Materials Bonding - Ethylene Propylene Rubber

DeBeil and Richardson, Inc.

prepared for
Office of Naval Research

APRIL 1973

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FINAL REPORT
ON
MATERIALS BONDING

Prepared For
OFFICE OF NAVAL RESEARCH
Arlington, Virginia 22217

Contract No. N00014-72-C-0209
Item: A001AE
NR 294-006/11-18-71 (485)

Project 6041.1

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April 1973

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MATERIALS BONDING - ETHYLENE PROPYLENE RUBBER

An EPDM formulation has been developed, utilizing a peroxide cure system, that will develop satisfactory physical properties over a cure temperature range compatible with polyethylene, polypropylene, and neoprene. This formulation has been molded and cured against samples of these materials as well as stainless steel, and beryllium copper, with various surface treatments, and the adhesion bonding obtained measured quantitatively. Test results indicate that, dependent on surface treatment and cure parameters, a reasonable degree of bonding can be achieved between the EPDM formulation and each of the other materials. Work, beyond the scope of this study, remains to be done to optimize the adhesion obtained; to investigate EPDM bonding to other materials; and to correlate the results with service testing of dual or multicomponent systems.
1. Ethylene Propylene Rubber
2. Underwater cable insulation
3. Cable splice encapsulation
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INTRODUCTION

The reliability of an underwater cable system for the gathering and/or transmission of data depends on the reliability of both its electronic components, and its electrical network of cable, splices, and connectors. The integrity of this network against the effects of sea water and hydrostatic pressure is maintained by insulation, using a suitable, dielectric material. Ideally, the same insulating material would be used throughout the system-restored at joints, splices, and connectors to maintain continuity of coverage. However, under certain conditions, it may not be possible or desirable to use the same insulation throughout a system. The electrical or mechanical requirements for part of a system may dictate the use of a different insulating material, or it may be necessary to incorporate standard or stock components available only with different insulation. In these instances, the re-insulation of joints between different materials becomes both a technical and a reliability problem.

Polyethylene, polypropylene, and neoprene are commonly used insulating materials on wire and cable for underwater service, as are stainless steel and beryllium copper for connector hardware. Ethylene Propylene Diene Rubber (EPDM), a synthetic rubber having chemical building blocks in common with polyethylene and polypropylene and physical properties similar to neoprene, has been investigated as a potential tie material between these insulations.

An EPDM formulation has been developed, utilizing a peroxide cure system, that will develop satisfactory physical properties over a cure temperature range compatible with polyethylene, polypropylene and neoprene. This formulation has been molded and cured against samples of these materials as well as stainless steel, and beryllium copper, with various surface treatments, and the adhesion bonding obtained measured quantitatively. Test results indicate that, dependent on surface treatment and cure parameters,
a reasonable degree of bonding can be achieved between the EPDM formulation and each of the other materials. Work, beyond the scope of this study, remains to be done to optimize the adhesion obtained; to investigate EPDM bonding to other materials; and to correlate the results with service testing of dual or multicomponent systems.
SCOPE OF WORK

The evaluation of EPR as a possible tie material for bonding between polyethylene, polypropylene, neoprene, stainless steel, and beryllium copper required a two-stage program. In Phase I, desirable properties for an EP rubber formulation were specified, and a formulation developed and tested for conformance to those properties. In Phase II, the formulation selected was molded against treated samples of the five materials under study and the bond strength measured.

PHASE I

EP Rubber Properties

The following properties and/or characteristics were used as the basis for the development of an EP Rubber compound (formulation) for use in the study. In each case, a goal was set and ingredients selected for trial to reach the goal.

1. Reactivity

Ethylene-Propylene Rubbers are available either as copolymers of ethylene and propylene with no unsaturation (Vistalon 404, Enjay Chemical) or as terpolymers of ethylene, propylene and diene where the diene adds a reactive double bond to the mixture. The copolymer is curable with peroxides only, while the terpolymers can be cured with either peroxide or sulfur systems. The double bond in the terpolymer appeared to offer a plus factor as far as reactivity in a potential chemical bond was concerned, and for this reason, terpolymers (EPDM) were used as the starting point for trial formulations. In an attempt to get additional reactivity, several formulations were tried with polyacrylate crosslinking agents (ref: Sartomer Resins' letter, appended). These materials had the added advantage of lowering uncured formulation viscosity, and the possibility of being added to the interface prior to molding.

2. Uncured Viscosity

A compound for use as a tie material would have to be molded around a splice or connector, and frequently forced between
several insulated wires eliminating voids and acting as an insulator. Low viscosity in the uncured state thus becomes a requirement for any such formulation to avoid bending wires or damaging existing insulation as the material is forced into a cavity (mold) under pressure. Nordel 1320, an EPDM from DuPont, had the lowest viscosity (Mooney ML-4 @ 250° of 18) of any of the commercial rubbers used in our formulations, and therefore was a prime candidate.

3. Cure System

Although the terpolymers (EPDM) can be cured with either sulfur or peroxide catalyst systems, peroxide cures were used exclusively for this program. This was done to eliminate the possibility of sulfur reactions with electrical components in future work, and also in the hope that peroxides in the rubber might give some crosslinking with other polymers during cure.

4. Cure Temperatures

One of the major problems in the formulation of a suitable rubber formulation, was the range of temperatures required by the various materials to which we wished to bond. The normal range of rubber cure temperatures is 300° - 350° F, and most compounds and cure systems are tailored to this range as are most primer systems for rubber to metal adhesion. The two metals, therefore, were no problem; neoprene as used in this study was already cured; polypropylene (cable grade SE-023) has a sharp melting point of about 330°F; but polyethylene (DFD 0160 Melt Index .3) has a crystallization temperature in the 230° - 250° F range and a softening point somewhat below that - with the result that a 300°F cure temperature would cause severe damage to polyethylene insulation.

At first we felt that two formulations with different temperature cure systems would be required, and tried several compounds with benzoyl peroxide or t-butyl peroctoate as low temperature systems, and dicumyl peroxide (Di-cup) as a high temperature system. These low temperature peroxides gave problems of decomposition on the rolls during mixing, and would have made formulations with low shelf life under normal storage conditions. In the search for more stable alternates to benzoyl peroxide, we tested Luperco 230XL - later replaced with D-231XL. The latter
compound, a peroxyketal – data given in the appended bulletin, appeared to give satisfactory results both at 240°F, the maximum temperature picked for polyethylene, and 315°F, selected for propylene and the other materials. The availability of a wide range catalyst eliminated the need for more than one formulation.

TABLE I

Thermal Decomposition Data for Peroxides

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<tr>
<th>Peroxide</th>
<th>85°C</th>
<th>100°C</th>
<th>115°C</th>
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<td>2.1 hrs.</td>
<td>0.4 hrs.</td>
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<td>t-Butyl Peroctoate</td>
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<td>0.4 hrs.</td>
<td>0.1 hrs.</td>
</tr>
<tr>
<td>D-231 &amp; D-231XL</td>
<td>27.0 hrs.</td>
<td>3.8 hrs.</td>
<td>0.71 hrs.</td>
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<tr>
<td>Di-cup</td>
<td>132.0 hrs.</td>
<td>46.0 hrs.</td>
<td>9.2 hrs.</td>
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5. Physical Properties

A compound for use as a tie material or as encapsulation for cable connections and splices should have adequate physical properties to resist damage during handling and storage. It should also be as flexible as the material to which it is to be bonded to eliminate stress concentrations at the interface. With this end use in mind, the following targets were chosen for tensile strength, elongation, and hardness.

- Tensile: 500 psi minimum
- Elongation: 300% minimum
- Hardness: 40 (Shore D) minimum

With most of the rubbers tested, the attainment of these targets required the addition of carbon black as reinforcement with quantities kept as low as possible to avoid loss of electrical properties. The carbon black has the added advantage of increasing UV light and weathering resistance – a potential storage problem.

Rubber Formulations

During this first stage of the program, rubber formulations were selected for test with the foregoing considerations and properties in mind. In each case the ingredients were mixed on a 6" x 12" laboratory mill roll at the minimum temperature required to sheet, and the resulting compound molded and tested per ASTM D412-68. The following tables give the formulations tried and the results obtained:

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### TABLE 2

Formulations (phr)
(parts per hundred, rubber)

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<th>Benzoyl</th>
<th>t-Butyl Peroxide</th>
<th>Di-cup 40C</th>
<th>Luperco 230XL</th>
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* 50% paste Luperco ATC

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Mooney Visc. 18  Mooney Visc. 45  Mooney Visc. 40  Mooney Visc. 55  Mooney Visc. 40  Mooney Visc. 50
# TABLE 3

Cure Conditions and Physical Properties per ASTM D412-63

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<th>Compound No.</th>
<th>Mold Temperature °F</th>
<th>Cure Time min.</th>
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Not fully cured

Not fully cured

Peroxide decomposition on mill

Peroxide decomposition on mill

N00014-72-C-0209
### Table 3 - continued

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N00014-72-C-0209
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Table 3 - continued
Selection of Formulation

Based on the test results shown in Table 2, formulation #44 was selected as the standard rubber for bonding trials. While several others would have met the physical property targets, they were eliminated for other reasons. Those made with Royalene 611 as a base rubber showed outstanding tensile and elongation values (#5, 10, 11, and 20), but the presence of 40 phr paraffinic oil in the rubber would have meant introducing another variable. On the other hand #44 was chosen over #38 because #44 contained 10 phr SR297 an additional reactive component.

With the wide variety of ingredients available for rubber compounding, there is no doubt that #44 can be improved or replaced with another formulation. However, it met the criteria that we had set initially, and improvement did not appear necessary for Phase II of our study.

PHASE II BONDING TRIALS

Preparation of Samples

Samples for bond strength test were prepared as follows. A transfer mold (Figure 1, p 12A) was made with the following components: an electrically heated bottom plate; a 1/4" thick chase with a 2-1/4 x 5-1/4 rectangular cavity; an electrically heated top plate center gated; and a transfer pot and plunger also electrically heated. In operation, a 1/8" x 2-1/4" x 5-1/4" strip of a substrate material (polyethylene, polypropylene, neoprene, stainless steel, or beryllium copper) was placed in the chase against the bottom plate, the mold assembled with a charge of 32 gms of rubber in the transfer pot, and the assembly loaded into a Carver Laboratory press (Figure 2, p 12A). The mold was heated to 180°F - a temperature below the initiation of cure - and the rubber forced into the cavity over the substrate sheet under a pressure of 1000 psi. When the cavity was filled, the temperature of the mold was raised to the cure temperature selected and pressure maintained for the duration of the cure. At the end of the cure time, the mold was cooled slowly and the sample removed as a 1/4" x 2-1/4" x 5-1/4" "sandwich".

Test Procedure

The samples prepared as above were tested for bond between the molded rubber and the substrate as follows: Each "sandwich" was cut into 1/2" x 2-1/4" strips, or for the steel and beryllium specimens, the rubber cut
Figure 1. Transfer Mold for Sample Preparation

Figure 2. Molding Set-up for Sample Preparation
Figure 3. Instron Testing Machine Set-up

Figure 4. 90° Peel Test - 1/2" Sample Width
down to the metal surface in 1/2" wide strips. The substrate base of the sandwich was clamped horizontally, a length of rubber sufficient to clamp separated by cutting at the interface, and the rubber pulled from the substrate at 90° in an Instron testing machine Model TM. The 90° peel was used for all substrates except neoprene, which was too flexible to clamp in a vise, and was tested in 180° pull (T peeled). For all samples, cross head speed was set at 0.5-inch per minute, chart speed at 0.5-inch per minute and full load of 0-20 and 0-50 pounds. The test setup is shown in Figure 3, p 12B, and a sample clamped for 90° peel shown in Figure 4, p 12B.

Record of Trials

The following information is given for each sample prepared and tested.

1. Sample Number
2. Substrate Material
3. Substrate pre-treatment (prior to molding)
4. Cure temperature (°F) and cure time (minutes)
5. Peel strength - reported as pounds per 1/2 inch width, average estimated from chart
6. Appearance of substrate surface after peel or type of failure.

#1 Substrate: SE-023 Polypropylene copolymer - Hercules
Treatment: A. Trichloroethane wash
           B. Chromic acid for 30 min. @ 210°F
Cure: 315° 30 min.
Peel: 48 hours 5.9 lbs.
       6 months 7.1 lbs.
Appearance: Some discoloration and spots of rubber left on surface

#2 Substrate: SE-023
Treatment: A. Trichloroethane wash
Cure: 240° 60 min.
Peel: 48 hours 2.1 lbs.
       6 months 4.3 lbs.
Appearance: Clean peel

N00014-72-C-0209
#3 Substrate: SE-023
Treatment: A. Trichloroethane wash
Cure: 280° 45 min.
Peel: 48 hours 4.2 lbs.
6 months 4.6 lbs.
Appearance: Clean peel

#4 Substrate: SE-023
Treatment: A. Trichloroethane wash
Cure: 320° 30 min.
Peel: 48 hours 8.4 lbs.
6 months 9.3 lbs.
Appearance: Clean except for stop-start lines transverse to peel direction. Rubber shows on these lines.

#5 Substrate: SE-023
Treatment: A. Trichloroethane wash
B. Soak 10 min. @ 140° in the following solution
   Tetrachloroethylene 100 parts
   Sartomer SR 298 10 parts
   D-221 (liquid) 5 parts
C. Dry 5 min. @ 140°F
Cure: 320° 30 min.
Peel: 48 hours 8.6 lbs.
6 months 8.3 lbs.
Appearance: Clean peel.

#6 Substrate: SE-023
Treatment: A. Trichloroethane wash
B. Soak 10 min. @ 140°F in the following solution
   Tetrachloroethylene 100 parts
   Sartomer SR 350 10 parts
   D-231 (liquid) 5 parts
C. Dry 5 min. @ 140°F
Cure: 320° 30 min.
Peel: 48 hours 7.6 lbs.
6 months 7.2 lbs.
Appearance: Clean peel

N00014-72-C-0209
#7  Substrate: SE-023
Treatment: A. Trichloroethane wash  
B. Soak 10 min. @ 140°F in the following solution  
   Tetrachloroethylene 100 parts  
   Sartomer Saret 515 10 parts  
   D-231 (liquid) 5 parts  
C. Dry 5 min. @ 140°F  
Cure: 320°F 30 min.  
Peel: 48 hours 7.1 lbs.  
   6 months 6.8 lbs.  

#8  Substrate: Polyethylene - Union Carbide DFD 0160  
Treatment: A. Trichloroethane wash  
Cure: 240°F 60 min.  
Peel: 48 hours 7.7 lbs.  
   5 months 7.9 lbs.  
Appearance: Thin rubber left on approximately 90% of surface  

#9  Substrate: Polyethylene - Union Carbide DFD 0160  
Treatment: A. Soak 15 min. @ 140°F in the following solution  
   Toluene 100 parts  
   SR-297 10 parts  
   Lucidol D-231 5 parts  
B. Dry 5 min. @ 140°F  
Cure: 240°F 60 min.  
Peel: 48 hours 8.0 lbs.  
   5 months 9.6 lbs.  
Appearance: Thin rubber left on approximately 80% of surface  

#10  Substrate: Polyethylene - Union Carbide DFD 0160  
Treatment: A. Soak 15 min. @ 140°F in the following solution  
   Toluene 100 parts  
   SR-350 10 parts  
   D-231 5 parts  
B. Dry 5 min. @ 140°F  
Cure: 240°F 60 min.  
Peel: 48 hours 6.7 lbs.  
   5 months 8.2 lbs.  
Appearance: Thin rubber left on approximately 40% of surface
#11 Substrate: SE-023
Treatment:
A. Abrade surface with 150 grit emery paper
B. Soak 15 min. @176°F in the following solution
   Trichloroethane 100 parts
   SR-297 10 parts
   D-231 5 parts
C. Dry 5 min. @ 176°F

Cure: 320° 30 min.
Peel: 48 hours 8.6 lbs.
5 months 9.8 lbs.
Appearance: Thin rubber left on surface - primarily in the scratch lines from Treatment A.

#12 Substrate: SE-023
Treatment:
A. Abrade surface with 150 grit emery paper
B. Soak 15 min. @ 176°F in the following solution
   Trichloroethane 100 parts
   SR-350 10 parts
   D-231 5 parts
C. Dry 5 min. @ 176°F

Cure: 320° 30 min.
Peel: 48 hours 11.6 lbs.
5 months 12.9 lbs.
Appearance: Similar to #11

#13 Substrate: SE-023
Treatment:
A. Abrade surface with 150 grit emery paper
B. Soak 15 min. @ 176°F in the following solution
   Trichloroethane 100 parts
   SR-515 10 parts
   D-231 5 parts
C. Dry 5 min. @ 176°F

Cure: 320° 30 min.
Peel: 48 hours 10.7 lbs.
5 months 10.7 lbs.
Appearance: Similar to #11
#14 Substrate: Stainless Steel - Type 316
Treatment: A. Vapor degrease in perchloroethylene
B. Grit blast with 80 mesh Aluminum Oxide
C. Vapor degrease in perchloroethylene
D. Prime with two coats Thixon D 12809 (0.001 in.) and 1 coat Thixon AP 1434 (.001)
Cure: $320^\circ$ 30 min.
Peel: 48 hours 25.1 lbs.
5 months 30.3 lbs.
Appearance: No peel. Rubber tab broke.

#15 Substrate: Beryllium Copper
Treatment: A. Vapor degrease in perchloroethylene
B. Grit blast with 80 mesh Aluminum Oxide
C. Vapor degrease in perchloroethylene
D. Prime with two coats Thixon D 12809 (0.001 in.) and 1 coat Thixon AP 1434 (.001)
Cure: $320^\circ$ 30 min.
Peel: 48 hours 17.2 lbs.
5 months 20.4 lbs.
Appearance: Peeled at rubber - AP 1435 interface - one of four tabs broke during test

#16 Substrate: SE-023 Polypropylene
Treatment: A. Abrade surface with 150 grit emery paper
B. Trichloroethane wash
Cure: $320^\circ$ 30 min.
Peel: 48 hours 8.8 lbs.
5 months 9.6 lbs.
Appearance: Thin rubber left in surface scratches.

#17 Substrate: SE-023 Polypropylene
Treatment: Oxidizing Flame
Cure: $320^\circ$ 30 min.
Peel: 48 hours 4.0 lbs.
5 months 4.1 lbs.
Appearance: Clean peel.
#18  Substrate: Polyethylene - Union Carbide DFD 0160
Treatment: Oxidizing Flame
Cure: 240° 60 min.
Peel: 48 hours 6.3 lbs.
5 months 6.2 lbs.
Appearance: Thin rubber left on approximately 20% of surface

#19  Substrate: SE-023 Polypropylene
Treatment: A. Abrade surface with 150 grit emery paper
           B. Trichloroethane wash

Rubber Formulation: (phr)  
Nordel 1320 100  
SE-023 polypropylene 20  
Zinc Oxide 5  
Carbon Black 20  
SR-297 12  
D-231XL 8.4  

Cure: 320° 30 min.
Peel: 48 hours 6.2 lbs.
5 months 7.0 lbs.
Appearance: Clean peel except for scratches

#20  Substrate: Polyethylene - Union Carbide DFD 0160
Treatment: A. Abrade surface with 150 grit emery paper
           B. Trichloroethane wash

Rubber Formulation: (phr)  
Nordel 1320 100  
DFD 0160 polyethylene 10  
Zinc Oxide 5  
Carbon Black 20  
SR-298 11  
D-231XL 7.7  

Cure: 240° 60 min.
Peel: 48 hours 10.9 lbs.
5 months 11.6 lbs.
Appearance: Thin rubber coating on interface 90%.
#21 Substrate: SE-023 Polypropylene
Treatment: A. Abrade with 150 grit emery paper
B. Trichloroethane wash
Rubber Formulation: (phr) Nordel 1320 100
SE-023 polypropylene 10
Zinc Oxide 5
Carbon Black 20
SR-297 11
D-231XL 7.7
Cure: 320° 60 min.
Peel: 48 hours 6.0 lbs.
5 months 6.4 lbs.
Appearance: Clean peel except for scratches

#22 Substrate: Stainless Steel Type 316
Treatment: A. Vapor degrease in perchloroethylene
B. Grit blast with 80 mesh Aluminum Oxide
C. Vapor degrease in perchloroethylene
D. Prime with 2 coats Chemloc 205 (.0006) and 2 coats Chemloc 236 (.0028)
Cure: 320° 30 min.
Peel: Rubber blistered @ bond interface - not tested

#23 Substrate: Beryllium Copper
Treatment: A. Vapor degrease in perchloroethylene
B. Grit blast with 80 mesh Aluminum Oxide
C. Vapor degrease in perchloroethylene
D. Prime with 2 coats Chemloc 205 (.0005) and 2 coats Chemloc 236 (.0028)
Cure: 320° 30 min.
Peel: Rubber blistered @ bond interface - not tested

#24 Substrate: Stainless Steel Type 316
Treatment: A. Vapor degrease in perchloroethylene
B. Grit blast with 80 mesh Aluminum Oxide
C. Vapor degrease in perchloroethylene
D. Prime with 2 coats Thixon D-12809 (.0005) and 1 coat Thixon AP 1435 (.0028)
Cure: 320° 30 min.
Peel: 48 hours 27.7 lbs.
3 months 27.1 lbs.
Appearance: 40% failure at interface (RC-40)
All four tabs tested broke.

N00014-72-C-0209
#25 Substrate: Beryllium Copper
Treatment: A. Vapor degrease in perchloroethylene
B. Grit blast with 80 mesh Aluminum Oxide
C. Vapor degrease in perchloroethylene
D. Prime with one coat Thixon D 12809 (.0005) and 2 coats Thixon AP 1435 (.0026)
Cure: 240° 60 min.
Peel: 48 hours 3.5 lbs.
3 months 7.6 lbs.
Appearance: Interface failure 40% (RC-40) Rubber failure 60% (R-60) Rubber at interface not fully cured.

#26 Substrate: Neoprene Shore D 60
Treatment: A. Trichloroethane wash
B. Prime with Chemloc 236 (.003)
Cure: 240° 60 min.
Peel: 48 hours 0.7 lbs.
3 months 0.8 lbs.
Appearance: Smooth Interface

#27 Substrate: Neoprene Shore D 60
Treatment: A. Trichloroethane wash
B. Prime with Chemloc 236 (.003)
Cure: 320° 30 min.
Peel: 48 hours 1.1 lbs.
3 months 1.5 lbs.
Appearance: Dull surface

#28 Substrate: Beryllium Copper
Treatment: A. Vapor degrease in perchloroethylene
B. Grit blast with 80 mesh Aluminum Oxide
C. Vapor degrease in perchloroethylene
D. Prime with 2 coats Chemloc 205 (.0007) and 2 coats Chemloc 236 (.0017)
Cure 240° 60 min.
Peel: 48 hours 9.5 lbs.
3 months 10.0 lbs.
Appearance: Interface failure 70% (RC-70) Rubber failure 30% (R-30)
#30 Substrate: Neoprene Shore D 60  
Treatment:  
A. Trichloroethane wash  
B. Prime with Chemloc 234  
Cure:  
320° 30 min.  
Peel:  
48 hours 4.6 lbs.  
3 months 6.3 lbs.  
Appearance: Dull, rough surface. More evidence of adhesion than #27.

#33 Substrate: Neoprene Shore D 60  
Treatment:  
A. Trichloroethane wash  
B. Prime with Chemloc 220  
Cure:  
320° 30 min.  
Peel:  
48 hours >14.0 lbs.  
3 months >14.7 lbs.  
Appearance: Tabs broke

#34 Substrate: Neoprene Shore D 60  
Treatment:  
A. Abrade surface with 150 grit emery paper  
B. Trichloroethane wash  
C. Prime with Chemloc 220  
Cure:  
320° 30 min.  
Peel:  
48 hours 9.5 lbs.  
3 months 11.8 lbs.  
Appearance: Surface of molded rubber very rough - Tab broke.

#35 Substrate: Stainless Steel Type 316  
Treatment:  
A. Vapor degrease in perchloroethylene  
B. Grit blast with 80 mesh Aluminum oxide  
C. Vapor degrease in perchloroethylene  
D. Prime with two coats Thixon and 1 coat Thixon AP 1435.  
Cure:  
240° 60 min.  
Peel:  
48 hours 3.8 lbs.  
3 months 3.3 lbs.  
Appearance: Interface failure 90%
#36 Substrate: Stainless Steel Type 316  
Treatment:  
A. Vapor degrease in perchloroethylene  
B. Grit blast with 80 mesh Aluminum Oxide  
C. Vapor degrease in perchloroethylene  
Cure: $320^\circ$ 30 min.  
Peel: 48 hours 2.5 lbs. 3 months 2.7 lbs.  
Appearance: Clean peel  

#37 Substrate: Beryllium Copper  
Treatment:  
A. Vapor degrease in perchloroethylene  
B. Grit blast with 80 mesh Aluminum Oxide  
C. Vapor degrease in perchloroethylene  
Cure: $320^\circ$ 30 min.  
Peel: 48 hours 2.7 lbs.  
Appearance: Clean peel  

#38 Substrate: SE-023 Polypropylene  
Treatment: Trichloroethane wash  
Rubber Evaluation: (phr)  
<table>
<thead>
<tr>
<th>Component</th>
<th>100</th>
<th>10</th>
<th>5</th>
<th>20</th>
<th>11</th>
<th>7.7</th>
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<tbody>
<tr>
<td>Nordel 1320</td>
<td></td>
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<tr>
<td>Polyethylene OFD 0160</td>
<td>10</td>
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</tr>
<tr>
<td>Zinc Oxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Black</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SR-297</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-231XL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Cure:             | $320^\circ$ 30 min.  
Peel: 48 hours 8.1 lbs. 3 months 7.3 lbs.  
Appearance: Clean peel - dull finish  

Sources of Primers used:  
"Chemloc"  Hughson Chemical Co.  
Division of Lord Corp.  
Erie, Pennsylvania 16512  
"Thixon"  Dayton Chemical Products Division  
Whittaker Corp.  
West Alexandria, Ohio 45381  

N00014-72-C-0209
<table>
<thead>
<tr>
<th>Substrate</th>
<th>Sample #</th>
<th>Cure</th>
<th>Peel Short Term</th>
<th>Peel Long Term</th>
<th>Avg.</th>
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<tr>
<td>Polyethylene</td>
<td></td>
<td></td>
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<tr>
<td>8</td>
<td>240° 60 min.</td>
<td>7.7</td>
<td>7.9</td>
<td>7.8</td>
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<tr>
<td>9</td>
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<td>9.6</td>
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</tr>
<tr>
<td>10</td>
<td>240° 60 min.</td>
<td>6.7</td>
<td>8.2</td>
<td>7.5</td>
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</tr>
<tr>
<td>18</td>
<td>240° 60 min.</td>
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<td>6.2</td>
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<tr>
<td>20</td>
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<td>10.9</td>
<td>11.6</td>
<td>11.3</td>
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<tr>
<td>Polypropylene</td>
<td>1</td>
<td>315° 30 min.</td>
<td>5.9</td>
<td>7.1</td>
<td>6.5</td>
</tr>
<tr>
<td>2</td>
<td>240° 60 min.</td>
<td>2.1</td>
<td>4.3</td>
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</tr>
<tr>
<td>3</td>
<td>280° 45 min.</td>
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<td>4.4</td>
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<tr>
<td>4</td>
<td>320° 30 min.</td>
<td>8.4</td>
<td>9.3</td>
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</tr>
<tr>
<td>5</td>
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<td>6</td>
<td>320° 30 min.</td>
<td>7.6</td>
<td>7.2</td>
<td>7.4</td>
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<tr>
<td>7</td>
<td>320° 30 min.</td>
<td>7.1</td>
<td>6.8</td>
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<tr>
<td>11</td>
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<td>8.6</td>
<td>9.8</td>
<td>9.2</td>
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<tr>
<td>12</td>
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<td>11.6</td>
<td>12.9</td>
<td>12.2</td>
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<tr>
<td>13</td>
<td>320° 30 min.</td>
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<td>10.7</td>
<td>10.7</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>320° 30 min.</td>
<td>8.8</td>
<td>9.6</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>320° 30 min.</td>
<td>4.0</td>
<td>4.1</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>320° 30 min.</td>
<td>6.2</td>
<td>7.0</td>
<td>6.6</td>
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<tr>
<td>21</td>
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<td>6.4</td>
<td>6.2</td>
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<tr>
<td>Neoprene</td>
<td>26</td>
<td>240° 60 min.</td>
<td>0.7</td>
<td>0.8</td>
<td>0.7</td>
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<tr>
<td>27</td>
<td>320° 30 min.</td>
<td>1.1</td>
<td>1.5</td>
<td>1.3</td>
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<tr>
<td>30</td>
<td>320° 30 min.</td>
<td>4.6</td>
<td>6.3</td>
<td>5.4</td>
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<tr>
<td>33</td>
<td>320° 30 min.</td>
<td>&gt;14.0</td>
<td>&gt;14.7</td>
<td>&gt;14.0</td>
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<tr>
<td>34</td>
<td>320° 30 min.</td>
<td>&gt;9.5</td>
<td>&gt;11.8</td>
<td>&gt;10.0</td>
<td></td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>14</td>
<td>320° 30 min.</td>
<td>25.1</td>
<td>30.3</td>
<td>27.7</td>
</tr>
<tr>
<td>24</td>
<td>320° 30 min.</td>
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<td>27.1</td>
<td>27.4</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>240° 60 min.</td>
<td>3.8</td>
<td>3.3</td>
<td>3.6</td>
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<tr>
<td>36</td>
<td>320° 30 min.</td>
<td>2.5</td>
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<td>2.6</td>
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<tr>
<td>Beryllium Copper</td>
<td>15</td>
<td>320° 30 min.</td>
<td>17.2</td>
<td>20.4</td>
<td>18.8</td>
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<tr>
<td>25</td>
<td>240° 60 min.</td>
<td>3.5</td>
<td>7.6</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>240° 60 min.</td>
<td>9.5</td>
<td>10.0</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>320° 30 min.</td>
<td>2.7</td>
<td>-</td>
<td>2.7</td>
<td></td>
</tr>
</tbody>
</table>
CONCLUSIONS

1. The EPDM formulation (44) as used for this study shows a fair degree of adhesion to polyethylene when molded and cured in contact at 240°F for 60 minutes—-even with no surface treatment of the polyethylene except solvent wash (ref. #8). The best treatment found increased the force required to peel by 13% (ref. #9 SR-297 and D-231 in toluene). If we assume that 20 lbs. is required to break tabs in 90° peel, the best reading on polyethylene would rate 44% of break.

The addition of polyethylene to the EPDM formulation (ref. #20) gives a definite improvement in adhesion and would rate at 57% of break.

2. The EPDM formulation (44) when molded against polypropylene at 240°F for 60 minutes has very low adhesion (ref. #2). As the temperature is raised to 320° the adhesion (untreated) approaches that of polyethylene (ref. #4). Surface treatment appears to be more effective with polypropylene, with the best treatment found (ref. #12 SR-350 and D-231 in toluene) giving a 39% improvement over no treatment and a rating of 61% of break.

3. The EPDM formulation (44) has very little adhesion when molded and cured against untreated neoprene. A commercial primer system is available (ref. #33) which will give sufficient adhesion to cause tab failure in 180° peel.

4. The EPDM formulation (44) molded against clean mechanically roughened surfaces of either stainless steel or beryllium copper shows very little adhesion (ref. #’s 36 & 37). In both cases, however, commercial primer systems are available which will give sufficient adhesion when properly used to cause tab failure in 90° peel. (ref. #’s 14 & 15).

N00014-72-C-0209
RECOMMENDATIONS

Although a degree of bonding has been achieved between Ethylene Propylene Rubber and the substrate materials used in this study, there is no correlation between the peel strength measured and its performance as a "tie" material between the different components of an underwater system. We would, therefore, recommend that the performance of bonds between components and EPR be evaluated under simulated or actual service conditions, and the results correlated with the peel strength values obtained.

SBK/jcv
April 1973
Attachments

N00014-72-C-0209
LUCIDOL® Benzoyl Peroxide

Product Bulletin 1.100

LUCIDOL Benzoyl Peroxide is a mild organic oxidizing agent and a convenient source of free radicals for polymerization of numerous unsaturated monomers and polyesters.

Formula

\[
\text{C} - \text{O} - \text{O} - \text{C}
\]

Molecular Weight 242.22

SPECIFICATIONS

Benzoyl Peroxide 98.5% ± 1%
Active Oxygen 6.5% ± 0.07%

PROPERTIES

Melting Point (Decomposes) 103°-105°C (216°-222°F)
Form Fine granules
Color White
Solubility @ 20°C (Weight Percent)
   Insoluble (<1%) Water, ethylene glycol, petroleum ether, mineral oil
   Slightly Soluble (1-5%) Carbon tetrachloride, cyclohexane, alcohols, esters
   Moderately Soluble (5-15%) Ethyl acetate, styrene, toluene, trichloroethylene
   Soluble (15-50%) Acetone, benzene, chloroform, methyl ethyl ketone, dioxane

(Two data in Bulletin 20.11)

THERMAL DECOMPOSITION DATA

Half-life in dilute solutions.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Temperature (°F)</th>
<th>Benzene</th>
<th>Cyclohexanone</th>
<th>Acetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>158</td>
<td>13.0 hr.</td>
<td>11.7 hr.</td>
<td>7.3 hr.</td>
</tr>
<tr>
<td>85</td>
<td>185</td>
<td>2.15 hr.</td>
<td>1.9 hr.</td>
<td>1.4 hr.</td>
</tr>
<tr>
<td>100</td>
<td>212</td>
<td>0.4 hr.</td>
<td>0.38 hr</td>
<td>0.33 hr.</td>
</tr>
</tbody>
</table>
t-Butyl Peroctoate* is an efficient medium temperature initiator exhibiting catalytic activity in the same range as that of benzoyl peroxide. Because this new perester is a liquid, it dissolves much more easily in monomers and resins and can be metered or pumped like any liquid catalyst.

\[
\text{Formula} \quad \begin{align*}
\text{C}_4\text{H}_9 & \quad \text{O} \\
\text{CH}_3 & \quad \text{CH}_3 \\
\text{C}_2\text{H}_5 & \quad \text{CH}_3 \\
\text{CH}_3 & \quad \text{CH}_3
\end{align*}
\]

\text{Molecular Weight} \quad 216.3

**SPECIFICATIONS**

- **t-Butyl Peroxy (2-ethyl hexanoate)** ............................................. 97.0% minimum
- **Active Oxygen** ................................................................. 7.18% minimum

**PROPERTIES**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>Liquid</td>
</tr>
<tr>
<td>Color</td>
<td>Colorless</td>
</tr>
<tr>
<td>Odor</td>
<td>Faint</td>
</tr>
<tr>
<td>Freezing Point</td>
<td>Below -30°C</td>
</tr>
<tr>
<td>Specific Gravity @ 25°C/25°C</td>
<td>0.895 minimum</td>
</tr>
<tr>
<td>Refractive Index @ 25°C</td>
<td>1.426 minimum</td>
</tr>
<tr>
<td>Viscosity @ 20°C (68°F)</td>
<td>3.8 centipoises</td>
</tr>
<tr>
<td>@ 30°C (86°F)</td>
<td>2.8 centipoises</td>
</tr>
<tr>
<td>@ 40°C (104°F)</td>
<td>2.1 centipoises</td>
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<tr>
<td>Flash Point</td>
<td>Above 88°C (190°F)</td>
</tr>
<tr>
<td>Solubility</td>
<td>Miscible with esters, ketones, alcohols, hydrocarbons; practically insoluble in water.</td>
</tr>
</tbody>
</table>

The following table shows that t-Butyl Peroctoate has approximately the same half-life as benzoyl peroxide. This means that t-Butyl Peroctoate will also perform over the wide temperature range which has made benzoyl peroxide useful in so many applications.

* U. S. Patent 2,567,615

WALLACE & TIERNAN INC./ LUCIDOL DIVISION/ 1740 MILITARY ROAD • BUFFALO, N.Y. 14240
D-231, a new peroxyketal, is especially designed for vulcanization of elastomers such as SBR, NBR, EPM, EPR, Urethane and Silicones. The material is also suited for polyester molding at temperatures slightly above the benzoyl peroxide temperatures. D-231XL is a free flowing powder in which the peroxide has been blended with inert fillers.

Chemical Structure:

\[
\begin{align*}
\text{Empirical Formula C}_{17}\text{H}_{34}\text{O}_{4} \\
\text{Molecular Weight} & \quad 302.5 \\
\text{Change E, Kcal} & \quad 33
\end{align*}
\]

**SPECIFICATIONS**

D-231 | D-231XL
--- | ---
1,1-Bis(t-butylperoxy)3,3,5-trimethyl-cyclohexane | 92% min. | 40% min.
Active Oxygen | 9.73 min. | 4.23 min.

**PROPERTIES**

Form | Liquid | Powder
Color | Colorless | White
Freezing Point | -40°C. | -
Specific Gravity | 0.9039-0.9088 | -
Flash Point (micro open cup) | 155°F. | -
Solubility | Soluble in common organic solvents | -

**THERMAL DECOMPOSITION DATA**

<table>
<thead>
<tr>
<th>Compound</th>
<th>85°C</th>
<th>100°C</th>
<th>115°C</th>
<th>10 Hour Half Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzoyl peroxide</td>
<td>2.1 hrs.</td>
<td>.4 hrs.</td>
<td>.1 hrs.</td>
<td>72°C.</td>
</tr>
<tr>
<td>D-231</td>
<td>27 hrs.</td>
<td>3.8 hrs.</td>
<td>.71 hrs.</td>
<td>92°C.</td>
</tr>
<tr>
<td>t-Butylperoxy</td>
<td>57 hrs.</td>
<td>8.3 hrs.</td>
<td>1.42 hrs.</td>
<td>99°C.</td>
</tr>
<tr>
<td>isopropyl carbonate</td>
<td>115 hrs.</td>
<td>12 hrs.</td>
<td>-6.2 hrs.</td>
<td>105°C.</td>
</tr>
<tr>
<td>t-Butyl perbenzoate</td>
<td>132 hrs.</td>
<td>46 hrs.</td>
<td>9.2 hrs.</td>
<td>114°C</td>
</tr>
</tbody>
</table>
April 5, 1972

Mr. George Patterson
DeBell & Richardson Company
Water Street
Enfield, Connecticut 06092

Dear Mr. Patterson:

Thank you for your interest in Sartomer monomers. I have forwarded to you, under separate cover, one pound samples of -

- SR-297, 1,3 Butylene glycol dimethacrylate
- SR-350, Trimethylol propane trimethacrylate
- SARE™ 500 Crosslinking Agent*
- SARE™ 515 Crosslinking Agent*

These are samples and, of course, there is no charge.

Enclosed are three booklets on the use of our monomers in elastomers. As I pointed out on the telephone, we prefer to recommend SR-297, SR-350, and the SARE™ Crosslinking Agents* rather than SR-206, Ethylene glycol dimethacrylate, for use in elastomers.

The biggest problem in using methacrylate monomers in elastomers is usually scorch. For this reason, Sartomer Industries introduced the SARE™ Crosslinking Agents*. These are polyfunctional methacrylate type systems, but are scorch retardant, and give excellent processing properties, along with excellent physical properties.

If I may be of any further use to you whatsoever, please do not hesitate to give me a call.

Very sincerely yours,

Barrie Hands
Technical Sales Representative

BH:ne
Enc.

*Patent applied for on composition.
A new development, SARET™ Crosslinking Agents* offer maximum scorch and processing safety when used with the peroxide cure of elastomers while maintaining the property improvements typical of acrylic coagents. These new coagents are tailor-made for injection and transfer, as well as compression molding.

**Typical Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>SARET 500</th>
<th>SARET 515</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Dark liquid</td>
<td>Dark liquid</td>
</tr>
<tr>
<td>Color, APHA</td>
<td>&gt;1000</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>Odor</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td>Boiling point</td>
<td>&gt;200°C @ 1 mm</td>
<td>&gt;200°C @ 1 mm</td>
</tr>
<tr>
<td>Refractive index @ 25°C</td>
<td>1.473-1.475</td>
<td>1.473-1.475</td>
</tr>
<tr>
<td>Weight/gallon @ 25°C</td>
<td>9.0 lbs.</td>
<td>9.0 lbs.</td>
</tr>
<tr>
<td>Viscosity @ 25°C</td>
<td>85-92</td>
<td>85-92</td>
</tr>
<tr>
<td>Specific gravity @ 25°C</td>
<td>1.078</td>
<td>1.078</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.3% max.</td>
<td>0.3% max.</td>
</tr>
<tr>
<td>Flash point, Cleveland Open Cup</td>
<td>326°F</td>
<td>326°F</td>
</tr>
<tr>
<td>Solubility</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These crosslinking esters are compatible with alcohols, ethers, ketones, esters, and aromatic hydrocarbons.

**Storage and Handling**

SARET™ 500 and SARET™ 515 Crosslinking Agents* are stable over an extended period of time if stored at room temperature away from direct sunlight. The use of amber bottles is recommended if stored in glass.

**Toxicity**

Complete toxicity data of SARET™ 500 and SARET™ 515 Crosslinking Agents* is not available. However, preliminary testing has not shown general skin sensitivity. Caution should be exercised when handling to prevent contact with skin, eyes or ingestion. Copious washing with warm soapy water should be used immediately if spilled on the skin.

*Patent applied for on composition.
SARTOMER'S MONOMERS

SR-206  ETHYLENE DIMETHACRYLATE

\[
\begin{align*}
&\text{CH}_3 \\
&\text{CH}_2 = \text{C} - \text{O} - \text{CH}_2 - \text{CH}_2 - \text{O} - \text{C} - \text{C} = \text{CH}_3 \\
&\text{CH}_3 \\
\end{align*}
\]

SR-297  1,3 - BUTYLENE GLYCOL DIMETHACRYLATE

\[
\begin{align*}
&\text{CH}_3 \\
&\text{CH}_2 = \text{C} - \text{O} - \text{CH}_2 - \text{CH}_2 - \text{O} - \text{C} - \text{C} = \text{CH}_3 \\
&\text{CH}_3 \\
&\text{CH}_3 \\
\end{align*}
\]

SR-350  TRIMETHYLOL PROPANE TRIMETHACRYLATE

\[
\begin{align*}
&\text{CH}_3 \\
&\text{CH}_2 = \text{C} - \text{O} - \text{CH}_2 - \text{CH}_2 - \text{C} - \text{O} - \text{CH}_2 \\
&\text{CH}_3 \\
&\text{CH}_2 = \text{C} - \text{O} - \text{CH}_2 - \text{CH}_2 - \text{C} - \text{O} - \text{CH}_2 \\
&\text{CH}_3 \\
&\text{CH}_3 \\
&\text{CH}_3 \\
\end{align*}
\]
**THIXON D-12509**

**FUNCTION:**
1) A vulcanizing primer cement for bonding all elastomers to all metals when used with appropriate cover cement.
2) Especially formulated for coil coating applications.
3) May be used as a one-coat cement for nitrile and neoprene compounds.

**TYPICAL PHYSICAL PROPERTIES:**
- **Color:** Gray
- **Wgt./Gal. (U.S.A.):** 8.8 lbs.
- **Specific Gravity:** 1.05
- **Viscosity (#3 Zahn Cup):** 22 sec.
- **Viscosity (#4 Ford Cup):** 50 sec.
- **Non-Volatile Solids:** 36%
- **Shelf Life at 75° F:** 6 mos. min.
- **Flash Point (Tag Closed Cup):** 28° F.
- **Dry Film:** 0.5 mil
- **Theoretical Per Gal. Coverage:** 1000 sq. ft.
- **Bond Temp. Range:** 300-450°F

**ENVIRONMENTAL RESISTANCE:**
- Oil, water. High temp. 300-350°F.

**DIRECTIONS FOR USE:**
May be applied by brushing, dipping, or spraying. Should be agitated thoroughly before use, preferably with a high speed propeller-type agitator. Stir while adding diluents.

For spraying or dipping, dilute to a viscosity of 22 seconds using a #2 Zahn Cup at 78° F.

Must be applied to clean metal surfaces, preferably to gritblasted (#40 or #50 grit) and solvent degreased substrates. After application, dry the film for 20 to 30 minutes at room temperature before applying the cover cement. Stored parts should be kept free of contamination.

**DILUENTS:** Ketones and Aromatic Solvents

**TOXICITY:**
Non-toxic in ordinary handling, but ingestion or prolonged breathing of vapors may be harmful. Usual fire safety measures should be observed.
THIXON AP-1435
RUBBER-TO-METAL BONDING ADHESIVE

Function: Vulcanizing secondary cement for bonding Ethylene-Propylene terpolymer (EPDM), Butyl (IIR), and Ethylene-Propylene Copolymer (EPM) rubber to primed metals.

Advantages:
1. Formulated to give good performance over a wide curing range.
2. Maintains excellent bond under high temperature service conditions when used over THIXON D-12809 primer.

Composition: Special rubber and chemical derivatives in volatile solvent.

Typical Physical
Properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Black</td>
</tr>
<tr>
<td>Odor</td>
<td>Hydrocarbon</td>
</tr>
<tr>
<td>Weight</td>
<td>6.9 lbs./gal.</td>
</tr>
<tr>
<td>Consistency</td>
<td>Brushing</td>
</tr>
<tr>
<td>Shelf Life</td>
<td>Approximately 1 year at 75°F. or less</td>
</tr>
</tbody>
</table>

Toxicity: Non-toxic in ordinary handling but usual personal and fire safety measures should be observed due to its inflammable characteristics.

Brushing: THIXON AP-1435 can be used as received for all brushing applications. It brushes out to a smooth film and provides excellent coverage.

Dipping: For dipping operations, suggest 2 parts THIXON AP-1435 to 1 part (by volume) of heptane or similar solvent. High speed stirring is required before and adding diluent.

Spraying: When used in spraying equipment, suggest 2 parts THIXON AP-1435 to 1 part (by volume) of aliphatic solvent with a 30 to 40% Naphthenic Value and an initial boiling point in the range of 230°F to 280°F. Example, Super Naphtholite. Stir vigorously before and after adding diluent.

Drying of Cement Film: If cement coated parts are subjected too quickly to above normal temperatures, blistering of the film may occur. Most of the solvent should be allowed to evaporate at normal or near normal room temperature before vulcanizing takes place.
Chemlok® Adhesive Systems

This guide presents the one and two coat adhesive systems suggested for bonding the common elastomers during vulcanization. These systems are widely accepted throughout the rubber industry. Their reliability has been demonstrated under a broad range of conditions.

One Coat vs. Two

One coat systems are entirely satisfactory for many applications if your bonding involves:
1. Standard production compounds
2. Normal environmental resistance
3. Good substrate preparation

Two coat systems are suggested for:
1. Maximum environmental resistance
2. Severe after-bonding service requirements (deflashing or plating)
3. Wider processing tolerances with minimum surface preparation
4. Reduced scrap
5. Higher bonding temperatures — above 320°F (75 psi steam)
6. Elimination of adhesive changes between production runs

Alternate Adhesive Systems

The systems and dilutions listed here are our “best” suggestions. They will produce dependable, high-quality bonded assemblies for most applications. Thus, they are the logical ones to be tried first.

Other Hughson systems will also produce successful results and may be required for some compounds or special conditions. For suggestions on alternate systems or dilutions, contact your Hughson technical representative or Hughson Chemical Company, Erie, Pennsylvania 16512. Phone: 814-455-7581.

For bonding elastomers to metals and certain plastics (nylon, cured phenolic, epoxy, polycarbonate, Teflon®, Delrin®)

<table>
<thead>
<tr>
<th>Elastomer</th>
<th>Chemlok 1-Coat System</th>
<th>Chemlok 2-Coat System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyl</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>Chlorobutyl</td>
<td>(Requires 2-coat system)</td>
<td>205</td>
</tr>
<tr>
<td>EPM (EPR)</td>
<td>231 (Only to fabric, rubber or brass)</td>
<td>205</td>
</tr>
<tr>
<td>EPDM (EPT)</td>
<td>(Requires 2-coat system)</td>
<td>205</td>
</tr>
<tr>
<td>Fluoro Elastomers</td>
<td>607 (up to 200% dilution)</td>
<td>—</td>
</tr>
<tr>
<td>Hypalon*</td>
<td>231</td>
<td>205</td>
</tr>
<tr>
<td>Neoprene</td>
<td>217</td>
<td>205</td>
</tr>
<tr>
<td>Nitrile</td>
<td>205 or EX-B60-03</td>
<td>205</td>
</tr>
<tr>
<td>Neoprene — Carboxy Modified</td>
<td>EX-B60-03</td>
<td>205 or 231 or 234</td>
</tr>
<tr>
<td>Neoprene — Vinyl Modified</td>
<td>EX-B60-03</td>
<td>205 or 231 or 234</td>
</tr>
<tr>
<td>Polyacrylate</td>
<td>607 or 205</td>
<td>205</td>
</tr>
<tr>
<td>Polybutadiene</td>
<td>220</td>
<td>205</td>
</tr>
<tr>
<td>Polysoprene</td>
<td>220</td>
<td>205</td>
</tr>
<tr>
<td>SBR</td>
<td>220</td>
<td>205</td>
</tr>
<tr>
<td>SBR — natural</td>
<td>220</td>
<td>205</td>
</tr>
<tr>
<td>Silicone</td>
<td>607 (up to 500% dilution)</td>
<td>—</td>
</tr>
<tr>
<td>Urethane — Castable</td>
<td>218</td>
<td>218</td>
</tr>
<tr>
<td>Urethane — Millable</td>
<td>218 or 220</td>
<td>218 or 220 or 231</td>
</tr>
</tbody>
</table>

For bonding elastomers to elastomers (any combination of vulcanized and unvulcanized)

Use Chemlok 234. Coat both surfaces.

*DuPont trademark