Load-Deformation Characteristics of Elastomeric Bridge Bearing Pads

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Summary

In 1959, a tentative specification for elastomeric pads as expansion bearings was adopted by AASHO. This specification was based largely on the results of a cooperative program undertaken by the State of Rhode Island Department of Public Works and the engineering firm of Charles A. Maguire and Associates. Their work was based on the load bearing properties of neoprene measured at room temperature. The adequacy of neoprene as a bearing material has been proven by the success of elastomeric bearing pads. Other elastomers are equally suited, however. A cooperative program by the Enjay Laboratories and the University of Rhode Island was undertaken to extend the work to two such materials, butyl rubber and chlorinated butyl rubber (chlorobutyl), and as a further extension of the previous work, to investigate the effects of accelerated aging and load bearing properties at low temperatures.

The results of these evaluations demonstrated that butyl, chlorobutyl, and neoprene bearing pads were equivalent in compressive and shear load deformation properties when evaluated at room temperature. Further, these materials displayed excellent resistance to the effects of accelerated aging. All three bearings displayed the same dynamic and static creep properties.

The one significant difference observed was in low temperature load bearing properties. The butyl and chlorobutyl bearing pads were two to three times more flexible than the neoprene pad and retained their low temperature flexibility advantage even after accelerated aging conditions.

Introduction

In recent years, elastomeric pads have been widely used as bridge bearings because of their low cost, freedom from maintenance, and effectiveness under compressive and shear loads. The pads take very little space compared to steel rollers or rocker arms, distribute the load evenly at all times, and compensate for mechanical and thermal stress in all directions. In Great Britain and in France, elastomeric pads have been used as bearings for railroad bridges. In this country, a number of states, including California, Florida, North Dakota, Rhode Island, and Texas, have used these bearings for highway bridges.

In 1958, the State of Rhode Island Department of Public Works, Division of Roads and Bridges, in cooperation with the engineering firm of Charles A. Maguire and Associates of Providence, Rhode Island, con-

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ducted an evaluation of the load-deformation characteristics of elastomeric bearings. The results of this study were published in a report by the firm[1] and also in a paper by Pare and Keiner.[2] This work served as the basis for a tentative specification for expansion bearings adopted in 1959 by the operating committee on Bridges and Structures of the American Association of State Highway Officals.

Available reported information on elastomeric bearings is confined to the load-deformation properties of neoprene measured at room temperature. In 1959, a cooperative program was undertaken by the Enjay Laboratories of Linden, New Jersey, and the University of Rhode Island to extend this work to other selected elastomers and to investigate the effects of simulated aging and load-deformation at low temperatures. Since elastomeric properties can be markedly affected by temperature, this information should be particularly useful to design engineers in specifying elastomeric bearings for applications where low temperatures persist during winter months. The main problem that might be encountered at low temperatures is excessive slippage caused by an increase in stiffness of the pads. Elastomeric materials characteristically become stiffer as temperature is lowered.

The elastomer used in bearings should possess mechanical stability under compressive and shear loads and should be resistant to atmospheric aging. The adequacy of neoprene in this respect is one of the reasons for its choice as a bearing material. However, other elastomeric materials are equally suited. Two such materials are covered in this study—a copolymer of isobutylene and isoprene called butyl rubber and a chlorinated modification of this basic structure called chlorobutyl. Chlorination improves the heat aging characteristics and low temperature properties of the basic butyl polymer. Both polymers are characterized by low chemical unsaturation and hence are inherently resistant to degradation by aging (combination of heat, oxygen, ozone) and most chemicals. Also, butyl's unique molecular structure is responsible for high hysteresis (mechanical damping), impermeability to gases and liquids, and excellent low temperature flexibility. Therefore, butyl polymers should be admirably suited to serve the primary function of elastomeric bearing pads, particularly in those areas where low temperatures are experienced.

This paper describes the load-deformation studies conducted by the University of Rhode Island and the Enjay Laboratories on bearing pads made from neoprene, butyl, and chlorinated butyl rubber. The studies are similar to those of Maguire and Associates,[1,2] except provisions were made to conduct tests at low temperatures (−45°F).

Materials

The materials selected for testing consisted of 6 x 12 x 1 inch molded pads of butyl, chlorobutyl, and neoprene. The neoprene was a commercially produced bearing pad. Pads of this size, 6 x 12 x 1 inch, have a shape factor of 2, which is well above the minimum of 1.25 specified in the AASHO specification. Shape factor indicates the relative compressive stiffness of a pad and is the ratio of loaded area to the total area free to bulge. The formula for computing shape factor is: $$S = \frac{ab}{2t\,(a+b)}$$

where S = shape factor, a and b = length and width, and t = thickness

When pads having the same compression area and same hardness are subjected to the same load, the pad having the greatest free bulging area, hence lowest shape factor, will have the greatest vertical deformation.

Pads of both hardness levels listed in the AASHO tentative specification were tested (60 ± 5 and 70 ± 5 Shore "A" Hardness). The properties of the pads are compared to the specification in the Appendix. The butyl and neoprene pads were well within the specification limits. The chlorobutyl pad was below the tensile strength specification, but as will be shown, it gave load bearing properties equivalent to the higher tensile strength butyl and neoprene pads. The inadequacy of tensile strength in predicting the general performance of elastomeric materials is well known. In fact, it is discussed in the Maguire report.[1]

Test Equipment

The equipment used at the University of Rhode Island simulated a typical bridge beam pier interface. Compressive loads simulating bridge loads were applied by means of a 300,000 pound Tinius-Olsen Universal Testing Machine. Shear loads simulating expansion and contraction effects were applied by means of a 40,000 pound hydraulic jack.

The apparatus consisted of two concrete blocks cast between two pairs of structural steel angles. Vertical loads were applied through the concrete blocks to the bearing assembly. The steel angles formed a frame which allowed horizontal loads to be applied to the bearing unit without subjecting the test apparatus to external lateral stresses. The pads to be tested, two at a time, were placed between the concrete blocks, and a steel plate was then placed between them. A sketch of the arrangement is shown in Figure 1.

Compressive loads were applied vertically by means of the testing machine and shearing loads were applied horizontally by the hydraulic jack. Two dial indicators, one on each side and calibrated in 0.001 inch graduations, were used to measure vertical deformation. One dial, centrally located, was used to measure horizontal deformation.

Low temperatures were obtained by pumping methylene chloride, cooled by dry ice, through copper tubes to cylinders embedded in the concrete compression blocks. The steel plate placed between the pads was also cooled by the methylene chloride. The temperature was measured by means of thermocouples placed between the pad and the concrete blocks and between the steel plate and one of the pads.

Discussion of Results

The following information was obtained on butyl, chlorobutyl, and neoprene bearing pads of 60 ± 5 and 70 ± 5 Shore "A" Hardness.

1. Compression and shear load-deformation at room temperature (75 ± 5° F) and at low temperature (−45 ± 5° F).
2. Compression and shear load-deformation at the above conditions after accelerated aging at 250°F for 5 days and after additional 5 days aging of the same pads (referred to in the text as 5 + 5 days aging).
3. Simulated fatigue at room tem-

perature by cyclic horizontal deformation under compressive load.
4. Compression set at room temperature and under conditions of outdoor exposure.
5. Water absorption measured by volume increase of the bearing pads at room temperature.

Information was obtained on both 60 and 70 Shore "A" Hardness pads. The data on the 70 hardness pads will be discussed in detail while those obtained on the 60 hardness pad will be summarized only. The data on the 70 Shore "A" Hardness pads are included for reference.

Before discussing the results of investigation, a comparison with the earlier data reported by Maguire and Associates seems worthwhile. Compressive load-deformation data in this study on the neoprene pad are shown in Figure 2 in comparison to similar data reported by Maguire and Associates.[1] The agreement between these two sets of data is excellent, indicating good reproducibility of the test in spite of the normal variations expected in rubber compounding. A similar comparison of shear loading data is shown in Figure 3. Again, the agreement between the two sets of data is quite good. It should be noted that in this study the maximum horizontal and vertical loads were maintained for 5 minutes resulting in an increase in horizontal deformation. However, in the Maguire work, on these particular tests, the load was released immediately after the maximum values were obtained. Hence no increase in horizontal deformation was reported.

The excellent agreement between these two sets of data is gratifying and lends considerable substance to the comparison of the elastomeric materials.

Room Temperature Evaluations

The compressive load-deformation characteristics of the butyl and neoprene bearing pads were found to be identical as shown in Figure 4. It will be noted that the chlorobutyl pad showed greater deflection under the same load conditions. However, this pad was 7 Shore "A" points softer than the butyl or neoprene pad (Appendix) hence would be expected to give slightly greater deflection. The pad could also be made stiffer by an increase in shape factor as discussed by Maguire and Associates[1] and Cardillo and Kruse.[3] After the load was removed, the pads for all practical purposes showed equal recovery.

Careful inspection of Figure 4 shows that during the time the vertical load was held constant both butyl bearings demonstrated a slightly larger increase in deformation than the neoprene bearing. This phenomenon of increased deflection with time is termed creep. While the difference between the butyl and the neoprene pads is small, it was observed consistently throughout this work during the 5 minute constant load conditions. However, it will be shown subsequently that the long term creep properties of butyl and chlorobutyl are not substantially different from neoprene.

The shear load-deformation (combined horizontal and vertical load) characteristics of the butyl, chlorobutyl, and neoprene bearings are shown in Figures 5, 6, nad 7 respectively. For each polymer the data are plotted for vertical loads up to 1,200 psi. As was the case with compressive load, the butyl and neoprene pads are nearly identical in load deflection while the softer chlorobutyl bearing showed greater deflection. The no-load recovery and creep properties of the polymers were similar in shear as in compression.

Low Temperature Evaluation (—45°F)

Elastomeric materials will all tend to stiffen as the temperature is decreased. Stiffening can be controlled to some extent by the choice of compounding ingredients, for example, plasticizer and filler type. However, the inherent temperature sensitivity of the polymer itself is by far the most important variable. The differences among the three pads in compressive deformation are shown in Figure 8. At the same hardness level the butyl bearing was over twice as flexible as the neoprene bearing as measured by per cent deformation at 800 psi vertical load. The softer chlorobutyl pad, as would be expected, was approximately 1½ times more flexible than the neoprene bearings. The no-load recovery was a further demonstration of the good low temperature flexibility of the two butyl materials. The rate of recovery was almost identical to that at room temperature.

Under shear loading conditions (combined horizontal and vertical load) the difference between the two butyls and the neoprene pads was even greater. The shear deformation properties of the three bearings are shown in Figures 9, 10, and 11. The rate of no-load recovery again was an indication of the good low temperature flexibility of the two butyl pads.

A temperature of —40 to —45° is commonly used when testing elastomeric materials. In fact, the AASHO tentative specification for bearing pads requires a Young's modulus determination at —40°F. Although the load deformation studies were conducted only at —45° F, similar results would be expected over a range of temperatures as indicated by the hardness data shown in the following table.

POINT INCREASE IN SHORE "A" HARDNESS COMPARED TO R. T.*

BASE ELASTOMER	0°F	—10°F	—20°F	—40°F
BUTYL	6	6	6	10
CHLOROBUTYL	4	4	5	8
NEOPRENE	11	11	15	19

*70 SHORE "A" HARDNESS PADS STORED 48 HOURS AT TEMPERATURE INDICATED.

It must be recognized that hardness is only a rough measure of stiffness. However, it is well known that hardness correlates with compressive modulus.[3] Hence, the differences shown are a reasonable indication of the relative load deformation properties of the bearings at the various temperatures indicated. It is clear that over the entire temperature range shown neoprene was substantially stiffer than the two butyl bearings.

Accelerated Aging Evaluations

When subjected to the effects of atmospheric aging, elastomeric materials will slowly undergo changes in physical properties. Neoprene characteristically becomes hard and brittle, while butyl tends to become more flexible. However, when properly compounded, both polymers are exceptionally resistant to atmospheric degradation. In fact, retention of physical properties after 15 to 20 years of atmospheric exposure can be demonstrated for both polymers in certain types of applications. These properties were substantiated in this study by subjecting the bearing pads after testing at room temperature and —45° F to accelerated aging under severe conditions of 5 days at 250° F, retesting, and again aging for 5 days at 250°F (5 + 5 days aging). These conditions would be comparable to many years of normal temperature exposure.

The compressive deflection data of Figures 4, 12, and 13 show that characteristic effect of aging on the butyl, chlorobutyl, and neoprene bearings. While there was a slight increase in compressive deflection at room temperature with the butyl pads and a slight stiffening with the neoprene pad, all three materials displayed excellent stability under the severe conditions chosen.

Similar effects were noted when the aged pads were subjected to shear loading at room temperature. This can be seen from Figures 5-7 and 14-19.

Accelerated aging did not greatly affect the low temperature compressive load bearing properties of the three bearings. This is demonstrated by data from Figures 8, 20, and 21.

Shear loading studies at –45° F after aging also showed the butyl pads to retain their good low temperature flexibility. Interestingly enough, it was not possible to obtain accurate horizontal deformation on the neoprene pad until a vertical load of 1,200 psi was achieved. At the lower vertical loads the pad consistently slipped, hence the data recorded are not a true measure of horizontal deflection. It might be inferred from these observations that slippage could be a problem if the bearing pads become too stiff. The low temperature shear loading data are summarized in the following table from data taken from Figure 9-11 and 22-27.

SHEAR LOAD-DEFORMATION AT –45°F

		HORIZONTAL DEFLECTION, INCHES		
BASE ELASTOMER	VERT. LOAD, PSI	ORIG.	AGED 5 DAYS AT 250°F	AGED 5 + 5 DAYS AT 250°F
BUTYL	600	0.17	0.17	0.23
	800	0.28	0.29	0.27
CHLOROBUTYL	600	0.21	0.35	0.26
	800	0.28	0.38	0.29
NEOPRENE	600	0.008	0.035*	0.016*
	800	0.012	0.040*	0.038*

*PAD SLIPPED

One point worth noting is the effect that the test condition used for aging has on the properties of butyl and neoprene compounds. The compressive and shear load data on pads aged at 250°F showed a tendency toward stiffening of neoprene and softening of butyl. This is consistent with the known properties of these polymers on aging. However, at less severe conditions, for example 70 hours at 212°F as required in the AASHO specification, butyl polymer will show no change or a slight stiffening (Appendix). As the test time is prolonged or the temperature raised, most butyl compounds will show the characteristic softening. Actually, the exact opposite will occur with neoprene, initial softening followed by stiffening, if the appropriate test conditions are chosen.[4] The main point, however, is that both polymer types are extremely resistant to aging.

Fatigue Tests

In their report on elastomeric bearing pads, Maguire and Associates[1] point out that under actual service conditions bearing pads are subjected to dynamic loading and the resulting deflections result in dynamic creep. To determine whether the three elastomeric bearing pads would show any gross differences in dynamic creep, tests similar to those conducted by Maguire and Associates were performed, namely, alternating horizontal loadings over a three hour period.

While the butyl and chlorobutyl bearings were slightly more flexible than neoprene, showing greater horizontal deflection, the change in deflection during the test period was virtually the same for all three pads.

Comparison of the data obtained on the neoprene pad with those reported by Maguire on similar pads showed approximately the same horizontal deflection.

Creep, as measured by the change in vertical deformation with time, is shown in Figures 28, 29, and 30 for the three polymers. While the butyl pads showed slightly greater initial vertical deformation as compared to neoprene, the increase in deformation, creep, was essentially the same for all three bearings.

As pointed out by Maguire and Associates in their report, a true measure of dynamic creep would require much longer term testing.

Compression Set

Compression set as defined in ASTM D-395, run at constant deflection and at constant load, is a measure of the resistance of an elastomeric material to long term deformation under load. While by no means an absolute measure, materials that show high set when run at constant deflection would very likely be poor in load bearing applications. Again, although not absolute, materials that show the same compression set at constant deflection might be expected to give reasonably equivalent long term compressive and shear load bearing properties. When run under constant load conditions, compression set gives a rough measure of creep. High compression set at constant load would be indicative of poor creep properties. Also, similar constant load set properties of different materials would be an indication of similar creep properties.

Compression set at constant deflection was run on samples of the three polymers. The evaluation was carried out over a 14 month period with the samples exposed to ambient conditions beginning January 9, 1961, in New Jersey. The data summarized in the following table shows the three polymers are equivalent in set at constant deflection.

COMPRESSION SET AT CONSTANT DEFLECTION

BASE ELASTOMER	% SET AT MONTHS INDICATED				
	4	6	8	10	14
BUTYL	14.2	21.0	25.4	26.6	26.6
CHLOROBUTYL	15.1	21.1	26.4	28.1	28.4
NEOPRENE	14.3	19.1	25.8	26.3	26.6

As mentioned previously, compression set at constant load is a rough indication of the creep properties of an elastomeric material. Tests run for 6 months at room temperature, showed that a butyl, chlorobutyl, and neoprene pad are identical in this respect. These data are summarized in the following table.

COMPRESSION SET AT CONSTANT LOAD

BASE ELASTOMER	% SET AT DAYS INDICATED		
	14	60	180
BUTYL	5.2	7.0	8.2
CHLOROBUTYL	5.4	7.1	8.3
NEOPRENE	5.1	7.5	8.9

Water Absorption

Bridge-bearing pads will be subjected to water contact from rain and water run-off from the deck span. Depending upon the location of the pad and the construction of the bridge, they may be in contact with water for reasonably long periods of time. The water absorption properties of the butyl, chlorobutyl, and neoprene bearing pads were evaluated by immersing the materials in water at room temperature for one year. The results in Figure 31 show that all three polymers are excellent with respect to water absorption. The butyl shows virtually no increase in volume, the chlorobutyl only 1½%, and the neoprene pad approximately 4½%.

The most important aspect of water absorption, and not evaluated in this study, is the effect it might have on the load bearing properties of the polymers. This might be particularly important at subfreezing temperatures. Generally speaking, however, at normal temperatures the properties of elastomeric materials are little affected by water.

Evaluation of 60 ± 5 Shore "A" Hardness Bearing Pads

A similiar series of evaluations were made with neoprene, butyl, and chlorobutyl bearings in the 60 ± 5 hardness range. Data from room temperature tests follow the same trends as those noted with 70 hard pads, i.e., all three bearing pads are about equivalent in compressive and shear load bearing properties both before and after accelerated aging. Although the differences are slight, the characteristic increase in flexibility with butyl and chlorobutyl and stiffening with neoprene was observed on aging.

Overall, the low temperature data on pads at the two hardness levels agree fairly well. This was particularly true with chlorobutyl. The data on the pads aged 5 days were all somewhat inconsistent with the 70 Shore "A" data and with the 5 + 5 day aged 60 Shore "A" pads. No logical explanation is apparent unless temperature control was poor or bearing slippage occured.

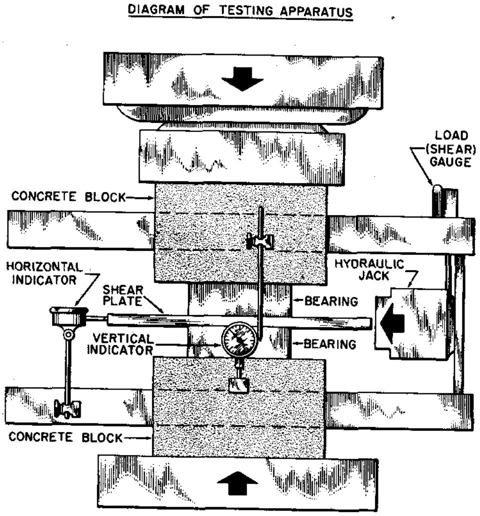
References

1. "Elastomeric Bridge Bearing Pads—Report of Tests and Design Procedures." Charles A. Maguire and Associates. (1959)

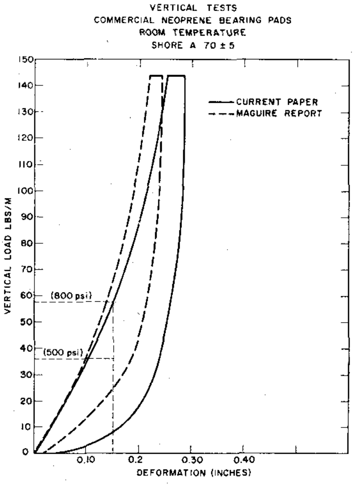
2. Highway Research Board Bulletin #242—Elastomeric Bridge Bearings. R. L. Pare and E. P. Keiner.

3. Load Bearing Characteristics of Butyl Rubber. R. M. Cardillo and D. F. Kruse, Paper (61-WA-335) presented to ASME (1961).

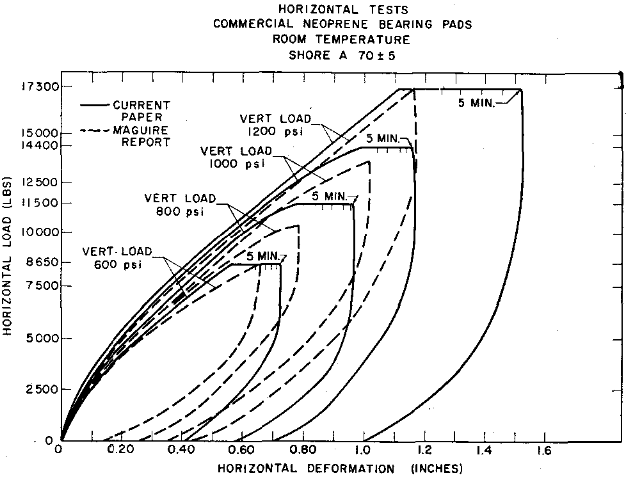
4. Rubber Techology, M. Morton, Reinhold Publishing Corporation (1959).



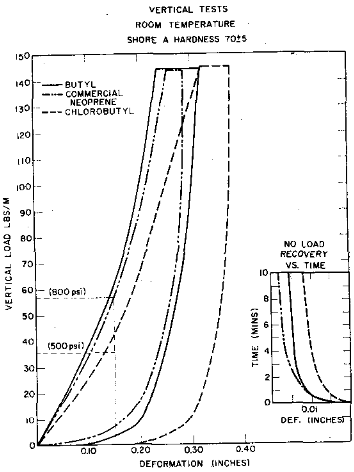
1. Diagram of testing apparatus



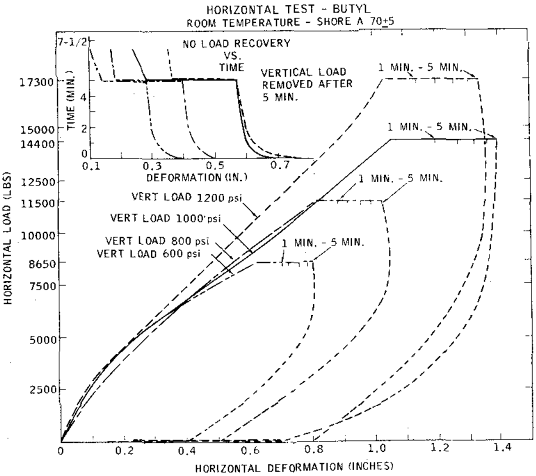
**2. Vertical Tests
Commercial Neoprene Bearing Pads
Room Temperature
Shore A 70 ± 5**



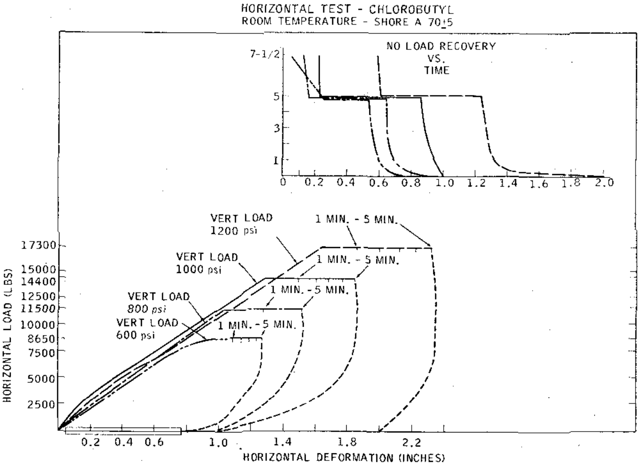
**3. Horizontal Tests
Commercial Neoprene Bearing Pads
Room Temperature
Shore A 70 ± 5**



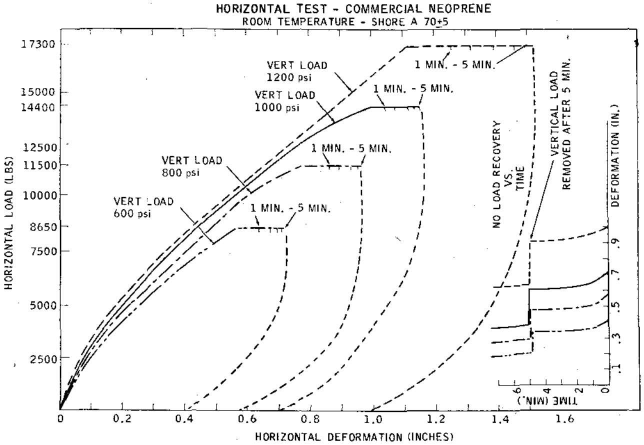
4. Vertical Tests
Room Temperature
Shore A 70 ± 5



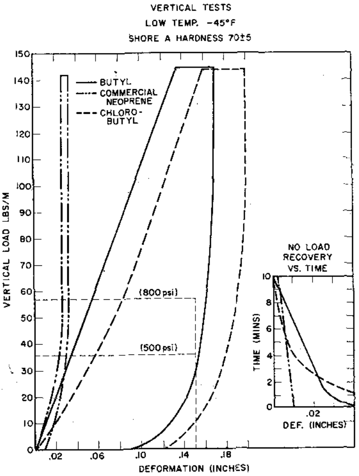
5. Horizontal Test—Butyl
Room Temperature—Shore A 70 ± 5



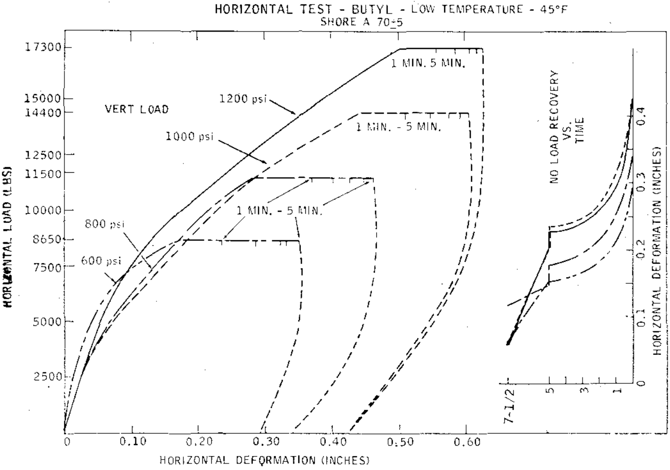
6. Horizontal Test—Chlorobutyl
Room Temperature—Shore A 70 ± 5



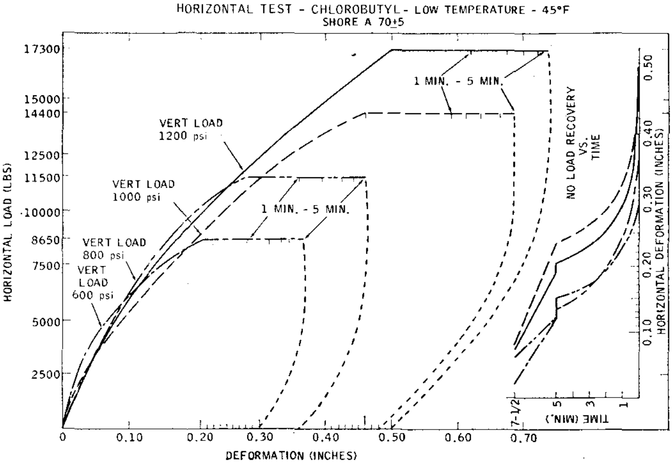
7. Horizontal Test—Commercial Neoprene Room Temperature—Shore A 70 ± 5



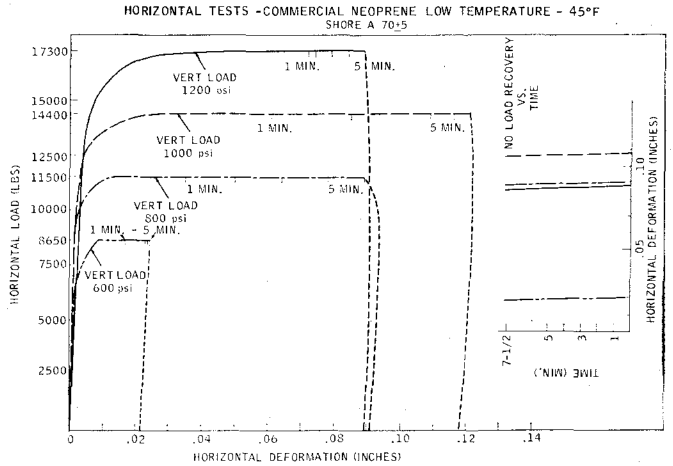
8. Vertical Tests Low Temp.—45°F Shore A Hardness 70 ± 5



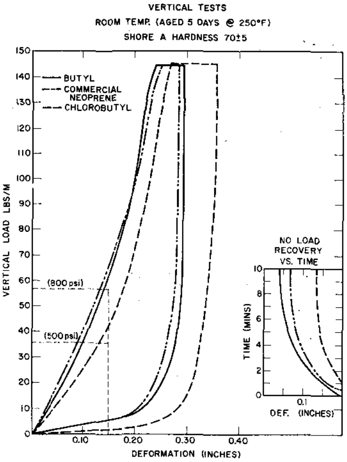
9. Horizontal Tests—Butyl—Low Temperature—45°F Shore A 70 ± 5



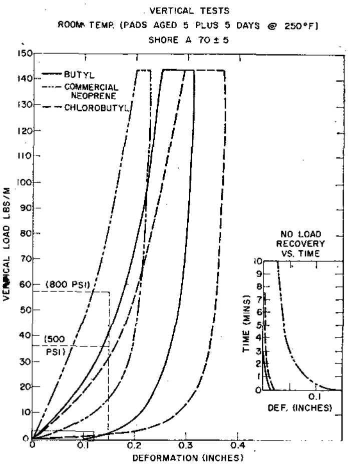
10. Horizontal Test — Chlorobutyl — Low Temperature—45°F Shore A 70 ± 5



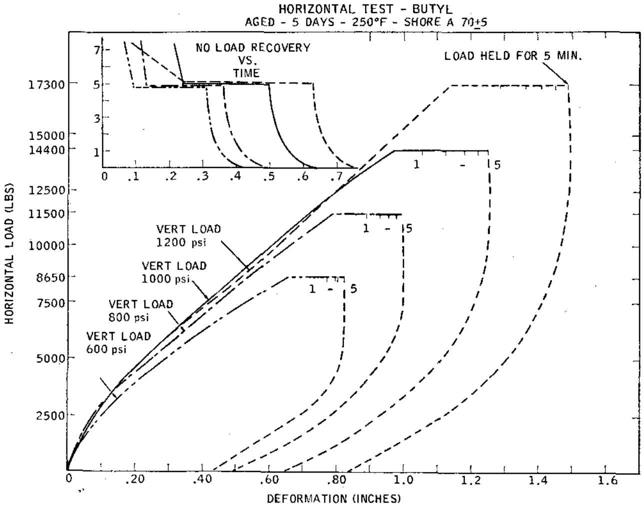
11. Horizontal Tests — Commercial Neoprene—Low Temperature—45°F Shore A 70 ± 5



12. Vertical Tests Room Temp. (Aged 5 Days @ 250°F) Shore A Hardness 70 ± 5

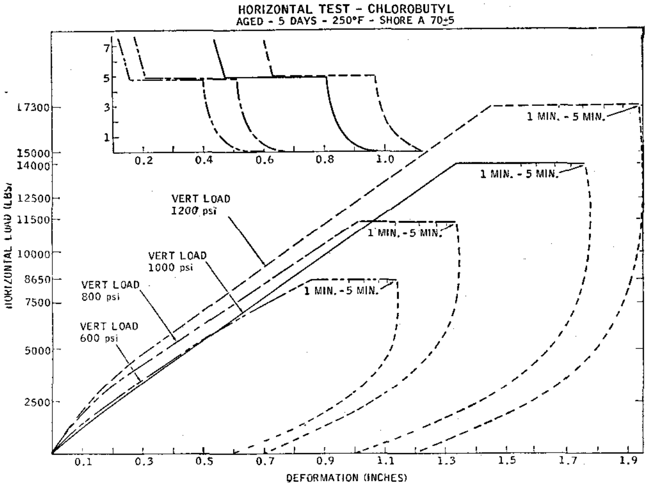


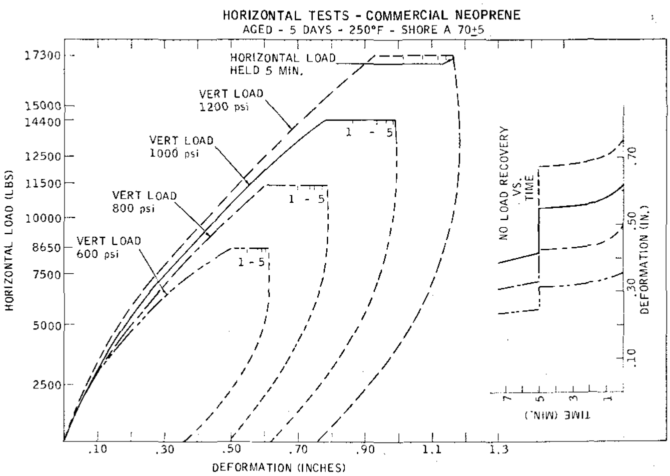
13. Vertical Tests
Room Temp. (Pads Aged 5 Plus 5 Days @ 250°F)
Shore A 70 ± 5



14. Horizontal Test—Butyl
Aged—5 Days—250°F—Shore A 70 ± 5

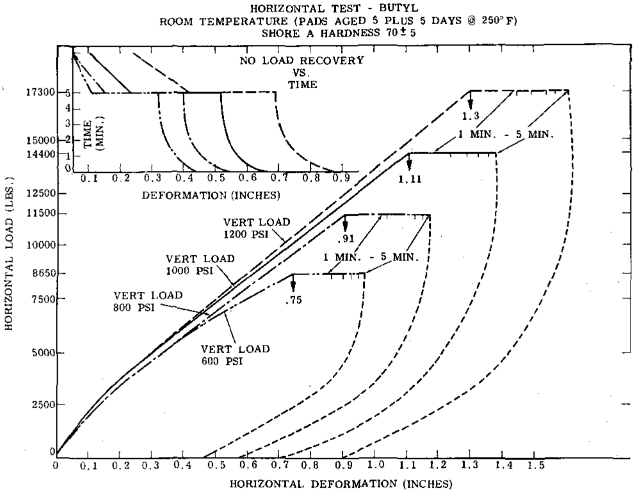
15. Horizontal Test—Chlorobutyl
Aged—5 Days—250°F—Shore A 70 ± 5



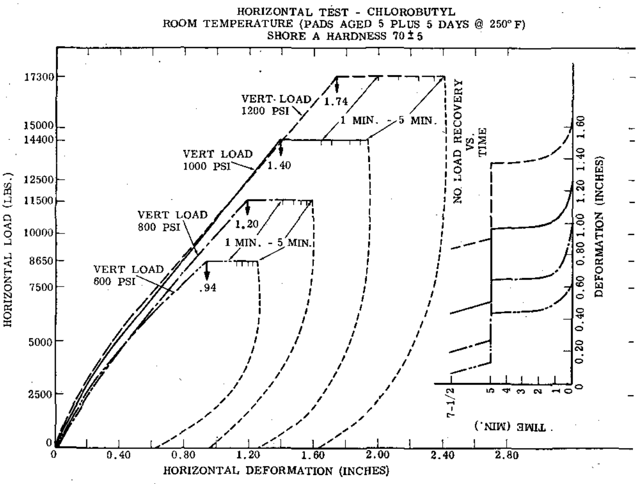


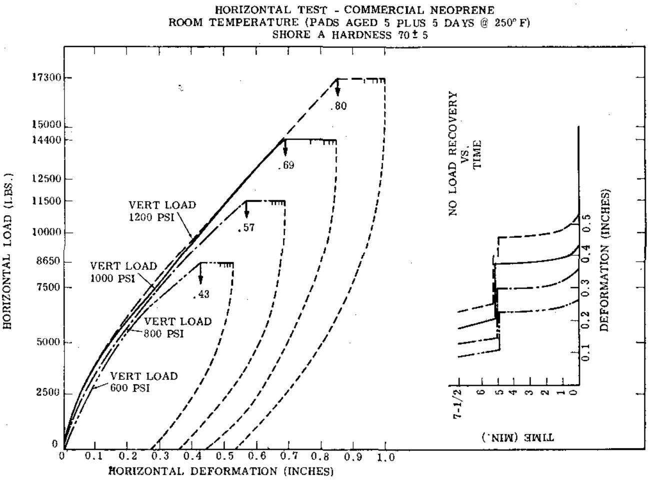
16. Horizontal Tests—Commercial Neoprene Aged—5 Days—250°F—Shore A 70 ± 5

17. Horizontal Test—Butyl Room Temperature (Pads Aged 5 Plus 5 Days @ 250°F) Shore A Hardness 70 ± 5

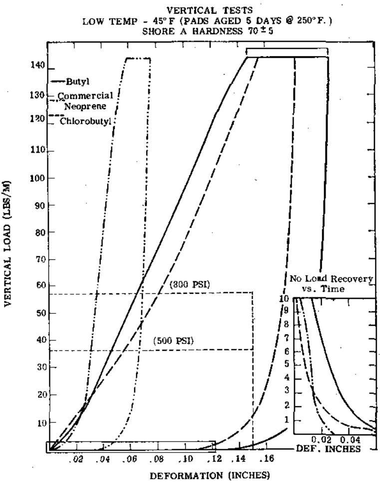


18. Horizontal Test—Chlorobutyl Room Temperature (Pads Aged 5 Plus 5 Days @ 250°F) Shore A Hardness 70 ± 5



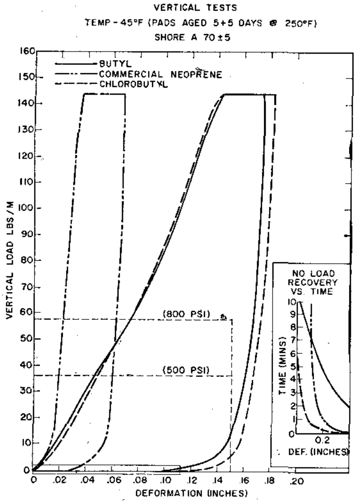


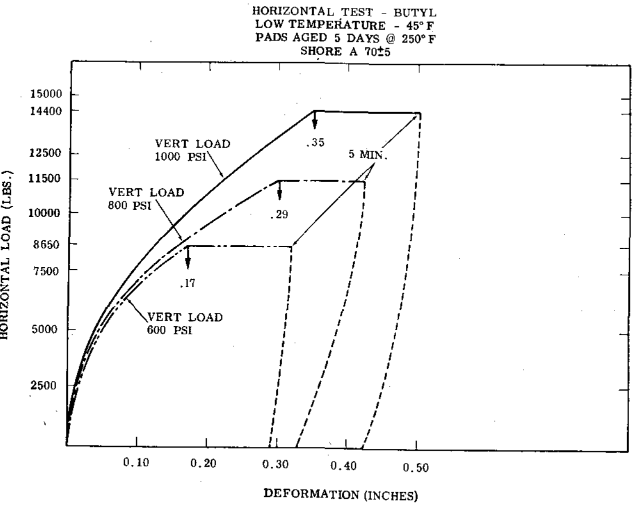
19. Horizontal Test—Commercial Neoprene Room Temperature (Pads Aged 5 Plus 5 Days @ 250°F) Shore A Hardness 70 ± 5



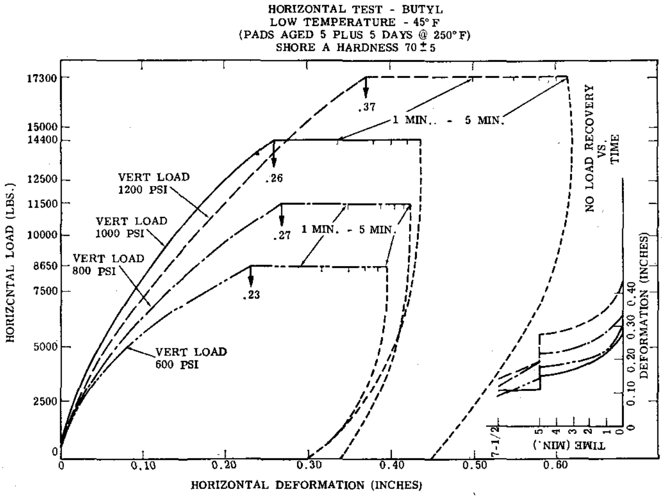
20. Vertical Tests Low Temperature —45°F (Pads Aged 5 Days @ 250°F) Shore A Hardness 70 ± 5

21. Vertical Tests Temp.—45°F (Pads Aged 5 Days @ 250°F) Shore A 70 ± 5

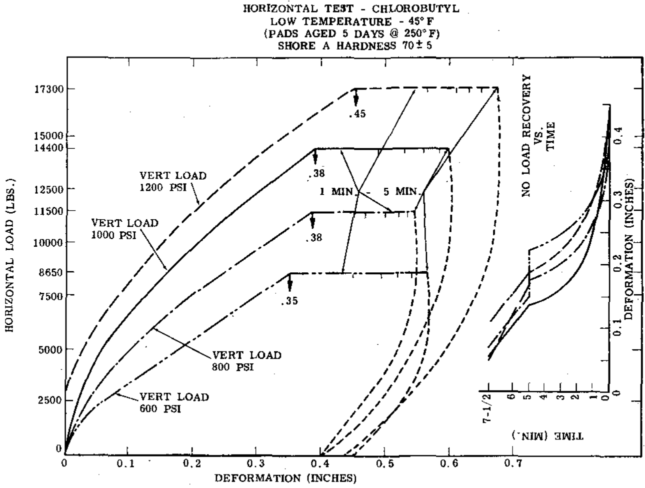




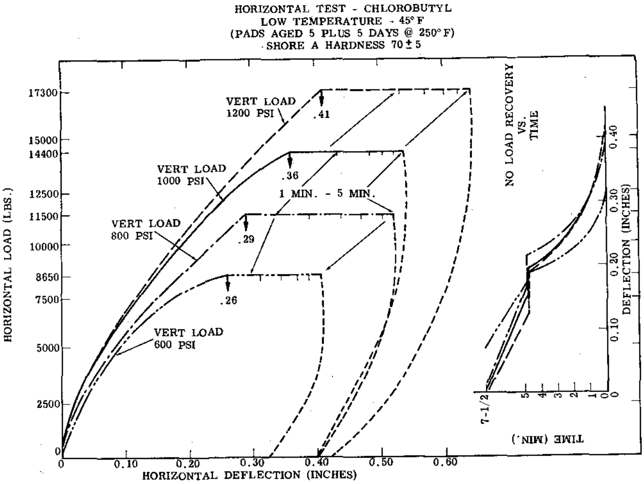
22. Horizontal Test—Butyl Low Temperature—45°F Pads Aged 5 Days @ 250°F Shore A 70 ± 5



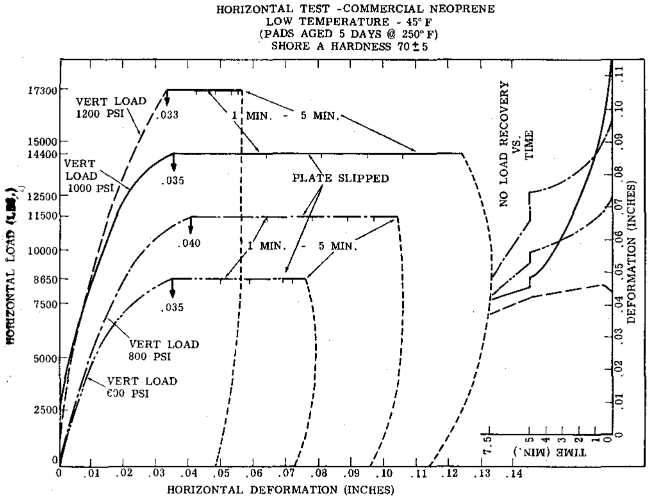
23. Horizontal Test—Butyl
Low Temperature—45°F
(Pads Aged 5 Plus 5 Days @ 250°F)
Shore A Hardness 70 ± 5



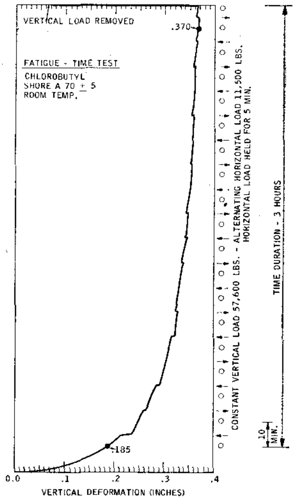
24. Horizontal Test—Chlorobutyl
Low Temperature—45°F
(Pads Aged 5 Days @ 250°F)
Shore A Hardness 70 ± 5



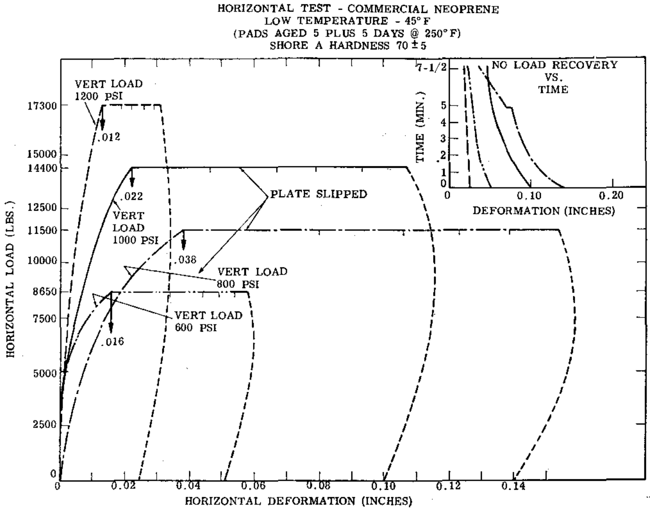
25. Horizontal Test—Chlorobutyl
Low Temperature—45°F
(Pads Aged 5 Plus 5 Days @ 250°F)
Shore A Hardness 70 ± 5



26. Horizontal Test—Commercial Neoprene
Low Temperature—45°F
(Pads Aged 5 Days @ 250°F)
Shore A Hardness 70 ± 5

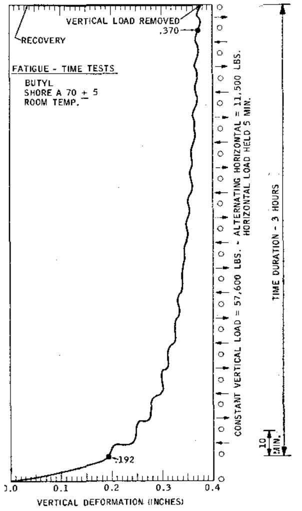


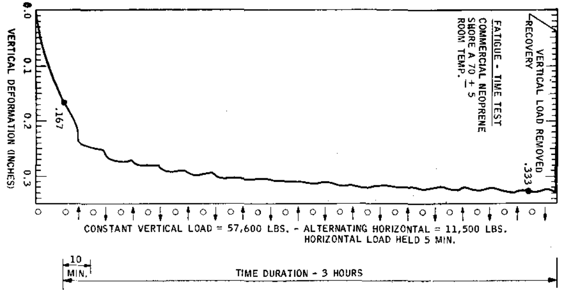
28. Fatigue—Time Test
Butyl
Shore A 70 ± 5
Room Temp.



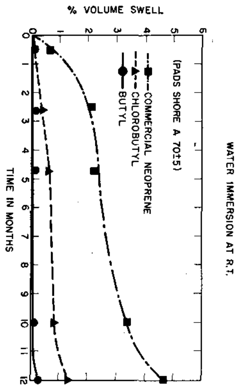
27. Horizontal Test—Commercial Neoprene
Low Temperature—45°F
(Pads Aged 5 Plus 5 Days @ 250°F)
Shore A Hardness 70 ± 5

29. Fatigue—Time Test
Chlorobutyl
Shore A 70 ± 5
Room Temp.





30. Fatigue—Time Test Commercial Neoprene Shore A 70 ± 5 Room Temp.



31. Water Immersion At R.T.

APPENDIX

ELASTOMERIC BEARING PADS

	60 Durometer				70 Durometer			
	AASHO Spec	Commercial Neoprene[1]	Butyl	Chlorobutyl	AASHO Spec	Commercial Neoprene[1]	Butyl	Chlorobutyl
Original Physical Properties								
Tensile Strength, psi	2500 min	2650	2710	2330	2500 min	2900	2650	2200
Elongation, %	350 min	575	680	530	300 min	340	480	430
Hardness, Shore "A"	60 ± 5	60	64	61	70 ± 5	75	75	68
Oven Aged 70 Hours at 212°F								
Tensile Change, %	±15 max	—10	—8	—14	±15 max	+5	—8	—9
Elongation Change, %	—40 max	—27	—23	—15	—40 max	—25	—27	—9
Hardness Change, Pts	0 to + 15	+7	+1	+6	0 to + 15	+5	+6	+4
Ozone Resistance, After 100 Hours at 1 ppm 100°F, 20% Strain	No Cracks	No Cracks	No Cracks	No Cracks	No Cracks	No Cracks	No Cracks	No Cracks
Tear Strength ASTM D-624, Die "C" Pounds Per Linear Inch	250 min	270	290	275	225 min	270	305	275
Low Temperature Stiffness, Young's Modulus, psi At —40°C (40°F)	10,000 max	8500	5000	7800	10,000 max	7600	9200	5400
Compression Set, Method B, % 22 Hours at 158°F	25 max	18	21	19	25 max	12	22	19

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[1] Information obtained from Supplier