H-83282 FLUID

	Time Days	Royco 782			Mobil RM 230A			Bray 882		
		RT	100°C	150°C	RT	100°C	150°C	RT	100°C	150°C
Tensile (psi)	0	1376	1376	1376	1376	1376	1376	1376	1376	1376
	4			1040			797			879
	8			872			733			774
	90	1321	1008	*	1228	828	*	1474	1110	*
	180	1468	947	*	1418	791	*	1121	803	*
	360	1460	784	*	1312	788	*	1559	907	*
Elongation (%)	0	152	152	152	152	152	152	152	152	152
	4			112			89			100
	8			87			80			80
	90	155	42	*	150	35	*	226	78	*
	180	175	43	*	172	24	*	162	68	*
	360	191	25	*	168	14	*	168	30	*
Thickness (%) Change	4			0.9			0.3			0.9
	8			0.9			0.5			1.0
	90	1.1	0.5	*	1.9	0.2	*	2.4	1.2	*
	180	0.9	0.3	*	1.8	0.1	*	1.5	0.0	*
	360	0.7	0.2	*	2.3	0.07	*	1.9	1.1	*
Hardness Shore A Point Change	4			+ 8			+ 8			+ 9
	8			+11			+10			+12
	90	+5	+15	+24	+5	+18	+24	+13	+18	*
	180	+8	+19	*	+7	+22	*	+ 8	+17	*
	360	+8	+21	*	+8	+26	*	+ 8	+22	*

TABLE 3. PRECISION 19357 (VITON) VERSUS MIL-H-83282 FLUID

	Time	Royco 782			Mobil RM 230A			Bray 882		
	Days	RT	100°C	150°C	RT	100°C	150°C	RT	100°C	150°C
Tensile (psi)	0	1589	1589	1589	1589	1589	1589	1589	1589	1589
	4			1355			1226			1132
	8			1282			1213			1403
	90	1268	1204	1174	1227	1273	1202	1422	1427	1300
	180	1462	1363	1124	1259	1322	989	1073	1052	1049
	360	1545	1227	1023	1359	1165	*	1651	1446	1352
Elongation (%)	0	168	168	168	168	168	168	168	168	168
	4			188			175			166
	8			184			170			176
	90	179	177	130	179	182	99	196	195	238
	180	179	196	95	176	190	92	185	173	132
	360	216	178	1	185	161	*	196	179	105
Thickness (%) Change	4			1.8			1.7			1.5
	8			1.2			1.7			1.3
	90	0.8	1.5	2.9	1.1	1.5	7.7	0.5	1.2	2.6
	180	0.5	1.2	3.0	1.1	2.0	19.8	0.2	1.5	3.6
	360	0.4	1.5	4.9	1.3	1.8	*	1.2	2.2	5.8
Hardness Shore A Point Change	4			+ 8			+ 8			+ 7
	8			+ 8			+ 8			+10
	90	+1	+6	+ 4	+ 1	+7	+10	+11	+13	+13
	180	+6	+6	+ 8	+10	+8	+16	+10	+ 9	+19
	360	+6	+6	+26	+ 3	+7	*	+12	+ 7	+16

TABLE 4. EFFECT OF DRY HEAT ON SELECTED RUBBER COMPOUNDS

	Time	Precision 737-7 (BN)			Parker N304-75 (BN)			Precision 19357 (Viton)		
	Days	RT	100°C	150°C	RT	100°C	150°C	RT	100°C	150°C
Tensile (psi)	0	1328	1328	1328	1376	1376	1376	1589	1589	1589
	4	1328	1328	1143	1376	1376	1225	1589	1589	1460
	8	1328	1328	1067	1376	1376	1083	1589	1589	1477
	90	1328	1158	*	1376	1471	*	1589	1533	1639
	180	1328	1340	*	1376	1514	*	1589	1479	1514
	360	1328	1659	*	1376	1256	*			
Elongation (%)	0	186	186	186	152	152	152	168	168	168
	4	186		79	152		87	168		194
	8	186		48	152		68	168		199
	90	186	30	*	152	100	*	168	172	151
	180	186	27	*	152	52	*	168	181	146
	360	186	48	*	152	32	*			
Thickness (%) Change	4	0		-0.9	0		-0.7	0		-0.6
	8	0		-0.7	0		-0.3	0		-0.1
	90	0	-1.0	*	0	0	*	0	-0.2	+0.2
	180	0	-3.0	*	0	-1.7	*	0	-2.3	-2.5
	360	0	-0.6	*	0	0	*			
Hardness Shore A Point Change	4	0		+13	0		- 8	0		+4
	8	0		- 8	0		-18	0		-7
	90	0	+17	*	0	+14	*	0	+8	-8
	180	0	+26	*	0	+24	*	0	-8	-8
	360	0	+23	*	0	-23	*			

TABLE 5. TENSILE STRENGTH OF SELECTED RUBBER COMPOUNDS VERSUS MIL-H-83282 FLUIDS $N/m^2 \times 10^{-6}$

Rubber Compound	Time Days	Royco 782			Mobil RM 230A			Bray 882		
		RT	100°C	150°C	RT	100°C	150°C	RT	100°C	150°C
Precision 737-7 Buna-N	0	9.156	9.156	9.156	9.156	9.156	9.156	9.156	9.156	9.156
	4			7.143			7.232			8.115
	8			5.757			5.122			6.391
	90	10.135	8.522	*	9.122	8.418	*	10.549	9.942	*
	180	9.970	7.046	*	9.825	6.826	*	7.219	5.895	*
	360	10.556	7.329	*	7.777	6.040	*	11.549	6.743	*
Parker N304-75 Buna-N	0	9.487	9.487	9.487	9.487	9.487	9.487	9.487	9.487	9.487
	4			7.219			5.495			6.060
	8			6.012			5.054			5.336
	90	9.108	6.950	*	8.467	5.709	*	10.163	7.653	*
	180	10.121	6.529	*	9.777	5.453	*	7.729	5.536	*
	360	10.066	5.405	*	9.046	5.433	*	10.749	6.253	*
Precision 19357 Viton	0	10.956	10.956	10.956	10.956	10.956	10.956	10.956	10.956	10.956
	4			9.342			8.453			7.805
	8			8.839			8.363			9.673
	90	8.742	8.361	8.094	8.460	8.777	8.287	9.804	9.839	8.963
	180	10.080	9.397	7.749	8.680	9.115	6.819	7.398	7.253	7.232
	360	10.652	8.460	7.053	9.370	8.032	*	11.383	9.970	9.322

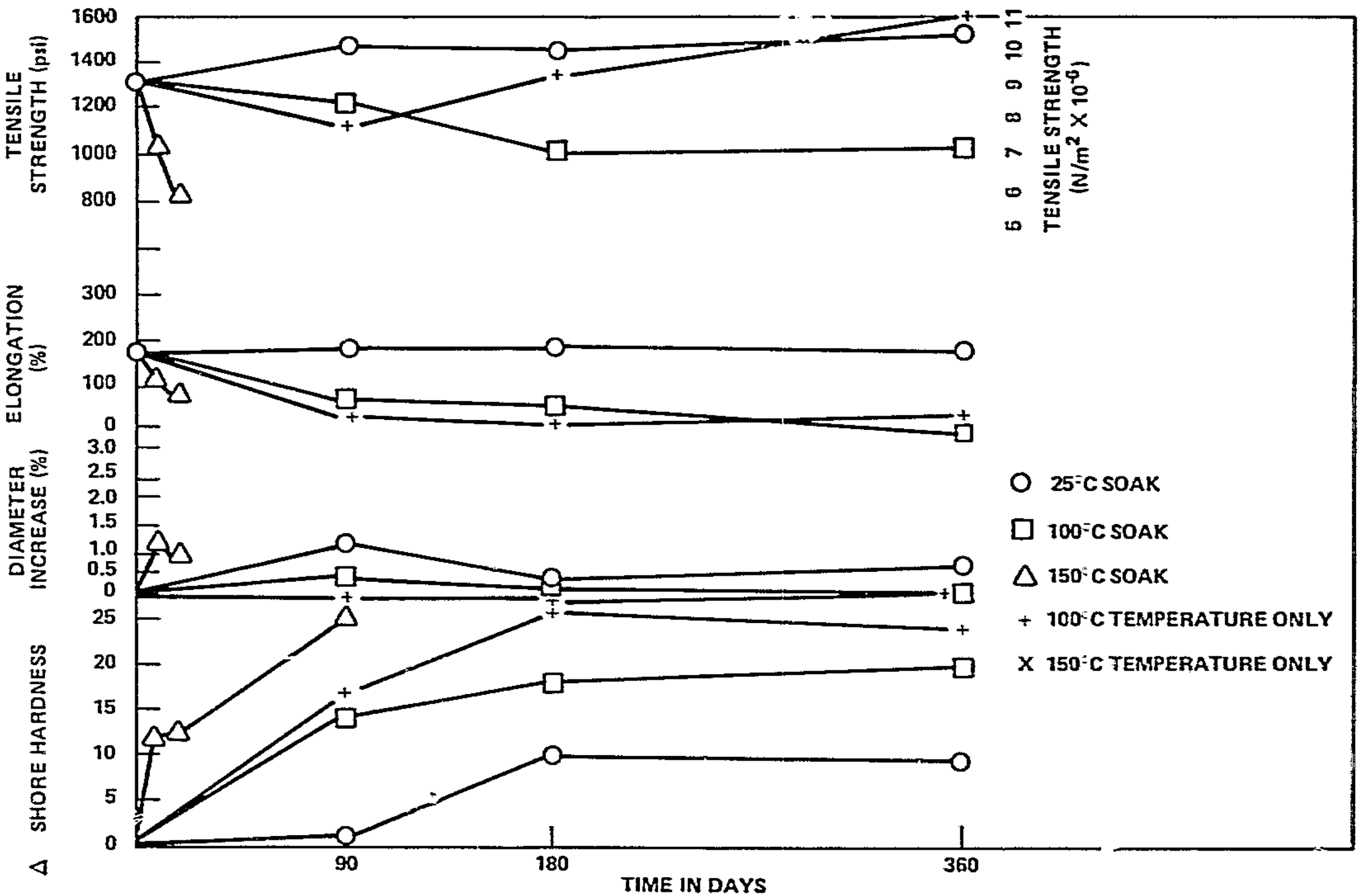

Figure 1. Effect of Royco 782 fluid exposure upon properties of Precision Rubber Company compound 737-7 Buna-N O-rings.

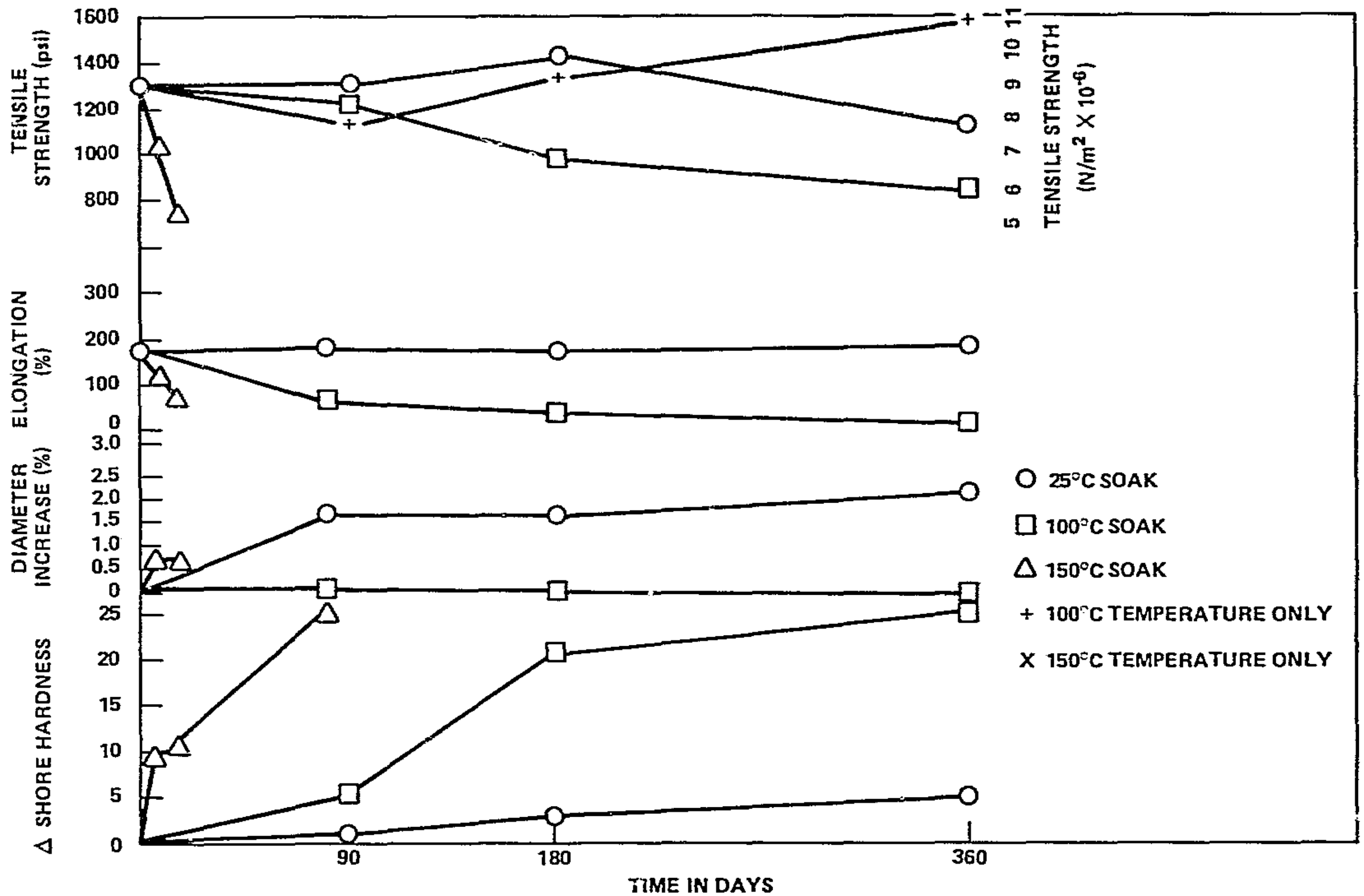

Figure 2. Effect of Mobil RM 230A fluid exposure upon properties of Precision Rubber Company compound 737-7 Buna-N O-rings.

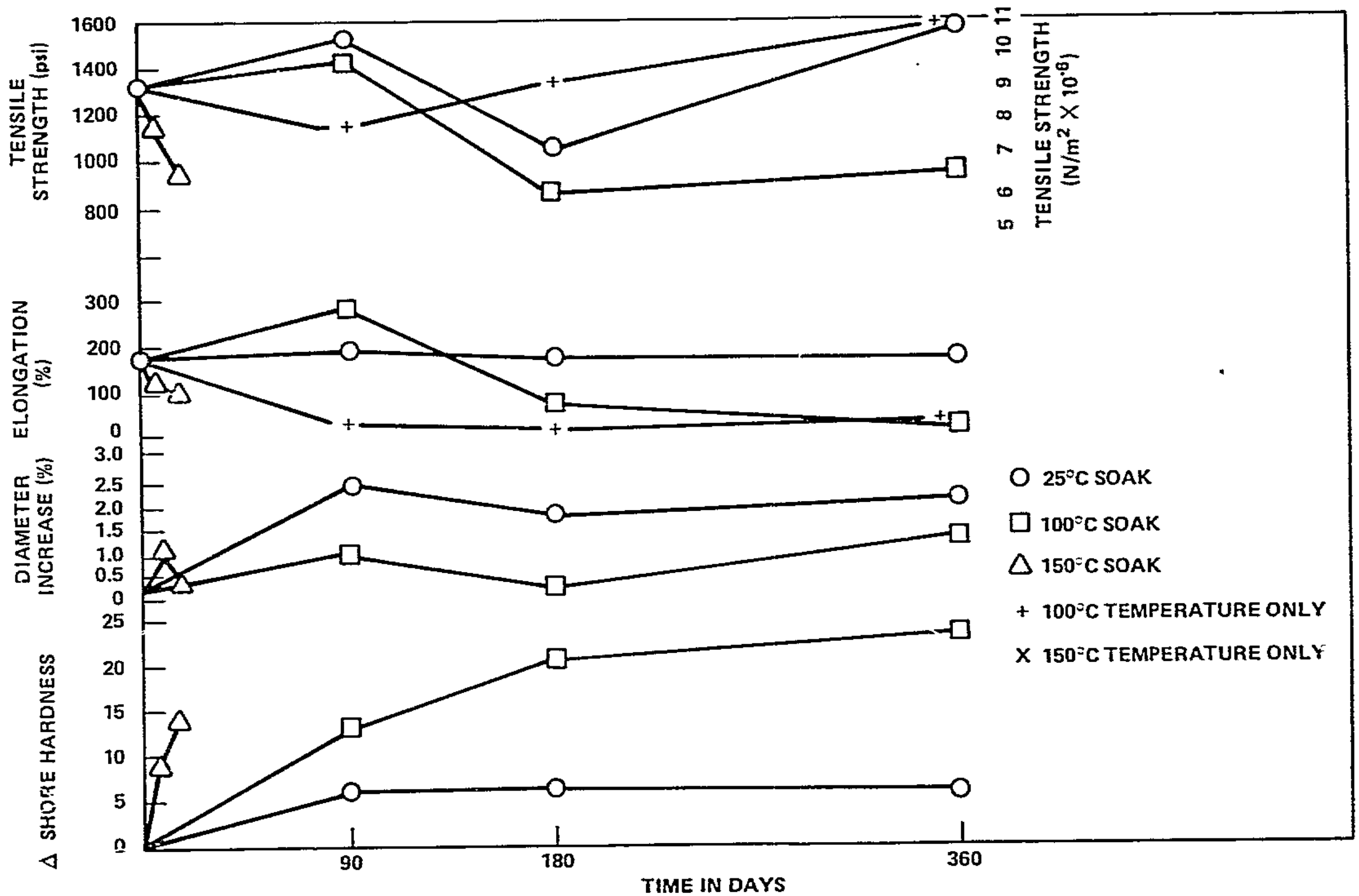

Figure 3. Effect of Bray 882 fluid exposure upon properties of Precision Rubber Company compound 737-7 Buna-N O-rings.

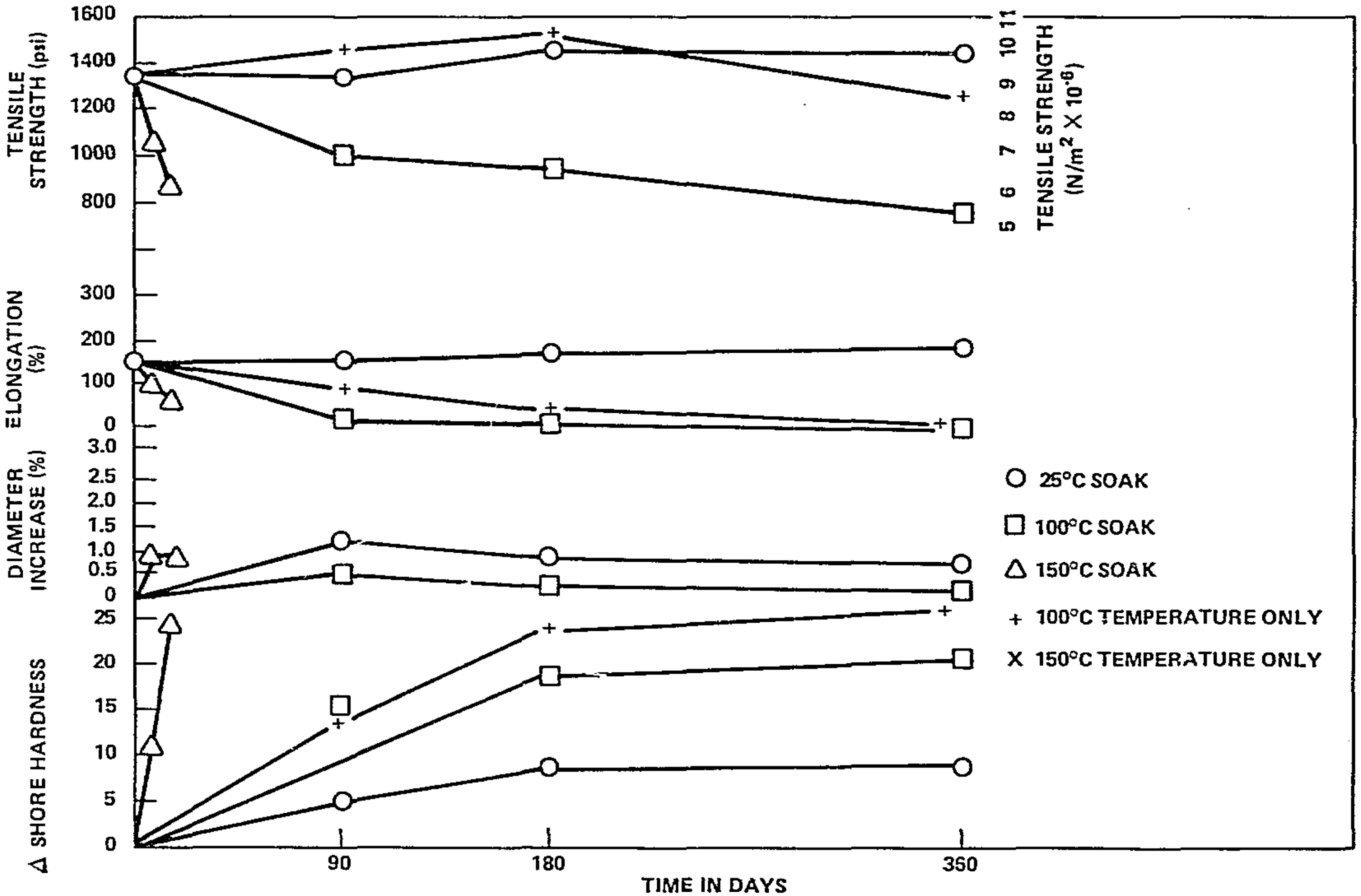

Figure 4. Effect of Royco 782 fluid exposure upon properties of Parker Rubber Company compound N304-75 Buna-N O-rings.

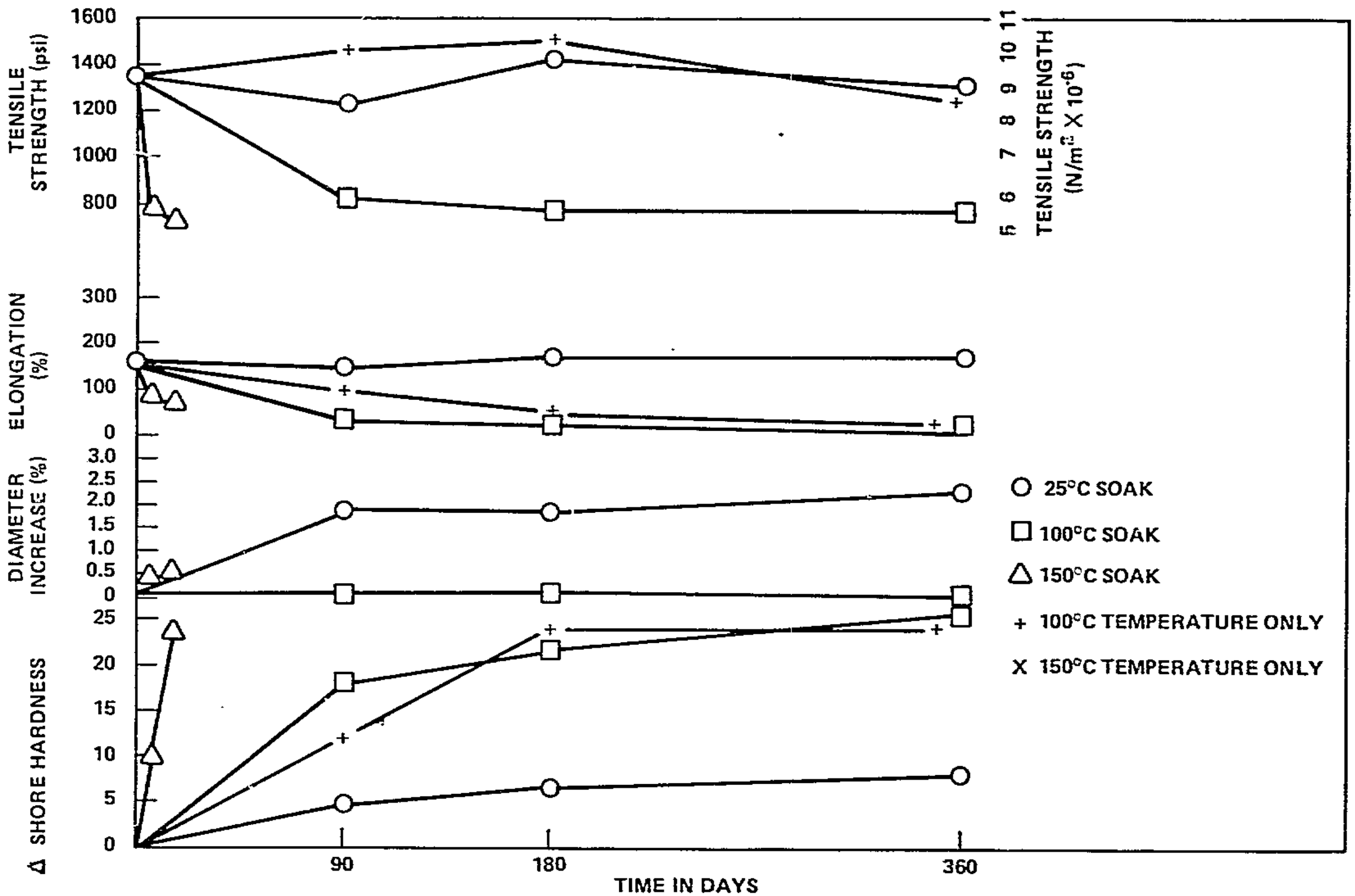

Figure 5. Effect of Mobil RM 230A fluid exposure upon properties of Parker Rubber Company compound N304-75 Buna-N O-rings.

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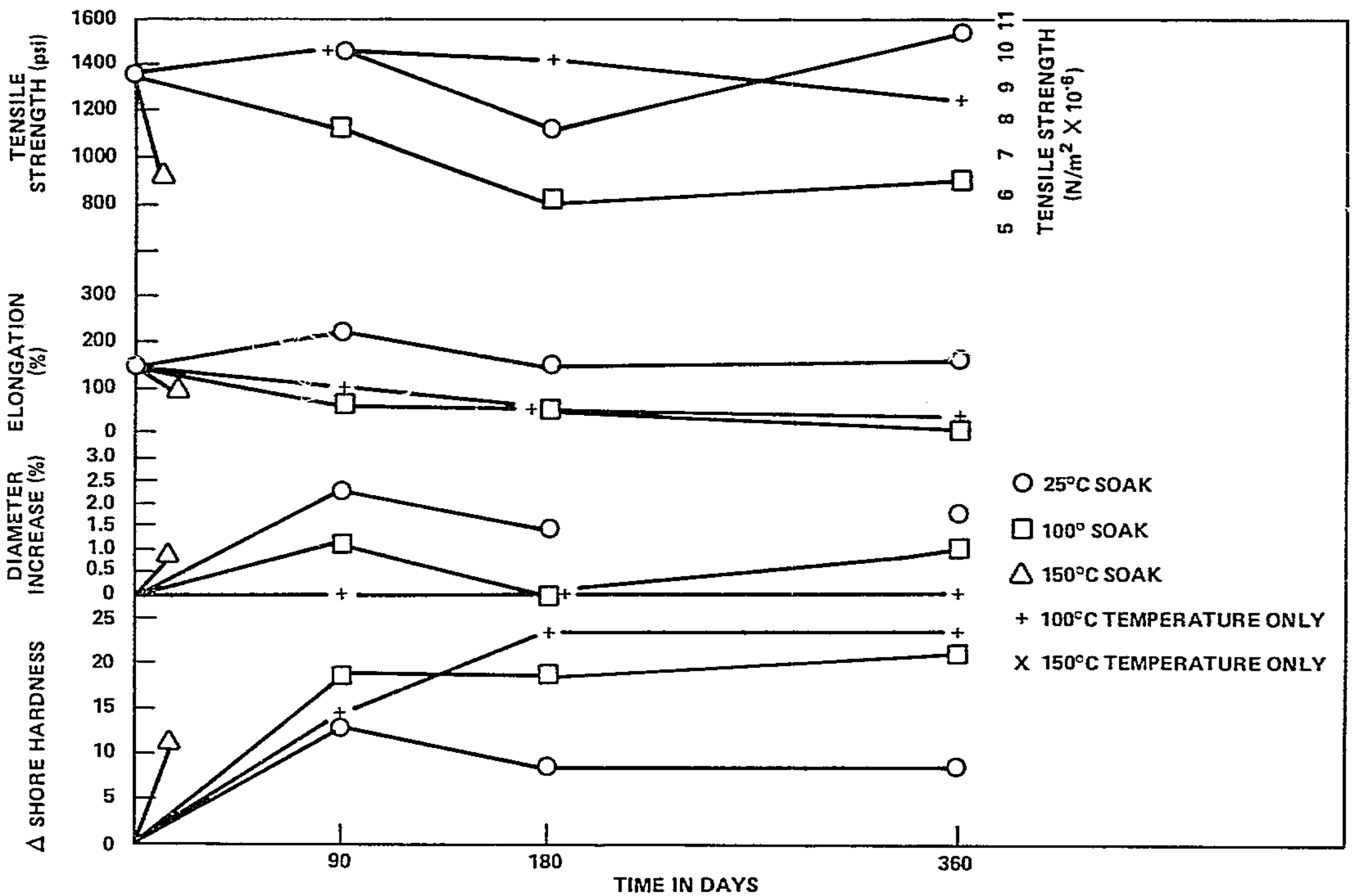

Figure 6. Effect of Bray 882 fluid exposure upon properties of Parker Rubber Company compound N304-75 Buna-N O-rings.

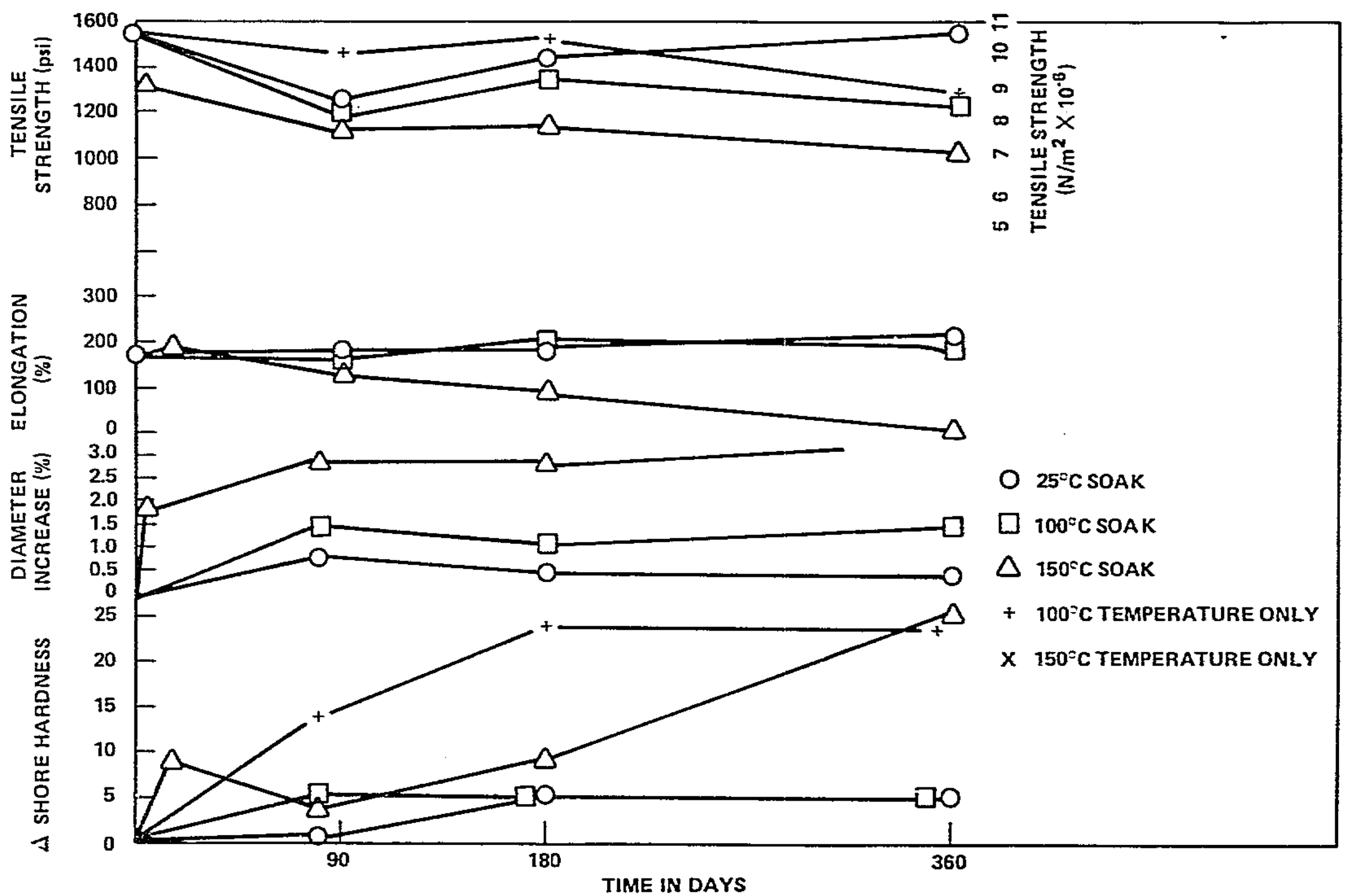

Figure 7. Effect of Royco 782 fluid exposure upon properties of Precision Rubber Company compound 19357 Viton O-rings.

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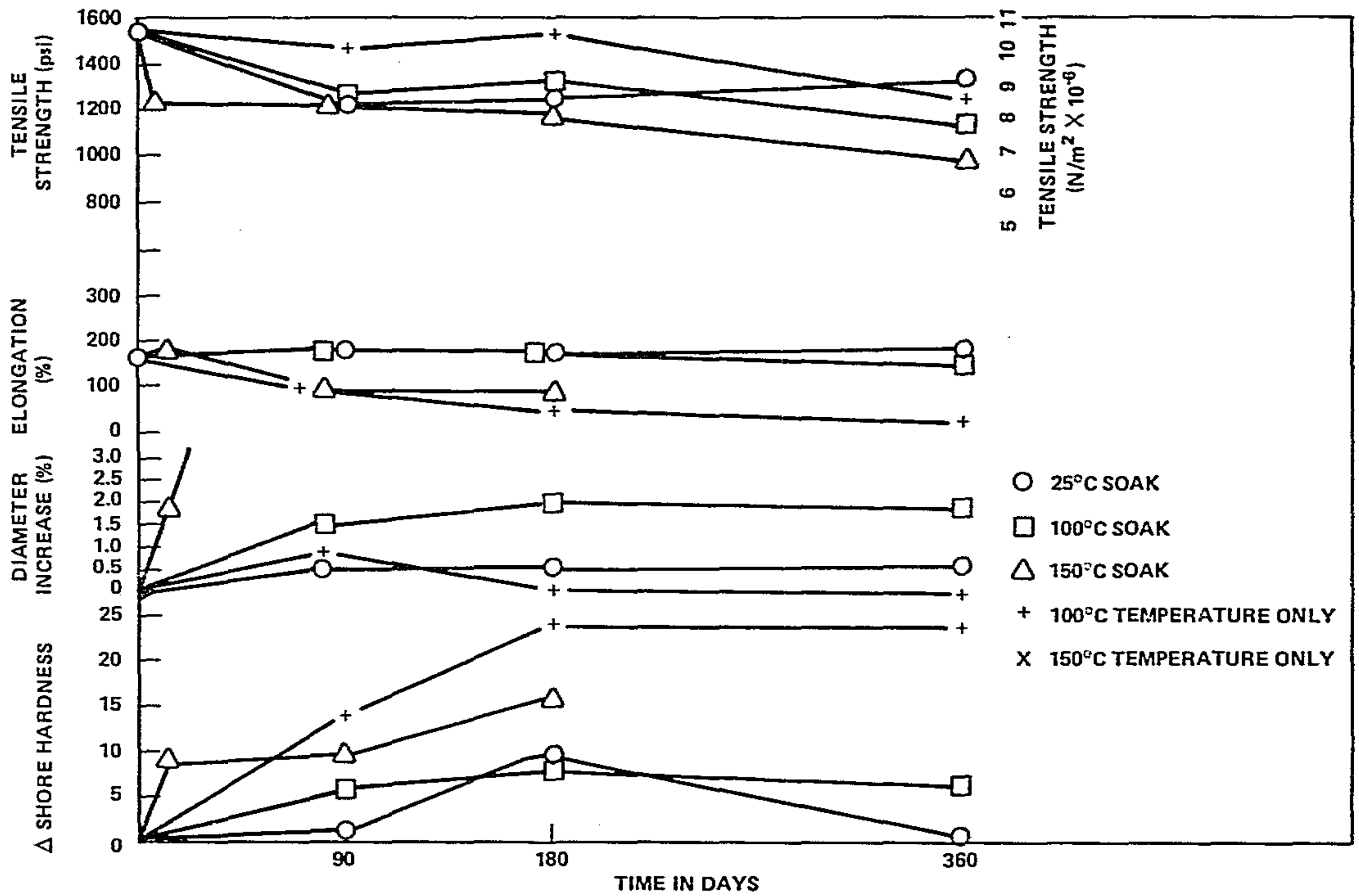

Figure 8. Effect of Mobil RM 230A fluid exposure upon properties of Precision Rubber Company compound 19357 Viton O-rings.

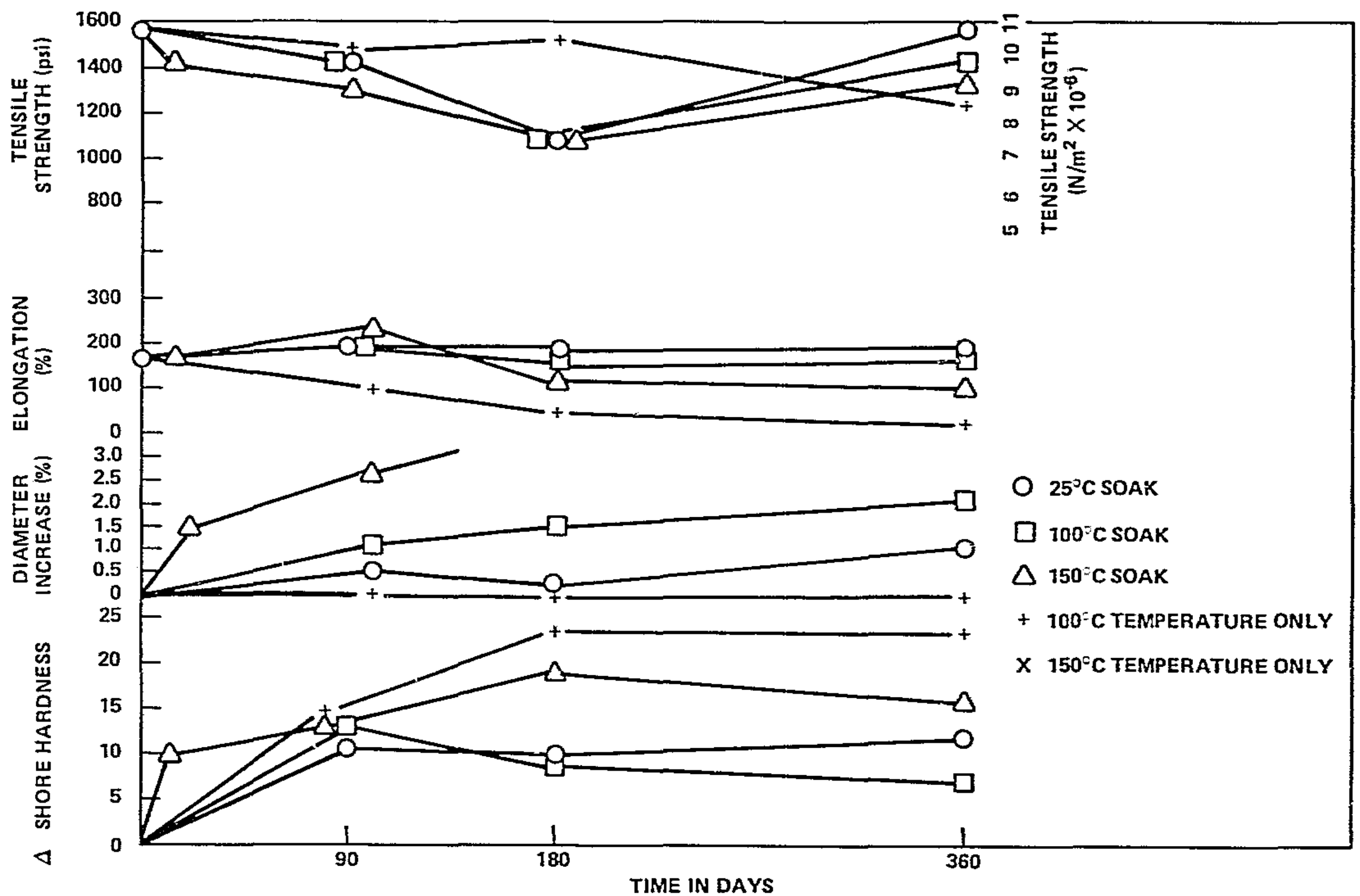

Figure 9. Effect of Bray 882 fluid exposure upon properties of Precision Rubber Company compound 19357 Viton O-rings.

APPROVAL

EFFECT OF HYDRAULIC FLUID (MIL-H-83282) ON SELECTED COMMERCIAL O-RING COMPOUNDS

By T. E. Wood and W. P. Stone

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

J. T. SCHELL
Chief, Polymers and Composites Branch

J. E. CURRY
Chief, Non-Metallic Materials Division

R. J. SCHWINGHAMER
Director, Materials and Processes Laboratory

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