Hypalon® chlorosulfonated polyethylene

A Product of DuPont Dow Elastomers

Types, Properties and Uses of Hypalon®

Hypalon® is the registered trademark for a series of chlorosulfonated polyethylene synthetic rubbers manufactured by DuPont Dow Elastomers. Vulcanizates of Hypalon® are highly resistant to the deteriorating effects of ozone, oxygen, weather, heat, oil and chemicals. Hypalon® resists discoloration on exposure to light, and is widely used in light-colored vulcanizates. It can be compounded to give excellent mechanical properties—for example, high tensile strength and abrasion resistance.

Several types and grades of Hypalon® are available for a variety of end use requirements. A general description of each of these products is shown in *Table 1*, and additional details are given in other sections of this technical bulletin. All of these types may be processed and used in the usual manner for solid elastomeric vulcanizates. However, several types are also of value in two additional areas—unvulcanized applications and solution coating applications.

When compounding with Hypalon®, proper selection of polymer type is the starting point for a suitable finished product. Equally important is the selection of the other compounding ingredients. A general outline of compounding ingredients and their functions (arranged in alphabetical order) is shown.

This technical bulletin is intended as a brief guide to selection of the most suitable type of Hypalon®—the first step in developing a practical, serviceable compound to meet the requirements of a particular application.

Handling Precautions for Hypalon®

Safe Handling

Hypalon® synthetic rubber contains low levels of carbon tetrachloride (CCl_4) and chloroform ($CHCl_3$) as residues from manufacturing. Carbon tetrachloride and chloroform are classified by The International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP), and the American Conference of Governmental Industrial Hygienists (ACGIH) as substances for which there is limited evidence of carcinogenicity to humans. Under the Occupational Safety and Health Act (OSHA), exposures to carbon tetrachloride must be kept below the permissible exposure limit of 10 ppm and chloroform must be kept below the permissible exposure limit of 50 ppm. When large quantities of raw polymer are stored or processed in enclosed areas with restricted air exchange or ventilation, the air must be monitored for carbon tetrachloride and chloroform; and, if necessary, ventilation must be supplied to comply with OSHA regulations.

For additional information concerning this and other potential industrial health hazards when handling Hypalon®, see DuPont Dow Elastomers technical bulletin, “Toxicity and Handling Guide,” and the Material Safety Data Sheet (MSDS).

Compounding Ingredients

Compounding ingredients, including peroxides and lead-based curatives, used with Hypalon® to prepare finished products, may present hazards in handling and use. Before proceeding with any compounding or processing work, consult and follow label directions and handling precautions from suppliers of all ingredients.

Waste Disposal

All grades of Hypalon® raw polymer exceed the regulated maximum leachate level for carbon tetrachloride in the U.S. Environmental Protection Agency (EPA) toxicity characteristic leaching procedure (TCLP test); therefore, discarded polymer should be considered a Resource Conservation and Recovery Act (RCRA) hazardous waste by anyone who generates more than 220 lb of total hazardous waste (includes waste from all sources) at a site in a calendar month.

Table 1
Description of Types of Hypalon®

	20	30	45	6525
Description				
Chlorine Content, %	29	43	24	27
Sulfur Content, %	1.4	1.1	1.0	1.0
Physical Form	Chips	Chips	Chips	Chips
Color	White	White	White	White
Odor	None	None	None	None
Specific Gravity	1.12	1.27	1.07	1.10
Mooney Viscosity, ML 1 + 4 at 100°C	28	30	37	90
Storage Stability	Excellent	Excellent	Excellent	Excellent
Distinguishing Features	Readily soluble in common solvents. Good low-temperature flexibility.	Readily soluble in common solvents. Forms hard, glossy films.	High uncured strength. Good heat resistance. Good low-temperature flexibility.	High polymer viscosity. Good low-temperature and heat resistance. Good processing at high extensions
Processing Characteristics				
Extruding	Fair	Fair	Good	Excellent
Molding	Good	Fair	Excellent	Excellent
Calendering	Fair	Fair	Excellent	Good
Solution Properties				
Brookfield Viscosity, MPa·s				
25 wt% Polymer in Toluene	1,300	400	—	—
5 wt% Polymer in Xylene	9	4	60	45
Vulcanizate Properties				
Hardness, Durometer A	45–95	60–95	65–98	40–95
Tensile Strength, MPa				
Carbon Black Stocks	Up to 20	Up to 24	Up to 27	Up to 27
Gum Stocks	Up to 8	Up to 17	Up to 27	Up to 27
Color Stability	Excellent	Excellent	Excellent	Excellent
Low-Temperature Properties	Good	Poor	Excellent	Excellent
Tear Strength	Fair	Fair	Good	Good
Resistance to				
Abrasion	Very Good	Very Good	Excellent	Excellent
Chemicals	Good	Excellent	Good	Very Good
Compression Set	Fair	Poor	Good	Very Good
Flame	Fair	Very Good	Fair	Fair
Heat-Aging	Very Good	Fair	Very Good	Very Good
Ozone	Excellent	Excellent	Excellent	Excellent
Petroleum Oils	Fair	Excellent	Fair	Fair
Weathering	Excellent	Excellent	Excellent	Excellent

Note: All values on this table are approximate. They are presented to describe the various products, and are not intended to serve as specifications.

(continued)

Table 1 (continued)
Description of Types of Hypalon®

	40S	40	4085	48
Description				
Chlorine Content, %	35	35	36	43
Sulfur Content, %	1.0	1.0	1.0	1.0
Physical Form	Chips	Chips	Chips	Chips
Color	White	White	White	White
Odor	None	None	None	None
Specific Gravity	1.18	1.18	1.19	1.27
Mooney Viscosity, ML 1 + 4 at 100°C	46	56	94	78
Storage Stability	Excellent	Excellent	Excellent	Excellent
Distinguishing Features	Low polymer viscosity. Improves processing of dry, stiff stocks.	Medium polymer viscosity. Versatile, suitable for many applications.	High polymer viscosity. Good green strength. Improves processing of soft or highly extended stocks.	High polymer viscosity. Excellent oil and fluids resistance. High uncured strength.
Processing Characteristics				
Extruding	Excellent	Excellent	Excellent	Good
Molding	Excellent	Excellent	Excellent	Good
Calendering	Excellent	Excellent	Excellent	Good
Solution Properties				
Brookfield Viscosity, MPa·s				
25 wt% Polymer in Toluene	—	—	—	—
5 wt% Polymer in Xylene	20	25	50	12
Vulcanizate Properties				
Hardness, Durometer A	40–95	40–95	40–95	60–95
Tensile Strength, MPa				
Carbon Black Stocks	Up to 27	Up to 27	Up to 27	Up to 27
Gum Stocks	Up to 27	Up to 27	Up to 27	Up to 24
Color Stability	Excellent	Excellent	Excellent	Excellent
Low-Temperature Properties	Good	Good	Good	Poor
Tear Strength	Good	Good	Good	Good
Resistance to				
Abrasion	Excellent	Excellent	Excellent	Excellent
Chemicals	Excellent	Excellent	Excellent	Excellent
Compression Set	Good	Good	Good	Fair–Good
Flame	Good	Good	Good	Very Good
Heat-Aging	Very Good	Very Good	Very Good	Good
Ozone	Excellent	Excellent	Excellent	Excellent
Petroleum Oils	Good	Good	Good	Excellent
Weathering	Excellent	Excellent	Excellent	Excellent

Note: All values on this table are approximate. They are presented to describe the various products, and are not intended to serve as specifications.

The level of residual carbon tetrachloride in compounds is less than in Hypalon® because of dilution by other ingredients in the compound. Compounding ingredients, processes, and applications vary significantly, so you will need to reach your own conclusions as to whether waste generated by your process exceeds TCLP regulatory limits subject to RCRA regulations.

Hypalon® contains no lead, but lead containing materials are sometimes compounded with it. If lead can be extracted from the compound in amounts that exceed the regulatory limit of EPA's TCLP test, then the compounded waste is a RCRA hazardous waste (Federal Register, 3/29/90, p 11862; 40CFR261.24), and must be handled as such. The amount of lead extracted in the TCLP test will depend on the amount and type of lead compound present, other compounding ingredients, and compounding and/or curing conditions. If you have any questions, please contact your DuPont Dow Elastomers sales representative.

General Characteristics and Uses of Hypalon®

Hypalon® is the trademark assigned to a group of sulfur and peroxide curable elastomers that are based on chlorosulfonated and chlorinated polyethylene. These polymers are manufactured in such a manner as to produce an elastomer with a completely saturated backbone and pendant groups suitable for varied approaches to vulcanization. As a result of this configuration, vulcanizates of Hypalon® synthetic rubber are extremely resistant to attack by ozone, oxygen and weather. In addition, properly prepared vulcanizates of Hypalon® are outstanding in resistance to deterioration by heat, oils, and many chemicals and fluids.

Hypalon® is used in the rubber industry because of its wide range of unique properties. The properties may be summarized as:

- Permanent bright colors
- Superb ozone and weather resistance, even in non-black products
- Heat resistance to 150°C
- Resistance to a wide range of aggressive chemicals
- Intermediate oil and solvent resistance depending on the chlorine level
- Electrical insulating properties
- Low flammability characteristics (associated with chlorinated polymers)
- Excellent resistance to abrasion and mechanical abuse

The following are areas of application where Hypalon® is the preferred polymer.

Hypalon® is used in the hose industry whenever its specific properties are required. Thus, it is used in power steering and oil cooler hoses for automotive and industrial hydraulic hose, where impulse testing is performed up to 150°C. Hypalon® is also widely used for fuel hose covers and various vacuum and emission tubing applications.

Hypalon® is used widely as a sheathing material for cable constructions. It is often specificed in this application for resistance to weathering, sunlight, ozone, and heat.

Certain grades of Hypalon® are used to produce a single-ply roofing system. This is white in color for heat reflectance while possessing good water, weather, and UV light resistance. The same technology with Hypalon® is used to produce fabric reinforced, heat weldable linings for reservoirs and effluent pits. Hypalon® liners are noted for their resistance to oils as well as chemicals.

Roll covers resist a large variety of chemicals and solvents over a wide range of temperatures. While possessing good resilience and resistance to wear, Hypalon® has all these characteristics and is one of the most commonly used polymers in this field.

Hypalon® coatings, both rigid and flexible, are used in many fields to provide resistance to weather, chemicals, oils and solvents while maintaining an attractive colored appearance.

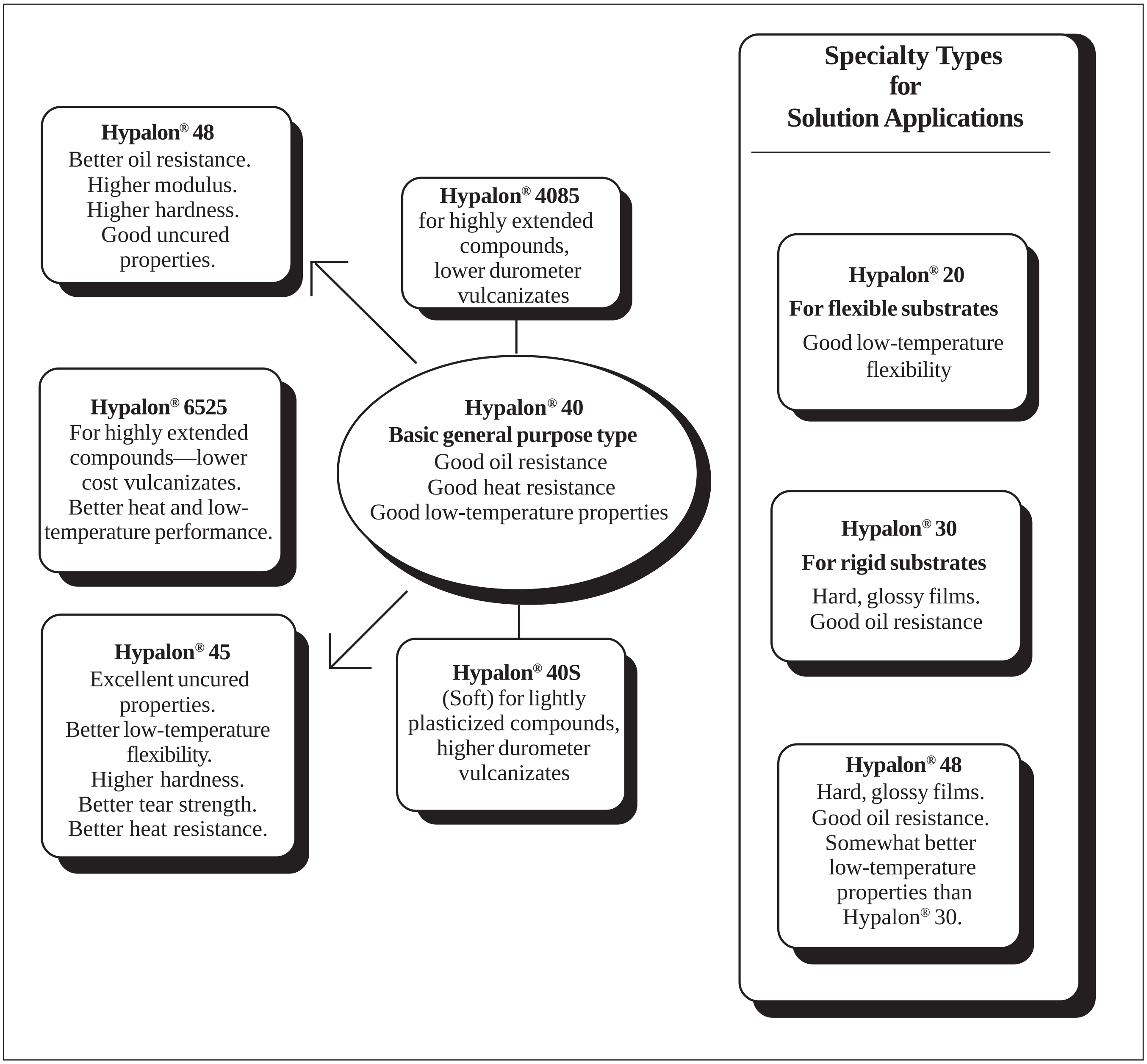
Selecting the Type of Hypalon®

All of the available types of Hypalon® synthetic rubber, when properly compounded and cured, possess the basic characteristics for which Hypalon® is known—good "rubberlike" mechanical properties and excellent resistance to the deteriorating effects of oxygen, ozone, weather, heat, oils and chemicals.

However, there are chemical and physical differences between the various types which affect processibility and properties. The compounder must select the type that will best produce the desired end-product.

The principal features of each type are summarized in *Figure 1* and described more fully in the text.

Figure 1. Selection Guide for Hypalon®



General Purpose Types

Hypalon® 40 synthetic rubber is considered the basic general purpose chlorosulfonated polyethylene elastomer, having a good balance of processibility and vulcanizate properties. It provides good oil and chemical resistance and intermediate low-temperature performance.

Higher and lower viscosity grades of Hypalon® 40 are available to provide a range of compounding and processing capability within the general purpose family. Hypalon® 4085 is a higher viscosity grade, which offers improved processibility and dilutability for highly extended formulations, or low durometer vulcanizates. On the lower end of the viscosity range is Hypalon® 40S (soft). This polymer provides easier processing in lightly-plasticized, higher durometer compounds.

Specialty Types for Dry Applications

Hypalon® 45 is more thermoplastic than Hypalon® 40; it has a lower viscosity at processing temperature, but gives better room temperature green strength and harder vulcanizates. Hypalon® 45 has a lower chlorine content than does Hypalon® 40; therefore, it is more flexible at low temperatures, but has reduced oil and fuel resistance. It also provides higher modulus and better heat resistance than the general purpose types.

Hypalon® 45 can be compounded to give very good mechanical properties in *uncured* stocks. It is frequently used uncured in sheeting applications because of its strength and ease of seaming.

Hypalon® 6525 is a high viscosity, extensible polymer with some characteristics similar to Hypalon® 45. It has a lower chlorine content than Hypalon® 40, which yields compounds with excellent low-temperature properties and slightly improved oven aging performance. It can be compounded for lower cost because it can accept high filler loadings and can use less expensive plasticizers. Some decrease in oil and flame resistance is to be expected.

Hypalon® 48 is intermediate in thermoplasticity between Hypalon® 40 and Hypalon® 45. It provides better oil resistance, but poorer low temperature properties than Hypalon® 40 (or Hypalon® 45). It also has very high resistance to permeation by some refrigerants and other gases.

Hypalon® 48 can be compounded for good uncured properties, but not as good as those of uncured compounds of Hypalon® 45. Hypalon® 48 will impart greater oil and flame resistance than Hypalon® 45 in comparable compositions, at a sacrifice in low temperature flexibility.

Specialty Types for Solution Applications

Hypalon® 20 and Hypalon® 30 are suitable primarily for solution applications. They are more readily soluble in organic solvents than are the other types and can be formulated to yield solutions having relatively low viscosity at high solids content.

Solutions of compounds of Hypalon® are used for coating fabrics, fluid applied roofing, decorative and ozone-proof coatings for elastomeric articles, and as chemical resistant maintenance coatings.

Hypalon® 20 yields films that are more flexible and extensible at low temperatures than Hypalon® 30. On the other hand, films of Hypalon® 30 are more oil and chemical resistant, harder, and glossier than films of Hypalon® 20.

Hypalon® 20 or Hypalon® 30 can be used to prepare dry rubber compounds, but they are more difficult to process than the general purpose types and yield vulcanizates having poorer mechanical properties.

Hypalon® 48 also finds some use in solution applications, primarily because of its good oil and chemical resistance. Solution viscosity is generally higher than that of Hypalon® 20 or Hypalon® 30 at the same solids content. Film characteristics are similar to those of Hypalon® 30, except that the films are somewhat more extensible at low temperatures.

Vulcanizate Properties

Hypalon® 40 synthetic rubber gives an excellent combination of vulanizate properties. Hypalon® 40S and Hypalon® 4085 offer a similar balance of properties while broadening the range of compound viscosities to meet most processing needs.

Gum Vulcanizates

Gum vulcanizates of Hypalon® 40 and its viscosity variants have excellent tensile strength. Therefore, the use of highly reinforcing fillers to obtain high quality vulcanizates is not necessary (See *Table 2*). Hypalon® 45 gives higher modulus, tear strength, and hardness as compared with the Hypalon® 40 and Hypalon® 48 types. Hypalon® 30 also gives a gum vulcanizate with high modulus and hardness, but lower tensile strength. The gum tensile strength of Hypalon® 20 is very low and therefore, to achieve high quality vulcanizates, highly reinforcing fillers must be used.

Carbon Black Filled Vulcanizates

A comparison of the various types of Hypalon® in a carbon black filled stock (*Tables 3* and *4*), shows the good balance of properties obtainable with Hypalon® 40. Hypalon® 4085, and Hypalon® 6525 give higher modulus, tensile strength, and hot physical properties. Hypalon® 30 gives high hardness with low compound viscosity. Hypalon® 30 and 48 have the best resistance to oil. The good oil and fluid resistance of Hypalon® 48 are further illustrated in *Table 5*.

Mineral Filled Vulcanizates

A similar comparison, in a mineral filled stock is shown in *Table 6*. Note that Hypalon® 4085, besides giving high compound viscosity, gives high modulus and tensile strength, and good hot properties. The higher hardness of Hypalon® 45 at this low loading level allows the formulation of easy processing, high durometer stocks. Hypalon® 30 and 48 give maximum resistance to oil, with Hypalon® 48 providing better physical and low-temperature properties.

Table 2
Properties of Gum Compounds

Hypalon® (grades below)	100					
Magnesia (high activity)[a]	4					
Pentaerythritol (200 mesh)[b]	3					
Tetrone® A	2					
Type of Hypalon®	**20**	**30**	**40**	**4085**	**45**	**48**
Stock Properties						
Mooney Viscosity,						
ML 1 + 4 at 100°C	34	37	62	96	45	87
Mooney Scorch, MS at 121°C						
Minimum Viscosity, units	11	9	18	30	14	23
Time to 10-unit rise, min	25	41	35+	29	35+	45
Vulcanizate Properties						
Cured: Time 30 min at 153°C						
Original Physicals						
100% Modulus, MPa	1.8	2.8	1.0	1.4	3.0	1.4
300% Modulus, MPa	—	12.4	4.2	5.2	6.9	6.7
Tensile Strength, MPa	8.3	18.3	28.1	31.0	24.6	31.7
Elongation, %	280	400	520	550	480	490
Hardness, Durometer A	54	69	53	54	80	60
Tear Strength, Die C						
kN/m	41.1	28.0	28.0	31.5	37.2	28.9

[a] Maglite® D was used
[b] Hercules® PE-200 was used

Table 3
Properties of Black Filled Compounds

Hypalon® (grades below)	100
N762 Carbon Black	60
Aromatic Process Oil	25
LMW Polyethylene Process Aid	2
Magnesium Oxide	5
Pentaerythritol	3
Tetrone® A	2
MBTS	0.5

Type of Hypalon®	**40S**	**40**	**4085**	**6525**	**45**	**48**	**30**	**20**
Stock Properties								
Mooney Viscosity,								
ML 1 + 4 at 100°C	49	52	88	82	39	60	33	30
Mooney Scorch, MS at 125°C								
Minimum Viscosity, units	14	16	28	30	13	16	7	9
Time to 10-pt rise, min.	14	13	12	13	13	13	9	11
MDR at 160°C, 0.5° arc, 30-min chart								
Tc-90, min	11.6	10.8	10.2	10.0	7.6	12.8	18.1	19.1
Vulcanizate Properties								
Cure Time at 160°C	20	20	20	20	20	20	30	30
Original Physicals at 23°C								
50% Modulus, MPa	2.5	2.3	3.0	2.8	4.5	4.1	6.9	3.8
100% Modulus, MPa	6.5	6.2	8.1	7.4	8.1	10.1	15.0	9.6
200% Modulus, MPa	16.2	16.4	20.0	18.9	16.6	19.6	—	—
Tensile Strength, MPa	20.5	21.3	23.7	24.1	20.0	21.0	18.5	14.9
Elongation, %	292	287	270	275	266	253	152	147
Hardness, Shore A	70	67	72	68	83	78	84	70
Oven Aged 168 hr at 125°C								
Change in 50% Modulus, %	169	184	219	95	86	219	197	137
Change in Tensile Strength, %	11	6	10	4	0	18	25	10
Change in Elongation, %	–42	–44	–42	–23	–40	–49	–58	–40
Change in Hardness, pts	12	14	12	12	7	12	12	13
Volume Change, %								
IRM903 Oil, 168 hr at 125°C	61	64	41	99	150	30	21	90
Distilled Water, 168 hr at 70°C	28	24	28	23	22	30	34	32
Compression Set, Method B								
22 hr at 100°C, % set	67	65	59	55	63	80	86	74
Tear Strength, Die C								
kN/m	38	38	42	42	44	35	27	25
Low Temperature Properties								
DSC-Tg, °C	–21	–22	–17	–27	–24	0	7	–26
Brittle Point, °C	–28	–32	–30	–42	–44	–16	8	–26
DIN Abrasion								
Abrasion Index	118	112	110	99	154	148	243	154

Table 4
Properties of Peroxide Cured Black Filled Compounds

Hypalon® (grades below)	100						
Magnesia (high-activity)	20						
N774 Carbon Black	40						
Varox® DBPH–50	5.8						
Type of Hypalon®	**45**	**20**	**30**	**48**	**40S**	**40**	**4085**
Stock Properties							
Mooney Scorch, MS at 135°C							
Minimum Viscosity, units	43	36	34	51	42	50	81
Points rise at 30 min	9	9	1	0	2	2	3
ODR, 30 min at 177°C							
Minimum Torque, N·m	1.44	.85	.70	1.51	1.36	1.62	1.51
t_s2, min	1.1	1.9	3.2	2.0	1.6	1.3	1.4
t_c90, min	8.5	11.0	21.2	19.5	13	13.2	14.6
Maximum Torque, N·m	6.25	2.96	2.15	4.24	5.13	5.62	6.41
Vulcanizate Properties							
Original Physicals							
200% Modulus, MPa	17.8	10.4	12.6	18.1	14.8	15.8	18.9
Tensile Strength, MPa	18.5	12.2	13.6	19.3	19.2	19.1	22.3
Elongation, %	210	255	185	275	270	250	240
Hardness, Durometer A	87	71	83	84	76	76	77
Aged 70 hr at 100°C							
Tensile, % change	4	13	42	28	12	11	9
Elongation, % change	–10	–8	–43	–33	–13	–15	–14
Hardness change, pts	5	9	12	6	8	6	6
Aged 70 hr at 149°C							
Tensile, % change	–21	0	46	9	–31	–28	–26
Elongation, % change	–39	–72	–91	–88	–79	–78	–72
Hardness change, pts	3	15	18	10	10	13	10
Aged 70 hr at 121°C in IRM903 Oil							
Tensile, % change	–51	–55	–17	6	–27	–32	–33
Elongation, % change	–43	–52	–10	–17	–29	–35	–30
Hardness change, pts	–33	–30	–16	–15	–24	–24	–21
% Volume Increase	101	114	36	35	68	68	60
Compression Set, Method B, %							
22 hr at 100°C	21	35	—	47	28	27	24

Table 5
Fluid Resistance of Hypalon®

Base Compound No.	1	2
Hypalon® (grade as shown)	100	100
N762 Carbon Black	40	40
Atomite Whiting	40	40
TOTM Plasticizer	25	25
Vanwax® H	2	2
LMW Polyethylene Process Aid	2	2
HVA-2	1	1
MBTS	1	1
NBC	2	2
Tetrone® A	1	1
Magnesium Oxide	5	
Pentaerythritol	3	
Hydrotalcite (Kyowa® DHT-4A)		20
Total Parts	222	234

Hypalon® Type Compound No.	4085 1	4085 2	45 1	45 2	48 1	48 2
Mooney Scorch, MS at 125°C						
Minimum Viscosity, MU	20.7	23.0	10.3	11.8	11.0	11.9
Time to 5 pt rise, min	12.8	12.3	16.1	16.2	13.6	15.0
Original Physical Properties at 23°C						
Cure Time at 160°C, min	25	20	25	30	30	20
100% Modulus, MPa	3.7	4.3	5.3	5.4	4.3	5.0
200% Modulus, MPa	8.1	10.7	8.2	9.1	8.2	10.9
Tensile Strength, MPa	16.9	17.1	12.6	12.7	14.4	15.6
Elongation, %	363	299	342	282	376	280
Hardness, Shore A	61	65	82	83	67	72

Fluid Agings

Fluid	Exposure Conditions	Volume Change, %					
Dextron III	70 hr at 125°C	13.2	9.5	88.2	56.9	1.3	–1.9
Diesel Fuel	70 hr at 50°C	25.7	21.8	83.5	64.9	13.2	11.2
Fuel B	70 hr at 23°C	37.3	34.0	56.0	54.2	31.9	24.2
Fuel C	70 hr at 23°C	85.0	66.0	118.9	100.4	58.5	49.9
Hydraulic Oil (Harmony 46)	70 hr at 125°C	1.8	–0.3	58.5	37.5	–6.9	–7.8
ASTM IRM902 Oil	70 hr at 125°C	16.7	13.2	77.5	55.8	0.8	–0.5
ASTM IRM903 Oil	70 hr at 125°C	40.7	31.3	114.2	80.3	17.7	11.7
Motor Oil—5W30	70 hr at 125°C	12.0	7.9	91.4	53.5	0.5	–1.9
50-50 Antifreeze Water	168 hr at 105°C	33.3	1.9	29.1	2.5	43.9	2.5
Distilled Water	70 hr at 100°C	89.7	25.7	91.0	22.2	156.7	45.2
50% Conc. Sodium Hydroxide	70 hr at 100°C	2.9	1.6	4.1	2.8	3.5	1.9
50% Conc. Sulfuric Acid	70 hr at 100°C	2.8	2.7	2.6	2.9	2.7	2.8
37% Conc. Hydrchoric Acid	70 hr at 60°C	71.0	99.3	83.9	90.7	86.9	101.6

Fluid	Exposure Conditions	Volume Change After Dryout*, %					
Dextron III	70 hr at 125°C	10.6	6.6	82.3	52.5	–0.2	–3.2
Diesel Fuel	70 hr at 50°C	–3.4	–5.1	–10.1	–11.5	3.0	2.3
Fuel B	70 hr at 23°C	–12.9	–12.8	–17.9	–17.5	–6.5	–8.4
Fuel C	70 hr at 23°C	–13.8	–14.3	–18.9	–18.2	–10.4	–10.8
Hydraulic Oil (Harmony 46)	70 hr at 125°C	1.2	–1.2	55.3	36.6	–6.8	–7.7
ASTM IRM902 Oil	70 hr at 125°C	15.5	12.3	76.0	55.3	0.4	–1.2
ASTM IRM903 Oil	70 hr at 125°C	30.7	22.5	95.7	66.3	14.6	8.4
Motor Oil—5W30	70 hr at 125°C	8.7	4.9	82.5	48.9	–1.3	–3.7
50-50 Antifreeze Water	168 hr at 105°C	13.8	–1.0	11.1	–0.8	20.4	–0.8
Distilled Water	70 hr at 100°C	25.0	1.3	23.4	0.5	55.6	5.4
50% Conc. Sodium Hydroxide	70 hr at 100°C	–10.4	–11.9	–13.8	–14.3	–6.3	–8.1
50% Conc. Sulfuric Acid	70 hr at 100°C	–0.05	0.04	0.12	–0.21	0.34	0.19
37% Conc. Hydrchoric Acid	70 hr at 60°C	18.8	31.9	22.1	31.5	21.8	36.6

*Dryout Time, 24 hr at 70°C

Table 6
Properties of Mineral Filled Compounds

Hypalon® (grades below)	100
Magnesia (high-activity)[a]	4
Hard Clay[b]	80
Aromatic Process Oil[c]	30
Pentaerythritol (200 mesh)[d]	3
Tetrone® A	2

Type of Hypalon®	**20**	**30**	**40S**	**40**	**4085**	**6525**	**45**	**48**
Stock Properties								
Mooney Viscosity,								
ML 1 + 4 at 100°C	16	15	40	44	73	83	26	37
Mooney Scorch, MS at 121°C								
Minimum Viscosity, units	5	5	14	16	26	30	10	8
Time to 10-unit rise, min	38	35	29	24	23	26	46	48
Vulcanizate Properties								
Cured 30 min at 153°C								
Physical Properties at 24°C								
100% Modulus, MPa	5.6	12.4	5.5	6.0	6.0	5.3	5.0	6.2
200% Modulus, MPa	8.4	—	7.8	8.4	9.0	7.9	7.4	11.8
Tensile Strength, MPa	9.4	14	18.6	19	20.7	20	18.8	16.8
Elongation, %	260	140	550	550	520	530	540	470
Hardness, Durometer A	63	82	63	67	69	70	81	72
Aged 7 days at 121°C								
Tensile Strength, MPa	15.8	21.8	16.2	17.0	17.9	15.4	15.2	18.6
Elongation, %	120	80	200	210	205	270	250	180
Hardness, Durometer A	74	91	76	78	78	78	84	80
Original Physicals at 100°C								
Tensile Strength, MPa	3.8	3.0	2.8	3.1	3.7	4.0	3.0	4.4
Elongation, %	150	90	210	220	215	215	270	280
Tear Strength, Die C, kN/m	31.6	26.8	55.4	57.5	59.1	56.8	50.0	42.6
NBS Abrasion Index	70	52	108	146	203	247	70	73
Yerzley Resilience, %	67	Too Low	55	58	65	75	60	Too Low
Clash Berg Torsional Stiffness								
T-10,000 [68.9 MPa] °C	–23	4	–21	–21	–26	–25	–17	—
Brittlepoint, °C	–37	–5	–35	–33	–33	–37	–32	–14
Aged Volume Change, %								
ASTM #1 Oil, 70 hr at 121°C	–4	12	–11	–12	–13	10	16	–12
IRM903 Oil, 70 hr at 121°C	92	13	52	45	38	103	135	13
In water, 7 days at 70°C	71	52	78	74	67	47	60	56
Compression Set, Method B, %								
Cure: 35 min at 153°C								
22 hr at 70°C	60	69	59	59	54	47	46	65

[a]Maglite® D was used
[b]Suprex® Clay was used
[c]Sundex® 790 was used
[d]Hercules® PE-200 was used

Unvulcanized Applications

Hypalon® 45 can also be compounded to give remarkably good stress/strain properties in uncured stocks. These compounds may be used in applications such as cove base, magnetic door closures, roofing membranes, and pond and pit liners. Hypalon® 45 complies with the Food and Drug Administration regulation 21 CFR 177.2210-*Ethylene polymer chlorosulfonated*. This regulation covers compounds of Hypalon® 45, which may be safely used in contact with water used for drinking purposes.

Uncured compounds based on Hypalon® 48 have physical properties similar to those obtained with uncured Hypalon® 45. In applications for uncured stocks, Hypalon® 48 will impart greater oil and flame resistance than Hypalon® 45 in comparable compositions, but at a sacrifice in low temperature utility. (See *Table 7*).

Table 7
Uncured Properties of Hypalon® 45 and Hypalon® 48

Hypalon® (type shown)	100
Magnesia (high activity)[a]	4
N990 Carbon Black	100
Polyethylene Glycol[b]	1.5

Type of Hypalon®	**Hypalon® 45**		**Hypalon® 48**	
Stock Properties				
Mooney Viscosity, ML 1 + 4 at 100°C	49		—	
Film Properties, uncured 0.76 mm (30 mil) calendered film				
	At RT	At 50°C	At RT	At 50°C
Original Physicals				
100% Modulus, MPa	5.3	1.8	5.2	—
Maximum Strength, MPa	8.6	2.8	7.4	1.2
Elongation, %	345	650	510	500
Hardness, Durometer A	85	74	89	82
Tear Strength, Die C kN/m	52.2	21.2	—	—
Cold Bend, 3.18 mm [1/8 in] Mandrel, 3.1 rad [180°] Bend At –34°C	Passed		Failed	
Brittleness Temperature °C	–50		–2	
Aged 168 hr at 50°C in IRM903 Oil Volume Change, %	+160		+16	

[a]Maglite® D was used.
[b]Carbowax® 3350 was used.

Compounding Ingredient Functions

Function		Ingredients Normally Recommended
Acid Acceptor		Hydrotalcite Magnesia (High Activity) Epoxy Resin of Epoxidized Oil Calcium Hydroxide
Colorants		Carbon Black Titanium Dioxide Organic & Inorganic Pigments
Filler		Carbon Black Mineral Cork Magnetic Filler
Flame Retardant		Antimony Oxide Hydrated Alumina Halogenated Hydrocarbons
Plasticizer	Petroleum	Petroleum Oils Aromatic Naphthenic
	Synthetic	Esters Chlorinated Paraffins Polymeric Polyesters
Processing Aids		Waxes Stearic Acid Low Mol. Wt. Polyethylene Polyethylene Glycol Fatty Acid Amides Nordel® IP 4770 or *cis*-4 PBD Tackifiers
Vulcanizing Agents[a]	Sulfur-Bearing	TMTD (or TETD) Sulfur Tetrone® A MBTS NBC DOTG
	Nonsulfur	Peroxide plus a coagent HVA-2® plus a coagent

[a] For some applications, no vulcanizing agent is used.

Acid Acceptors

The high reactivity of the sulfonyl chloride cross-linking sites in Hypalon® synthetic rubber allows a wide choice of practical curing systems. The basic cross-linking system consists of a metal oxide combined with a sulfur-containing rubber accelerator or with a peroxide and coagent. Calcium hydroxide with HVA-2 and a coagent can also be used as a cross-linking system.

Metal oxides act both as cross-linking agents and acid acceptors in the curing of chlorosulfonated polyethylene. Magnesia and hydrotalcite are most commonly used. Zinc oxide is **undesirable** and **not recommended** because degradation reactions catalyzed by the formation of zinc chloride cause poor weathering and heat aging. The choice of metal oxide is particularly important to vulcanizate properties.

More detailed information on acid acceptors can be found in DuPont Dow Elastomers technical bulletin "Selecting a Cure System."

Magnesia-based acid acceptor systems are used when colorability is desired. They are low cost, provide good processing safety, and give vulcanizates with better elongation than is obtained with litharge systems. The magnesia system is suggested for general use, particularly when water, chemical, and compression set resistance are not critical properties. High activity magnesias are preferred and should be kept dry because exposure to atmospheric moisture can cause a considerable loss in activity. Dispersions of magnesia are available commercially that are generally easier to handle and mix than powdered magnesia.

A lower level of magnesia can be used when it is combined with primary polyols, such as pentaerythritol. This combination reduces compound viscosity, increases long-term storage time, and improves heat resistance.

Hydrotalcites are used to provide improved water and heat resistance compared to magnesia acid acceptors. Hydrotalcites produce compounds with good states of cure with good modulus values and lower compressions sets. In soft compounds, hydrotalcites can produce some porosity. If porosity occurs, a calcined hydrotalcite product should be used.

Epoxy resins may be used alone or combined with magnesia to give water resistant vulcanizates suitable for colored applications. Vulcanizates have high elongation and low modulus.

Litharge or organic lead bases are sometimes used for resistance to water when hydrotalcites do not provide the required resistance. Litharge is used to meet wet electrical properties in wire and cable applications. Due to the hazards associated with lead oxides and lead-based products, it is recommended that the masterbatch form of the product be used.

Calcium hydroxide can be used in combination with HVA-2® curing agent and an amine coagent for vulcanizates with excellent compression set resistance.

Colorants

For black vulcanizates of Hypalon®, carbon black may serve in the dual role of a colorant and filler. Black stocks are more versatile from a compounding standpoint in that they can utilize either litharge or magnesia based curing systems.

As discussed in the subsequent section on fillers, magnesia based systems must be used where non-black stocks are required. Litharge based systems form lead sulfide which discolors the vulcanizate.

White vulcanizates are obtained by using titanium dioxide. In addition to having high opacity and brightness, titanium dioxide serves as an ultraviolet screening agent when needed for outdoor weathering. A number of organic and inorganic pigments recommended for Hypalon® are given in DuPont Dow Elastomers technical bulletin "Compounding Hypalon® for Weather Resistance."

Fillers

Gum vulcanizates of Hypalon® 40 have excellent tensile strength, hence it is not necessary to use highly reinforcing fillers to obtain high quality vulcanizates.

Fillers are often added to Hypalon® for reasons of economy. Carbon black is the preferred filler for maximum physical strength and chemical resistance. SRF carbon black gives a good balance of properties and is widely used as a general purpose filler.

For mineral filled vulcanizates, the filler selection depends on the properties desired. No one particular mineral filler can be suggested for general use. Compared to carbon blacks, most mineral fillers impart higher elongation and better resistance to tear, but lower modulus, tensile strength, and resistance to water and abrasion.

Cork is sometimes used as a "filler" and results in a cork/elastomeric composition having good oil, heat and set resistance. Another specialty composition uses ferrite as a filler, yielding an elastomeric product which can be converted to a flexible magnet.

Specific details on compounding and physical properties of typical vulcanizates are available in DuPont Dow Elastomers technical bulletin "Selecting A Filler."

Flame Retardants

Vulcanizates of Hypalon® are generally more flame resistant than hydrocarbon elastomer compositions by virtue of their chlorine content. Flame resistance, as judged by limiting oxygen index,* can be improved through the addition of antimony oxide, hydrated alumina and halogenated hydrocarbons.

Plasticizers

The selection of a plasticizer for use in Hypalon® depends on such factors as compatibility, processing requirements, cost, and desired vulcanizate properties. Aromatic petroleum oils are used extensively, primarily because of their low cost and compatibility. Ester plasticizers are frequently used because of their light color and good low-temperature properties. Chlorinated paraffin plasticizers give vulcanizates with good flame resistance and weatherability. They are essentially colorless and non-discoloring upon exposure.

Polymeric plasticizers find use in Hypalon® because of their permanence or low volatility at elevated temperatures. Since they are relatively high in cost, they are usually used in compounds designed for maximum heat resistance. Specific details for selecting a plasticizer are available in DuPont Dow Elastomers technical bulletin "Selecting A Plasticizer and Processing Aids."

Processing Aids

Processing aids are used in Hypalon® to minimize mill and calender roll sticking, improve release from internal mixers, and improve extrudability. Microcrystalline waxes are effective release agents and are widely used in Hypalon® because of their good solubility. Petrolatum, low molecular weight polyethylene and paraffinic waxes are also effective, but must be used sparingly—used in excess, they bloom.

Green strength, for easier handling, can be achieved by adding Nordel® IP 4770 hydrocarbon rubber or *cis*-4-polybutadiene; Nordel® IP 4770 is especially effective in mineral filled stocks of Hypalon®. Fatty acid amides are good anti-blocking agents for calendered sheet. When tack is necessary for building operations, heat, solvents, or coumarone indene resin should be evaluated.

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* Values measured by this test are not intended to reflect hazards of this or any other material under actual fire conditions. DuPont Dow Elastomers technical bulletin "Selecting A Plasticizer and Processing Aid," gives the preferred materials for achieving desired physical properties in vulcanizates of Hypalon®.

Vulcanizing Agents*

The acid acceptors, such as magnesia function as crosslinking agents (in addition to acting as HCl scavengers), and as such can be considered vulcanizing agents. However, the cure rate and cure state of compounds of Hypalon® can be greatly improved through the use of organic vulcanizing agents and accelerators. Vulcanizing agents for Hypalon® can be classified or grouped into two categories—sulfur bearing agents and non-sulfur bearing agents. (See DuPont Dow Elastomers technical bulletin "Selecting A Curing System.")

Sulfur-Bearing Systems

A combination of magnesium oxide and pentaerythritol, TMTD, and sulfur is considered to be a good general purpose curing system for black products. This combination provides good processing safety and gives vulcanizates with a high state of cure, good compression set resistance, good heat and chemical resistance. The rate of cure can be increased, as judged by modulus values, by substituting either TETD/sulfur or Tetrone® A/MBTS for TMTD/ sulfur.

Vulcanizate resistance to heat degradation is also improved; however, these systems are more expensive and give less processing safety.

The addition of NBC to any of the sulfur bearing systems will significantly improve resistance to heat degradation, but reduces processing safety.

Non Sulfur Bearing Systems

Basically, there are two types of non-sulfur cure systems, both of which provide good processing safety and compression set resistance. The first is a peroxide system, and the other a maleimide system which utilizes HVA-2 from DuPont Dow Elastomers.

The peroxide system requires an alkaline medium, which can be provided by use of a high level of magnesia in combination with neutral or basic fillers. Coagents like triallyl-cyanurate (TAC) are used with peroxides to increase crosslink yield and obtain a satisfactory rate and/or state of cure.

In maleimide systems, HVA-2 is the primary curing agent. Calcium hydroxide is used as the acid acceptor, and amines are added as cure activators.

These alternate systems are described in detail in DuPont Dow Elastomers technical bulletin "Selecting A Curing System."

*For some applications, no vulcanizing agent or accelerator is used.

Abbreviated Chemical Names

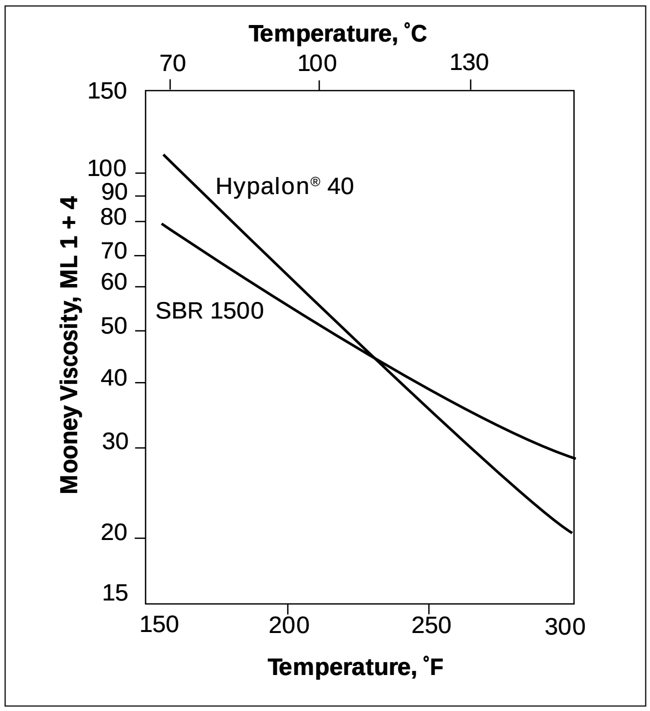
In many places throughout this technical information we have, for convenience, used abbreviations for the chemical names of the curatives discussed. In most cases, the abbreviations are familiar forms used throughout the rubber industry. Listed below are the abbreviations used and the full chemical name of the material.

Abbreviation	Chemical Name
DOTG	Di-ortho-tolyl guanidine
MBT	2 mercaptobenzothiazyl disulfide
NBC	Nickeldibutyl dithiocarbamate
TETD	Tetraethyl thiuram disulfide
TMTD	Tetramethyl thiuram disulfide

Polymer Processing Characteristics

Uncured Hypalon® synthetic rubber is more thermoplastic than other commonly used elastomers. It is generally tougher at room temperature, but softens more rapidly as temperature is increased. Viscosity temperature relationships for Hypalon® 40 and SBR are shown in *Figure 2*.

Figure 2. Viscosity-Temperature Relationship of Hypalon® 40 and SBR 1500



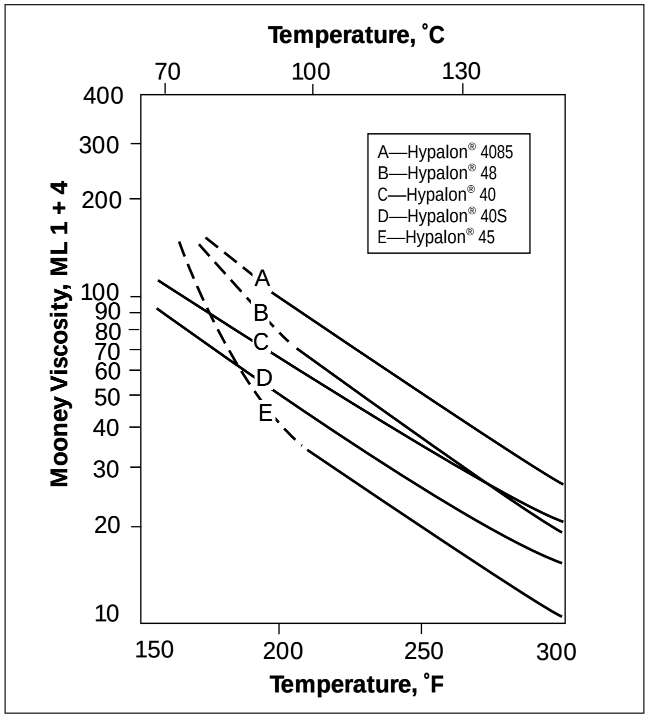
The low viscosity of Hypalon® 40 at elevated temperatures permits extrusions that are low in die swell, smooth at fast extrusion rates, and sharply defined, especially at thin edges. This softness under slightly warmed conditions (40°C) makes building operations practical, giving good ply adhesion and knitting without the use of tackifiers. However, because of this same softness, immediate cooling of extrusions is necessary to prevent distortion. The high viscosity of Hypalon® 40 at low temperatures makes it necessary to warm stocks before extruding or calendering for more uniform results. Variations in stock temperature cause variable extrusion rates and calendered sheet with uneven gauge and a rough surface.

Processing of either very soft or very stiff compounds can be improved by using one of the other grades of Hypalon® 40. The high viscosities of Hypalon® 4085 and Hypalon® 6525 help eliminate trapped air and blistering during processing and curing of highly extended or low durometer stocks. They also help minimize distortion of these compounds after extrusion and during open steam curing. The low viscosities of 40S permit easier processing of stocks containing highly reinforcing fillers or small amounts of plasticizers.

Viscosity temperature curves for these polymers and Hypalon® 45 and 48 are shown in *Figure 3*. Note that Hypalon® 45 and 48 are more temperature sensitive than any of the Hypalon® 40 types.

For additional information, see DuPont Dow Elastomers technical bulletin, "Processing Hypalon®."

Figure 3. Viscosity-Temperature Relationship of Hypalon® Polymers



Proprietary Materials

Proprietary compounding ingredients mentioned in this bulletin are listed below. This is not to imply that comparable ingredients from other sources might not be equally satisfactory.

Product Name	Composition	Supplier
Hypalon® Synthetic Rubber	Chlorosulfonated polyethylene	DuPont Dow Elastomers Wilmington, DE
HVA-2 Curing Agent	N, N'-*m*-phenylenedimaleimide	DuPont Dow Elastomers Wilmington, DE
Nordel® IP Hydrocarbon Rubber	EPDM	DuPont Dow Elastomers Wilmington, DE
Tetrone® A Rubber Accelerator	Dipentamethylene thiuram tetrasulfide	DuPont Dow Elastomers Wilmington, DE
Carbowax®	Polyethylene glycol of approximately 3350 MW	Union Carbide Corp. Industrial Chemicals Danbury, CT
Harmony Oil No. 46	Petroleum-base fluid	Gulf Oil Company-U.S. Houston, TX
Hercules® PE-200 Pentaerythritol	Fine particle size technical pentaerythritol—200 mesh	Hercules, Inc. Wilmington, DE
Maglite® D	High activity magnesium oxide	Marine Magnesium Co. Coraopolis, PA
Sundex® 790 Aromatic Oil	Aromatic hydrocarbon process oil	Sun Petroleum Products Co. Philadelphia, PA
Suprex® Clay	Kaolin clay	J. M. Huber Corporation Macon, GA
Vanox® NBC	Nickel dibutyl dithiocarbonate	R.T. Vanderbilt Company Norwalk, CT
Varox® DBPH-50	2,5 dimethy 2,5 di (t-butylperoxy) hexane	R.T. Vanderbilt Company Norwalk, CT
Vanwax® H	Microcystalline wax	R.T. Vanderbilt Company Norwalk, CT

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