CRAY VALLEY

Hydrocarbon Specialty Chemicals

Product Bulletin

Dymalink™ Metallic Coagents

TOTAL

Performance Advantages – Dymalink™ Metallic Coagents

Peroxide curing with Dymalink™ metallic coagents significantly enhances the performance of a variety of elastomers. These easy-to-handle, 100% reactive solids yield strong rubber-to-metal bonds and other highly desirable performance advantages, including:

Performance Advantages

- Greatly improved heat aging
- High tensile strength
- High tear strength
- Higher modulus
- Higher hardness
- Increased abrasion resistance
- Improved resilience
- Very high rubber-to-metal adhesion

Processing Advantages – Dymalink™ Metallic Coagents

Dymalink™ Metallic coagents contain a patented non-nitroso scorch retarder for safe, easy processing.

Processing Highlights

- High scorch safety
- 100% reactive solids
- Non-volatile
- Easily dispersed free flowing powders
- Low odor
- Available in pre-weighted, low melt polybutadiene bags

Economical Solutions – Dymalink™ Metallic Coagents

Dymalink™ Metallic coagents are an economical way to enhance the performance of peroxide-cured elastomers. They are available at a fraction of the cost of other commonly used agents, such as HVA-2, and yield comparable, even superior, mechanical properties.

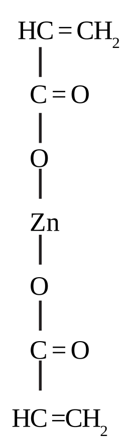
Dymalink™ Metallic Coagents

Dymalink™ 633 is anhydrous zinc diacrylate (ZDA) containing a patented non-nitroso scorch retarder. Dymalink™ 634 is anhydrous zinc dimethacrylate (ZDMA) containing a non-nitroso scorch retarder.

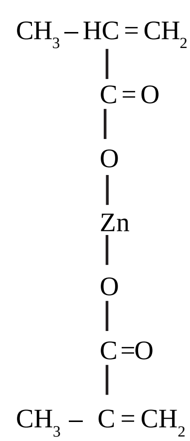
These are effective coagents in peroxide cured stocks and can be used with elastomers such as hydrogenated nitrile rubber, polybutadiene, ethylene propylene diene rubber, silicone, styrene butadiene rubber, natural rubber, and others.[1] The retarder increases the scorch time, thus providing processing safety. It has no deleterious effect on aged or unaged physical properties.

Dymalink™ SR633 and 634 are difunctional with the following structure:

Dymalink™ 633
Zinc Diacrylate



Dymalink™ 634
Zinc Dimethacrylate



The above coagents are free-flowing powders which disperse readily in most elastomers.

Physical Properties of Dymalink™ Metallic Coagents

	Appearance	Putity, %	Density mg/m³@25°C	Melting Point, °C	Fineness	Moisture, %
Dymalink™ 633 scorch-retarded zinc diacrylate	Yellow Powder	99	1.6	>250	99% thru 200 Mesh	0.2
Dymalink™ 634 Scorch-retarded zinc dimethacrylate	White Powder	99	1.5	240	99% thru 200 Mesh	0.2

[1] Coagent data is available for HNBR, EPDM, silicone, and PB elastomers.

Processing

The Dymalink™ metallic coagents are compatible and mix well with most rubbers. To insure maximum dispersion of all formulation ingredients and to minimize sticking, it is recommended that a certain "order of addition" be followed. This procedure applies for the two roll mill as well as the Banbury internal mixer.

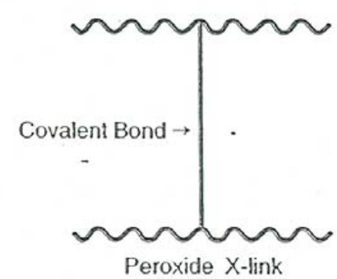
1. Introduce the rubber stock and process for approximately 30 seconds. There is no need to "break down" the rubber before adding the formulation ingredients. The initial high rubber viscosity will aid in dispersing the additives.
2. Add the Dymalink™ coagent and process just long enough to encapsulate the powder. This procedure minimizes sticking and interaction between the coagent and certain processing aids.
3. Add fillers and processing aids.
4. Add the peroxide curative.
5. Mix and blend as appropriate. Use standard processing temperatures and cycle times.

Dymalink™ Coagent Cure

Crosslinking with peroxide results in the formation of a covalent bond as shown in (A). This carbon-carbon bond is quite rigid and stable and accounts for the lower tensile and tear strength of peroxide cured stocks compared with sulfur vulcanizates. The good heat stability of this covalent bond also explains the superior heat aged characteristics of peroxide cured systems.

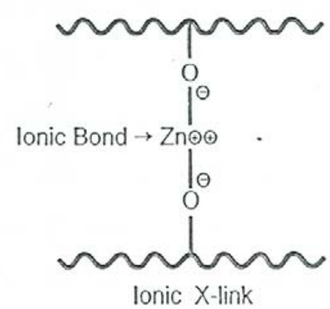
In contrast, polysulfide crosslinks formed in sulfur cure are thermally weak but are mobile under stress and can slip along the hydrocarbon chain. This mobility has been used to explain the superior tensile and tear strength in sulfur cured stocks.

A)



The Dymalink™ metallic coagent-peroxide crosslink bond is "ionic" as shown in (B) below. The technology and characteristics of this ionic bond have been detailed in the literature for the commercial ionomers. This ionic bond exhibits both good heat aged stability and the ability to slip along the hydrocarbon chain and reform. Thus, this unique system embodies the best characteristics of both the peroxide and sulfur crosslink systems, giving high tensile and tear strength and excellent heat aged properties.

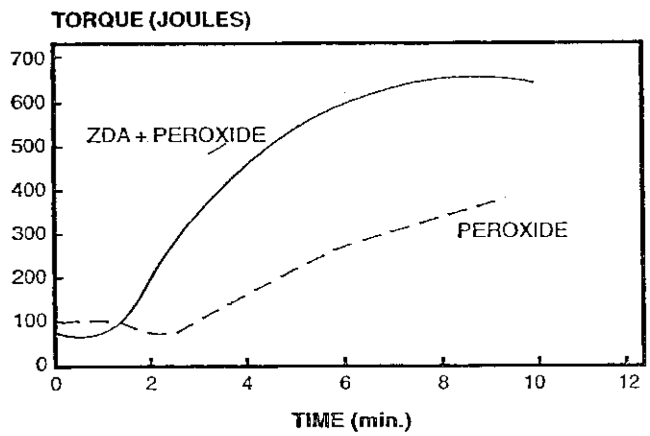
B)



Scorch Protection

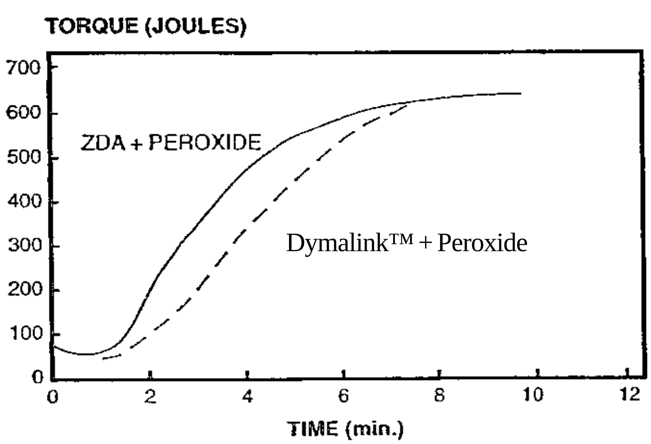
Control of scorch is accomplished in Dymalink™ 633 and 634 with a proprietary non-nitroso scorch retarder. Non-retarded coagents speed up the curing process causing a reduction in scorch time and can lead to premature cure in high temperature processing applications.

This reduction in scorch time with ZDA without the retarder is illustrated in the Monsato® ODR curve below for NBR.



The ZDA cure curve above displays a lower initial viscosity and then a more rapid torque increase to a much higher final torque and crosslink density than the peroxide alone. Scorch time is greatly reduced with the ZDA.

The effect of the scorch retarder on scorch time is shown in the cure curve below comparing Dymalink™ 633 with ZDA in NBR.



The Dymalink™ 633 above increases scorch time to the level of the previous peroxide curve while maintaining the same high crosslink density as the non-retarded ZDA.

Dymalink™ 633 scorch behavior compares favorably with competitive coagent TAC(1), giving equivalent scorch time and crosslink density, but with improved (shorter) total cure time.

Coagent Comparison in EPDM

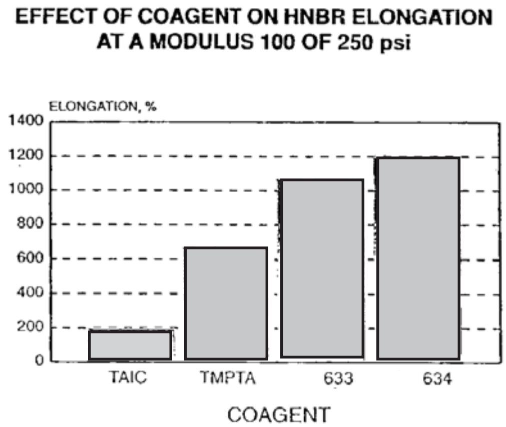
	TSI (min)	**TC90** (min)	**MH** (In-Lbs)
TAC	2.1	15.7	21.0
Dymalink™ 633	2.0	11.3	21.2

Total cure time for Dymalink™ 633 as measured by TC (90) is about 4 minutes shorter than TAC.

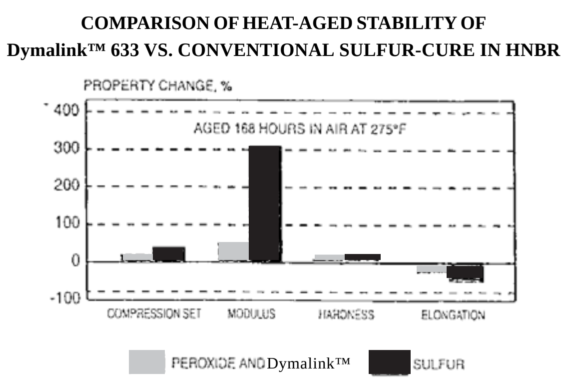
Hydrogenated Nitrile Butadiene Rubber (HNBR)

HNBR stocks which are peroxide-cured with Dymalink™ 633 and 634 demonstrate good tensile strength, cord adhesion, high hardness, high abrasion and fluid resistance, and high elongation. These enhanced performance properties make Dymalink™ 633 and 634 ideal for hard rolls, synchronous and V belts, seals, and engine mounts**.** Dymalink™ 633 is especially suited for applications requiring good hot air and oil resistance, loadbearing capacity, dynamic stability, ozone and abrasion resistance, and cord adhesion properties.

Both Dymalink™ 633 and 634 yield higher elongation values than TAIC and TMPTA. This results in HNBR with cnhanced toughness, tear strength, abrasion, anti-chunking, durability, and foam cell strength.



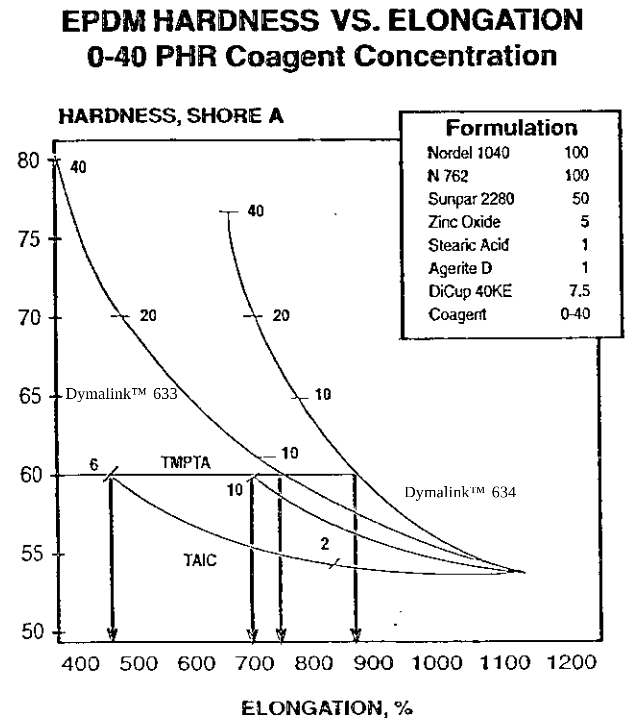
Peroxide-cured HNBR containing Dymalink™ 633/634 exhibits superior heat aging characteristics versus comparable sulfur-cured stocks. The two systems are compared below and are based on stocks which were initially cured to a constant modulus. The heat aged properties of the peroxide-cured Dymalink™ 633 system alter very little and are controllable in contrast to the large, uncontrollable changes in the sulfur system. By balancing Dymalink™ 633 and filler levels, optimum high temperature performance can be achieved.

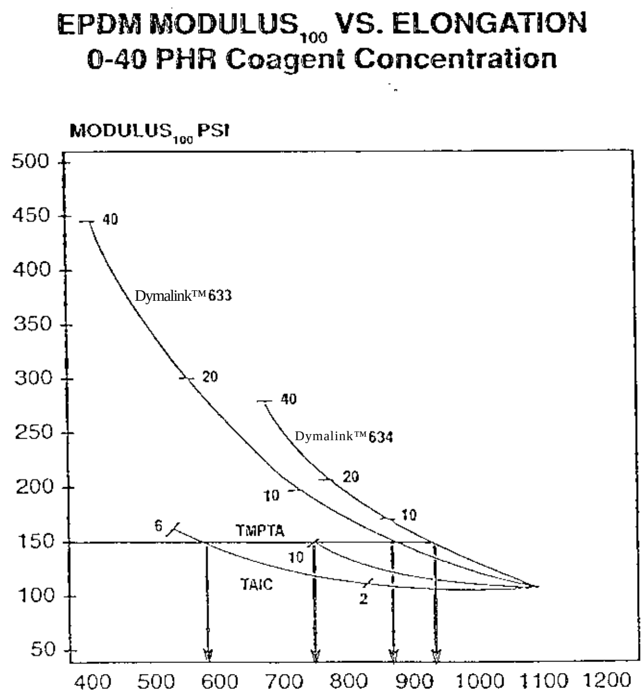


Ethylene Propylene Diene Rubber (EPDM)

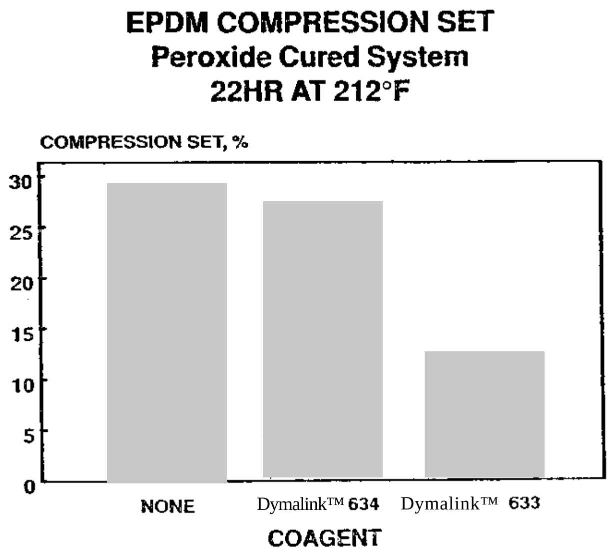
The following graphs illustrate the superior properties obtained with Dymalink™ coagents in EPDM.

Both the Dymalink™ 633 and 634 coagents give higher modulus and hardness than TMPTA or TAIC in aged (70HR, 212°F) EPDM.

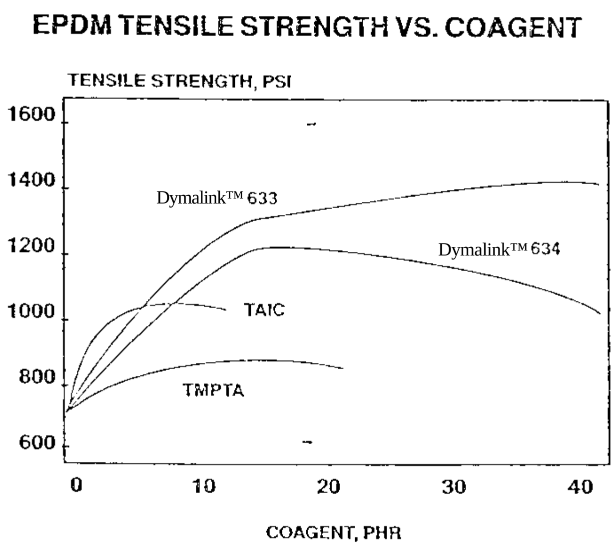




Compression set is improved significantly with the use of Dymalink™ 633. Compression set for peroxide alone is 29%, whereas Dymalink™ 633 lowers the compression set to 13% as shown below:



For a given modulus, for example 150 psi, TAIC gives the lowest elongation and Dymalink™ 634 the highest elongation.



In unaged EPDM, the highest tensile strength is obtained with Dymalink™ 633 while TMPTMA gives the lowest as shown above. For tear strength, both Dymalink™ 633 and 634 are superior to TMPTMA and TAIC.

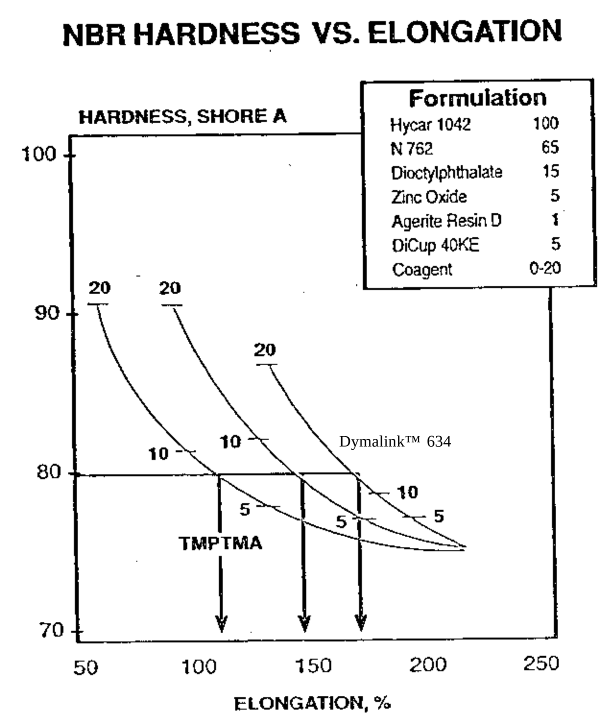
For a given modulus, for example 150 psi, TAIC gives the lowest elongation and Dymalink™ 634 the highest elongation.

Nitrile Rubber (NBR)

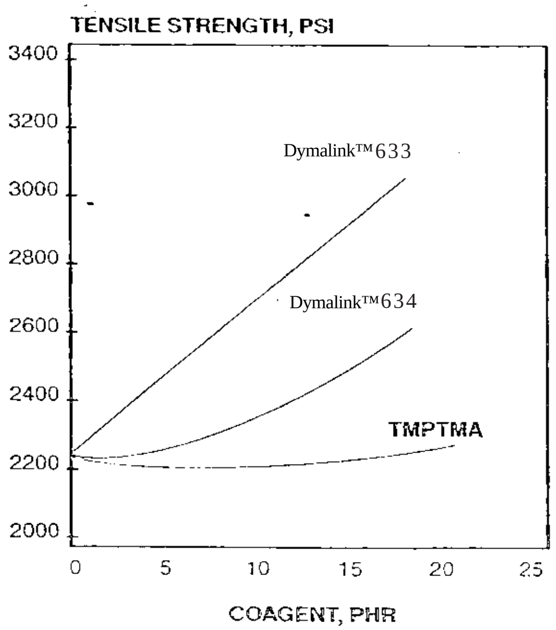
The four graphs for heat aged NBR (70HR, 212°F) show that increasing the concentration of the metallic coagent gives higher modulus, tensile strength, tear strength, and hardness compared with TMPTMA.

Additional property advantages include:

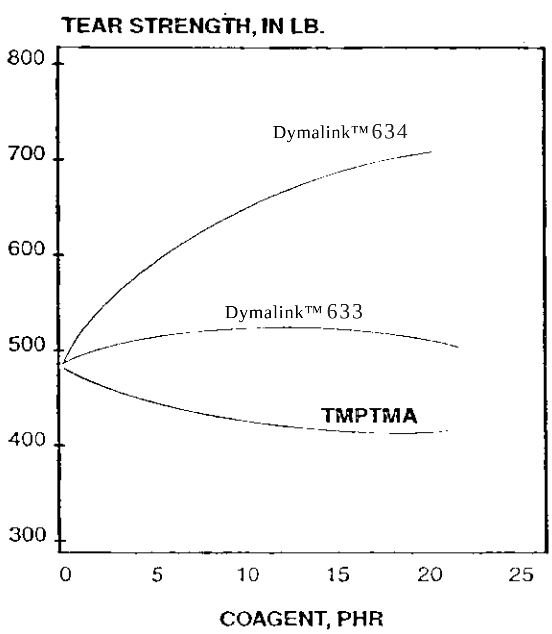
- Low compression set of 20% for all three coagent systems.
- Excellent oil resistance for Dymalink™ 633/634 with samples showing no weight gain in ASTM No.3 il after 283 hours at 75°F.
- Good high temperature tensile strength at 150°C at 20 PHR Dymalink™ 634 with no loss in elongation and a modest drop off in tensile strength.



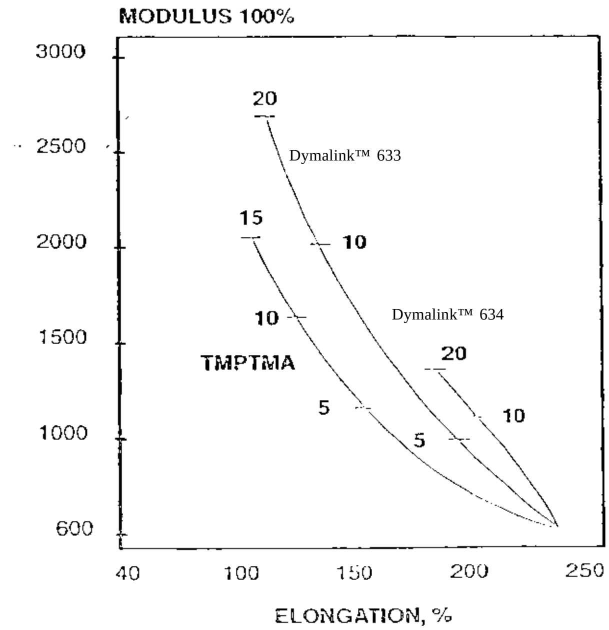
NBR TENSILE STRENGTH VS. COAGENT PHR



NBR HARDNESS VS. COAGENT PHR



NBR MODULUS100 VS. ELONGATION
0-20 PHR Coagent Concentration

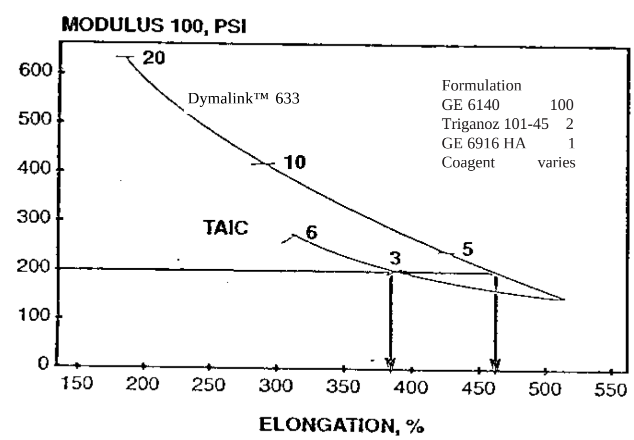


Silicone Rubber

Excellent heat aged (70HR, 300°C) properties are obtained with silicone (GE 6140) cured with Dymalink™ coagents. Coagent levels up to 20 PHR were successfully used without mold sticking using conventional mold release agents.

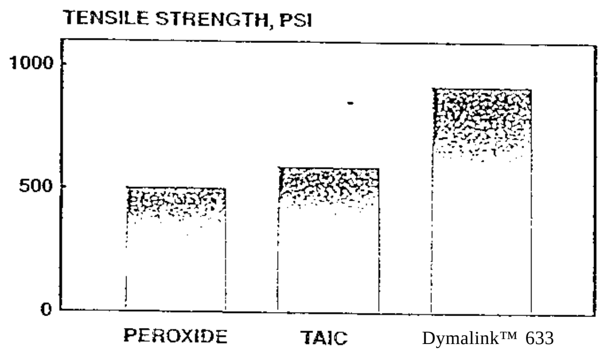
Dymalink™ 633 provides a compound with a higher elongation after aging than does TAIC for a given crosslink density. At a constant modulus of 200 psi, the TAIC elongation is 380% while Dymalink™ 633 gives an elongation of 470%.

SILICONE MODULUS$_{100}$ VS. ELONGATION
Coagent Concentration 0-20 PHR



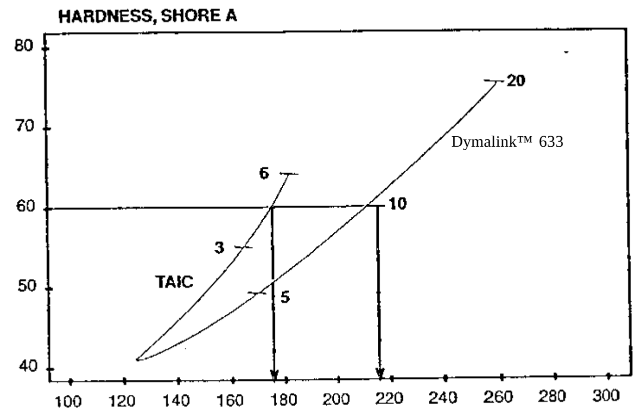
Heat aged tensile strength is improved with Dymalink™ 633 over TAIC as shown below at the same coagent concentration of 6 PHR.

COAGENT EFFECT ON TENSILE STRENGTH



Unaged hardness and tear resistance properties are also excellent for Dymalink™ 633. At a constant hardness level of 60 Shore A, tear resistance is 175 psi for TAIC and 215 psi for Dymalink™ 633.

SILICONE UNAGED HARDNESS VS. TEAR RESISTANCE



Dymalink™ 633 provides better overall properties than does TAIC in a silicone compound when compared at an equal coagent cost basis. The following table compares 5 PHR TAIC with 12 PHR Dymalink™ 633.

Property Comparison TAIC vs. Dymalink™ 633 Equal Coagent Cost Basis

	Aged Modulus 100	Aged Elongation	Aged Tensile Strength	Unaged Tear Resistance
TAIC	250	250	670	190
Dymalink™ 633	350	32-	97-	225

Adhesion Properties

Metallic coagents produce strong rubber-to-metal adhesive bonds without external adhesives or a separate curing step. During curing, Dymalink™ metallic coagents develop adhesive bonds at the metal-to-rubber interface while simultaneously generating strong crosslinks in the rubber.

These rubber-to-metal bonds remain stable, even when exposed to moisture and heat. Figure 1 shows no deterioration in lap shear strength under heat aging at 300°F and submersion in water at room temperature for 165 hours. These performance properties make ideal for rubber rolls, seals, gaskets, hoses, belts, and other under-the-hood applications.

Figure 1

Aged Lap Shear Adhesion, Mpa
EPDM to Cold Rolled Steel
10 PHR Dymalink™ 633

Unaged control	8.0
Heat Age 300°F	
96 HR	8.3
165 HR	8.5
Water Submersion, 70°F,	
66 HR	8.6
165 HR	7.9

Under certain harsh alkaline and salt spray invironments, Dymalink™ 633 and 634 are not recommended. Dymalink™ 634, however, maintains a more stable adhesive performance.

Dymalink™ metallic coagents can obtain excellent rubber-to-metal adhesion with a wide variety of elastomers (see Figure 2) and metals, including steel, stainless steel, brass, and zinc (Figure 3).

Dymalink™ metallic coagents can be used over a broad concentration range to tailor mechanical properties. For most metals, small additions of metallic coagents (1-5 phr) dramatically increase adhesion (Figure 4) and heighten performance characteristics, including modulus and Shore A hardness.

Figure 2

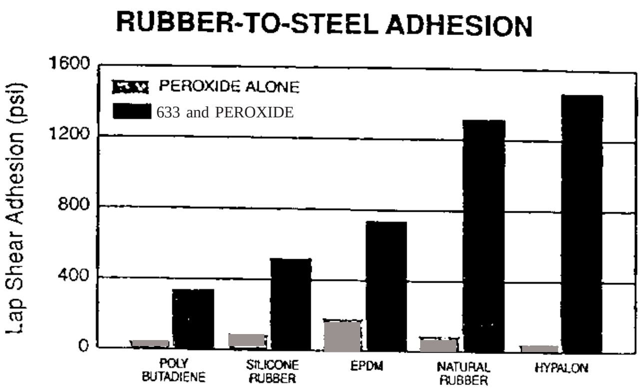


Figure 3

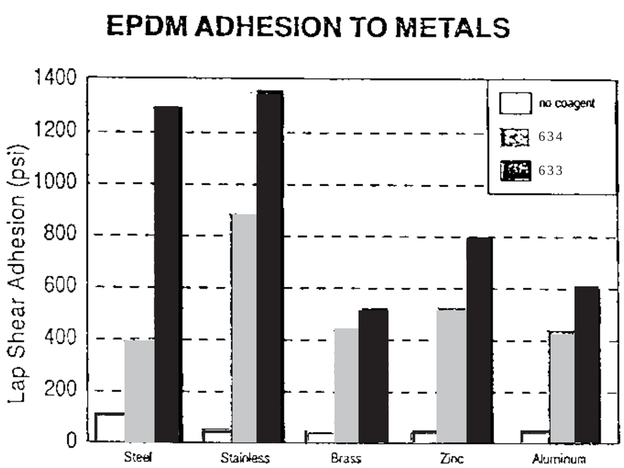
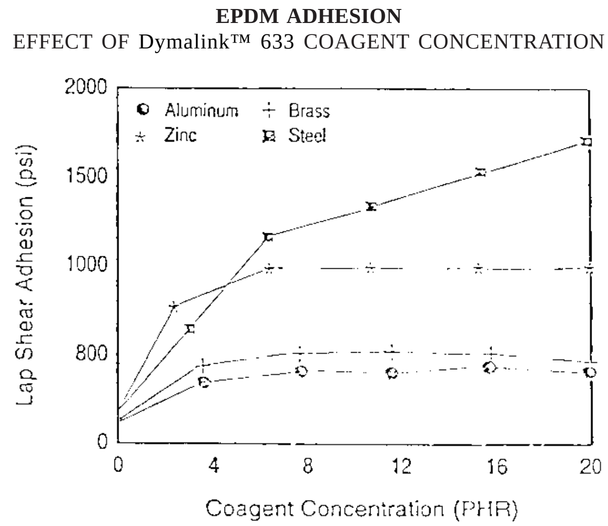


Figure 4



Handling and Storage

Dymalink™ metallic coagents demonstrate a low order of toxicity. Handle in accordance with good industrial hygiene practice which includes minimizing exposure of coagent to the eyes, skin, and clothing. Refer to the Material Safety Sheet for complete information on toxicity and recommended handling procedures.

Store in a cool and preferably air-conditioned area where the ambient temperature does not exceed about 80°F. Keep containers tightly closed until ready to use so as to avoid loss of activity. The Dymalink™ coagents are anhydrous salts that will readily absorb moisture upon exposure to a humid atmosphere. For optimum results, use within 6 months of receipt.

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Resins par excellence

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