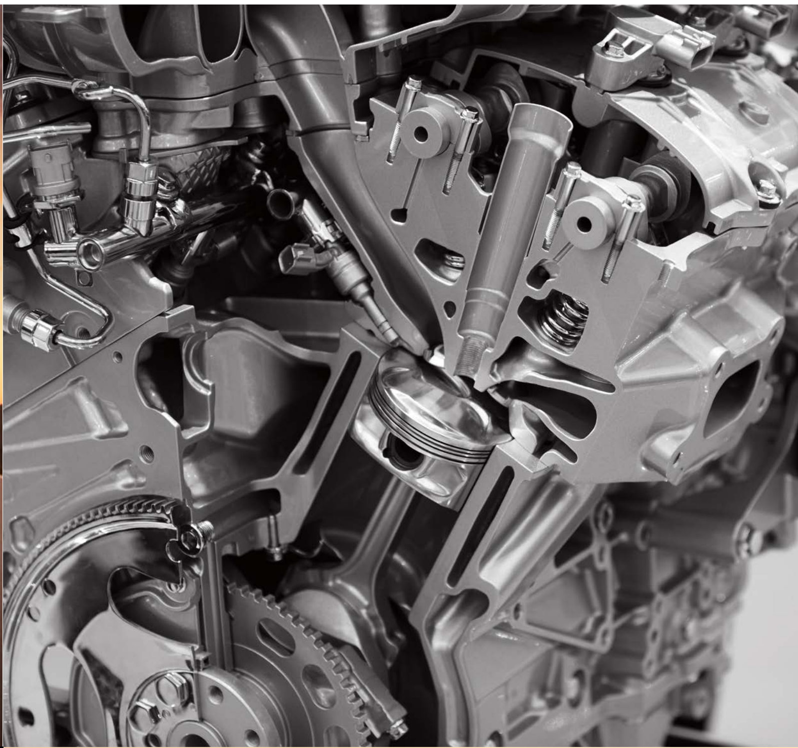
Solutions from DuPont

Specialty Adhesives

Rubber-to-Metal Bonding Agents
Technical Guide Bonding Performance



Evaluation of Bond Performance

Methods of Estimating Bond Performance

Bonding performance is analyzed by assessing bond strength in tension, peel or shear, or depending on the shape of the test piece. The rubber-to-metal bond is sometimes subjected to a combination of stresses (see Figure 1).

The results of static and dynamic tests are largely dependent on the size and shape of the components, the load conditions to which they are exposed, and the test method.

Tensile Strength
Our tests are conducted similarly to ASTM D 429 and DIN 53531, with a test specimen consisting of two steel discs with even, parallel surfaces of 5 cm^2, bonded to a rubber buffer of the same diameter, 20 mm thick. According to this test method, the bond value (tearing strength) and pattern of rupture are evaluated.

The upper limit of the adhesion value naturally depends on the quality of the compounds. The break pattern, however, indicates that the strength of the bond is higher than that of the rubber compound.

Peel Strength
Based on ASTM D 429 and DIN 53531, a rubber coating is vulcanized onto a 240 x 25 x 6 mm metal strip , and then peeled off at an angle of 90° at a rate of 50 mm/min. This test, corresponding closely to conditions in practice, permits the satisfactory evaluation of rubber-to-metal bonds in many fields of application.

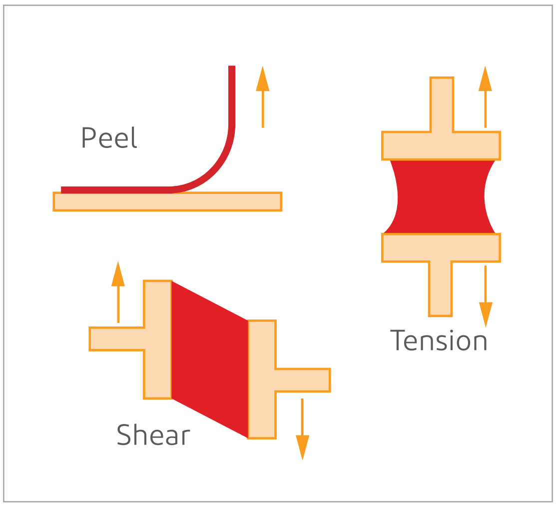
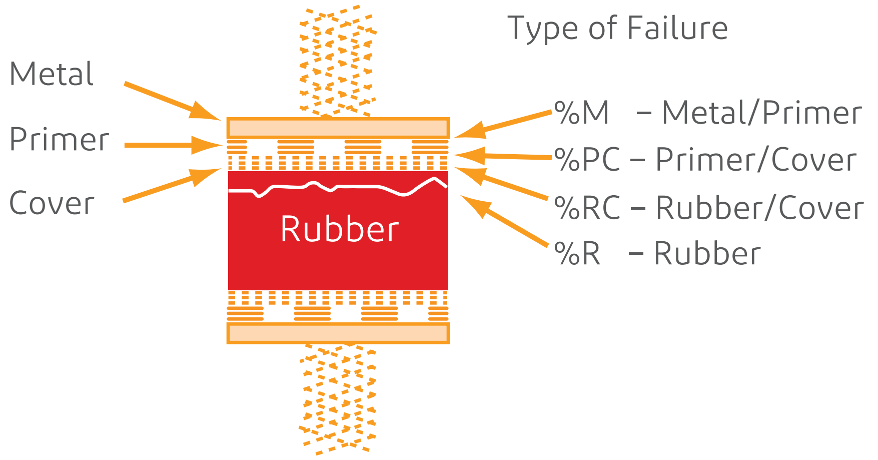


Figure 1

Characterizing the Type of Bond Failure

The bond is also analyzed as to the type or mode of failure that has occurred. The convention shown in Figure 2 is used:



Metal: %M
Failure between the metal substrate and the bonding agent primer.
Primer/Cement: %PC
Failure between the primer and the bonding agent cover coat
Rubber/Cement: %RC
Failure between the cover-cement and the rubber substrate
Rubber: %R
Cohesive rubber failure

Figure 2

A properly bonded rubber-to-metal component should fail within the rubber substrate, i.e. the rubber should fail cohesively. An analysis of the mode of bond failure can often indicate the areas in which the bonding process should be modified to give improved (cohesive rubber failing) bond performance.

Since the primer is light grey and the bonding agent is black, the failure mode can generally be easily identified. Each mode will be examined for the possible cause of failure.

Possible Causes of Failure Between MEGUM™ or THIXON™ Bonding Agent, Primer and Substrate (M Failure)

1. Inefficient pre-treatment
    - Ineffective shot blasting, grit contaminated or needs replacing
    - Inefficient or badly maintained phosphating process
    - Poor degreasing
    - Degreasing stage missed out
    - Degreasing medium needs replacing, contamination of degreasant
    - Properly prepared component contaminated prior to primer application

2. Primer applications
    - Ineffective primer application, e.g., “dry spray”
    - Insufficient drying time allowed between primer and cover-cement application
    - Primer application stage missed out
    - Too low or too high a primer film thickness applied
    - Poorly mixed primer
    - Incorrect choice of dilution
    - Primer over (or under) diluted
    - Contamination of compressed air in spraying

Possible Causes of Failure Between MEGUM™ or THIXON™ Bonding Agent, Primer and Substrate (PC Failure)

- Primer coating contaminated
- Film thickness of primer too low or too high
- Insufficient drying time allowed between primer and cover-cement application
- Poor application of primer or of cover cement
- Unsuitable application conditions, e.g., “dry spray” of cover cement
- Incorrect choice of dilution
- Primer over (or under) diluted
- Contamination of compressed air in spraying

Possible Causes of Bond Failure Associated with the Bonding Agent (RC Failure)

- Incorrect choice of cover cement
- Poorly mixed cover cement
- Incorrect dilution and/or application
- Cover cement pre-cured in drying process
- Too low or too high film thickness
- Poor sweep resistance
- Bonding agent film contaminated during storage of coated component due to exposure to sunlight

Possible Causes of Bond Failure Associated with the Rubber (RC Failure)

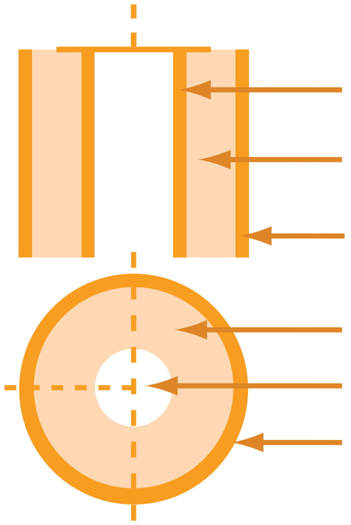
- Incorrect vulcanization time
- Incorrect vulcanization temperature
- Mold release contamination
- Scorched
- Composition of rubber mixture
- Accelerator
- Antioxidants
- Plasticizer
- Type of rubber
- Pressure build issues during vulcanization

Other Causes of Bond Failures

Hot bond strength: Another significant cause of rubber-cement bond failure is being applied to the bond after the bonding/vulcanization process and before the bonded component has been allowed to cool sufficiently to allow full bond strength to develop.

Avoid applying stress to the bonded components when they are being de-molded. The removal of the freshly bonded, hot components from a worn or damaged mold can be difficult. The use of excessive force can result in bond failures.

Concentric bush bonding: Rubber-cement failure can occur as the result of the shrinkage of the vulcanized rubber immediately after de-molding when the freshly formed rubber-to-metal bond is still at a relatively high temperature. These problems are typically encountered in the manufacture of concentric bush components in which the rubber is bonded between an outer and an inner concentric metal tube. Special purpose MEGUM™ or THIXON™ bonding agent cover cements, with improved hot bond strength, are recommended for such applications. See Figure 3.



Rubber-to-Metal Bonding between Rubber and Outer Concentric Bush Is in Tension as the Result of Rubber Shrinkage after Molding

Figure 3

Fresh Start Method

Many out-of-control material and process variables can affect the rubber-to-metal bonding process. Often, the failure mode is a combination of the M, PC, RC, and R type modes.

Production schedules do not permit the lengthy evaluation of all the process variables to immediately determine the problem.

A procedure that will allow production to resume with in-control material and processes is the "Fresh Start" method (see Figure 3):

1. Clean the mold to eliminate mold release or bonding agent residue.
2. Mix new rubber compound right away. Do not adjust the old compound or try to salvage it. Monitor the weights of each ingredient. Watch the mixing entirely, including the batching off. Test the compound completely to assure compliance to specifications. Carefully monitor the temperatures of the rubber compound throughout the mix, batch-off, warm-up, and preparation stages to assure conformity to specifications.
3. Check the line pressure of the molding press. Also check the platen and mold temperatures to make sure they are correct. Press platens must be free of dirt or wax contamination. Monitor the molding operation, including transfer time, the condition of the pot flash, and the parts themselves.

4. Start with fresh metal inserts. If none are available, clean the prepared metals that were used and start over.
5. Make sure the proper bonding agents are used. Check the viscosity, the drying time, and the thickness of the applied bonding agent. Remix the mold release.

After the process is under control, an investigation can be conducted with the previous rubber compound and metal inserts. Trying each individually and together in the molding process, which is under control, may show what the problems were and help to avoid future problems.

Estimating In-Service Performance of MEGUM™ and THIXON™ Agents Bonded Components

MEGUM™ and THIXON™ bonding agent bonds in practice are able to meet many different requirements. For very special cases, however, it is advisable to carry out preliminary tests.

Thermal Stability

Prolonged effect of heat on rubber-metal components can, under certain circumstances, result in rapid aging, leading possibly to subsequent reduction in strength. It has been found by experience that MEGUM™ and THIXON™ bonding agent bonds are able to withstand relatively high service temperature.

Chemical Stability

Considerable resistance is displayed toward aggressive liquids and hot water. Continuous exposure of the bond zone to the action of seawater for several months causes no weakening of the bond. Tests in tropical climates, a salt spray chamber and hot water, yield positive results both with and without initial stressing.

MEGUM™ and THIXON™ bonding agent bonds, in general, appear to have greater resistance to organic solvents than the rubber compounds themselves used in the production of the components. However, after thorough soaking of the rubber, swelling and attack of the bond coats do also occur, so that, in such cases, appropriate trials would appear to be indicated.

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