CHEMLOK® ELASTOMER BONDING GUIDE

Application Guide

In 1956, Parker Lord commercialized a Chemlok® primer and covercoat system that produced elastomer-tearing bonds with virtually all commercially available elastomers. This "quantum jump" in technology provided a broad processing latitude for bonding and drastically reduced scrap levels. The primer and covercoat system enabled bonded assemblies to have better environmental performance.

Continuing research at Parker Lord has produced a growing line of elastomer-bonding formulations that can accommodate all commercially available elastomers, diverse metals and rigid plastic substrates. Chemlok adhesives have earned worldwide preeminence for their superior consistency, reliability, versatility and ease of use.

New developments have focused on improved bonding performance and environmental acceptability of the formulations due to recent air quality (emissions) restrictions, OSHA regulations and other governmental mandates. These new adhesive systems use exempt solvents or water as their volatile component.

The Elastomer and the Adhesive – Choosing the Right Combination

Production of high-quality bonded parts begins with two choices: the elastomer and the adhesive system.

The first choice is the elastomer. The gumstock type and the details of its formulation will be predicated by the intended function of the bonded assembly. Thus, the rubber for a highly engineered automobile engine mount will be selected for its dynamic performance in controlling vibrations and for its ability to endure under-the-hood operating conditions. Conversely, the elastomer for an engine seal must provide superb resistance to attack by engine fluids.

The second choice is the adhesive system. The adhesive system must provide an excellent bond under the specified vulcanization conditions, as well as maintain its bond under service conditions.

Elastomers

Natural rubber and many synthetic elastomers make up the range of rubber polymers that are available for fabrication. Factors to consider when selecting the elastomer are performance requirements of the part, ease of mixing, processing and molding.

The largest percentage of vulcanization bonded assemblies makes use of:

- natural rubber (NR)
- styrene-butadiene copolymers (SBR)
- polychloroprene (CR)
- acrylonitrile-butadiene copolymers (NBR)

Other commonly used synthetic elastomers include:

- ethylene-propylene-diene monomer (EPDM)
- butyl rubber (IIR)
- isoprene, synthetic (IR)
- polybutadiene (BR)
- chlorosulfonated polyethylene (CSM)
- polyacrylate (ACM)
- ethylene-acrylate ester types (AEM)
- various castable polyurethanes (AU or EU)

High and ultra-high performance elastomers are specified where durability and extreme service conditions are mandated. These include various fluoroelastomer (FKM) and silicone (MQ) types, and hydrogenated NBR (HNBR).

Part designers occasionally use melt-processable or thermoplastic elastomers for assemblies whose main function is cushioning or shock control. These elastomers include various thermoplastic elastomers (TPE) and thermoplastic urethanes (TPU). TPEs can be subdivided into two main classes, styrene block copolymers and polyblends, which are comprised of vulcanized or unvulcanized elastomer phases in a thermoplastic matrix. These types of materials are melt processed in plastics injection molding equipment, which can offer high output with recycling waste. End-uses generally require service at ambient or slightly elevated temperatures.

Many of the above mentioned elastomers have features which satisfy specific end-use requirements: oil and organic fluid resistance, heat resistance, resistance to chemical attack, high strength, superior dynamic properties, and/or ease of processing. These elastomer properties are summarized in Chart 1.

Compounding Effects

Data generated by Parker Lord application engineering laboratories, combined with customer input, provides the information needed for understanding compounding variables and bonding. These formulation guidelines pertain mainly to the non-polar diene elastomers: EPDM, IIR, and NR, and to a lesser extent, the easier to bond and more polar types, such as CR and NBR.

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Chart 1. Elastomer Property Evaluation

Elastomers

Legend
1 Excellent
2 Good
3 Fair
4 Poor

	Natural Rubber	Isoprene, Synthetic	Styrene-Butadien Copolymer	Polybutadiene	Polychloroprene	Ethylene-Propylene-Diene Monomer	Butyl Rubber	Chlorosulfonated Polyethylene	Polyurethane	Acrylonitrile-Butadiene Copolymer	Hydrogenated Nitrile	Polyacrylate	Ethylene-Acrylate Ester	Silicone	Fluoroelastomer
	NR	IR	SBR	BR	CR	EPDM	IIR	CSM	AU/EU	NBR	HNBR	ACM	AEM	MQ	FKM
Physical Properties															
Tensile Strength	1	1	2	2	1	2	2	2	1	2	2	3	2	4	3
Elongation	1	1	2	2	1	2	1	2	1	2	2	3	3	1	3
Compression Set	3	3	3	3	2	2	3	2	2	2	2	2	2	1	1
Resilience	1	1	2	1	1	2	4	2	1	2	2	3	3	2	4
Electrical Resistivity	1	1	1	1	2	1	1	1	2	3	3	2	2	1	2
Mechanical Resistance															
Tear	1	1	2	2	1	3	2	1	1	2	2	3	3	3	3
Abrasion	1	1	1	1	1	2	2	2	1	1	1	3	3	4	3
Cut Growth	1	1	2	3	2	2	1	2	2	2	2	3	3	4	4
Temperature															
Heat Resistance	4	4	3	4	3	2	2	3	3	3	2	2	2	1	1
Low-Temperature Resilience	2	2	3	1	3	3	3	3	3	3	3	4	3	1	4
Service Performance															
Water	1	1	2	1	2	1	1	2	2	2	2	3	2	1	2
Acid	2	2	2	2	2	1	1	2	3	2	2	3	3	4	2
Alkali	2	2	2	2	2	1	1	1	3	2	2	3	3	4	2
Aliphatic Hydrocarbons	4	4	4	4	2	4	4	2	2	1	1	1	2	2	1
Aromatic Hydrocarbons	4	4	4	4	4	4	4	1	3	2	2	3	3	3	1
Chlorinated Solvents	4	4	4	4	4	4	4	1	2	4	4	4	4	3	3
Ketones	4	4	4	4	4	2	2	4	4	4	4	4	3	3	4
Alcohols	2	2	2	2	2	2	1	2	2	1	1	4	4	2	2
Lubricating Oils	4	4	4	4	2	4	4	4	2	1	1	1	2	2	1
Synthetic Oils	3	3	4	3	4	3	3	4	4	2	2	2	2	3	2
Hydraulic Oils	4	4	4	4	3	2	3	3	4	3	2	2	2	4	2
Fuels	4	4	4	4	3	4	4	3	2	1	1	1	2	3	1
Weather	3	3	3	3	2	1	1	1	1	2	1	1	1	1	1
Oxidation	4	4	3	4	3	2	2	3	3	3	2	2	2	1	1
Ozone	4	4	4	4	2	1	1	1	1	4	1	1	1	1	1

The following compounding ingredients, cure system, fillers, extender oils/plasticizers, and antidegradants all affect "bondability" to varying degrees. The effects of these ingredients are listed below:

Sulfur Levels – The amount of sulfur in the compound has a significant role: sulfur levels of one p.h.r. or higher have a favorable effect on bondability, whereas little or no sulfur results in a compound that is more difficult to bond.

Accelerators – Of the more commonly used accelerators, MBT generally allows good bondability. ZDMC and the ultra-accelerators such as TMTD detract from bondability, particularly in "EV" or "semi-EV" cure systems. The prevulcanization inhibitor (PVI) is often added to fast-vulcanizing stocks to increase processing safety. However, when using ultra-accelerators, high levels of PVI in NR formulations are detrimental to bonding. Amounts of PVI below 0.15 p.h.r. usually allow satisfactory bonding.

Fillers – The type and amount of filler is critical. Compounds with 40 to 80 p.h.r. of carbon black are easier to bond than those with lower black levels. Non-black fillers, such as clays and silicas, also facilitate bonding.

Waxes and Oils – Waxy or oily compounding ingredients that migrate to the vulcanizing elastomer surface cause bonding difficulties. These include low molecular-weight polyolefin auxiliaries, (i.e., low-melting polyethylene and polypropylene processing aids/lubricants), aromatic oils and fatty acid esters (i.e., ricinoleates). Naphthenic or paraffinic oils are less problematic.

Phthalate Ester Plasticizers – Although phthalate esters such as dioctyl phthalate are often recommended for maintaining the mechanical properties of polyolefinic elastomers (EPDM and IIR) in low-temperature, end-use applications, they are detrimental for bonding. Using phthalate esters can compromise the bondability of NBR stocks. However, incorporating high surface area, inorganic fillers, such as silicas, can sometimes neutralize the negative effects of phthalate ester plasticizers.

Anti-ozonants – High levels of anti-ozonants and certain antioxidants, particularly the p-phenylene diamine type, may detract from bondability.

Non-diene Elastomers – Elastomers not cured with sulfur and accelerators are easier to bond through inclusion of high surface area fillers. They become more difficult to bond when compounded with certain oils, plasticizers and waxes.

Elastomer Blends

Blends of two or more gumstocks (e.g., NR-SBR mixtures, NBR mill-mixed with IR) are chosen so the most desirable features or properties of each component are available. Blends are also selected in an effort to improve raw material economics, without compromising finished part quality.

Elastomer blends are almost always heterophase systems, i.e., dispersions of one type of elastomer in a continuum or matrix of the other. This heterogeneity is because most elastomer pairs are not mutually soluble. Blending results in less-than-uniform distribution of the compounding ingredients, which often causes one of the elastomers to be preferentially vulcanized by the sulfur and accelerators.

The overall effects of elastomer blending can impact bondability and adhesive selection. For example, blends of NBR and NR will be more difficult to bond than compounds comprised entirely of nitrile elastomer.

Why Choose Chemlok Adhesives?

Easy to Use – Chemlok adhesives wet and spread evenly on prepared metal substrates. They accommodate variations in compound formulations and in vulcanization processes.

Elastomer Compatibility – The adhesive must be compatible with the gumstock in providing bond qualities of strength, elongation, dynamic fatigue resistance and durability under expected service conditions. Depending on the elastomer compound selected and the specified vulcanization process, there will be one or more Chemlok adhesive offering this compatibility. This is especially true of the versatile adhesives that bond NR and most of the sulfur-vulcanizable synthetic diene elastomers.

Specialty Elastomers – Many of the high-performance elastomers (i.e., the non-diene types that are not vulcanized by sulfur) require adhesive bonding chemistries that are different from the broad-purpose Chemlok formulations. These formulations include Chemlok adhesives for peroxide-curing silicone elastomers, ionically-curing fluoroelastomers and castable polyurethane types. These Chemlok adhesives for specialty elastomers can often be applied in one coat.

Additional Considerations

The finer points of adhesive selection include considerations regarding the design of the part, the molding method and the compound formulation.

Part Design – The design or geometry of the assembly will influence bonding and how well that part will withstand service environments. Fluid engine mounts or bushings (i.e., those with contained fluid) may place atypical demands on the environmental resistance of the cured adhesive. If the elastomer-metal interface is exposed to a confined fluid such as hot glycol/water mixture, the adhesive system will need to withstand this particular service exposure.

Molding Method – The molding method will affect the tendency for undesirable wiping or sweeping of the adhesive. This phenomenon sometimes results when a molten elastomer compound moves across the adhesive-coated metal part surfaces prior to vulcanization. Under these conditions, some adhesives can be swept away from the interfaces where they are needed. Chemlok 6125 or 6224 adhesive has good resistance to sweeping or wiping. Ty-Ply BN adhesive, by contrast, should not be selected if sweeping is apt to be problematic.

Prebaking – Prebake tolerance is the adhesive's ability to withstand high-temperature exposure before it contacts the vulcanizing elastomer. Bonding is dependent on chemical reactions that occur at elevated temperatures between the adhesive and the vulcanizing elastomer compound (i.e., across the adhesive-elastomer interface). If chemical reactions begin in the adhesive

before elastomer contact, a significant amount of the adhesive's bonding capability can be lost. Reaction of key adhesive ingredients from the adhesive-coated metal surface can cause the adhesive to lose some of its bonding activity. Reaction may result in migration of highly reactive species to the compound surface. Pre-reaction of key ingredients can then occur at the outer layer of the elastomer, before adhesive-elastomer contact.

Further Reading

For a comprehensive listing of available Chemlok adhesives, refer to Chemlok Adhesives selector guide.
This easy-to-follow guide recommends adhesives for specific elastomer types. More detailed information on the adhesives is presented in the Chemlok Adhesives application guide.

Overview of the Bonding Process

There are four stages to the bonding process:
1) Substrate Preparation
2) Primer/Adhesive Application
3) Elastomer Preparation
4) Molding/Curing/Finishing

The flowchart (Chart 2) depicts the steps of the bonding process and lists factors to control in each step.

Chart 2. Elastomer Bonding Flowchart

Substrate Preparation

Chemical Treatment

1. Chemical Cleaning
   Removal of inorganic surface contaminants (Caustic or Acid)
   A. Concentration
   B. Temperature
   C. Cleanliness
2. Rinse
   A. Cleanliness
   B. Thorough Agitation
3. Conversion Bath (Zn or Fe Phosphate*)
   A. Concentration
   B. Temperature
   C. Crystal Size
   D. Film Weight
   E. Dispersal
   F. Residence Time
4. Rinse
   A. pH
   B. Temperature
   C. Concentration
5. Air Dry

*Zinc Nickel and other various electroplating options can be suitable chemical treatments.

Mechanical Treatment

1. Alkaline Degreasing
   Removal of oil/grease surface contaminants
   A. pH
   B. Contamination Level
   C. Time
   D. Temperature
   E. Water Rinse may be required
2. Mechanical Treatment
   Removal of inorganic surface contaminants (Grit or Sand)
   A. Cleanliness of media
   B. Avoid Steel Grit with Non-Fe Alloys
   C. Dust Collector
3. Alkaline Cleaning
   Removal of surface contaminants
   A. pH
   B. Cleanliness
   C. Time
   D. Temperature
4. Hot Air Dry (optional)

Elastomer Preparation

Elastomer
- A. Properties
- B. Bondability
- C. Mixing
- D. Dispersion
- E. Cure Rate

Bond Design
- A. Radii
- B. Interface Cut-off
- C. Stresses

Primer/Adhesive Application

1. Preheat Parts
2. Primer Application
   A. Primer Choice
   B. Agitation
   C. Viscosity
   D. Uniformity of Application
   E. Primer Thickness
3. Hot Air Dry
4. Covercoat
   A. Adhesive Choice
   B. Temperature
   C. Viscosity
   D. Agitation
   E. Uniformity of Application
   F. Avoidance of Precure
5. Warm Air Dry
6. Protection from Contamination

Molding/Curing/Finishing

Finished Part:
- A. Mold Design
- B. Loading Time
- C. Temperature
- D. Pressure
- E. Mold Integrity

Avoid the following:
- Bond-Destroying Solvents
- Excessive Heat
- Excessive Demolding Stress

Substrate Preparation

Proper surface preparation is essential to achieving maximum bond strength. Use Chart 3 to determine the appropriate surface-cleaning procedure. This chart lists guidelines and recommendations for metallic and non-metallic surfaces.

During the surface preparation, there are certain control parameters which need to be taken into account. These process control checkpoints are listed in Chart 4.

Removal of Oily Contaminants: remove cutting oils, die lubricants, and particle contaminants by alkaline degreasing. The alkaline bath must have temperature and concentration controls and have an overflow system. Cold and hot water rinse tanks are required to ensure removal of alkali and detergent traces.

Removal of Insoluble Materials: remove scale, rust or other oxide coatings by mechanical or chemical treatments.

- Mechanical Treatments include blasting, abrading, machining or grinding. Clean grit or abrasives must be used. Alkaline cleaning before and after blasting is preferred. These methods remove dry soil and corrosion, increase the surface area and provide an active surface for bonding.
- Chemical Treatments include phosphatizing or conversion coating to provide a clean surface. Treatment solutions must be controlled. Rinse water and drying air must remain pure.

Further details are provided in the Chemlok Adhesives application guide.

Maintaining Prepared Substrates: prevent exposure to dust, moisture, chemical fumes, mold sprays and other contaminants. Apply the primer as soon as possible after surface preparation.

Chart 3. Surface Preparation

Substrate	Mechanical Treatment	Chemical Treatment
Metals		
Steel, Low Carbon	Blast with clean, sharp 40-mesh steel grit, sand or aluminum oxide grit.	Zinc Phosphate, Microcrystalline Calcium-modified, or Solvent Degrease
Steel, Stainless	Blast with clean, sharp 40-mesh aluminum oxide grit or sand.	Acid Etch or Solvent Degrease
Aluminum and Magnesium		Chromate Conversion or Solvent Degrease
Brass and Copper		Ammonium Persulphate Etch
Titanium		Acid Pickle
Plastics		
Nylon	Light blast, using sand or aluminum oxide grit.	Clean with alkaline cleaner or solvent
Cured Phenolic		
Cured Epoxies		
Polycarbonate		
Teflon®	Light scuff or blast	Sodium-napthalene Process
Delrin®	Light scuff or blast	DuPont® Satinizing Process

Chart 4. Process Control Checkpoints

Processing	Element for Control	Control Parameters[1]
Chemical Cleaning		
Alkaline	Alkaline Bath	Provide overflow system or vigorous clean water flush Maintain pH, cleanliness, temperature[2]
Conversion Coating		
Zinc or Iron Phosphate	Chemical Baths	Maintain concentration, temperature, cleanliness[3] Provide adequate residence time, thorough rinsing between baths
Mechanical Cleaning		
Grit or Sand Blasting	Media Size	Visual or mesh screen inspection Dust collection inspection

[1] See text for specific recommendations.
[2] To ensure proper deposited film weight.
[3] To ensure proper crystal structure and deposited film weight.

Adhesive Application

Thoroughly mix pigmented adhesives prior to and during application. Evenly apply the primer and allow to completely dry before topcoating. A thin coat of primer is preferred, as heavy coats can lead to solvent entrapment and subsequent bond failure during molding. Maintain film uniformity by controlling the temperature and viscosity of the wet adhesive or primer. When applying more than one coat of primer or adhesive, allow adequate time and temperature between coats to ensure complete solvent evaporation.

Apply the primer or adhesive by dipping, spraying, brushing, roll coating, tumble spray or dip/spin. The choice of application method depends on size, shape of parts and the number of pieces being coated. Listed below are the features of the five application methods:

Dipping – used for solvent and aqueous adhesives. Dipping accommodates both large and small production runs, depending on the level of automation.

Spraying – provides the highest level of output and application consistency.

Brushing – recommended only for solvent adhesives. Useful for small runs or production which is not continuous.

Roll Coating – provides an excellent method of coating large flat areas as well as cylindrical objects.

Tumble Spray or Dip/Spin – economically coats the parts in a revolving barrel. The adhesive can be dried by discharging the parts into drying trays, by circulating warm air through the tumbling drum, or by drying in an oven.

Precise guidelines for control of the application processes can be found in the Chemlok Adhesives application guide.

Molding and Finishing Operations

Any variation in the individual molding parameters can result in bond failures or a high scrap rate. When designing the mold, make provisions for easy loading of the adhesive-coated metals as well as for easy removal of the vulcanized part.

Place the adhesive-coated metal and rubber compound in the mold cavity. Use the correct time, temperature and pressure to form a quality bonded assembly. Periodically check the mold cavity temperatures by using thermocouples, pyrometers, Tempilsticks® or selective melting point wax pencils. Leaky molds, temperature variations, lack of curing or overcuring will adversely affect the bond integrity.

The ideal bonding environment occurs when the elastomer is under maximum pressure and at a minimum viscosity during vulcanization and curing. To obtain these conditions, follow the specified time and temperature requirements of the elastomer being cured. Chart 5 lists the process control checkpoints for molding and finishing operations.

Molding Methods

There are three techniques of molding: transfer molding, injection molding and compression molding. Transfer and injection molding comprise the majority of all manufactured rubber-to-metal parts. Listed in Chart 6 are typical conditions imposed for satisfactory vulcanization bonding.

Finishing Operations

It is often necessary to perform additional treatments to bonded parts. Common bond failures associated with these additional treatments:

- Deflashing with dry ice or nitrogen – failures between the metal and rubber materials when large loads are in the tumbler at too low of a temperature for an extended period of time.
- Wire brushing, grinding or machining – failure of the bonded part due to heat build-up.
- Post-painting – failure when the adhesive does not resist the solvents in the post-paint operation.

Troubleshooting

ASTM International provides a set of detailed symptom descriptions for bond failures. These descriptions can be used to assess the problem and effect swift, corrective action. (In this document, the terms "elastomer" and "adhesive" should be interpreted as "rubber" and "cement," respectively.)

Covering approximately 80% of all bond failures, the four basic ASTM designations are:

- **R** – failure in the rubber. This classification can be further broken down into additional sub-classifications.
- **RC** – failure at the rubber-cement interface.
- **CM** – failure at the cover cement-metal interface; or at the primer-metal interface.
- **CP** – failure at the cover cement-primer interface.

Chart 5. Process Control Checkpoints for Molding and Finishing Operations

Processing Stage	Element for Control	Control Parameters
Assembly Design	Metal-Elastomer Configuration	Avoid sharp radii, abrupt elastomer-metal cutoff and stresses at elastomer-metal interface.
Molding	Mold	Strive for a relatively low cure rate. Control temperature and pressure. Minimize loading time. Maintain mold integrity.
Finishing Operations	Deflashing	Avoid high-solvent paints, high-solvent rust preventatives, acetone exposure and excessive heat and stress. Avoid strong acid exposure.
	Plating	
	Coating	

Chart 6. Typical Molding Parameters

	Mold Temperature	Transfer or Injection Time	Cure Time	Compound (Rubber) Temperature
Compression	137°C (280°F) to 171°C (340°F)	Not Applicable	10 minutes to multiple hours	21°C (70°F) to 82°C (180°F)
Transfer	149°C (300°F) to 171°C (340°F)	20 seconds to 2 minutes	10 to 60 minutes	82°C (180°F) to 93°C (200°F)
Injection	165°C (329°F) to 188°C (370°F)	20 to 60 seconds	3 to 30 minutes	99°C (211°F) to 121°C (250°F)

Note: This chart indicates typical processing. Actual processing will vary depending on elastomer formulation, adhesive choice, part size and other factors.

Rubber (R) Failures

Commonly used industry designations for types of rubber failure include:

SR (Spotty Rubber) – Appears on the metal surface looking like splattered rubber. Often caused by a metal surface contaminated with dust or other foreign deposits prior to bonding. An SR break can also be caused by ultra-fast drying of adhesive as it leaves the spray nozzle (cobwebbing).

TR (Thin Rubber) – An even, but very thin rubber residue on the metal surface indicates an acceptable bond. The amount of rubber thickness is often associated with the composition of the rubber, rubber-to-adhesive interactions, and processing conditions.

HR (Heavy Rubber) – A thick or heavy layer of rubber remaining on the metal surface indicates an excellent bond. The stock fails because it is stressed beyond its cohesive strength.

SB (Stock Break) – A failure of the rubber that makes the elastomer appear to have been folded back on itself and then broken off. The break is jagged and at a sharp angle to the metal surface.

Rubber-Cement (RC) Failures

Separation between rubber and cement is usually characterized by a relatively glossy, hard surface on the metal with little or no rubber visible.

Common causes of RC failure are: precuring of the adhesive or rubber before the rubber comes in contact with the adhesive; inadequate cement film thickness; low molding pressure or temperature; inadequate cure; and migration of plasticizers, oils and other incompatible compounding ingredients.

Cement-Metal and Primer-Metal (CM) Failures

A clean separation between metal and primer or adhesive indicates that no adhesion has occurred. This may be due to several factors. Oil, dirt, dust or other foreign matter on the metal surface may have prevented adhesion from taking place. Environmental factors affecting the metal surface may have caused under-bond separation. Other possible causes and remedies for cement-to-metal failure are listed in Chart 7.

Cement-Primer (CP) Failure

Separation at the cover cement-primer interface is easily detected if primer cement and cover cement are of different colors. Such a failure is invariably due to contamination of the primer, plasticizer migration from the elastomer, or inadequate primer/adhesive mixing or drying.

Combination Failure

Combination failures can occur when cement-metal, rubber-cement and rubber failures are found on the same part. Consult Chart 7 and Chart 8 for remedies to combination failures.

Chart 7. Remedies to Cement-Metal Failure

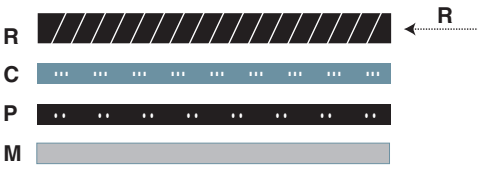
Possible Causes	Remedy
Poor metal surface, oil or powdery residue evident	Better chemical or mechanical cleaning.
	Check degreasing operations.
Adhesive dried before reaching metal (cobwebbing)	Adjust adhesive to proper viscosity.
	Add slower evaporation diluent.
	Reduce atomization pressure.
	Reposition gun to ensure adhesive spray coats the targeted area(s).
Solvent or water entrapped in adhesive film	Increase time between adhesive application and bonding.
Poor metal preparation - leading to CM failure in service	Check surface preparation.
	Use a primer on clean metal and follow with covercoat.
	Prebake primer 10-15 minutes at 121°C (250°F) to 149°C (300°F).
Galvanic decay or sacrificial metal activity	Avoid dissimilar metal contact upon installation of finished bonded parts.
	Avoid dissimilar metals in design of bonded parts.
	Avoid dissimilar metals in abrasive cleaning (i.e., steel grit for cleaning brass, copper, and aluminum).
Contamination of treated metal part before adhesive application	Cover parts in storage.
	Eliminate possible contamination from nearby equipment and/or operations.

Chart 8. Remedies to Rubber-Cement Failure

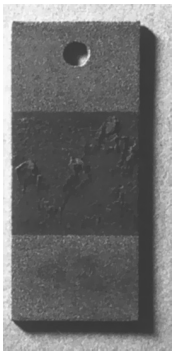
Possible Causes	Remedy
Precure of rubber	Use fresh stock.
	Reduce cure acceleration.
	Check rubber mixing and compound age before bonding.
Precure of adhesive (cement)	Accelerate loading cycle.
	Reduce molding temperature.
Low mold pressure	Check mold pressure.
	Check mold for leaks.
	Increase amount of rubber in mold.
Incorrect molding cycle	Check mold and platen temperature.
	Recheck cure rate of stock.
Low adhesive film thickness	Use heavier or multiple coats of adhesive.
Bloom or migration from rubber	Substitute more compatible ingredients.
	Reprocess or freshen stock.
Contamination of adhesive coated parts	Check unbonded specimens for oil or dust.
	Avoid over-spray or excessive use of mold release agents.
	Check for possible contamination from nearby equipment and/or operations.
Adhesive-rubber incompatibility	Select proper adhesive for elastomer and application.
Wiping or sweeping of adhesive	Slow transfer rate.
	Reduce molding temperature.
	Reduce topcoat dry film thickness.

Types of Failures

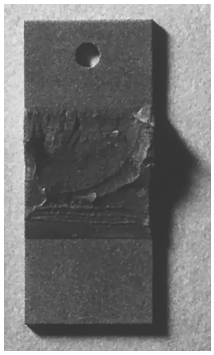
Figure 1. Rubber Failure



Photos at right illustrate types of rubber-bond failures: thin rubber (TR), heavy rubber (HR) and stock break (SB).



Thin Rubber (TR)

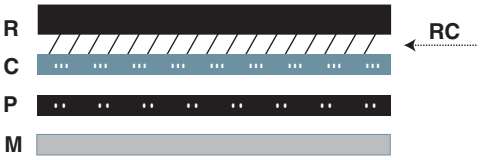


Heavy Rubber (HR)

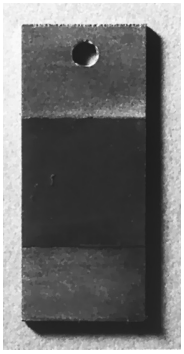


Stock Break (SB)

Figure 2. Rubber-Cement Failure

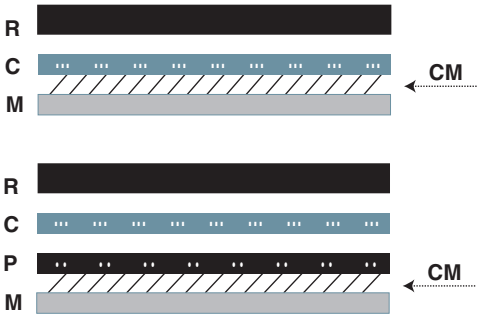


Separation at rubber-cement interface. Photo at right shows appearance of the part after such separation – relatively glossy, hard surface with little or no rubber visible.

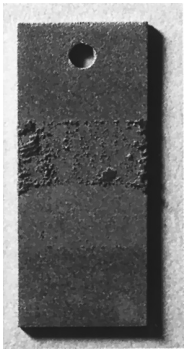


Rubber-Cement (RC)

Figure 3. Cement-Metal or Primer-Metal Failure

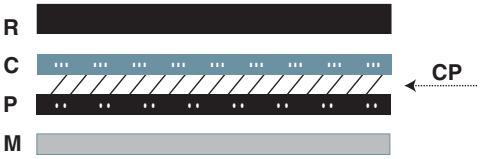


Separation at the primer-metal interface, or cement-metal interface for a one-coat adhesive, results in a part with a clean metal surface as depicted at right. Both are referred to as CM failure.

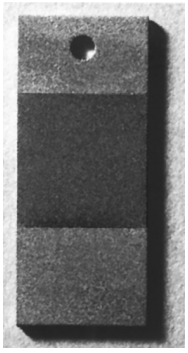


Cement-Metal (CM)
One-coat system

Figure 4. Cement-Primer Failure

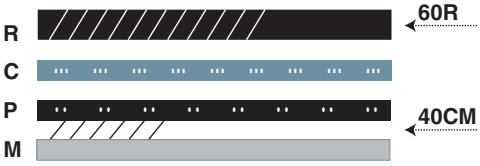


Separation at cement-primer interface. Photo at right shows appearance of the part after cement-primer failure caused by lack of time for solvents in primer to evaporate before cover cement is applied.

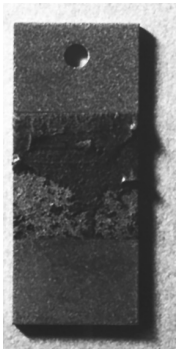


Cement-Primer (CP)

Figure 5. Combination Failure



Cross-sectional view shows typical rubber-to-metal failure in which 60% of bond area shows failure in rubber (60R), and 40% failure between cement or primer and metal (40CM).



Combination

Parker Lord
Engineered Materials Group
111 LORD Drive
Cary, NC 27511-7923
USA
phone +1 877 275-5673
www.parker.com/EPM

PB3025 OD 08/26 Rev.3

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