GPU Nuclear

GPU Nuclear
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Writer's Direct Dial Number:

June 25, 1982
5211-82-155

Mr. J. F. Stolz
Office of Nuclear Reactor Regulations
Operating Reactors Branch No. 4
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Request for Information - Environmental Qualification

On April 30, 1982, you requested certain additional information be provided concerning items A.2.6.7, A.3, B.1, B.2, and B.3. Responses to these items are attached.

Sincerely,

H. D. Hukill
Director, TMI-1

HDH:LWH:vjf

Attachment

cc: R. Jacobs (NRC)
C. J. Crane (FRC)

A0A4

A T T A C H M E N T

Item A.2.6.7 - Qualification Test for Rosemount Transmitter Model 1152, Report No. QR 4201-1152 GPJ, Rev. A, Rosemount Inc., 2/14/77

Response: We are unable to obtain this document from B&W. However, we have provided a summary report to FRC which we were able to obtain from B&W.

Item A.3a - A legible single copy of B&W Documents 58-0089-01, 58-1017404-01, 58-0528-00, 58-00181-00, 58-0079-00, 58-0372-00, 58-0261-00, 58-0220-00, and 58-0088-00.

Response: We have contacted B&W concerning these reports. We were told that B&W had third generation xerox copies, although readable, they are not reproducible. However, attached is a summary matrix which we were able to obtain which was redrawn from the requested reports.

Item A.3.b - "1000 Hour Heat Aging Study" by L. Small and E. Sheer (unpublish BF Goodrich Co. Report)

Response: The "1000 Hour Heat Aging Study" is attached.

Items B.1, B.2 and B.3 - TMI Action Plan Items

Response: Information concerning TMI Action Plan equipment installed in harsh areas will be provided on SCEW sheets only after the functionally installed equipment work packages have been turned over to TMI-1 operations.

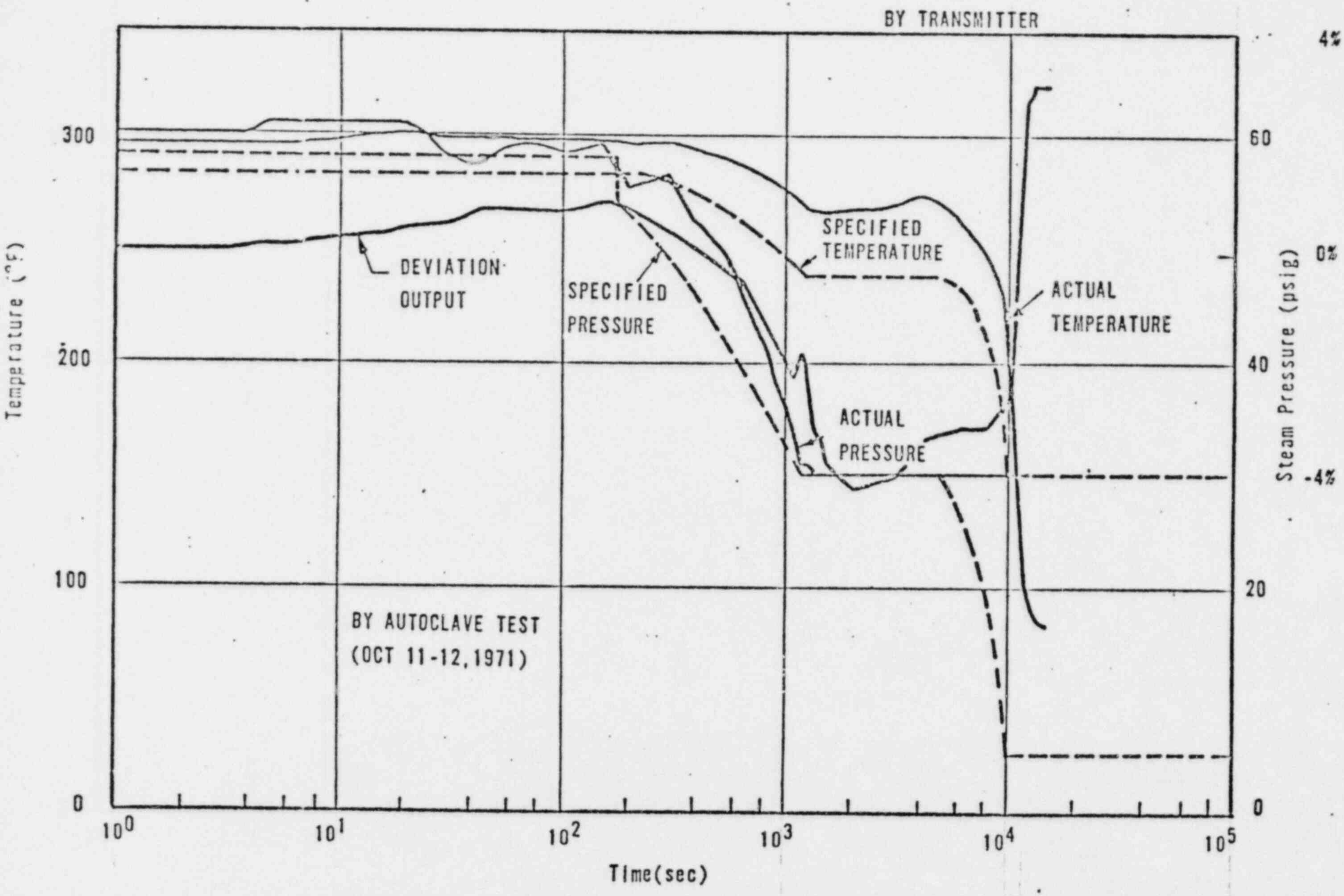
177 B&W OWNERS GROUP
ENVIRONMENTAL QUALIFICATION

OWNER	EQUIPMENT	FUNCTION	MANUFACTURE AND MODEL NO	EQUIPMENT SPECIFICATION	ACCIDENT ENVIRONMENT REQUIREMENT	EQUIPMENT QUALIFICATION DATA	DOCUMENTATION	REMARKS
(3-3-9) (5-6) (7) (8) (11) (14)	Reactor Coolant Flow	Input to Reactor Protection System	Bailey BY3X41X-AX	CS-3-17 NSS-9/1070 (3-4-9) NNI 1048 (5-6)-(7)-(8) (11)-(14)	$2X10^4$ Roentgen Press. 58 PSIG Temp. 285°F Steam/air atmosphere Max inaccuracy ±12% P/T vs Time Plot attached	$4X10^7$ with 4.5% shift $5X10^4$ Roentgen no effect Press. 59 PSIG Temp. 286°F Autoclave P/T vs Time attached Max inaccuracy ±8% Seismic Vibration 3 Axis 3G Reached at 12-15Hz below 12Hz Displacement Limited to .375 D.A. Max Inaccuracy 2%	B&W 58-0081-00	See Figure 1
(3-4-9) (5-6) (7) (8) (11) (14)	Pressurizer Level Transmitter	Indication and Control	Bailey BY3840-AX					
(3-4-9) (5-6) (7) (8) (11) (14)	Steam Generator Level Start-up and Operate	Indication and Control	Bailey BY84B1X-A					
(3-4-9) (5-6) (7) (8) (11) (14)	CF Tank Level	Indication and Control	Bailey BY8X31X-A	CS-3-17/NSS-9/1070 (3-4-9) NNI 1048 (5-6)-(7)-(8) (11)-(14)	Not Required Design Range Only			
(3-4-9)	Reactor Coolant Pressure	Input to Reactor Protection System	Motorola (Westinghouse) 56PH	CS-3-17/NSS-9/1070	$2X10^4$ Roentgen Press. 58 PSIG Temp. 285°F P/T vs Time See Attached Max Inaccuracy ±10%	$2.2X10^6$ Roentgen Press. 59 PSIG Temp. 286°F Autoclave P/T vs Time Plots Attached. Max. Inaccuracy ± 0.6% Seismic (vibration) 3G sinusoidal 1-50HZ 3 Axis. Max inaccuracy ± .25%	Certificate of Conformance Report for P/T 58-0093-00	See Figure 2 Copies of Test Reports Supplied to B&W LOCA, Radiation Vibration, Design Range

OWNER	EQUIPMENT	FUNCTION	MANUFACTURE AND MODEL NO	EQUIPMENT SPECIFICATION	ACCID. ENVIRONMENT REQUIREMENT	EQUIPMENT QUALIFICATION DATA	DOCUMENTATION	REMARKS
(3-2-9)	Reactor Coolant Pressure	Input to Engineer Safety Protection System (SFAS)	Motorola 56PH	CS-3-17/NSS-911070 (3-4-9)	$2X10^4$ Roentgen Press 58 PSIG P/T vs time see attached max. inacc'y ± 10%	$2.2X10^6$ Roentgen Press 59 PSIG Temp. 286°F Autoclave P/T vs time plots attached max inacc'y 8.6%. Seismic (Vibration) 3G sinusoidal 1-50 HZ 3 Axis max. inacc'y .25%	Certificate of Conformance 58-0093-00 For P/T	See Fig. 2 Copies of test reports supplied to B&W LOCA Radiation Vibration Design Range
(5-6) (7) (8) (11) (14)	Reactor Coolant Pressure	Input to SFAS and indication	Foxboro E11GH	NNI1048	$2X10^4$ Roentgent Press. 58 PSIG Temp. 285°F Steam/air max inacc'y ±10% Seismic (Vibration) 1-25HZ 3G (Vertical & Horizontal) max. inacc'y ± 5%	$4.6X10^4$ Rad; press 90 PSIA Temp 318°F RH 100% max inacc'y 5%; Vibration 3G; 3 Axis ≥ 3.0% 1 to 50 HZ Max. inacc'y ≥ 3.0%	58-0079-00	See Fig. 3A73B Copies of test reports suppli[ed] to B&W LOCA Radiation Vibration Design Range
(5-6) (7) (8) (11) (14)	Main Steam Pressure	Indication and Control	Foxboro E11GH	NNI1048		$4.6X10^4$ Rad Press 90 PSIA Temp. 318°F R.H. 100% Max. inacc'y 5% Vibration 3G 3 Axis ≥ 3.0%; 1 to 50HZ		
(3-4-9) (5-6) (7) (8) (11) (14)	Reactor Coolant Temperature Detector	Input to Reactor Protection System	Rosemount 177GY (3-4-9) (11) Rosemount 177HW (5-6) (7) (8) (14)	CS-3-17/NSS 9/1070 NNI1048 (5-6) (7) (8) (14)	Not required Design Range Requirements Only	$3.8X10^8$ Rad Temp. 325°F Press. 60 PSIG RH 100% 177 GY - Vibration by Analysis 177 HW - 1-33HZ, bi-axial 3G ZPA	Certificate of Conformance (177GY) 58-0372-00 (177HW)	The 177HW has [illegible] qualified for accident condi[tions] by similarity [to] the 104AFP and the replacement part for the 17[illegible]
(5-6) (7) (8) (14)	Reactor Coolant Pressure Transmitter	Input to Reactor Protection System	Rosemount 1152GP 9A92	NNI-1048 & 08-1001108-00	$7X10^4$ Rad Temp. 286°F Press. 58 PSIG 100% RH chemical spray steam/air; max inacc'y 10% Seismic 1-35HZ; 3G ZPA Biaxial; max. inacc'y 5%	$5X10^6$ Rad 70 PSIG 316°F Saturated Steam/Chemical Spray; max inacc'y 5% Seismic 1-14HZ .3 D.A. 14-100 HZ 3G,ZPA Max inacc'y ± 1%	58-0261-00 58-0220-00	See Figure 4

OWNER	EQUIP.	FUNCTION	MANUFACTURE AND MODEL NO.	EQUIPMENT SPECIFICATION	ACCIDENT ENVIRONMENT REQUIREMENTS	EQUIPMENT QUALIFICATION DATA	DOCUMENTATION	REMARKS
(3-4-9) (5-6) (7) (8) (11) (14)	NI Pre-amplifier	Input to Reactor Protection system	Bailey PT No. 6623140A1	NI/RPS-CS-2-18 Design Range Rad. $2.0X10^4$ Temp. 40-150 Humidity 0-90% Cont. NI/RPS-1018 (14 only)	Accident Requirement Design Range Only	Design Range (1) Rad $2.4X10^4$ (2) Temp 40° to 160° (3) Humidity 94% RH at 140°F Tested 1G 7 to 40 HZ 3 Axis	58-1017404-01 For T&H Seismic 58-0088-00	Seismic (Vibration) Below 7 HZ Limited by Shaker Table to ± 0.375 Copy of Rad. report avail.
(3-4-9) (5-6) (7) (8) (11) (14)	Source Range NI Detector	Input to Reactor Protection System	Westinghouse WL-23682	NI/RPS CS-2-18 NI/RPS 1018 (14 only)	(1) Rad. 30-60 CPS/NV (2) Press. 150 PSIG (3) Temp. 212°F (4) 90% RH No accident requirement Design Range Only	(1) Rad. 49.4 CPS/NV (2) Press. 150 PSIG (3) Temp. 212°F (4) 100% RH Seismic (Vibration) 1G Vertical & Horizontal	58-0528-00	
(3-4-9)	Intermediate Range Detector	Input to Reactor Protection System	Westinghouse WL-23635		(1) Rad $4\text{-}8X10^{-14}$ A/NV (2) Press. 150 PSIG (3) Temp. 212°F (4) 90% RH No accident requirement Design Range Only	(1) Rad $6.6x10^{-14}$ A/NV (2) Press. 150 PSIG (3) Temp. 212°F (4) 100% RH Seismic (Vibration) 1G Vertical & Horizontal	58-0529-00	
(3-4-9) (5-6) (7) (8) (11) (14)	Power Range Detector	Input to Reac. tor Protection System	Westinghouse WL-23636		(1) Rad $1.2\text{-}2.3X10^{-13}$ A/NV (2) Press. 150 PSIG (3) Temp. 212°F (4) 90% RH No accident requirement Design Range Only	(1)*Rad $1.62X10^{-13}$ A/NV (2) Press. 150 PSIG (3) Temp. 212°F (4) Humidity 100% RH *At 750 volts Seismic (Vibration) 1G Vertical & Horizontal	58-0089-01 Connector Test Rad Gamma 20R/Hr Neutron Flux 10^6NV Temp. 200°F Press. 180 PSI	

OWNER CODE
(3-4-9) Oconee 1,2,3
(5-6) TMI
(7) Florida
(8) Arkansas
(11) SMUD
(14) TECO



BY TRANSMITTER
300
200
100
0
60
40
20
0
4%
0%
-4%
Temperature (°F)
Steam Pressure (psig)
Output Deviation,%
DEVIATION OUTPUT
SPECIFIED PRESSURE
SPECIFIED TEMPERATURE
ACTUAL TEMPERATURE
ACTUAL PRESSURE
BY AUTOCLAVE TEST
(OCT 11-12,1971)
10^0
10^1
10^2
10^3
10^4
10^5
Time(sec)

FIGURE 1

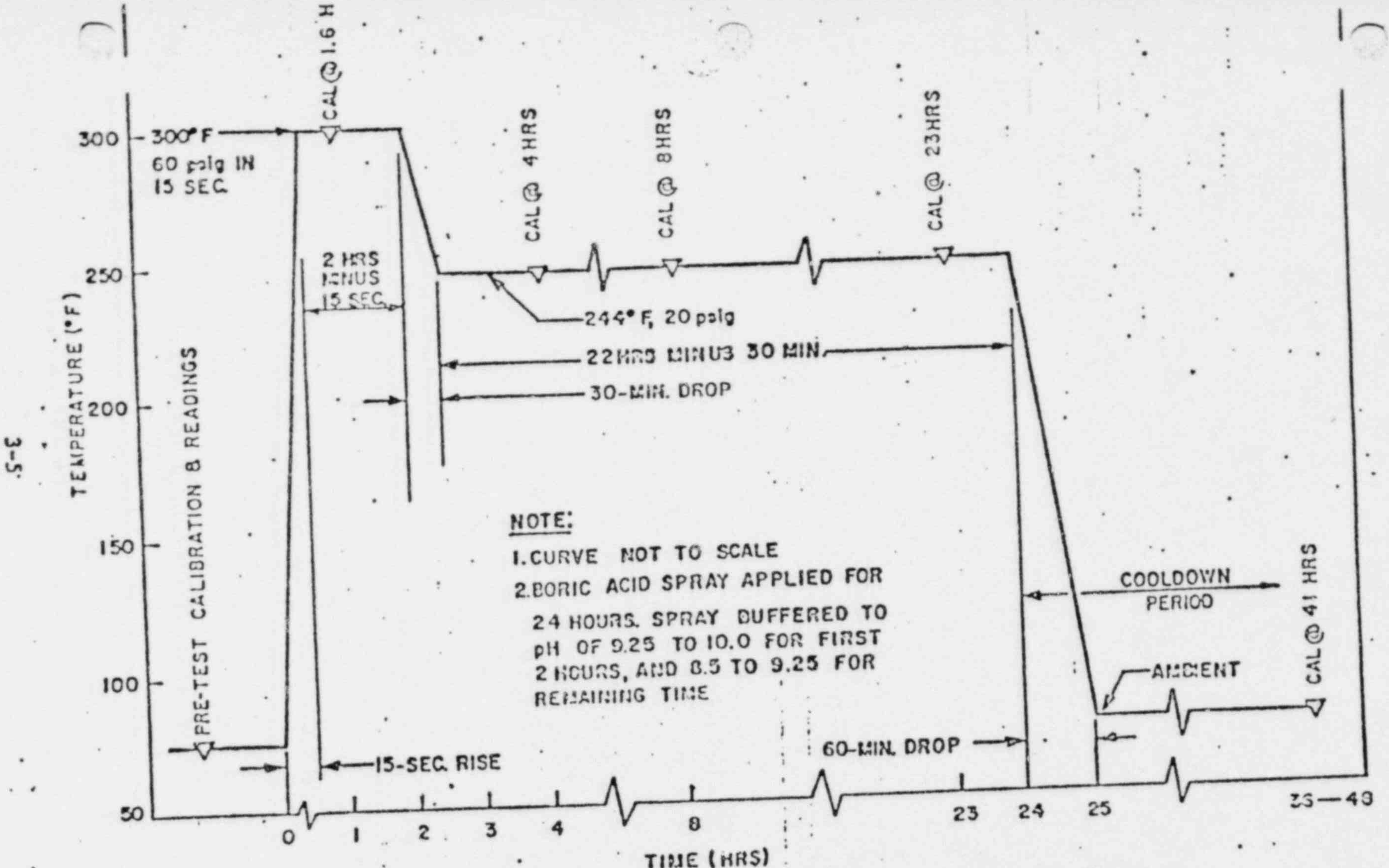
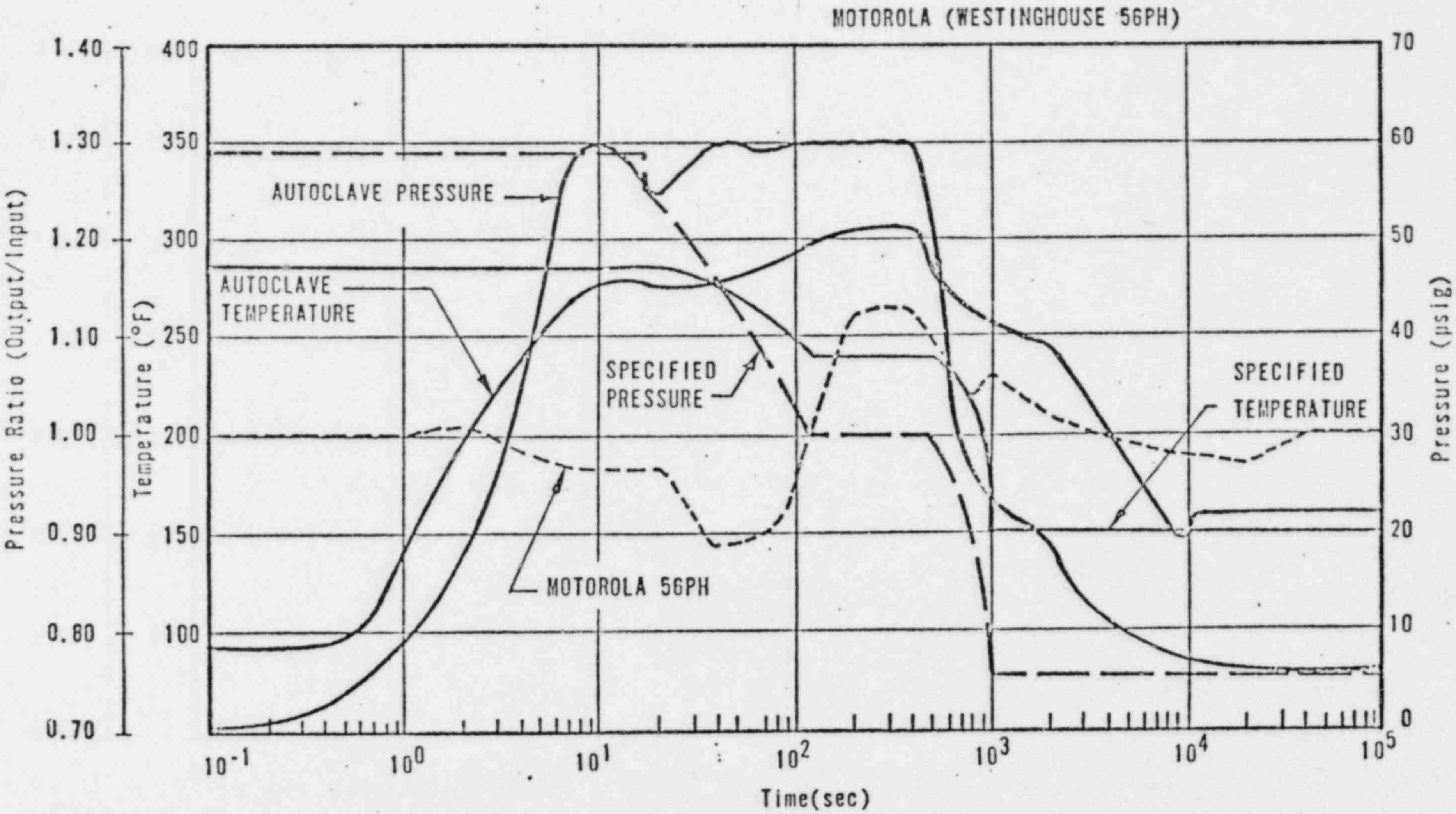


Figure 4. Specified Temperature/Pressure Profile of Steam/Chemical-Spray Exposure

F-C3635

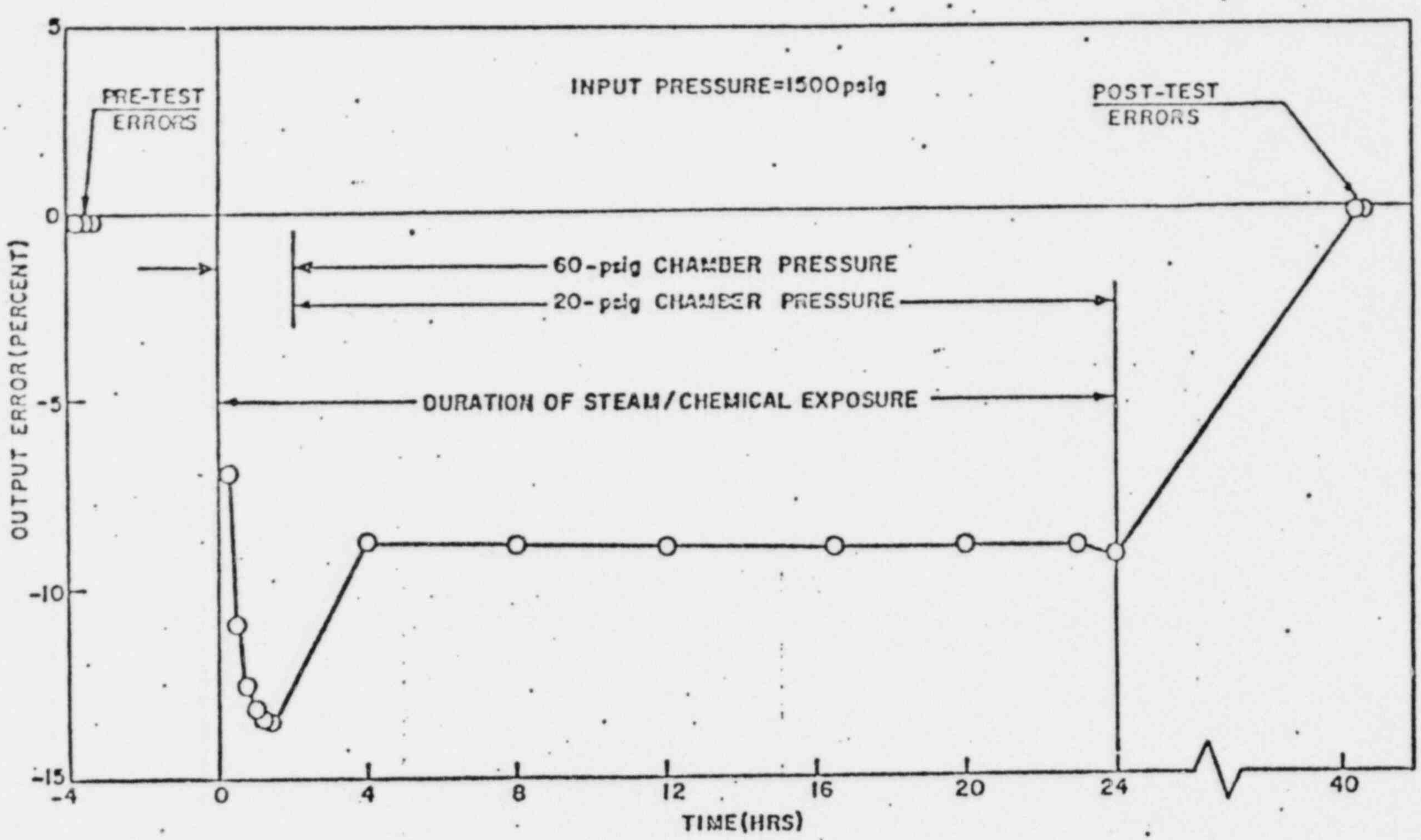
FIGURE 3A



VARIATION OF THE RATIO $\frac{\text{INDICATED PRESSURE}}{\text{ACTUAL PRESSURE}}$ FOR MOTOROLA 56PH PRESSURE TRANSMITTER DURING ENVIRONMENTAL VARIATIONS OF THE LOCA TEST F-C2574-01

FIGURE 2

FOXBORO E11GH

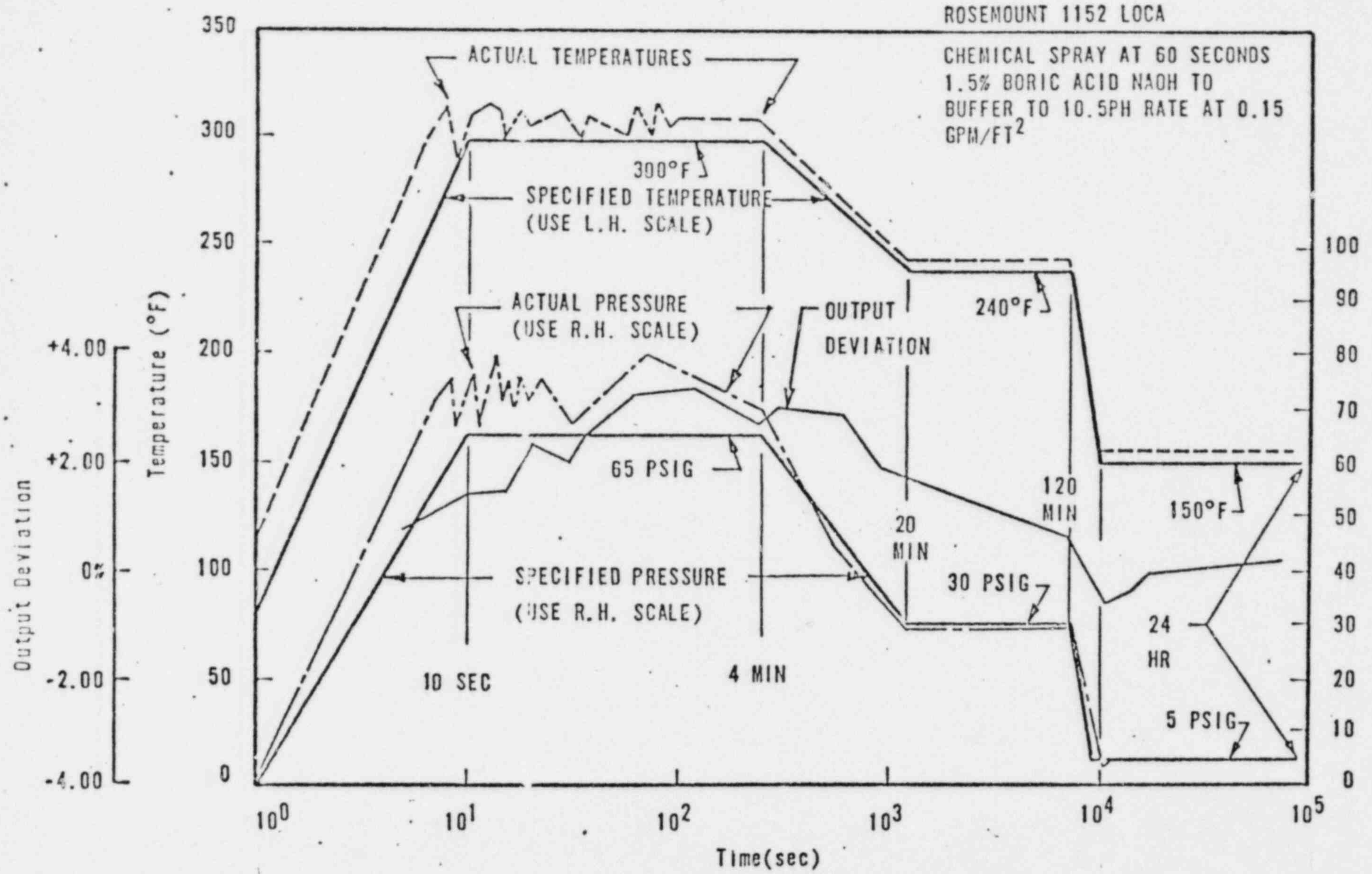


3-11

F-C3635

Figure 8. Test Output Errors for Transmitter No. 35 (Model E11GH)

FIGURE 3B



TEMPERATURE AND PRESSURE PROFILES

FIGURE 4

NBRs are Hycar 1041 1091-50

R-6

1000 HOUR HEAT AGING STUDY

By

Larry Small
Ev Scheer

Introduction

In its myriad of applications, rubber many times has to withstand heat. Temperature performance requirements for elastomers are becoming more demanding. This need for greater heat resistance is critical in the automotive industry, where the trend for higher under-the-hood temperatures has been escalating due to; smaller engines, more power equipment and emission control devices. Because of these factors more and more rubber parts are operating at temperatures very close to current accelerated heat aging test temperatures.

The convergence of service and accelerated test temperatures is creating difficulties in predicting rubber part life based on currently accepted, historically adequate, 70-hour test methods. Consequently, rubber chemists and engineers are beginning to use longer test times, up to 1000 continuous hours, at elevated temperatures to select properly-formulated rubber compounds. Automotive engineers have estimated that 1000 hours of continuous testing relates to the time required by the average motorist to accumulate 50,000 miles over three to five years; however, an exact correlation with on-car performance has not been established.(1)

This report was initiated to find the service temperatures of many common elastomers. The recipes chosen were representative of good heat resistant recipes for the elastomer used.

After testing, the question arises, when is a polymer no longer serviceable. This requires a person to define a fail point; however, an exact fail point can only be determined by testing actual parts in service. Therefore, this author chose not to define a fail point but to present the data in an objective and a comparatively new way. In this manner the reader is welcomed and encouraged to use his own criteria in defining service temperature life. (In the Appendix the reader can find the test recipes, actual results and a number of different presentations of this data.)

Discussion

Changes in the nature of a rubber vulcanizate during aging are reflected in the changes in stress-strain properties. These are used to compare the heat resistance of different vulcanizates. It would be useful if the changes in tensile strength and elongation could be combined in a single number so that compounds could be readily compared. This has led to the concept of the Retention Index:

$$\text{Retention Index} = \frac{(\%\ \text{Tensile retained})\ X\ (\%\ \text{Elongation retained})}{100}$$

This gives a value of 100 for no change and 0 for complete failure of either property. It was decided, that although some elastomers may show an increase in tensile or elongation after aging, that this increase should not be reflected in the index and therefore a 100 would be the highest possible index. Some examples will, perhaps, explain how it works.(1) (2)

Tensile Change	Tensile Retained	Elongation Change	Elongation Retained	Calculation		Retention Index
%	%	%	%			
-10	90	-20	80	$\frac{90X80}{100}$	=	72
-20	80	-40	60	$\frac{80X60}{100}$	=	48
-20	80	+20	100	$\frac{80X100}{100}$	=	80
+20	100	+20	100	$\frac{100X100}{100}$	=	100
+20	100	-20	80	$\frac{100X80}{100}$	=	80

Six types of elastomers were tested:

1) Polyacrylates
2) Epichlorohydrin
3) Ethylene Propylene
4) Nitrile
5) Chloroprene
6) Chlorosulfonated polyethylene

Temperatures from 250°F to 375°F were used, with exposure times of 70 hours, 3 weeks (504 hours) and 6 weeks (1008 hours). Three types of tests were run:

1) Air Test Tube; tested at room temperature
2) Air Test Tube; tested at elevated temperatures
3) ASTM #3 Oil ; tested at room temperature

The results of these tests appear in Tables 1, 2 and 3. The recipe for each elastomer listed can be found in the Appendix Tables 4 thru 9 and the raw data in chart form can be found in Tables 10 thru 25. Also, for those more comfortable with data presented in a more traditional form, the author would like to draw your attention to Tables 26 thru 28.

A look at Tables 1, 2 and 3 show Hycar 4041 to be the superior heat resistant elastomer tested. The author would like to reiterate that the compounds chosen were only representative of good heat resistant recipes and with proper compounding techniques all indices could be improved. These recipes were designed for commercial use, not to just withstand heat. Also, this data has shown that the concept of a Retention Index is a valuable concept by listing the elastomers in the traditional and expected order of heat resistance.

L. S. Small

Lawrence S. Small

E. N. Scheer

Everett Scheer

:wjw

TABLE 1

RETENTION INDEX

AIR TEST TUBE AGED AT GIVEN CONDITIONS; TESTED AT ROOM TEMPERATURE

	250°F			275°F			302°F			325°F			350°F			375°F		
	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.
Hycar 4041							93	94	89	100	96	81	81	57	26	83	42	10
Hycar 4043				83	77	71	73	70	47	87	54	24	58	11	0			
Hydrin 200/Hycar 4021							89	38	35	46	22	-						
Hydrin 100				62	58	35	72	30	17	39	2	-						
Hydrin 100/Hydrin 200				59	44	17	63	9	5									
ydrin 200/Non Black				44	22	10	34	9	2									
Hydrin 200	58	69	56	65	45	5												
Epcar 545/Peroxide				64	49	24	53	11										
Epcar 545/Sulfur				54	44	36	58	34										
Hypalon 40	96	67	46	100	32	7												
Hycar 1041	71	14	4	46	0	-												
Hycar 1041/Hycar 1091-50	61	26	5	64	0	-												
Neoprene W	86	10	0															

TABLE 2

RETENTION INDEX

AIR TEST TUBE AGED AND TESTED AT THE GIVEN ELEVATED TEMPFRATURES

	250°F			275°F			302°F			325°F			350°F		
	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.
Hycar 4041							100	100	84	100	77	54	100	41	14
Hycar 4043				100	84	69	97	78	68	60	31	18			
Hydrin 200/Hycar 4021										44	39	12			
Hydrin 100				87	53	40	86	25	8	18	-	-			
Hydrin 100/Hydrin 200				75	43	13	63	14	-						
Hydrin 200 Non Black				44	26	21	49	22	-						
Hydrin 200				86	53	2									
Epcar 545/peroxide				95	-	64	94	49	1						
Epcar 545/Sulfur Donor				90	-	78	100	80	1						
Hypalon 40	83	70	61												
Hycar 1041	86	24	-	50	-	-									
Hycar 1041/Hycar 1091-50	68	34	-	63	-	-									
Neoprene W	100	10	4												

TABLE 3

RETENTION INDEX

ASTM #3 OIL AGED AT GIVEN CONDITIONS; TESTED AT ROOM TEMPERATURE

	250°F			275°F			302°F		
	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.	70 Hrs.	3 Wks.	6 Wks.
Hycar 4041							83	82	73
Hycar 4043				65	53	55	62	60	54
Hydrin 200/Hycar 4021				57	37	43	46	-	17
Hydrin 100				70	42	34	62	29	5
Hydrin 100/Hydrin 200				63	44	17	56	29	4
Hydrin 200/Non-Black				44	22	10	40	8	3
Hydrin 200				100	58	22	58	25	1
Epcar 545/Peroxide		N.A.							
Epcar 545/Sulfur Donor		N.A.							
Hypalon 40	78	52	50						
Hycar 1041	89	49	6						
Hycar 1041/Hycar 1091-50	74	9	2						
Neoprene W									

B I B L I O G R A P H Y

1. R. S. Auda and Dr. Hazelton "A Method for Evaluating the Heat Aging Characteristics of Ethylene Propylene Elastomers" presented at the 105th Rubber Division Meeting of American Chemical Society; Toronto, Canada May 7-10, 1974.

2. P. H. Starmer "Heat Resistance of Nitrile Rubber Compounds II - Effect of Various Additives" B. F. Goodrich Development Report of May 10, 1974.

APPENDIX

APPENDIX

TABLES 4 thru 9 show the recipes used They were mixed according to standard procedures.

TABLES 10 thru 25 show the raw data. All tests were done in accordance with ASTM methods.

TABLE 10 shows Original Properties and Mooney Viscosities.

TABLE 11 shows Original Properties tested at elevated temperatures.

TABLES 12 thru 17 show the Air Test Tube data.

TABLES 18 thru 22 show the Air test tube tested at elevated temperature data.

TABLES 23 thru 25 show the ASTM #3 Oil data.

TABLES 26 thru 28 are summary charts of the preceeding 15 tables shown in a more traditional manner. The author would suggest that these three tables be referred to when you are trying to decide the best elastomer to use for your particular application.

Finally, TABLE 29 is a listing of compounding ingredients.

TABLE 4

HYCAR POLYACRYLATE RECIPES

Hycar 4041	100	-
Hycar 4043	-	100
Acrawax C	2	-
Stearic Acid	-	2
TE-80	2	2
N 550 Black	65	-
N 326 Black	-	75
Admex 760	10	5
Stalite S	1	2
Santowhite Crystals	1	-
Spider Sulfur	0.4	0.3
Sodium Stearate	4	1
Potasium Stearate	-	3
	185.4	190.3

TABLE 5

HYDRIN RECIPES

Hydrin 100	100	-	40	-	-
Hydrin 200	-	30	60	100	100
Hycar 4021	-	70	-	-	-
Stearic Acid	-	1.5	-	-	-
Magnesium Stearate	1	-	1	1	1
Red Lead	-	5	-	-	-
Dyphos	5	-	4	5	5
Dythal	7	-	6	7	7
Niclate	1	-	1	1	1.5
NBC	-	-	0.6	0.6	0.7
Stalite S	-	1	-	-	-
Cumate	0.1	-	-	-	-
N 770 Black	90	35	90	90	3
N 550 Black	-	40	-	-	-
DOP	7	7	7	7	7
Paraplex G50	5	5	5	5	5
ZO-9	1	-	1	1	1
Warecure C	1.2	1.4	1.2	1.2	1.5
Hi Sil 233	-	-	-	-	35
Zeolex 23	-	-	-	-	20
Silane A-189	-	-	-	-	0.5
	218.3	195.9	216.8	218.8	188.2

TABLE 6

EPCAR RECIPE

Epcar 545	100	100
N 550	75	50
Sunpar 2280	25	15
Zinc Oxide	5	7
Sulfur	0.5	0.3
Stearic Acid	1	-
MBT	3	-
TMTD	0.8	-
NBC	2	-
Butyl Zimate	1.5	-
Sulfasan R	0.8	-
Age Rite Resin D	-	1
Varox	-	8
	214.6	181.3

TABLE 7

HYPALON RECIPE

Hypalon 40	100
Litharge	20
Maglite D	5
N 991	50
Laminar	100
LMW Polyethylene	4
Coldflex 1000	20
Sundex 890	25
NBC	1.5
Kenflex A	5
Tetrone A	1
HVA-2	2.5
	334.0

TABLE 8

HYCAR NITRILE RECIPES

Hycar 1041	100	40
Hycar 1091-50	-	60
Zinc Oxide	5	5
Naugard 445	2	1.5
Agerite Stalite	-	1.5
Stearic Acid	1	1
N 550	40	-
N 991	80	80
Hi Sil 233	-	40
Admex 760	15	15
Flexricin P-4	10	10
TE-80	2	2
Witco 127	-	2
Sulfur	0.5	0.5
CBTS	-	1.0
TMTD	1.5	1.5
TETD	1.5	1.5
	258.5	262.5

TABLE 9

NEOPRENE RECIPE

Neoprene W	100
Aranox	1
Octamine	4
Dodecyl Mercaptan	1.5
Maglite D	4
Stearic Acid	0.5
FEF	20
Laminar	90
Linseed Oil	15
Zinc Oxide	10
NA-22	1
	247.0

TABLE 10

MOONEY VISCOSITY-LARGE ROTOR-121°C (250°F)

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
Mooney Viscosity													
Minimum	30	39	56	43	46	80	74	46	56	25	28	38	29
T5	>31	13	8.5	10.5	10	7	7.5	>30	7	14	5.5	7	9.5
Cure Conditions													
Time (min.)	20	20	30	30	30	30	30	60	6	20	9	13	10
Temp. (°C)	160	160	175	160	160	160	160	160	160	160	160	160	160
Temper Conditions													
Time (hrs.)	8	8											
Temp. (°C)	170	170											
Original Properties													
100% Modulus	800	460	750	900	920	470	720	460	450	500	550	225	260
300% Modulus						1350		1900	11 0			750	920
Tensile	1350	1260	1570	1370	1540	2210	1450	2440	1800	1130	1700	1325	1520
Elongation	200	250	280	260	270	610	260	490	500	280	280	580	410
Hardness	73	66	69	80	75	68	75	68	72	63	65	65	65
Gehman Torsional Stiffness (ASTM D1053)													
Θ^{o}	165	170	161	147	145	151	155			170	163	164	160
T2 (°C)	+2.5	-3	-16	-7.5	-17.5	-24.5	-20	-15	-9.5	-19	-13	-11	-30
T5 (°C)	-5.5	-20	-22	-21	-26.5	-33.5	-32	-35	-30	-28	-23	-22.5	-35
T10 (°C)	-8.5	-25	-24.5	-25	-30	-35.5	-36	-40	-38	-30	-25	-25	-36
T50 (°C)	-12.5	-33.5	-30	-29	-34.5	-40	-41.5	-47.5	-47	-36	-27	-29	-38
T100 (°C)	-15	-36.5	-33	-31	-35	-41	-43.5	-50	-50	-37	-29.5	-31	-39
FP (°C)	-16	-39	-32.5	-31	-36	-41.5	-42	-50.5	-50.5	-39	-31	-30	-40.5

TABLE 11

ORIGINAL PROPERTIES TESTED AT ELEVATED TEMPERATURES

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
ORIGINAL PROPERTIES AT ROOM TEMPERATURE													
100% Modulus	800	460	750	900	920	470	720	460	450	500	550	225	260
Tensile	1350	1260	1570	1370	1540	2210	1450	2440	1680	1130	1700	1325	1520
Elongation	200	250	280	260	270	610	260	490	450	280	280	580	410
Hardness	73	66	69	80	75	68	75	68	71	63	65	65	65
ORIGINAL PROPERTIES AT 250°F													
Tensile										400	910	610	450
Elongation										230	290	500	480
Hardness										59	57	51	60
ORIGINAL PROPERTIES AT 275°F													
Tensile		650		760	920	900	930	620	860		760	510	
Elongation		290		150	200	350	220	210	200		250	410	
Hardness		45		75	75	65	73				60	56	
ORIGINAL PROPERTIES AT 300°F													
Tensile	475	630		720	830	780	960	620	790		640	480	
Elongation	190	280		140	170	270	210	190	200		190	310	
Hardness	53	45		75	75	67	73				61	59	

TABLE 11

ORIGINAL PROPERTIES TESTED AT ELEVATED TEMPERATURES

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
ORIGINAL PROPERTIES AT 325°F													
Tensile	450	600	620	830				645	750				
Elongation	170	260	110	150				170	210				
Hardness	53	50	64	77									
ORIGINAL PROPERTIES AT 350°F													
Tensile	475												
Elongation	180												
Hardness	53												
ORIGINAL PROPERTIES AT 375°F													
Tensile													
Elongation													
Hardness													

TABLE 12

AIR TEST TUBE AGED AT 121°C (250°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED 121°C													
Ultimate Tensile, psi							1700			1200	1900	1250	1420
% Tensile Change							+17			+6	+12	-6	-7
% Ultimate Elongation							150			270	200	380	380
% Elongation Change							-42			-4	-29	-35	-7
Shore Hardness							78			64	72	74	-4
Points Hardness Change							+3			+1	+7	+9	+9
180° Bend							P			P	P	P	P
~~3 WEEKS AGED 121°C~~													
Ultimate Tensile, psi							1650			1200	2475	[illegible]	1600
% Tensile Change							+14			+6	+46	[illegible]	+5
% Ultimate Elongation							180			196	40	[illegible]	40
% Elongation Change							-31			-33	-86	[illegible]	-90
Shore Hardness							83			69	93	[illegible]	88
Points Hardness Change							+8			+6	+28	[illegible]	+23
180° Bend							P			P	F	[illegible]	F
6 WEEKS AGED 121°C													
Ultimate Tensile, psi							1320			1310	2875	2450	1250
% Tensile Change							-10			+16	+70	+85	-18
% Ultimate Elongation							160			130	10	30	0
% Elongation Change							-38			-54	-96	-95	-100
Shore Hardness							85			74	96	95	96
Points Hardness Change							+10			+11	+31	+30	+31
180° Bend							P			P	F	F	F

TABLE 13

AIR TEST TUBE AGED AT 135°C (275°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED 135°C													
Ultimate Tensile, psi		1190		1920	1950	1930	1780	2400	1890	1420	1870	1400	
% Tensile Change		-6		+40	+27	-13	+22	-2	+5	+26	+10	+6	
% Ultimate Elongation		220		160	160	310	170	320	240	300	130	370	
% Elongation Change		-12		-38	-41	-49	-35	-35	-46	+7	-54	-36	
Shore Hardness		68		87	83	73	82	67	75	67	79	73	
Points Hardness Change		+2		+7	+8	+5	+7	-1	+3	+4	+14	+8	
180° Bend		P		P	P	P	P	P	P	P	P	P	
Ultimate Tensile, psi		1160		1830	1620	1270	1140	2190	1920	1300	2500	2150	
% Tensile Change		-8		+34	+5	-43	-22	-10	+6	+15	+47	+62	
% Ultimate Elongation		210		110	120	230	150	270	200	90	0	0	
% Elongation Change		-16		-42	-56	-62	-42	-45	-56	-68	-100	-100	
Shore Hardness		72		90	87	74	84	69	77	73	97	96	
Points Hardness Change		+6		+10	+12	+6	+9	+1	+5	+10	+32	+31	
180° Bend		P		P	P	P	P	P	P	P	F	F	
6 WEEKS AGED 135°C													
Ultimate Tensile, psi		1120		1500	720	880	260	1550	1950	1360			
% Tensile Change		-11		+9	-53	-60	-82	-36	+8	+20			
% Ultimate Elongation		200		90	100	150	70	180	160	20			
% Elongation Change		-20		-65	-63	-75	-73	-63	-64	-93			
Shore Hardness		73		92	86	75	80	71	80	89			
Points Hardness Change		+7		+12	+11	+7	+5	+3	+8	+26			
180° Bend		P		P	P	P	P	P	P	F			

TABLE 14

AIR TEST TUBE AGED AT 150°C (302°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 H S AGED 150°C													
Ultimate Tensile, psi	1250	1100	1800	1860	1860	1620		2190	2000				
% Tensile Change	-7	-13	+14	+36	+21	-27		-10	+19				
% Ultimate Elongation	200	210	250	160	170	280		290	260				
% Elongation Change	0	-16	-11	-28	-37	-54		-41	-42				
Shore Hardness	73	68	73	90	87	73		68	78				
Points Hardness Change	0	+2	+4	+10	+12	+5		0	+6				
180° Bend	P	P	P	P	P	P		P	P				
3 WEEKS AGED 150°C													
Ultimate Tensile, psi	1270	1160	1050	1180	370	830		1090	1930				
% Tensile Change	-6	-8	-33	-14	-76	-62		-55	+15				
% Ultimate Elongation	200	190	160	90	100	150		170	160				
% Elongation Change	0	-24	-43	-65	-63	-75		-76	-64				
Shore Hardness	75	77	80	88	81	75		71	81				
Points Hardness Change	+2	+11	+11	+8	+6	+7		+3	+9				
180° Bend	P	P	P	P	P	P		P	P				
6 WEEKS AGED 150°C													
Ultimate Tensile, psi	1330	1000	1180	610	180	50							
% Tensile Change	-1	-21	-25	-55	-88	-98							
% Ultimate Elongation	180	140	130	100	10	70							
% Elongation Change	-10	-40	-54	-62	-96	-89							
Shore Hardness	75	81	85	93	75	64		88	91				
Points Hardness Change	+2	+15	+1[illegible]	+13	0	-4		+20	+19				
180° Bend	P	P	P	P	F	P		F	F				

TABLE 15

AIR TEST TUBE AGED AT 163°C (325°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED 163°C													
Ultimate Tensile, spi	1400	1190	1440	1810									
% Tensile Change	+4	-6	-8	+32									
% Ultimate Elongation	200	230	140	100									
% Elongation Change	0	-8	-50	-61									
Shore Hardness	73	71	78	94									
Points Hardness Change	0	+5	+9	+14									
180° Bend	P	P	P	P									
3 WEEKS AGED 163°C													
Ultimate Tensile, psi	1290	1130	900	370									
% Tensile Change	-4	-10	[illegible]	-73									
% Ultimate Elongation	200	150	110	20									
% Elongation Change	0	-40	-61	-92									
Shore Hardness	77	84	88	91									
Points Hardness Change	+4	+18	+19	+11									
180° Bend	P	P	P	F									
6 WEEKS AGED 163° C													
Ultimate Tensile, psi	1220	1300											
% Tensile Change	-10	+3											
% Ultimate Elongation	180	60											
% Elongation Change	-10	-76											
Shore Hardness	81	88	94										
Points Hardness Change	+8	+22	+25										
180° Bend	P	P	F										

TABLE 16

AIR TEST TUBE AGED AT 177°C (350°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED 177°C													
Ultimate Tensile, psi	1100	930											
% Tensile Change	-19	-27											
% Ultimate Elongation	200	200											
% Elongation Change	0	-20											
Shore Hardness	76	74											
Points Hardness Change	+3	+8											
180° Bend	P	P											
3 WEEKS AGED 177°C													
Ultimate Tensile, psi	900	1180											
% Tensile Change	-33	-6											
% Ultimate Elongation	170	30											
% Elongation Change	-15	-88											
Shore Hardness	80	97											
Points Hardness Change	+7	+31											
180° Bend	P	F											
6 WEEKS AGED 177°C													
Ultimate Tensile, psi	1090	1750											
% Tensile Change	-26	+28											
% Ultimate Elongation	70	0											
% Elongation Change	-65	-100											
Shore Hardness	92	98											
Points Hardness Change	+19	+32											
180° Bend	P	F											

TABLE 17

AIR TEST TUBE AGED AT 191°C (375°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
AGED													
Ultimate Tensile, psi	1120												
% Tensile Change	-17												
% Ultimate Elongation	200												
% Elongation Change	0												
Shore Hardness	77												
Points Hardness Change	+4												
180° Bend	P												
AGED													
Ultimate Tensile, psi	1130												
% Tensile Change	-16												
% Ultimate Elongation	100												
% Elongation Change	-50												
Shore Hardness	87												
Points Hardness Change	+14												
180° Bend	P												
AGED													
Ultimate Tensile, psi	2830												
% Tensile Change	+109												
% Ultimate Elongation	20												
% Elongation Change	-90												
Shore Hardness	93												
Points Hardness Change	+20												
180° Bend	F												

TABLE 18

AIR TEST TUBE AGED AT 121°C (250°F) TESTED AT 121°C

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED AND TESTED AT 121°C													
Ultimate Tensile, psi							1040			500	1040	670	570
% Tensile Change										+25	+14	+10	+26
% Ultimate Elongation							200			190	250	340	520
% Elongation Change										-17	-14	-32	+8
180° Bend							P			P	P	P	P
3 WEEKS AGED AND TESTED AT 121°C													
Ultimate Tensile, psi							880			620	1030	820	780
% Tensile Change										+55	+13	+34	+73
% Ultimate Elongation							170			160	70	170	50
% Elongation Change										-30	-76	-66	-90
180° Bend							P			P	F	P	F
6 WEEKS AGED AND TESTED AT 121°C													
Ultimate Tensile, psi							800			710			200
% Tensile Change										+77			-55
% Ultimate Elongation							180			140			20
% Elongation Change										-39			-96
180° Bend							P			P			F

TABLE 19

AIR TEST TUBE AGED AT 135°C (275°F) TESTED AT 135°C

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED AND TESTED AT 135°C													
Ultimate Tensile, psi		680		840	930	700	930	770	770	580	730	620	
% Tensile Change		+5		+11	+2	-22	0	+24	-10	0	-4	+21	
% Ultimate Elongation		300		130	150	200	190	200	200	230	130	260	
% Elongation Change		+3		-13	-25	-43	-14	-5	0		-48	-37	
180° Bend		P		P	P	P	P	P	P	P	P	P	
3 WEEKS AGED AND TESTED AT 135°C													
Ultimate Tensile, psi		635		870	800	580	670			440			
% Tensile Change		-2		+14	-13	-35	-28						
% Ultimate Elongation		250		80	100	140	160			90			
% Elongation Change		-14		-47	-50	-60	-27						
180° Bend		P		P	P	P	P			P			
6 WEEKS AGED AND TESTED AT 135°C													
Ultimate Tensile, psi		540		820	330	520	90	520	840	560			
% Tensile Change		-17		+8	-64	-42	-90	-16	-2				
% Ultimate Elongation		240		60	70	130	50	160	160	50			
% Elongation Change		-17		-60	-65	-63	-77	-24	-20				
180° Bend		P		P	P	P	P	P	P	F			

TABLE 20

AIR TEST TUBE AGED AT 150°C (302°F) TESTED AT 150°C

70 HRS AGED AND TESTED AT 150°C

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
Ultimate Tensile, psi	520	610	720	920	750	650		580	830				
% Tensile Change	+9	-3		+28	-10	-17		-6	+5				
% Ultimate Elongation	200	280	110	120	120	160		220	260				
% Elongation Change	+5	0		-14	-29	-41		+16	+30				
180° Bend	P	P	P	P	P	P		P	P				

3 WKS AGED AND TESTED AT 150°C

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
Ultimate Tensile, psi	540	570	520	420	240	470		430	810				
% Tensile Change	+14	-9		-42	-71	-40		-31	+3				
% Ultimate Elongation	200	240	160	60	80	160		130	160				
% Elongation Change	+5	-14		-57	-53	-63		-31	-20				
180° Bend	P	P	P	P	P	P		P	P				

6 WKS AGED AND TESTED AT 150°C

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
Ultimate Tensile, psi	500	460	550	260		60		140	90				
% Tensile Change	+5	-27		-64		-92		-77	-89				
% Ultimate Elongation	160	260	120	30		30		10	10				
% Elongation Change	-16	-7		-79				-95	-95				
180° Bend	P	P	P	F	F	F		F	F				

TABLE 21

AIR TEST TUBE AGED AT 166°C (325°F) TESTED AT 166°C

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED AND TESTED AT 166°C													
Ultimate Tensile, psi	510	550	375	550									
% Tensile Change													
% Ultimate Elongation	140	170	80	40									
% Elongation Change													
180° Bend	P	P	P	P									
3 WKS AGED AND TESTED AT 166°C													
Ultimate Tensile, psi	490	510	325										
% Tensile Change													
% Ultimate Elongation	130	100	80										
% Elongation Change													
180° Bend	P	P	P	F									
6 WKS AGED AND TESTED AT 166°C													
Ultimate Tensile, psi	410	560	340										
% Tensile Change													
% Ultimate Elongation	100	50	30										
% Elongation Change													
180° Bend	P	F	F										

TABLE 22

AIR TEST TUBE AGED AT 177°C (350°F) TESTED AT 177°C

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 [illegible] BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED AND TESTED AT 177°C													
Ultimate Tensile, psi	440	440											
% Tensile Change													
% Ultimate Elongation	180	150											
% Elongation Change													
180° Bend	P												
3 WKS AGED AND TESTED AT 177°C													
Ultimate Tensile, psi	350	175											
% Tensile Change													
% Ultimate Elongation	100	20											
% Elongation Change													
180° Bend	P												
6 WKS AGED AND TESTED AT 177°C													
Ultimate Tensile, psi	290	140											
% Tensile Change													
% Ultimate Elongation	40	10											
% Elongation Change													
180° Bend	F												

TABLE 23

ASTM 3 OIL AGED AT 121°C (250°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED 121°C													
Ultimate Tensile, psi										1120	2050	1425	
% Tensile Change										0	+21	+8	
% Ultimate Elongation										220	250	430	
% Elongation Change										-22	-11	-26	
Shore Hardness										53	68	73	
Points Hardness Change										-10	+3	+8	
% Volume Weight Change										+28	+2.3	0.7	
180° Bend										P	P	P	
3 WEEKS AGED 121°C													
Ultimate Tensile, psi										1030	1550	700	
% Tensile Change										-9	-9	-47	
% Ultimate Elongation										160	150	100	
% Elongation Change										-43	-46	-83	
Shore Hardness										50	74	78	
Points Hardness Change										-13	+9	+13	
% Volume Weight Change										+30	+4.5	+0.2	
180° Bend										P	P	P	
6 WEEKS AGED 121°C													
Ultimate Tensile, psi										1000	700	450	
% Tensile Change										-12	-59	-66	
% Ultimate Elongation										160	40	30	
% Elongation Change										-43	-86	-95	
Shore Hardness										50	84	88	
Points Hardness Change										-13	+19	+23	
% Volume Weight Change										+30	3.6	-1.2	
180° Bend										P	P	F	

TABLE 24

ASTM 3 OIL AGED AT 135°C (275°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED 135°C													
Ultimate Tensile, psi		970	2040	2160	2030	1920	1900			1350	2075	1400	
% Tensile Change		-23	+30	+58	+42	-13	+31			+19	+22	+6	
% Ultimate Elongation		210	160	180	170	310	180			280	250	420	
% Elongation Change		-16	-43	-30	-37	-49	+31			0	-11	-28	
Shore Hardness		45	73	82	77	72	78			42	70	71	
Points Hardness Change		-21	+4	+2	+2	+4	+3			-21	+5	+6	
% Volume Weight Change		+24	+3.3	+3.6	+2.3	0.7	+2.0			+35	+1.[illegible]	+0.4	
180° Bend		P	P	P	P	P	P				P	P	
3 WEEKS AGED 135°C		830	1510	1870	1680	1450	1580			1280	1175	350	
		-34	-4	+36	+9	-34	+9			-42	-31	-74	
Ultimate Tensile, psi		200	110	110	120	200	150			200	100	70	
% Tensile Change		-20	-61	-58	-56	-67	-42			-29	-64	-88	
% Ultimate Elongation		42	75	87	80	73	76			39	76	86	
% Elongation Change		-24	+6	+7	+5	+5	+1			-24	+11	+21	
Shore Hardness		+26	+5								+4	+0.3	
Points Hardness Change		P	P	P	P	P	P			P	P	F	
% Volume Weight Change													
180° Bend													
6 WEEKS AGED 135°C													
Ultimate Tensile, psi		960	1370	1120	770	1020	850			1160	750	450	
% Tensile Change		-24	-13	-18	-50	-54	-41			+3	-56	-66	
% Ultimate Elongation		180	140	110	100	130	100			170	60	50	
% Elongation Change		-28	-50	-58	-63	-79	-62			-39	-78	-91	
Shore Hardness		48	75	82	76	70	73			41	86	90	
Points Hardness Change		-18	+6	+2	+1	+2	-2			-22	+21	+25	
%Volume Weight Change		+26	+6	+9.7	+7.3	+6.0	+9.1			+48	+4.6	-0.7	
180° Bend		P	P	P	P	P	F			P	F	F	

TABLE 25

ASTM 3 OIL AGED AT 150°C (302°F) TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
70 HRS AGED 150°C													
Ultimate Tensile, psi	1120	930	2060	2350	2100	1890	1880						
% Tensile Change	-17	-26	+31	+70	+36	-14	+30						
% Ultimate Elongation	200	210	130	160	150	280	150						
% Elongation Change	0	-16	-54	-38	-44	-54	-42						
Shore Hardness	56	42	75	84	77	73	77						
Points Hardness Change	-17	-24	+6	+4	+2	+5	+2						
% Volume Weight Change	+14	+28	+4	+5.0	+3.2	1.6	+4						
180° Bend	P	P	P	P	P	P	P						
3 WEEKS AGED 150°C													
Ultimate Tensile, psi	1230	950	1390	1020	1070	920	870						
% Tensile Change	-9	-25	•	-25	-30	-58	-40						
% Ultimate Elongation	180	200	100	100	110	120	110						
% Elongation Change	-10	-20		-61	-59	-80	-58						
Shore Hardness	60	43	73	83	77	70	70						
Points Hardness Change	-13	-23		+3	+2	+2	-5						
% Volume Weight Change	+13	+29		+8									
180° Bend	P	P	P	P	P	P	P						
6 WEEKS AGED 150° C													
Ultimate Tensile, psi	1320	1000	1020	300	140	430	10						
% Tensile Change	-2	-21	-35	-78	-91	-81	-99						
% Ultimate Elongation	150	170	70	80	110	110	20						
% Elongation Change	-25	-32	-73	-79	-59	-82	-93						
Shore Hardness	63	49	81	80	64	65	50						
Points Hardness Change	-10	-17	+12	0	-9	-3	-25						
% Volume Weight Change	+13	+27	+6	+9	+5.1	+7.8	+12						
180° Bend	P	P	P	F	P	P	F						

TABLE 26

AIR TEST TUBE TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1041 HYCAR 1091-50	NEOPRENE W
Hours until 180° Bend Failure @													
225 °F													
250 °F							>1000			>1000	>70	>500	>70
275 °F		>1000		>1000	>1000	>1000	>1000	>1000	>1000	>500			
302 °F	>1000	>1000	>1000	>1000	>500	>1000		>500	>500				
325 °F	>1000	>1000	>500	>70									
350 °F	>1000	>70											
375 °F													
ORIGINAL TENSILE	1350	1260	1570	1370	1540	2210	1450	2440	1800	1130	1700	1325	1520
% Tensile Change After 1000 Hours @ 225 °F													
250 °F						-10				+16	+70	+85	-18
275 °F		-10		+9	+53	-60	-82	-36	+8	+20			
302 °F	-1	-21	-25	-55	-88	-98							
325 °F	-10	+3											
350 °F	-26	+28											
375 °F													
ORIGINAL ELONGATION	200	250	280	260	270	610	260	490	500	280	280	550	410
% Elongation Change After 1000 Hours @ 225 °F						-38				-54	-96	-95	-100
275 °F		-20		-65	-63	-75	-73	-63	-64	-93			
302 °F	-10	-40	-54	-62	-96	-89							
325 °F	-10	-76											
350 °F	-65	-100											
375 °F													
ORIGINAL HARDNESS	73	66	69	80	75	68	75	68	72	63	65	65	65
Hardness Change After 1000 Hours @ 225 °F													
250 °F						+10				+11	+31	+30	+31
275 °F		+7		+12	+11	+7	+5	+3	+8	+26			
302 °F	+2	+15	+16	+13	0	-4		+20	+19				
325 °F	+8	+22	+25										
350 °F	+19	+32											

TABLE 27

AIR TEST TUBE TESTED AT ELEVATED TEMPERATURES

		HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1041	HYCAR 1042 HYCAR 109[illegible]	NEOPRENE W
Hours until 180° Bend Failure @	225°F													
	250°F							>1000			>1000	>70	>500	>70
	275°F		>1000		>1000	>1000	>1000	>1000	>1000	>1000	>500	>70	>70	
	302°F	>1000	>1000	>1000	>500	>500	>500		>500	>500				
	325°F	>1000	>500	>500	>70									
	350°F	>500												
	375°F													
ORIGINAL TENSILE														
% Tensile Change After 1000 Hours @	225°F													
	250°F										+77			-55
	275°F		-17		+8	-64	-42	-90	-16	-2				
	302°F	+5	-27		-64		-92		-77	-89				
	325°F													
	350°F													
	375°F													
ORIGINAL ELONGATION														
% Elongation Change After 1000 Hours @	225°F										-39			-96
	275°F		-17		-60	-65	-63	-77	-24	-20				
	302°F	-16	-7		-79				-95	-95				
	325°F													
	350°F													
	375°F													
ORIGINAL HARDNESS														
Hardness Change After 1000 Hours @	225°F													
	250°F													
	275°F													
	302°F													
	325°F													
	350°F													

TABLE 28

ASTM #3 OIL TESTED AT ROOM TEMPERATURE

	HYCAR 4041	HYCAR 4043	HYDRIN 200 HYCAR 4021	HYDRIN 100	HYDRIN 100 HYDRIN 200	HYDRIN 200 NON BLACK	HYDRIN 200	EPCAR 545 PEROXIDE	EPCAR 545 SULFUR DONOR	HYPALON 40	HYCAR 1042	HYCAR 1042 HYCAR 1051-50	NEOPRENE W
Hours until 180° Bend Failure @													
225 °F										>1000	>1000	>500	
250 °F										>1000	>500	>70	
275 °F		>1000	>1000	>1000	>1000	>1000	>1000						
302 °F	>1000	>1000	>1000	>500	>1000	>1000	>500						
325 °F													
350 °F													
375 °F													
ORIGINAL TENSILE	1350	1260	1570	1370	1540	2210	1450			1130	1700	1325	1520
% Tensile Change After 1000 Hours @ 225 °F										-12	-59	-66	
250 °F										+3	-56	-66	
275 °F		-24	-13	-18	-50	-54	-41						
302 °F	-2	-21	-35	-78	-91	-81	-99						
325 °F													
350 °F													
375 °F													
ORIGINAL ELONGATION	200	250	280	260	270	610	260			280	280	580	410
% Elongation Change After 1000 Hours @ 225 °F										-43	-86	-95	
275 °F		-28	-50	-58	-63	-79	-62			-39	-78	-91	
302 °F	-25	-32	-73	-79	-59	-82	-93						
325 °F													
350 °F													
375 °F													
ORIGINAL HARDNESS	73	66	69	80	75	68	75			63	65	65	65
Hardness Change After 1000 Hours @ 225 °F										-13	+19	+23	
250 °F										-22	+21	+25	
275 °F		-18	+6	+2	+1	+2	-2						
302 °F	-10	-17	+12	0	-9	-3	-25						
325 °F													
350 °F													

TABLE 29

COMPOUNDING INGREDIENTS

NAME	SUPPLIER	FUNCTION
Acrawax C	Glyco Cehmicals	Finishing Agent
Admex 760	Ashland Chemical	Plasticizer.
Age Rite Resin D	Vanderbilt	Antioxidant
Age Rite Stalite	Vanderbilt	Antioxidant
Aranox	Uniroyal	Antioxidant
Butyl Zimate	Vanderbilt	Accelerator
CBTS	B. F. Goodrich	Accelerator
Coldflex 1000	C. P. Hall	Plasticizer
Cumate	Vanderbilt	Accelerator
Dodecyl Mercaptan	Pennwalt	Modifier
DOP	B. F. Goodrich	Plasticizer
Dyphos	National Lead	Heat Stabilizer
Dythal	National Lead	Heat Stabilizer
Epcar 545	B. F. Goodrich	Ethylene Propylene Elastomer
FEF	Phillips	Reinforcer
Flexricin P-4	Baker Castor Oil	Plasticizer
Hi Sil 233	PPG Industries	Reinforcer
HVA-2	DuPont	Activator
Hycar 1041 (1091-50)	B. F. Goodrich	Nitrile Elastomer
Hycar 4021 (4041, 4043)	B. F. Goodrich	Polyacrylate Elastomer
Hydrin 100 (200)	B. F. Goodrich	Epichlorohydrin Elastomers
Hypalon 40	DuPont	Chlorosulfonated Polyethylene
Kenflex A	Kenrich Petrochemicals	Plasticizer
Laminar	H. M. Royal	Filler
Linseed Oil	Woburn Chemical	Activator

TABLE 29

NAME	SUPPLIER	FUNCTION
Litharge	National Lead	Activator
LMW Polyethylene	Merck	Activator *Lubricant*
Magnesium Stearate	Proctor and Gamble	Activator *Lubricant*
MBT	Royal	Accelerator
N-326	Cabot	Reinforcer
N-550	Philblack	Reinforcer
N-770	Cabot	Reinforcer
N-991	R. T. Vanderbilt	Reinforcer
NA-22	DuPont	Accelerator
Naugard 445	Uniroyal	Antioxidant
NBC	DuPont	Antiozonant
Neoprene W	DuPont	Polychloroprene Elastomer
Niclate	Vanierbilt	Antiozonant
Octamine	Uniroyal	Antioxidant
Paraplex G-50	Rohm and Haas	Plasticizer
Potassium Stearate	Proctor and Gamble	Activator
Red Lead	Eagle Picher	Activator
Santowhite Crystals	Monsanto	Antioxidant
Silane A-189	Union Carbide	Coupling Agent
Sodium Stearate	Nopco Chemical	Dispersant
Stalite S	Vanderbilt	Antioxidant
Stearic Acid	National Bureau Standards	Activator
Sulfasan R	Monsanto	Vulcanizing Agency
Sulfur (Spider)	C. P. Hall	Vulcanizing Agent
Sundex 890	Sun Oil	Plasticizer
Sunpar 2280	Sun Oil	Plasticizer
TE-80	Technical Processing	Processing Aid
TETD	Vanderbilt	Accelerator

TABLE 29

NAME	SUPPLIER	FUNCTION
Tetrone A	DuPont	Accelerator
TMTD	Royal	Accelerator
Varox	Vanderbilt	Vulcanizer
Warecure C	Ware Chemical	Accelerator
Witco 127	Witco	Antiozonant
Zeolex 23	J. M. Huber	Reinforcer
Zinc Oxide	New Jersey Zinc	Activator
ZO-9	Harwick Chemical	Accelerator