ADIPRENE® L 100

TDI-terminated liquid urethane prepolymer

PRODUCT DATA

Urethane Prepolymers

ADIPRENE® L 100 urethane elastomer is one of a series of liquid urethane polymers which can be cured to a strong, rubbery solid by reaction of the isocyanate groups with polyamine compounds. When cured with MBCA[1] curing agent, ADIPRENE L 100 yields vulcanizates in the 88 to 92 Shore A hardness range. Lower hardness values and special properties can be obtained with other curing systems. Cured ADIPRENE L 100 has high tensile strength and resilience, as well as excellent resistance to abrasion, compression set, oils, solvents, oxidation, ozone, and low temperatures.

ADIPRENE L 100 can be cast, sprayed, or spread to produce a great variety of molded goods as well as protective and decorative coatings. It can be cured over a wide range of temperatures. Curing time varies from five minutes to twenty-four hours, depending upon the curing agent and temperature.

ADIPRENE L 100 is a fully saturated polymer with properties as shown in Table I and typical vulcanizate properties as shown in Table II on the following page.

[1] MBCA is an abbreviation for 4,4-methylene-bis (2-chloroaniline)

Chemtura

ADIPRENE® L 100
TYPICAL POLYMER SPECIFICATIONS

Table I
Typical Specifications of ADIPRENE L 100 Polymer

Available Isocyanate Content, % NCO	3.95-4.30
Brookfield Viscosity	
@ 30°C	150 - 225
@ 100°C	4 - 6
Color, Gardner	0 - 3
Appearance @ 25°C	Clear viscous liquid free from contamination
Color	Honey colored
Odor	Slight isocyanate
Specific Gravity at 25°C/4°C	1.06
Flash Point, °F (°C)	480 (249)
Storage Stability	Excellent in the absence of moisture.
Viscosity, Brookfield, cps (Pa·s)	
@ 86°F (30°C)	18000 ± 3000 (18 ± 3)
@ 212°F (100°C)	500 - 600 (0.5 to 0.6)
Solubility	Soluble in aromatic hydrocarbons, ketones, esters and chlorinated hydrocarbons.

Note: These data are presented to describe ADIPRENE L 100, and are not intended to serve as specifications.

Table II
Typical Vulcanizate Properties

ADIPRENE L 100	100 pts
MBCA	12.4 pts

Mixing and Curing

Mix temperature °F (°C)[b]	212 (100)
Cure: hours/°F (°C)	1/212 (100)
Postcure: hours/°F (°C)	16 at 158 (70)

Note: Test specimens were conditioned one week at 75°F (24°C), 50% RH before testing.

Pot life at mix temperature, minutes	10
Typical demolding time for a 2 to 10 lb. (0.9 to 4.54 kg) casting at 212°F (100°C), minutes	30 - 45

Physical Properties

Hardness, durometer A	90
100% Modulus, psi (MPa)	1100 (7.6)
300% Modulus, psi (MPa)	2100 (14.5)
Tensile strength, psi (MPa)	4500 (31.0)
Elongation at break, %	450
Tear strength, ASTM D-470, lb/in (kN/m)	75 (13.1)
Tear strength (Die C) lb/in (kN/m)	400 (70)
Compression set (Method B) (22 hours at 158°F (70°C), %	27
Resilience, Rebound, %	45
Abrasion resistance, NBS Index	175
Brittleness temperature (Solenoid), °F (°C)	< -94 (< -70)

Table II

Typical Vulcanizate Properties (cont'd)

Torsional Stiffness, psi (MPa)	
Clash-Berg Method,	
@ 75°F (24°C)	2600 (17.9)
@- 0°F (-18°C)	3250 (22.4)
@-40°F (-40°C)	10600 (73.1)
@-70°F (-57°C)	30400 (209.6)
Thermal conductivity, BTU/(hr) (sq. ft) (°F/in)	0.917
(W/m-K)	(0.132)
Linear coefficient of thermal expansion, in/in/°F (°C¹)	
-32°F to 32°F (-36°C to 0°C)	1.43×10^{-4}
32°F to 75°F (0°C to 24°C)	1.01×10^{-4}
75°F to 212°F (24°C to 100°C)	0.95×10^{-4}
212°F to 302°F (100°C to 150°C)	0.90×10^{-4}
Specific gravity at 75°F (24°C)	1.10
Linear shrinkage, %	1.2

a The desired amount of MBCA can be determined by using the formula:

$$\text{parts MBCA per 100 parts polymer} = \frac{\%\ \text{NCO x 3.18 x \% theory}}{100}$$

Example: polymer NCO = 4.10%

desired % theory = 95%

$$\frac{(4.10)\,(3.18)\,(95)}{100} = 12.4 \text{ parts MBCA per 100 parts Adiprene L 100}$$

b MBCA at 250°F (121°C)

c Statistical range of values based on 90% confidence limits

ADIPRENE® L 100
HANDLING PRECAUTIONS

ADIPRENE POLYMER

ADIPRENE L 100 urethane rubber, in its uncured liquid form, contains a small quantity of free toluene diisocyanate (TDI), which is known to cause severe irritation to the eyes, skin and mucous membranes. Avoid contact with eyes, skin and clothing, and wash thoroughly after handling. Avoid breathing vapor. Use only with adequate ventilation. For additional information on potential hazards and handling precautions for ADIPRENE L 100, see bulletin AP-1101.1, "Toxicity and Safe Handling of ADIPRENE."

Curatives and Other Ingredients

4,4'-Methylene-bis [2-chloroaniline] (referred to in this bulletin as MBCA) may cause cancer, based on tests with laboratory animals. It may also cause cyanosis (reduction in the oxygen carrying capacity of the blood). For additional information on handling precautions and possible health hazards, contact the supplier and consult product labels.

Various volatile organic liquids are mentioned in this bulletin as solvents for ADIPRENE L 100 and as cleaning or degreasing agents. These materials present varying degrees of hazard in handling; employee exposure to the vapors may be regulated. Before using any solvent with ADIPRENE L 100, contact the supplier and read product labels for handling precaution information, and consult appropriate regulatory agencies for allowable exposure limits. Use only with adequate ventilation.

Combinations of trimethylol propane (TMP) and certain phosphorous compounds can form a toxic gas if burned. These materials are not normally combined in products of ADIPRENE, and no such combinations are mentioned in this bulletin. However, TMP can be used as a polyol curative for ADIPRENE L 100, and phosphorous is present in some plasticizers, anti-degradants and flame retardant additives that might be used with ADIPRENE. If such combinations are used, the resulting products should not be burned.

Before proceeding with any compounding or processing work, consult and follow label directions and handling precautions from suppliers of all ingredients.

ADIPRENE® L 100
CURING SYSTEMS

DIAMINE CURING SYSTEMS

Aromatic diamines are the most widely used materials for curing ADIPRENE L 100. They react with the terminal isocyanate groups in the polymer to form linear, high molecular weight polyurea urethanes.

In diamine vulcanization, the substituted urea groups formed in the chain create strong intermolecular forces which function as physical "crosslinks." The forces, which provide internal reinforcement, are believed to be due principally to hydrogen bonding between molecular chains. The bonds are responsible for the development of the characteristic strength of diamine-cured ADIPRENE L 100.

Curing With MBCA

MBCA curing agent, 4,4'-methylene-bis-[2-chloroaniline], is the most widely used curing agent for ADIPRENE L 100. It provides an excellent balance of pot life, cure rate, vulcanizate properties, and overall handling ease.

MBCA is a solid at room temperature, with a melting range of 212-228°F (100-109°C). In the processing of ADIPRENE L 100, MBCA is usually handled as a liquid at 250°F (121°C).

The pot life or fluid casting time of compounds of ADIPRENE L 100 and MBCA is about 10 minutes, depending upon the mixing temperature. The amount of MBCA used has very little effect upon the pot life of the compound.

Concentration of MBCA - a 95% stoichiometric level of MBCA for nominal NCO content is suggested for general purpose use because it produces vulcanizates with the best balance of physical properties. This concentration of MBCA is about 95-97% of the theoretical stoichiometric amount required for ADIPRENE L 100. However, particular properties can be maximized for specific applications by varying the concentration of MBCA. The MBCA level should be calculated using the formula in *Table II* for the specific NCO content of each lot of ADIPRENE L 100.

The amount of MBCA used controls the extent of crosslinking or chain branching developed in the final vulcanizate. If less than the required theoretical amount of MBCA is used, the excess isocyanate in the system reacts with a substituted urea group to form a biuret structure, which is a chain branch point since it is trifunctional. As the concentration of biuret groups is increased, the chain-to-chain hydrogen bonding decreases. The biuret crosslinks cause increases in modulus and resistance to compression set and decreases in resistance to abrasion and tearing. As the level of MBCA is increased to or slightly beyond the theoretical amount, the end product is more linear in structure, with a high level of hydrogen bonding, and has maximum resistance to physical abuse.

The effects of varying the concentration of MBCA on the physical properties of the vulcanizates are shown in *Figure 1* (shown on the next page).

The trends shown in *Figure 1*, may be summarized as follows:

Vulcanizate Hardness is unaffected by the concentration of MBCA over the range of 90 to 110 percent of theory. The vulcanizates prepared for this study had a hardness of 90 ± 2, durometer A.

Highest Tensile Strength is obtained with 90 - 95 percent of theory MBCA. Increasing the concentration of MBCA decreases tensile strength and increases ultimate elongation.

Good Compression Set is also obtained with 90 - 95 percent of theory MBCA. Compression set increases markedly at higher concentrations of MBCA.

Good Abrasion Resistance is obtained over the range of 90 - 105 percent of theory MBCA. However, increasing the concentration to 110 percent of theory causes a significant decrease in abrasion resistance.

Best Tear Resistance is obtained with 100 - 110 percent of theory MBCA. Tear strength decreases at lower concentration.

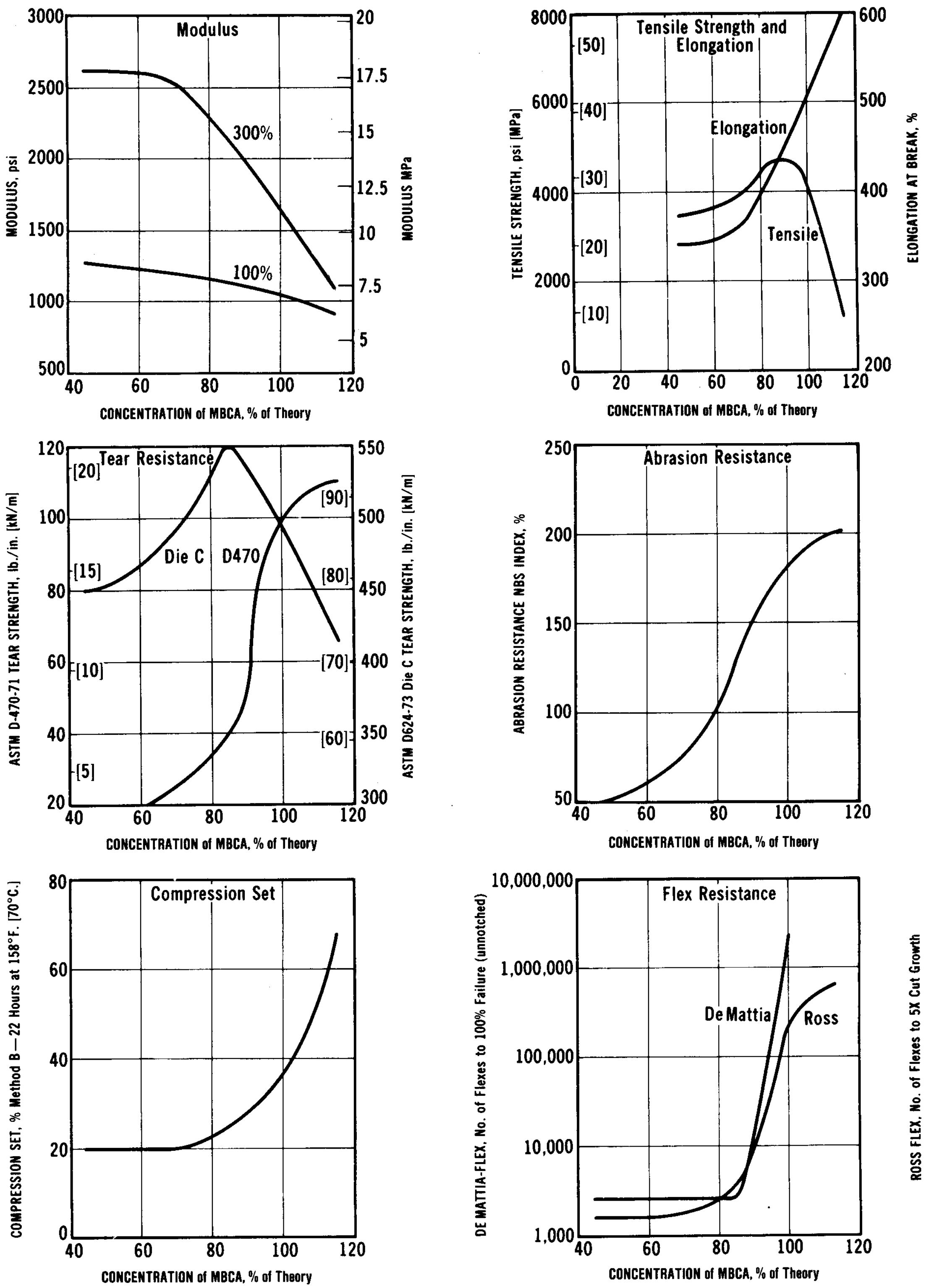
Flex Life (DeMattia flex test, not nicked) improves markedly at concentrations to 105 to 110 percent of theory. As noted previously, compounds that contain an excess of MBCA have reduced tensile strength and compression set resistance. Adequate flex life for most applications is obtained with 95 percent of theory MBCA and by using thin cross-sections in parts which are to be flexed.

Mixing and Curing Temperatures - The curing reaction begins the moment MBCA is mixed with ADIPRENE L 100; it continues throughout the fluid stage, and beyond the point of solidification until the vulcanizate is completely cured.

ADIPRENE® L 100
FIGURE 1

Figure 1

Effect of Concentration of MBCA on Physical Properties



ADIPRENE® L 100
CURING PROPERTIES

The reaction between ADIPRENE L 100 and MBCA is exothermic; the temperature of the mass rises about 44°F (25°C) when the reaction is carried out in a fully insulated calorimeter. This effect is shown in *Figure 2.* This represents the maximum temperature rise for the largest castings, since essentially no heat can escape. The actual temperature reached is influenced by: the temperature of the polymer and curing agent; the mold material and configuration; the mold temperature; and the environmental, or oven, temperature. The size of the casting has an effect also, since small castings can lose heat to the surroundings, and may not reach as high a temperature as large castings.

The temperature at which the curing reaction takes place has an important effect on vulcanizate properties. At room temperature, the amount of biuret branching is negligible, and the vulcanizate properties are dependent primarily on urea group attraction. Resistance to compression set is poor, but tensile strength, tear strength and modulus are high. The primary result of increasing the reaction temperature (up to about 240° F [116°C]) is an increase in the proportion of biuret branching and an increase in compression set resistance. At reaction temperatures above 240°F (116°C), the amount of biuret branching formed reaches a concentration at which the orderly structure of the vulcanizate is reduced and the vulcanizates produced are softer, more flexible, and have lower strength than those produced at temperatures below 240°F (116°C).

The effects of mixing and curing temperature on vulcanizates of ADIPRENE L 100 cured with MBCA are shown in *Figure* 3. Highly consistent vulcanizates are formed when the mixing temperature is held within the range of 158 to 212°F (70-100°C), since the maximum **reaction** temperature then rarely exceeds 240°F (116° C).

Within this temperature range, the polymer has good stability, low viscosity, and may be degassed readily. MBCA is generally handled at 250°F (121°C). However, it represents such a small part of the total compound that its heat increases the temperature of the ADIPRENE only a few degrees. ADIPRENE L 100 should not be processed outside this temperature range unless the vulcanizate properties have been shown to be satisfactory for the intended application. The improved tear strength characteristic of ADIPRENE L 100 urethane rubber cured at reduced temperatures may also be obtained with MBCA curing agent at levels of 100 - 105% of theory *(Figure 1);* this concentration keeps branching to a minimum level.

Cure Time - The optimum time for curing ADIPRENE L 100 with MBCA is 1 hour at 212°F (100°C) with 16 hours post cure at 158°F (70°C). The effect of cure time at 212°F (100°C.) for a standard compound of ADIPRENE L 100 is shown in *Table III.* It should be noted that the ultimate vulcanizate properties are not attained by the heat cure alone, but only after the vulcanizates have been allowed to post cure at room temperature for several days. The cure times shown are those which yield optimum properties after this postcure period.

ADIPRENE® L 100
FIGURES 2 & 3

Figure 2

Effect of Exotherm on Mass Temperature

(500g batch size. Temperature of mass in insulated calorimeter.)

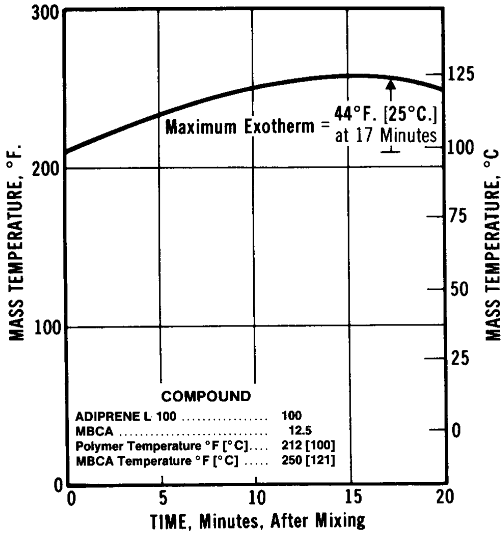
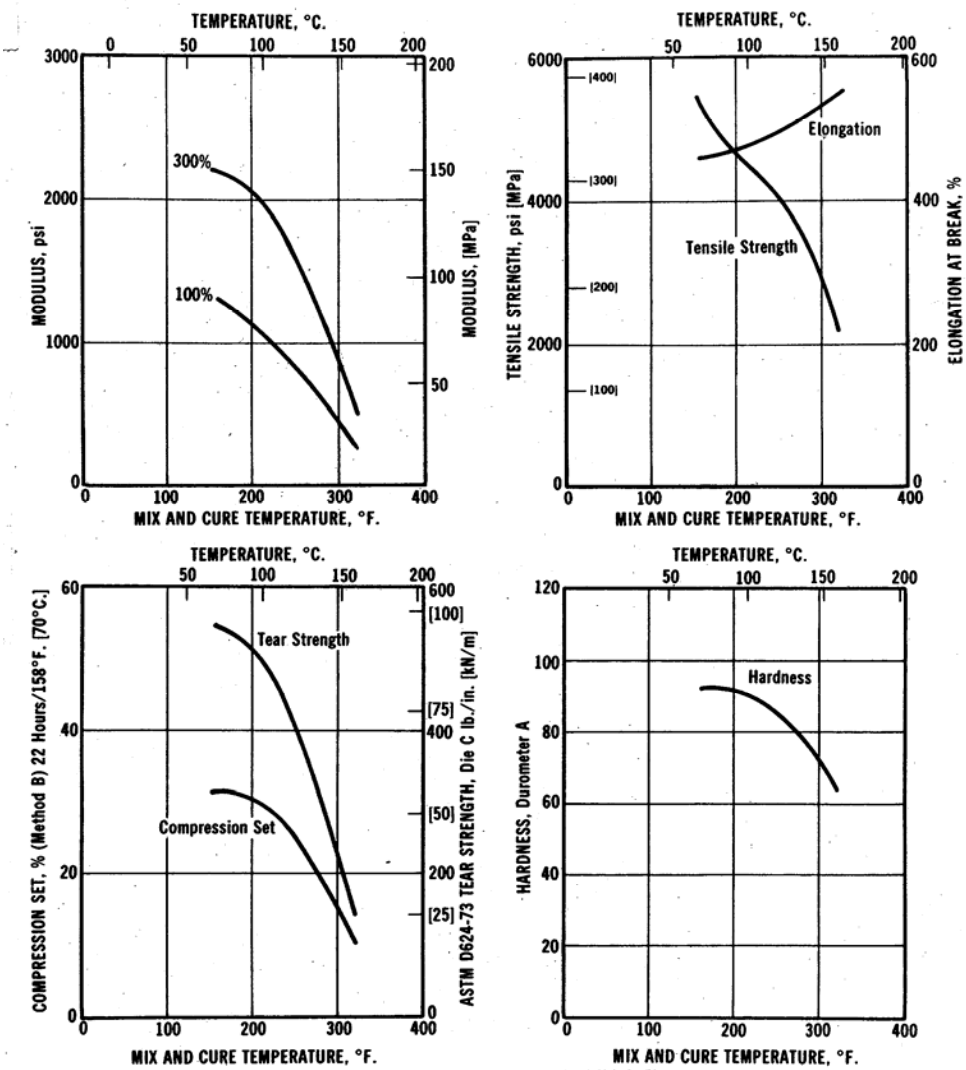


Figure 3

Effect of Mixing and Curing Temperatures on Vulcanizate Properties



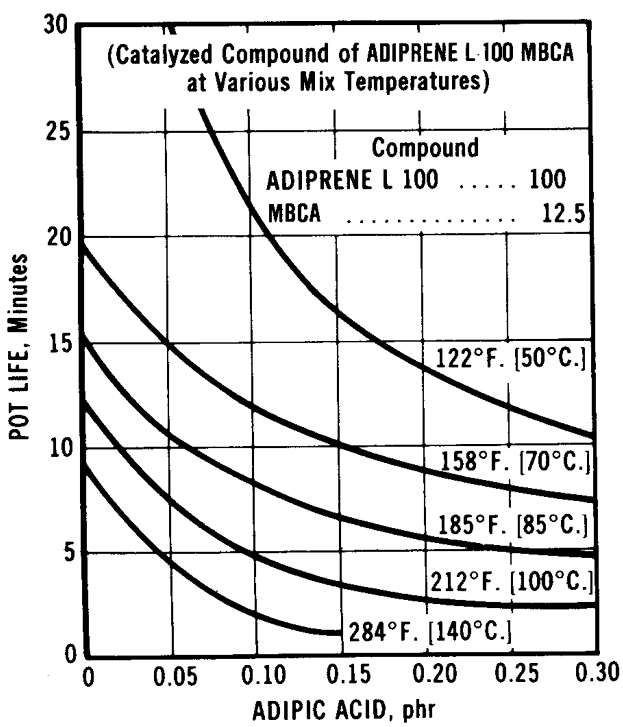
Catalysis of Reactions with MBCA - A small amount of carboxylic acid accelerates the curing reaction and permits reduction in demolding time[d] from 30 - 45 to 10 - 15 minutes. Short demolding times (increased mold turn-over) significantly reduce the number of molds required to produce a given number of molded parts. Adipic acid is a very effective catalyst and has been used in most of the catalytic studies for ADIPRENE L 100. Other organic acids (e.g. acetic, benzoic, and oleic) are also effective and behave similarly to adipic acid.

Adipic acid is most conveniently dissolved in molten MBCA before it is added to ADIPRENE L 100. Although adipic acid melts at 306°F (152°C), it is soluble in MBCA at 250°F (121°C) and blends completely with the amine. The combination should be well mixed and free of un-dissolved material. As much as 20 g of adipic acid can be dissolved in 100 g of MBCA at 250°F (121°C), but at this concentration crystallization of the acid begins to occur as the temperature is reduced to 220°F (104°C).

The acid/amine mixture has limited stability. As a result of prolonged exposure at elevated temperature, the acid is believed to react with the amine to form an amide structure. This change is indicated by rapid darkening of the MBCA curing agent and a loss of catalytic activity. No changes have been observed after exposure for 6 hours at 250°F (121°C), but curing activity should be checked after longer heating.

The pot life, or working time, of a compound of ADIPRENE L 100 and MBCA is also reduced significantly when adipic acid is used as a catalyst. The effect of adipic acid concentration on pot life at various mix temperatures is illustrated in *Figure 4*. Catalysis is most pronounced at mix temperatures below 185°F (85°C), but even at the normal mix temperature of 212°F (100°C), 0.20 phr adipic acid reduces pot life from 10 minutes to less than 5 minutes. Concentrations of adipic acid greater than 0.30 phr appear to give essentially no further reduction in pot life, and yield very little additional reduction in demolding time.

Figure 4
Effect of Adipic Acid Level on Pot Life



[d] Demolding time is the cure time after which a simple small part can be removed from the mold without permanent distortion. It is measured from the time the curing agent is added to the polymer.

ADIPRENE® L 100
EFFECT OF CURE TIME ON VULCANIZATE PROPERTIES

Acid catalysts accelerate the final cure of compounds of ADIPRENE L 100 cured with MBCA. Catalysis with adipic acid reduces the total cure time required at any temperature and permits equivalent cures to be obtained at temperatures lower than are normally used with MBCA alone. When an after cure of one week at 75°F (24°C) and 50% RH is used, the final vulcanizate properties obtained with catalyzed compounds cured either 15 minutes at 212°F (100°C) or 60 minutes at 158°F (70°C) are essentially equivalent to those of an uncatalyzed control cured 60 minutes at 212°F (100°C). This effect is shown in *Table IV*. Longer cure times add very little to the physical properties other than tear resistance when the week-long after cure is used. The strength of the catalyzed compounds develops much faster than that of the control, permitting early demolding; however, parts should not be placed into service immediately following demolding because good resistance to compression set requires additional heating or a room temperature after cure.

Room Temperature Cures - Adipic acid is useful for acceleration of room temperature cures of compounds of ADIPRENE L 100 and MBCA (see *Table V).* A catalyzed compound is stronger after one day's cure than an uncatalyzed compound after seven days. However, compression set resistance is poor even after curing for seven days, indicating that some heat cure or considerably longer storage at room temperature is required before good compression set resistance is developed. The effectiveness of adipic acid catalysis's not impaired by the presence of ester plasticizers at concentrations up to 40 phr.

Table III
Effect of Cure Time on Vulcanizate Properties

ADIPRENE L 100	100
MBCA	12.5

Mixing and Curing

Mixed at 212°F (100°C)

Cured, minutes at 212°F (100°C)	**15**	**30**	**60**	**120**

Test specimens were conditioned for 7 days at 75°F (24°C), 50% RH before testing.

Physical Properties

Hardness, durometer A	90	90	90	90
100% Modulus, psi (MPa)	1000 (6.9)	1050 (7.2)	1075 (7.4)	1100 (7.6)
300% Modulus, psi (MPa)	2000 (13.8)	2000 (13.8)	2150 (14.8)	2200 (15.2)
Tensile strength, psi (MPa)	4175 (28.8)	4550 (31.4)	4600 (31.7)	4800 (33.1)
Elongation at break, %	410	440	460	475
Tear strength, ASTM D-470, lb/in (kN/m)	79 (13.8)	67 (11.7)	70 (12.3)	81 (14.2)
Compression set (Method B), %, 22 hrs at 158°F (70°C)	29	29	22	24

ADIPRENE® L 100
ADIPIC ACID AND POSTCURE ON VULCANIZATE PROPERTIES

Table IV

Effect of Adipic Acid and Postcure on Vulcanizate Properties

ADIPRENE L 100	100	100	100
MOCA	12.5	12.5	12.5
Adipic acid	—	0.2	0.2
Mixing and Curing			
Mix temperature, °F (°C)	212 (100)	212 (100)	158 (70)
Cured, minutes/°F (°C)	60/212 (100)	15/212 (100)	60/158 (70)
Physical Properties			
Postcured: 6 hours at 75°F (24°C), 50% RH			
Hardness, durometer A	88	86	87
100% Modulus, psi (MPa)	875 (6.0)	1025 (7.1)	1000 (6.9)
300% Modulus, psi (MPa)	175 (8.1)	1525 (10.5)	1425 (9.8)
Tensile strength, psi (MPa)	2200 (15.2)	3250 (22.4)	3750 (25.8)
Elongation at break, %	800	500	520
Compression set (Method B), %, 22 hours at 158°F (70°C)	90	78	85
Postcured: 1 week at 75°F (24°C), 50% RH			
Hardness, durometer A	90	91	91
100% Modulus, psi (MPa)	1075 (7.4)	1200 (8.3)	1175 (8.1)
300% Modulus, psi (MPa)	2150 (14.8)	2350 (16.2)	2175 (15.0)
Tensile strength, psi (MPa)	4600 (31.71	4150 (28.0)	4425 (30.5)
Elongation at break, %	460	380	400
Compression set, (Method B), %, 22 hours at 158°F (70°C)	22	30	26
Postcured: 16 hours at 158°F (70°C)			
Hardness, durometer A	90	91	92
100% Modulus, psi (MPa)	1050 (7.2)	1050 (7.2)	1050 (7.2)
300% Modulus, psi (MPa)	1775 (12.2)	1725 (11.8)	1800 (12.4)
Tensile strength, psi (MPa)	4575 (31.5)	4000 (27.6)	4450 (30.7)
Elongation at break, %	480	440	450
Compression set, (Method B), %, 22 hours at 158°F (70°C)	28	36	38

Table V

Room Temperature Cures Catalyzed with Adipic Acid

ADIPRENE L 100	100		100	
MBCA	12.5		12.5	
Adipic Acid	0.0		0.2	
Mixing and Curing				
Mix temperature, °F (°C)	140 (60)		140 (60)	
Cured: days at 75°F (24°C), 50% RH	1	7	1	7
Physical Properties				
Hardness, durometer A	69	80	80	85
100% Modulus, psi (MPa)	575 (4.0)	825 (5.7)	575 (4.0)	800 (5.5)
300% Modulus, psi (MPa)	625 (4.3)	1050 (7.2)	950 (6.6)	1400 (9.6)
Tensile strength, psi (MPa)	675 (4.6)	1850 (12.8)	3050 121.0)	4375 (30.2)
Elongation at break, %	380	560	530	440
Compression set (Method B), %, 22 hours at 158°F (70°C)	100	77	87	68

EFFECT OF ENVIRONMENT ON PHYSICAL PROPERTIES

Since MBCA curing agent gives the best balance of properties, most data presented in this section are based on ADIPRENE L 100 urethane rubber cured with MBCA. The effects of alternate curing systems on physical properties are discussed under the individual section.

HIGH TEMPERATURE PROPERTIES

In selecting an elastomer for use at elevated temperatures it is necessary to consider the changes in physical properties: (1) as temperature is increased; (2) as the elastomer is aged at elevated temperatures; and (3) when the elastomer is aged and tested at elevated temperatures.

As the test temperature is increased, physical properties of vulcanizates of ADIPRENE L 100 decrease. However, even though the net change is significant above 200°F (93°C), the resulting physical properties are still very good compared to conventional elastomers *(Figure 7).*

ADIPRENE® L 100
FIGURE 7

Figure 7 — **Properties at Elevated Temperatures (No Heat Aging)**

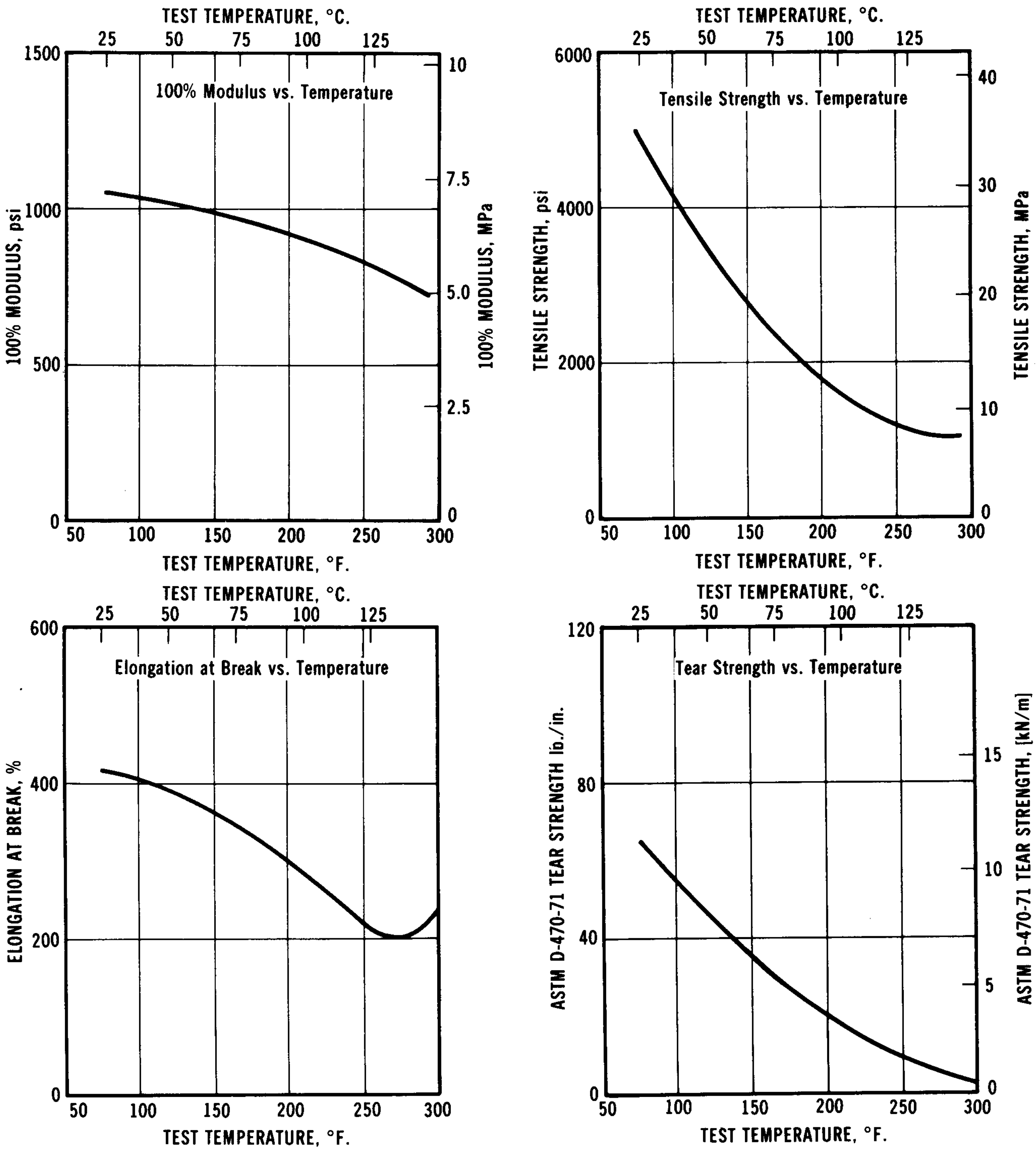
COMPOUND

ADIPRENE L 100	100
MBCA	12.5
% Theory MBCA	95

Mixed at 212°F [100°C]

Cured 1 hour at 212°F [100°C], Postcured 16 hours at 158°F [70°C]

Specimens were conditioned for 7 days at 75°F [24°C], 50% RH before testing. All samples were preconditioned at test temperature for 30 minutes.



ADIPRENE® L 100
PROPERTIES AT ELEVATED TEMPERATURES

Compound formulation and heat post curing may be used to improve the retention of physical properties at elevated temperatures. The use of MBCA at 100 to 105% of theory substantially improves strength properties above 212°F (100°C). Further use of heat postcure (16 to 70 hours at 250°F [121°C])[e] will provide additional improvement particularly in tear strength. In Table XVII are shown the effects of changes in level of MBCA and heat post cure on the high temperature physical properties of ADIPRENE L 100.

Table XVII
Properties at Elevated Temperatures

ADIPRENE L 100	100	100	100	100
MBCA	11.8	13.2	13.8	13.2
% Theory MOCA	90	100	105	100

Mixing and Curing

Mixed at 212°F (100°C)
Cured: 1 hour at 212°F (100°C)

Postcure:		
Time	16 hours	70 hours
Temperature	158°F (70°C)	250°F (121°C)

Specimens were conditioned 7 days at750°F (24°C), 50% RH before testing.
Test specimens were preconditioned at test temperature for 30 minutes.

Physical Properties

Measured at 75°F (24°C)				
Hardness, durometer A	90	88	88	87
100% Modulus, psi (MPa)	1000 (6.9)	975 (6.7)	1000 (6.9)	850 (5.9)
300% Modulus, psi (MPa)	2050 (14.1)	1725 (11.9)	1675 (11.6)	1350 (9.3)
Tensile strength, psi (MPa)	4975 (34.3)	3925 (27.1)	4625 (31.9)	4600 (31.7)
Elongation at break, %	420	440	510	850
Tear strength, ASTM D-470, lb/in (kN/m)	52 (9.1)	98 (17.2)	107 (18.7)	120 (21.0)
Measured at 212°F (100°C)				
Hardness, durometer A	89	88	80	87
100% Modulus, psi (MPa)	875 (6.0)	775 (5.3)	700 (4.8)	675 (4.6)
300% Modulus, psi (MPa)	—	1350 (9.3)	1325 (9.1)	1025 (7.1)
Tensile strength, psi (MPa)	1475 (10.2)	2800 (19.3)	3350 (23.1)	2975 (20.5)
Elongation at break, %	290	480	580	800
Tear strength, ASTM D-470, lb/in (kN/m)	15 (2.6)	21 (3.7)	30 (5.2)	54 (9.4)

Table XVII
Properties at Elevated Temperatures (cont'd)

Physical Properties				
Measured at 250°F (121°C)				
Hardness, durometer A	88	88	87	87
100% Modulus, psi (MPa)	850 (5.9)	775 (5.3)	625 (4.3)	675 (4.6)
300% Modulus, psi (MPa)	—	1250 (8.6)	1100 (7.6)	925 (6.4)
Tensile strength, psi (MPa)	1200 (8.3)	1500 (10.3)	2375 (16.7)	2375 (16.4)
Elongation at break, %	220	350	520	790
Tear strength, ASTM D-470, lb/in (kN/m)	10 (1.8)	15 (2.6)	28 (4.9)	45 (7.9)
Measured at 300°F (149°C)				
Hardness, durometer A	86	87	85	86
100% Modulus, psi (MPa)	700 (4.8)	625 (4.5)	575 (4.0)	600 (4.1)
300% Modulus, psi (MPa)	–	1025 (7.1)	850 (5.9)	775 (5.3)
Tensile strength, psi (MPa)	1025 (7.1)	1800 (12.4)	2375 (16.4)	1875 (12.9)
Elongation at break, %	240	420	620	810
Tear strength, ASTM D-470, lb./in (kN/m).	2 (0.4)	8 (1.4)	15 (2.6)	50 (8.8)

[e] 70 hours at 250°F (121°C) is required to get optimum tear strength when levels of MBCA below 95% theory are used. For higher levels, postcure time may be reduced to 16 hours.

HEAT AGING RESISTANCE

Heat aging resistance of vulcanizates of ADIPRENE L 100 is a function of time and temperature. As would be expected, the loss in vulcanizate properties is accelerated as time and/or temperature are increased. However, as shown in *Figure 8,* most properties do not change significantly on extended exposure at temperatures up to 225°F (107°C). Above 225°F (107°C) there is a more rapid decrease in tensile strength. However, tear resistance is significantly improved after high temperature conditioning. These data suggest that vulcanizates of ADIPRENE L 100 will function satisfactorily up to 200 to 225°F (93 to 107°C) continuously and may be considered for short term exposure up to 250°F (121°C). However, it is recommended that demanding applications requiring high temperature exposure be thoroughly evaluated prior to full use commitment.

The combined effect of heat aging and testing at elevated temperatures does not seriously harm the elastomeric properties. *Figure 9* shows that properties of ADIPRENE L 100 tested at 158°F (70°C) change very little when aged as long as 28 days at that temperature. These data also show that the overall heat resistance is significantly improved by raising the level of MBCA curing agent to 100-105% of theory.

ADIPRENE® L-100
FIGURE 8

Figure 8 — **Effect of Dry Heat Aging on Vulcanizate Properties**

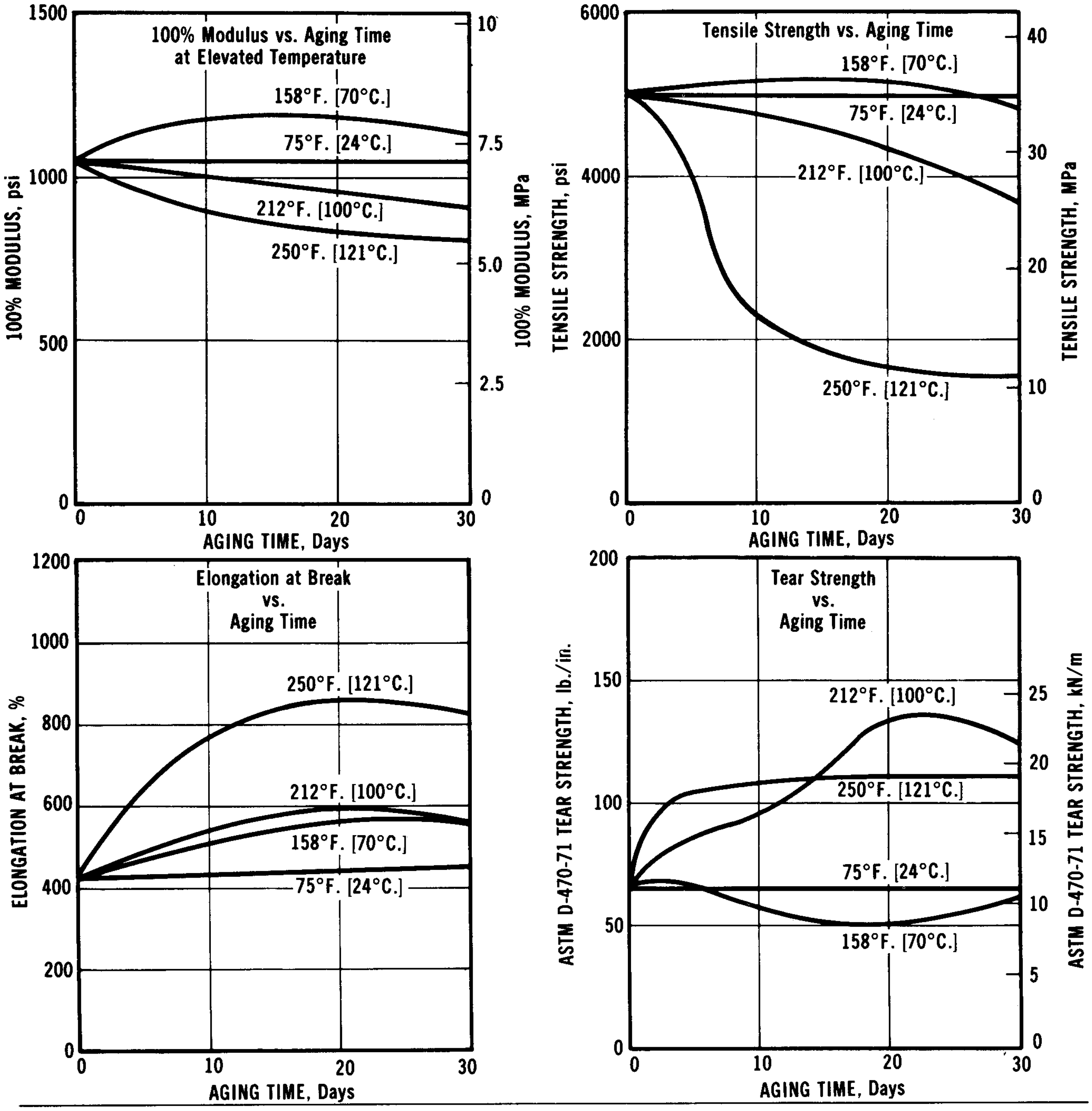
COMPOUND

ADIPRENE L 100	100
MBCA	12.5
% Theory MBCA	95

Mixed at 212°F [100°C]

Cured 1 hour at 212°F [100°C], Postcured 16 hours at 158°F [70°C]

Specimens were conditioned for 7 days at 75°F [24°C], 50% RH before heat exposure. All samples were tested at RT.

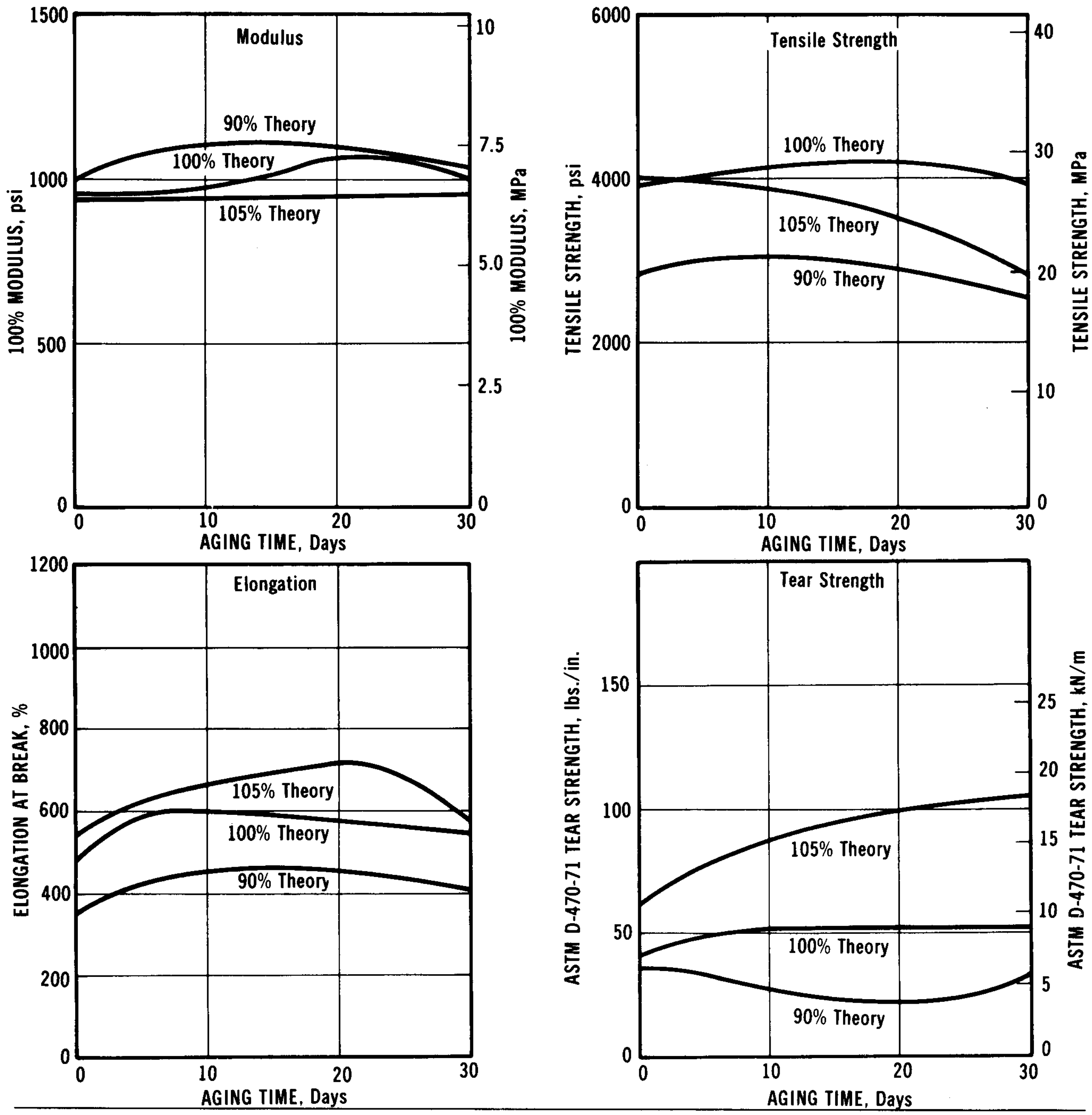


ADIPRENE® L-100
FIGURE 9

Figure 9 — **Properties at Elevated Temperatures**
(After Heat Aging, Aged and Tested at 158°F. [70°C])

COMPOUND

ADIPRENE L 100 100
% Theory MBCA .... As indicated
Mixed at 212°F [100°C]
Cured 1 hour at 212°F [100°C], Postcured 16 hours at 158°F [70°C]
Specimens were conditioned for 7 days at 75°F [24°C], 50% RH and aged 28 days at 158°F [70°C] before testing.



LOW TEMPERATURE PROPERTIES

Vulcanizates of ADIPRENE L 100 have outstanding properties at low temperatures. They do not become brittle at -100°F (-73°C) although stiffening occurs as the temperature is reduced. *Table XVIII* shows typical properties of ADIPRENE L 100 urethane rubber at low temperatures.

Table XVIII

Low Temperature Properties

ADIPRENE L 100	100
MOCA	12.5

Mixing and Curing

Mixed at 212°F (100°C)

Cured: hour/°F (°C)	1/212 (100)
Postcure: hour/°F (°C)	16 @ 158 (70)

Test specimens were conditioned one week at 75°F (24°C), 50% RH before testing.
Stress strain tests were run 1 inch (2.54 cm) per minute.

Physical Properties

Measured at 75°F (24°C)	
Hardness, durometer D	43
100% Modulus, psi (MPa)	1100 (7.6)
Tensile strength, psi (MPa)	4500 (31.0)
Elongation at break, %	450
Measured at O°F (-18°C)	
Hardness, durometer D	47
100% Modulus, psi (MPa)	1300 (9.0)
Tensile strength, psi (MPa)	5500 (37.9)
Elongation at break, %	300
Measured at -50°F (-46°C)	
Hardness, durometer D	66
100% Modulus, psi (MPa)	3700 (25.5)
Tensile strength, psi (MPa)	8200 (56.5)
Elongation at break, %	250
Measured at-100°F (-73°C)	
Hardness, durometer D	90
100% Modulus, psi (MPa)	7400 (51.0)
Tensile strength, psi (MPa)	14000 (96.5)
Elongation at break, %	250

WATER RESISTANCE

Water (liquid or vapor) is nearly always present and in contact with urethane rubber parts in service. Therefore, it is very important to know what effect water has on the vulcanizates.

The over-all strength of vulcanizates of ADIPRENE L 100 is reduced slightly when they are exposed to water. This is a reversible effect and the properties are restored when the samples are dried. ADIPRENE, a polyether urethane, is 5 to 10 times more resistant to degradation by moisture than are polyester based urethanes. This is particularly apparent under conditions of long-term aging. The curing agent used has little effect on the rate of degradation of the esters. These comparative results are shown in *Table XIX*.

Table XIX

Water Resistance

ADIPRENE L-100	100	—
Polyester [f]	—	100
MBCA	12.5	11.1

Mixing and Curing

Mixed at	212°F (100°C)	212°F (100°C)
Cured: hour/°F (°C)	1/212°F (100°C)	1/212°F (100°C)
Postcure: hour/°F (°C)	16 @ 158 (70)	16 @ 158 (70)

Test specimens were conditioned one week at 75°F (24°C), 50% RH before testing.

Physical Properties

Tensile strength, psi (MPa), after immersion in water at 75°F (24°C). (Tested dry.)

Original	4500 (31.0)	6100 (42.0)
6 months	4500 (31.0)	6000 (41.4)
12 months	4500 (31.0)	5600 (38.6)
18 months	4500 (31.0)	4600 (31.7)

Tensile strength, psi (MPa), after immersion in water at 122°F (50°C). (Tested dry.)

Original	4500 (31.0)	5900 (40.7)
3 months	4300 (29.6)	4000 (27.6)
6 months	4200 (29.0)	500 (3.4)
9 months	4100 (28.3)	—

Tensile strength, psi (MPa)/Elongation, %, after immersion in water at 158°F (70°C). (Tested dry.)

Original	4500 (31.0)/450	5900 (40.7)/680
5 weeks	2300 (15.9)/650	200 (1.4)/100
10 weeks	1500 (10.3)/900	—
15 weeks	1000 (16.9)/500	—

Table XIX
Water Resistance (cont'd)

Tensile strength, psi (MPa), after immersion in water at 212°F (100°C). (Tested dry.)		
Original	4500 (31.0)	5900 (40.7)
5 days	1000 (6.9)	200 (1.4)
10 days	600 (4.1)	—
15 days	500 (14)	—
Compression set (Method B) %, 22 hours at 158°F (70°C) after immersion in water at 158°F (70°C). (Tested dry.)		
Original	26	40
5 weeks	50	90
10 weeks	60	100
15 weeks	65	100
Tensile strength, psi (MPa), after exposure to 80% RH at 158°F (70°C). (Tested dry.)		
Original	4500 (31.0)	5900 (40.7)
5 weeks	2500 (17.2)	200 (1.4)
10 weeks	1900 (13.1)	—
15 weeks	1200 (8.3)	—
Tensile strength, psi (MPa), after immersion in wet ASTM Oil No. 3 at 158°F (70°C) (Tested dry)		
Original	4500 (31.0)	5900 (40.7)
5 weeks	3900 (26.9)	200 (1.4)
10 weeks	2700 (18.6)	—
15 weeks	1900 (13.1)	—

[f] 4.0% NCO based on polyethylenepropylene adipate glycol/TDI

WEATHER RESISTANCE

Vulcanizates of ADIPRENE L 100 urethane rubber, cured with 12.5 phr (95% of theory) of MBCA curing agent have undergone weathering tests for ten years in air, soil and sea in the Panama Canal Zone. Retention of properties is excellent except for the samples exposed outdoors, unprotected from sunlight.

Vulcanizates of ADIPRENE L 100 darken and their physical properties are reduced by exposure to sunlight. Compounds of ADIPRENE L 100 may be protected against the effects of weathering with ultraviolet screening materials or combinations of ultraviolet absorbers and antioxidants. Screening materials, such as pigments or carbon black, are effective for longer time periods than UV absorbers and are generally preferred. UV absorbers afford excellent protection until they are consumed; after this has occurred, the physical properties of the urethane elastomer are reduced at the same rate as an unprotected compound.

ADIPRENE® L 100
OXYGEN/OZONE RESISTANCE

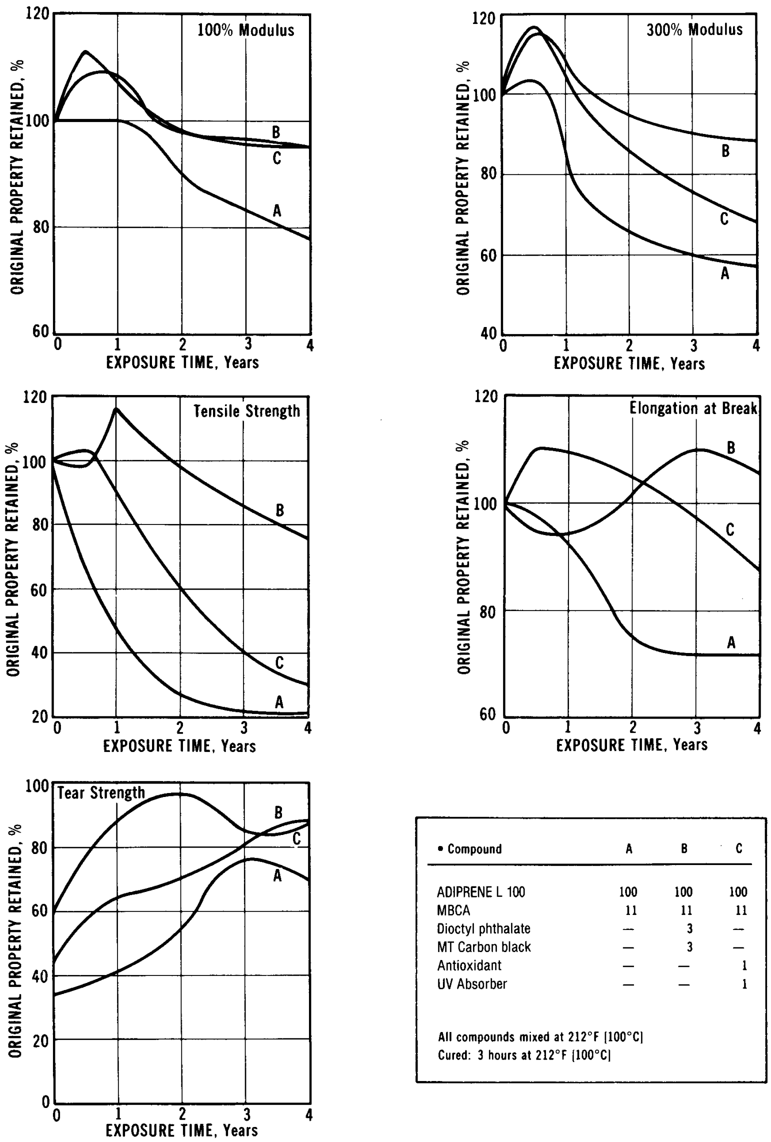
One to three parts of a medium thermal carbon black provide good resistance to the effects of weathering without significantly altering original properties. A plasticizer such as dioctyl phthalate may be used as a carrier for the carbon black and aids in dispersing it in the polymer. Graphs showing the relative effectiveness of UV screening agents and a UV absorber are given in *Figures 10*. During outdoor exposure (in Florida) the specimens were exposed 45° to the horizontal, facing south.

OXYGEN AND OZONE RESISTANCE

Compounds of ADIPRENE L 100 are highly resistant to degradation by oxygen and ozone. The most useful measure of ozone resistance is obtained by testing in an atmosphere containing 3 ppm ozone. Past experience has shown that materials which resist this concentration for several hundred hours are virtually immune to attack by normal atmospheric concentrations of ozone. *Table XX* shows the resistance of vulcanizates of ADIPRENE L 100 to ozone attack at both 3 ppm and 100 ppm ozone, under static strain conditions.

The stress-strain properties of ADIPRENE L 100 show little change after oxygen bomb exposure for 4 weeks at 158°F (70°C) and 300 psi (2.1 MPa) oxygen pressure. The slight changes can be attributed to the elevated temperature exposure during the test.

Figure 10
Effect of Protective Agents on Weather Resistance
(Diamine Cure)



• Compound	A	B	C
ADIPRENE L 100	100	100	100
MBCA	11	11	11
Dioctyl phthalate	—	3	—
MT Carbon black	—	3	—
Antioxidant	—	—	1
UV Absorber	—	—	1

All compounds mixed at 212°F [100°C]
Cured: 3 hours at 212°F [100°C]

ADIPRENE® L 100
OXYGEN/OZONE RESISTANCE

Table XX - Ozone Resistance

ADIPRENE L 100	100
MBCA	12.5

Mixing and Curing

Mixed at 212°F (100°C)
Cured: 1 hour at 212°F (100°C)
Postcure: 16 hours at 158°F (70°C)

Test specimens were conditioned two weeks at 75°F (24°C), 50% RH before testing.

Ozone Attack, 3 ppm ozone

Under 20% strain	No attack after 500 hours

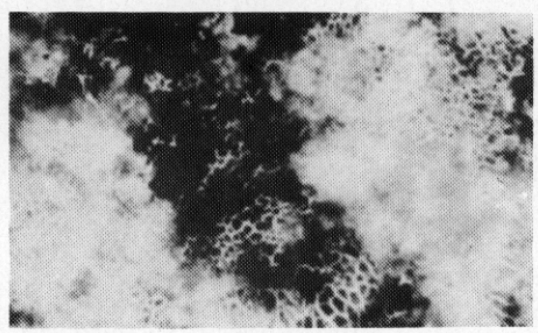
Ozone Attack, 100 ppm ozone

Under 20% strain, hours to:	
Slight cracking	45
Noticeable cracking	68
Break	460
In Bent Loop, hours to:	
Slight cracking	25
Noticeable cracking	45
Break	>500

FUNGUS RESISTANCE

ADIPRENE L 100 cured with MBCA is inherently resistant to fungus attack. Samples buried for ten years in moist, inoculated soil showed no evidence whatever of attack after being rinsed, and the vulcanizate properties were unchanged. By contrast, polyester based urethanes were severely attacked in less than six months. These samples are shown in *Figure 12.* Since many compounding ingredients such as plasticizers are attacked by fungi, only those known to be resistant to fungus attack should be used in applications where fungus growth might occur.

Figure 12 — **Fungus Resistance of Urethanes**



Polyester based urethane after 6 months

ADIPRENE after 10 years

OIL, CHEMICAL AND SOLVENT RESISTANCE

Vulcanizates of ADIPRENE L 100 have excellent oil and solvent resistance and are particularly suited for service in lubricating oils and automotive fuels. Aromatic and polar solvents cause moderate to severe swelling. A general guide to the fluid resistance of vulcanizates of ADIPRENE L 100 is shown in *Table XXI*. Volume swell data after immersion in oils, solvents and chemicals are shown in *Table XXI-A.*

Table XXI - Oil, Chemical and Solvent Resistance of ADIPRENE

The following tabulation has been prepared as a guide to the fluid resistance of properly compounded products made from ADIPRENE. The table should be used as a guide only. Other requirements necessary for satisfactory performance must also be taken into consideration. The best way to determine whether or not the product will be entirely satisfactory for a given application is to test it in actual service. If this is impractical, then tests should be devised which simulate actual service conditions as closely as possible.

Unless otherwise noted, all ratings are at room temperature and the concentrations of all aqueous solutions may be considered saturated. The parenthetical temperatures listed are those that were actually used in tests of service applications, but do not necessarily represent temperature limits.

The A, B and C ratings are based upon data from laboratory tests and records of actual service performance. In some instances, where specific information is not available, T and X ratings are indicated. These are educated guesses based upon experience, analogy and a familiarity with the chemistry involved. T means, "test before using but most likely to be satisfactory." X means, "most likely to be unsatisfactory."

Table XXI

Oil, Chemical and Solvent Resistance of ADIPRENE

A - Little or no Effect.
B - Minor to moderate effect.
C - Severe effect to complete destruction.
T - Test before using. No data but most likely to be satisfactory.
X - No data but most likely to be unsatisfactory
.

CHEMICAL	RATING
Acetic acid, 20%	B
Acetone	C
Aluminum chloride solutions	T
Ammonia, anhydrous	X
Ammonium hydroxide solutions	X
ASTM hydrocarbon test fluid	T
ASTM oil #1 158°F (70°C)	
ASTM oil #3 158°F (70°C)	
ASTM reference fuel A	A
ASTM reference fuel B 122°F (50°C)	B
ASTM reference fuel C	C
Barium hydroxide solutions	A
Benzene	C
Borax solutions	A
Boric acid solutions	A
Butane	A
Calcium bisulfite solutions	A
Calcium chloride solutions	T
Calcium hydroxide solutions	A
Calcium hypochlorite, 5%	X
Carbon dioxide	A

ADIPRENE® L 100
OIL, CHEMICAL AND SOLVENT RESISTANCE (cont'd)

CHEMICAL	RATING
Carbon monoxide	A
Carbon tetrachloride	C
Castor oil	A
Chlorine gas, dry	X
Chlorine gas, wet	X
Chromic acid, 10-50%	X
Copper chloride solutions	A
Copper sulfate solutions	A
Cottonseed oil	A
Cyclohexane	A
Dowtherm A	B
Ethyl acetate	C
Ethyl alcohol	C
Ethylene glycol	B
Formaldehyde, 37%	X
Formic acid	X
FREON-11 fluorocarbon	B
FREON-12 130°F (54°C)	A
FREON-22	C
FREON-113	A
FREON-114	T
Fuel oil	B
Gasoline	B
Glue	A
Glycerin	A
n-Hexane 122°F (50°C)	B
Hydraulic oils	B
Hydrochloric acid, 20%	B
Hydrochloric acid, 37%	X
Hydrogen	A
Isoctane 158°F (70°C)	B
Isopropyl ether	B
JP-4	C
JP-5	C
JP-6	X
Kerosene	C
Lacquer solvents	X
Linseed oil	B

CHEMICAL	RATING
Lubricating oils	B
Magnesium chloride solutions	A
Magnesium hydroxide solutions	A
Mercury	A
Methyl alcohol	C
Methyl ethyl ketone	C
Mineral oil	A
Naphtha	B
Naphthalene	B
Nitric acid, 10%	C
Oleic acid	B
Palmitic acid	A
Perchloroethylene	C
Phenol	C
Phosphoric acid, 20%	T
Potassium hydroxide solutions	A
SAE #10 oil 158°F (70°C)	A
Skydrol 500	
Soap solutions	A
Sodium hydroxide,20%	T
Sodium hydroxide, 46½%	A
Sodium hypochlorite, 5%	C
Sodium hypochlorite, 20%	X
Soybean oil	
Stearic acid	A
Sulfur dioxide, liquid	T
Sulfuric acid, up to 50%	T
Sulfuric acid, 50 to 80%	C
Sulfurous acid	T
Tannic acid, 10%	A
Tartaric acid	A
Toluene	
Trichloroethylene	C
Tricresyl phosphate	B
Trisodium phosphate solutions	A
Tung oil	B
Turpentine	C
Water 122°F (50°C)	A

Table XXI A

Oil, Solvent & Chemical Resistance

ADIPRENE L 100	100
MBCA	12.5

Mixed at 212°F (100°C)
Cured: 1 hour at 212°F (100°C), Postcure 16 hours at 158°F (70°C)
Test specimens were conditioned one week in air at 75°F (24°C), 50% RH before testing

	% Volume Increase
70 Hours at 212°F (100°C)	
ASTM Oil No. 1	1
ASTM Oil No. 3	16
1 week at 158°F (70°C)	
ASTM Oil No. 1	1
ASTM Oil No. 3	14
Toluene	94
Dioctyl phthalate	22
Arochlor 1254	60
Castor oil	9
Ethylene glycol	5
Trioctyl phosphate	60
Automatic transmission fluid	8
Amyl acetate	130
Cellosolve acetate	74
Cottonseed oil	4
Amyl alcohol	6
Dimethyl formamide	Dissolved
1 week at 122°F (50°C)	
Ref. Fuel B	32
Denatured alcohol, 2B	56
Trichloroethylene	209
Perchloroethylene	63
Methyl ethyl ketone, dry	115
Methyl ethyl ketone, wet [g]	225

[g] Containing 2% water.

ELECTRICAL PROPERTIES

Compounds of ADIPRENE L 100 may be used successfully in potting and encapsulation applications. Vulcanizates are serviceable at frequencies up to 100 kilocycles (100 kHz) at temperatures of 212°F (100°C) or less. The electrical properties of a vulcanizate of ADIPRENE L 100 urethane rubber, measured at different temperatures and frequencies, are shown in *Table XXII*. The level of MBCA curing agent (13 phr) was selected because it gives the best overall electrical properties without sacrificing physical properties.

FLAMMABILITY

Burning characteristics of compounds of ADIPRENE can be changed by addition of some commercial compounds as shown in *Tables XXIII* and *XXIV*.

RADIATION RESISTANCE

ADIPRENE offers the greatest resistance to the damaging effects of gamma ray radiation of all of the many elastomers and plastics tested by an independent investigator [h]. Its products appear capable of giving satisfactory service even when exposed to the relatively large gamma ray exposure of 1×10^9 Roentgens (258 kC/ kg). They are more resistant than are other elastomers to stress cracking and retain a great amount of their original flexibility and physical toughness while exposed to gamma radiation.

[h] Robert Harrington, Hanford Laboratories Operation, General Electric Co.

ADIPRENE® L 100
ELECTRICAL PROPERTIES

OUTGASSING

Products made from ADIPRENE L 100 are very stable under high vacuum conditions. They exhibit extremely low weight losses in standard outgassing tests. This property, combined with excellent low temperature performance, suggests applications in the aerospace field.

Table XXII

Electrical Properties

ADIPRENE L 100	100
MBCA	13

Mixing and Curing

Mixed at 212°F (100°C)
Cured: 1 hour at 212°F (100°C), Postcure 16 hours at 158°F (70°C)

Test specimens were conditioned one week at 75°F (24°C), 50% RH before testing.

Electrical Properties	0.1 kHz	100 kHz
Power Factor, @75°F (24°C), %	9.45	5.92
@158°F (70°C), %	4.70	4.15
Dielectric Constant (SIC)		
@ 75°F (24°C)	9.37	7.78
@ 158°F (70°C)	11.05	9.62
@ 212°F (100°C)	11.48	9.87
DC Volume Resistivity, ohm-cm		
@ 25°F (24°C)	4.8×10^{11}	
@ 158°F (70°C)	3.8×10^{10}	
@ 212°F (100°C)	2.3×10^{10}	

Table XXIII

Flammability Tests - Diamine Cures

ADIPRENE L100/MBCA (12.5 phr)

Flame Retardant	Retardant Conc (phr)	Burning Rate inch/min (cm/min)†
None	0	1.05 (2.68)
FyrolFR-2	5	—
	10	—
	15	—
Thermoguard H	5	1.12 (2.87)
	10	—
	15	1.26 (3.20)
Thermoguard L	5	—
	10	—
	15	—
Oncor-23A	5	0.45 (1.14)
	10	0.81 (2.06)
	15	—
Compound		
ADIPRENE L 167/MBCA (19.1 phr)	0	0.73 (1.85)
ADIPRENE L 315/MBCA (26 phr)	0	0.86 (2.18)
ADIPRENE L 420/MBCA (8.8 phr)	0	2.21 (5.61)

† This numerical flame spread rating is not intended to reflect hazards presented by this or any other material under actual fire conditions.

PROCESSING

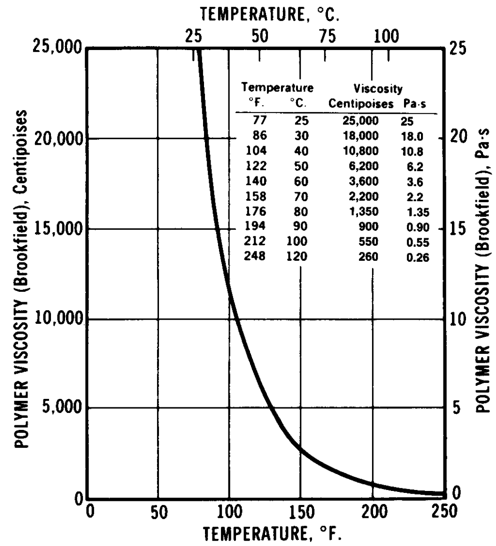
The low viscosity and reactivity of ADIPRENE L 100 make it relatively easy to process, either by batch or machine mixing. These properties also permit products based on ADIPRENE L 100 to be formed by any of a variety of methods (to be discussed later), which include casting, spraying and spread coating. It is even possible to make such unique items as conveyor belts by these special processing techniques.

POLYMER VISCOSITY

The viscosity of ADIPRENE L 100 polymer is 15,000 to 21,000 centipoises (15 to 21 Pa·s) at 86°F (30°C). Viscosity decreases rapidly with increasing temperature up to 158°F (70°C) and is relatively constant at temperatures above 212°F (100°C). The relationship between viscosity and temperature for ADIPRENE L 100 urethane rubber is shown in *Figure 13.*

Figure 13

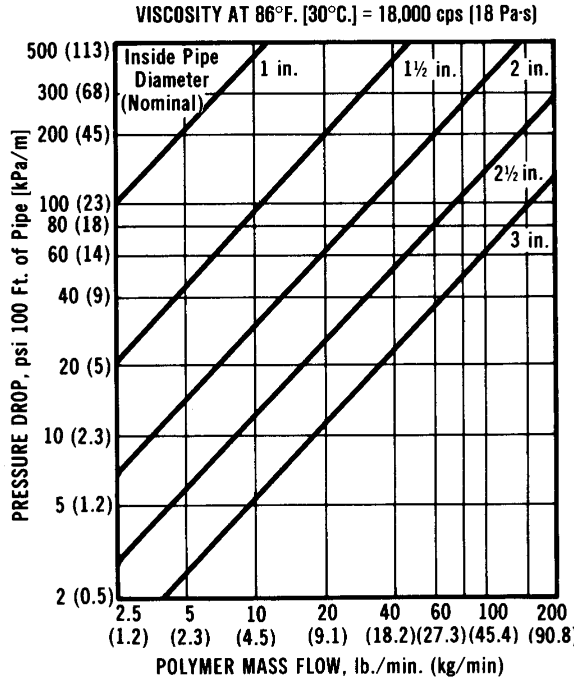
Viscosity vs Temperature



Because of its high viscosity at room temperature, particular attention must be given to the size of piping and transfer pumps for handling ADIPRENE L 100. Positive displacement pumps of gear, piston or screw design can be used for bulk transfer. Pump ports should be larger than those required for less viscous fluids. For handling the polymer at viscosities greater than 5,000 centipoises (5 Pa·s), gear pumps are usually the most satisfactory; they should be used for throughputs of no more than 50% of the manufacturer's rating. (*Figure 14)*

Figure 14 ·

VISCOSITY AT 86°F. [30°C.] = 18,000 cps (18 Pa·s)



The selection of pipe size for processing fluid polymers is dependent upon the specific system requirements. The Fanning Equation develops data of line loss when these requirements are known. A series of data plots are presented here for ADIPRENE L 100 utilizing the Fanning Equation. The curves are plotted using a known (or assumed) specific gravity, viscosity, pipe size and length, velocity of flow, and friction factor. The plots show pressure drop per 100 ft. of pipe plotted against pipe size and fluid flow. The equivalent pipe lengths for valves, pipe turns, and fittings can be obtained from published data and used to determine total hydraulic line loss.

The data are based on the fluid viscosity at 86°F (30°C). The viscosity effect due to temperature change cannot be included in the data as plotted and a correction must be made to obtain the actual ΔPat processing temperature. The corrected ΔP can be obtained by multiplying the plot data by the viscosity of the polymer at the required temperature divided by the viscosity at 86°F (30°C).

The Fanning Equation is:

$$h = \frac{flv^2}{2gd}$$

When h = head loss due to friction,
f = friction factor involving viscosity
l = length of pipe line,
v = velocity of flow,
g = acceleration of gravity,
d = inside diameter of pipe

POLYMER DEGASSING

Because of its viscosity and surface tension characteristics, ADIPRENE L 100 will entrap air and other gases during shipping and handling. To insure uniform, void-free vulcanizate castings, the polymer must be degassed prior to addition of the curing agent.

Degassing is accomplished by heating the polymer to 180°F (82°C)-212°F (100°C), at an absolute pressure as low as two to five millimeters of mercury (266 to 666 Pa). Degassing is complete when vigorous foaming stops. (Note: Minor bubbling persists after the polymer has been effectively degassed, but bubbles do not appear in the vulcanizate.) The time required to degas depends upon the amount and temperature of the polymer, the size and shape of the vessel, the degree of vacuum used, and the amount of air and other gases entrapped. Degassing time for a given set of conditions must be determined experimentally. However, up to one pound (0.45 kilogram) of ADIPRENE L 100 may be effectively degassed within eight to ten minutes at 185°F (85°C) and at two to five millimeters of mercury (266 to 666 Pa) pressure; two to two and one-half gallons (7.6 to 9.5 liters) of the polymer may be degassed in 45 to 60 minutes under the same conditions.

Continuous degassing equipment that is commercially available effectively degasses as much as ten pounds (4.5 kilograms) of ADIPRENE L 100 per minute under these conditions.

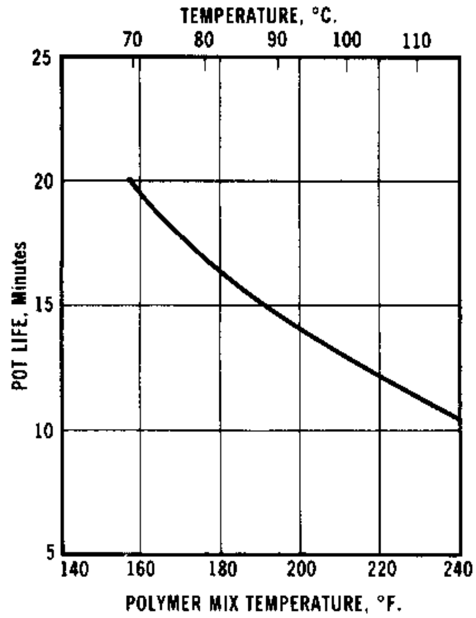
Batch degassing systems should provide at least 50% freeboard — i.e., the vessel should be twice the volume of the polymer to be degassed — to allow for the foaming action which occurs at the beginning of the degassing step.

If necessary, foaming of ADIPRENE L 100 can be effectively reduced by adding small amounts (0.01 to 0.25 phr) of methylsilicone oil to the polymer. At this low concentration the silicone oil appears to have little effect on vulcanizate properties. These points should be checked for each application.

BATCH MIXING Curing with MBCA

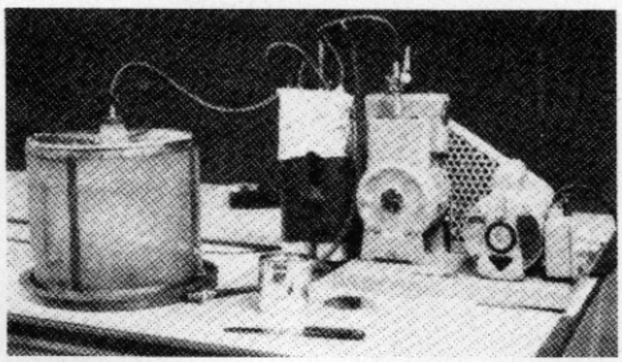
The pot life of ADIPRENE L 100 urethane rubber cured with MBCA curing agent is long enough to make the batch mixing technique very useful as a method of preparing products. Pot life at 212°F (100°C) is about 10 minutes, and may be further extended by reducing the mixing temperature (*see Figure 15*).

Figure 15 — **Pot Life vs Mix Temperature for Compounds Cured with MBCA**



Batches as large as 1 to 2 lbs. (0.45 to 0.90 kilogram) in weight can be prepared by the batch mixing procedure outlined in *Table XXV* using the equipment shown in *Figure 16.*

Figure 16 — **Equipment for Batch Mixing**



Although this procedure has been developed for small batches, the basic elements, i.e., a pot with facilities for heating, cooling, stirring and vacuum, also apply to large-scale batch or continuous mixing operations.

Table XXV

Batch Mixing of Compounds of ADIPRENE L 100 and MBCA

Step:	**1**.	Weigh out the proper amounts of polymer and curing agent into separate containers.
Contents:	a.	The container should have at least twice the volume of the polymer to allow for foaming during degassing. Unlined metal cans or glass containers may be used. Paper cups should not be used.[I]
Step:	**2.**	Heat the polymer at 212°F (100°C) in a dry air oven and stir the mixture. Add fillers or plasticizers until it is homogeneous.
Contents:	a	The container should be covered with aluminum foil during preheating.
	b.	The polymer is preheated to a temperature above the mixing temperature to allow for cooling while degassing.
	c.	Additives should be dry.
Step:	**3**.	Melt and heat MBCA to 250°F (121°C) in a controlled temperature oven.
Contents:	a.	MBCA, a solid at room temperature, melts quickly at 250°F (121°C). CAUTION: MBCA should not be heated above 285°F (140°C).

ADIPRENE® L 100
BATCH MIXING (cont'd)

Step: **4**. Place the polymer in a vacuum desiccator and degas for 10 a. minutes at a maximum absolute pressure of 5 mm of mercury (666 Pa).

Contents: a. A protective shield should be used to cover the desiccator.

b. Degassing should be observed carefully until initial foaming has subsided, to prevent "boil-over."

c. Some bubbling may still be evident at the end of ten minutes, but degassing is essentially completed.

d. After degassing, air is introduced into the desiccator. This should be done carefully to avoid agitating the polymer surface.

Step: **5**. Remove mixing can from desiccator and adjust the polymer a temperature to the desired mixing temperature.

Contents: a. The mixing temperature is critical and should be controlled within ±5°F (±2.8°C) of the selected temperature.

Step: **6**. While slowly stirring the polymer by hand with a spatula, add the MBCA as a liquid at 250°F (121°C) over a 3-5 second period and mix thoroughly for approximately two minutes.

Contents: a. Mixing should be thorough, but done gently to prevent air entrapment.

b. Agitation of the polymer should begin before the MBCA is added in order to obtain good dispersion and prevent settling of the heavier MBCA.

c. The mixture may be degassed again if air is entrapped during mixing, provided pot life permits.

d. An electric mixer may be used, but must be set to run slowly to prevent air entrapment.

Step: **7**. Cast mixed compound into the mold.

Contents: a. Casting should be done as quickly as possible.

b. The drop distance between the mixing container and mold should be kept to a minimum to prevent air entrapment.

Step: **8**. Place the filled mold in an oven and cure for the required time.

Contents: a. It is not necessary to complete the cure in a mold; the article may be removed from the mold when strong enough, and the cure continued in an oven or at room temperature.

Step: **9**. Clean-up.

Contents: a. The mixing equipment should be cleaned as soon as possible after casting. Excess compound may be removed by wiping with paper towels saturated with acetone, methylene chloride or xylene. Toluene may be used for the final cleaning.

[I] The paper cups may contain sufficient moisture to upset the balance between curing agent and polymer. The result is a poor cure. For example, an 8 oz (237 cm^3) paper cup, required for convenient mixing of 100 g of ADIPRENE L polymer, may lose 0.8 to 1 gram in weight when heated 15 minutes at 285°F (140°C). This quantity of water is sufficient to react with all the isocyanate in 100 grams of ADIPRENE L 100. Contamination of the ADIPRENE L 100 with only a small portion of this water can increase the total curing agent/ isocyanate ratio to well over 100% of theory. Drying the cups in an oven before use will not help, since the cellulose absorbs water from the air at a relatively rapid rate after the cup is removed from the oven.

MACHINE MIXING

ADIPRENE L 100 can be processed satisfactorily with commercially available mixing machines. An effective machine should be able to (1) heat the reactants, (2) degas the polymer, and (3) accurately meter and (4) uniformly mix the reactants. The handling system for MBCA curing agent must be designed to keep it molten without overheating it. (Not above 285°F (145°C).

Two basic types of machines, **intermittent** and **continuous,** are available; the choice between them depends upon the mold sequence and the reactivity of the system.

Intermittent Mixers

An intermittent machine is one which delivers mixed compound in discrete shots, in a pulsating manner, and in which the mixing chamber is kept full of mixed material between shots. Molds can be filled successively without waste of material, since there is always mixed material available for discharge. However, the dwell time between shots is limited by the pot life of the mixed reactants. For ADIPRENE L 100 cured with MBCA, mixed at 195°F (90°C), the maximum time between shots is about three minutes.

The available operating time of an intermittent mixer is limited by buildup of gelled material within the mixing cavity and around the agitator. This build-up leads to inadequate mixing and, eventually, to complete stoppage of the mixer cavity. This normally is not a problem for ADIPRENE L 100 cured with MBCA, but must be considered for catalyzed cures with MBCA or faster amine systems. When using MBCA, with a delay period of 20 seconds between 90 gram shots (during which the mixing chamber is filled with mixed compound), the machine may be expected to run continually in excess of twelve hours before the mixer must be removed for cleaning. If the compound is catalyzed to give 5 minutes pot life, eight hours is the limit under the same conditions; if the compound is catalyzed to a pot life of 2 minutes, the limit is about four hours. These factors must be considered in planning for the use of an intermittent machine for production processing.

Continuous Mixers

A continuous machine delivers a stream of mixed material on demand. When the delivery is stopped, the mixing head empties and remains empty until more material is called for. The first mixed material discharged after a shutdown and subsequent startup contains entrapped air and must be discarded.

Metering in continuous mixing machines may be accomplished by gear pumps, double-acting piston pumps, or phased multiple pulsating pumps. Compounds of ADIPRENE L 100 and MBCA have been satisfactorily processed in a continuous gear pump machine. In this type of equipment, even catalyzed cures of ADIPRENE L 100 may be processed without time limitation, since the residence time of any segment of mixed compound within the mixing chamber is extremely short. At the end of a mixing run, the head is usually flushed with solvent and remains empty until the next run is begun.

TECHNIQUES OF MACHINE PROCESSING

Metering

A mixing machine should be designed to provide reactant stream metering accuracy within ±1.0%. ADIPRENE L 100 urethane rubber polymer presents no unusual metering problems.

Changes in viscosity affect the accuracy of machines which meter volumetrically without a mechanical linkage between the polymer and curing agent metering systems. Gross changes in viscosity can result in significant metering variations, and must be taken into consideration in establishing processing conditions. At temperatures above 158°F (70°C), the polymer viscosity changes only slightly with temperature changes. (see *Figure 13*). Processing temperatures above 158° F (70°C) should, therefore, provide satisfactory metering accuracy.

Mixing

Good mixing is essential for uniformity and reproducibility of products based on ADIPRENE L 100. If mixing is marginal, some phase separation may occur. Separation is more likely to occur when the components differ greatly in density, as is the case with ADIPRENE L 100 and MBCA. Fortunately, most diamines, and particularly MBCA, are readily soluble in ADIPRENE L 100, and can be easily mixed with the polymer in a well designed mixing head. Generally, a high shear mixer should be used, with a minimum rotational speed of 4000 rpm.

Cleaning of Equipment

Solvent Flushing – Methylene chloride[j] is the preferred solvent for flushing the mixing head for machine shut down. Little solvent activity is required for this use, and methylene chloride is adequate for purging reactive material from the mixer. It is suggested that the amount of solvent used during the flushing step be equal to at least ten times the volume of the mixing chamber, to insure complete purging. The degasser and all lines should be flushed with a suitable plasticizer such as Benzoflex 988 or dioctyl phthalate.

Cleaning of Parts – Gelled ADIPRENE L 100 may be removed from mixer parts by solvent soaking or burning. The parts should be immersed for at least 16 hours at room temperature in dimethyl formamide[k] (DMF) containing 2% n-butylamine. After this treatment, the compound can be peeled or brushed easily from the part.

For difficult cleaning jobs, or where rapid cleaning is desired, cured material may be burned or melted away.

[j] Methylene chloride should be used only in a well-ventilated area. Contact of the liquid or vapor with the eyes and skin should be avoided.

[k] DMF should be used only in a well-ventilated area; if ventilation is inadequate fresh air masks should be used. Contact of liquid DMF with the skin should be avoided. If any is spilled on the skin, it should be removed immediately by flushing with generous quantities of water. DMF should never be mixed with halogenated solvents (i.e. methylene chloride, carbon tetrachloride, per chloroethylene, trichloroethylene, FREON®, etc.) because explosive mixtures may, develop.

ADIPRENE® L 100
MOLDING

MOLDING

The fact that ADIPRENE L 100 is a liquid is an advantage in that most molded goods may be prepared without the use of heavy equipment. In addition, a fluid-based process lends itself to a high degree of automation.

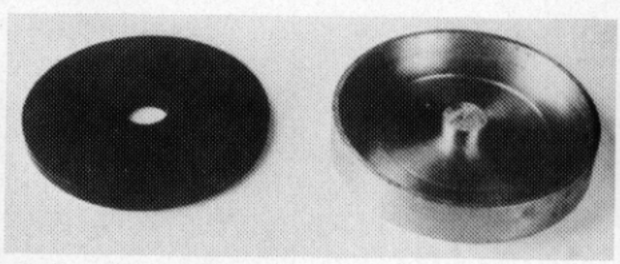
Compounds of ADIPRENE L 100 are adaptable to a wide variety of molding methods. Before discussing specific methods, however, it may be helpful to review some general considerations which apply to all these techniques.

Molding Methods

Open Casting is the simplest method of preparing parts of ADIPRENE L 100. The polymer/curing agent mix is poured into an open mold and kept there, without applying pressure, until the mix sets. The major concern in open casting is to distribute the mixed material carefully to avoid air entrapment. One basic principle is to keep the drop distance to the mold at a minimum to prevent splashing.

Large parts can be made readily by casting ADIPRENE L 100 with MBCA as the curing agent, even though some sections of the casting may be gelled before the mold has been filled completely. For example, parts weighing 1000 pounds (454 kilograms) have been cast, using a mixing machine with a discharge rate of 15 to 20 pounds (6.8 to 9 kilograms) per minute. Care should be taken to prevent voids from forming at the knitting line between fluid and gelled material. Newly poured material knits well to previously gelled material if subsequent pours are made within 45 minutes of each other.

Figure 17
Open Casting



The top surface of an open casting is necessarily flat, but the presence of a meniscus prevents it from being a dimensionally accurate plane. *Figure 17* shows a flat seal made by open casting — a typical application of this molding technique.

Molds with irregular interiors are sometimes best cast using the *bottom-fill* method. The mix is fed into the bottom of the mold by means of a fill tube; as the material rises to fill the mold, air is purged through vents in the top. Air entrapment is thus minimized.

Casting-Compression Molding, (or gel molding) is generally used with parts which must be molded to close tolerances. The polymer/curing agent mix is cast into a compression mold and allowed to gel. Pressure is applied to form the gelled material, and held until the reactants have set. The best time at which to apply pressure should be determined by experiment for each individual molding application. Heat is applied through the platens of the press. Mold venting is not generally required.

Liquid Injection Molding is similar to transfer molding, except that the fluid mix is forced, under pressure, directly from the mixer into the mold. Pressures of 40 to 100 psig (0.38 to 0.79 M Pa) are required with ADIPRENE L 100. The distance the mix can be made to flow is determined by the gelation characteristics of the compound. Vents, runners, or flash grooves are used to purge air ahead of the mix.

Transfer Molding can be used for volume production of small parts. The polymer/curing agent is deposited as a liquid in the cylindrical transfer cavity and allowed to thicken. Pressure is then applied to the cavity by means of a piston, and the gelled material is forced through sprues and runners into the mold. Runner and vent sizes in the mold depend upon the viscosity of the gel, pressure in the transfer cavity, and desired throughput. One type of transfer mold is shown in *Figure 18.*

Figure 18
Transfer Molding

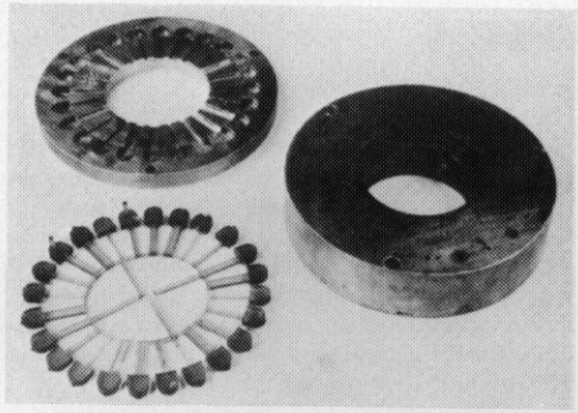
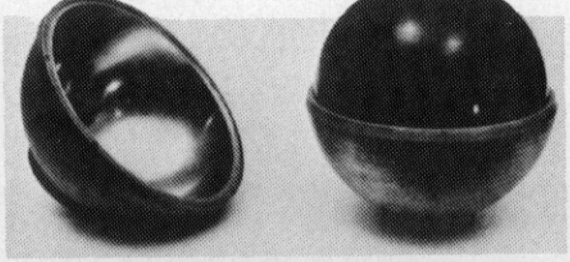


Figure 19
Rotational Casting

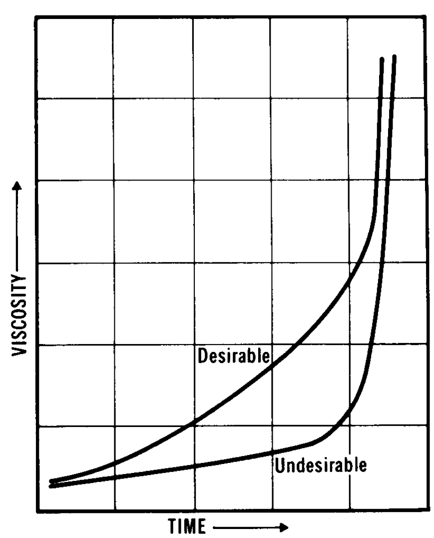


Rotational Casting is used to mold hollow objects, such as the ball shown in *Figure 19.* The technique is similar to that used with vinyl plastisols. The polymer/curing agent mix is deposited in the mold and the mold is rotated in two planes simultaneously until the compounds sets.

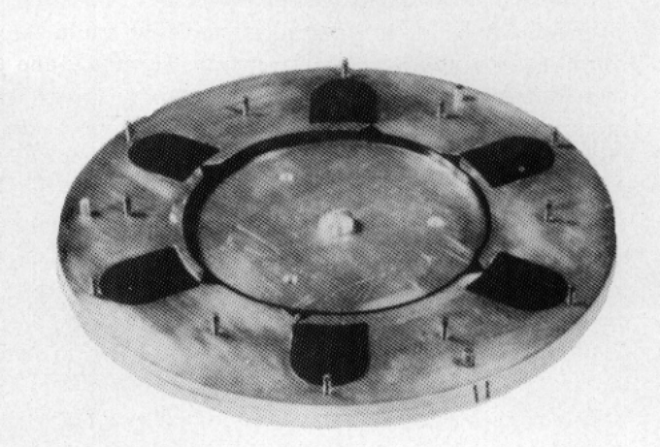
The speed of rotation is 2 to 15 r/ min. Hollow objects with walls up to ½ inch (1.3 cm.) thick can be made by this technique, depending upon the characteristics of the compound.

Pot life and viscosity build-up of the compound are the two most important factors for rotational casting. The minimum pot life required is 8 to 10 minutes. This is necessary to permit the compound to uniformly coat the walls of the mold before gelation begins. The ideal viscosity curve has a gradual rate of increase to gelation instead of an abrupt viscosity rise. A representation of an idealized viscosity curve is shown, in *Figure 20.*

Figure 20
Ideal Viscosity Increase for Rotational Molding



ADIPRENE® L 100
CASTING



Centrifugal Casting is used to produce molded items with sharp detail. The fluid mix enters the center of the mold and is pushed into the cavity by centrifugal force. Degassing can be accomplished simultaneously. Even highly catalyzed cures of ADIPRENE L 100 may be distributed in this manner. Rotational speeds required depend upon mold configuration and the viscosity of the mix, but are generally in the range of 1500 to 6000 feet/minute (7.6 to 30.5 m/s) at the mold cavity. *Figure 21* shows a mold for centrifugal casting.

Vacuum Casting is used for finely detailed and intricately shaped pieces, where air entrapment would be a serious problem. The mold is placed in a large chamber and the entire chamber is evacuated. The mold can be filled by gravity flow or by utilizing the pressure of the mixer. The polymer is degassed during the molding cycle. Vacuum casting is most practical for compounds having a pot life of five minutes or longer.

Mold Materials

For molding methods not requiring the application of external pressure, molds may be made from a wide variety of materials, ranging from wood or plastic to steel. Three standards should be applied to any material being considered for use as molds for ADIPRENE L 100:

Dimensional stability - particularly at processing temperatures.
Heat resistance - ability to resist processing temperatures without degradation.
Inertness - having no influence on the reaction of the cast material.

Considering the above, ADIPRENE L 100 cured with MBCA is the most practical mold material for use with all of the ADIPRENE urethane rubbers. Molds are quickly fabricated and can be machined with ease. It is durable enough for high volume production usage, yet inexpensive enough for short run or prototype work. When used with 100% of the stoichiometric amount of MBCA curing agent (13 phr) to provide the highest practical tear strength for prolonged mold life.

Other materials useful for molding applications are:

steel	sealed mahogany	reinforced polyester
cast iron	silicone rubber	nylon 66
aluminum	metal-filled urethanes	acetal resins
low-melt alloys		polypropylene
metal-filled epoxy		FEP fluorocarbons

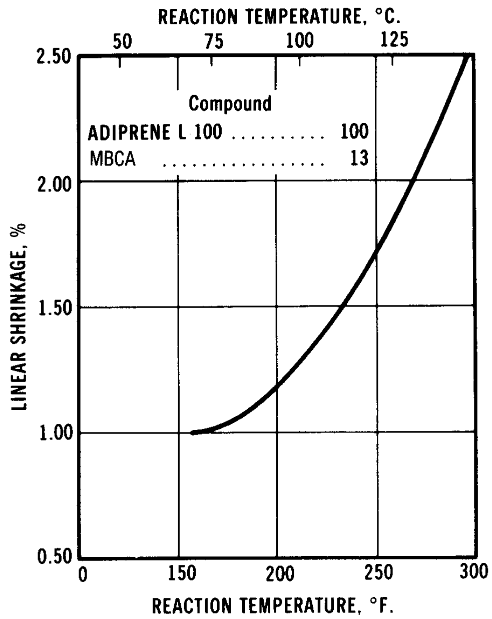
Plaster is generally not acceptable as a mold material for use with ADIPRENE L 100. Moisture within the plaster is driven out at elevated temperatures and will be available for reaction with the ADIPRENE L 100. Even sealed plaster is not acceptable for use. Most woods present similar problems. However, high density woods such as mahogany may be filled and sealed adequately for use in prototype work.

Shrinkage

The normal linear shrinkage of ADIPRENE L 100 cured with MBCA is 1.0 to 1.5% in all molding methods. Shrinkage is primarily thermal rather than chemical and therefore increases as the cure temperature or the exotherm temperature increases. The relationship between linear shrinkage and reaction temperature is shown in *Figure 22.* If molding tolerances are to be held within close limits, shrinkage must be taken into account in mold dimensions; i.e., they should be oversize. The molded part may be expected to shrink inward from the walls of a containing mold and inward against an insert within the mold.

Figure 22

Linear Shrinkage vs Reaction Temperature



In certain critical cases involving complex molds, the slight amount of chemical shrinkage may be sufficient to cause internal tearing before the compound has sufficient strength to resist it. This can be minimized by reducing the mixing and mold temperatures 10 to 15°F (6 to 9°C) and increasing the oven temperature 10 to 15°F (6 to 9°C). This causes the ADIPRENE L 100 urethane rubber to expand slightly as it cures, offsetting the effect of chemical shrinkage.

Note that the exothermic temperature rise can cause the interior of a casting to become warmer than the part of the casting in contact with the mold surface. This may result in differential shrinkage with one part of the casting shrinking slightly more than another. This is generally not a problem except in highly critical work, but it can be minimized by reducing the mix temperature by an amount equal to the exothermic temperature rise, so that the final temperature differentials in the body of the casting are reduced.

The actual dimensions of a molding depend upon its moisture content, which in turn depends upon the relative humidity of the air to which the part is equilibrated. ADIPRENE L 100 cured with MBCA changes in dimension very little over the range of 0 to 70% relative humidity at room temperature, but swells slightly as the relative humidity approaches 100%:

Relative Humidity, 73°F (23°C)	Relative Linear Expansion
0%	0%
50%	+0.1%
100%	+0.6%

Thus, the measurement of shrinkage depends upon the moisture content of the air and the length of time for which the part is exposed to the air. A part measured immediately after removal from the mold will appear to show more shrinkage than the same part measured two days later, if the humidity is high, since the part will have expanded slightly during exposure to the air. For consistent results, the shrinkage should be determined immediately after the part has been demolded and cooled to room temperature.

Mold Release

Effective release techniques are important in the molding of parts of ADIPRENE L 100. There are three types of treatment for molds. Molds can be recoated after each cycle with temporary release agents; they can be retreated after every 15 to 20 cycles with a semi-permanent agent; or they can be coated permanently with a durable film. Representative mold release agents of each type are listed below:

One-Shot	Semi-Permanent	Durable Film
DC-4 Silicone	TEFLON TFE Nonsticking finish	TEFLON FEP Film
DC-20 Silicone	VYDAX AR fluorocarbon telomer	Polypropylene
Chesterton film Product No. 81801		MYLAR polyester film

Adhesion

The adhesion to metal of compounds of ADIPRENE L 100 is very good if an adhesion primer is used. (See *Table XXVI*) Excellent bond strengths are obtained when primers are properly applied. For example, peel adhesion values exceeding 300 lb/in (52.5 kN/m) at 90° peel and 2 in/min (5.08 cm/min) ASTM D-429-73, Method B) have been measured between steel surfaces and cast ADIPRENE L 100 urethane rubber cured with MBCA curing agent. Stock failure — not bond failure — occurred in most test samples.

Table XXVI

Primers for Bonding Liquid Cast ADIPRENE to Metals

Primer	Function
Thixon 405	General purpose one-coat primer. Provides strong bonds for high temperature service.
Thixon 406	One coat adhesive for liquid cast ADIPRENE with diamine or polyol curing systems.
Chemlok AP 218	General purpose one-coat primer for ambient or elevated temperature application and service.
Chemlok AP 210	General purpose one-coat adhesive for ambient or elevated water immersion application and service.

ADIPRENE® L 100
ADHESION

Static adhesion values cannot always be correlated with bond performance in dynamic service; therefore, end-use tests should be run before selecting an adhesive for dynamic service. The adhesives tested have been found satisfactory for many dynamic applications. For specific bonding problems, it is suggested that the primer manufacturers be contacted for their best recommendations.

Table XXVII outlines the procedure for bonding ADIPRENE urethane rubber to metal surfaces.

Table XXVII
Procedures for Bonding Liquid Cast ADIPRENE to Metals

1. Degrease metal surface with suitable solvent to reduce contamination of grit.

2. Grit blast metal surface to be bonded. Satisfactory metal surfaces have been prepared using No. G40 or No. G50 steel grit or aluminum oxide - 60 mesh at 80-100 psi (0.65 to 0.73 MPa) air pressure.

3. Degrease metal with solvent; toluene, methyl ethyl ketone, trichloroethylene or perchloroethylene. Avoid using fast evaporating solvents such as acetone or methylene chloride as they may cause moisture condensation on the metal surface and result in poor adhesion.

   - It is best to prepare surfaces just before application of the primer to prevent rusting and contamination. Care should also be taken in the selection and application of mold releases required on adjacent surfaces. Contamination with mold releases will seriously affect bond strengths. Do not handle surfaces to be bonded with bare hands; use only clean gloves.

4. Apply primer coat (brush, spray, dip or roller) and allow to air dry for about 30 minutes.

   - Note: there are a number of variables which must be considered when applying the primer; one coat versus two coats (optimum coating thickness is 0.5 to 1.5 mils), (0.013 to 0.038 mm), air drying versus prebaking, etc. In any case, the supplier should be consulted for specific instructions.

5. Preheat metal part and mold to 212°F (100°C) before casting. Lower processing temperatures may reduce "wetting" of the surface and could result in poor bond strengths.

6. Cast mixture of ADIPRENE prepolymer and crosslinking agent and cure according to procedures prescribed for the ADIPRENE system being used.

Solution Techniques

Compounds of ADIPRENE L 100 and MBCA react much more slowly in solvent solution than as simple mixtures. Consequently, the working life of these compounds, which is normally measured in minutes, can be extended to several hours if they are prepared in solution. These solution systems have relatively low viscosity at room temperature and are of interest for spraying, brushing, knife or roller coating, dipping, saturation, or impregnation. The solution technique can also be used with curing agents other than MBCA.

The moisture content of the solvent affects the working life of the solution, since water reacts with the ADIPRENE L 100 polymer. Solvents used should be as dry as possible.

The procedure for preparation of solutions of ADIPRENE L 100 and MBCA curing agent is as follows:

1. Mix the ADIPRENE L 100 and the solvent at room temperature (about 75°F [24°C]).
2. Add MBCA which has been melted and heated to 250°F (121°C). MBCA dissolves readily and does not crystallize if stirred rapidly into the cooled polymer solution.
3. Mix well.

Alternatively, MBCA can also be dissolved in a separate portion of the solvent at room temperature, and the two solutions can then be mixed together. The use of this technique is dependent upon the solubility of MBCA in the solvent at room temperature. Solubility of MBCA in the solvents used in this study is shown in *Table XXVIII*.

Table XXVIII

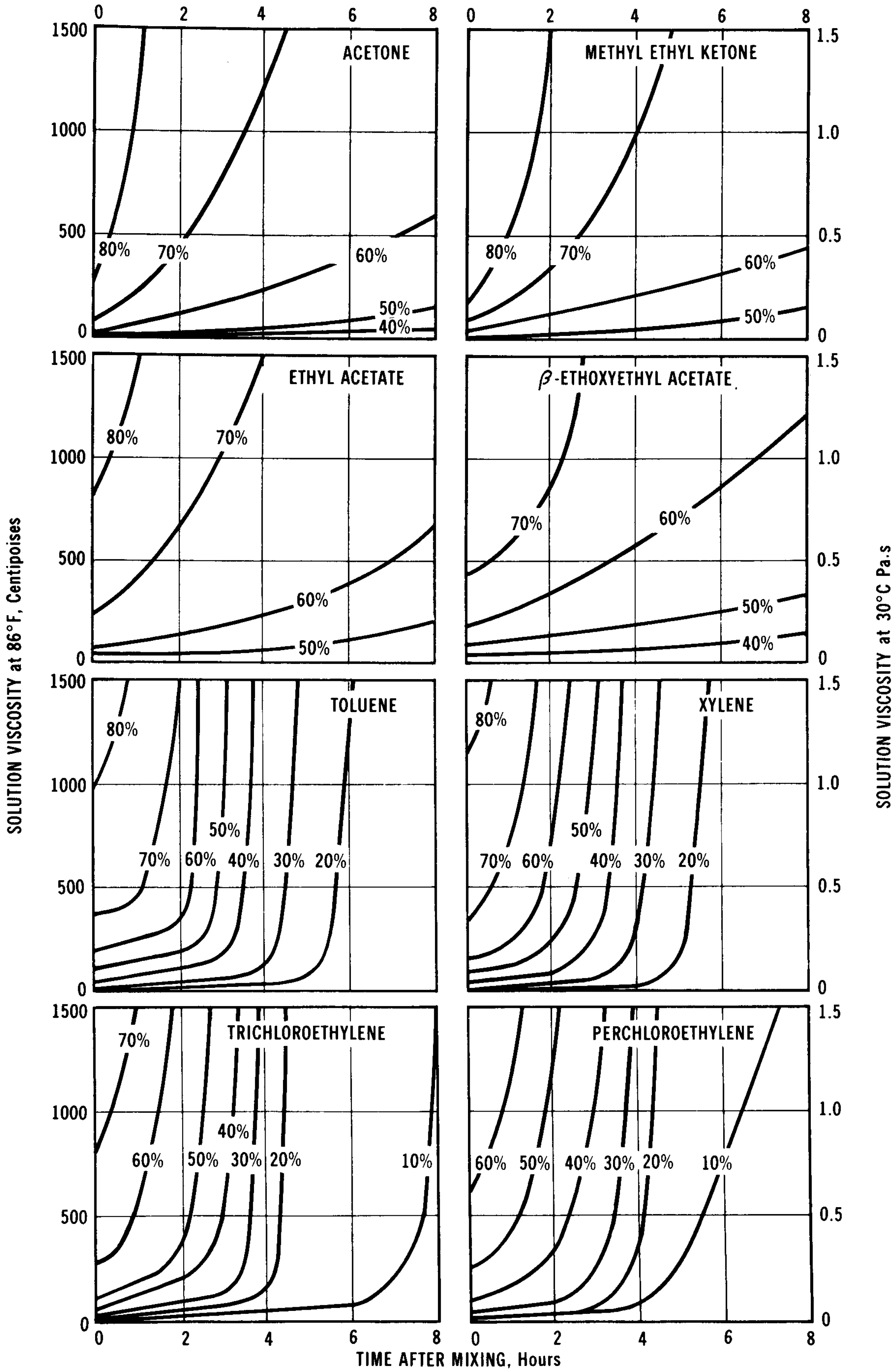
Solubility of MBCA in Various Solvents at 75°F (24°C)

Solvent	Solubility, % by weight
Acetone	54.0
ß-Ethoxyethyl acetate	34.4
Ethyl acetate	32.6
Methyl ethyl ketone	51.0
Perchloroethylene	0.9
Trichloroethylene	4.2
Toluene	7.5
Xylene	4.3

Figure 23 show the viscosity-time relationship of a typical compound of ADRIPRENE L 100 and MBCA in various solvents. In the graphs, the numbers on the curves represent the concentration (% by weight) of the compound in solution. The solutions were stored a temperatures of 75 to 86°F (24 to 30°C).

ADIPRENE® L 100
Viscosity Time Relationship

Figure 23 —**ADIPRENE L 100 in Solution**
ADIPRENE L 100 . . . 100/MBCA . . . 12.5



ADIPRENE® L 100
PROPERTIES OF SPRAYED COATINGS

Airless Spraying

High quality coatings of ADIPRENE L 100 may be applied using the techniques described. Typical film properties of sprayed coatings are shown in *Table XXIX*.

Table XXIX
Properties of Sprayed Coatings Cured with Methylene Dianiline

Cure	**7 days at 86°F (30°C)**	**60 minutes at 212°F (100°C)**
100% Modulus,[1] psi (MPa)	800 (5.5)	900 (6.2)
300% Modulus, psi (MPa)	1300 (9.0)	1525 (10.0)
Tensile strength, psi (MPa)	3600 (24.8)	5200 (35.8)
Elongation at break, %	430	450
Tear strength, ASTM D-470, lb/in (kN/m)	43 (7.5)	49 (8.6)
Abrasion resistance (Taber) mg/1000 rev. CS-1y wheel with 1000 g weights	2.5	2.3

[1] Tested according to ASTM D-412; samples were 5 to 9 mils (0.13 to 0.23 mm) thick; head speed was 20 in. (50.8 cm) per minute.

The airless spray system (*Figure 24*) uses a positive displacement metering unit and an internal-mix airless spray gun. The required equipment is listed in *Table XXX*. A typical formulation for use with this system in shown in *Table XXXI.*

Figure 24
Airless Spray System

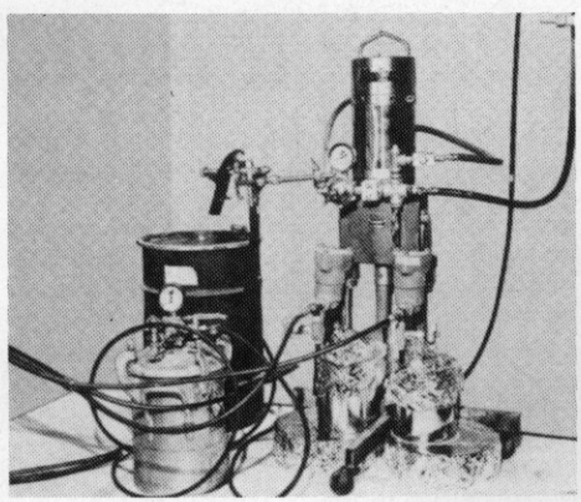


Table XXX

Equipment for Airless Spraying of ADIPRENE L 100

Spray Gun	Binks Internal Mix Airless Gun, #102-1700, #43P.
Metering Control	Binks Formulator "C" Model 101-2700 with 5 inch (12.7 cm) air motor.
Auxiliary Equipment	9-1860, 9-1560 Airless nozzles. Lined rubber hose. Solvent flush pot (2-gal [17.6 litres] size).

Table XXXI

Spraying Formulation for a Two-Component Airless Spray System (1:1 Ratio Binks Formulator C)

Polymer Solution	Parts by Weight	Stream Ratios-cm^3
ADIPRENE L 100	650	1000
Toluene	335	
Curing Agent Solution		
Methylene dianiline (MDA)	62.4	1000
Ethyl acetate, urethane grade	853	

Dry film build-up is about 5 mils (0. 13 mm) per pass. Films up to 50 to 60 mils (1.3 to 1.5 mm) thick can be obtained by discontinuous spraying. The technique is to spray 15 mils (0.39 mm), allow the wet coating to dry 25 minutes until tacky, spray again, and continue the process until the desired thickness is obtained.

The airless system has three advantages over the air pressure spray system:

1. The positive displacement metering unit gives a degree of control and accuracy that cannot be obtained with needle valve orifices.
2. The low pressure exit from the spray gun substantially reduces over-spray.
3. Thicker films may be deposited on a single pass.

Curing

An oven cure of 60 minutes at 212°F (100°C) is sufficient to cure coatings of ADIPRENEL 100. An equivalent cure is obtained at room temperature within seven days. If an oven cure is used, a delay of 20 to 30 minutes at room temperature is advisable to permit solvents to evaporate so that the film does not develop bubbles during cure.

Adhesion

A primer is required to obtain a good bond between the coating of ADIPRENE L 100 and metal. Hughson and Thixon primers are satisfactory for **room temperature** bonding, although a heat cure yields improved adhesion. (See *Tables XXVI and XXVII).*

APPENDIX A
CALCULATION OF AMOUNT OF CURING AGENT

The amount of amine or polyol to be used in curing ADIPRENE L 100 (or any liquid urethane prepolymer) can be calculated from the general formula:

Parts curing agent per 100 parts polymer =

$$\% \text{ NCO of polymer} \times \frac{\text{equivalent weight of curing agent}}{\text{equivalent weigh tof NCO}} \times \frac{\text{desired \% theory}}{100}$$

For **MBCA**, this formula reduces to: parts MBCA per 100 parts polymer

$$= \% \text{ NCO} \times \frac{133.5}{42.02} \times \frac{\% \text{ theory}}{100}$$

$$= \frac{\% \text{ NCO} \times 3.18 \times \% \text{ theory}}{100}$$

For **CAYTUR 21**, the formula reduces to: parts CAYTUR per 100 parts polymer

$$= \% \text{ NCO} \times \frac{217}{42.02} \times \frac{\% \text{ theory}}{100}$$

$$= \frac{\% \text{ NCO} \times 5.17 \times \% \text{ theory}}{100}$$

For **1,4-butanediol**, the formula reduces to: parts 1,4-butanediol per 100 parts polymer

$$= \% \text{ NCO} \times \frac{45}{42.02} \times \frac{\% \text{ theory}}{100}$$

$$= \frac{\% \text{ NCO} \times 1.07 \times \% \text{ theory}}{100}$$

EXAMPLES:

If % NCO of polymer = 4.1, and % theory = 95

parts CAYTUR 21 per 100 parts polymer

$$= \frac{4.1 \times 5.17 \times 95}{100} = 20.1$$

parts MBCA per 100 parts polymer

$$= \frac{4.1 \times 3.18 \times 95}{100} = 12.5$$

parts 1,4 - butanediol per 100 parts polymer

$$= \frac{4.1 \times 1.07 \times 95}{100} = 4.2$$

APPENDIX B
USA SOURCES OF MBCA

MVR Corporation
Executive Park North
Albany, NY 12203
Phone: (518) 489-6963

Anderson Development Co.
1415 East Michigan Street
Adrian, MI 49221
Phone: (517) 263-2121

NOTES ON TEST PROCEDURES
Test temperature is 24°C (75°F) except where specified otherwise

Test	Method
Abrasion Resistance, NBS	ASTM D1630, National Bureau of Standards Abrader
Brittleness Temperature, Solenoid	ASTM D746
Compression Set	ASTM D395, Method B (Type 1 pellets, 25% deflection)
Compression Modulus	ASTM D695
Electrical Properties:	
Dielectric Constant	ASTM D150
Dielectric Strength	ASTM D149
Power Factor Volume Resistivity	ASTM D150
Volume Resistivity	ASTM D257
Flex Life	ASTM D1052
Hardness, Durometer A or D	ASTM D2240
Ozone Resistance:	
Bent Loop	ASTM D 1149
Static Exposure, 20% strain	ASTM D 1149
Peel Adhesion	ASTM D429, Method B, pulled at 0.85 mm/s (2 in/ min)
Stress-Strain Properties 100% and 300% Modulus Tensile Strength Elongation at Break	ASTM D412, pulled at 8.5 mm/s (20 in/min)
Resilience, Rebound	ASTM D2632
Shrinkage, Linear	Accurate measurement of a 254 mm x 12.7 mm x 12.7 mm (10 in x 0.5 in x 0.5 in) bar after heat cure
Specific Gravity	ASTM D792
Tear Strength, Split	ASTM D470
Graves	ASTM D624, Die C
Torsional Modulus, Clash-Berg	ASTM D1043
Viscosity	Brookfield
Volume Change In Fluids	ASTM D471
Water Absorption (Weight Change)	ASTM D471
Young's Modulus	ASTM D797

PROPRIETARY MATERIALS

Proprietary compounding ingredients, solvents and equipment mentioned in this bulletin are identified below. The materials cited were those used in our work to obtain the reported results. This list is not exhaustive, nor is it intended to infer an endorsement of these manufacturers over any other who supply comparable products. For further information, request our TelTech "suppliers of urethane components and equipment."

PRODUCT NAME:	COMPOSITION:	SUPPLIER:
ADIPRENE® urethane rubber, "L" types	Reaction products of an aromatic diisocyanate and polyalkylene ether glycol.	Chemtura World Headquarters Middlebury, CT 06749
CAYTUR® 21	Approximately 50% (by weight) dispersion of methylene dianiline/sodium chloride complex in dioctyl phthalate	
Benzoflex*9-88SG plasticizer	Dibenzoate ester of dipropylene glycol or polyethylene glycol	Velsicol Chemical Co. 341 E. Ohio Street Chicago, IL 60611
Binks Spray gun with Formulation "C" metering control		Binks Manufacturing Co. 9205 W. Belmont Ave. Franklin Park, IL 60131
CHEMLOK * 218 and 210 adhesives	Proprietary adhesion primer of undisclosed composition	Lord Corporation Hughson Chemicals Div. 2000 W. Grandview Blvd. Erie, PA 16512
Chesterton Mold Release No. 81801	Proprietary release agent of undisclosed composition	A.W. Chesterton Co. Stoneham, MA 02180
Dow Corning *4 compound Dow Corning*20 release coating Dow Corning *200 fluid	Silicone grease Silicone oil Methylsilicone oil	Dow Corning Corp Saginaw Road Midland, MI 48640
Mylar* polyester film	Proprietary polyester resin in film form	DuPont Company Polymer Products Dept. Wilmington, DE 19898
SKYDROL* 500 hydraulic fluid	Phosphate ester	Monsanto Company 800 N. Lindbergh Blvd. St. Louis, MO 63166
TEFLON* FEP fluorocarbon film TEFLON* TFE fluorocarbon resin	Fluorinated ethylene propylene resin Polytetrafluoroethylene	DuPont Company Polymer Products Dept. Wilmington, DE 19898
THIXON* 405 and 406 bonding agents	Proprietary adhesive systems of undisclosed composition	Dayton Coatings and Chemicals-Whittaker Corp. P.O. Box 27 West Alexandria, OH 45381
VYDAX* AR fluorotelomer dispersion	Waxy short-chain telomers of tetra-fluoroethylene dispersed in trichlorotrifluoroethane	DuPont Company Chemicals, Dyes and Pigments Dept. Wilmington, DE 19898

* Reg. U.S. Pat. & Tm. Off.