

Development of Liftgate Hinge-to-Roof Sealing Gasket Material for Uncoated Steel Roof Panels

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ABSTRACT

The sealing of a lift gate hinge to the body structure is necessary to avoid both the onset of corrosion and to avoid water intrusion into the interior compartment. The hinge-to-body interface typically involves horizontal metal-to-metal surface contact, creating the perfect environment for moisture entrapment and corrosion initiation.

The choice of body panel material (uncoated (bare) steel vs. coated (galvanized) steel) drives different sealing approaches especially when considering corrosion avoidance.

INTRODUCTION

REVIEW OF PREVIOUS APPROACHES

Across the automobile industry, many different approaches exist to prevent corrosion beneath the liftgate hinge. These approaches include one, or a combination of, the following:

- One piece galvanized steel roof panel
- Fibrous material gasket located between the hinge and the roof panel
- Separately welded rear panel that utilizes galvanized steel ([Figure 1](#))
- Manual application of sealer (or zinc rich primer) on the vehicle body at the hinge surface within the body shop ([Figure 2](#))
- Manual application of sealer around the perimeter of the hinge after it has been installed. This sealing operation is done in the paint shop after E-coat. ([Figure 3](#))

Concerns with the above approaches include:

- The cost of galvanized steel.

- The many negatives with respect to the implementation of a separately welded galvanized steel header. These include investment for dies and weld tools, poor secondary surface appearance due to visible spot welds, and poor accessibility in paint to seal the joint between the bare steel roof panel and the galvanized header panel.

- Applying sealer around the perimeter of the liftgate hinge is typically a difficult operation for paint shop application due to limited accessibility. This makes it difficult to achieve both corrosion performance and secondary surface appearance objectives.



Figure 1. Two piece roof construction.



Figure 2. Roof panel shown with roll-on sealer applied prior to liftgate hinge installation.



Figure 3. Liftgate hinge shown with paint shop applied sealer around the perimeter of the hinge.

This paper investigates different approaches to sealing the liftgate hinge to a bare steel roof, including fiber gaskets, adhesive films, foam tapes, weld tapes, and die cut expandable materials with embedded wire mesh. The results of both laboratory and full vehicle (Proving Ground) physical testing, conducted to assess both cosmetic and crevice corrosion performance will be presented. The paper will then discuss the steps taken to implement the optimum performance gasket material into a production body shop environment, including requirements such as fastener torque retention, maneuverability of the hinge, and secondary surface appearance.

Based on the targeted program body-in-white cost and labor targets, the assignment was to achieve all performance requirements with the use of a single piece uncoated (bare) steel roof panel and without the need to have a process sensitive operation (such as having the perimeter of the hinge sealed in the paint shop). Therefore the focus of the work was on the development of a hinge-to-roof gasket material that could be applied over uncoated metal in the body shop. The following section will review corrosion tests performed using a variety of materials. The best performing material was then built into a running vehicle for Proving Ground durability and corrosion testing in order to confirm the lab test findings.

CORROSION PERFORMANCE REQUIREMENTS AND TEST RESULTS

Two corrosion performance requirements helped guide the material selections. From a Cosmetic Corrosion perspective, the requirement was that the hinge-to-body interface must be free of any visible corrosion (red rust) after five years of exposure in a severe corrosion environment. From a Perforation Corrosion perspective, the requirement was no perforation of body panel sheet metal after twelve years of exposure in a severe corrosion environment.

TEST MATRIX

The initial corrosion performance screening using laboratory tests involved the follow matrix of materials:

Table 1. Lab Test Matrix

Sample IDs	Sample Type
	(All with bare steel roof except as noted)
A1-A3	Fiber Gasket
B1-B3	Fiber Gasket (with 60G galvanized roof)
C1-C3	Structural Adhesive Film (Manuf. A)
D1-D3	Foam Tape (Manuf. A)
E1-E3	Weld Tape (Manuf. B)
F1-F3	Die Cut Magnetic Tape (Manuf. B)
G1-G3	9984187 Type G Sealant w/ Wire Mesh

The test samples were constructed to simulate the vehicle roof or rear header-to-liftgate hinge joint. Except for samples B1-B3, the test samples all used bare steel body panels. All hinges were zinc plated (6 microns) and attached using

production fasteners and production torque values prior to painting. All samples were painted (zinc phosphate, ELPO, white topcoat) at a local assembly plant using production paint processes and materials.

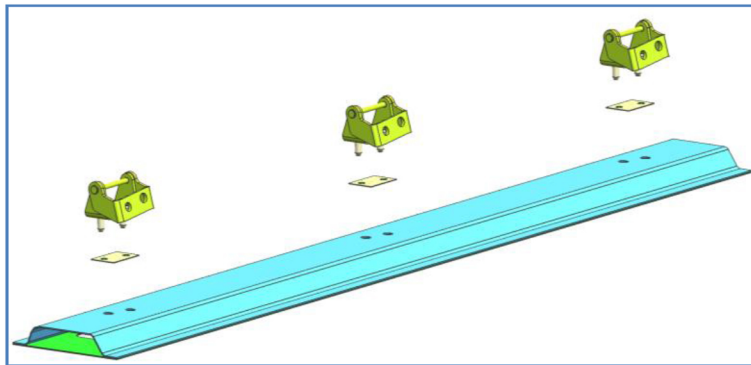


Figure 4. Test Sample Configuration

TEST PROCEDURE

Accelerated corrosion lab testing was for a total of 52 cycles by means of the GMW14872 Accelerated Corrosion Lab Test. This test duration represents ten years of cosmetic corrosion exposure in a severe corrosion environment. The test cycle can be generally described as follows:

- 8 hours: Ambient Soak: 1% Complex Salt Sprays - 4 per cycle
- 8 hours: Wet Soak: 49° C / 100% Relative Humidity
- 8 hours: Dry Soak: 60° C / $\leq 30\%$ Relative Humidity

The 21 hinges were manually exercised once per cycle during each ambient portion of the test using a steel bar to apply enough force to the hinge to flex the panel. The load applied simulated full open liftgate abusive loading conditions. The subsequent flexing of the joint provided the opportunity for the salt spray and moisture to penetrate the hinge-to-body interface.

The cosmetic corrosion performance of the samples (at the hinge-to-body interface) was assessed after 28 cycles, representing five years of cosmetic corrosion exposure. Perforation corrosion analysis was conducted after 52 cycles by assessment of the crevice corrosion performance of the samples. The results of this assessment, along with field equivalent corrosion exposure and penetration rate data, were combined to estimate (mathematically) the time to pinhole perforation in a severe corrosion environment.

TEST RESULTS

The results of this testing are summarized in the following table:

Table 2. Lab Test Results

Sample IDs	Sample Type (All with bare steel roof except as noted)	5 Year Cosmetic Corrosion Performance (Worst)	Perforation Life Estimate (Lowest)
A1-A3	Fiber Gasket	Trace of Corrosion	8-10 years
B1-B3	Fiber Gasket (with 60G galvanized roof)	No Visible Red Rust	10-12 years
C1-C3	Structural Epoxy Adhesive Film (Manuf. A)	No Visible Red Rust	8-10 years
D1-D3	Foam Tape (Manuf. A)	Light Corrosion	6-8 years
E1-E3	Weld Tape (Manuf. B)	No Visible Red Rust	9-11 years
F1-F3	Die Cut Magnetic Tape (Manuf. B)	No Visible Red Rust	9-11 years
G1-G3	9984187 Type G Sealant w/ Wire Mesh	No Visible Red Rust	12+ years

In the case of a bare steel roof panel, only samples G1-G3 met both the 5 year cosmetic corrosion requirement of no visible red rust, and the 12 year no perforation corrosion requirement ([Figure 5](#)).

Test samples G1-G3 utilized a hinge gasket comprised of L&L Products sealant 9984187 and ASTM A510 wire mesh. Each material provides a specific function for the hinge gasket. The EPDM based expandable sealant has been used for years in the auto industry as a weld tape for body joint sealing. For the hinge gasket, the sealant is extruded in sheets and the wire mesh through a series of rollers is embedded into the sealant (calendar embedded). Individual gaskets are then die cut from the sheets of sealant/embedded wire.



Figure 5. Expandable Sealer with Wire Mesh Samples at End-of-Test

Figure 6 illustrates the wire mesh: there are 16×16 wires per square inch $\times$ 0.016" diameter wire. For corrosion avoidance purposes this mesh is galvanized. Figure 7 illustrates the sealant with embedded wire before the gasket is installed to the vehicle. Figure 8 shows that the sealant must displace easily with low force to the wire mesh, the mesh keeps sealant in the joint, and the non-compressible mesh is the spacer that sets the joint gap. The mesh enables in-joint bolt torque retention, and the sealant is the corrosion protector to the interface.

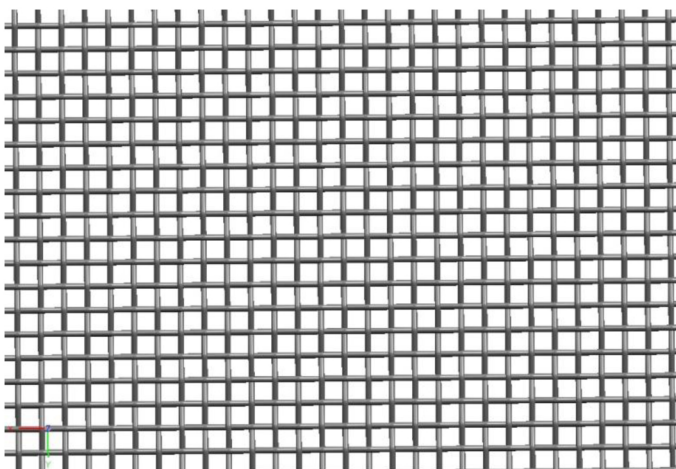


Figure 6. Wire Mesh

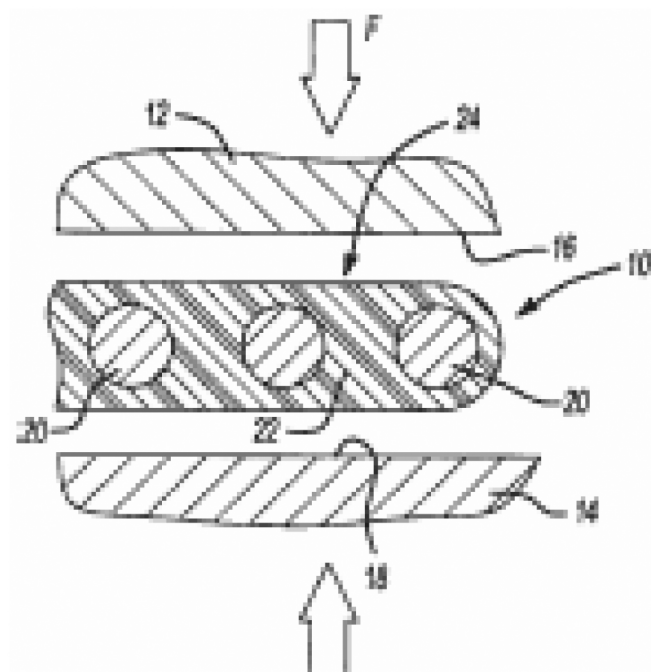


Figure 7. Wire Mesh embedded within the Sealer

One of the advantages of using an expandable sealer with a wire mesh substrate is that the sealer (when exposed to heat in the vehicle painting process) flows into the void between the body side hinge strap and the roof mounting surface. Consequently, the sealer adheres to the interfacing parts, prevents moisture from reaching the roof material, and leaves the wire mesh to crush between the mating parts (reference images 15, 16, 17, 18, 19, 20 in the Appendix). Additionally, as compression of the steel mesh is minimal, less relaxation of the hinge joint occurs, which translates into more effective torque control.

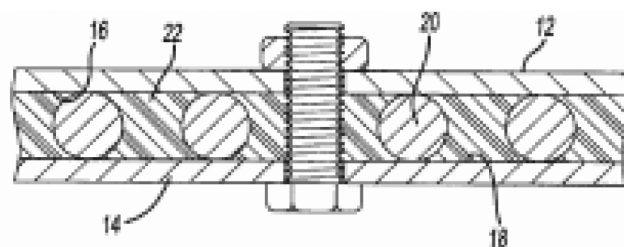


Figure 8. Finished Joint

PROVING GROUND CORROSION VEHICLE TESTING

Having identified via lab testing a candidate sealing material for use with bare steel roof panels, plans were developed to use this material in an upcoming vehicle build. This vehicle would then be tested (full vehicle general durability +