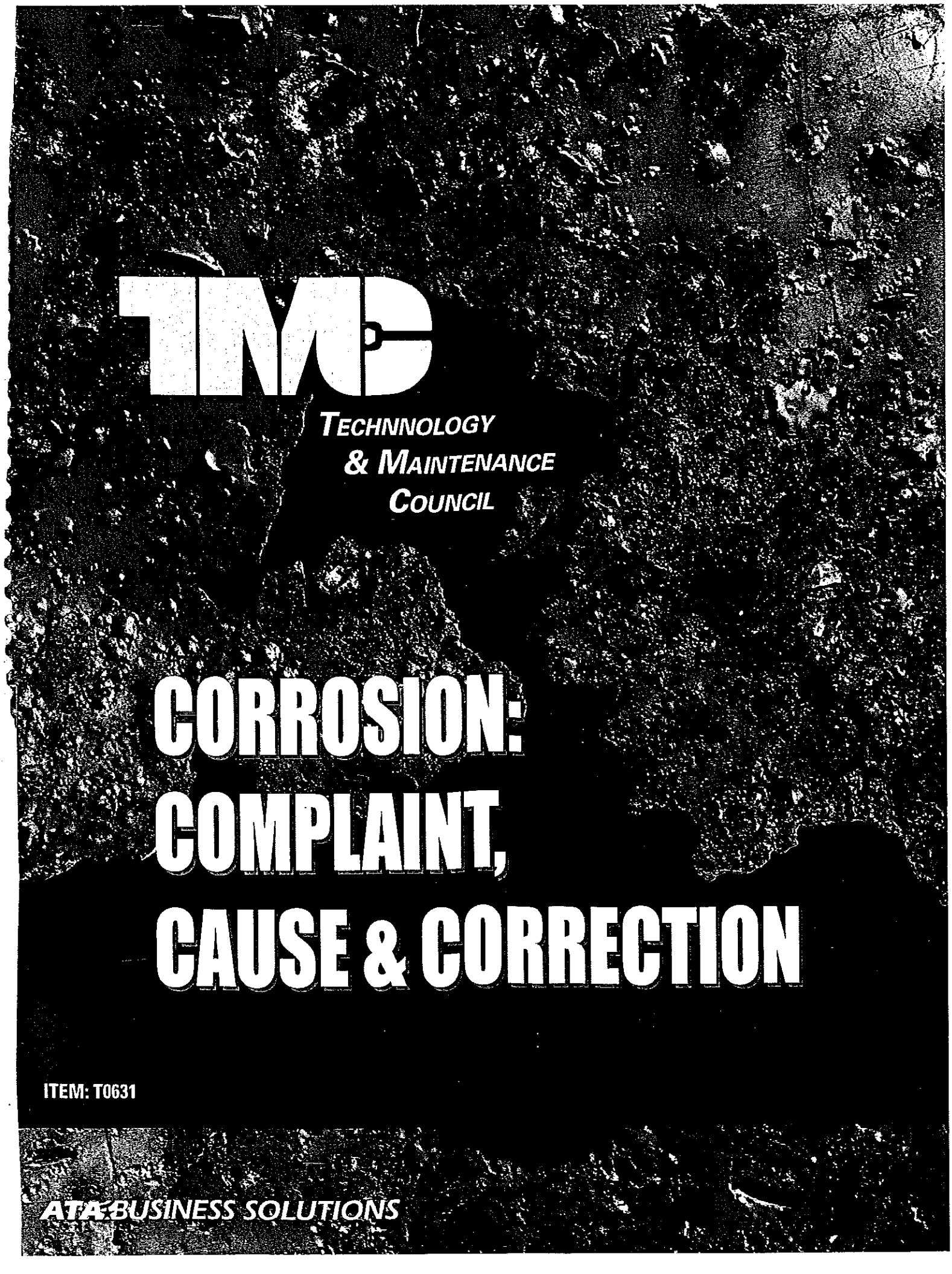
TMC
TECHNNOLOGY
& MAINTENANCE
COUNCIL
CORROSION:
COMPLAINT,
CAUSE & CORRECTION
ITEM: T0631
ATA BUSINESS SOLUTIONS

CORROSION: COMPLAINT, CAUSE & CORRECTION

First Edition (2012)

Item Number T0631

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The material in this manual is compiled from presentation highlights that appeared in TMC's technical journal *The Trailblazer* and from TMC Recommended Practices:

- *RP 132B, Battery Charging, Testing and Handling*
- *RP 155, Selection and Application of Corrosion Preventive Materials for Electrical Terminals and Connectors*
- *RP 159, Installation and Inspection Guidelines for Seven Conductor Truck-Trailer/ Converter Dolly Jumper Cable and Connector*
- *RP 167, Vehicle Electrical Fires: Causes and Preventive Solutions*
- *RP 205B, Use of Tire Bead Lubricants*
- *RP 206B, Tire Repair Procedures*
- *RP 209E, Tire and Rim Safety Procedures*
- *RP 222C, User's Guide to Wheels and Rims*
- *RP 240, Steel Wheel And Rim Refinishing Guidelines*
- *RP 245, Tire Assembly Balancing with Wheel Weights*
- *RP 249, Safety Issues Related to the Use of Flammable Fluids*
- *RP 301C, Maintaining Air Intake Systems*
- *RP 322B, Coolant Pump Failure Modes and Life Extension*
- *RP 326, Recycling Engine Coolant*
- *RP 333A, Heat Exchanger Exterior Maintenance and Cleaning*
- *RP 336A, Aluminum Radiator Maintenance*
- *RP 362, Guidelines for Used Coolant Analysis of Heavy-Duty Vehicles*
- *RP 410A, Seat Belt Assembly, Inspection and Maintenance Procedures*
- *RP 426, Service Guidelines for Occupant Restraints*
- *RP 433, Truck Washing and Cleaning Guidelines*
- *RP 435, Installation and Inspection Guidelines for Pneumatic Tractor-Trailer Hookup Lines*
- *RP 606B, Brake Lining Procedures*
- *RP 607B, Preventive Maintenance and Inspection of S-cam Foundation Brakes*

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- *RP 608B, Brake Drums and Rotors*
- *RP 617A, Contaminant Elimination Procedure for Tractor, Trailer or Dolly Air Brake Systems*
- *RP 619B, Air System Inspection Procedure*
- *RP 622A, Wheel Seal and Bearing Removal, Installation and Maintenance*
- *RP 644A, Wheel End Conditions Analysis Guide*
- *RP 646, Driveline Fastener Preventive Maintenance*
- *RP 656, Hub and Spoke Wheel Fastener Maintenance*
- *RP 740, Corrosion Protection From Dissimilar Metals*
- *RP 734, Van Moisture Contamination Guidelines*
- *RP 758, Van Moisture Contamination Maintenance and Repair Guidelines*
- *RP 1405, Minimizing Dirt and Water Intrusion in Cargo Areas*
- *RP 1423, Specifications To Prevent Galvanic Corrosion In Aluminum Walk-In Van Bodies*
- *RP 1424, Maintenance Guidelines For Minimizing Corrosion In Aluminum Walk-In Van Bodies*

Please refer to the latest edition of *TMC's Recommended Practices Manual* to find these specific RPs.

For information on obtaining additional copies of this manual, contact:
Technology & Maintenance Council
American Trucking Associations
950 N. Glebe Road
Arlington, VA 22203
(703) 838-1763
tmc@trucking.org
http://tmc.trucking.org

or

ATA Business Solutions
(866) 821-3468
http://www.atabusinesssolutions.com

PURPOSE AND SCOPE

This manual is intended to serve as a comprehensive resource that addresses various aspects of vehicle corrosion. This document will provide users with a practical guide for better understanding proper procedures and guidelines for selecting, servicing, and maintaining commercial vehicles so as to minimize premature corrosion during the useful service life of the vehicle.

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ACKNOWLEDGEMENTS

The development of TMC's *Corrosion: Complaint, Cause & Correction* manual was spearheaded by the Council's Corrosion Control Action Committee (CCAC), with the assistance of many individuals working within TMC's Study Groups and Task Forces.

The work was performed under the leadership and guidance of:

- TMC General Chairman & Treasurer
  Roy Gambrell, Truck It.
- CCAC Chairman Todd Cotier, Hartt Transportation
- Carl Kirk, TMC Executive Director & Vice President of Maintenance, Technology & Logistics and;
- Robert Braswell, TMC Technical Director.

TMC thanks the following individuals and their companies for their substantial contribution to the development of this work:

- Al Anderson, Bose Corporation
- Brad Van Riper, Truck Lite
- Jim LeClaire, Horton
- Peggy Fisher, TireStamp, Inc.
- Darry Stuart, DWS Fleet Management
- Glen McDonald, Ozark Truck Lines
- Mac Whittemore, Meritor
- George Mayhew, Verizon
- Dave Williams, Verizon
- Lou Stumpp, Navistar
- Anita Byrne, Tectran
- Larry Horning, Waste Management
- David McCorkendale, Watson & Chalin Mfg.
- Roger Lackore, Oshkosh Truck Corp.
- Remus Scobercea, Volvo Trucks North America

SECTION I: CORROSION COMPLAINT

INTRODUCTION

Aggressive corrosion, caused by new formulations of road ice clearing chemicals, is a serious maintenance problem for many equipment users. Use of magnesium chloride- and calcium chloride-based products by certain states is especially associated with increased incidence of corrosion on vehicles, causing damage in as little as a single winter season.

The scope of the problem is far-reaching, representing a multi-billion dollar toll on the entire trucking industry. This does not include the damage caused to highway, local road and other public utility infrastructures in North America.

In order to reduce this problem, the Technology & Maintenance Council (TMC) of American Trucking Associations (ATA) has developed this manual to help equipment managers and users combat this serious problem.

Areas Prone to Corrosion

When it comes to vehicle corrosion, many people often think it is a problem that's limited to the traditional "rust belt" region of the United States. Certainly, the "rust belt" states are greatly afflicted with corrosion issues, but it is a mistake to think that the problem is limited to this particular geographic area.

Figure 1-1 contains a map that illustrates regions of the United States where vehicle corrosion is most predominant. Note the area along the gulf coast and Atlantic seaboard in the southeastern part of the country and on up into New England that shows the likelihood of high corrosion. While the inland areas indicate the use of the anti-icing and de-icing chemicals that we are going to focus on in this manual, corrosion along the seaboard areas is due to salt in the air from the ocean.

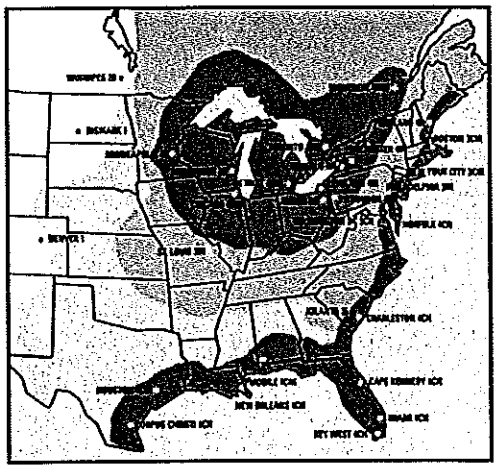


Fig. 1-1: Areas Prone to Corrosion

Anti-Icing and De-Icing Chemicals

There are generally four anti-icing and de-icing chemicals currently used in North America: potassium chloride, calcium chloride, sodium chloride, and magnesium chloride.

- *Potassium Chloride (KCl)*—This is considered to be the least effective and least commonly used road salt. It is mainly used today as a sidewalk de-icer. It is considered relatively easy to use because it requires no special handling to maintain the integrity of its chemical properties.
- Calcium Chloride ($CaCl_2$)—Calcium Chloride is a desirable chemical in both the de-icing and anti-icing processes for two reasons— it is effective at low temperatures and it has a high ability to absorb water. Calcium chloride is somewhat corrosive, but it is relatively harmless to vegetation as it is washed off the roadways. Because of its high ability to absorb water, calcium chloride must be stored in a mostly humidity-free atmosphere or sealed container. At room temperature, calcium chloride is a solid.
- *Sodium Chloride (NaCl)*—Sodium chloride is one of the earliest de-icing compounds used. More effective as a de-icer than potassium chloride, it is an aftertreatment compound—applied to the roadways mainly after ice or snow has formed/fallen. It is still used quite regularly in the west and southwest parts of the United States where the temperatures aren't as extreme. Today, it is often used in conjunction with one or more other chemicals to enhance the effectiveness of the combination.
- *Magnesium Chloride ($MgCl_2$)*—Magnesium chloride is considered the harshest and most corrosive chemical used in snow and ice control today. It is somewhat more corrosive than calcium chloride, and by itself less corrosive than sodium chloride. The problem is that it sticks to surfaces much more aggressively than do other road salts. Thus, it is hard to remove and continues to corrode even after attempts to remove it have been made. Generally, magnesium chloride is deployed in a brine solution and most often as a cocktail in conjunction with either sodium chloride or calcium chloride. Because magnesium chloride is applied as a brine solution, it does tend to wick and as a result can be especially harmful when it gets into electrical grids by causing tracking and arcing. By its nature, magnesium chloride is difficult to work with, handle and store. It tends to plug application equipment at lower temperatures and absorb water and therefore must be stored in a low-humidity environment. There is one factor which seems to make it the choice of many transportation agencies – its relatively low cost as compared to other chemicals. Because of its continued and growing acceptance as a roadway anti-icer and de-icer, there is extensive research going on to develop solutions of magnesium chloride that are less harmful to roads and vehicles.

Table 1-1 compares the different properties of each of the chemicals.

TABLE 1-1: ANTI-ICER/DE-ICER COMPARISON				
	KCl	$CaCl_2$	NaCl	$MgCl_2$
Corrosiveness	*	**	***	****
Difficult to Remove	*	**	*	****
Effectiveness in Ice	*	****	**	***
Coldest Effective Temp	-25°F	-60°F	+20°F	+5°F
Harmful to Environment	*	*	***	**
Difficult to Store/Handle	*	***	*	****
	* = Least **** = Most			

Figure 1-2 attempts to show road salt usage by type across the United States. In most cases, the chemicals are deployed in combination to provide the best anti-icing/de-icing effectiveness.

More than 20 states currently use some form of magnesium chloride for road treatment. Some states, such as Oregon, Montana and Idaho combine it with a corrosion inhibitor, which makes it about 70 percent less corrosive than salt. Some of the chemicals are put down in liquid form, some are put down before the snow and ice, and others applied after snow and ice. When the chemicals are applied to the roadways before snow or ice, they act like an acid when contacting the metal parts of a vehicle.

These new formulations of road ice clearing chemicals, which have replaced sodium chloride (road salt) and sand strategies, do an excellent job of minimizing ice on highways. The problem for

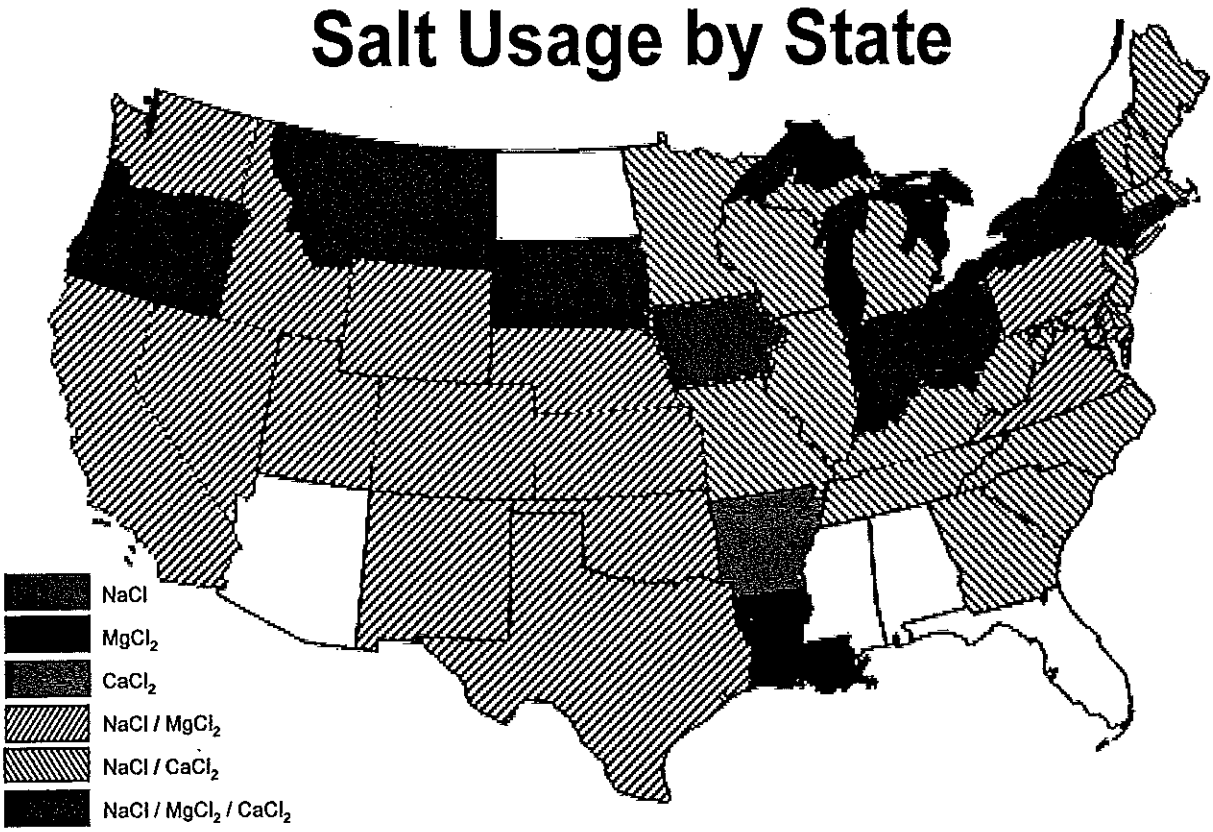


Fig. 1-2: Salt Usage by State

COLORADO: CASE STUDY IN CORROSION

Adapted from *The Trailblazer*, October 2001, originally published by ATA's Technology & Maintenance Council (TMC).

Patricia Olsgard, director of safety for the Colorado Motor Carriers Association, discussed [at TMC] Colorado's use of liquid deicers and winter road maintenance.

In 1996, the State of Colorado began to hear complaints about anti-icing and deicing-related corrosion from some Colorado fleets. [Anti-icing maintenance is defined as treating the roadways prior to snow, rain, or ice. This maintenance typically consists of a 30 percent concentration of chemical and is applied up to 96 hours prior to a storm. Deicing is defined as treating the roadways during and after snow, rain or ice.]

Winter road products used across the country consist of both solid materials and liquid brine solutions. Solid products consist of sand, gravel, scoria, coarse salts and a mixture of sodium chloride. The liquid brine products consist of magnesium, calcium, sodium chlorides, calcium-magnesium and potassium acetates. Some of these chemicals are also mixed to provide a more effective deicing solution, Ms. Olsgard said.

In Colorado, the main solution used in snow and ice control is magnesium chloride, for both anti-icing and deicing. However, some mountain cities have banned the use of magnesium chloride because of the health considerations of the chemical. Colorado also uses a salt/sand mixture at some intersections and in some highly traveled urban areas, she said.

In addition to the magnesium chloride and salt/sand mixture, Colorado has experimented with other solutions and additives. One such product is propylene glycol, which amounts to nothing more than recycled antifreeze. One major side effect of using this solution in conjunction with chloride compounds is that the propylene glycol allows the chlorides to wick into electrical systems and brake systems.

Colorado has also used some alcohol-based solutions such as a product called Calabran M 1000. This method of treating winter roads is considered cutting-edge technology and is less harmful to the environment, but is still somewhat corrosive. Lastly, they are testing various granular products. These products are really nothing more than a liquid treatment with the water removed, Ms. Olsgard said.

Because Colorado uses mainly the highly corrosive magnesium chloride on its roads, corrosion complaints come regularly from the trucking industry during winter. Ms. Olsgard said many of the complaints are of "cosmetic" corrosion on everything from vehicle bumpers and wheels to entire trailers. The complaints are of pits and blemishes on the components, affecting aluminum, stainless steel and chrome surfaces. In the past, fleets have tried to counter the effects of the winter road treatments by using stainless steel components on critical areas on their vehicles. But, because magnesium chloride is considerably more corrosive to stainless steel than sodium chloride, even that doesn't work anymore.

In the past, fleets have tried to counter the effects of the winter road treatments by using stainless steel components on critical areas on their vehicles. But, because magnesium chloride is considerably more corrosive to stainless steel than sodium chloride, even that doesn't work anymore.

Other complaints about magnesium chloride are that it leaves a coating on vehicle windshields, lights and reflectors, making vehicles extremely difficult to get clean and keep clean. It also gets into electrical systems, corroding them and shorting out wiring and electrical connectors. The use of magnesium chloride has even been tied to pitting of hoses, belts and tires on vehicles that are regularly subjected to it.

Ms. Olsgard said she made some progress by working with state and local transportation departments on product selection, corrosion inhibitor additives and application methods. For example, in Colorado, the magnesium chloride used must be 75 percent less corrosive on mild steel than sodium chloride. This is done through the use of corrosion inhibitors in the chloride solutions. "You must be cautious, however; because some corrosion inhibitors contain heavy metals and that can cause issues with wastewater or storm water runoff in fleet maintenance locations," she cautioned.

Colorado has also considered reducing its application time before an anticipated storm from 96 to 24 hours. The state is also helping to ensure local municipalities have adequate testing and quality control procedures to be sure the products applied to the roadways meet the specifications mandated.

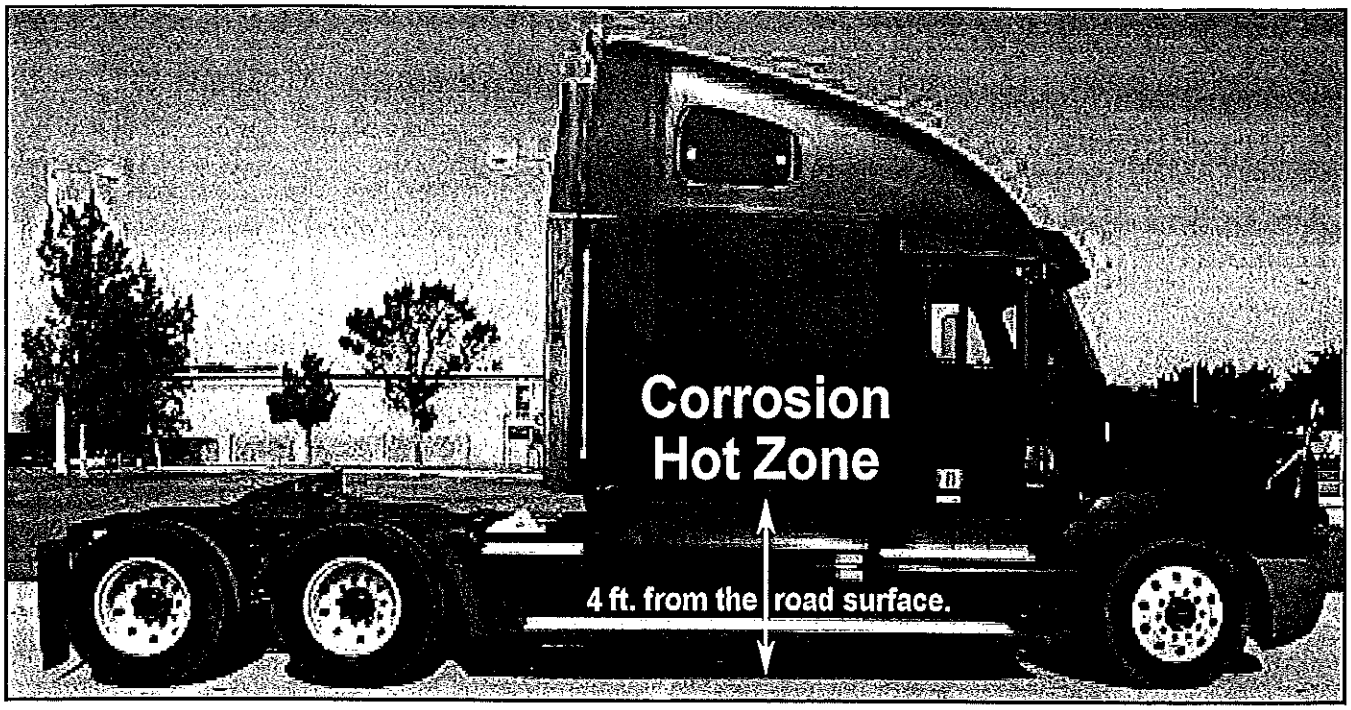


Fig. 1-3: Corrosion Hot Zone for a Class 8 Tractor

fleets, however, is that its use has become a serious maintenance problem for many equipment users. Use of magnesium chloride- and calcium chloride-based products by certain states has been associated with increased incidence of corrosion on vehicles. And the chemicals reportedly can cause significant damage in as little as a single winter season.

Corrosion on vehicles operating in these areas has been reported on chrome, aluminum—even stainless steel. According to some fleet managers, the corrosion is found most frequently on:

- trailer longitudinal rails.
- electrical connectors.
- exposed aluminum components.
- exposed chrome components.
- brake tables.
- fifth wheel and landing gear.

Other areas affected include electronic control module (ECM) and headlight connectors, various sections of trailer frames and bodies, spring hangers, fuel tank straps, wheels and wheel fasteners, and fins on aluminum radiators. The areas affected generally are splash-prone areas on the front, underside, and lower portions of tractors and trailers, and on foot pedal linkages in cabs. This constitutes the "hot zone" of the vehicle, which is up to four feet high from the road surface. (See **Fig. 1-3.**)

Since 1999, this problem has been frequently reported at meetings of ATA's Technology & Maintenance Council (TMC). Examples of failed parts attributed to this phenomenon were displayed at special Failure Analysis sessions of TMC's Shop Talk, and during various technical sessions on the same topic. The pictures that appear in the **Corrosion Conditions** section of this document illustrate the problem well.

In some cases, fleets have reported success in dealing with the problem through more aggressive vehicle washing. However, no washing can completely solve the problem as it pertains to electrical connectors, brake components, and many other affected systems because the components are not readily accessible.

So, why do states use magnesium chloride? Many of the states that use it had to get away from the use of solids because of air quality and environmental issues. One major benefit to the states using it is that it can be applied to roadway surfaces up to 96 hours before a storm and snow will not stick to the surface. It is relatively inexpensive, costing about 30 cents per gallon as opposed to more than twice as much for competing products.

Based on member concern, TMC launched a Corrosion Control Action Committee to study the problem and develop recommendations to help solve it. In its study on the matter, TMC has identified other groups who also share concern with these new formulations—specifically electrical utilities, whose infrastructure is compromised by the same chemicals through aggressive corrosion, state trucking associations such as the Colorado Motor Carriers Association, and the Pacific Northwest Snowfighters Association.

ARE YOUR FLEET'S BRAKES RUSTING AWAY?

Taken from *The Trailblazer*, October 2001, originally published by ATA's Technology & Maintenance Council (TMC).

"Are your brakes rusting away?" asked Roy Gambrell, director of maintenance for Truck It, Inc. He said corrosion on fleet equipment is a much bigger problem in our industry than most fleet operators realize. If a fleet doesn't think it has the problem, it had better take a closer look at the brakes on its equipment, he said.

If your brakes are more than 18 months old and you equipment travels in states that use chemicals to treat their roads for ice, snow or dust, then you more than likely have the problem, Mr. Gambrell said. He added that the trucking industry must pay attention to this problem and find a solution before it can become a safety issue.

Mr. Gambrell said when the problem first appeared on his trucks, it looked like a heat problem. Since he had never had a heat problem in his braking systems, it caused him to look further into what was happening. There were cracks in the brake shoes, but no other symptoms of heat in the shoes or on the drums. When the shoes were removed from the shoe table, He found a significant amount of rust built up under the shoe.

Rust Starts to Build Under the Lining

Because the rivets hold the lining to the shoe, the lining cracks as rust builds under the shoe. As the rust builds, it can sometimes build up to a thickness of 1/4". And as the rust builds, it can occupy two to four times its iron constituent. The buildup of rust forms a wedge and eventually cracks the shoe.

As everyone in the maintenance community knows, brakes are the number one item vehicle inspectors look at, said Mr. Gambrell. They are also the system on the vehicle that cause the most out-of-service violations. If a brake shoe has surface cracks, they aren't detected because they are hidden under the brake drum. If the crack goes down the side of the shoe, it can be seen. If an inspector catches that, your vehicle is placed out of service.

Tracking Down the Problem

Mr. Gambrell said that once he confirmed that he had the problem of cracking shoes in his fleet, he began the search for the root cause of the problem. But he found more than one cause of the problem.

- **Thicker brake linings** — Thicker linings can yield longer brake life. Longer brake life means more time to be exposed to the elements. Cracks begin as corrosion under the brake lining sets in.
- **Improperly installed linings** — Re-liners don't always do a good job reinstalling brake linings on the shoes. They need to be certain the right lining is used on the right shoes. The rivet holes must line up for the shoe to be properly installed. Demand for their product is high and there aren't always enough qualified personnel to do the job correctly. This can lead to less than acceptable quality and problems for the fleet later in the lining's life.
- **Changes to the brake table, or brake shoe** — Brake shoes are not as rigid as they once were. This was done to cut down on the weight of the shoe, but it also compromises the strength of the shoe. Mr. Gambrell noted that arcing of the shoe is called "coining." If the shoes are not arced properly, or "coined," the lining can crack prematurely. Worse yet, if there are gaps between the lining and shoe because of improperly matched components rust jacking can occur at an even faster rate.
- **Improperly prepared tables** — Removal of lead from the paint used to coat brake shoes also lessened the paint's rust inhibiting qualities. This allows corrosion to attack the shoes quicker, leading to the rust-jacking phenomenon.

A Manufacturer's View

Rod Russell, senior product specialist for Dana Corporation, addressed the corrosion issue on behalf of a group of suppliers representing the Heavy Duty Brake Manufacturer Committee (HDBMC) and concentrated his discussion on the phenomenon of brake lining rust jacking from a manufacturer's point of view.

Mr. Russell said lining rust jacking is the formation of an oxides layer developing and growing on the brake shoe table. The oxide layer is caused by corrosion due to corrosive elements working their way between the brake block and brake shoe table. The formation of the rust layer on the table causes the brake block to be pushed away from the brake shoe table. Since the rivets hold the block tightly to the table, the result is cracked brake shoe blocks. In severe cases, rust jacking can cause the shoes to come off the brake shoe table.

Identifying Brake Lining Complaints

In the past, cracked brake lining complaints were normally considered to be from stretched shoes and oversized brake drums, said Alan Matsumoto, tech manager for Carlisle Motion Control. Over a period of several years, a pattern started to emerge that the cracks in brake shoes were more noticeable on vehicles exposed to icy weather conditions. He said the major complaint was that fleets were getting "out-of-service" violations for cracked brake linings.

As a method of trying to determine what the issues were, a sample of 492 shoes was inspected. While separating the shoes for inspection, at least four different friction material manufacturers were identified. All had some form of cracking or were oil soaked, indicating that the problem is not isolated to any single friction material manufacturer.

The group inspected included relined, remanufactured and OEM shoes. Each of the different types of shoes exhibited rust jacking, Mr. Matsumoto noted. The rust scale on some shoes was measured to be up to 0.180" thick, he said.

If a crack of any kind can be seen looking in from the back of the brake drum, roadside inspectors will issue a citation. Technicians should be trained to inspect for this condition, Mr. Matsumoto said. Once the brake drum is pulled off, deep cracks down the center of the brake lining will be evident. Some cracks may "spider web," starting in the center of the shoe and work toward the outside of the shoe. This will most likely be from rust accumulation between the friction shoe and the shoe table.

Conditions Leading to Rust Jacking

Mr. Matsumoto pointed out what he sees as several contributing factors that lead to rust jacking. Improper relining of brake shoes can be a major contributor. Standard shoes placed in an oversized brake drum not only creates clearance between the heels of the shoes, it also stretches the brake shoes. Drum expansion from heat also contributes to more stretch in the shoes and clearance between the lining and brake shoe table. Most users do not realize that brake drums have a natural wear indicator. The bevel in the opening of the drum is approximately 1/16" thick. This is almost exactly the allowable wear limit in a brake drum. What that means is if the bevel on the inside of the drum is gone, the drum is worn at or past the acceptable limit.

Mr. Matsumoto affirmed earlier discussion that corrosion can spread from holes not filled with rivets when the shoe table that has a different drill pattern on the rivet holes than the brake block itself. Corrosion can spread from holes not filled with rivets. This happens mostly when the empty holes are in the table on the bottom shoe position. Always try to match the drill pattern of the shoe table with the hole pattern on the brake block, Mr. Matsumoto said.

Knowledge of the process of remanufactured or relined brake shoe preparation by your shoe supplier is paramount to getting the full service life of the friction material. Removing the old brake block, washing and shot blasting will reveal most of the imperfections of the shoe table, Mr. Matsumoto said. Restoring the table radius further insures that the inner radius of the lining will fit the outer radius of the shoe table. Brake shoe tables should be checked for web stretch and elongated rivet holes. These conditions should be corrected if possible and the shoes discarded if correction is not possible. Next, the shoe table should be painted or dipped to apply a protective coating on the core. This will protect the shoe from corrosion. Lastly, the brake block is riveted to the shoe. Consistent rivet pressure ensures the lining will remain tight on the table.

There are potential solutions to the rust jacking problem. Treatments that worked in the past to combat the corrosion caused by deicing chemicals are questionable in today's environment, Mr. Matsumoto explained. There are shoe coatings that can abate the effects of rust jacking, but they are more costly than today's coatings. Long-term studies are needed to determine whether these coatings will actually offer long-term solutions, he said, adding that many of the treatments are restricted by the U.S. Environmental Protection Agency or the Occupational Safety and Health Administration.

Influencing Rust Jacking

There are several factors that influence the issue of rust jacking. One factor is the geographic region of operation. Rust jacking is more prevalent in the northern areas where states use corrosive chemicals to deice roadways, Mr. Russell noted. Chemical deicing compounds such as salt, magnesium chloride, calcium chloride and others are caustic in nature and serve to accelerate the corrosion that causes rust jacking.

Brakes on container chassis are also highly susceptible to the phenomenon because they sit for extended periods of time at or near seaports where there is salt in the air. Time itself is a factor in the process, Mr. Russell said. The oxidation process takes time to develop. Light-duty applications or improved linings

that allow longer brake life are more likely to be affected by rust jacking. Light-duty applications do not allow brake linings to dry out, therefore allowing corrosion to set in, he said. Longer life OEM brake linings stretch intervals between relines, so the rust has a longer time to develop.

Pressure Washing Can Play a Part

Increased use of pressure washing has a significant effect on corrosion in the brake system. If there is a direct spray of high-pressure water to the inside of the wheel end, unwanted moisture can be introduced to the brake shoes and linings. Caution must be used to be sure there aren't corrosive solvents in the solutions added to wash water. All of the above issues are in addition to increased fleet awareness that has caused more frequent and closer scrutiny during preventive maintenance inspections, Mr. Russell said.

There are several factors to keep in mind concerning rust jacking. At times, rust jacking may crack the brake block around the rivet holes and push up corrosion past the rivets rather than cracking across the face of the block. Rust-jacking problems on new OEM manufactured shoes are very isolated with only a few cases being reported. Even these cases are more prevalent in areas that use highly corrosive deicing compounds.

Again, rust jacking takes time to develop. In most of the cases reported, the linings that were cracked because of rust jacking were close to wear out. There have been a few isolated cases of rust jacking occurring on extended-service or long-life brake blocks where a considerable amount of lining material was remaining. Block flexural strength also plays a part in the issue. No two block formulations are the same; therefore each has a different threshold at which it will crack due to rust jacking. Also, a block worn thin will crack sooner than a thicker brake block.

The climates of specific areas and the deicing compounds used in the traditional "rust belt" areas lead to a higher incidence of rust jacking. Heat generated from brake applications tends to dry out the shoe table area, reducing the propensity to corrode. The thicker blocks associated with extended service or long life products tend to insulate the shoe table area, therefore the shoe table doesn't see the heat as quickly, allowing corrosion to set in.

Also, longer intervals between brake applications (line haul versus city or local applications) also can reduce heat input so the interface between the brake block and shoe table does not dry. Mr. Russell said the whole rust jacking issue seems to be much more prevalent on relined shoes, but there have been some reported occurrences on OEM shoes that have been on vehicles for extended periods of time.

Detecting lining block rust jacking is done strictly by visual inspection, Mr. Russell said. With the wheels on, the technician should look for radial cracks in the edge of the lining block. With the wheels off, the brake blocks should be inspected for cracks across the lining block face. The cracks will be easy to detect of they are present. The cracks associated with rust jacking should not be confused with those associated with heat issues or lining glazing exhibited by many linings during use.

Other Factors

Other factors that influence the issue of rust jacking are more closely related to the construction of the brake shoe assembly itself, Mr. Russell explained. Things such as the material composition of the shoe table and the coating applied to it are important. Numerous coatings are used, all with different resistances to corrosion. Everything from standard painted surfaces to e-coating to patented technologies like B-Lock are being employed. B-Lock is popular in the container chassis segment of the market because of its high resistance to corrosion.

Dimensional conformity refers to a mismatch of the radius of the shoe table and brake block. If such a mismatch occurs, Mr. Russell pointed out, the radius differences leave a void where corrosive contaminants can collect. Also, if the shoe table is not flat across the width, the same types of voids are formed. This is primarily an issue with relined shoes, especially if they are not recoined or reshaped.

Brake shoe configuration is another important factor in rust jacking. If 16 hole shoes are used with 12 or 14 hole brake blocks, the hole locations that are not filled with rivets provide opportunities for corrosion to begin. The quality of the riveting process itself is important. Loose rivets allow the brake block to move on the shoe table. This makes it easier for moisture and corrosive materials to get in and under the block, allowing corrosion to start. Loose rivets also allow the brake block to rub the protective coating from the shoe table.

Equipment User Expectations

Based on its research, TMC—in its 2002 Information Report entitled "Road Chemical Induced Corrosion"—recommended the following to solve this serious durability and safety problem:

1. TMC called on suppliers of road ice clearing chemicals to change the formulation of their products to make them less prone to cause corrosion in commercial vehicles. TMC is aware that some suppliers of both trucks and components are doing laboratory work on the effects of certain deicers on their products. With a little extra work and coordination with deicer suppliers, the opportunity exists to develop different chemical formulations as part of the ongoing projects.
2. Should this prove not possible, then TMC has asked that states stop using these chemicals to clear road ice.
3. Should states not agree to do this because of the advantages of these new formulations, then TMC has asked that manufacturers of vehicles make design and/or material changes to their product to resist road ice clearing chemical induced corrosion.

As additional guidance for manufacturers, TMC issued several equipment user expectations for corrosion resistance in its 2005 Future Truck Position Paper entitled "Recommendations for Corrosion Abatement." These guidelines are as follows:

- Commercial vehicle users should not need to replace a component over the vehicle's useful life, or the useful life of that component, due to corrosion. (This includes surface corrosion.)
- Additionally, commercial vehicle users should not need to perform any maintenance (other than normal, periodic washing) to prevent corrosion. **Table 1-2** defines the users' expected level of corrosion protection by vehicle type.

It was not TMC's intention to advise manufacturers on how to produce products (coatings, choice of materials, etc.) to comply with **Table 1-2**. Rather, TMC issued this position paper as a road map to assist OEMs and suppliers in producing products that meet users' expectations.

TMC also asked industry for the following:

- Standardized laboratory tests that accurately simulate today's real world environment and (as best we can) identify what should be anticipated in the future road environment. These standardized tests are to have provisions for testing electrical components. Furthermore, electrical components must be active during this testing.
- Recognition that different zones of a vehicle have different corrosion protection needs. These zones need to be identified and the test requirements for each zone determined. A zone "from the road level to four feet above the road level" should have the greatest corrosion protection (compared to other zones) and must withstand impact by sand and stones.
- Build/engineer components and the vehicle as a whole for the worst case corrosion scenario. While realizing that eight years service in northern states is not the same as eight years service in southern states, we must assume the worst case scenario and consider the vehicle as being based in a northern state climate and in a coastal area.

Corrosion Testing

There are a number of tests that manufacturers have traditionally used to test for corrosion. However, most of these predate the use of modern anti-icing and de-icing compounds.

The American Society of Testing and Materials (ASTM) B117 test is one of the most widely adopted, continuous salt spray test specifications available. The test is used to test the relative resistance to corrosion of coated and uncoated metallic specimens, when exposed to a salt spray climate at an elevated temperature.

TABLE 1-2: CORROSION PROTECTION MATRIX

Vehicle	Heavy Duty	Medium Duty	Light Duty
Tractor	8 years	N/A	N/A
Truck	8 years	10 years	10 years
Trailer and Converter Dolly	16 years	N/A	N/A
Truck Body	N/A	16 years	10 years

- Corrosion protection for add-on components (i.e., liftgates, spare tire holders, reefers, tool box, etc.) should be based on **Table 1-2.**
- OEMs and suppliers should back up the corrosion performance levels listed in **Table 1-2** with a 100 percent parts and labor warranty.

When using this test to measure the potential for brake rust jacking, for example, brake shoes are burnished as per the Federal Motor Vehicle Safety Standard (FMVSS) 121 procedure, placed in an enclosed salt fog chamber and exposed to a continuous indirect spray of neutral (pH 6.5 to 7.2) five-percent sodium chloride solution. This solution falls-out on to the specimens at a rate of 1.0 to 2.0 ml/80cm/hour, in a chamber temperature of +35°C. The testing should run 24-hours continuously and the brake shoes should be rotated every 100 hours. Every 24 hours, a visual inspection is performed and pH level checked for the duration of the test.

As reported at TMC meetings, there are well-known shortcomings associated with ASTM B117 testing which prevent it from accurately reproducing corrosion performance in brake shoes. The testing process exposes the shoes to a continuous salt spray, but on a vehicle those parts are subjected to wet and dry cycles which contributes to accelerated corrosion. Also, the FMVSS 121 burnish procedure does not create sufficient abrasion between the shoe and table, and the test ignores corrosive agents beyond sodium chloride.

While use of aggressive de-icing solvents on roads is a definitive cause of the increased incidence of rust jacking, industry manufacturers have reported the problem is more complex than that. Products the industry once used for corrosion protection, such as lead, cadmium and hexavelent chrome are now illegal and suppliers have had to develop new techniques and product for corrosion protection. The problems and challenges associated with corrosion and rust jacking have highlighted the need for better corrosion standards for commercial vehicles.

In 2003, the Society of Automotive Engineers (SAE) responded to the need for better test methods by forming a Corrosion Control Task Force. Membership of the task force included 40 suppliers, 11 OEMs, five fleets, four industrial groups, four consultants, two test centers and one member of the press. The Task Force's objective was to establish a recommended practice that could be used to validate acceptable corrosion performance of truck and bus components.

The general premise for the group was that a test needed to be developed which overcame the shortcoming of ASTM B117 and was more representative of test results in the field. While vehicle field testing is best, it is often too expensive and time consuming. Component suppliers needed an accelerated test that correlated to customer field experience. Thus, a laboratory test needed to be developed and tailored to component function and location on the vehicle. The test procedure had to include cycles of exposure, drying, thermal cycle abrasion etc. For the test to be credible it also needed to test corrosive agents other than just sodium chloride.

The final work product of the task force was SAE J2721, "Recommended Corrosion Test Methods for Commercial Vehicle Components." The reference documents that were used in development of the test included:

- ASTM B117, B287, B368-68T;
- SAE J447, J1455, J2334, J2139;
- Mil Std 202, 810D;
- DIN 50021-ASS, 50021-CASS;
- GM9540P;
- FLT 49-00023;
- Volvo STD 423-0014, STD 5711-102; and
- NACE "Forms of Corrosion - Recognition and Prevention."

According to J2721 Task Force Chairman Vern Caron, ArvinMeritor, the task force needed a test that was representative of field experience so it looked at GMC 9540P and SAE J2334, "Cosmetic Corrosion Lab Test." GMC 9540P was considered obsolete because it is labor intensive, but the task force looked at it closely and adopted some of its elements. SAE J2334 is a cosmetic corrosion lab test, but it is a good test for more than just cosmetic corrosion, when chemical mixes other than just sodium chloride are used.

Some significant features of the new SAE J2721 test include:

- Customer expectations;
- Corrosion zones (see **Figure 1-4**);
- Chemicals other than sodium chloride, such as magnesium

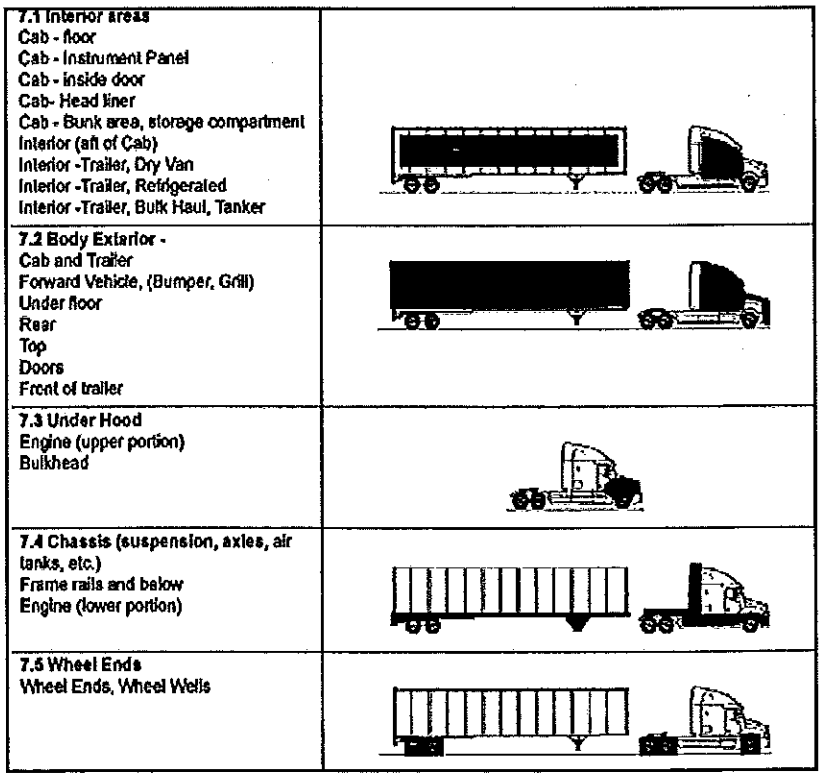


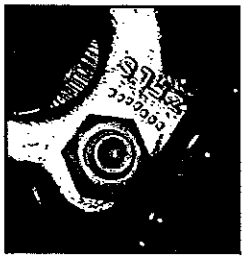
Fig. 1-4: J2721 Corrosion Zones

chloride, calcium chloride and other deicer cocktails;
- More complex test cycle;
- Correlation methodology;
- Evaluation methodology; and
- Target performance levels.

In fact, the customer expectations for service life listed in J2721 were developed directly from TMC's Future Truck Committee position paper published in 2005. (See **Table 1-2.**)

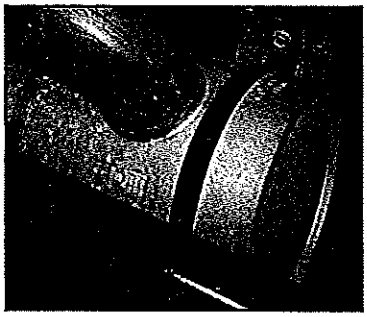
SAE J2721* established a corrosion grading scale to evaluate cosmetic, functional and structural corrosion. The scale ranges from a severity of Stage 0 to Stage 6 as follows (photos below are graded by TMC and do not appear in SAE J2721):

- **Stage 0**
No visible signs of corrosion of corrosive attack. No presence of white, red or black corrosion products. No presence of paint fill blistering indicating corrosive attack. Discoloration of a coat system, other than caused by corrosion, is permissible.



Stage 0

- **Stage 1**
General surface corrosion is present. White corrosion products are present on the surface of the component being evaluated, but no significant attack is present. Minor blistering of the coating may have occurred.

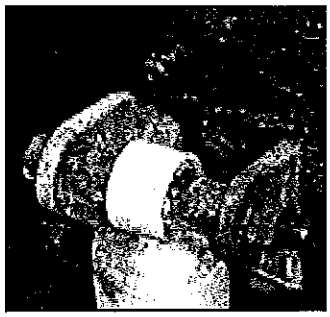


Stage 1

- **Stage 2**
General surface corrosion is present. Red and/or black corrosion products are present on the surface of the component being evaluated, but no significant attack is present. Minor blistering of the coating may have occurred.

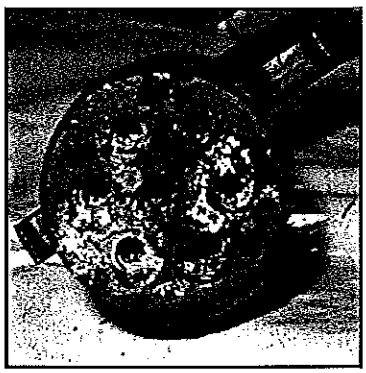
Stage 2

- **Stage 3**
Heavy corrosion products are present on the surface of the component. This is the beginning of metal loss; however, no significant loss has yet occurred. Moderate white, red and/or black corrosion products are present on the component surface. Severe blistering of the paint may have also occurred.



Stage 3

- **Stage 4**
Corrosion has resulted in mechanical malfunction such as bearing seizure or loss of motion in sliding or moving parts. Electrical components experience shorts or opens, resulting from corrosion.

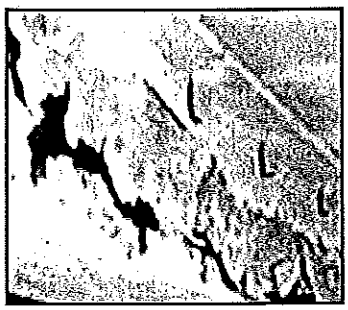


Stage 4

- **Stage 5**
Corrosive attack has resulted in significant base metal loss. Reduction in the cross-section thickness of the component has occurred. Voluminous white, red and/or black corrosion product present on the component. The structural integrity of the component may or may not be compromised. Pinholes have developed.

Stage 5

- **Stage 6**
Perforation of the base metal has occurred. No metal remains at the point of severest corrosive attack. The component has lost structural integrity.



Stage 6

SAE J2721 contains a correlation procedure that uses mass loss coupons. These coupons are 1"x 3" strips of cold-rolled steel (1010 or 1008) that are mounted on a vehicle to help determine the corrosive environment in the field. Eight mass loss coupons are weighed and then mounted in the area of interest on the vehicle. The coupons are

** SAE standards such as J2721 can be obtained from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001 USA; (724) 776-0790; www.sae.org*

TABLE 1-3: SAE J2577 CORROSION RESISTANCE REQUIREMENTS

Fluid	Concentration	Classification
Motor oil 30 wt	100%	ASTM D 471, IRM-902
Brake fluid (Type 1)	100%	SAE RM66-04
Diesel fuel #2	90/10%	IRM-903/T-xylene
50/50 antifreeze mixture	50/50	ASTM D 471 service fluid 104
Gear oil 90 wt	100%	ASTM STP 512, API GL-5
Windshield washer fluid	100%	Methyl alcohol Ref.: SAE J1944
Magnesium chloride	5%	SAE J2174 (Ref)
Muriatic acid	12.5%	Diluted in water 1:8 by volume
Calcium chloride	5%	SAE J2174 (Ref)
Cleaning fluid	85%	Mineral spirits/15% xylene trisodium phosphate per manufacturers recommendations

then removed after a year to determine the extent of metal loss that is present. To be able to include mass loss rates in J2721, SAE used data from General Motors and the military provided by the Aberdeen Proving Grounds.

In support of user community requests, the SAE task force modified test procedures to make them easier to use, gathering user experience and responding to user questions. The task force is conducting a correlation study, the object of which is determining typical mass loss rates for mild steel corrosion test coupons when subjected to the environment found at various locations on commercial vehicles in operation on North American roads.
The locations of interest on the vehicle are:

- Lower to middle engine compartment, preferably in the area of the engine radiator;
- Chassis area, approximately at the frame rails, possibly above or in-line with the axle;
- Lower vehicle area in the splash zone near the wheel ends; and
- Body area, tentatively on trailers in the area where the glad hands/J560 connector are mounted.

The SAE Task Force has also reported an interest in mounting test coupons on bridges, highway overpasses and guard rails to help gauge the impact of corrosion on the transportation infrastructure. The regions of operation for the test would be on primary and secondary roads in the U.S. and Canada that are subject to ice and snow control chemicals, or chemicals used for dust control. Areas subject to salt water corrosion because of the proximity to oceans, or other salt-water bodies are also of interest.

A possible secondary objective is testing coupons to determine their ability to resist corrosion. Examples include aluminum and stainless steel as well as coupons that are treated or coated to provide corrosion resistance.

SAE J2577 and Industry Efforts to Meet It

There are other important standards that both SAE and TMC have developed in the ongoing fight against corrosion. Two such examples that pertain to lighting/electrical corrosion are SAE J2577 and TMC RP 153, which were developed separately, but within the same general timeframe in response to equipment user needs.

The SAE Heavy Duty Lighting Standards Committee was charged with developing a heavy-duty lamp electrical connector standard. The task force consisted of a cross section of experts from the light manufacturers, connector manufacturers and trucking OEMs. The scope of the SAE standard encompasses connectors that form the electrical interface between the heavy duty lighting device and the truck and truck/trailer wiring harness system. The resulting work product was SAE J2577, "Heavy Duty Lamp Electrical Connector Standard."

SAE J2577 provides design and performance requirements based upon the mechanical, electrical and environmental conditions and covers applications of connectors for direct current electrical systems of 24-volt nominal or less in heavy-duty signaling and marking devices.

In 2001, TMC's Future Truck Committee saw the need to improve the corrosion problem occurring with heavy-duty vehicle lighting. The S.1 Electrical & Instruments Study Group was asked to develop a recommended practice that would focus on the performance of the trailer lamp connector interface occurring as the result of corrosion problems and non-interchangeability for field repairs, and as a result S.1 developed TMC RP 153, "Lamp-to-Connector

Interface Guidelines." RP 153 was published in January 2004.

The goal of the RP was to promote the development and implementation of a lamp connection system that possesses improved mechanical, electrical and environmental performance requirements, and meet the requirements of SAE J2577, "Heavy Duty Lamp Electrical Connector Standard." It was intended that the lamp connector be maintenance free for at least one million miles and/or 10 years of life. The RP applies to exterior lamp connections used in Class 5-8 tractors, trucks, trailers and dollies and covered recommended performance, design and installation requirements for the lamp-to-connector interface system.

The RP specifically covers lamp connections, but does not include forward-lighting devices. The task force looked at the main elements of performance, design and installation, and determined that the lamp-to-connector interface must — at a minimum — be capable of service of 10 years and/or 1,000,000 miles, meet the TMC performance requirements in SAE J2577.

Those performance requirements include:

- Environmental requirements for shock and vibration and drop testing.
- Water submersion
- Power wash
- Engagement and disengagement forces
- Corrosion requirements
- Current cycling
- Ultraviolet resistance
- Exposure to all vehicle truck fluids

The design of the connector must follow that of SAE J2577. Lamp location, environmental exposure and mounting requirements must be reviewed as part of the basis for determining how the connection system will interface to the lamp. As new lighting technologies are developed, this RP will be reviewed and reevaluated to determine the appropriate connection system to incorporate into the vehicle.

SAE J2577 includes the criteria for "corrosion resistant" from SAE J1455 that requires connectors to be resistant to a specific concentration of fluids. (See **Table 1-3.**)

Testing Procedures for J2577

Testing procedures for J2577 begin with an initial visual inspection on seals, wire insulation, raised lettering, latching mechanism, plastic housing, etc. The next step is to subject one mated assembly to each fluid in the list below in **Table 1-3** to an elevated ambient condition for one hour; then submerge mated assembly in a fluid for 30 minutes (gasoline, diesel fuel, ethanol, oil/diesel mix fluids soak at 23°C) (automatic transmission fluid, engine oils, brake fluid, coolants, and wiper fluids soak at 50°C). After 30 minutes, the procedure is to soak, remove samples and place inside a fume hood for five days at 23°C.

For seal performance, it requires performing a visual inspection after five days. Inspection for seal swelling, insulation swelling, lettering deformation, plastic deformation and discoloration. Then, the test administrator carefully removes the single wire lead and replaces it with plastic tubing, watching the overall diameter of the insulated wire lead. Next, the mated assembly is immersed in clean tap water at a maximum depth of 210mm. An application of four psi of compressed air is made through the plastic tube and the administrator looks for any bubbles after 10 seconds.

The connector is visually examined for corrosion which could affect the performance of the connector. If corrosion is found, other tests are repeated to determine compliance with these requirements. If the requirements are not met, the corrosion shall constitute a failure. There shall be no evidence of cracking, warping, discoloration, corrosion or other damage which would be detrimental to normal operation of the connector.

SECTION II: CORROSION CONDITIONS

The following photographs and explanations depict common premature corrosion-related failures and their causes that may shorten the anticipated service life of a component or vehicle. This section is designed to be a reference source and training aid to assist users in corrosion identification, cause and correction. This section is not designed to be the sole basis on which to base warranty claims and repair practices.

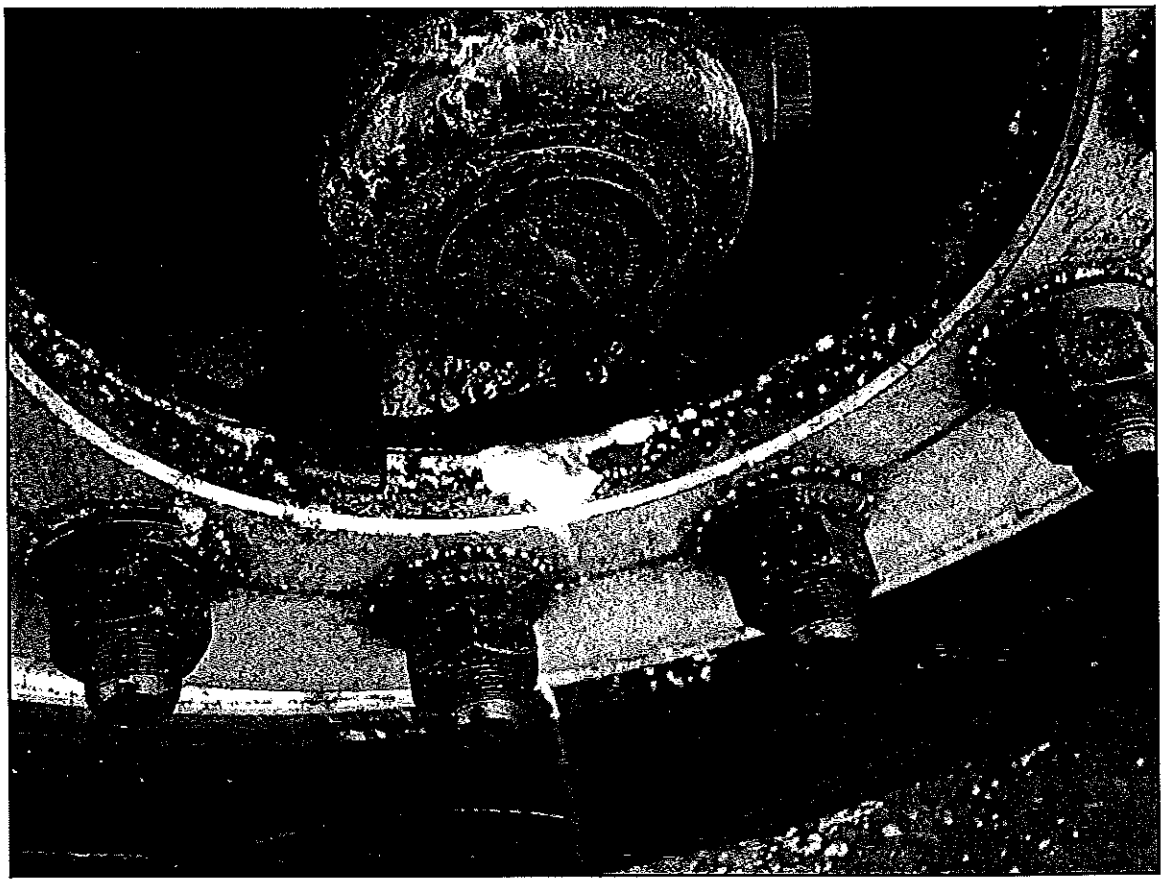
DEICER RESIDUE ON VEHICLE COMPONENTS

APPEARANCE

White, chalky substance covering various components within the corrosion "hot" zone of the vehicle (up to three feet from the road surface).

PROBABLE CAUSE

Snow/ice-removal chemicals such as magnesium chloride, calcium chloride, etc. adhering tenaciously to surface areas.



VMRS SYSTEM CODE (CODE KEY 31): 999

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT

Wash components thoroughly. Look for signs of corrosion on affected areas and not-so-obvious areas such as electrical connectors, sensors, wiring harnesses, etc.

VEHICLE

Inspect other areas in the "hot zone" of the vehicle where these chemicals may have coated components.

OPERATIONS

Consider spec'ing options aimed at preventing corrosion. Also review truck washing and cleaning guidelines.

CORROSION AT REAR OF TRACTOR CAB

APPEARANCE

Salt spray deposits on the surface coating at the rear of the tractor cab/sleeper unit. May be severe enough to compromise coating integrity. In this case, corrosion also appears on the surface of the exhaust stack supporting bracket near the rear of the cab.

PROBABLE CAUSE

Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment.

VMRS SYSTEM CODE (CODE KEY 31): 002

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT

Clean and remove salt spray deposits from surfaces. Inspect for severity of corrosion. Repair and replace as necessary.

VEHICLE

Inspect surrounding components (such as electrical and pneumatic connections) for corrosion related damage.

OPERATIONS

Review specifications for opportunities for better corrosion control. Review truck washing practices to remove deicing chemicals. Consider coatings/treatments that disrupt the corrosion forming process.

CORROSION — EXTERIOR VEHICLE FUSE

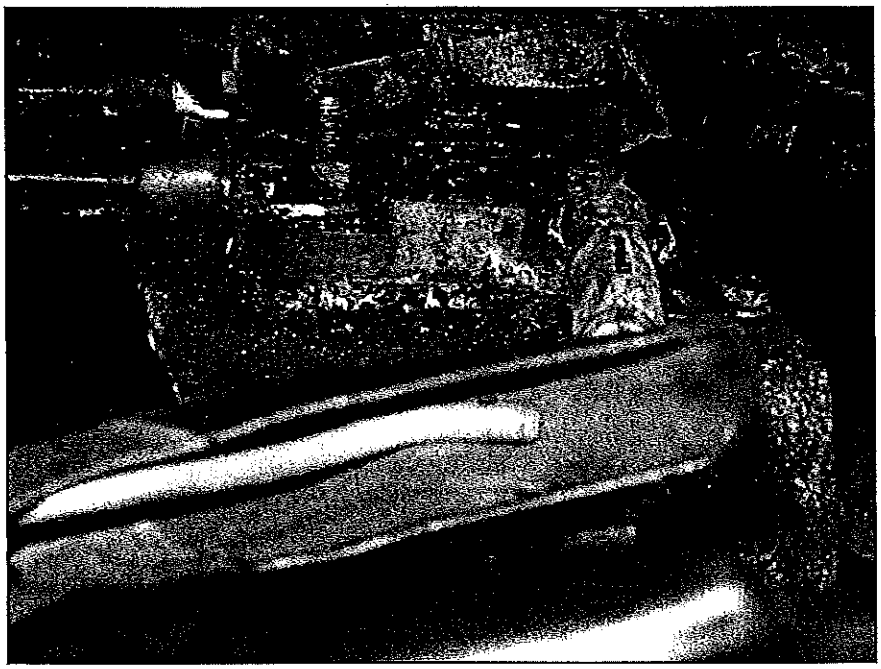
VMRS SYSTEM CODE (CODE KEY 31):

034

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

APPEARANCE	Abrasive wear, pitting and corrosion on exterior vehicle fuse (mega-fuse) surface. Low cab voltage is the complaint.
PROBABLE CAUSE	Corroded ring terminal, connections at the main vehicle fuse. Corrosion can be caused by operating in corrosive environments, prolonged use, lack of proper maintenance, inadequate dielectric grease applied and corrosive washes used to clean vehicles.



ACTION

COMPONENT	Attempt to clean. If corrosion is severe, replace both male and female connectors and cabling. Be sure to apply quality dielectric grease at both ends.
VEHICLE	Consider replacing fuse holder with different style to increase distance to mounting bracket or relocate fuse to protected area.
OPERATIONS	Consider service program to clean all starter/relay connections and renew corrosion inhibitor material every six months.

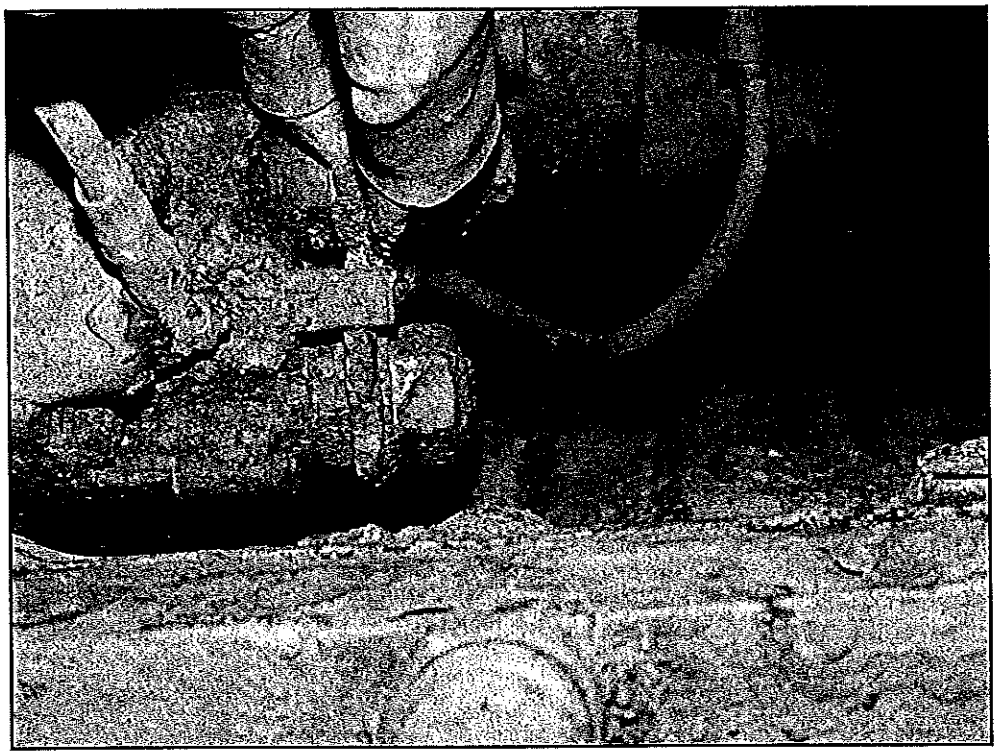
CORROSION — STARTER MOTOR CONNECTIONS

APPEARANCE

Starter motor connections appear corroded. Complaint is poor cranking.

PROBABLE CAUSE

Corroded starter connections cause high voltage drop in starting circuit. Corrosion can be caused by operating in corrosive environments, prolonged use, lack of proper maintenance, inadequate dielectric grease applied and corrosive washes used to clean vehicles.



VMRS SYSTEM CODE (CODE KEY 31): 034

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT

Attempt to clean connector. If corrosion is severe, replace both male and female connectors and cabling. Be sure to apply quality dielectric grease at both ends.

VEHICLE

Inspect wiring harness and nearby grounds for corrosion. Keep connectors secured tightly.

OPERATIONS

Consider service program to clean all starter connections and renew corrosion inhibitor material every six months.

CORROSION — STARTER SOLENOID/RELAY

ELECTRICAL—CORROSION CONDITIONS

VMRS SYSTEM CODE (CODE KEY 31):

032

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

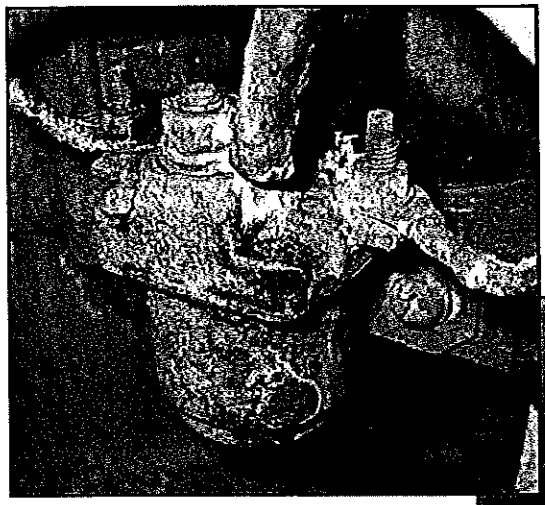
35

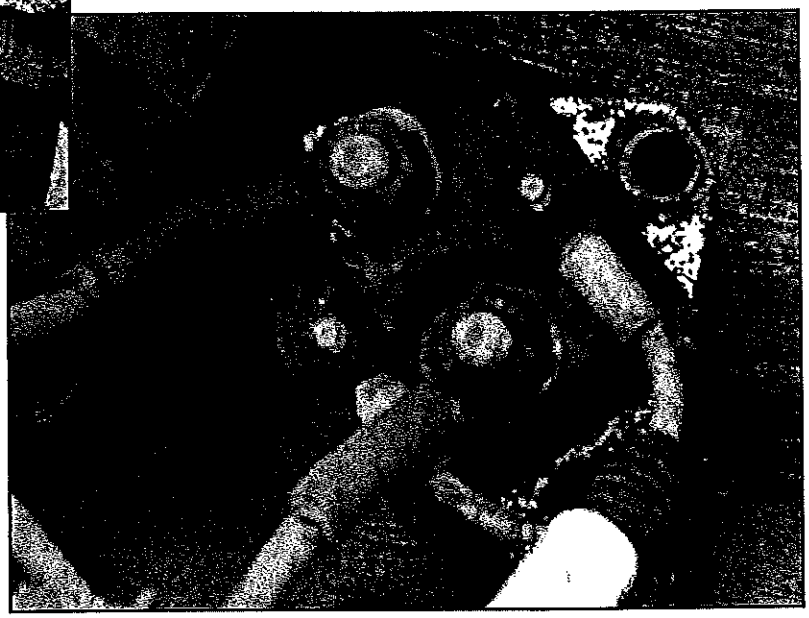
APPEARANCE

Abrasive wear, pitting and corrosion on relay/solenoid surface. No cranking, relay will not engage.

PROBABLE CAUSE

Corroded relay connections cause high resistance of the control circuit (practically an open circuit). Corrosion can be caused by operating in corrosive environments, prolonged use, lack of proper maintenance, inadequate dielectric grease applied and corrosive washes used to clean vehicles.





ACTION

COMPONENT

Attempt to clean. If corrosion is severe, replace both male and female connectors and cabling. Be sure to apply quality dielectric grease at both ends.

VEHICLE

Inspect wiring harness and nearby grounds for corrosion. Keep connectors secured tightly.

OPERATIONS

Consider service program to clean all starter/relay/solenoid connections and renew corrosion inhibitor material every six months.

CORROSION — 7-PIN CONNECTOR

VMRS SYSTEM CODE (CODE KEY 31):
034

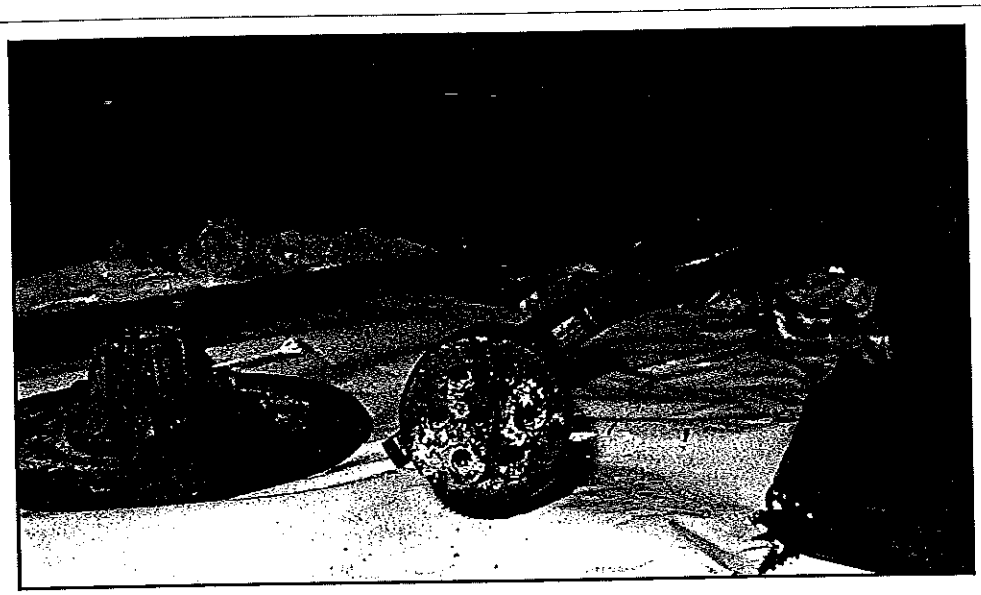
VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):
35

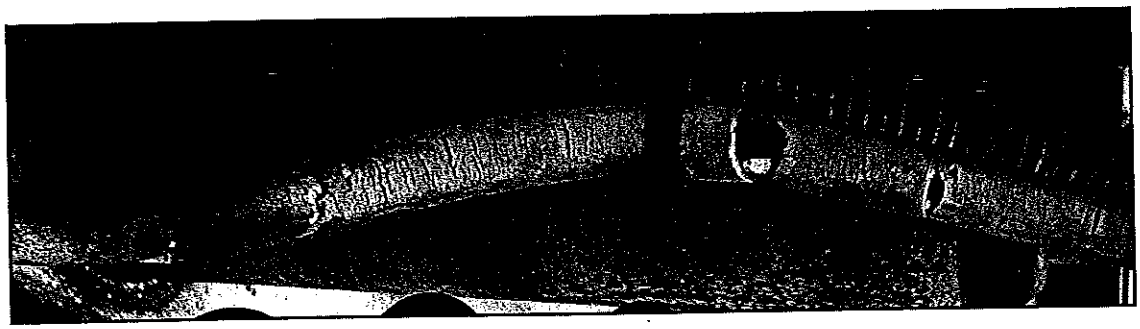
APPEARANCE

Seven-pin connector appears corroded. Trailer lights not operative. Power cord may also be compromised.

PROBABLE CAUSE

Operating in corrosive environments, prolonged use, lack of proper maintenance, inadequate dielectric grease applied and corrosive washes used to clean vehicles.





ACTION

COMPONENT

Attempt to clean connector. If corrosion is severe, replace both male and female connectors and cabling. Be sure to apply quality dielectric grease at both ends.

VEHICLE

Keep connectors secured tightly.

OPERATIONS

None.

CORROSION — TAIL LIGHT

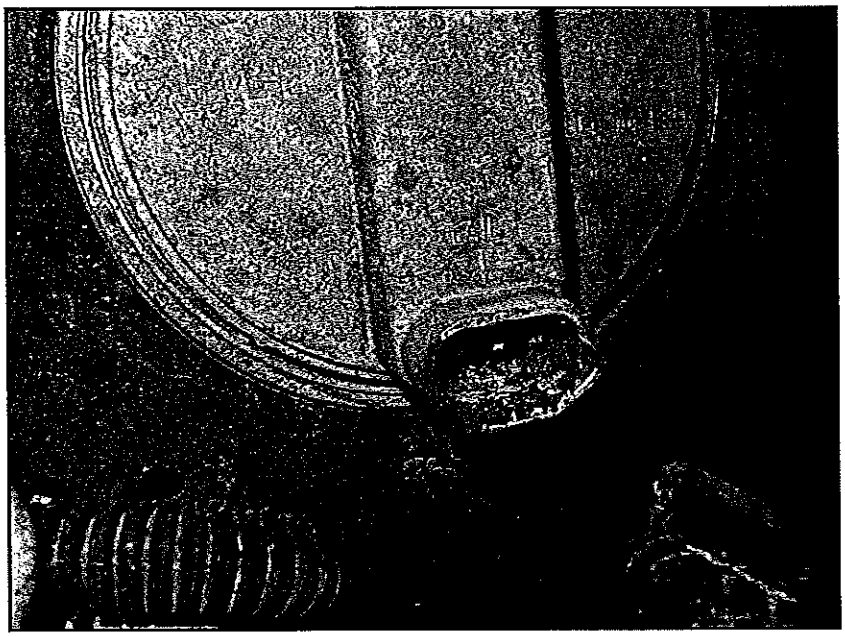
APPEARANCE	Tail light connector appears corroded. Tail light not operative.
PROBABLE CAUSE	Seal of tail light assembly broken by being hit/struck. Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment.

VMRS SYSTEM CODE (CODE KEY 31):

034

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

05



ACTION

COMPONENT	Replace bad components and shield unit against future damage. Consider use of dielectric grease at tail light connector to help prevent corrosion.
VEHICLE	Inspect for corrosion in nearly wiring harness and vehicle ground(s).
OPERATIONS	None.

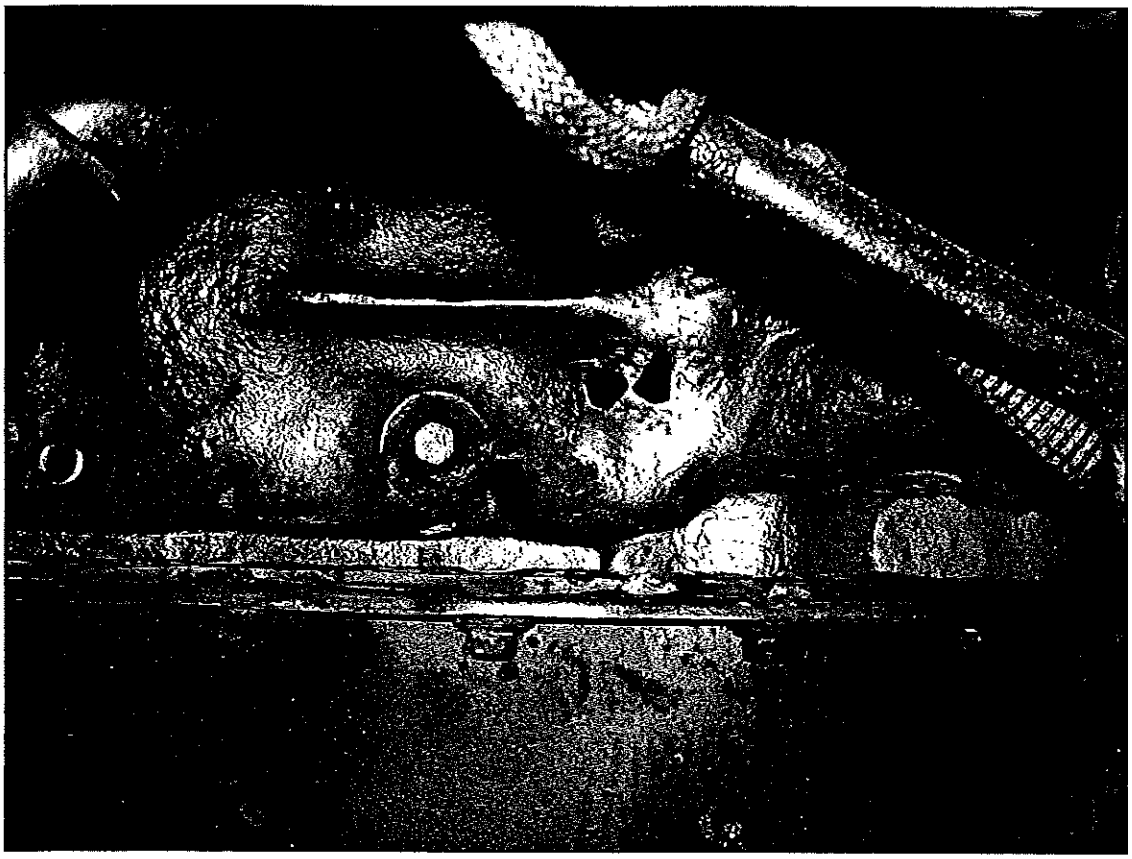
CORROSION ON ENGINE BLOCK

APPEARANCE

Premature corrosion of the engine block, resulting in complete rust through of the component.

PROBABLE CAUSE

Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment.



VMRS SYSTEM CODE (CODE KEY 31):
045

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):
35

ACTION

COMPONENT

Follow manufacturer recommendations for repair and/or replacement.

VEHICLE

Inspect other areas in the "hot zone" of the vehicle where corrosion may also have occurred.

OPERATIONS

Consider spec'ing options aimed at preventing corrosion. Also review truck washing and cleaning guidelines.

CORROSION — FUEL TANK

ENGINE—CORROSION CONDITIONS

VMRS SYSTEM CODE (CODE KEY 31): 044

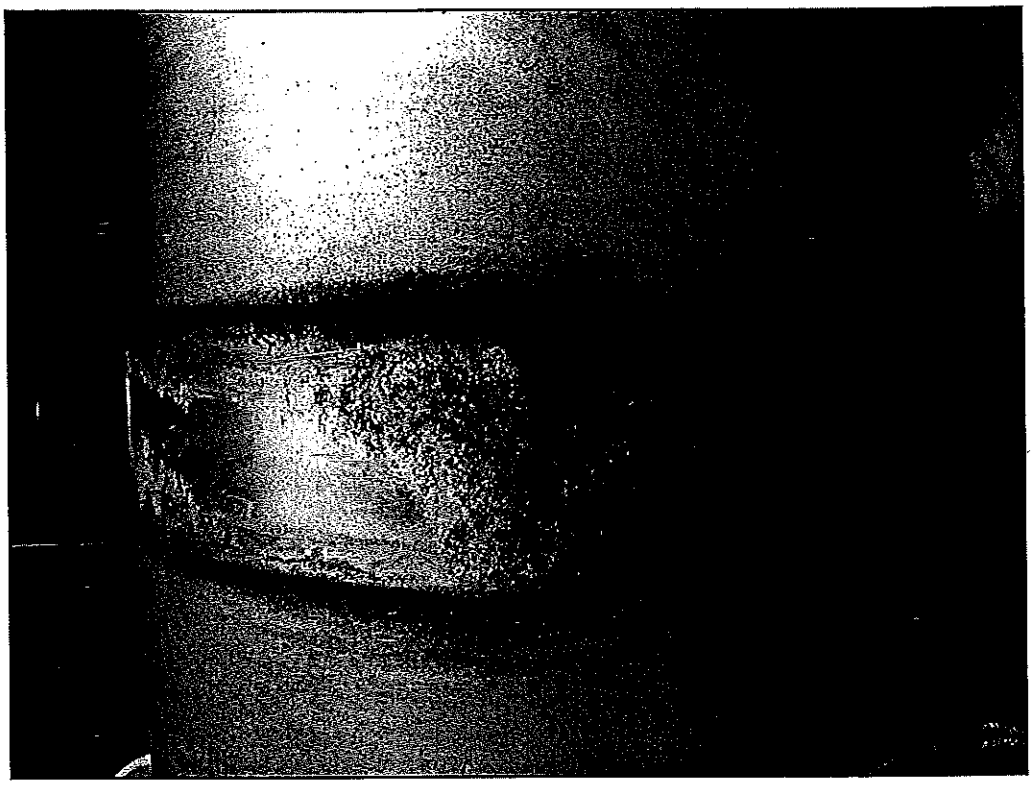
VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

APPEARANCE

Corrosion on an aluminum or steel fuel tank, often originating under the mounting strap. May be severe enough to compromise tank integrity.

PROBABLE CAUSE

Caused by dissimilar metals being in close proximity. Anti-icing/deicing chemicals may aggravate/accelerate this condition. Also, operation in salt-water/coastal environment.



ACTION

COMPONENT

Inspect for severity of corrosion. Repair and replace as necessary.

VEHICLE

Inspect nearby components for collateral damage.

OPERATIONS

Review fuel tank specifications for opportunities for better corrosion control. Avoid use of dissimilar metals in this type of application. Review truck washing practices to remove deicing chemicals.

CORROSION — MUFFLER

APPEARANCE	Corrosion on an muffler/exhaust system, often originating under the mounting strap. May be severe enough to compromise component integrity.
PROBABLE CAUSE	Caused by dissimilar metals being in close proximity. Anti-icing/deicing chemicals may aggravate/accelerate this condition. Also, operation in salt-water/coastal environment.

VMRS SYSTEM CODE (CODE KEY 31): 043

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT	Inspect for severity of corrosion. Repair and replace as necessary.
VEHICLE	Inspect nearby components for collateral damage.
OPERATIONS	Review specifications for opportunities for better corrosion control. Avoid use of dissimilar metals in this type of application. Review truck washing practices to remove deicing chemicals.

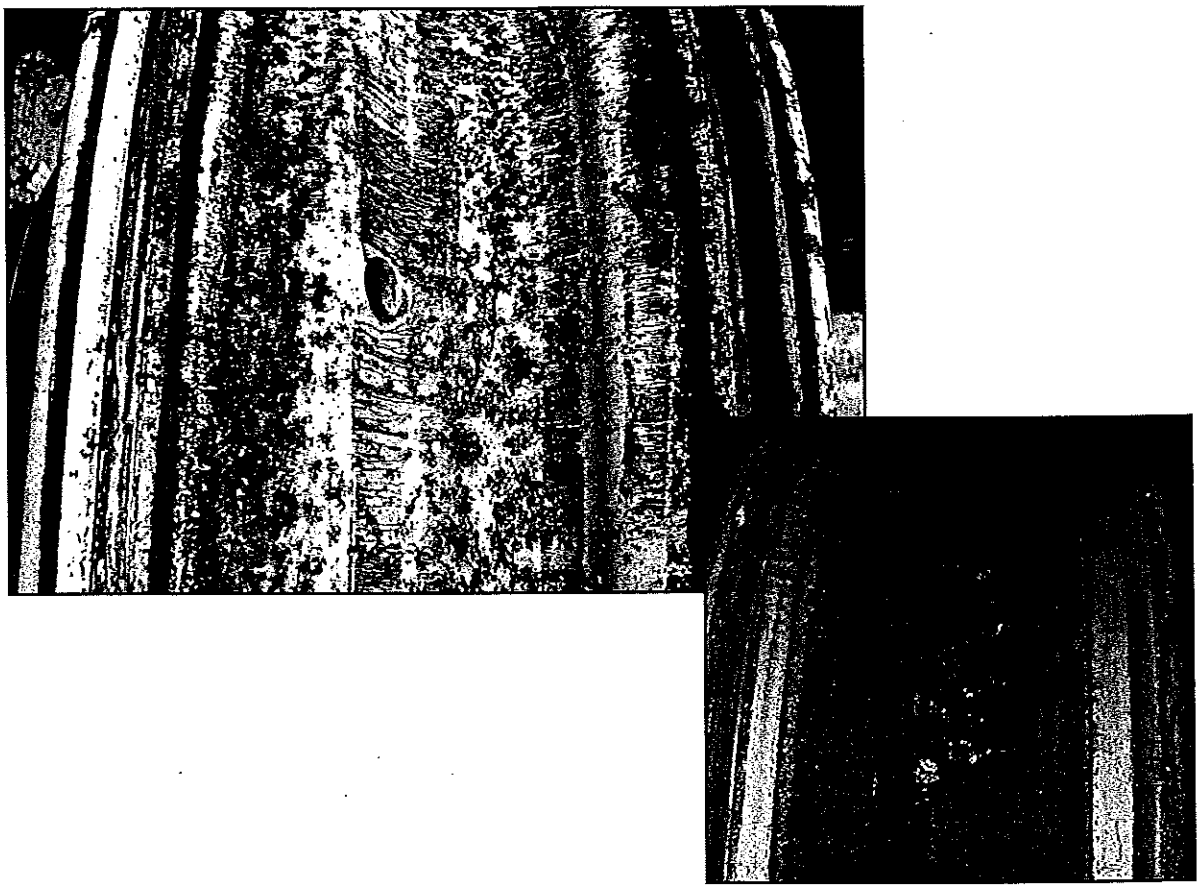
CORROSION ON THE TIRE SIDE OF RIM

APPEARANCE

Corroded, pitting or flaking areas on the tire side of the rim.

PROBABLE CAUSE

Excessive air line moisture, unsuitable lubricants or liquids in a tubeless tire assembly. Foreign materials in the tire chamber may create or aggravate this condition if moisture is present.



VMRS SYSTEM CODE (CODE KEY 31): 018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

WHEEL

If excessive pitting exists due to corrosion, remove from service and scrap. Clean the tire side of rim and inspect for cracks (steel wheels should be refinished). If desired, apply corrosion inhibitor to help avoid further corrosion.

VEHICLE

Use properly maintained dryers on air supply lines and drain regularly. Use tire lubricants that meet TMC RP 205B, *Tire Bead Lubricants*, and if additives are used, ensure they are noncorrosive and contain rust inhibitors.

OPERATIONS

None.

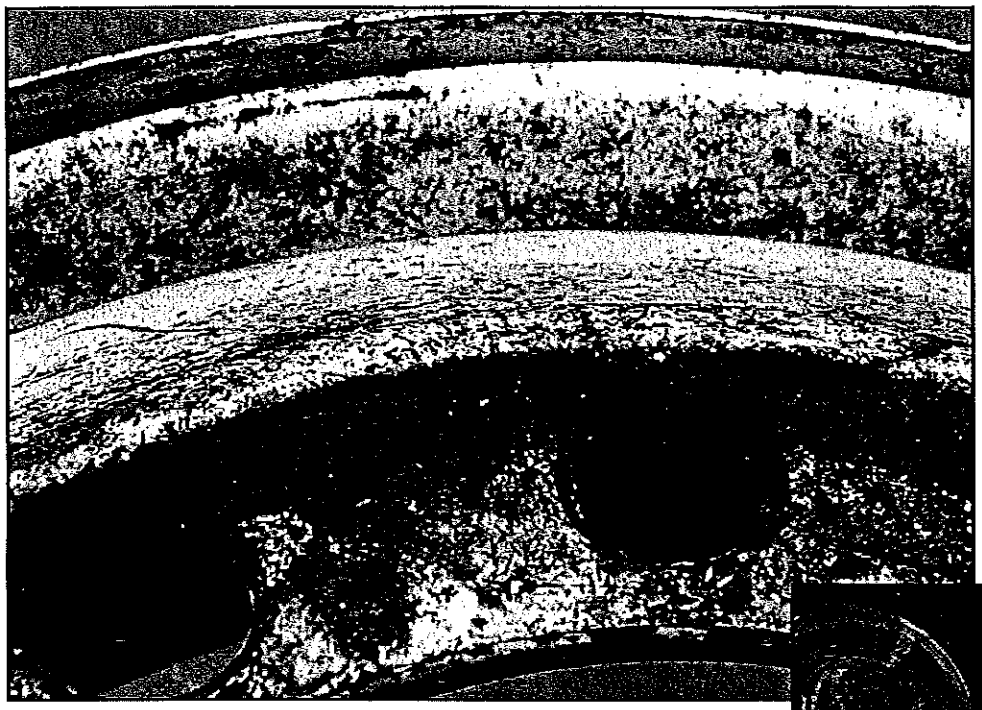
EXCESSIVE WEAR/CORROSION OF DISC FACE

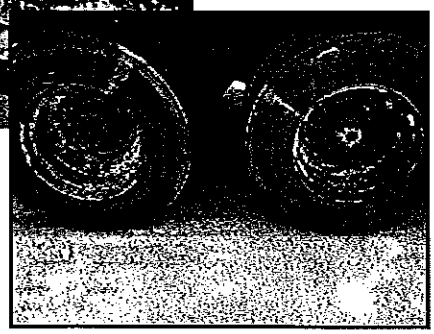
APPEARANCE

Abrasive wear, pitting and corrosion on disc mounting surface.

PROBABLE CAUSE

Insufficient refinishing of mating surfaces prior to installation, insufficient hub or drum backup, or worn mating surfaces. Corrosive or abrasive environments, overloading, and not cleaning the mounting surfaces prior to wheel installation also aggravate this condition.





VMRS SYSTEM CODE (CODE KEY 31):

018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

ACTION

WHEEL

Remove from service and scrap.

VEHICLE

Refinish wheel or clean mating surfaces prior to installation. Review service application of the wheel.

OPERATIONS

Check mating surfaces of hub or drum backup for wear or corrosion. Consider using wheel separators designed to control corrosion and wear.

CORROSION IN THE GUTTER AREA OF A TUBE-TYPE RIM BASE

WHEEL/RIM — CORROSION CONDITIONS

VMRS SYSTEM CODE (CODE KEY 31): 018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

APPEARANCE

Corroded. pitting or flaking areas in the rim gutter.

PROBABLE CAUSE

Water, mud, salt accumulation in the rim gutter of a tube-type rim base; extended use/age.

ACTION

RIM	Remove from service and scrap.
VEHICLE	Keep rim gutter area free of dirt accumulation or rust buildup. Clean the tire side of the rim and inspect for cracks; paint as necessary following manufacturers' recommendations.
OPERATIONS	None.

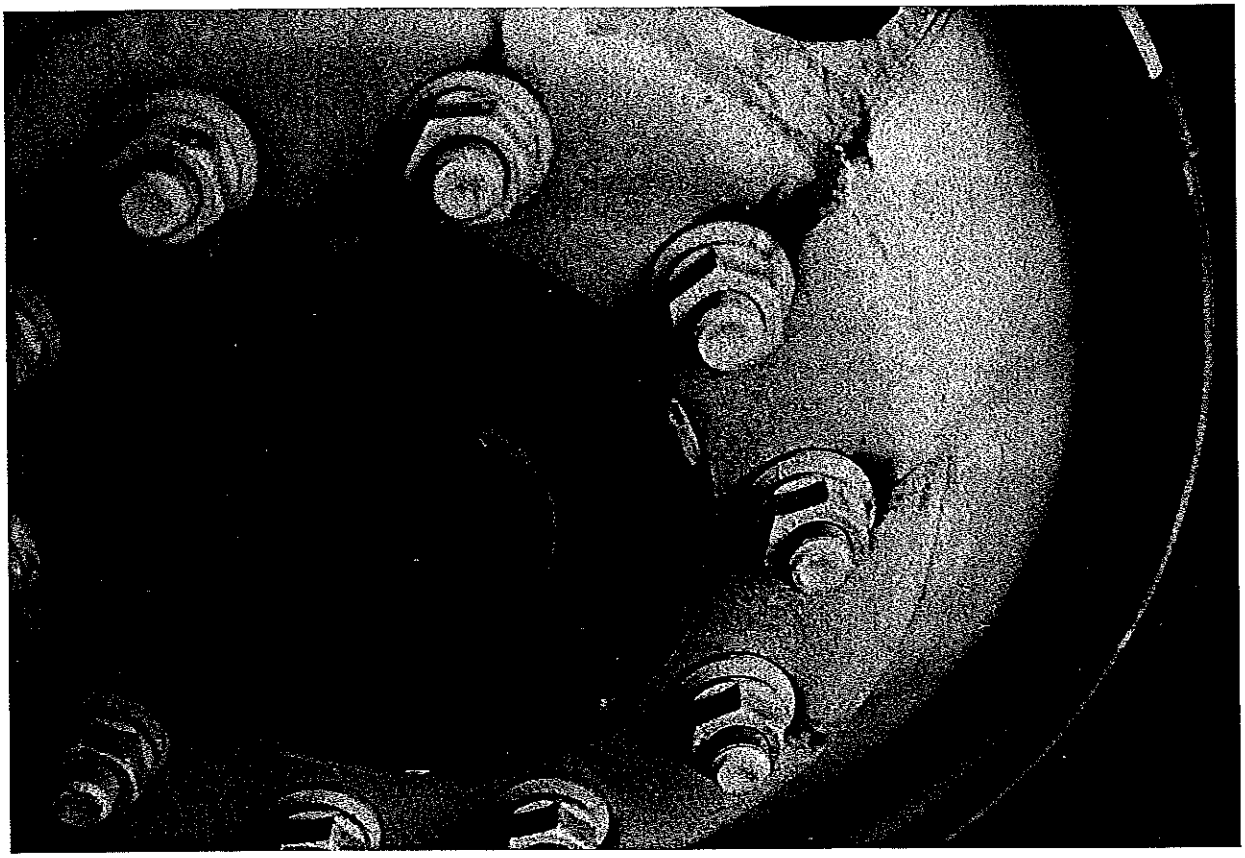
CORROSION STREAKS FROM BOLTHOLES

APPEARANCE

Rust streaks extending from the boltholes.

PROBABLE CAUSE

Rust streaks usually indicate either worn, poor quality, or loose wheel nuts.



VMRS SYSTEM CODE (CODE KEY 31): 018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT

Make sure the correct nuts for the wheel system are being used. Inspect wheel boltholes for wear or damage, then remove rust streaks.

VEHICLE

None.

OPERATIONS

Review parts replacement practices for correct specification.

CORROSION — NUT AND STUD

FASTENERS—CORROSION CONDITIONS

VMRS SYSTEM CODE (CODE KEY 31): 018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

APPEARANCE	Evidence of rust and scale on fastener.
PROBABLE CAUSE	Operating in corrosive environments, prolonged use, lack of proper maintenance, inadequate coating during manufacturing, and corrosive washes used to clean vehicles.

ACTION

FASTENERS	Scrap the fastener.
VEHICLE	Wire brush studs at every installation. Inspect fasteners and replace as necessary. Use recommended installation procedures.
OPERATIONS	None.

HUB CORROSION ON DRUM PILOT

APPEARANCE

Corrosion or debris buildup in corner of hub at drum pilot.

PROBABLE CAUSE

Galvanic corrosion, improper hub maintenance procedures. Corrosion buildup between hubs and cast drums prevent drums from properly seating against the hub flange.

POTENTIAL EFFECT

Drum may become cocked, bent or cracked, loose wheels, dragging brakes.

VMRS SYSTEM CODE (CODE KEY 31):

018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

ACTION

HUB/DRUM

Check for cracks in hub and drum face and replace if necessary.

VEHICLE

Inspection should be performed every time the brake drum is removed.

OPERATIONS

Remove rust and corrosion buildup from hub according to hub manufacturer's recommendations.

CORROSION — BRAKE VALVE

VMRS SYSTEM CODE (CODE KEY 31): 013

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

APPEARANCE

Corrosion on/in a pneumatic brake valve. May be severe enough to compromise component integrity.

PROBABLE CAUSE

Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment.

ACTION

COMPONENT

Inspect for severity of corrosion. Repair and replace as necessary.

VEHICLE

Inspect nearby components for collateral damage.

OPERATIONS

Review specifications for opportunities for better corrosion control. Avoid use of dissimilar metals in this type of application. Review truck washing practices to remove deicing chemicals.

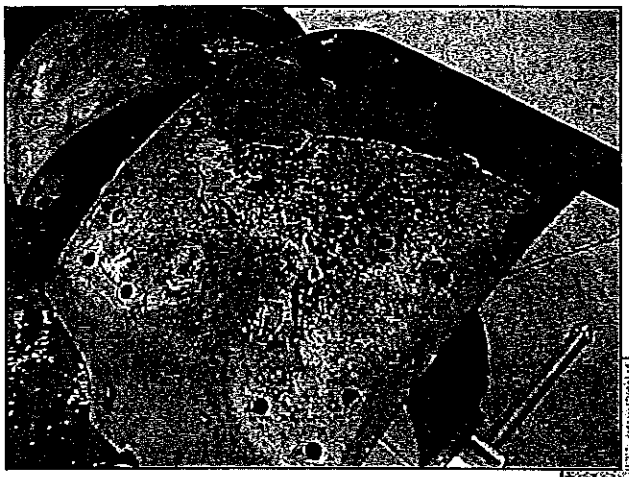
RUST JACKING

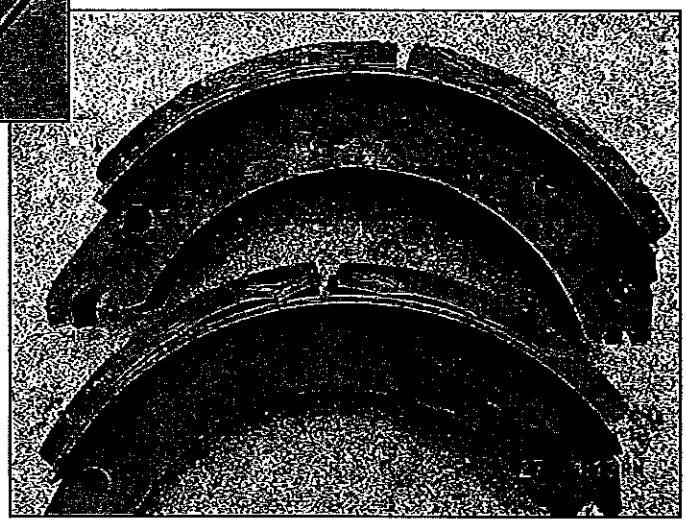
APPEARANCE

Defined as rust forming between lining and shoe. Progression of rust can lift lining from the shoe, resulting in cracks or splits in lining material. When severe, lining moves freely on brake shoe, breaks apart, and falls off shoe.

PROBABLE CAUSE

Can be caused by snow/ice-removal chemicals such as magnesium chloride. Also, operation in salt-water/coastal environment. Other causes are not related to deicer/anti-icing chemicals, such as brake shoe out of specification, imperfections in the brake lining, drum out of specification. Improper assembly of lining to shoe, and overheated brakes.





VMRS SYSTEM CODE (CODE KEY 31): 013

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT

Remove and replace brake shoes. See TMC RP 627A, *Brake Lining Structural Defects* for additional guidelines and recommendations.

VEHICLE

Inspect foundation brake, electrical system, and other systems within the "hot zone" of the vehicle for signs of other component failures.

OPERATIONS

Review brake specifications. Consider spec'ing options aimed at preventing corrosion. Also review truck washing and cleaning guidelines.

CORROSION — GLADHAND AND SEAL

BRAKES—CORROSION CONDITIONS

VMRS SYSTEM CODE (CODE KEY 31):
013

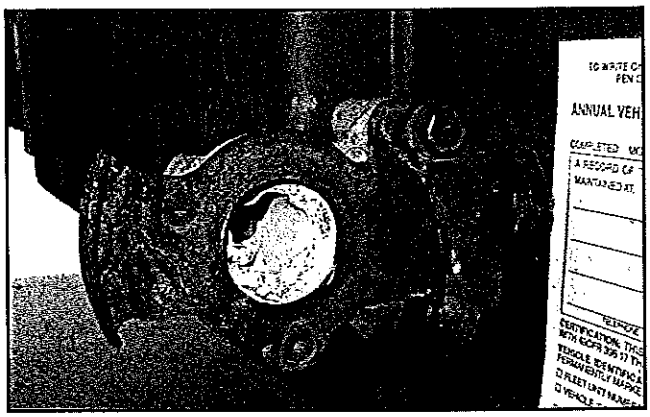
VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):
35

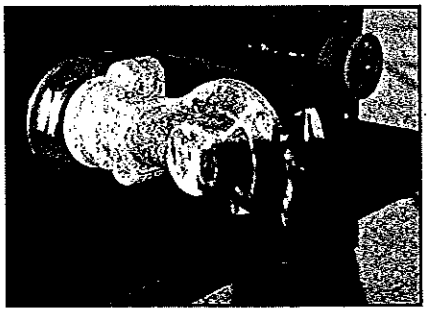
APPEARANCE

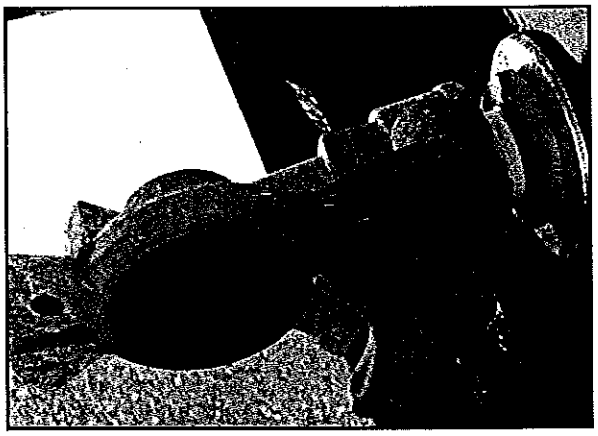
Corroded, pitting or flaking on the gladhand seal, causing the gladhand not to seal properly. Gladhand striker plate, post or body may also be corroded.

PROBABLE CAUSE

Operating in corrosive environment; inadequate maintenance to address corrosion.







ACTION

COMPONENT

Replace defective component with corrosion-resistant gladhand. Review gladhand inspection and maintenance practices.

VEHICLE

None.

OPERATIONS

None.

CORROSION — SPRING BRAKE CHAMBER

APPEARANCE	Complaint of air leak. Air spring housing appears rusty.
PROBABLE CAUSE	Top air spring brake chamber housing rusted though. Operating in corrosive environments, prolonged use, lack of proper maintenance, and corrosive washes used to clean vehicles.

VMRS SYSTEM CODE (CODE KEY 31):

018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

ACTION

COMPONENT	Replace air spring chamber. Before installation, spray with quality rust inhibitor and/or paint/coating.
VEHICLE	None.
OPERATIONS	None.

CORROSION — BRAKE ROTOR

VMRS SYSTEM CODE (CODE KEY 31):

013

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

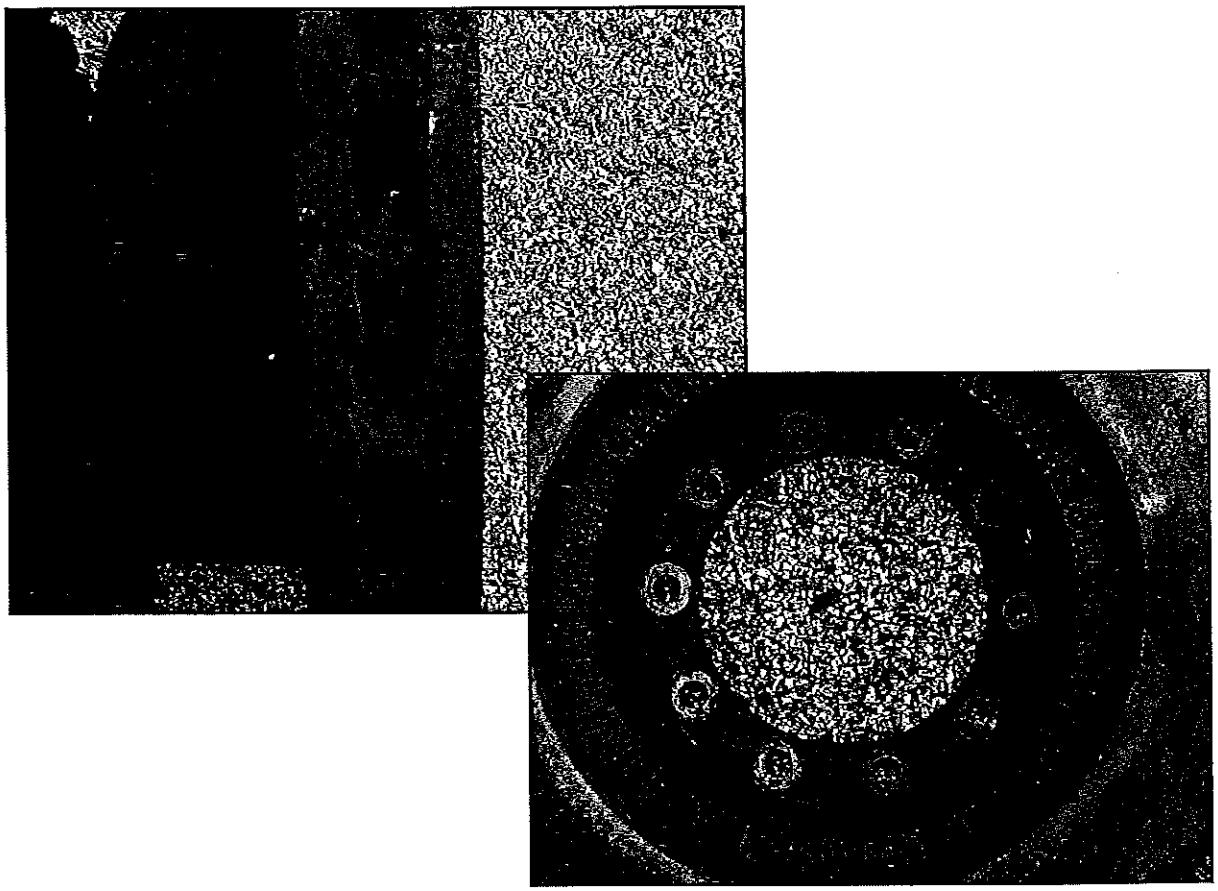
35

APPEARANCE

Corrosion on the surface of the brake rotor, the cooling fins and bolt holes. Flaking and loss of metal also could be evident.

PROBABLE CAUSE

Caused by operating in corrosive environment; inadequate maintenance to address corrosion. Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment.



ACTION

COMPONENT	Replace defective component.
VEHICLE	None.
OPERATIONS	None.

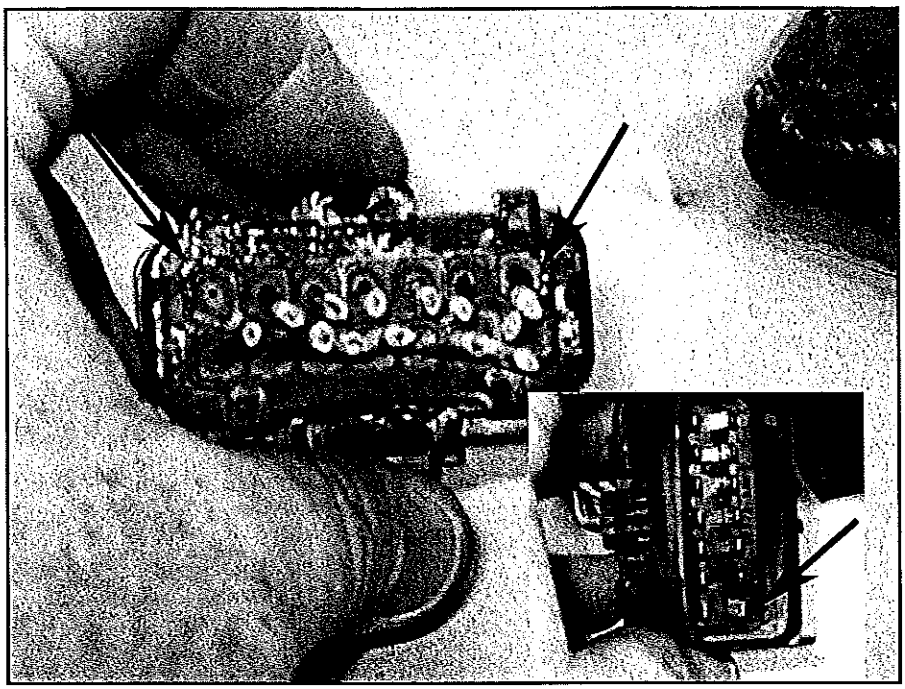
CORROSION — CHASSIS CONNECTOR (ABS)

APPEARANCE

Complaint began with low voltage on antilock braking system (ABS) wheel speed sensor. Connector shows signs of corrosion.

PROBABLE CAUSE

Corroded terminal in the sealed connector located between front and rear chassis harnesses. Water penetration due to damaged wire seal and missed cavity plug.



VMRS SYSTEM CODE (CODE KEY 31):

018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

ACTION

COMPONENT

Replace connector and damaged terminals. Ensure all empty cavities in the connector are plugged.

VEHICLE

Correct routing and clipping to prevent wires from deforming the wire seal.

OPERATIONS

None.

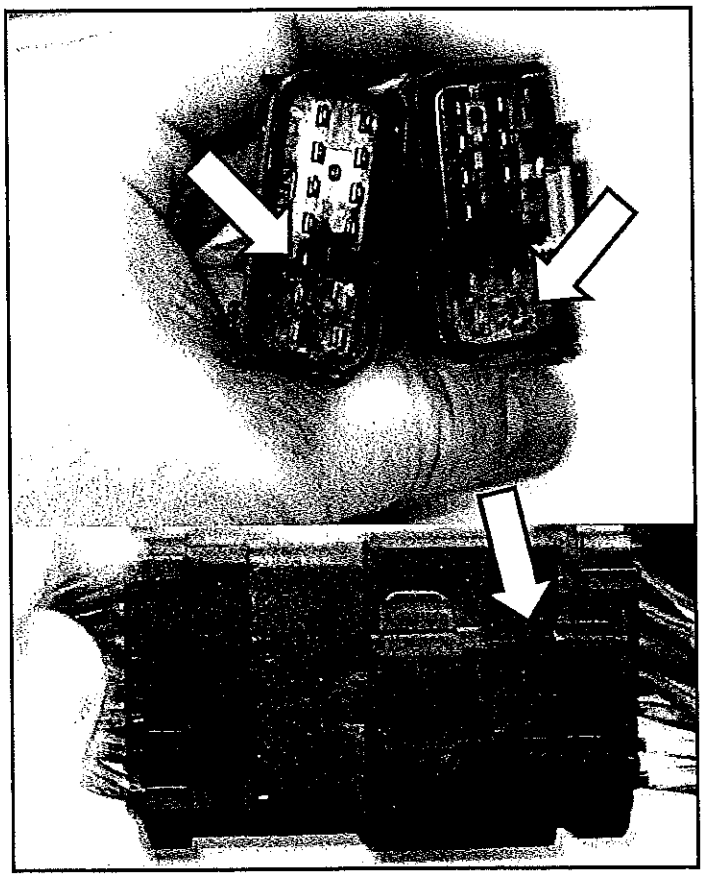
CORROSION — CHASSIS CONNECTOR (LIGHTING)

APPEARANCE

Complaint began with loss of tail light function. Corrosion is apparent at the chassis inline connector.

PROBABLE CAUSE

Corroded terminal in the sealed connector located between the front and rear chassis harnesses. Water penetration due to damaged connector seal. Connector was improperly reassembled and cleaned after previous disconnection (for other reasons).



VMRS SYSTEM CODE (CODE KEY 31):

013

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

ACTION

COMPONENT

Replace connector seal and damaged terminals. Review cleaning and assembly instructions for chassis connectors. Clean all connector seals and interface areas with cotton swab and dielectric grease as approved by connector supplier.

VEHICLE

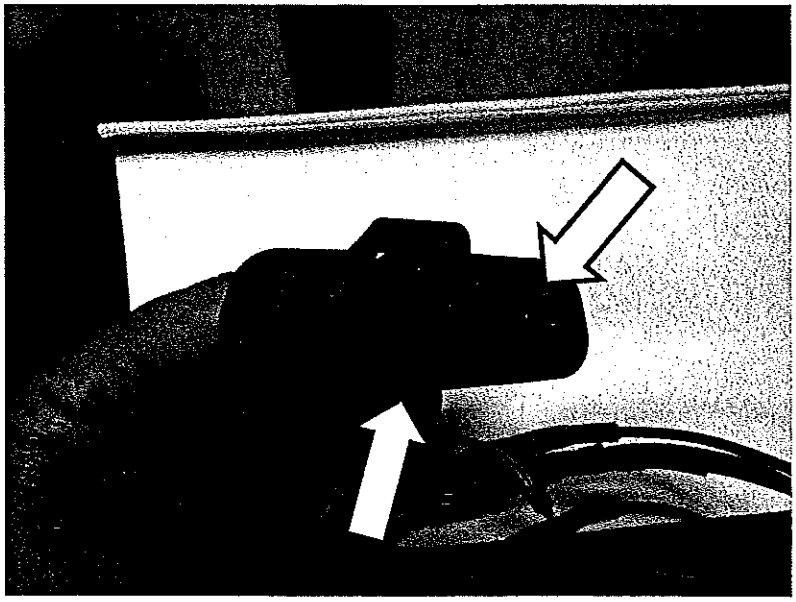
None.

OPERATIONS

None.

CORROSION — CHASSIS CONNECTOR (GENERAL)

APPEARANCE	Complaint began with loss of various electrical-related functions. Chassis connector shows signs of corrosion.
PROBABLE CAUSE	Connector lost sealing due to unexpected deformation for this specific type/family of connector.



VMRS SYSTEM CODE (CODE KEY 31): 018

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT	Replace connector. Check with manufacturer to see if updated connector design is available to prevent recurrence.
VEHICLE	None.
OPERATIONS	None.

CORROSION — AIR SUPPLY TANK

VMRS SYSTEM CODE (CODE KEY 31): 013

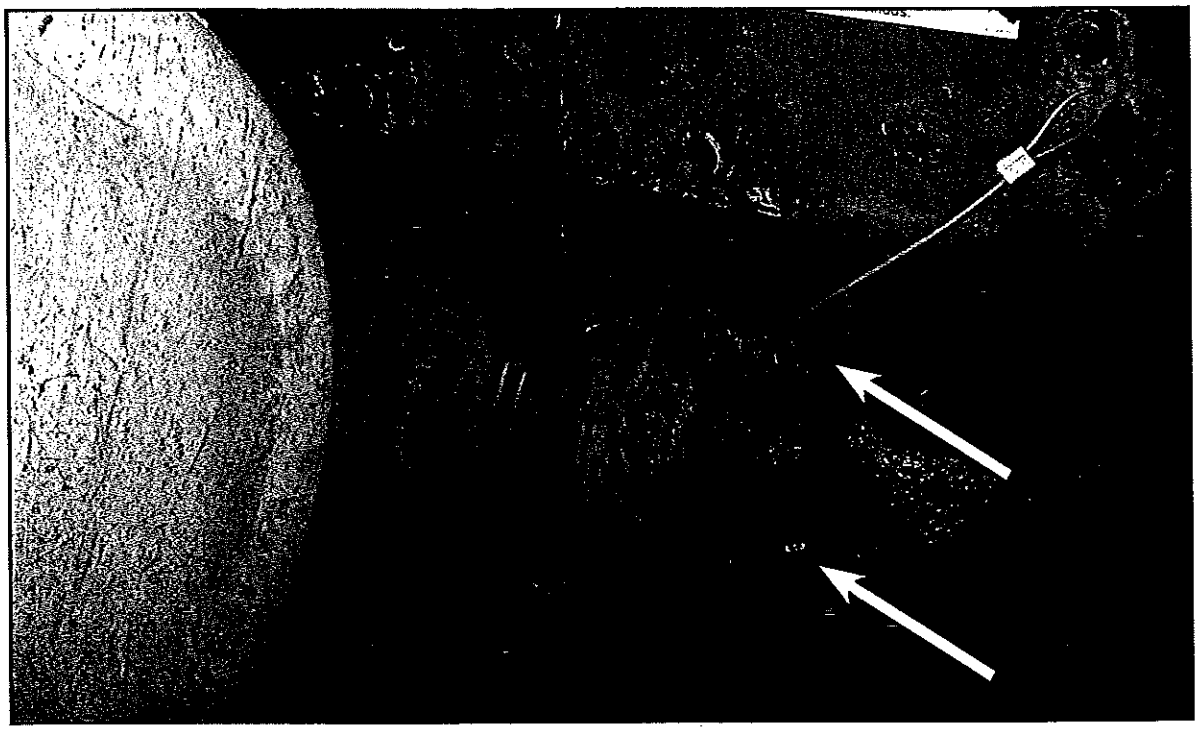
VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

APPEARANCE

Corrosion on/in a pneumatic system supply tank. May be severe enough to compromise component integrity; for example, drain valve may be corroded to the point that the valve either does not open and close or leaks. Tank fittings may also leak.

PROBABLE CAUSE

Caused by dissimilar metals being in close proximity. Anti-icing/deicing chemicals may aggravate/accelerate this condition. Also, operation in salt-water/coastal environment.



ACTION

COMPONENT

Inspect for severity of corrosion. Repair and replace as necessary. Refer to TMC RP 619B, *Air System Inspection Procedure* for inspection guidelines.

VEHICLE

Inspect for air leaks and proper valve/fitting operation.

OPERATIONS

Review specifications for opportunities for better corrosion control. Avoid use of dissimilar metals in this type of application. Review truck washing practices to remove deicing chemicals. Consider coatings/treatments that disrupt the corrosion forming process.

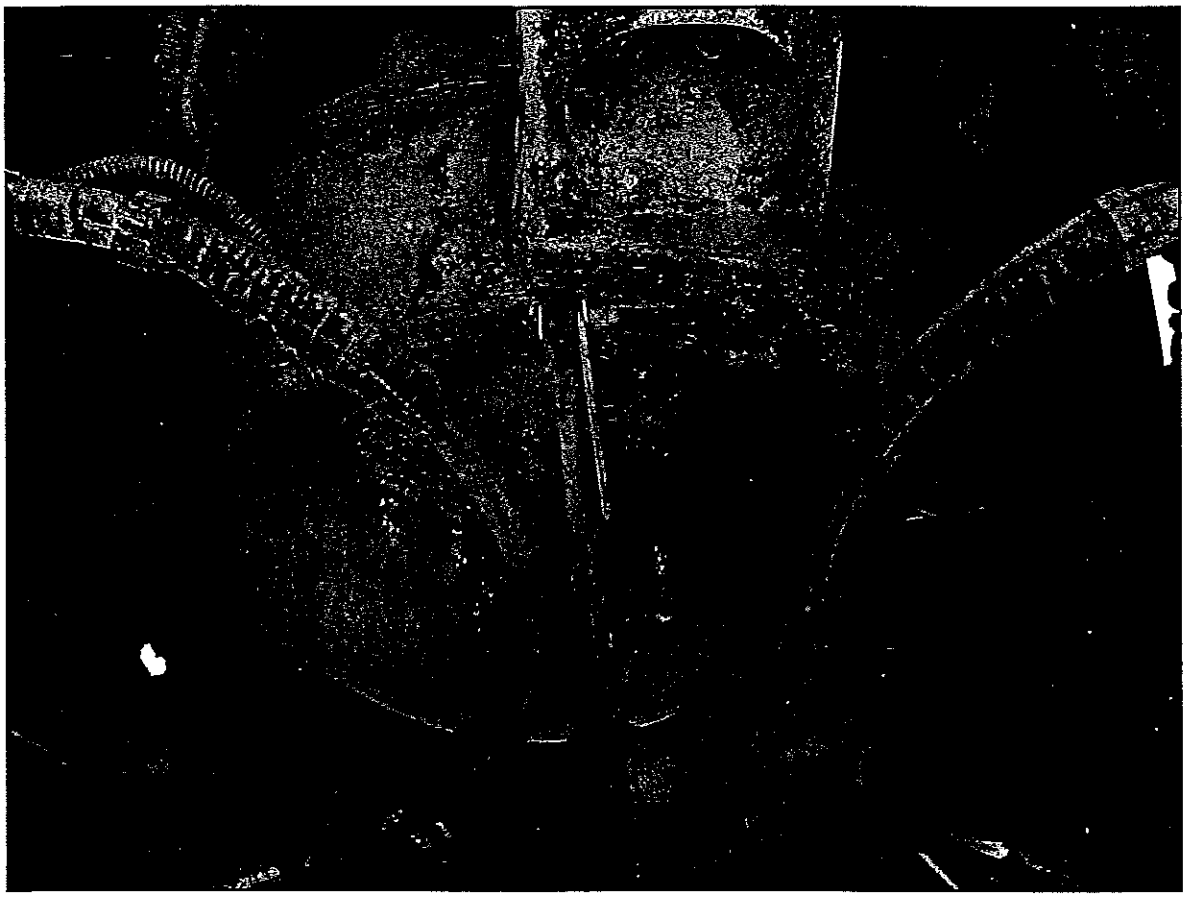
CORRODED AXLE HOUSING/RIDE HEIGHT VALVE

APPEARANCE

Corrosion on drive axle housing. May be severe enough to compromise housing structure. Corrosion also appears in this case on the ride height valve and arm.

PROBABLE CAUSE

Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment.



VMRS SYSTEM CODE (CODE KEY 31):

016, 022

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

ACTION

COMPONENT

Inspect for proper component function and severity of corrosion. Inspect ride height valve for air leaks and air system integrity. Neutralize the effects of what is causing the corrosion to prevent further spread. Repair and replace as necessary.

VEHICLE

Inspect component attachment points for signs of corrosion.

OPERATIONS

Review specifications for opportunities for better corrosion control. Review truck washing practices to remove deicing chemicals. Consider coatings/treatments that disrupt the corrosion forming process.

CORROSION — TRACTOR FRAME

CHASSIS—CORROSION CONDITIONS

VMRS SYSTEM CODE (CODE KEY 31): 014

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

APPEARANCE

Corrosion on vehicle frame at bracket attachment points. Corrosion may have spread to the fastener/frame interface. May be severe enough to compromise component integrity. Corrosion has bubbled the surface coating. Corrosion may have been covered with paint during inadequate repair.

PROBABLE CAUSE

Caused by dissimilar metals being in close proximity. Anti-icing/deicing chemicals may aggravate/accelerate this condition. Also, operation in salt-water/coastal environment.

ACTION

COMPONENT

Inspect for severity of corrosion. Neutralize the effects of what is causing the corrosion to prevent further spread. Repair and replace as necessary.

VEHICLE

Inspect nearby components for collateral damage.

OPERATIONS

Review specifications for opportunities for better corrosion control. Avoid use of dissimilar metals in this type of application. Review truck washing practices to remove deicing chemicals. Consider coatings/treatments that disrupt the corrosion forming process.

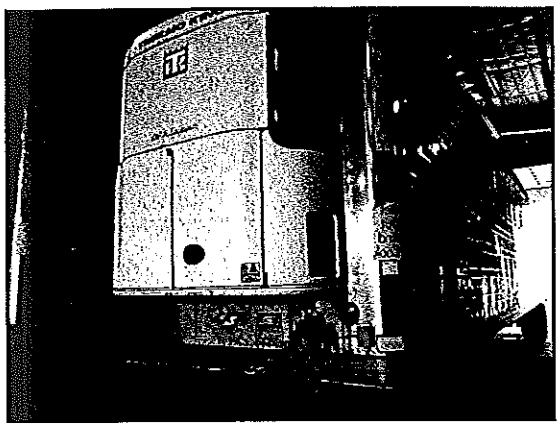
CORROSION ON REFRIGERATED TRAILER

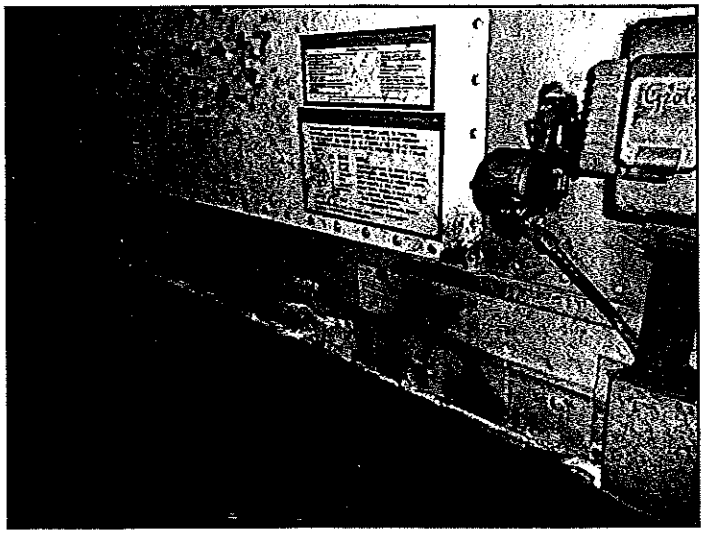
APPEARANCE

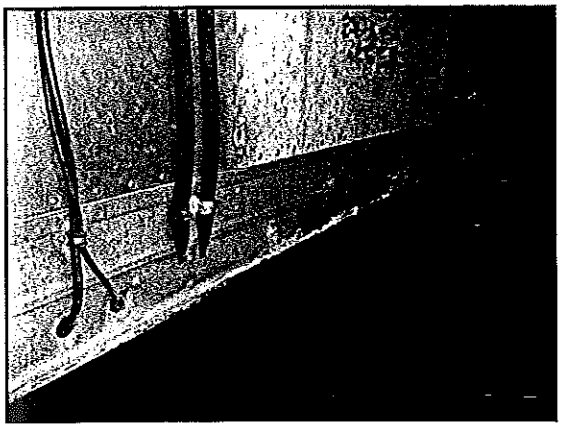
Corrosion on the trailer rub rail, body, doors, typically originating near refrigerated trailer component and related systems.

PROBABLE CAUSE

Condensation and/or water intrusion related refrigerated trailer operation, such as damage caused by leakage. Anti-icing/deicing chemicals may aggravate/accelerate this condition. Also, operation in salt-water/coastal environment.







VMRS SYSTEM CODE (CODE KEY 31):

082

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

ACTION

COMPONENT

Inspect for severity of corrosion. Repair and replace as necessary to stop leakage. Check seals, fittings and related components for the beginning stages of deterioration that may contribute to this problem.

VEHICLE

Inspect nearby components for collateral damage.

OPERATIONS

Review trailer specifications for opportunities for better corrosion control. Avoid use of dissimilar metals in this type of application.

CORROSION — TRAILER LANDING GEAR

TRAILER—CORROSION CONDITIONS

VMRS SYSTEM CODE (CODE KEY 31): 077

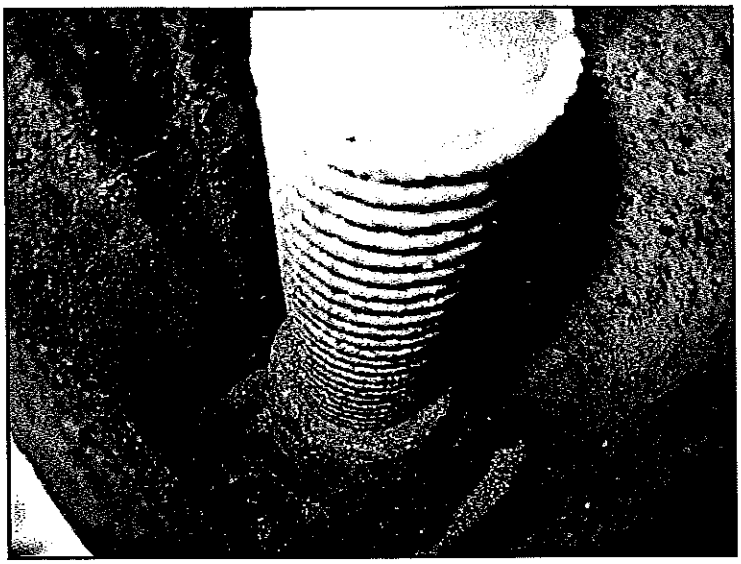
VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

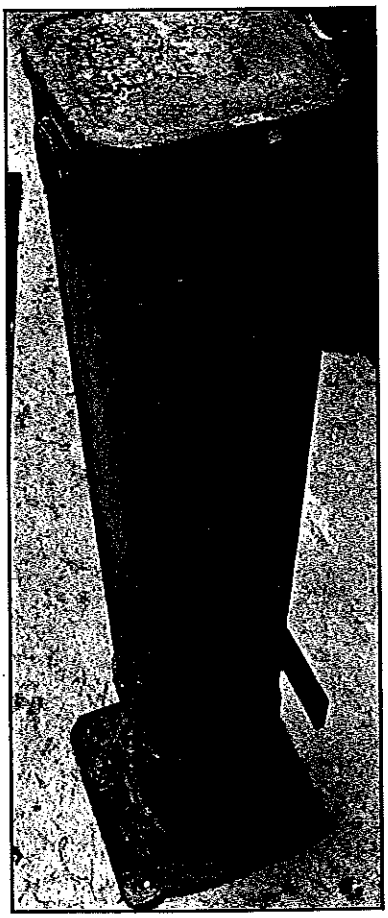
APPEARANCE

Corrosion on/in the trailer landing gear assembly. May be severe enough to compromise function. In this case, corrosion is evident inside/outside the housing. Corrosion can compromise the lift screw as shown below. Lubricant can also be compromised when contaminated by deicing/anti-icing chemicals. The housing and/or lid can rust through, allowing corrosion to take hold in the inner workings of the assembly.

PROBABLE CAUSE

Caused by anti-icing/deicing chemicals getting inside the assembly or compromising the outer casing/lid.





ACTION

COMPONENT

Inspect for proper component function and severity of corrosion. Crank should move freely without excessive resistance and/or lurching motion. For internal components: relubricate gear box and other grease fittings. For external components: remove corrosion and recoat/refinish. Repair and replace as necessary.

VEHICLE

Inspect attachment points for landing gear to trailer frame.

OPERATIONS

Periodically lubricate landing gear as per manufacturer recommendations. Review specifications for opportunities for better corrosion control. Review washing practices to remove deicing chemicals. Consider coatings/treatments that disrupt the corrosion forming process.

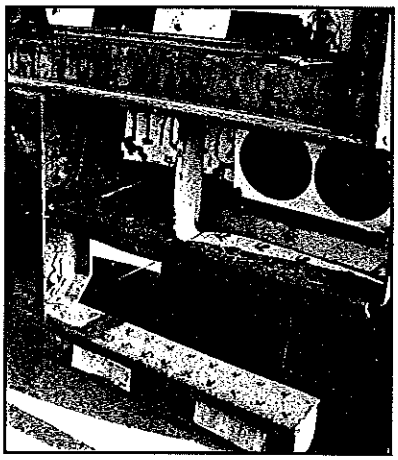
CORROSION — TRAILER UNDERRIDE GUARD

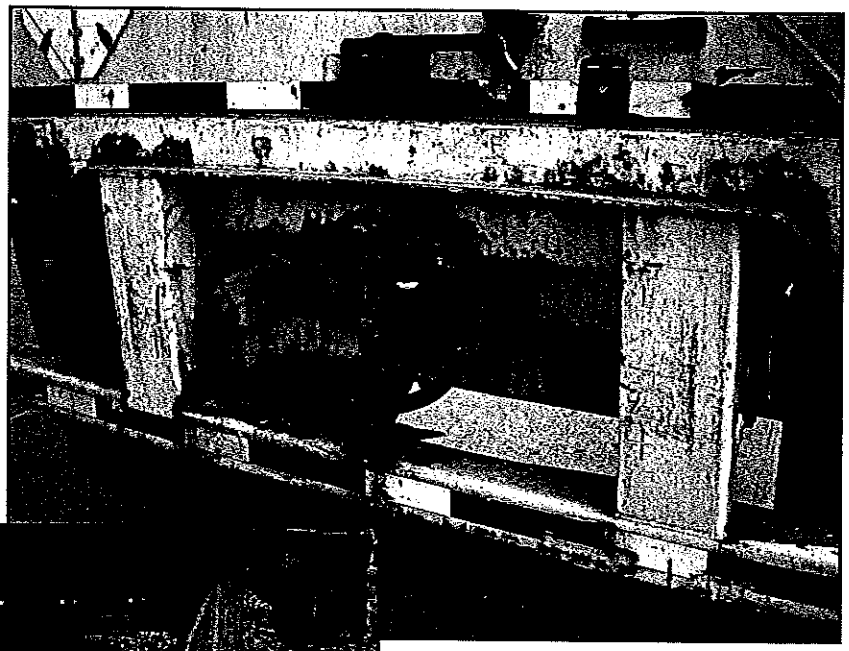
APPEARANCE

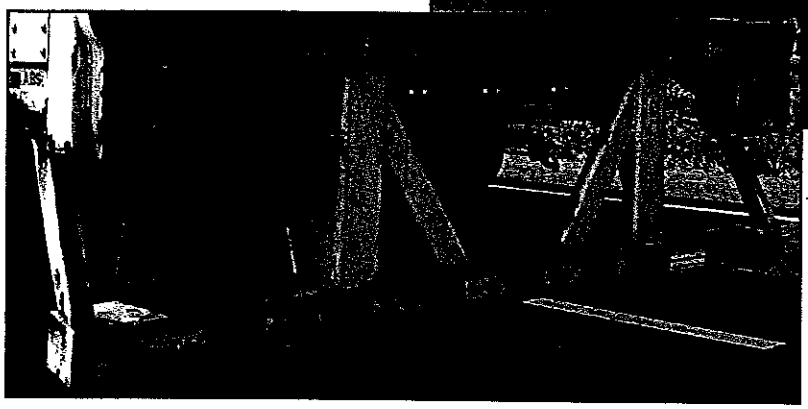
Corrosion on the trailer rear impact guard. Can occur when underride guard is damaged and coating surface is compromised; exposure to deicing/anti-icing chemicals can accelerate the process.

PROBABLE CAUSE

Can be caused by impact damage and/or coating failure and accelerated by road spray containing anti-icing/deicing chemicals.







VMRS SYSTEM CODE (CODE KEY 31):

072

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18):

35

ACTION

COMPONENT

Clean and remove salt spray deposits and rust from surfaces. Inspect for severity of corrosion. See TMC RP 732, *Trailer Rear Impact Guard Repair Guidelines* for repair and inspection recommendations.

VEHICLE

Inspect surrounding components (such as lighting or coupling devices) for corrosion related damage.

OPERATIONS

Review specifications for opportunities for better corrosion control. Review truck washing practices to remove deicing chemicals. Consider coatings/treatments that disrupt the corrosion forming process or stainless steel construction.

CORROSION — UPPER COUPLER

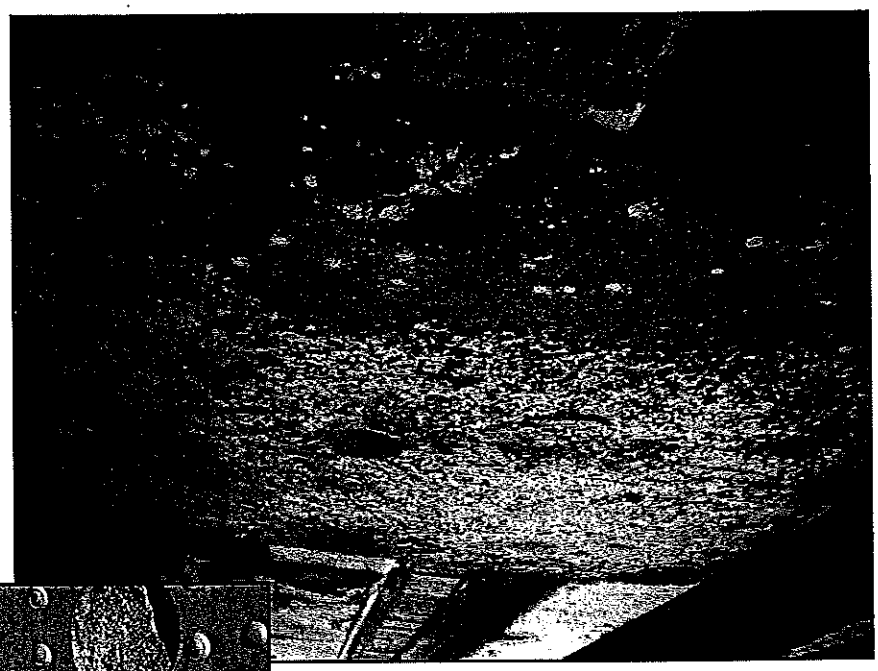
TRAILER—CORROSION CONDITIONS

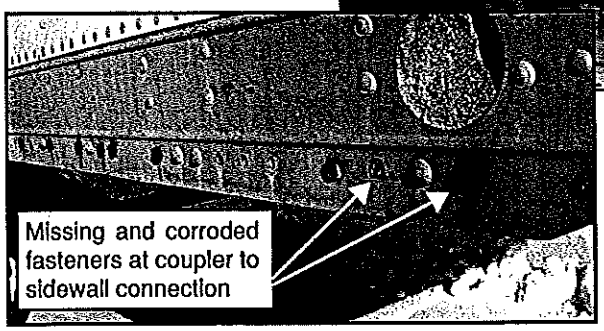
APPEARANCE

Corrosion on the trailer upper coupler plate. May be severe enough to compromise function. In this case, corrosion has rusted through from the outside.

PROBABLE CAUSE

Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment. Lack of proper fifth wheel lubrication can also be a factor.





VMRS SYSTEM CODE (CODE KEY 31): 077

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT

Inspect for proper component function and severity of corrosion. Check for cracks and areas where the bottom plate is worn or corroded through. See TMC RP 750, *Upper Coupler Inspection Guidelines* for additional recommendations. Repair and replace as necessary.

VEHICLE

When inspecting the coupler of an aluminum flatbed, check for corrosion between the steel coupler structure and aluminum main beams. If excessive corrosion exists between the steel and aluminum, the bolted connections and base materials at these interfaces may be compromised. It may also indicate that the bolts have been corroded and need replacement.

OPERATIONS

Review specifications for opportunities for better corrosion control. Review truck washing practices to remove deicing chemicals. Check with your manufacturer to see if coatings/treatments that disrupt the corrosion forming process are available.

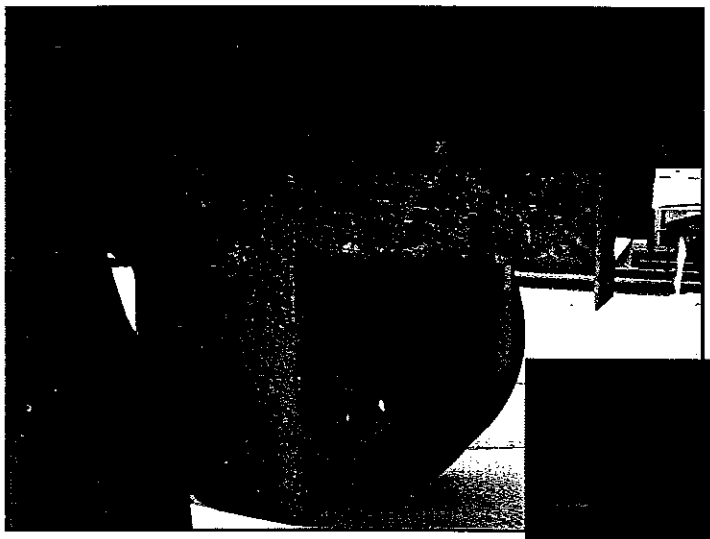
CORROSION — TRAILER FRAME

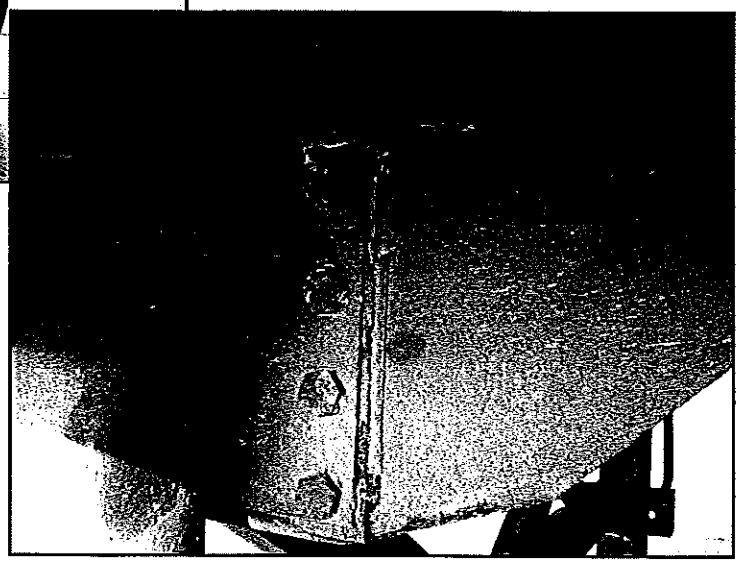
APPEARANCE

Corrosion on trailer frame at bracket attachment points. Corrosion may have spread to the fastener/frame interface. May be severe enough to compromise component integrity. Corrosion has bubbled the surface coating.

PROBABLE CAUSE

Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment.





VMRS SYSTEM CODE (CODE KEY 31): 077

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT

Inspect for severity of corrosion. Neutralize the effects of what is causing the corrosion to prevent further spread. Repair and replace as necessary. See TMC RP 736, *Repair, Section and Replacement of Longitudinal Van Rails.*

VEHICLE

Inspect nearby components for collateral damage.

OPERATIONS

Review specifications for opportunities for better corrosion control. Avoid use of dissimilar metals in this type of application. Review truck washing practices to remove deicing chemicals. Consider coatings/treatments (e.g., galvanizing/hot dip coatings) that disrupt the corrosion forming process.

CORROSION — CROSSMEMBERS

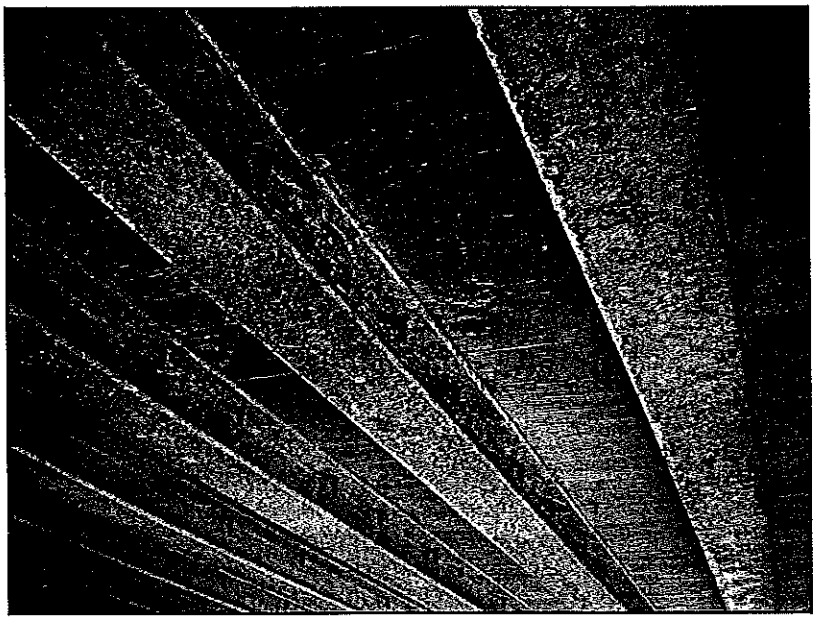
TRAILER—CORROSION CONDITIONS

APPEARANCE

Corrosion on trailer crossmembers. May be severe enough to compromise function. In this case, corrosion is evident throughout the crossmember surface. Rust trails are also evident on the wood floor where the fasteners attach to the crossmembers.

PROBABLE CAUSE

Prolonged exposure to anti-icing/deicing chemicals. Also, operation in salt-water/coastal environment.



VMRS SYSTEM CODE (CODE KEY 31): 077

VMRS TECHNICIAN FAILURE CODE (CODE KEY 18): 35

ACTION

COMPONENT

Inspect for proper component function and severity of corrosion. Look for fastener corrosion and integrity. See TMC RP 725, *FRP Maintenance and Repair* for guidelines when repairing fiberglass reinforced plywood.

VEHICLE

Inspect trailer flooring integrity.

OPERATIONS

Review specifications for opportunities for better corrosion control. Review washing practices to remove deicing chemicals. Check with your manufacturer to see if coatings/treatments/materials that disrupt the corrosion forming process are available.

SECTION III: CORROSION CORRECTION

ELECTRICAL SYSTEM CORROSION

Vehicle Wiring

Vehicle wiring has become increasingly complex during the past 20 years and this trend will continue for the foreseeable future. The electrical wiring system is routed in many areas of the vehicle and many locations have special design, routing or materials requirements. The harness design reflects the specific environment in the location of the vehicle where it is routed. The primary environmental considerations to consider in harness construction include:

- Water
- Corrosion
- Chemicals
- Vibration
- Abrasion
- Impact
- Sand & Dust
- Temperature Extremes
- EMI/RFI
- Tensile Loads
- Flexing (as in a door hinge area)

Understanding the design, routing and materials used to meet these requirements in various vehicle locations is necessary to effectively maintain and repair today's electrical wiring harnesses.

On a rainy day, there are few places where the wiring system will not get wet. Water has the potential to cause shorting between adjacent conductors or initiate corrosion processes due to the presence of very small amounts of salt, wash agents or other dissolved materials. Once water enters the wiring system, it can wick down the conductor stranding to distant areas of the harness. For example, if water is found in the wiring system, the entry point of water may be 20 feet away.

Water may enter through compromised wire seals, unsealed splices, unsealed crimps (e.g. ring terminals), unsealed connectors, unmated sealed connectors, poorly latched connector interfaces, connector interface seals missing or out of position, missing cavity plugs, cut or damaged cable insulation and devices that are connected to the wiring harness such as through sensors, actuators, control modules, etc.

Clearly, water may enter the wiring system at any unsealed locations but water may also enter "sealed" wiring by localized application of high pressure water spray, the presence of water in unsealed areas, vibration working water through seals, or through seals due to changes in internal and external air pressure. A four psi differential air pressure between the inside of the cable and ambient conditions can result due to temperature changes. Rapid cooling may cause some "sealed" connections to pull in water.

To minimize problems associated with water:

- Use sealed connector systems. Do not replace with an unsealed connector system.
- Ensure all connector seals are in place and in good condition and all cavity plugs are in place. Inspect seals for cuts, nicks, tears, etc.
- All external wiring interfaces must be sealed. Seal all exposed copper stranding (splices, crimps, etc.) with adhesive lined heat shrink tubing.
- Protect cable seals that may be exposed to high pressure water spray by assuring the proper positioning of back shells, molds, boots, heat shrink, shields, or reposition the connector to a limited access area where it is less likely to be spray washed (in a hard-to-service area).
- Don't spray wash connectors.
- Unused connector should have a cap which provides a water seal.
- Avoid locating connection systems in high splash or high water exposure areas.
- Ensure all coverings are in place and the harness is securely mounted.
- Avoid sharp bends of cable when exiting a sealed connector. Cable seals may be compromised from the cable bend.
- Harness routing should provide drip loops to funnel water away from connectors.
- Do not pierce wire when trouble shooting an electrical problem.

Chemical corrosion of metallic parts will not occur without moisture and salts. Corrosion will not occur within a dry, sealed wiring system, but many metallic parts of the harness assembly remain outside of this sealed environment. The corrosion rate is dependent upon the types of salts present, the susceptibility of the metal to corrosion, and to the specific corrosive material. The corrosion rate may be accelerated by voltage, such as the galvanic potential generated by contact between dissimilar metals such as when a grounding ring terminal is bolted to a frame rail.

Corrosion may cause electrical opens, intermittents, short circuits or increased resistance. Battery acid will corrode most metals of wiring harness construction.

Copper is the primary electrically conducting metal in any electrical system and used in connector terminals and wiring. Corroded copper will generate a green or white corrosion product. Often copper is plated to afford improved corrosion protection. Typical plating materials includes tin, gold, and occasionally, nickel or silver (see TMC RP 740, *Corrosion Protection From Dissimilar Metals*).

Mounting hardware such as mounting clips and fasteners are typically iron based alloys. These may either be passivated or plated with metals such as zinc galvanize. Stainless steel or aluminum alloy parts may also be present and are normally passivated to minimize deterioration due to corrosion. All carbon

steel based mounting hardware must be protected against corrosion using zinc galvanizing, paints, or plastic coatings. Stainless steel fasteners should be passivated to insure proper corrosion resistance. Aluminum parts should have some type of protective coating such as paint, conversion coating, or anodizing.

To avoid problems with metal corrosion:

- Avoid having exposed metals in a wet or salt spray environment. Fix or replace any spray protection, drip shields, rubber boots or other protective barriers. Reroute the wiring if necessary to avoid continuous exposure to water spray, splash, or battery acid.
- All metal parts shall be protected by a corrosion resistant plating, passivation, plastic coating, or a combination of these.
- Application of an insulating grease or coating is desirable where electrical terminals exposed to water and/or corrosive liquids are connected to vehicle ground studs.

Battery Terminal Connections

Battery terminal connections must be kept clean and tight. Never overtighten terminal connections. Refer to the manufacturers specifications for the proper torque setting. Always wire brush both the terminal and connector to a tarnish-free condition before assembling cables to the battery. A baking soda solution should be used to wash away any build-up of corrosion that may have occurred.

Corrosion forms on the exposed metal areas of terminal connections from exposure to air, moisture, and traces of electrolyte that come into contact with them. If the terminal connectors are not designed to seal the connection from the atmosphere, periodic disassembly and cleaning of the terminals will be necessary to prevent high resistance connections from developing. After cleaning and reassembling the cables, application of light grease or other commercial preparations will retard the formation of new corrosion. The time between cleanings will vary from application to application. A good rule of thumb is to clean them when changing engine oil.

Electrical Connectors and Terminals

There are many methods of maintaining the electrical circuit integrity of electrical connectors in harsh environmental conditions. The use of plated terminals (both noble and tin), hermetically sealed connectors, positive pressure housings, and high terminal contact pressure can all help to minimize the environmental effect on electrical connections. In addition to these methods, **connection system lubricants** have been used successfully for decades to protect electrical connections. The lubricant not only has the ability to protect the electrical connector from environmental corrosion, but can also inhibit fretting corrosion and galling, reduce the force required to mate and unmate the electrical connectors, and help seal the connectors from contaminants. These become important benefits to the user.

When properly applied connector lubricants provide many benefits, and generally, with no ill affect. Lubricants are non- conductive (Dielectric) in bulk and are only conductive if specifically formulated as a conductive lubricant. The lubricants used with electrical connections must be of the non-conductive (Dielectric) type. The resistivity of the lubricant should have a minimum value of 10^12 ohm/cm. The non-conductive lubricant will not affect the current flow within the electrical connection. The contact surface of an electrical terminal is a series of peaks and valleys. The current will only flow where the peaks or asperities of the metal conductors touch. When normal force on the contact is distributed across the tips of the asperities, it easily squeezes the lubricant out of the contact area. The valleys continue to retain lubricant, thus protecting the terminal from environmental or fretting corrosion.

Some advantages to applying lubricants to the wiring harness connection system are that they can:

- Improve the corrosion resistance of unsealed electrical connections.
- Provide redundant protection for sealed electrical connections.
- Provide environmental protection for electrical connections that may be unmated for some extended period of time. (i.e., when a chassis is being transported to a body builder).
- Inhibit fretting corrosion or wear on electrical connections that experience high vibration.
- Reduce the engagement force of multi-contact electrical connections. Lubricants can reduce the coefficient of friction of the terminal by 80 percent.

Some disadvantages to applying lubricants to the wiring harness connection system are:

- Lubricated-electrical connections may cause material handling problems. Excess grease maybe transferred to the handler or near by components.
- Applying an excess amount of lubricant to an electrical connection may displace the connectors seal when the connector is mated. This opens a leak path for contaminants to enter the connection system and may interfere with proper mating of the connection.
- Unmated lubricated electrical connections can retain dust and other contaminants. These contaminates may be forced into the connections when the connectors are mated.
- Some lubricants may be non-compatible with plastic materials they come in contact with.
- The base oil of lubricants exposed to excessive heat may evaporate or thermally degrade causing carbon deposits. This can leave the electrical connection with no fretting or corrosion protection.

Electrical connector lubricants are available in three forms: oil, grease, or dispersion. The lubricants can be formulated to provide specialized protection.

Oil—Oils are very easy to apply by dipping or spraying but may have a tendency to migrate. Oils may be used in a connection system with a very light contact force and in a benign environment. Areas with exposure to water should avoid oils. Even though oil is not water-soluble it is easily displaced by water.

Grease—Grease is base oil immobilized by a thickener. This provides the oil (necessary for lubrication) with a thickener to prevent migration. Greases comprise the bulk of the usage for truck and automobile electrical connection lubricants. Neat greases are always used in power applications where contact area tends to be large.

Dispersion—Dispersion are oils and greases diluted in a solvent carrier. This type of lubricant application is sometimes called "grease plating"; where the connections are dipped or sprayed with the lubricant in the solvent carrier. The solvent evaporates off, leaving a thin film of lubricant on the contact surface. Solvents can be formulated based on the lubricant chemistry, evaporation rate, and environmental requirements.

Connector Lubricant Selection Criteria

Factors to consider when selecting a lubricant are operating temperature, material compatibility, performance, and application method.

a. Operating Temperature

The long-term temperature limits of the base-oil of a lubricant determine the appropriate operating temperature for the three forms of lubricants. When using grease, the dropping point (or softening point) should **not** be used to define the upper limit of grease. Modern thickeners technology far exceeds the maximum long term operating temperature of the oil. The dropping or softening point should be well above the maximum temperature expected for short-term exposure, but the thermal degradation limit of the base oil will determine a lubricant's maximum operating temperature. See **Table 3-1** for the maximum operating temperature of typical base-oils. Another consideration is the pour point of the base oil. This is not the lowest operating temperature of the oil but gives an indication where the oil is no longer pliable. The lubricants pour point must meet the minimum operating temperature of the vehicle.

TABLE 3-1

Base Oil Chemistry	Max. Operating Temp.
Petroleum / Mineral Oil	100°C
Synthetic Hydrocarbon (PAO)	125°C
Polyphenyl Ether (PPE)	+200°C
Fluorinated Oils (PFPE)	+200°C

b. Material Compatibility

Specifically lubricants do not affect most thermoplastics. Esters are noted for their incompatibility with polycarbonate, polyvinyl chloride, polystyrene and ABS. Material density (high vs. low) and additives such as a flame retardant can also have an effect on compatibility. Elastomeric cable seals are vulnerable as well. Only the fluoroethers are inert enough to be safe with most seals. Compatibility charts are available from lubricant manufacturers, but testing the lubricant with the exposed materials is the only way to guarantee a successful match between a lubricant and the plastic and/or elastomeric components of a connector. Compatibility testing involves exposing the plastic connector, cable seals, and cable to elevated temperatures and evaluating any change in their physical properties. A typical test would be to expose the lubricated components to temperatures of approximately 100°C for a period of 168 hours. The evaluation would involve any changes in physical appearance, weight, dimensional changes, or tensile strength property changes, when compared to an untested or original component.

c. Lubricant Performance

Corrosion prevention (especially on non-noble metals) tends to be the major need, either for environmental or fretting protection. The longevity of the lubricant is important and is usually indicated by low evaporation properties. The properly selected lubricant will enhance the electrical connections longevity and meet the electrical circuit performance. Poorly suited lubricants can degrade the performance of an electrical connection. For example, silicones should not be used in an electrical connection because they provide poor fretting corrosion protection, harden or polymerize increasing contact resistance, migrate from the interface, and swell other silicone components such as cable seals. A performance advantage offered by grease is the fact that they can fill voids and spaces within connectors and prevent the entry of contaminates. However, care must be taken not to apply too much grease during application, which could affect the positive mating of the connector. Another concern is the thickener or additive in the grease, that can affect the mating and unmating force of an electrical connection. Again, testing will always be required to insure all the required performance parameters are met. See **Table 3-2** for the characteristics of base oils and thickeners.

d. Application

The application of the lubricant to the electrical connection tends to be one of the more difficult operations whether it is in a production application or a service procedure. In production when a contact stamper applies a lubricant a secondary station will apply the lubricant automatically usually by dispersion (spraying) or by the use of dip tanks. If a lubricant is applied in the cavity of a connector the lubricant can be metered into the female contact using a positive displacement devise with a needle tip for precision accuracy. This meter method applies a premeasured amount of lubricant to prevent seal damage in a sealed connector system. In the unsealed connectors, the total cavity is filled with lubricant

TABLE 3-2

Base Oil Chemistry	Characteristics
Petroleum / Mineral Oil	Shortest life, fair oxidation protection
Synthetic Hydrocarbon (PAO)	Significantly longer life than petroleum
Polyphenyl Ether (PPE)	Excellent surface oxidation protection and life
Fluorinated Oils (PFPE)	Best life, poor surface oxidation protection
Thickeners	**Characteristics**
Metallic soaps (Li, Ca, Na, Al) will melt at elevated temperatures.	Fair to good water resistance, low engagement force benefit,
Organo-Clay	Excellent water resistance
Amorphous Silica	Good water resistance protection, low solid to oil ratio.
PTFE	Best in force reduction, excellent water resistance.

to prevent moisture egress. The excess lubricant is displaced and pushed from the connector when the unsealed connection is mated.

In a service environment the lubricant can be applied to the connection through the use of a tube, syringe, acid brush, or dispersion. Dipping would be very difficult since the connection system would need to be disassembled to dip the terminal. Dipping is not a recommended method of applying a lubricant in a service application. The lubricant application should consist of applying a thin coat of lubricant to both contact surfaces; this will ensure total connection protection. Again the entire housing of the unsealed connector must be filled with lubricant to prevent water entry.

UV dyes can be added to the lubricant, as a quality check. The UV dye will be visible under a black light insuring lubricants have been applied and confirm adequate coverage.

After the lubricant is applied, special care must be taken when the contacts are handled or stored. Although lubricants do not attract airborne dust or dirt, once a contaminate particle lands on the lubricated surface, it will become wetted and adhere to the contact.

The information found in **Table 3-3** is to be used as a general guide to define a lubricant for specific applications.

e. Lubricant Life

With proper lubrication selection and application, re-application is typically not needed unless under inspection the lubricant appears dried out or has physically been removed. The life of properly selected lubricants is expected to match the useful life of the connection system.

TABLE 3-3

Connector Usage	Data/Signal—Low voltage/current Type 1	Data/Signal or General Purpose, High Temp. Type 2	General Purpose, Inside or Outside Cab Type 3	Water or Environmental Exposure. High Splash or Washout Type 4
Temperature	-40° to 125°C	+ 150°C	-40° to 125°C	-40° to 125°C
Base Oil	Petroleum—PAO, PPE	PFPE, PPE	Petroleum/ Mineral Oil—PAO, PPE	Petroleum, PAO
Thickener	Metallic Soap, Amophorus Silica	Amophorus Silica, PTFE	Metallic Soap, Amophorus Silica, Organo Clay	Amophorus Silica, PTFE, Al Soap
Application Method	Grease or Dispersion	Grease or Dispersion	Grease or Dispersion	Grease
General Product Description	Light viscosity base oil, low contact force	High viscosity base oil, low evaporation	Consider need to protect from moisture	Thickener needs good water and chemical resistance

NOTE: All petroleum-based products have a 100°C max operating temperature. The pour point of the oil determines the lower operating limits of the lubricant.

The following lists some commercially available lubricants. Other commercial products may be available and TMC does not recommend any specific product or brand.

Dispersions / Sprays

- Miller-Stephenson Connector Cleaner & Lubricants (PPE) (Type 1, 2, 3)
- Nyetact 502J-20-UV (PAO/Silica)(Type 1 ,3)
- Nyetact 523H-2-UV (PPE) (Type 1, 2, 3)
- Nyetact 570H-2 (PFPE) (Type 2)

Greases

- Grote Ultra-Seal Corrosion Protection (Mineral Oil/Metallic Soap) (Type 1,3)
- Lubriplate DSES (Petroleum/LiSoap) (Type 3)
- Nyogel 760G (PAO/Silica) (Type 1, 3, 4)
- Truck-Lite NYK Grease (Mineral Oil / Clay) (Type 3)
- Uniflor 8512 (PFPE/PTFE) (Type 2)

TIRE CORROSION

Bead Lubricants

Preferred materials for usage as bead lubricants are typically produced from either vegetable oils or animal fats. Typical concentrations of liquid lubricants are 10-25 percent solids in water but no less than 10 percent and must contain a corrosion inhibitor. Ready-to-use paste lubricants do not require dilution and typically have higher solid concentrations and must contain corrosion inhibitors. In all cases, follow the directions and recommendations of the lubricant manufacturer.

Use proper concentration of lubricants. The effectiveness of corrosion inhibitors is substantially reduced when water concentrations are above manufacturers' recommended levels, which may result in wheel corrosion.

Bead Breaker Fluids

Aftermarket flammable demounting ("bead breaker") fluid products, sold under various brand names, are often used to aid in tire demounting when any excessive bonding at the rim caused by corrosion, heat exposure, etc., makes demounting difficult. These products use penetrants in solvent solutions to loosen the bond between the casing bead toe and rim. (They are typically comprised of xylene or toluene and other low cost solvents.) The tire retread industry recommends that tires should not be retreaded or repaired (if the repairs are chamber cured) unless the user/retreader is absolutely certain that the tire has not been exposed to flammable demounting fluid.

TMC recommends that fleets and commercial tire service centers adopt a strict prohibition on the use of any flammable fluids on tires at any time. This will help reduce the risk of curing chamber fires, as well as benefit the safety and health of tire service technicians. As an alternative to using flammable bead breaker fluids, TMC recommends that non-flammable demounting fluids currently available be used during the demounting process, if needed.

WHEEL CORROSION

Pitting or corrosion that has reduced the metal thickness is a serious concern. Replace any wheel that has excessive corrosion. (General Guideline: If the manufacturer stampings on the disc face are no longer legible, remove wheel for further inspection.)

Rust streaks extending from the boltholes usually indicate either worn, poor quality, or loose wheel nuts. Make sure the correct nuts for the wheel system are being used. Inspect wheel boltholes for wear or damage, then remove rust streaks.

Excessively corroded or cracked rims are dangerous during the removal of the assembly. Deflate the tire (both tires of a dual assembly) before removing the rim from the vehicle. Insert a wire through the valve to ensure debris has not prevented deflation.

STEEL WHEEL REFINISHING

This section provides guidelines and inspection criteria for steel wheel and rim refinishing and for evaluating refinishing vendors.

The following represents an overview of the three primary coating system components: primer, powder coat, and paint.

- **Primer**—The primer is an optional base coat applied to bare metal to improve adhesion of subsequent coat(s).
- **Powder Coat**—This powder coat system involves the application of an electrostatically charged powder paint that is cured in an oven. Once the wheel or rim emerges from the oven, it can be returned to service in a relatively short period of time.
- **Solvent or Water-Based Paints**—This system involves the application of a solvent or water-based paint. After applying the paint, the wheels or rims dry at room temperatures or are cured in an oven.

Process Guidelines

1. Initial Inspection

Prior to the refinishing process, the wheel or rim should be thoroughly inspected for any damage or out-of-service conditions. Technicians should refer to TMC RP 222B, *User's Guide to Wheels and Rims*, for a comprehensive listing of conditions. Any rejected wheels or rims should be marked and tagged unserviceable and returned to the fleet if applicable.

2. Pre-Wash

Any existing dirt, grease or debris should be removed prior to the paint removal process. Failure to perform this step may have a negative effect on the coating performance.

3. Coating Removal
The primary objective in this step is to remove all of the previous coating without damaging the wheel or rim surfaces. If the date code or part number stampings are not easily legible or the surface is severely pitted after the coating is removed, then the blasting method/media may be too aggressive or the rim/wheel could be worn out. If the DOT stamp or manufacturers identifying marks are not legible for any reason, remove the rim/wheel from service and scrap.

Most processes use a blasting cabinet that uses a variety of media ranging from metal shot, to glass beads, to other material. Sandblasting or grit by itself is not recommended as it tends to reduce wheel or rim durability. Smaller, less aggressive steel shot size is recommended, typically less than S330. Blasting cabinet manufacturers recommend the most effective shot size to be used with their equipment. Machines designed to remove only solvent or water-based coatings may not effectively remove powder coat finishes without excessive surface damage. Whatever the media, it is absolutely imperative that the paint removal system results in bare metal on the mounting surfaces and bead seats. Complete removal of the old coating is recommended to facilitate inspection and refinishing.

4. Inspection Following Coating Removal
After the coating has been removed, the rim/wheel should be inspected for any cracks or out of service conditions (see RP 222B). If the DOT stamp or manufacturers identifying marks are not legible, remove the wheel from service.

5. Cleaning/Pretreatment
Following the coating removal process, some steel wheel or rim refinishing systems use solvent/alkaline cleaning solutions or other methods to prepare the bare metal surfaces for coating. Consult the coating manufacturer for recommended cleaning and pretreatment guidelines. This step in the process has a positive effect on coating performance. In order to maintain consistently clean surfaces, TMC recommends that the cleaning agent be periodically replaced.

6. Bare Wheel Handling/Storage
Technicians should only handle bare wheels with clean, lint-free, dry gloves. Bare wheels should not come in contact with the floor or anything that may contaminate the cleaned wheel/rim surfaces. Since bare wheels have no protection from moisture and other contaminants, the surface should be coated promptly to prevent flash rusting.

7. Primer Application
Aftermarket processes that include a primer or base coat may improve the performance and durability of the finish. Check with the coating manufacturer for recommendations on the use of primers or base coats.

8. Finish Application
Regardless of the type of finish being applied to the wheel or rim, it should be no more than 3.5 mils total thickness on the mounting surfaces. Coating thickness should be measured mid-way between the bolt holes in a minimum of five locations on both sides of the wheel. It is extremely important to avoid any runs or excessive coating thickness, especially around the bolt circle, wheel/rim mounting, or bead seating surfaces.

Excessive coating thickness can lead to loose fasteners, premature wear or wheel loss as the result of the joint settling in.

9. Curing
All powder coat steel wheel refinishing systems use an oven or other heat source to cure the coating. For air-dry coatings, the typical time required to ensure complete curing of the material is at least three days. Baking the painted wheel/rim will speed up curing time. Consult the coating manufacturer for curing specifications. Undercured coating will have the same effect as excessive coating thickness since the soft coating will be squeezed from the mounting surfaces and from under wheel fasteners when they are tightened.

10. Post Finish Inspection
After the finish has been cured according to manufacturers recommendations, the rim/wheel should be inspected for any runs or excessive coating thickness. If the DOT stamp or manufacturers identifying marks are not legible, remove the wheel from service.

Prospective Vendor Checklist
The following checklist of questions may be used to help evaluate refinishing vendors:

- Is each wheel or rim thoroughly inspected in a well-lit area by a trained technician prior to refinishing?
- Does the inspector have access to TMC RP 222B as a reference for potential out-of-service conditions? (RP 222B is also made available as a stand-alone TMC publication entitled, *User's Guide to Wheels and Rims.*)
- Does the coating removal process use the correct size media and is it replaced on a regular basis?
- Does the coating removal process result in completely bare metal mounting and bead seating surfaces?
- Are the wheels cleaned prior to coating application?
- Are bare wheels promptly processed to prevent flash rusting?
- Are there quality controls in place to ensure that worn or damaged wheels are identified prior to the finish application process and removed from service?
- Does the coating application process ensure that the total thickness does not exceed 3.5 mils on the wheel/rim mounting surfaces?
- Are there quality controls in place to ensure that the proper thickness of the coating is applied to the rim or wheel?
- Can the original rim/wheel manufacturers stamps and identifying marks be read after refinishing?

WHEEL GUARDS OR SPACERS

Wheel guards or spacers are nylon separator discs, approximately 0.040" thick. They are placed in the bolt hole circle between the hub or drum and the wheel, and/or between the two wheels in dual applications. They are recommended in severe applications where corrosion and/or wear have been identified as a problem to disc wheel mounting faces. Wheel guard/spacers may also be used in non-severe applications to protect painted, polished, or other coated wheel surfaces.

Both aluminum and steel wheels can benefit from the use of these components. Care must be exercised in centering the wheel guard/spacer prior to torquing and stud length must be checked as each wheel guard is about 0.040" thick. Stud length must be adequate for proper nut thread engagement to ensure that proper torque is achieved. Wheel guards and spacers must be replaced at least at every tire change and examined for serviceability when wheels are removed for routine maintenance. Other products on the market such as aluminum wheel protectors are not designed for this purpose. Wheel protectors will compress under torque, which will result in loose wheels. Care must be taken to select products that are designed for this application.

WHEEL WEIGHTS

Aluminum wheel manufacturers recommend the use of coated wheel weights to protect the finish from the effects of galvanic corrosion.

BRAKE SYSTEM CORROSION

AIR SYSTEM CORROSION PREVENTION

This section includes procedures for eliminating contaminants from the air systems of tractors, trailers and converter dollies equipped with air brakes. Efficient elimination of these contaminants requires specification of the right equipment, good driver and technician preventive maintenance practices, along with periodic cleaning of the air system as suggested herein.

Contaminants enter the air system of powered vehicles through the air delivered by the compressor. The entrance to trailers and dollies is through their front gladhand air couplers.

Air to the compressor is usually filtered through the engine air cleaner. Air coming from the compressor is hot and contains moisture and often other contaminants, such as compressor oil. This air is then directed to an air dryer where most—depending on the condition of the air cleaner, compressor, and dryer—are removed. Sometimes, when high volumes of air are required for accessories, a condenser/separator is placed between the compressor and dryer to reduce the dryer/cleaner load and extend maintenance intervals.

Contaminants entering towed vehicle air systems through the front gladhands comes either from contaminated towing vehicle air, or contaminants entering the air system through uncovered gladhands. Open gladhands give easy entrance to rain, snow, sand, bugs, and other contaminants. Trailers are often seen parked in yards and on railroad cars in piggyback service with open gladhands.

Open gladhands are not a problem for tractors since contaminants entering through its gladhands are blown into the towed vehicle's air system to which it is coupled when the trailer protection valve is opened.

Vehicle Specifications

Tractor specifications should include air dryers and drain valves which are easily accessed and manually operable. If it is not practical to make the drain valves easily accessible, easily accessed lanyards should be provided which are connected to spring loaded drain valves.

Each tractor should also be required to have a bracket on the back of its cab which can secure the gladhand end of the tractor-to-trailer hoses in such a manner that contaminants cannot get into the air lines. Dolly specifications should also include such brackets.

Trailer and dolly specifications should specify that these vehicles be equipped with either an automatic means of covering the gladhand openings when vehicles are separated, or dummy gladhands to manually cover the openings. Vehicle-mounted brackets, like those specified for tractors, should be spec'ed for dollies to secure hose-mounted gladhands.

Preventive Maintenance Practices

Driver Inspections—Air Reservoirs

One of the most important preventive maintenance practices for drivers is the routine bleeding of air reservoirs, and the inspection for contaminants.

Unless a fleet has an established policy to bleed air reservoirs of contaminants during inbound or outbound safety lane inspections, drivers should be instructed to bleed all reservoirs on the vehicle daily. A good procedure would be to have the drivers bleed the reservoirs during the pre-trip walkaround inspection and note any unusual amounts of contamination in the "driver vehicle inspection report."

Driver Inspections—Gladhand Air Couplers

Since contaminants, obtained from dirty tractors or open gladhands, go directly to either the service brake relay valve or the parking brake valve of towed vehicles without passing through a reservoir, draining reservoirs does not solve the towed vehicle dirty air problem. The major solution, in addition to having clean tractor air systems, is to keep gladhand openings covered.

CORROSION CORRECTION

When vehicles in combination are separated, drivers must make sure gladhands on towing, as well as towed vehicles, are covered by either an automatic means or a dummy gladhand, and that hose-mounted gladhands are secured in the holding bracket provided on the vehicle for them.

Contaminant Elimination Procedure For Tractor Air Brake Systems

NOTE: It is important that a supply of clean, dry compressed air be provided to execute the following procedure.

Step 1: Apply spring brakes, chock wheels and open petcock fully to drain the air system. Use eye protection and secure any air brake lines before blowing shop air through them.

Step 2: Mark all lines removed from their respective ports to ensure proper reconnection.

Step 3: Before attaching the discharge line to the compressor, disconnect the line from the air dryer. Using air pressure from a shop compressor, blow through the discharge line toward the compressor end until the line is clean. Also, check this line for carbon build-up. If build up is found, consider installing a new discharge line as this material is very difficult to remove.

Step 4: Disassemble the dryer and replace the desiccant and filter. Using a clean shop towel, make sure all parts of the dryer—including the one-way check and purge valve—are clean and in working order. Consult the dryer manufacturer for proper service procedures.

Step 5: Next, clean the tanks. Remove all air lines to the primary and secondary reservoirs and plug. Install the shop air line to the opening that the dryer line would normally hook to. Using a pressure-regulating valve, set the pressure at 5-8 pounds, open the drain petcock and allow at least 30 minutes for the tank to be completely cleaned. Check the safety valve for proper operation and clean or replace if necessary.

Step 6: Before installing the governor reservoir line, or any other line supplied by the wet tank, remove and blow backwards with air from the shop air line, until the line is clean.

Step 7: Remove the two one-way check valves protecting the two service tanks and blow through them with shop compressor air until clean. Some systems have multi-compartment reservoirs with internal check valves. Check these valves for proper operation.

Step 8: Use shop compressor air to blow through lines between service and wet tanks. Blow in the direction from the service end to the wet tank end (i.e., backwards).

Step 9: Remove the supply lines connecting the service reservoirs to the foot valve. Using shop compressor air, blow backwards from the foot valve end towards the service reservoir end and blow through the lines until clean. If no oil is found in this line, cleaning is complete. If oil is found in this line, all lines delivering air from the service reservoirs must be cleaned by connecting at the foot valve and blowing backwards toward the reservoir.

Step 10: If oil was found in the supply line, check the bottom section of the foot valve by removing the lower housing. If oil is found there, all valves (foot, dash, tractor protection, relay and two-way checks) will have to be dismantled and cleaned, or replaced. Check with the specific valve manufacturers for proper cleaning and repair information.

Step 11: Brake chamber diaphragms should be checked in the event of oil contamination. Check with the specific chamber manufacturer for proper disassembly and repair information.

Step 12: Perform a complete systems operation check to ensure proper component function. If excessive contamination is found, steps should be taken to correct the source of contamination. Example: With excessive oil contamination, repair or replace air compressor. With excessive dirt contamination, check air compressor intake source for broken line or malfunctioning filter.

Contaminant Elimination Procedure For Trailer Or Dolly Air Brake System

NOTE: It is important that a supply of clean, dry compressed air be provided to execute the following procedure.

Step 1: Check the service and supply gladhands. Often there is a small screen inside the gladhand, which could be clogged. Remove, clean and replace screen. If no screen is present, clean any contamination which may impede air flow from the gladhands.

Step 2: Open petcocks and drain all trailer reservoirs. Mark all lines removed from their respective ports to ensure proper reconnection.

Step 3: Disconnect the service and supply lines at their respective valves or the supply tank at the rear of the trailer. Secure lines and blow shop air through gladhands until the lines are clean.

Step 4: Next, clean the trailer reservoir tanks. Remove all air lines leading to the reservoir tanks and plug. Install the shop air line to the opening that the supply line would normally hook to. Using a pressure-regulating valve, set the pressure at 5-8 pounds, open the drain petcock and allow a minimum of 30 minutes for the tank to be completely cleaned.

Step 5: Check the exhaust portion of all trailer valves for oil and sludge. If found, these valves may have to be dismantled and cleaned, or replaced. Check with the specific valve manufacturers for proper cleaning and repair information.

Step 6: Check the interior of the service and parking (emergency) brake chamber lines. If contaminated, remove them from the trailer and blow clean with shop air from the chamber end of line.

Step 7: Continue checking all interconnected reservoir lines for contamination. If dirty, clean by blowing air in the opposite direction of normal operation, until completely clean.

Step 8: Check all other air accessories for contamination such as air bags, leveling valves, etc. If found, these will have to be cleaned and/or replaced. Check with the specific manufacturer for proper cleaning and repair information.

Step 9: Check the service brake and pintle hook air snubber chamber for contamination. If contamination is found, check with the specific manufacturer for proper cleaning and repair information.

Step 10: Reassemble system and perform an operation check to ensure proper component function and system integrity.

FOUNDATION BRAKES

Rust Jacking

Rust jacking can occur when corrosive deicing/anti-icing chemicals cause rust to form on a brake shoe table, which eventually can crack the brake lining—thus, shortening the component service life and compromising performance. Rust-jacking usually occurs on front shoes, where intense brake heat cannot dry out the shoe table. Moisture can accumulate and the layers of rust that form put pressure on the lining, which is riveted to the shoe.

Some things that can help prevent rust jacking are:

- spec'ing shoes with thicker linings. This helps insulate the shoe table from whatever brake heat is generated.
- paying attention to brake shoe duty cycle and replacement rate. The less use brakes get, the more likely a candidate they are for rust jacking.
- spec'ing brake table coatings that improve the component's ability to resist micro-abrasion. Several manufacturers offer UV or other technology coatings that can resist rust from forming.
- spec'ing brake table materials that resist corrosion, such as stainless steel for example.
- routinely spray the vehicle's undercarriage to wash away salt and road grime that promotes rust jacking. Brake suppliers recommend using a gentle stream from a hose to do this, not a pressure washer.

Other Brake Components

Most antilock brake (ABS) tone rings are coated with a factory rust inhibitor; however, the ABS ring should be examined for excessive corrosion. Excessive corrosion or debris can induce an ABS malfunction. Most corrosion or debris can easily be removed by using a wire brush. If the ABS ring requires replacement, the hub assembly must be removed from the axle.

See TMC RP 607B, *Preventive Maintenance and Inspection of S-cam Foundation Brakes* and RP 652, *Service and Inspection of Air Disc Brakes* for more service information.

WHEEL END CORROSION

Corrosion problems can occur in severe applications (e.g., livestock hauling), or in applications involving frequent or heavy contact with chloride compounds (e.g., salt), high alkaline materials. Hub and wheel assemblies used in particularly corrosive environments must be regularly and thoroughly cleaned.

Hub outer surfaces and pilots can be cleaned with a mild detergent and high-pressure steam or water to remove dirt, road grime, ice-clearing chemicals and application-specific corrosives. The hub assembly should be cleaned and inspected for wear or damage any time the tires are removed. Soap, high-pressure water, a wire brush or steel wool pads can be used to remove corrosion or chemical residue. Corrosion must be removed from all pilot areas to permit proper brake drum and wheel assembly.

Anything that interferes with how the hub mates with other components should be removed, including paint and dirt. The presence of wheel-end lubricant, burrs, rust or corrosion may indicate a more serious problem involving the wheel-end system and should be investigated. All threaded or seating surfaces of the hub and associated components (studs and ball seats) should be cleaned with a wire brush. If the wire brush does not remove interfering material, the hub should be replaced.

For corrosion prevention, place a light film of grease on all metal components, including the hubcap, when servicing wheel bearings and seals. Wipe off the excess grease. Install the bearings and wheel seals as described in TMC RP 622A. *Wheel Seal and Bearing Removal, Installation and Maintenance.* Pre-lubricating the inner and outer wheel bearing cones with clean lubricant of the same type used in the hub assembly will help inhibit fretting corrosion and make assembly easier.

If pitting or corrosion is present, damaged bearings should be replaced. Examine the other wheel-end components for damage, especially seals. Ensure technicians inspect hubcap window rings during service. Increase frequency of inspection as required by seasonal, operational or application conditions. Ensure window rings are receiving appropriate attention during washing or other cleaning procedures, especially during winter. For more information, see TMC RP 644A, *Wheel End Conditions Analysis Guide.*

ENGINE-RELATED CORROSION

AIR INTAKE SYSTEM

Accumulation of road salt, calcium chloride, or sodium chloride deposits in the engine intake cause serious problems. Chemical buildup in the throat of a compressor intake reduces throat diameter and causes an increase in the intake air temperature (which leads to power loss and possible valve train damage) and an increased load on the turbocharger bearing (which leads to bearing failure). Ingestion of salt, calcium chloride or sodium chloride can cause corrosion of the blower housing and lobes, bearing failure, and possibly blower seal leaks. In areas where salt, calcium chloride or sodium chloride is used for snow removal or in humid coastal areas, salt water solution from road splash and spray enters the system through the air inlet cap or through system leaks on the dirty side of the air cleaner.

When enough salt water solution, calcium chloride or sodium chloride mixtures enter the air cleaner, the filter media becomes saturated. Because the corrosive material is in suspension, as dirt would be, the salt, calcium chloride or sodium chloride passes through the media with the water into the engine. The water then evaporates, and the salt, calcium chloride or sodium chloride is deposited on metal surfaces. To avoid this, every intake system must have some means of removing water before it can reach the filter element.

Water-separating devices must be regularly inspected and maintained to ensure proper operation. As previously mentioned, salt water can enter through either the air inlet or through system leaks. Even if salt is not present, water interferes with normal operation and promotes corrosion. For more information, see TMC RP 301C, *Maintaining Air Intake Systems*, and RP 310, *Water Ingestion Prevention*.

COOLING SYSTEM

If the cooling system is exposed to corrosive elements, such as road salt or sea water, it is recommended that the cooling surfaces be cleaned periodically with water. Ice melting chemicals such as magnesium chloride and calcium chloride are especially corrosive and the vehicle should be washed after every exposure to these chemicals.

If inspection of the engine coolant reveals rust or turbid appearance or if deposits have formed on the top header of the radiator, clean the cooling system. Also clean the cooling system if truck history denotes the above mentioned chronic cooling system complaints. Then, follow the recommended cleaning procedure to remove rust, corrosion by-products, solder bloom, scale, and other deposits. Cleaning opens coolant passages and removes insulating scale and deposits that will cause overheating and possible engine block damage.

NOTE: When using cleaning chemicals, rinse thoroughly with water to remove all residual traces or corrosion could result.

Exterior Cleaning of Aluminum Radiators

Exercise care when cleaning aluminum radiators, as many of the commercially available cleaners remove the outer layer of material and excessive exposure will damage radiators. TMC recommends that, for most cleaning purposes, a mixture of water and dishwashing detergent will do a good job with little potential for damage. When cleaning, be sure to rinse the radiator thoroughly. Refrain from using equipment or techniques that will damage the fins, such as wire brushes or close direct high pressure air or water. Please refer to TMC RP 333, *Heat Exchanger Exterior Maintenance and Cleaning* for guidance on cleaning clogged airways, minimizing corrosion, heat exchanger mounting inspection, and component structural integrity.

Interior Maintenance and Cleaning of Radiators

Aluminum radiators may require cleaning due to contamination and/or corrosion problems. The use of high silicate antifreeze/coolants along with standard supplemental cooling additives (SCAs) may cause silicate gelation problems and/or silicate dropout. When this occurs, alkaline-based cleaners may be required. An acid-based cleaner may be required to totally clean the engine/radiator cooling system if block corrosion, rusting, oil contamination or radiator plugging occurs. Cleaner should specifically state that it is safe or inhibited for use with aluminum. It is extremely important to follow cleaner and/or OEM truck manufacturers' cleaning recommendations. In addition, several cleaning tips should be followed:

1. Cleaner concentrates, either alkaline or acid based, normally require dilution with water prior to use. It is recommended that the cleaners be diluted before adding to the radiator. Adding cleaner concentrates directly to a radiator and then adding water is not recommended since cleaner concentrates may corrode aluminum radiator components.
2. After following cleaner manufacturers recommendations for circulating diluted cleaner solutions in the cooling system, it is extremely important to thoroughly drain the cleaner, reload the cooling system with clean water and thoroughly circulate and drain the water. A cleaned cooling system must be thoroughly flushed with clean water to remove all cleaner solution before loading the system with fresh coolant.
3. If the engine block is cleaned with rust removal chemicals it is recommended that the rust removal chemical not be circulated through the radiator. Rust removal chemicals are likely to strong for aluminum and could damage the radiator.

For additional guidance on maintenance procedures and coolant condemnation limits, please refer to TMC RP 313, *Checklist for Cooling System Maintenance*, and RP 326, *Recycling Engine Coolant*.

Due to the thinness of the core tubes as found in heater cores and radiator heat exchangers will suffer damage long before

aluminum used in plate oil coolers and heavy cast aluminum used in engine components show any sign of corrosion damage from cleaning agents. Many engines used in the truck industry have cooling system components composed of heavy plate or cast aluminum. Use of cooling system cleaners appears to have little detrimental effect on their surfaces. Radiator and heater core coolant passages are typically composed of thin aluminum tubing and are at risk of significant damage from the use of cooling system cleaners composed of alkaline compounds or acid compounds.

Aluminum can be easily damaged by cleaners with pH factors of 11.0 and greater. Typical alkaline cleaners have a pH factor of 12.0 plus. Aluminum exposed to acid-type cleaners with a pH less than 6.0 will also suffer significant surface damage from these cleaning agents. Engine cooling systems with rust require the use of potent acid cleaners which will not be good for aluminum heat exchangers.

Use cleaning agents that specifically state that they are safe for aluminum (wrought tube stock, not just cast stock). Follow manufacturer's instructions. Do not deviate from recommended cleaning procedures and times.

Aluminum is more sensitive to erosion damage from abrasives in the coolant than traditional copper/brass radiators. Therefore, TMC recommends that coolant filters be used to remove core sand, dirt and other abrasives that may accumulate over time in the coolant system. TMC also recommends avoiding activities which increase coolant flow velocity in the radiator tubes, such as plugging tubes or using replacement cores with tube areas of smaller size than the radiator was originally designed for.

Coolant Maintenance

Used aqueous engine coolant analysis is a "preventive maintenance tool" which can be used to determine the overall condition of the engine coolant, detect contaminants and/or corrosion metals, and identify possible cooling system problems. TMC RP 362, *Guidelines for Used Coolant Analysis of Heavy-Duty Vehicles* provides guidelines for cooling system sampling procedures, commonly run field and laboratory tests, and warning/condemnation limits for used engine coolants.

Sulfate levels continually increase as the coolant is used. Heavy-duty engine manufacturers recommend that the maximum sulfate level in make-up water be 100 ppm. Sulfate levels in engine coolant exceeding 2000-2500 ppm can be a source of corrosion.

Corrosion in a cooling system can damage metal components, block coolant passages, reduce heat transfer, and cause cooling system malfunctions. Therefore, engine coolants are formulated with various corrosion inhibitors that protect metal components in the cooling system from corrosion. Current engine coolant formulations may contain inorganic (conventional), extended life (organic additive technology), or hybrid (both inorganic and organic) corrosion inhibitors.

Corrosion inhibitors protect against corrosion by forming a thin insulating and inhibiting film on metal surfaces in the cooling system. As the inhibitors perform this function, the inhibitors will deplete through contact with metal surfaces and prolonged service.

The various types of corrosion inhibitors will deplete at different rates, often depending on the severity of the operating conditions (high temperatures), service, quality of the make-up water, and other factors. Studies indicate that nitrites and silicates deplete rapidly in service, phosphates and triazoles are consumed at moderate rates, and nitrates and borates have slow depletion rates. Organic additive corrosion inhibitors deplete much more slowly than inorganic additives which allows longer service and testing intervals.

Extensive analytical data has shown that engine coolant corrosion Inhibitors deplete at different rates. For example, nitrite depletes quicker under high engine load factors while much slower in lightly loaded operation. Because of this, test strip and other field test methods test for nitrite more frequently, such as at PM intervals. Depending on the inhibitor chemistry (OAT, hybrid, or conventional), the coolant analysis results may vary as to how often or if specific action is required. Laboratory analysis results are often based on general limits. Contact your coolant supplier for recommendations on testing and interpretation of inhibitor level results.

TMC RP 329 specifies that prediluted antifreeze coolant must contain either:

a: at least 1200 ppm nitrite (as NO2), or;
b: a combined total of at least 780 ppm nitrite (as NO2) plus molybdate (as MoO4) with a minimum of 300 ppm either.

Laboratory analysis of coolants will have specific recommendations based on the TMC RP 329 type classification of inhibitors used. For OAT coolants that are RP 329 compliant, the same recommendations apply.

Operating with conventional chemistry coolants can allow for mixing with other conventional chemistry coolants without concern for weakening the cavitation pitting protection. When operating with OAT coolants, care should be taken to minimize dilution of the OAT inhibitor when mixed with conventional chemistry coolant. Generally, a 15-20 percent dilution is considered to be the upper acceptable limit of mixing. Treat such mixed coolants as "conventional" chemistry and maintain on an engine PM Interval basis, drain the mixed coolant and refill with new OAT coolant or treat with an OAT correction fluid as per the manufacturers recommendation.

NOTE: Care must be taken when adding SCAs and/or extender additives to replenish depleted corrosion inhibitors. Under-dosing may result in insufficient corrosion protection. Overdosing of inorganic additives (particularly silicate) may result in precipitate (silicate gel), deposits, and scale. Different types of coolants should not be mixed by more than 15-20 percent to avoid dilution of corrosion inhibitors.

NOTE: Conventional and OAT automotive coolants are generally not recommended for heavy-duty applications. These coolants do not contain sufficient additives for liner pitting, corrosion control and hard water anti-scale protection.

Hose Clamps

Hose clamps should be secured as close to end of pipe as possible to prevent tube corrosion.

CORROSION AND HVAC SYSTEMS

Preventive Maintenance for Minimizing Corrosion

Inspect the evaporator coil and heater core to see that it is free of debris and oil residue which may have been drawn through the air inlet. Debris on the evaporator coil or fan blades will impair the cooling efficiency and reduce the air flow. Remove debris using an air or vacuum hose. Use care to prevent possible damage to nearby components such as blower wheels, wiring, and capillary tubes. Ensure that the condensation drain hose is clear of all debris.

Inspect the condenser coil to be certain it does not exhibit extreme corrosion, bent fins, or any obstructing debris. These conditions will cause excessive head pressure, reduce cooling performance, and shorten compressor and clutch life. Damaged condensers should be repaired or replaced.

Check for loose nuts and bolts on the compressor mounting bracket and clutch. These fasteners should be tightened and torqued to the vehicle manufacturer's torque specifications.

CORROSIONAND SEAT BELT/OCCUPANT RESTRAINT SYSTEMS

Check all hardware for breakage, distortion, or excessive corrosion. Replace if necessary. See TMC RP 426, *Service Guidelines for Occupant Restraints.*

Refer to the vehicle owner's manual or vehicle manufacturer for the specific replacement policy. The belt assembly should also be completely replaced if there is malfunctioning of any of the major system components and/or damage to the hardware or webbing.

BODY CORROSION PROTECTION FROM DISSIMILAR METALS

This section addresses the mechanism of two-metal (galvanic) corrosion. Its purpose is to explain the process as well as offer ways to minimize corrosion where dissimilar metals contact each other in construction and repair of trailers and bodies.

Two-metal (Galvanic) Corrosion

In order to avoid or minimize the effect of two-metal corrosion, it is important that one understands why this type of corrosion occurs. The following is a brief and simplistic explanation of this type of corrosion and how it applies to trailers and bodies.

When two different metals are in contact and subject to a corrosive or conductive environment, there is a current flow between them. This current flow causes the corrosion of the least corrosion-resistant (active) metal to increase and corrosion of the more corrosion-resistant (inactive) metal to decrease. Because current flow and dissimilar metals are involved, this form of corrosion is called Galvanic, or two-metal corrosion. Corrosion progressively destroys the metal causing weakness, which can lead to failure.

This mechanism is what allows a dry-cell battery to produce electricity. (See **Figure 3-1.**) The plus terminal of the battery is a corrosion-resistant metal while the minus terminal is the least corrosion-resistant and therefore corrodes. This promotes current flow through the conductive gel in the battery. When the least corrosion-resistant metal is corroded away the battery has to be replaced.

Dissimilar Metals (Galvanic Series)

Metals used in trailer or body construction can be ranked as "active" and "inactive." **Figure 3-2** shows, in order of activity, a list of metals typically used.

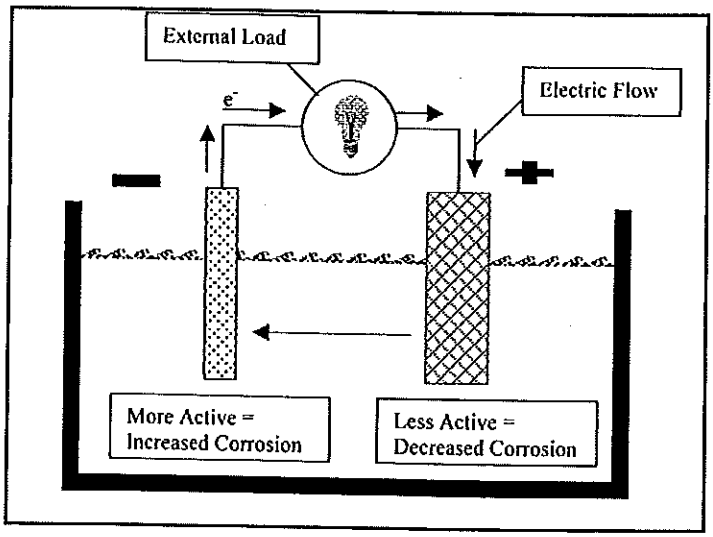


Figure 3-1

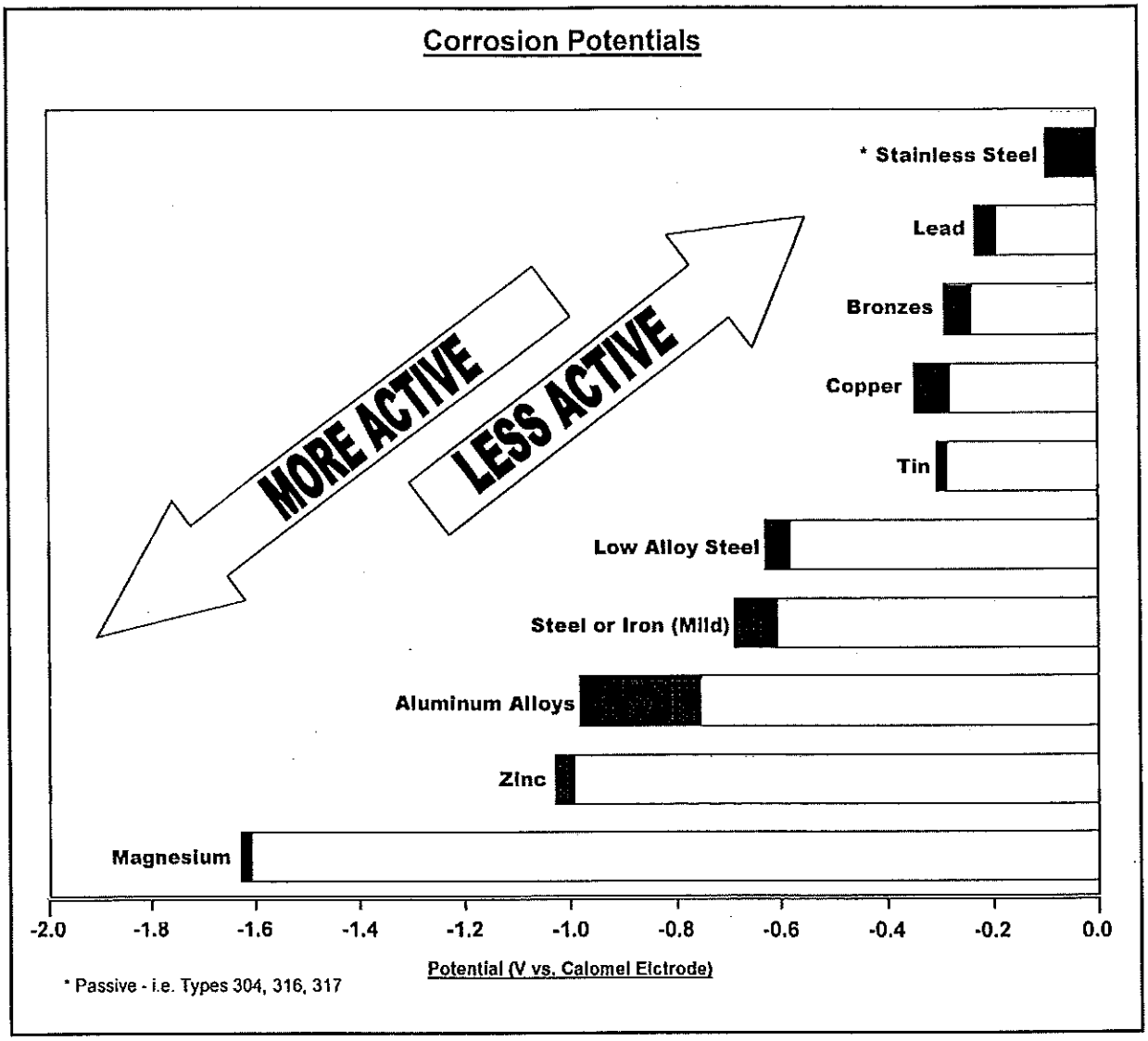


Figure 3-2

The corrosion rate is related to the distance between the metals in the ranking; the further apart the metals, the worse the corrosion rate. For example, aluminum is listed toward the active end while stainless steel is listed toward the inactive end of the list. If aluminum and stainless steel were immersed in a corrosive environment (road salt solution), the corrosion rate of the aluminum would be highly accelerated while the rate of the stainless steel would be reduced.

Note that aluminum is close in activity with steel. However, they are still dissimilar metals and are subject to considerable galvanic corrosion when in contact in a corrosive atmosphere. Awareness of this ranking and the effect it has on corrosion rates is critical to the initial construction and repair of trailers and bodies. When dissimilar metals come in contact, which is unavoidable, there are several design guidelines that can be employed to minimize galvanic corrosion, which will be discussed further.

Environment

Dissimilar metals do not have to be submerged in a conductive medium for galvanic corrosion to occur. Galvanic corrosion also occurs in the atmosphere and is dependent on the amount of moisture, the amount of oxygen, the conductivity, and the temperature. Galvanic corrosion does not occur when dissimilar metals are completely dry. The likelihood of trailer and body components remaining completely dry is questionable. Therefore, care must also be taken to keep moisture to a minimum throughout the entire production of the trailer.

NOTE: TMC RP 734, *Van Moisture Contamination Guidelines* addresses moisture in van trailers caused by external sources and internal condensation.

Joint Design

The corrosion rate of the dissimilar metals not only depends on the environment and the difference in potential, but also the

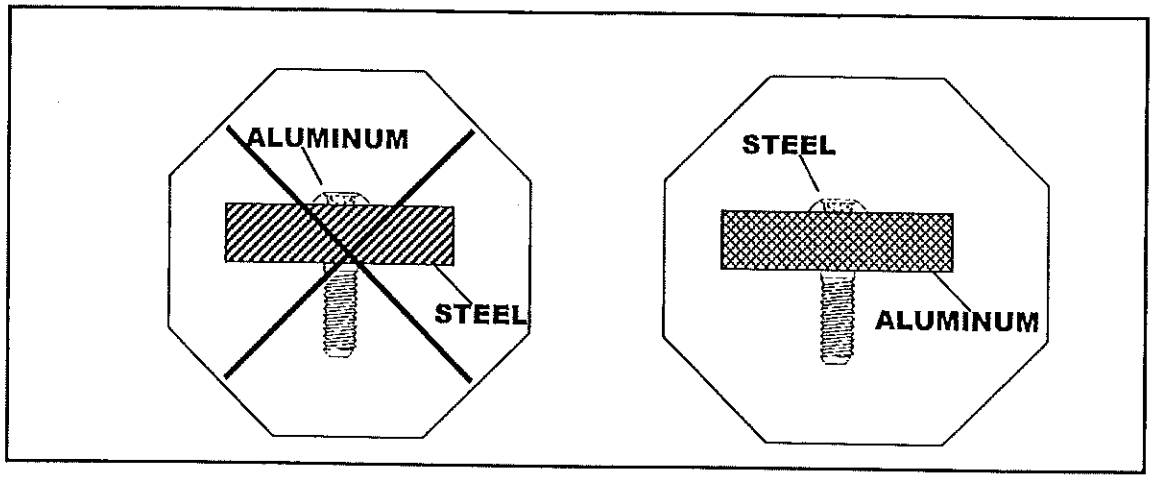


Figure 3-3

respective amount of the dissimilar metals. For example, an unfavorable situation would be to have a large area of inactive metal and a small area of active metal in any particular joint design. (See **Fig. 3-2.**) If this condition exists, the smaller active metal could corrode at an accelerated rate. This fact is particularly important to remember when using fasteners, bolts, and rivets, since they have a relatively small area in respect to the pieces of metal that are being connected (see **Fig. 3-3**). See next section for more information on using fasteners, bolts, and rivets.

Fasteners, Rivets, Screws and Bolts

When joining dissimilar metals with fasteners, rivets, screws, or bolts, etc. follow these points:

1. Pay careful attention to the corrosion potential chart and remember not to place a small amount of active metal in contact with a large amount of inactive metal. For example, never place an aluminum rivet in a large piece of steel. (See **Fig. 3-3.**)
2. When connecting two pieces of the same material, use a fastener/bolt made of the same material. For example, use an aluminum fastener when connecting two pieces of aluminum.
3. If the subjects being fastened are structural, use a fastener/ bolt of strength. For example, when fastening aluminum and steel in a structural application, use a fastener made of carbon steel with suitable plating.
4. Use the corrosion potential chart (**Fig. 3-2**) when selecting fastener/bolt material. Remember to never use materials far apart, (i.e., never use a fastener made of brass or copper to fasten aluminum and steel.)

When unavoidable conditions exist, follow preventive measures where possible.

Preventive Measures

1. If using the same metal is not possible, select combinations of metals as close together in the previously shown ranking.
2. Avoid small active metal contact with large inactive metal.
3. When dissimilar metals come in contact, use a nonabsorbent insulate between them. A polypropylene tape of 1.7 mils minimum thickness with a dielectric strength of 300-400 volts/mil is adequate for most trailer and body applications.
4. Paint or prime the two metals or select pieces, even if they have protective coatings. This is especially helpful in joints, if kept in good repair. It is particularly important to coat the active metal.
5. Avoid threaded fittings with materials far apart in the ranking and use washers, gaskets, and sleeves made of plastic or a compatible metal before connecting dissimilar metals.
6. Design for the use of replaceable active metal components or make them thicker for longer life.
7. Caulk in a joint between dissimilar metals can squeeze out and allow the two metals to contact; the use of a closed-cell neoprene tape tends to isolate dissimilar metals better.
8. The installation of yet a more active metal than the active metal in a joint will tend to corrode the most active metal and protect the less active metal. This is known as a sacrificial anode but seldom done on trailers and bodies.

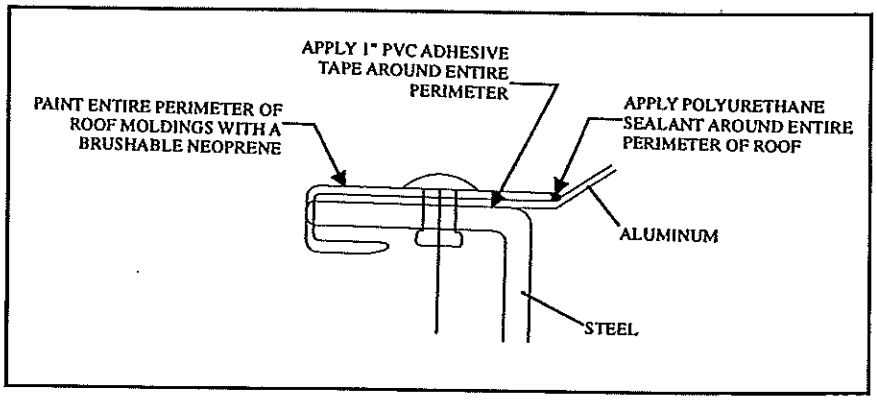


Figure 3-4: Sealing Joint Example

9. Use one-piece or welded construction versus bolting or riveting when possible.
10. If the above measures are not applicable for a joint design, care must be taken to ensure that moisture is allowed to drain.
11. Apply corrosion-inhibiting material (pastes, washers, compounds, etc.) under heads of screws or bolts inserted into dissimilar metal, even if they have already been treated.

Standard Test Methods

ASTM G-71: Guide for conducting and evaluating galvanic corrosion tests in electrolytes.

ASTM G-82: Guide for development and use of a galvanic series for predicting galvanic corrosion performance.

ASTM G-104: Test method for assessing galvanic corrosion caused by the atmosphere.

Informative Internet Websites

If more information involving galvanic corrosion is desired, see the following internet sites:

http://www.clihouston.com/howmetals.htm
How Metals Corrode

http://www.corrosionsource.com/learningcenter/galvanic.htm
Prevention, Tests, & Evaluation

http://www.anchorguard.com/reference_understand_what.cfm
What's Corrosion?

http://www.engineersedge.com/galvanic_capatability.htm
Anodic Index

http://www.ocean.udel.edu/mas/masnotes/corrosion.html
Galvanic Corrosion

http://www.corrmet.ndirect.co.uk/page6.html
Area Effect

http://www.astm.org/DATABASE.CART/PAGES/G71.htm
Std. Guide for Galvanic Corrosion Tests

http://www.eaa1000.av.org/technicl/corrosion/galvanic.htm
Galvanic Table

http://corrosion-doctors.org/Aircraft/galvseri.htm
Galvanic Series and Information

http://homepage.dtn.ntl.com/gordon.england/corrosion.htm
The Corrosion Process

SPEC'ING GUIDELINES FOR MINIMIZING VAN TRAILER MOISTURE CONTAMINATION

This section addresses moisture contamination in van trailers caused by external sources and internal condensation. This section offers suggestions to minimize this problem through equipment specifications, and proper construction techniques. It applies to van trailers used in Class 7-8 combination vehicles.

The next section, **Van Moisture Contamination Maintenance and Repair Guidelines,** offers recommendations on correcting moisture contamination.

Construction Techniques

The method used to connect the various components that make up the highway van is extremely important in preventing moisture contamination. All fasteners that pierce the exterior of the van should be watertight. Joints between panel connections and panel-to-rail connections must provide for a water-tight joint. Some type of sealant material applied during the assembly process is the most common way of doing this.

The attachment of the front and rear assemblies to the van body must be of sufficient design as to provide for a means of a protective water-tight joint. Some type of sealant material applied during the assembly process is the most common way of doing this. All mating surfaces should be free of any oils used during fabrication, and free of any metal shavings produced during the manufacturing or assembly process.

Careful consideration must be given to routing air and electrical lines in and out of the van body. Sealant alone may not be adequate or permanent. The use of properly sized grommets is encouraged. Whenever possible, route lines into the body on a vertical plane from below the body. This helps prevent moisture from running down the line and into the van body.

The rear door frame design is also critical to moisture contamination. The upper horizontal should be configured as to provide a rain-shed over the upper part of the doors. There are door gasket designs that incorporate multiple lips. Should one lip become damaged, there is another to prevent moisture intrusion. Whenever possible, the rear door lower edge should seal below the top of the van floor. This can prevent moisture from running on to the floor surface, should a gasket be defective. Lock rods and door gaskets should be inspected regularly for tightness of fit.

When overhead doors are specified, TMC recommends that side seals should be nylon brush-type. Head seals should be nylon brush-type when mounted on doors and standard polymer vinyl when mounted on header. Bottom seals should be polymer vinyl and mounted to allow seal replacement without disassembly

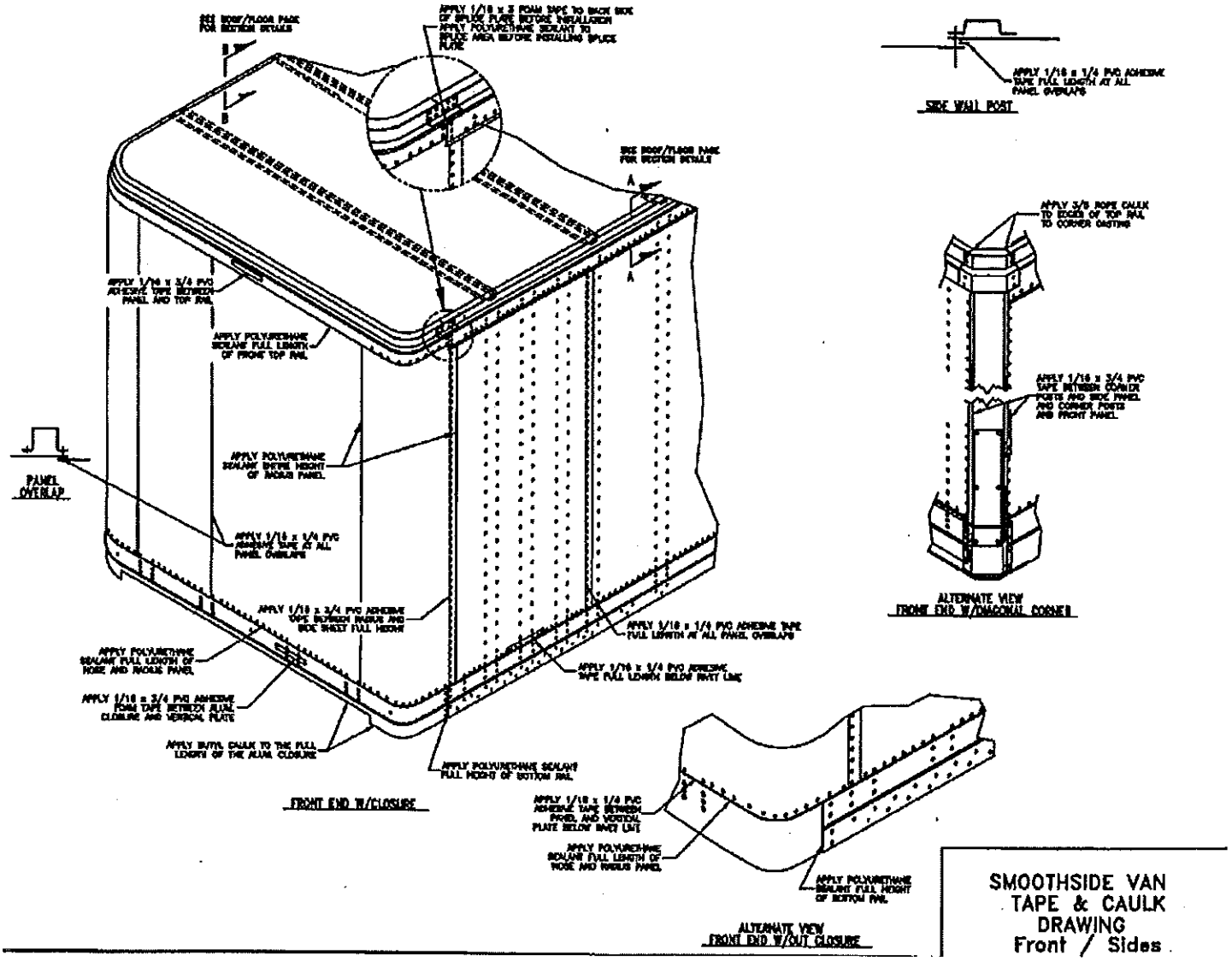


Figure 3-5: Front/Sides

of the door or hardware. (as per TMC RP 710A, *Overhead Door Selection, Installation, and Maintenance for a Dry Van or Body.*)

Most vans are furnished with wooden flooring. It is important that the bottom surface of the floor be entirely sealed prior to installation in the van. This ensures that the floor is sealed over each crossmember. Most floors are made up of approximately 12-inch wide boards that are full length.

The longitudinal joints between boards must be designed to accommodate expansion and contraction, as well as provide surface for the application of sealant. At each side of the van, where the floor contacts the side, there should be a shelf or top overlap for the floor to be sealed against the sidewall with sealant.

Figures 3-5 through 3-7 illustrate the concepts described previously. However, they are not intended to dictate any particular designs.

Prevention of Mold and Mildew Caused by Condensation

Moisture contamination due to condensation normally occurs when cargo high in moisture content, such as roll paper, is loaded into a van while its temperature is well above ambient conditions. The air surrounding the cargo is heated and absorbs moisture from the product. When the air comes in contact with the cooler van walls, the moisture condenses and form water droplets on the walls. There are several ways this condition can be minimized:

1. Heavily insulate the van.
2. Allow cargo to cool to ambient temperature before loading.
3. Provide a means of proper ventilation.

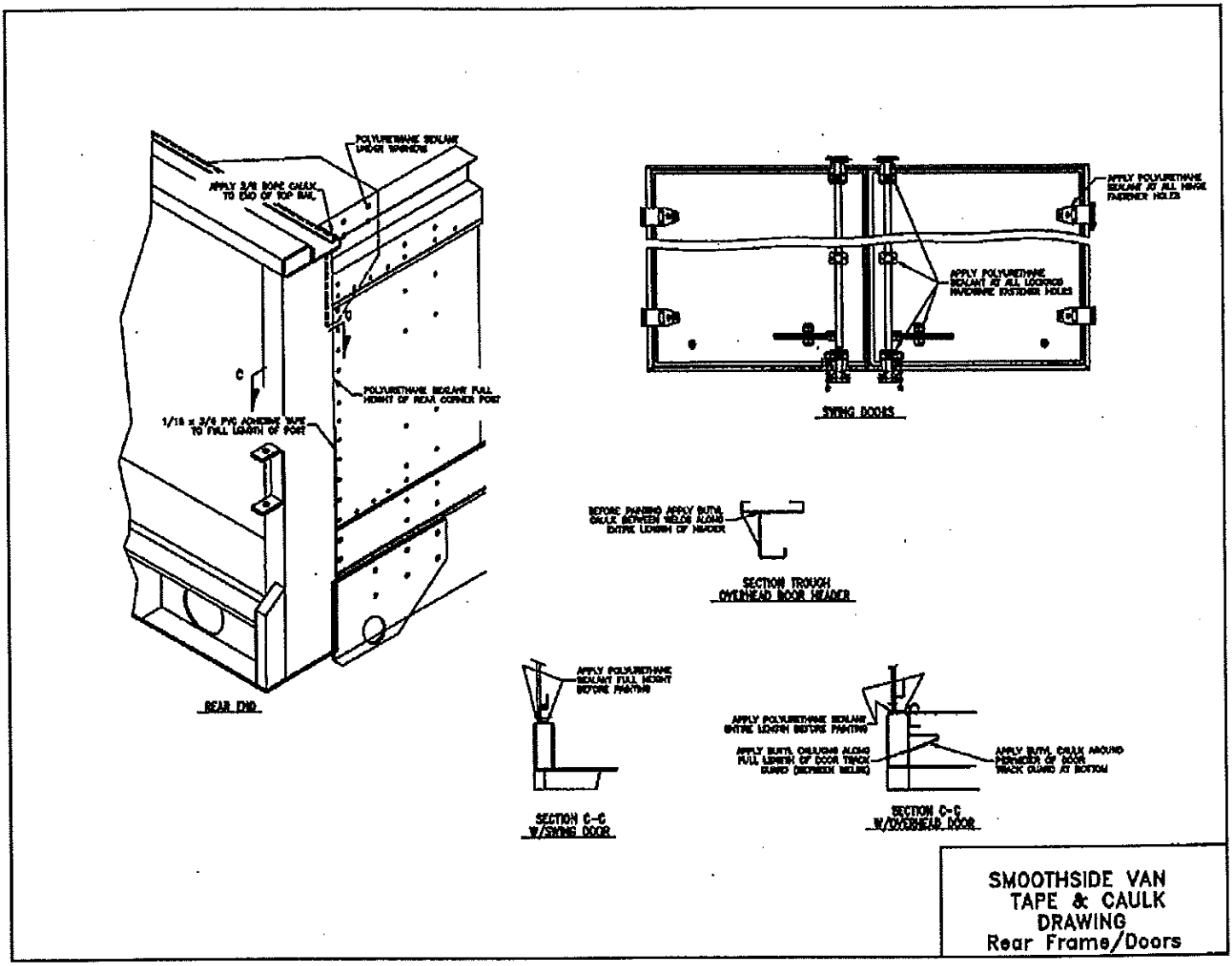


Figure 3-6: Rear Frame/Doors

Solutions 1 and 2 are not always practical. A van can generally obtain adequate ventilation with a passive ventilation system. Placing air vents in the front wall and rear doors generally ensures that trailer motion will generate sufficient air circulation inside the van to eliminate condensation.

Sealant Types And Usage

There are generally three types of high-performance sealants used in trailer construction:

- Polyurethanes
- Polysulfides
- Silicones

There are generally four types of general purpose sealants used in trailer construction:

- Butyl
- Non-Drying Butyl
- Butyl Tape
- Neoprene Coating

a. High-Performance Sealants

Polyurethane—A one-component, flexible sealant that cures in the presence of atmospheric moisture to produce watertight joints when used between panels and when panels are attached to rails. It can also be used as an adhesive when a primer is applied to the substrates prior to bonding. Polyurethanes exhibit good adhesion to most substrates, cure fast to an elastic seal, and can be painted.

Typical Uses:

- Sealing of top and bottom rail.
- Sealing front radius and nose panel seams.

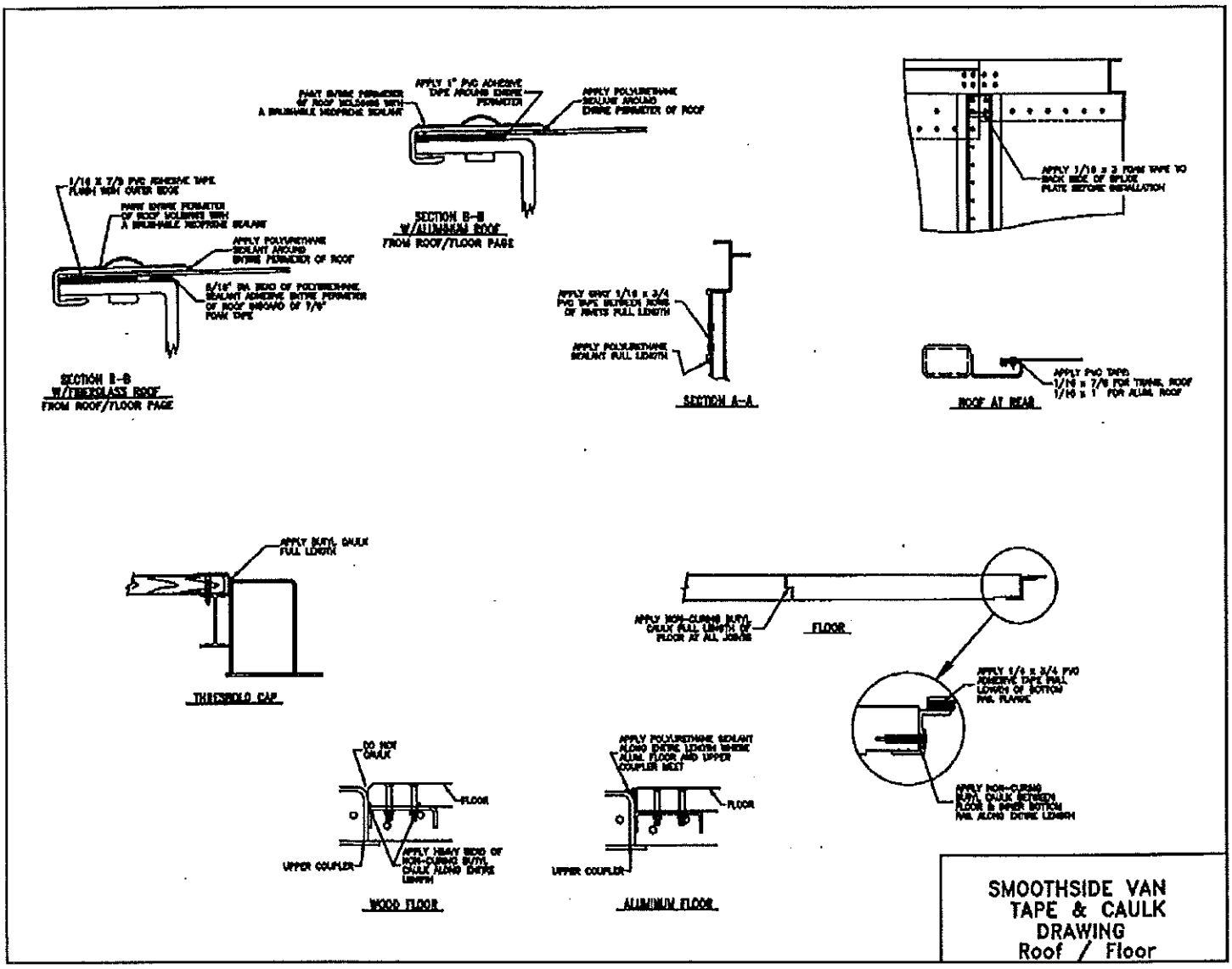


Figure 3-7: Roof

- Sealing of corner caps.
- Sealing under washers of rear frame, door assembly.
- Sealing front and rear corner posts.
- Sealing all hinge and lock-rod fastener holes.
- Sealing overhead door header.
- Sealing around perimeter of roof panel.

Polysulfides—A two-component adhesive/sealer designed to cure quickly at room temperature or within minutes with the application of heat. Forms a durable, high-strength bond without the use of a primer. Remains flexible and maintains its adhesion even in high and low temperature extremes. Polysulfides demonstrate high impact resistance even at low temperatures—unlike epoxies that crack on impact.

Typical Uses:
Adhesive for bonding aluminum or galvanized roof bows to aluminum or translucent roof panels either on- or off-line. Off line assemblies can be coiled and delivered to installation point on assembly line within 15 minutes when applied with external heat source.

Silicones—A one-component sealant, designed for sealing structural materials such as glass, aluminum, steel and plastics. Silicones have excellent resistance to weathering and temperature extremes. Painting is not recommended over silicone and, even when painting is not intended, ions tend to migrate to the surfaces to be painted causing "fish-eyes" to form on painted surface.

Typical Uses:
Sealing glass, and around plumbing and wiring harnesses. Also used as an exterior/interior sealant where surfaces are pre-painted.

b. General Purpose Sealants

Butyl—A one-component, low-cost, durable sealant with excellent adhesion, sealing properties and weather resistance. Designed primarily for interior sealing of trailers, vans and truck bodies.

Typical Uses:

- Sealing perimeter of wood and metal flooring.
- Sealing of air and electrical lines.
- Sealing around rear sill.
- Sealing between weld of door track.
- Sealing threshold caps.
- Interior sealing of corner caps.

Non-Drying Butyl—A one-component, non-curing butyl sealant used to protect against moisture and air leaks. Accommodates expansion and contraction between joint and seams. Also protects against corrosion and may be used for insulating dissimilar metal against electrolysis.

Typical Uses:

- Sealing longitudinal joints between boards of wood flooring.
- Sealing between floor and inner bottom rail.
- Sealing between floor and upper coupler.

Butyl Tape—100 percent solids pre-formed synthetic polymer based adhesive/ sealant tape having excellent adhesion to aluminum, galvanized steel, FRP, translucent panels, and other porous and non-porous surfaces. Adhesion improves with age and remains permanently flexible, even at low temperatures.

Typical Uses:

- Roof bow adhesive
- Seal between top rail and roof panel
- Seal between panel overlaps
- Seal edges of top rail to corner casting
- Seal bottom rail flanges
- Sealing of vents

Neoprene Coating—Brushable neoprene rubber sealer with excellent adhesion, weather resistance, and sealing properties. Dries quickly to form a tough durable seal and retains its flexibility for years.

NOTE: Since neoprene coatings are compounded with various solvents, use a nonflammable product.

Typical Uses:

- Seal entire perimeter of roof moldings.
- Seal perimeter stitching of roof panel.
- Seal rivet heads.

VAN TRAILER MOISTURE CONTAMINATION MAINTENANCE AND REPAIR GUIDELINES

This section offers maintenance and repair guidelines for moisture contamination in van trailers caused by external sources and internal condensation. It applies to van trailers used in Class 7-8 combination vehicles.

See the previous section, **Spec'ing Guidelines for Minimizing Van Moisture Contamination** for recommendations on preventing moisture contamination through proper specification.

Treatment of Mold and Mildew Caused by Condensation

Moisture contamination due to condensation normally occurs when cargo high in moisture content, such as roll paper, is loaded into a van while its temperature is well above ambient conditions. The air surrounding the cargo is heated and absorbs moisture from the product. When the air comes in contact with the cooler van walls, the moisture condenses and form water droplets on the walls.

Depending on the degree of infestation, there are several ways to remove mold and mildew from wood products:

- Commercial mildew removers, used in accordance with manufacturer's directions; or with a solution of one part bleach mixed in three parts by volume of warm water.

⚠ WARNING: Only use chemicals in accordance with the Material Safety Data Sheet (MSDS) precautions stated on the label.

- Power cleaning, using spray equipment such as media blasting using baking soda or dry ice. Also, dry-process spray cleaning, using baking soda or dry ice, followed by HEPA vacuuming of the work area.

⚠ WARNING: Always read the manufacturer's instructions/warnings before beginning a job using a potentially hazardous chemical. If you have questions about the chemical, refer to the MSDS or conduct the chemical manufacturer directly.

Typical Repair Techniques

a. Adhesive Patch

The following method should be used for aluminum panels such as roofs, sidewalls, and front panels.

1. Cut away damaged material around the area where the patch will be applied.
2. Clean the area where the patch will be applied with Scotchbrite-type pads that can be used on a die grinder. If applicable, remove old adhesive from any roof bows or top rails. A metal grinding wheel should not be used.

3. Clean the area with a glass cleaner or other non-acidic cleaner.
4. The patch must be applied to a flat surface. Cut out dents and kinks if possible.
5. Remove any rivets the patch will overlap, Rivets in rails and rivets in posts at sheet seams will be replaced.
6. Chose the correct patch material. Use only the listed materials for each patch.
   - Roof Patch—0.04 Aluminum Sheet (Typical)
   - Sheet and Post Patch–0.05 Aluminum Sheet (Typical)
7. Cut the patch at least 10 inches larger than the hole in both dimensions to allow for five-inch overlap on all sides of the patch.
8. Use a pen to mark the patch area on the surface. Make sure that all of the patch area is clean.
9. Apply automotive grade double-sided acrylic foam tape directly to patch. Place (2) two-inch wide strips along each side. Butt tape together at each corner to prevent leaks. Do not overlap tape at patch corners as this will cause the patch to leak.
10. Seal outer tape seams with a small amount polyurethane sealer.
11. Run a 1/4" bead of polyurethane sealer around perimeter of hole.
12. Heat surface in patch area.
13. Install patch. Ensure that the patch is centered in marked area. Apply pressure over entire patch.
14. Replace rivets as necessary, see **Step 6.**
15. Apply a bead of polyurethane sealer along all sides of the patch. A patch without a proper bead will leak.

b. Patch Installed with Fasteners

1. Surface preparation and patch configuration is the same for the adhesive patch.
2. Driven rivets are the preferred fastener, however if blind fasteners are used, they must be water tight configurations.
3. Polyurethane sealant should be placed on surfaces where the patch contacts the van skin.
4. Fasteners should penetrate the patch, polyurethane sealant and van skin. Fastener spacing should not exceed 1" center to center.
5. Fastener can be either 3/16" or 1/8" diameter and should not be placed closer than 1/2" from the edges of the patch.
6. After fasteners are installed, a bead of polyurethane sealant should be placed around the perimeter of the patch.

c. Major Repairs

Repairs that involve replacement of the whole panels or numbers of whole panels must be preformed as the original equipment was constructed. All sealants, foam tapes, etc. must be replaced as is indicated elsewhere in this RP and in TMC RP 734A.

d. Leak Detection Methods

In most cases, where water is found in the van interior is not where the site of water intrusion is. It may be necessary to remove liner panels to locate the leak site.

Light Test – This is the simplest, fastest test to conduct. Enter the trailer and close the doors while the entire exterior is exposed to light such as, outside during a bright day. A careful visual inspection of the interior looking for light leaks will reveal potential water leak sites. Several minutes of sight normalization will be necessary before light can be detected adequately.

Water Test – In this test, the entire van is run through a truck wash under relatively high pressure. Immediately afterward, the entire interior is physically examined for presence of water. It is highly recommended that the van manufacturer water test each van at final assembly.

Smoke Test—A smoke bomb is lit and placed in a pan on the floor at the center of the trailer. The doors are closed and after several minutes the entire exterior is examined for leaking smoke. This test must be run indoors unless there is little to no wind outdoors. These smoke bombs are usually available at theatrical supply stores. The interior can easily be pressurized to 0.50" water column, which will make leaking smoke much more visible.

Ultrasonic Leak Detection—A sonic generator is placed in the interior of the van and the doors are closed. An electronic detection device is scanned over the entire van exterior. The device has a signal strength meter, which is used to precisely locate the leak site. This will require proper frequency settings which can be obtained from the device manufacturer.

MINIMIZING DIRT AND WATER INTRUSION IN LIGHT/MEDIUM VEHICLE CARGO AREAS

This section describes the best design technologies available for reducing water and dirt intrusion into cargo areas for walk-in type vans and dry-freight bodies. It also describes the maintenance and repair procedures to support these technologies. This section offers both design goals for vehicle and component suppliers, and specification and maintenance guidelines for equipment users.

There are two approaches to keeping dirt and water out of the cargo area. One approach—the cargo area differential pressure approach—tries to control the air flow in and around the vehicle so that the interior air pressure remains slightly higher than the exterior pressure. In this situation, air flows out through any openings in the vehicle body. The other approach—which is more common and probably more effective—attempts to improve vehicle and component design. This section addresses both approaches.

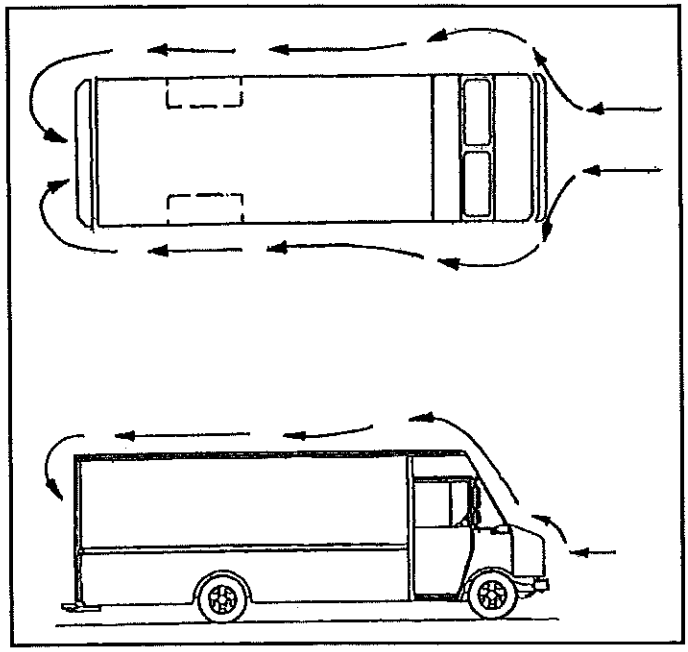


Figure 3-8

Minimizing Dirt and Water Intrusion via Cargo Area Differential Pressure

(Walk-in Vans)
Due to design characteristics, the cargo area of the walk-in van is in a state of reduced atmosphere pressure (partial vacuum) during normal operation. This condition allows dirt and water to be drawn past seals and through seams and openings into the unit. There are several things than can be done to minimize this phenomenon.

One option is to seal off the front of the cargo area with a sealed partition between the driver and cargo areas, and incorporate a vent system that pressurizes the cargo area to a higher level than the low pressure exterior areas. This approach can also reduce cargo area temperatures in hot climates, due to air exchange.

Current pressure differential vent designs are relatively new and can allow water to be carried in along with intake air. Because of this, the vehicle operator must monitor the intake air vents to make certain that dirt and water don't intrude into the cargo area.

If this approach is used, a venting system needs to be designed to keep water out during wet conditions. It also requires an air filter to eliminate dust intrusion.

Drawbacks of cargo area differential pressure system are as follows:

1. The increased costs for the body or add-on system.
2. The increased costs associated with sealing the bulkhead and increased costs/ complexity of the bulkhead and the bulkhead door.
3. The entire system is ineffective if vents, windows or the bulkhead door are open.
4. This system does not allow for accurate temperature control of the cargo area in cold climate operation or operation with cargo area air conditioning.

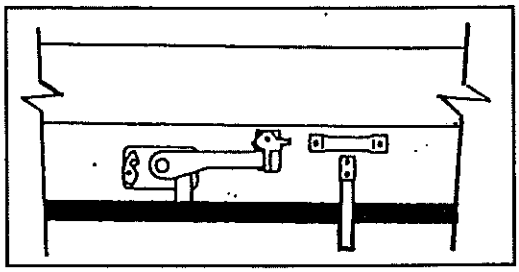


Figure 3-9

Another method of creating a differential pressure is through better understanding and control of the airflow around the exterior of the vehicle. **(See Fig. 3-8.)** If this method is employed, an analysis of the exterior vehicle airflow under various conditions needs to be conducted so that high and low pressure areas on the exterior surface of the vehicle can be identified. The objective is to ensure that the interior pressure remains greater than the exterior pressure in areas where the vehicle is most susceptible to water and dirt intrusion, such as rear roll-up doors. The analysis also reveals optimum areas for venting air into the vehicle to increase interior pressure.

The drawbacks of this approach are:

1. Increased costs if add-on accessories are needed to control air flow, such as fairings, air foils, etc.
2. Vehicle air flow characteristics could be negatively affected by the addition of other optional exterior accessories.

Minimizing Dirt and Water Intrusion Through Vehicle/Component Recommendations

The following section offers fleets and manufacturers guidance in vehicle/component design and specification to help minimize dirt and water intrusion in cargo areas.

a. Rear Roll-up Doors
(Walk-in Van and Dry Freight Bodies)
Doors should be designed to be at least one inch wider than the door opening on each side to allow for door and seal overlap. Fleets should specify a locking mechanism that keeps doors from bouncing and moving fore and aft when the vehicle is in motion: this movement accelerates seal wear. A self-adjusting door latch of the type shown in **Fig. 3-9** is recommended to minimize door movement.

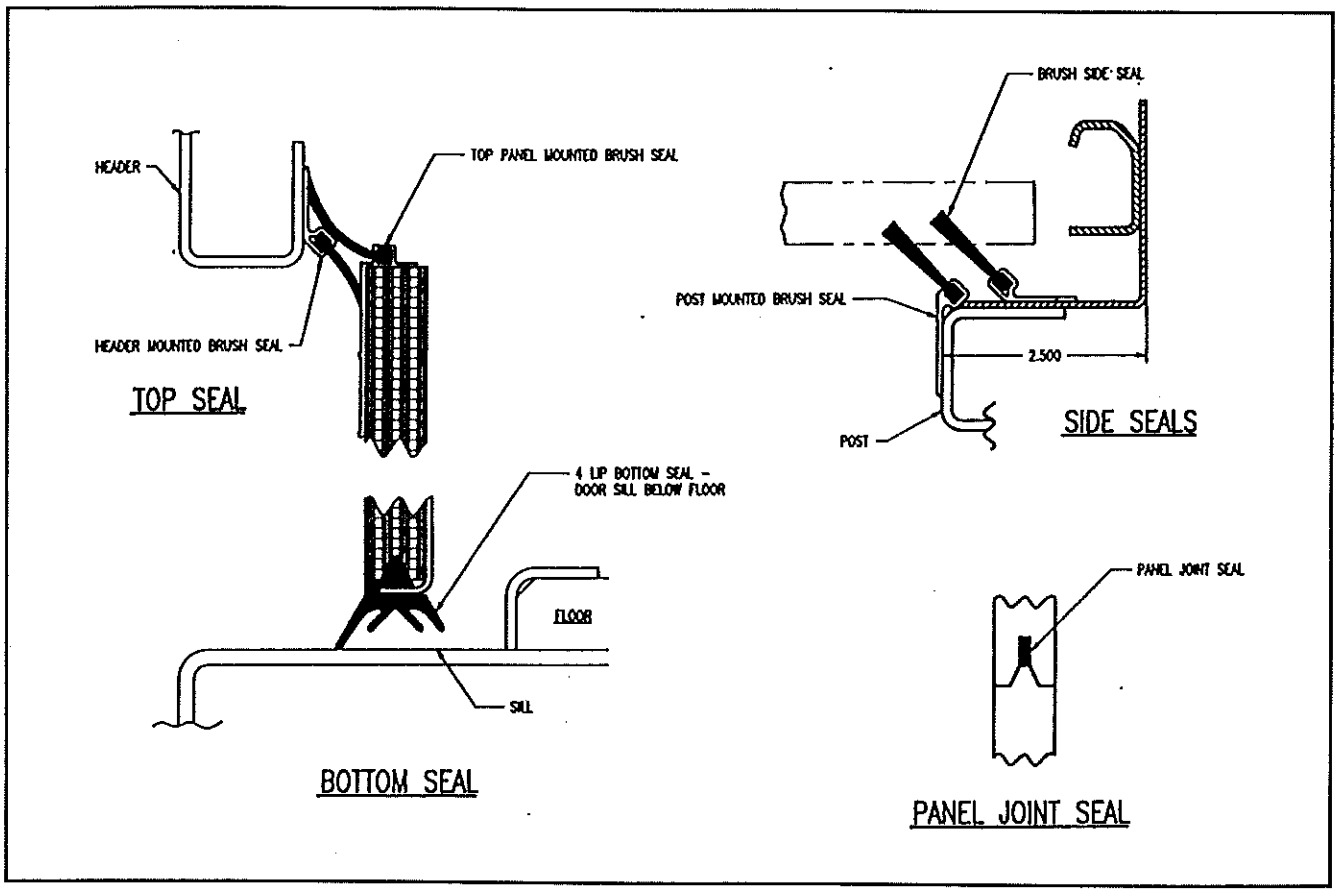


Figure 3-10

Rear roll-up doors must be specified with the appropriate seals for the application. **Fig. 3-10** shows current seal designs which seal against both water and dirt intrusion:

- **Top Seal**: A double nylon brush seal should be used—one mounted to the top door panel and the other mounted to the header.
- **Bottom Seal**: A four-lip rubber seal should be used which rests on a sill slightly below the floor level. However, if a liftgate will be installed on the truck, the sill may need to be kept at floor level, or a ramped transition from the floor to the sill may be needed.
- **Side Seals**: A double nylon brush seal should be used.
- **Panel Joint Seal**: A closed-cell foam or bulb seal along with a tongue and groove mating surface.

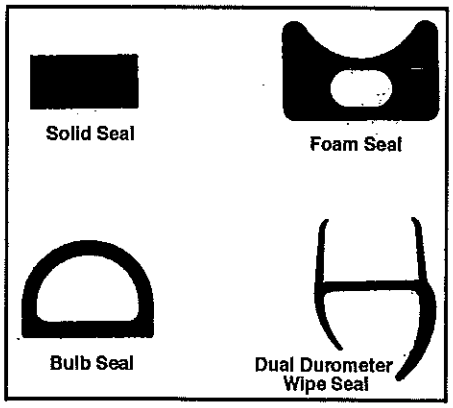


Figure 3-11

It is very important to develop a maintenance program to inspect and replace worn and/or damaged seals as needed.

b. Rear Swing Doors (Walk-in Van and Dry-Freight Bodies)

A wide variety of seals are used to seal rear swing doors. (See **Fig. 3-11.**) They are all effective as long as the latching mechanism is adjusted properly. The dual durometer wipe seal is typically used only on dry-freight bodies.

Of the various types of latches available for rear swing doors (See **Fig. 3-12**), the best latch is one that draws the door tightly into the seal and ensures a secure fit. Deadbolt locks and cam-type locks fit this criteria. The drawback of a cam-type lock, however, is that there is no inside release. These systems feature low maintenance. However, a maintenance schedule to inspect and replace worn and/or damaged seals remains essential.

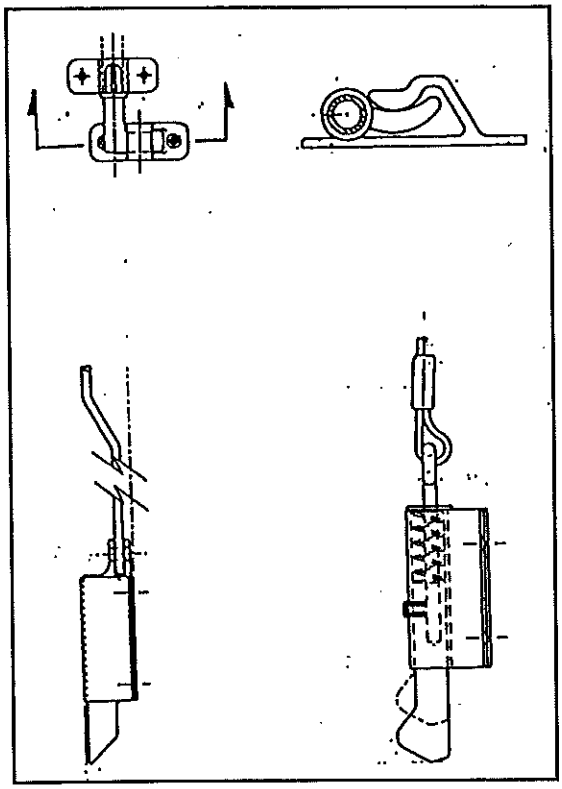


Figure 3-12

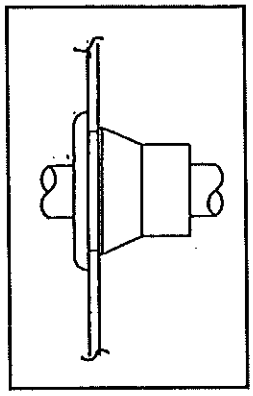


Figure 3-13

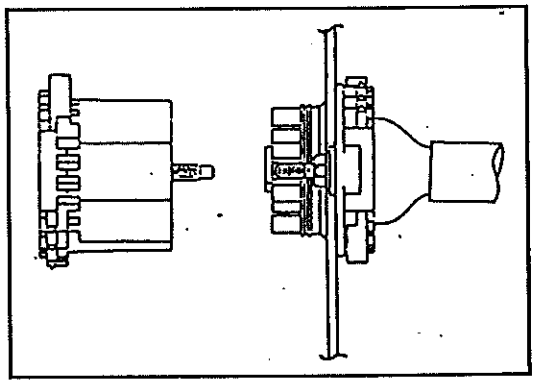


Figure 3-14

c. Wheelwells
(Walk-in Van and Dry Freight Bodies)
Wheelwells are usually sheet aluminum assemblies attached to the floor to provide clearance for tires. These wheelwell sub-assemblies extend through the floor and are sealed to the floor assembly to prevent water and dirt intrusion. It is good practice to specify that mechanical fasteners should not extend through the wheelwell.

If leaks occur, due to a failed seal joint or damage from other sources, the recommended repair is to reseal the appropriate area with urethane sealer, and/or patch seal the appropriate area.

d. Floors:
(Walk-in Van)
Floor designs today for walk-in delivery vans are of a transverse extruded aluminum floor beam design with a tongue-and-groove joint. These are designed to prevent water from traveling through the joint. However, due to the reduced cargo area pressure, water and air may be pulled thru these joints.

If the floor beam joint is allowing water to intrude, locally sealing the joint with a urethane sealer—internally or externally—is the most appropriate method of repair. Water that may be on the floor from other leak sources may be incorrectly interpreted as a floor joint water leak.

NOTE: Undercoating will not help water intrusion. Undercoating is designed as a corrosion protection and is not a good leak prevention material.

e. Side-sliding Doors
(Walk-in Van and Dry-Freight Bodies)
Fleets currently face a trade-off between minimizing sliding friction and maximizing sealing in the design of sliding door seals.

Door seals should be designed so that they are not exposed when the door is open. This prevents the seals from being damaged by drivers entering and exiting with packages.

Maintaining proper door adjustment is essential. Body manufacturers should provide customers with proper specifications and door adjustment procedures.

f. Windshields and Windows
(Walk-in Van and Dry Freight Bodies)
The most common method for installing windshield glass in walk-in vans, as well as in medium and heavy trucks, is to use a rubber "H-molding" to "zip" the glass into the opening. Although this method allows for quick and easy windshield replacement, this design requires very tight controls on glass size and opening size to ensure waterproof installation.

Industry leaders are investigating other methods of windshield installation to improve sealing.

g. Front End (Walk-in Van)

Manufacturers should minimize the number of separate wires and cables passing through the cowl panel from engine compartment to the cab. Wires and cables should be bundled and molded grommets or sealant on the bundles should be used where they pass thru the cowl panel. (See **Fig. 3-13.**) The same approach applies to wires passing through the front radius cap for clearance lights.

Also, when possible, connections between engine compartment wire harnesses and cab interior harnesses should be made using a sealed, surface mount connector on the cowl panel. (See **Fig. 3-14.**)

h. Roofs (Walk-in Van and Dry Freight Bodies)

Body manufacturers need to continue to focus on designing body joints which inherently seal to minimize the dependence on sealants. Also, the body design must—as much as possible—direct water away from seams and joints. Bodies should be designed to minimize body seams.

Manufacturers should design sealant channels into body seams so that a sealant can be applied during construction and is therefore not exposed on the completed vehicle. This would protect the sealant from damage caused by ultraviolet light, ozone, abrasion, etc. Manufacturers should also make every effort to minimize the number of fasteners which go directly through the roof and into the cargo area.

i. Vents (Walk-in Van and Dry Freight Bodies)

Vent location and type is critical to ensuring that the vent allow dirt and water intrusion. Vents should be located on the body in an area where it is shielded as much as possible from dirt and water, and where the airflow past the vent is as clean as possible. Manufacturers should make air filtration and water traps an integral part of vent designs.

j. Sealants and Adhesives: (Walk-in Van and Dry Freight Bodies)

Keeping water and dirt out of the cargo areas is the main purpose for using sealants and adhesives. Any time a hole is drilled or sheets of panels lap, the potential exists for water and dirt intrusion. This RP offers the following guidelines for using sealants and adhesives.

Of all the sealants and adhesives on the market today, one-compound polyurethanes have proven to be the most effective at keeping cargo areas sealed. One-compound polyurethanes:

- are paintable, which allows more flexibility in the repair process.
- remain permanently elastic, which means you won't have to worry about the seal cracking due to shrinkage.
- require no mixing, which reduces waste.
- bond as well as seal, which can eventually reduce the amount of mechanical fasteners needed to hold the unit together. Bonding with these adhesives will also reduce the amount of noise and eliminate corrosion.

The following are recommended application instructions for one-compound polyurethanes adhesives.

Substrate:

The substrate should be clean, dry, free of water, grease or rust and of sound quality. Remove all loose particles such as residues of color, splashes, etc. Clean surface with a strong jet of compressed air, sandblast, or solvent.

Priming:

Usually no priming is required. Since substrate type and uniformity can vary, a pretest is recommended. Sealant manufacturers offer primers when substrates require them. Since compatibility between different manufacturers' products is in question, do not mix and match different manufacturers' primers and sealants.

Application:

Recommended application temperatures: 40-100° F. For cold weather applications, store sealants at approximately 70° F; remove just prior to using. Make sure joint is frost free. Cut tip of plastic nozzle to joint size. Puncture airtight seal. Install with hand or power operated caulking gun. For best performance, sealant should be gunned into joint when joint slot is midpoint of its designed expansion and contraction. To facilitate tooling, wet pointing tool or finger with soapy solution.

Limitations:

- Since system is moisture cured, permit sufficient exposure to air.
- Do not apply over silicones, or in the presence of curing silicones.
- Avoid contact with alcohol, and alcohol containing-solvents during cure.
- For best results, use open cartridges the same day.

k. Miscellaneous (Walk-in Van and Dry Freight Bodies)

Mirrors, Lights, Wipers, License Plates, etc.

Wherever possible, accessories should be located so that the fasteners do not pass through the body into the interior. However, when it is necessary, wires should be covered with molded grommets and all fasteners should be self-sealing or rubber washers should be used.

SPECIFICATIONS TO PREVENT GALVANIC CORROSION IN ALUMINUM WALK-IN VAN BODIES

This section is designed to offer specification guidelines to minimize galvanic corrosion in aluminum walk-in van bodies. This RP only addresses the aluminum walk-in van body itself because the service life of the entire vehicle is usually determined by service life of the body.

For corrosion to take place, all three of the following conditions must be met:

- Two dissimilar metals must be present.
- These metals must be connected electrically.
- An electrolyte must be present (i.e., calcium chloride or road salt, once in liquid form).

If any one of the above items isn't present, galvanic corrosion cannot occur.

Recommended Specifications for Stopping Galvanic Corrosion

Much of the effort to minimize galvanic corrosion has focused on road de-icing materials. Salts of many types are excellent electrolytes, but aluminum and steel can corrode by merely being placed together in a higher humidity (above 60 percent relative humidity) environment (since water is also an effective electrolyte). Some chemicals, such as magnesium salts, have proven to be particularly corrosive because of their propensity to absorb water.

In humid climates, the conductive path between the dissimilar metals must be broken to completely stop corrosion. This is often very difficult, if not impossible, in existing vehicles. Manufacturers try to prevent the establishment of a conductive path in new vehicles by using a variety of coatings (paint, powder coating, etc.).

In instances where metal fixtures (i.e., mirrors brackets, inside shelving, etc.) are mounted on an aluminum body, galvanic corrosion can be minimized by placing an insulator between the aluminum body and mounting surface. Additionally, the use of stainless steel or coated hardware will inhibit the conductive path and reduce galvanic corrosion. This practice should be followed when mounting any dissimilar metal fixture on an aluminum body.

With regards to the vehicle underside, there are several coatings and sealants that have proven to be very effective in reducing galvanic corrosion, if applied correctly.

When specifying new vehicles, equipment purchasers should consider the following:

- Using coatings that isolate the bolts and the dissimilar metals Some examples of effective coatings are:
  - zinc chromate primer (MIL-P-8585)
  - strontium chromate primer (MIL-P-23377
- Gluing or bonding dissimilar metals together. Glues are now capable of handling much higher stresses than they were only a few years ago.
- Using stainless steel hardware. [Note that stainless steel can still corrode in a salty environment.] When using stainless steel hardware, it is still necessary to insulate the hardware from the body. Using insulated bushings in the mounting holes and insulated washers will also help reduce the conductive path.
- Reducing areas that trap moisture by implementing designs that provide better drainage.
- Reducing the cathode-to-anode ratio. This can be achieved by using advanced coatings or metal treatments that prevent metal transfer. By coating the cathode with the proper material, the exposed cathode-to-anode ratio can be reduced. Do not coat the anode without coating the cathode, because accelerated corrosion may occur in areas of coating imperfection on the anode.

Maintenance Guidelines

Equipment users face a difficult task in stopping corrosion on existing vehicles. Since it isn't usually possible to reduce or eliminate the amount and severity of the electrolyte present, the last strategy left is trying to break the conductive path. (Remember, just spraying a coating over a corroded area usually does little or nothing to affect the conductive path).

Although it is often difficult, determining the conductive path should be the first step to preventing further corrosion. After determining the path, try to identify methods to break the path, such as using well-isolated fasteners. If corrosion damage is extensive, don't merely paint over it. Either sand blast the rust away, or better still, cut out the rusty metal and replace it with new metal.

There are also some recently-developed coatings designed to neutralize rust before sealing over the entire area. These can be used very effectively in applications where there is no relative motion. If corrosion persists, contact the truck body manufacturer for more information.

TRUCK WASHING AND CLEANING GUIDELINES

This section offers guidelines for the washing and cleaning of commercial vehicles. It is meant to provide information on establishing, and the benefits of, a proper vehicle washing program. It is not intended to endorse any single method or chemistry. These guidelines apply to all commercial vehicles.

Benefits Of Vehicle Washing

Vehicle washing is incorrectly viewed by some as an expense

with little or no return. Many studies show that the use of proper cleaning methods can extend vehicle life by eliminating tenacious soils and reducing corrosion issues caused by today's road chemicals, such as calcium and magnesium chlorides.

Company and public image is an important benefit, as is the protection of costly vehicle decals and paints. Clean vehicles also help ease maintenance, which ultimately increases vehicle safety. Lastly, clean vehicles support fleet driver retention programs and can increase employee morale.

Regulatory Considerations

a. Regulatory Requirements

Vehicle wash water is considered an industrial waste water discharge and must meet special conditions imposed by federal, state and local agencies. If vehicle wash water is allowed to mix with storm water runoff, the discharge is subject to federal permit conditions under the National Pollution Discharge Elimination System (NPDES). These regulations, which were created as part of the 1987 amendments to the Clean Water Act, require vehicle wash water to be separated from storm water in its collection, treatment and discharge. Vehicle washing operations that discharge to surface waters risk violation notices and fines of up to $50,000 per day for knowingly violating these regulations.

b. Wash Water Disposal Options

Acceptable vehicle wash water disposal options include:

- Closed-loop water recycling—which uses recycled water and eliminates discharge to surface water, storm sewers, municipal sewer systems or the ground. Additional services may be needed to dispose of chemical sludge and other contaminants and pollutants that accumulate in the water reservoir.
- Partial water recycling (reclaim) —which uses recycled water in some stages of the wash process, but introduces fresh water during the rinse cycle. Filtration and settling systems are used to reclaim a portion of the wash water, allowing the remaining wash water to be discharged to the sanitary sewer after meeting pretreatment requirements.
- Discharge to municipal sewer system—in which waste water is discharged directly into the municipal sewer system. Local sewer authority may require approvals and pretreatment of discharge.

c. Water Treatment Considerations

Fleet managers should properly evaluate the following factors when establishing a washing/cleaning program:

1. Operating Environment
   - Fleet description
   - Cargo
   - Weather conditions
   - Road chemicals
   - Sand / Dirt / Soil contents
2. Quality of Rinse Water Needed
   - USDA / FDA requirements
   - Proper removal of harsh detergents
   - Appropriate rinsing of undercarriage road chemicals
   - Hardness of water
3. Solids Disposal/Treatment Plan and Costs.
   - Plan for treatment and disposal of wastes/liquids
   - Annual costs for treatment and disposal
4. System Odors and Proper Treatment.
   - Is water in constant motion and have contact with air?
   - Will additional chemical treatment (chloride, etc.) be needed?
   - Will biological by-products need treatment?
   - Costs and labor for above.

Business Considerations

The following list contains items that fleet managers should consider when establishing a vehicle washing/cleaning program.

- Desired wash quality
- Vehicle condition
- Fleet size
- Fleet type
- Frequency
- Overall budget and/or budget per vehicle
- Labor—available and trained
- Space available
- Time constraints/time per vehicle
- Water availability/restrictions
- Ongoing maintenance costs
- Capital expenditures
- OSHA compliance issues
- Environmental compliance
- Administration/control
- Anticipated equipment downtime

Washing Methods

Vehicle washing methods can be categorized into three methods: mobile/hand (pressure washing), permanent wash facility, and commercial wash facilities off property. What follows is an overview of the pros and cons of each method.

a. Mobile/ Hand (Pressure Washing)

Pros

- Minimum Labor Issues (mobile)
- Minimum Maintenance Costs (mobile)
- Low Equipment Costs
- On Premise
- Convenience

Cons

- Wastewater Containment
- Total / Shared Liability for Waste Water

- Wash Speeds & Volumes
- Verification / Audit
- Chemical Consistency
- Labor Intensive
- Health and Safety Precautions for Chemicals

Important Considerations for
Mobile/Hand (Pressure Washing) Method

- What are the state/local waste water permit requirements?
- Does your provider follow EPA regulations and capture the waste water?
- Who is responsible for permit cost and possible fines?
- Where will waste water be disposed?
- How will authorization and proof of wash completion be transacted?
- What equipment will be used?
- What detergents will be used?
- What is the definition of a wash (roofs, underchassis, etc.)?

b. Permanent Wash Facility (Dedicated On-site Wash Bay)

Examples of this method include: manual, pressure washer; automated—brush, touch-free, or combination.

Pros

- On-Premise
- Reduced Labor
- Consistency
- Liability Control
- Cost Controls
- Labor Reduction

Cons

- Capital Investment
- Operating Costs
- Dedicated Facility
- Regulatory Requirements
- Training of Operators
- Safety and Training Issues

Important Considerations for the Permanent
Wash Facility Method

- How many vehicles per day need to be washed?
- What labor is available?
- What is the required capital investment?
- What modifications and utility hook ups will be needed?
- Is there a "cost per wash" option available?

c. Commercial Washing (Off-Site Hand, Automatic or Combination Wash)

Pros

- No Space Requirements
- No Capital Investment
- No Labor
- Reduced Liability

Cons

- Off Premise
- Driver Inconvenience and Downtime
- Availability/Hours Open
- Chemical Variance
- Costs
- Larger Time Blocks Required

Important Considerations for the
Commercial Washing Method

- What chemicals will be used?
- What is the policy on damage caused by wash/chemicals?
- Is fresh or recycled water used in rinse application?
- Are appointments needed?
- What is the average wait time?
- What is the satisfaction guarantee?

Recommended Cleaning Practices

Although there are several accepted methods of cleaning a vehicle, they have one thing in common— the "cleaning equation" or W.A.T.C.H. formula.

W

"W" stands for water. Water used for cleaning should be heated and soft—not hard—to optimize cleaning chemical performance. Rinse water should always be clean. **Table 3-4** illustrates the estimated detergent savings for using soft water.

TABLE 3-4

Water Hardness In Grains/Gal.	Estimated Detergent Savings
2 - 5	15%
5 - 10	25%
10 - 15	35%
15 - 20	45%
Over 20	50%

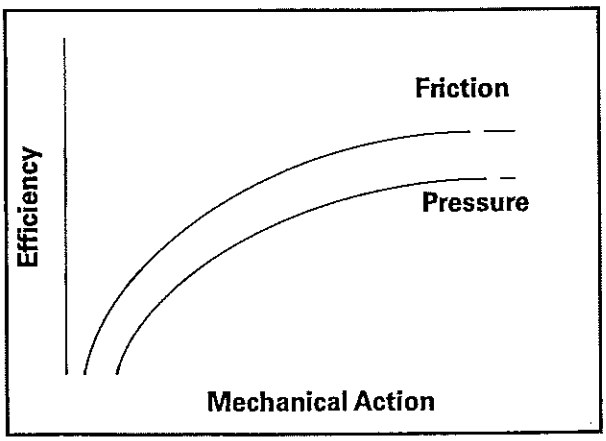


Fig. 3-15

A
"A" stands for Action. Action refers to physical processes that occur during the wash process. Actions items include: high-pressure, brushes, roof mops/curtains, etc.

When it comes to water pressure (touch-free) or friction (brush pressure), there are four important elements:

- pounds per square inch (psi).
- water volume.
- impingement angle to surface.
- relative velocity to surface.

Fig. 3-15 illustrates the relationship of mechanical action to efficiency.

T
"T" stands for Time. Proper chemical dwell time (or time required for optimal cleaning performance) and mechanical processes are very important.

C
"C" stands for Chemical. Using the correct cleaning agent selected for proper soils/films, correct dilution ratio (optimal suggested mix ratio of chemical to water) is also important.

H
"H" stands for Heat. Heat optimizes chemical activity and performance. The more fats or oil contained in the dirt, the more need there is for a higher water temperature. **Fig. 3-16** illustrates the relationship between ambient and required wash water temperature. Air temperature, surface temperature and the temperature of the detergent solution must all be considered for proper wash operation. Temperature is a measure of activity, and extremes of either too high or too low create problems.

When it is cold outside, and the surfaces are very cold, the temperature of your detergent solutions must be increased to compensate and achieve the necessary activity to clean properly.

Extremely hot surfaces have more serious problems. The surfaces themselves become reactive and can be damaged through reactions with the detergent solutions. Wax coatings are the most susceptible surfaces, however aluminum bright work and wheels can also be cosmetically affected. In addition, most detergents have an upper temperature limit where they begin to lose effectiveness. This limit is called the cloud point, which is the temperature at which the surfactant in the detergent compound comes out of solution and becomes less effective.

The relationship of these five factors can be found in any cleaning process from washing your hands, mopping a floor to cleaning a vehicle. The ideal cleaning scenario would be a non-aggressive chemical, diluted in hot, softened water for application purposes; adequate dwell time for the cleaning solution to work, followed by proper mechanical action (brushes/pressure) and a proper rinse will result in a high quality wash.

Adjustments made to any portion of the wash equation will adversely affect cleaning benefits, results and cost. Apply this formula to your current wash procedures to gain an understanding of your cleaning program.

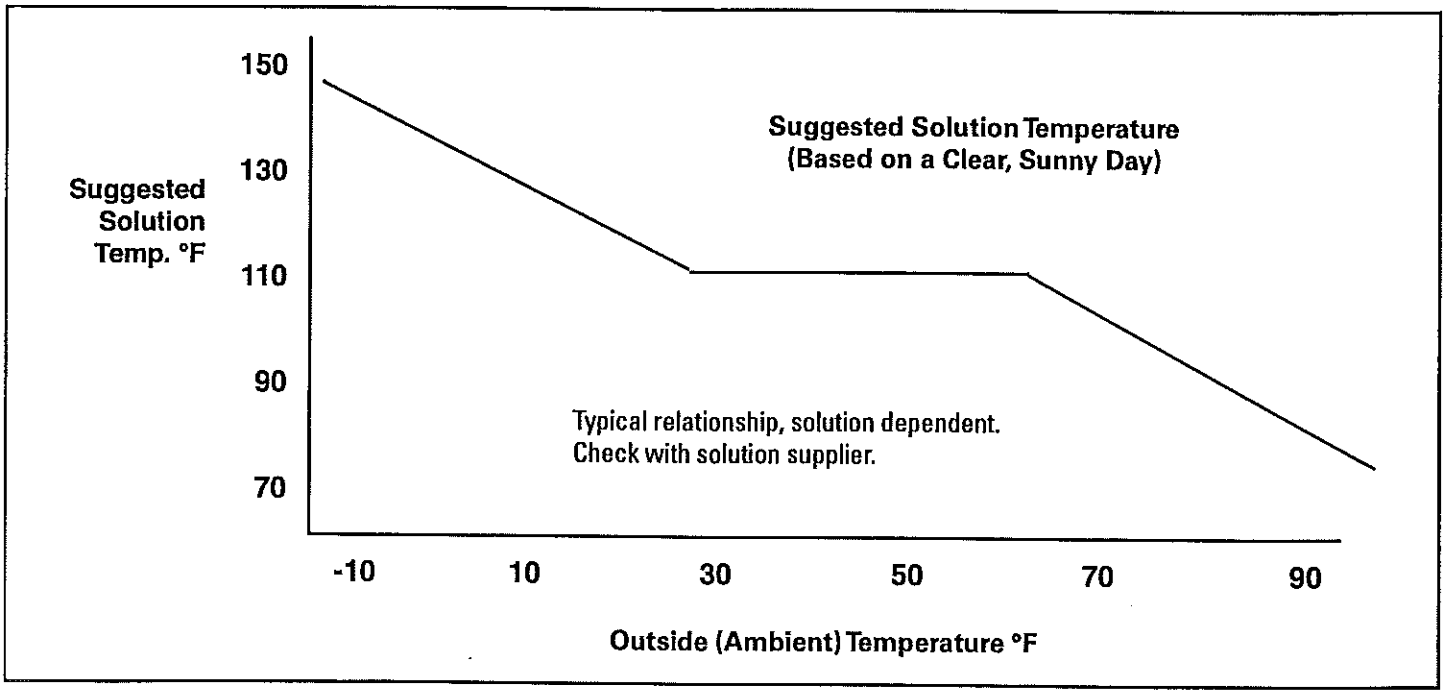


Fig. 3-16: Relationship Between Ambient and Cleaning Solution Temperature

Cleaning practices can adversely affect vehicle appearance and maintenance requirements. For example:

Brushes
- Aggressive on paint and decals
- Physical contact with mirrors, placards, etc.

High Pressure
- Aggressive on wiring harnesses, paint, decals

Chemicals
- Corrosive issues: vehicle, facility, and decals/paint
- Employee safety
- Environment

Vehicle cleaning programs available to our industry have changed considerably. Since new innovations and methods are introduced regularly, one should stay abreast of new cleaning technology.

Important Chemical Questions

Fleet managers should consider the following questions regarding washing/cleaning chemicals.

Chemicals

1. What soils need to be cleaned?
2. What is the recommended dilution ratio?
3. What is the supplier's incentive to meet performance requirements and maintaining dilution ratios?
4. What chemical is specified for use with Recycling / Reclaim equipment (if needed)?
5. What is the cost per vehicle based on this suggested dilution ratio?
6. What is the recommended dwell time?
7. What is the recommended water temperature?
8. What is the specified cleaning equipment (hand brush, pressure washer, automated brush, automated touchless)?
9. What is your water hardness?
10. What are the local wastewater treatment requirements / restrictions?
11. What are the possible hazards stated on the Material Safety Data Sheet (MSDS)?
12. How will the chemical be delivered?
13. Who will handle the chemical (delivery truck to storage to bay) and set the dilution ratios?
14. Who is responsible for maintaining recommended dilution ratios?
15. Can Risk Management / Safety review MSDS and take a sample?
16. Is detergent freight included?
17. Will certain chemicals void the warranty of your equipment?
18. Is the chemical safe for both short-term and long-term exposures?
19. Is the chemical a Hydrofluoric Acid or Ammonium bifluoride product? (See Section "10 Tips for Safe Handling of Hydroflouric Acid.")

10 Tips for Safe Handling of Hydrofluoric Acid

NOTE: The following is an excerpt from an original article that appeared in *Professional Carwashing & Detailing*, January 1999)

1. Never store hydrofluoric acid (HF) in a glass container. It is incompatible with glass, concrete and all silicon-bearing materials.
2. Store only in a tightly closed polyethylene container.
3. Be careful what automotive surfaces HF touches. It is extremely corrosive to leather and rubber.
4. Store HF where temperatures won't exceed 100°F, and be sure to keep it from freezing.
5. Contact with metals creates dangerous hydrogen gas. Don't smoke around HF, and avoid using it near a flame or sparks.
6. Always use in a well-ventilated area. An air concentration of even 50 parts per million can be fatal, even from a brief exposure.
7. Follow manufacturer's recommendations to safely dispose of all containers and leftover HF.
8. Never dispose of any HF solution in a sewer or waterway.
9. Remember that even empty containers can carry enough fumes and residual material to be lethal if inhaled.
10. Always wear protective clothing, including gloves and safety shoes, when working with HF. Most manufacturers recommend protective clothing made of polyvinyl chloride or neoprene and goggles or a full-face shield.

Liability Concerns Regarding HF

Any operator using HF should be especially alert to the liabilities it brings to the workplace. In the event an employee is injured from contact with HF, workers' compensation covers most types of work-related accidents, but insurance carriers are increasingly looking for more operator responsibility in keeping rates down. For operators using HF and other potentially dangerous chemicals, that includes providing safety glasses and other protective equipment for workers, educating them about safety and making every effort to use HF and other chemicals safely.

Fleets that don't follow OSHA's guidelines regarding use of HF are likely to have trouble renewing a carwash insurance policy. Pollution coverage can provide for site cleanup after a spill, but this generally applies only to spills that threaten a third party—i.e., a neighboring property, or a water or sewer system.

Worksheet 1, "Wash Cost Questionnaire" and Worksheet 2, "Wash Process: Total Cost Analysis Worksheet" can help fleet managers determine their needs for a wash program.

TABLE 3-5
WASH FREQUENCY INSPECTION CLEANING RESULTS

Description	Cleanliness	POST-Wash Mark	PRE-Wash Mark	Required Wash Frequency
Showroom	Extremely Clean	Gone	Gone	Daily
New Truck	Very Clean	Undetectable	Hard to Detect	Every Other Day
Clean to Touch	Clean	Hard to Detect	Seen from 3 Ft	Weekly
Hands Off Clean	Mostly Clean	Seen from 3 Feet	Seen from 15 Ft	Biweekly
3 Feet Clean	Hard to Detect	Seen from 15 Feet		Monthly
15 Feet Clean	Film from 3 Feet			Every 6 weeks
No Dirt	Film from 15 Feet			Every 2 Months
Spotted	Hard to Detect Dirt			Every Quarter
Striped	Film & Dirt Streaks			Twice Per Year
Wet	Film & Dirt			Once Per Year
Unwashed	Unwashed			Never

Pre-Wash Mark: refers to finger marking on side of vehicle prior to wash
Post-Wash mark: refers to finger marking on side of vehicle after surface is dry.

TABLE 3-6
COMPARISON OF HF VERSUS AMMONIUM BUFLUORIDE

Comparison	Hydrofluoric Acid	Ammonium Bifluoride Solution(20%)
Chemical Name	Hydrofluoric Acid	Ammonium Bifluoride
CAS Number	7664-39-3	1341-49-7
Chemical Formula	HF	NH4F HF
pH	1-2	3
Extremely Hazardous	Yes	Yes
Toxic	Yes	Yes
Caustic Poison	Yes	Yes
Corrosive	Yes	Yes
Health Rating-NFPA	4-Contact	4-Contact
Health Rating	4-Poison	3-Poison
Fire Rating-NFPA	0-None	0-None
Reactivity-NFPA	2-Moderate	2-Moderate
Air exposure limits	2.5 mg(F)/m3	2.5 mg(F)/m3
Skin contact	Severe tissue damage	Severe tissue damage
Eye contact	Severe injury/burns	Severe injury/burns
Ingestion	Brain/kidney damage	Brain/kidney damage
Inhalation	Respiratory tract burns	Respiratory tract burns
Chronic exposure	Mottling of teeth/bones	Mottling of teeth/bones

Worksheet 1: Wash Costs Questionnaire

Fundamentals:

What is the?

Number of washes per month - current _____
Number of washes per month - desired _____
Average vehicle size _____
Rate at which you borrow money _____

Equipment:

What is the?

Purchase price of equipment in use _____
Expected operating life of the current equipment _____
Costs for Installation of current equipment _____
Costs to modify building for the current equipment _____

Wash labor:

What is the?

Manual labor hourly wage rate _____
Number of hours used to wash each truck _____
Hourly rate for the Managers of wash laborers _____
Number of hours used per month to manage wash laborers _____
Hourly rate for the personnel that hire/orient/train wash laborers _____
Number of hours spent per month to hire/orient/train wash laborers _____
Taxes/insurance/fringe benefits rate (as a percent of labor dollars) _____

Utilities:

What is the?

Electricity cost per kWh _____
KWH used per wash _____
Cost of water per gallon _____
Gallons used per wash _____
Cost of sewer per gallon _____
Gallons released to sewer per wash _____

Detergents:

What is the?

Detergent use per wash in gallons _____
Detergent cost per gallon in dollars _____
Freight cost per gallon _____
Number of hours used per month to order and manage detergent supply _____
Hourly rate for the personnel that order and manage detergent supply _____
Number of hours spent unloading or handling detergent _____
Number of hours spent handling or dealing with empty totes & drums _____

Service:

What is the?

Cost for parts for equipment repair on a monthly basis _____
Cost of freight on the parts needed _____
Hourly rate for the service personnel that perform equipment repairs _____
Number of hours per month spent on equipment repairs _____
Hourly rate for the manager that supervises service personnel _____
Number of hours per month spent to manage service personnel _____
Monthly cost of service/repair to building and floor _____

Other costs:

What is the?

Monthly cost to track/authorize wash activity _____
Monthly costs due to damage to vehicles _____

Performance:

What is the?

"Quality of Wash, rate 1-10" _____
Elapsed time per wash _____

Worksheet 2: Wash Costs Questionnaire

Cost Contributor	Current Process	Comments
EQUIPMENT		
Equipment Cost	$	
Amortization Period	Years	What is the expected operating life
Installation Costs	$	
Bay & Utility Preparation	$	
Existing Eqmt –Depreciation Left	$ Years	
Interest/Lease Rate %	%, Years	What is the lending rate?
Extended Warranty Coverage	$	
Monthly Program Fee	$	
TOTAL EQUIPMENT COSTS	$	
VEHICLES WASHED MONTHLY		
Cabs & Trailer		? minutes per wash
Cabs Only		? minutes per wash
Trailers Only		? minutes per wash
Off-Site Washes		? minutes per wash
TOTAL UNITS PER MONTH	$	
DETERGENT		
Ounces per Vehicle- 1 Step or 2 Step		1 Step = 2 Step =
Cost per Ounce – 1 Step or 2 Step	$ $	1= $ /gallon 2= $ /gallon
Administrative Costs		Dilution Settings, Inventory Management, Reordering, Receiving
Shipping Costs	$	Extra?, Rush Charges, Tail Gate, Fork Lift
Drum/Tote Costs	$	Handling, Mixing, Testing, Storage, Removal
Protective Clothing/Supplies	$	Gloves, Masks, Suits, Dilution Tools
TOTAL DETERGENT COSTS	$	
MAINTENANCE		
Scheduled	$	Brushes, Bearings, Nozzles, Hose – Life Cycles
Emergency	$	What is contracted response time? Costs of Labor, Travel, Parts
Parts	$	Ordering, Stocking, Freight – What are life cycles of each?
Warranty	$	Length of Warranty, Coverage
Building	$	Walls, Doors, Lighting
Floor	$	Floor, Grates
Wash Equipment Upgrades	$	Included or Extra? How are diagnostics performed?
Vehicle Damage from Wash	$	Glass, Chrome, Mirrors, Antenna, Wires, Decals, Placards
TOTAL MAINTENANCE COSTS	$	
LABOR		
Hourly rate – Wash & Management		
Benefits % - Wash & Management		Taxes, Insurance, Workers Comp, Benefits
Training Cost – Wash & Management		
Recruiting		
Maintenance		How much time spent in wash repairs
Administration - Tracking		Who/How determined what vehicles washed
TOTAL LABOR COSTS	$	
UTILITIES		
Electricity – kWh per wash		Cost per kWh
Sewer – Gallons per wash		Cost per Gallon
Water – Gallons per wash		Cost per Gallon
Salt – Pounds per Wash		Cost per Pound
TOTAL UTILITY COSTS	$	
OPPORTUNITY COSTS		
HazMat & Workers Comp Insurance Premiums		Extra Coverage needed due to chemicals used or increased risk due to wash process or work conditions?
Equipment Downtime		What is availability of Equipment? What is expected downtime? Is pro rata clause provided for excessive downtime?
Backup Wash Costs		If Eqmt down, what is cost of back-up plan?
Labor Reallocation		Can wash bay labor be moved to other jobs?
TOTAL: WASH COSTS	$	
TOTAL: UNITS WASHED	$	
TOTAL: AVG. COST per VEHICLE	$	

UPPER COUPLER CORROSION

An upper coupler can last the life of a trailer. Equipment users can help maximize coupler service life by working with the equipment manufacturer to identify and address various factors, such as corrosion, that shorten coupler life.

Upper couplers must be inspected (at minimum) as part of the Federal Annual Inspection, or whenever there is suspicion or indication of damage, wear, or an out-of-service condition (see the CVSA North American Standard Out-of-Service Criteria). More frequent inspection may be needed if the trailer is:

- older,
- used in trailer-on-flat-car (TOFC) service,
- used in severe-duty service, or;
- subject to atypically corrosive environments.

Inspection and Maintenance Guidelines

To inspect the upper coupler, the trailer must be parked on a level surface with parking brakes set, uncoupled, unladen, and clean. If practical, the bottom surface of the coupler should be cleaned of grease and debris.

a. Front of Coupler

Inspect the front of the upper coupler where the fifth wheel makes first contact during coupling. The leading edge of the upper coupler should allow smooth contact with the fifth wheel. Some coupler designs include pick-up plate lips which extend forward of the face of the coupler. These pick-up plate lips should also be smooth and uniform where the lip makes contact with the fifth wheel. Sharp edges, gouges, dents, punctures, cracks, holes, excessive corrosion or any other irregularity that interferes with the smooth coupling or uncoupling of the fifth wheel should be repaired or replacements should be made.

If the original upper coupler design provides air and electrical line protection at the front of the coupler, it should be present and functional.

b. Bottom of Coupler

Inspect the entire bottom surface of the coupler. Check that air and electrical lines are recessed properly in the coupler. The bottom surface of the coupler should be smooth and even. Any welds on the bottom side of the coupler that extend below the surface of the coupler bottom plate should be ground smooth and even with the bottom plate.

Hand-holes in the bottom plate and pick-up plate should have no gouges, tears or any other damage that extends below the bottom surface of the bottom plate. Any such damage must be repaired. Any dents, dishing or other irregularities that affect the smooth approach of the fifth wheel to the kingpin when coupling and uncoupling, or the smooth and even contact of the fifth wheel to upper coupler interface, require repair or upper coupler replacement.

Check for cracks and areas where the bottom plate is worn or corroded through. Cracks in the area around the kingpin may indicate that the bottom plate has worn or corroded significantly. The CVSA North American Standard Out-of-Service Criteria defines as out-of-service conditions any repair weld cracking, any cracks in stress or load-bearing areas, or cracks through 20 percent or more of original welds or parent metal. In these cases, the coupler must be repaired or replaced. The area within an 18-inch radius around the kingpin, where the coupler rides on the fifth wheel, is particularly susceptible to friction wear. Proper fifth wheel lubrication minimizes the wear in this area.

Coupler designs vary, utilizing different materials and material thicknesses in the coupler bottom and pickup plate areas. If there is any indication or concern that the bottom plate has been significantly worn or corroded, contact the trailer manufacturer to determine the allowable wear. (Most manufacturers allow up to a 20 percent reduction in bottom plate thickness. Consult the original trailer manufacturer to determine acceptable wear.) If necessary, measure the thickness of the bottom plate with an ultrasonic thickness-measuring device. When using this device, take measurements in areas away from welds and other structural members that may be above the bottom plate. Clean the surface to be checked thoroughly prior to measurement.

Flatbed couplers have a bottom plate that is welded to the main beams. Be sure to inspect the coupler bottom-plate-to-main-beam welds. Broken welds or cracks at/or near welds must be repaired. The CVSA North American Standard Out-of-Service Criteria defines as out-of-service conditions any repair weld cracking, any cracks in stress or load-bearing areas, or cracks through 20 percent or more of original welds or parent metal. In these cases, the coupler must be repaired or replaced.

When inspecting the coupler of an aluminum flatbed, check for corrosion between the steel coupler structure and aluminum main beams (see **Figures 3-17** and **3-18**). If excessive corrosion exists between the steel and aluminum, the bolted connections and base materials at these interfaces may be compromised. It may also indicate that the bolts have been corroded and need replacement. Check for missing, damaged, corroded or loose fasteners at this connection. Suspect, damaged, missing or loose fasteners must be replaced. Contact the equipment manufacturer for proper fasteners and installation procedures.

c. Kingpin Inspection

Manual Check—Attempt to move the kingpin by hand. A trailer with a kingpin that can be moved by hand in any direction must be taken out of service.

Check the kingpin for wear. A new two-inch kingpin is 2.875 inches in diameter at the throat contact area and two inches in diameter at the jaw contact area. Wear of 0.125 inches or more in

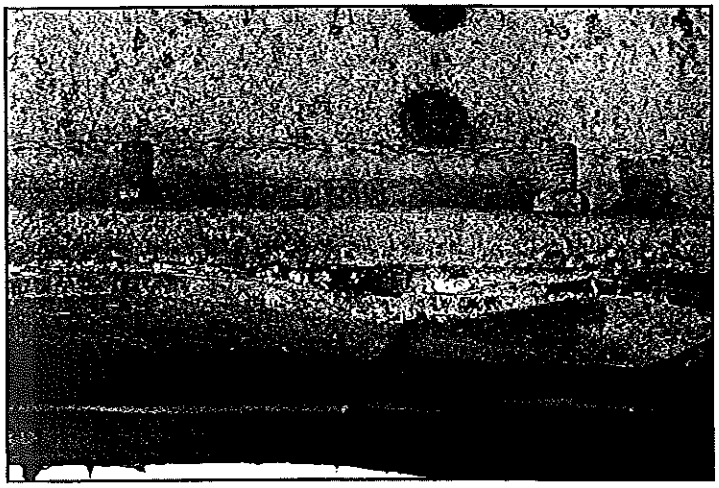


Fig. 3-17: Corrosion Between Aluminum I-beam and Steel Bottom Plate

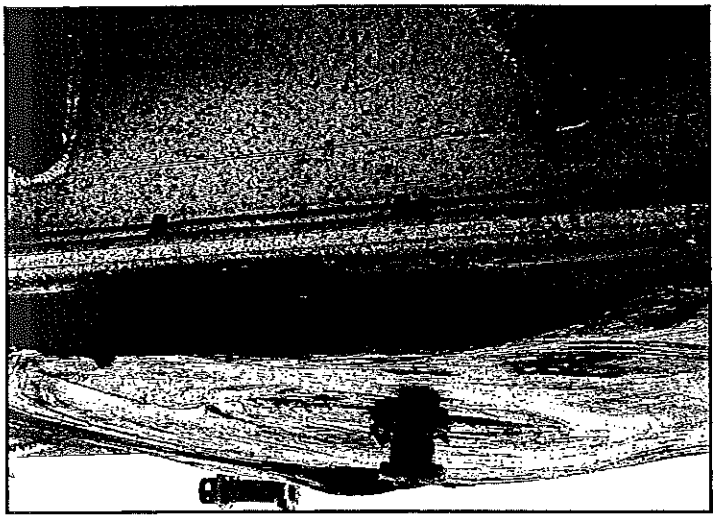


Fig. 3-18: Aluminum Flatbed Damage

these areas at any point around the circumference requires that the trailer be placed out of service. Manufacturers offer gages to check kingpin wear against the limits of SAE J2228 and the kingpin length, squareness and bolster (bottom plate) flatness of SAE J700.

Check the kingpin for damage. Any nick or gouge greater than 0.12 inches deep in the throat contact area or the jaws contact area requires that the kingpin be replaced. Also, any burr in those two areas that extends beyond the surface of the kingpin is not acceptable. Nicks, burrs or gouges should not exceed 0.25 inch in length, measured at the maximum length. There should be no more than 10 nicks, burrs or gouges of 0.06 inch in length in the jaw contact area.

NOTE: Trailers used in TOFC rail service may be more susceptible to wear and damage. Couplers and especially kingpins of trailers in rail service should be checked for wear and damage more frequently.

Be certain that the kingpin has no cracks. If the kingpin has a crack, the trailer should be placed out of service. Never attempt to repair weld a kingpin. Never grind a kingpin.

Check that the kingpin is perpendicular to the bottom plate of the upper coupler by means of a square or gage. The kingpin should be within one degree of perpendicular with the bottom plate at any point around the kingpin. Any trailer with a bent kingpin must be taken out of service until the kingpin is replaced.

Check the bottom plate flatness around the kingpin. SAE J700 allows the amount of downward bow in the bottom plate to be no more than 0.12 inches within a 10-inch radius from the kingpin, or 0.25 inches within a 19-inch radius from the kingpin center. The maximum amount of upward bow allowed is 0.06 inch in the 38-inch diameter around the kingpin.

A flat bar or a template may be used to check bow in the bottom plate. The template shown in Figures 18 and 19 quickly locates the kingpin center and allows quick measurement of bow.

d. Rear of Coupler
Move to the rear of the coupler. The rear edge of the bottom plate should be smooth, beveled or rounded to allow the fifth wheel to rotate freely around the kingpin. This is especially important if using a no lube fifth wheel. Sharp edges must be removed.

Check the attachment and condition of any stanchion or tire plates to the upper coupler. Repair or replace welded or fastened attachments per original equipment specifications.

Check the rear of the coupler for cracked welds between the bottom plate and upper coupler cross member and coupler top plate. The *CVSA North American Standard Out-of-Service Criteria* defines as out-of-service conditions any repair weld cracking, any cracks in stress or load-bearing areas, or cracks through 20 percent or more of original welds or parent metal. In these cases, the coupler must be repaired or replaced.

For trailers with floors that cover the top of the coupler, check the rear of the coupler near the floorboards for indications of moisture or corrosion. If this condition exists, when you inspect the coupler cavity, pay particular attention to this area.

e. Side of Coupler (Coupler to Side Rail Connection)
For van trailers, move to the side of the coupler to inspect the upper coupler connection to the sidewall. For flatbed trailers inspect the coupler connection to the main beams.

Van Trailers—Inspect the fasteners that secure the sidewall of the trailer to the upper coupler (see **Figure 3-19**). Loose, missing

or damaged fasteners must be replaced with fasteners of equal or greater size and strength. The lower side rails of the trailer should be inspected for corrosion. If excessive corrosion exists at any fastener, a few fasteners should be removed so fastener condition can be checked. Do not reinstall fasteners removed for inspection. Install new fasteners of the same size and strength. Consult trailer manufacturer for proper fasteners (larger fasteners may be recommended) and installation procedures.

Aluminum rails that show signs of swelling (see **Figures 3-20 and 3-21**) should be checked frequently to be sure the rails do not begin to crack. Cracked rails should be properly repaired or replaced.

Check condition and welds of the upper coupler end plates at the sides of the coupler if possible through the hand holes or sides of coupler for excessive corrosion, fastener condition and cracks. If cracks are found in this area, the trailer should be taken out of service (as per CVSA *North American Standard Out-of-Service Criteria*) until cracks are repaired.

Flatbed Trailers—If the upper coupler design allows, inspect any fastened or welded connections between the coupler and main beams. Loose, missing or damaged fasteners must be replaced. Cracked welds should be repaired. The CVSA North American Standard Out-of-Service Criteria defines as out-of-service conditions any repair weld cracking, any cracks in stress or load-bearing areas, or cracks through 20 percent or more of original welds or parent metal. In these cases, the coupler must be repaired or replaced. Check for areas of corrosion and electrolytic corrosion between dissimilar metals.

f. Upper Coupler Cavity

An inspection of the coupler cavity can identify the condition inside the coupler and the general condition of accessible coupler structural members.

⚠ WARNING: Use caution when inspecting the coupler cavity of a trailer that has not been in service for an extended period. Insects, birds and mammals can occupy this area and create a hazard when trying to inspect the upper coupler cavity.

Debris inside the coupler cavity can hold moisture, which can accelerate the deterioration of the coupler. If practical, remove debris from the coupler cavity. Do not attempt to remove debris from inside the coupler cavity by means of pressure wash or spray. Pressure washing the inside of the coupler may allow water to get into cavities that will not drain.

With a mirror and a flashlight, inspect the inside of the coupler for visible cracks, corrosion damage, crushed, bent or damaged structural members. Using a small pick or awl, tap or scrape the accessible members to determine soundness. It may be necessary to scrape away layers of corroded metal to determine the condition of coupler components.

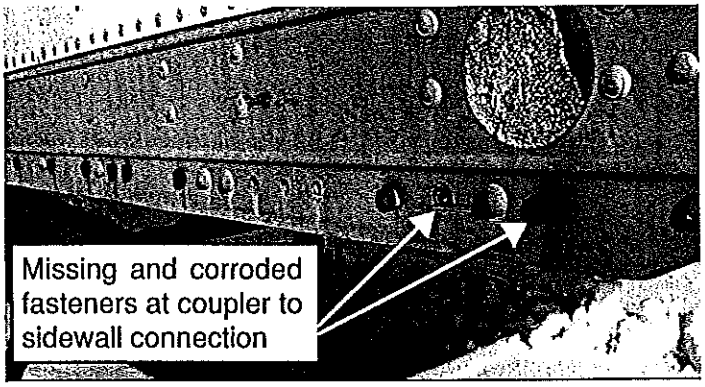


Fig. 3-19: Corroded Fasteners

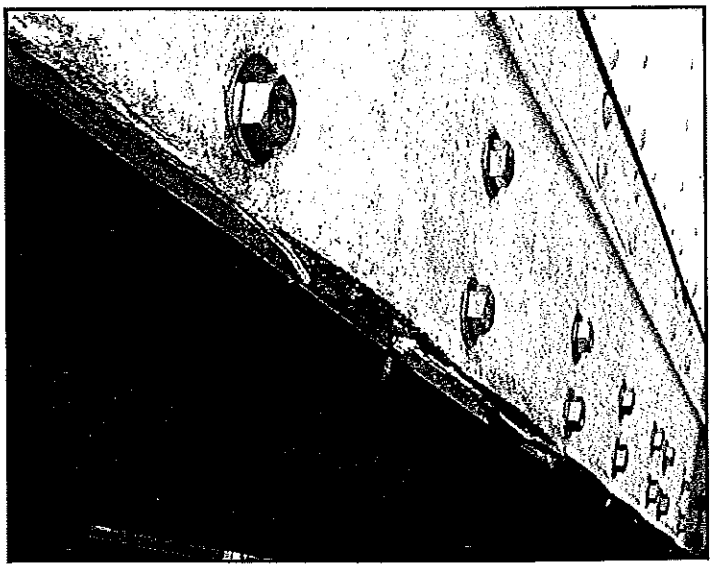


Fig. 3-20: Swelling Between Fasteners

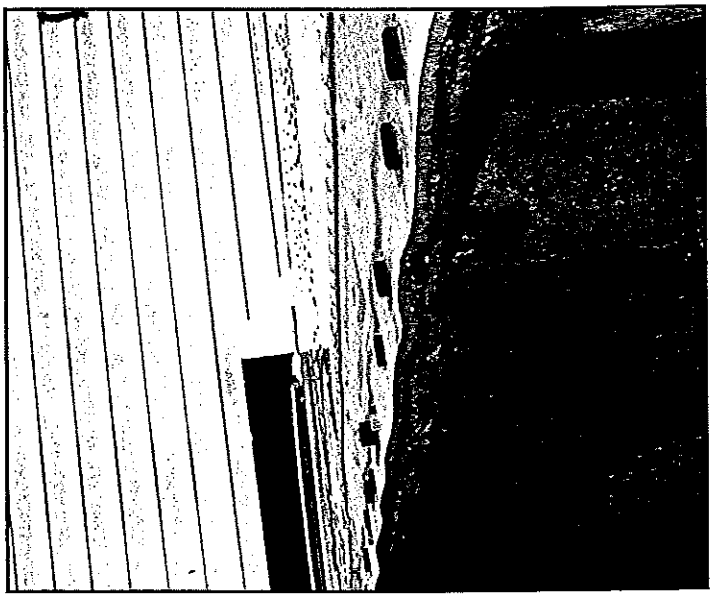


Fig. 3-21: Swelling

If the trailer has a floor over the coupler, also check the top of the structural members in the cavity. Moisture trapped between the floor and the top of the coupler can accelerate deterioration in this area. This is the only means of inspecting the structural condition of the top of the coupler without removing the floor over the coupler.

g. Top of Coupler

If there is no floor over the coupler, the top of the coupler is normally in plain view after unloading. Occasionally check to see if the top of the coupler sags. Sagging sometimes occurs between interior stiffeners that run from one side of the coupler to the other. This is normally not a problem unless sagging is excessive, the safe loading and unloading of the trailer is affected, or if cracks have developed.

Check the condition of any welds for cracks. There should be no tears in the top of the coupler. Tears and cracks must be repaired. The CVSA *North American Standard Out-of-Service Criteria* defines as out-of-service conditions any repair weld cracking, cracks in stress or load-bearing areas, or cracks through 20 percent or more of original welds or parent metal. In these cases, repair or replace the coupler.

MERLIN'S MAGIC COATINGS: AN OVERVIEW OF COATINGS FOR CORROSION PROTECTION

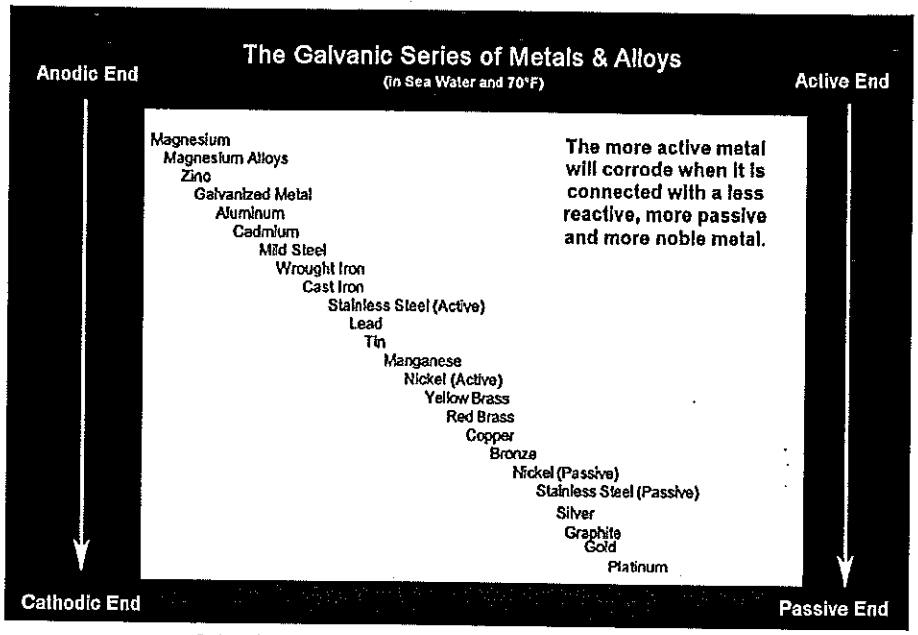
Taken from *The Trailblazer*, September 2011, originally published by ATA's Technology & Maintenance Council (TMC).

Most of the equipment built today uses aluminum alloys which are extremely corrosion resistant, thus the corrosion rate on equipment should be low. Yet, this does not match what the industry is experiencing today when steel or other dissimilar metal is in direct contact with aluminum alloy, said Melvin Shelton, business marketing development manager for PPG Industries.

There are many areas on a vehicle where dissimilar metal contact occurs, such as hinges, steps, door-frame welds and fasteners. When two dissimilar metals are in contact with each other and an electrolyte is present it creates galvanic corrosion. In this situation the more active metal becomes the anode and corrodes at an accelerated rate and the more noble metal becomes a cathode and corrodes at a retarded rate.

Figure 3-22 shows the Galvanic Series of Metals and Alloys in sea water. The more active metal will corrode when it is connected with a less reactive and more noble metal. As shows in **Figure 3-22**, the farther the spread of the metals, the faster the corrosion process.

Galvanic corrosion requires the presence of dissimilar metals, metal-to-metal contact and the presence of an electrolyte. Electrolytes are readily available from nature in the form of rain and road



Galvanic Series of Metals and Alloys (Industrial) in sea water

Fig. 3-22: Galvanic Series

splash and are magnified by the use of deicers and road salt which provides an even better conductor for ions to travel in.

If any of these three elements are missing, galvanic corrosion cannot occur. Thus, removing one of the three elements is key to reducing the incidence of corrosion. Shelton said the use of sacrificial barrier products or isolator tape to create an insulator between the two dissimilar metals. Other preventive measures include the use of corrosion resistant materials and nonmetallics such as synthetic fasteners and nylon washers and inserts.

Shelton said corrosion prevention ultimately begins with the structural design of the equipment. In designing equipment it is important to control dissimilar metal contact, to minimize voids, crevices and seams and to provide proper weep holes where possible. The use of paint is key to preventing the corrosion process it provides a barrier to protect underlying metal from the environment and thus reduces corrosion.

One coat of paint will not by itself provide all of the necessary properties for corrosion protection. To adequately protect against corrosion requires the use of a primer, undercoat and top coat. The primer is the first coat of paint in contact with the metal, and is used to obtain good adhesion to chemically treated or bare substrates. The most commonly found primers include alkyd, epoxy and urethane. Zinc-rich epoxies provide the best protection against corrosion.

Figure 3-23 shows the requisite characteristics of these primers.

Top coats compensate for the matte finish of the primer, they provide a bright lustre as well as give the equipment its final color. They protect undercoats from the effects of weathering and UV attack, are resistant to chemical staining and slow water and electrolyte transport. Topcoat options include; direct gloss polyurethane which does not require a clear coat, polyurethane basecoat which requires polyurethane clear coat and direct to metal coatings.

The paint and coat industry is under continual pressure to reduce the amount of volatile organic compounds (VOCs), hazardous air pollutants (HAPs) and heavy metals in their formulations. As an equipment manufacturer it is important to assure that coating films are applied as required by the coating manufacturer and that all sharp edges, voids, etc., are inspected for proper coating coverage.

Feature:	Good	Better	Best
Adhesion	Alkyd	Urethane	Epoxy
Corrosion Protection	Alkyd	Urethane	Epoxy
Surface Tolerant	Alkyd	Urethane	Epoxy
Application Ease	Alkyd	Urethane	Epoxy
Mixing Ease	Urethane	Epoxy	Alkyd
Ultra-Violet Tolerant	Alkyd	Epoxy	Urethane
Through Dry	Alkyd	Epoxy	Urethane
Applied Texture	Alkyd	Epoxy	Urethane
Lowest Applied Cost	Urethane	Epoxy	Alkyd
Top Coat Gloss Holdout	Alkyd	Epoxy	Urethane
Recoat ability	Alkyd	Urethane	Epoxy

Fig. 3-23: Primer Characteristics

After the painting process has been completed, causation must be taken when drilling holes to ensure that exposed substrates are protected with isolator materials. Ensures the repair facility you select is certified by coating manufacturers, uses certified repair technicians and that repairs are completed using only approved products and systems. Ongoing maintenance is important to ensuring vehicle longevity. Wash the unit regularly, touch up all chips, scrapes, etc., and be sure that proper modifications are made to the unit.

Galvanizing as an Option

Corrosion is the tendency for metal, after production and shaping, to revert back to its lower, more natural energy state, according to Kevin Irving, marketing manager for AZZ Galvanizing

Services. This tendency is known as the Law of Entropy. As corrosion is the chemical or electrochemical reaction between a material and its environment that produces a deterioration of the material and its properties, those reaction differ significantly by metal type.

In the Galvanic Series of Metals and Alloys, metals higher on the scale provide cathodic or sacrificial protection to the metals below them. Magnesium, aluminum, cadmium and zinc are higher on the galvanic scale than steel, and should provide it with protection. Yet magnesium, aluminum and cadmium have limitations which make them less attractive choices. Magnesium is highly reactive and is too rapidly consumed. Aluminum forms a resistant oxide coating and its effectiveness in providing cathodic protection is limited. Cadmium, while providing the same cathodic protection as zinc, has economic and technical limitations.

Zinc provides long term protection to steel as a result of three factors. Zinc coatings act as barriers against the penetration of water, oxygen, and atmospheric pollutants. The zinc coatings cathodically protect the steel from coating imperfections caused by accidental abrasion, cutting, drilling or bending. Lastly, zinc protects steel as a result of the formation of zinc corrosion by-products, known as the zinc patina. Zinc offers the benefit of being a safe and abundant element. In fact, said Irving, zinc is essential to all life. It is needed for digestion, reproduction, kidney functioning, and much more. Some common uses of zinc are sunscreens, cosmetics and even relief for the common cold. Zinc exists naturally in air, water and soil and is a recyclable material.

Zinc Patina Formation

Like any other metal, zinc begins to corrode when exposed to atmospheric conditions. When material is removed from the galvanizing bath, the zinc will immediately begin to corrode as it is exposed to air. A corrosion resistant film of zinc oxide is formed usually within 24 hours of galvanizing. The silvery metallic appearance of galvanized material changes to a light grey color as the zinc oxidizes. zinc oxide is a thin, hard, tenacious layer and is the first step in the development of the protective zinc patina.

When the whitish layer of zinc oxide is exposed to freely moving air, the surface reacts with moisture in the atmosphere, such as dew, rainfall or even humidity, to form a porous, gelatin-type, greyish-white zinc hydroxide. This is a progressive build-up. The zinc oxide progresses into zinc hydroxide. Depending on the type of exposure, the zinc hydroxide can form anywhere between 24 hours and up to three months after galvanizing.

During drying, the zinc hydroxide reacts with carbon dioxide in the atmosphere and progresses into a thin, compact, tightly adherent layer of basic zinc carbonate. This greyish-white powdery film can take anywhere between three months up to one year to form. This progression to zinc carbonate provides the excellent barrier protection afforded by the galvanized coating. Because the zinc patina is relatively insoluble, it prevents rapid atmospheric corrosion of the zinc on the surface of galvanized steel. The rate of formation of the zinc patina depends, not only on the amount of moisture in the atmosphere, but also on the period during which the zinc surface remains wet. The rate at which the carbon dioxide reacts with the zinc hydroxide to form zinc carbonate, also determines the rate of formation of the zinc patina.

The Galvanizing Process

The galvanizing process is comprised of four basic phases. The first phase is pre-inspection. This phase begins with the material arriving at the galvanizing facility. The material is then inspected to ensure that proper vent and drainage holes have been provided in tubular designs. Included is this phase is the hanging the steel pieces on a racking system which will carry the material through the galvanizing process.

The second phase of the process is cleaning. The metallurgical bond between zinc and steel is ensured through cleaning of the steel before immersion in the molten zinc. Steel goes through a three-step cleaning process. Degreasing, the first step, uses a hot alkali solution that removes organic contaminants like dirt, water-based paint, grease and/or oil. After degreasing, the article goes through a water rinse. The steel is then moved to the pickle bath consisting of an acidic solution of either ambient hydrochloric or heated sulphuric acid, that removes iron oxides and mill scale from the surface of the steel. After

pickling, the steel is rinsed again. The final step is to move the steel to a flux tank. The flux serves two purposes; first the lightly acidic solution cleans any remaining iron oxides, and second it provides a protective layer to prevent any iron oxide formation prior to immersion in the galvanizing kettle.

Galvanizing is the third phase of the process and consists of completely immersing the steel in a minimum 98 percent pure zinc bath. The bath temperature is maintained at 815°F (435°C) or higher. The steel is lowered at an angle by crane hoist. This allows air to escape from tubular shapes or pockets that may be within the design of a fabricated piece and of course permits the molten zinc to displace the air. Approximately five to seven minutes after complete immersion (depending on the size of the articles), the steel reaches the bath temperature and the metallurgical reaction is complete. The steel is then submerged in a chromate quench to cool the material so it can be handled sooner and to stop the growth of zinc/iron alloy layers. The final phase of the process is final inspection. A visual inspection of the material provides a very accurate determination as to the quality of the galvanized coating.

Zinc Coating

During galvanizing, the molten zinc naturally reacts with the surface of the steel to form a series of zinc-iron alloy layers. **Figure 3-24**, the metallurgical bond photomicrograph diagram, shows a cross section of a galvanized steel coating. The first zinc-iron alloy layer, the gamma layer, is approximately 75 percent zinc and 25 percent iron. The next layer, the delta layer, is approximately 90 percent zinc and 10 percent iron. The third layer, the zeta layer, is approximately 94 percent zinc and six percent iron. The last layer, which forms as the material is withdrawn from the zinc bath, is approximately 100 percent pure zinc. As you can see, the gamma, delta and zeta layers form approximately 60 percent of the total galvanized coating.

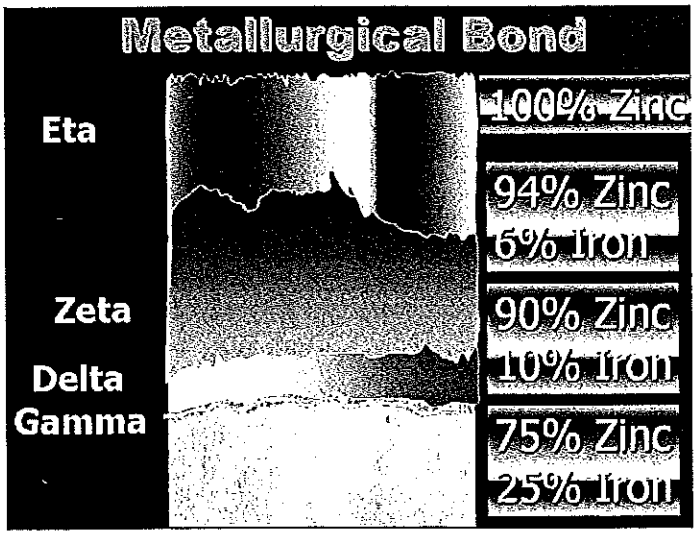


Fig. 3-24: Cross Section of Coating

All of these layers have an abrasion resistance factor. Galvanizing's ductile outer zinc layer, provides good impact resistance for the bonded galvanized coating. **Figure 3-25.** the abrasion resistance photomicrograph, shows that base steel has a DPN of approximately 159. The DPN refers to the Diamond Pyramid Number which is a progressive measurement of hardness. The higher the number, the greater the hardness. Even though the gamma layer is a thin molecular layer, it has a DPN of approximately 250. The delta layer has a DPN of approximately 245. The zeta layer has a DPN of approximately 180. Lastly, the eta layer has a DPN of approximately 70. The gamma, delta and zeta layers are actually harder than the base steel.

Coating damage is most likely to occur at the edges. The galvanizing process naturally produces coatings that are at least as thick, if not thicker, at the corners and edges as the coating on the rest of the part. The nature of the metallurgical bond ensures a coating that forms perpendicular to the steel surface. In contrast, brush or spray applied barrier coatings have a natural tendency to thin at the corners and edges.

Service Life of Hot Dip Galvanizing

The atmospheric classifications are a guide to predicting corrosion rates for general environmental conditions. However, since applications and environments vary, the appropriate classification should be carefully selected on a job-by-job basis. A galvanized coating's protective life is determined primarily by the thickness of the coating and the severity of the exposure conditions. The thickness of a galvanized coating is expressed in

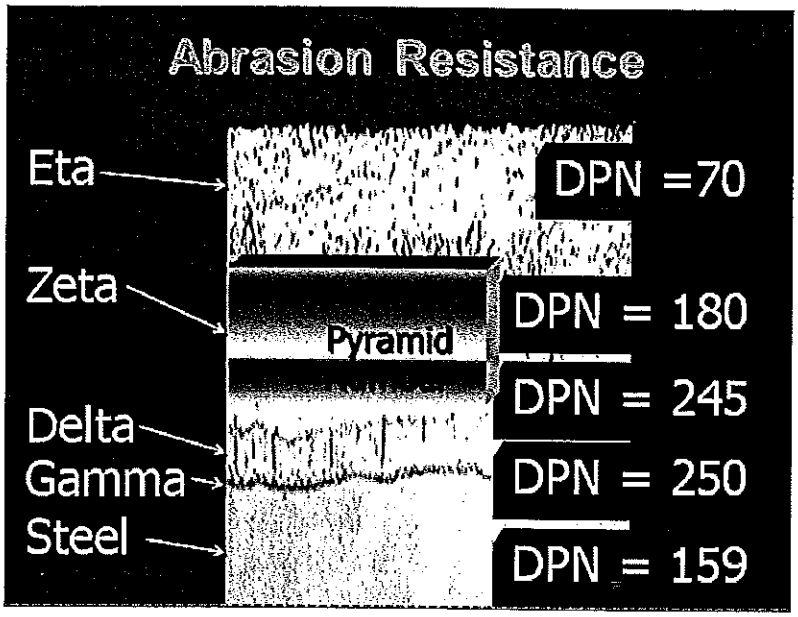


Fig. 3-25: Abrasion Resistance

"mil thickness." One 'mil' is equal to 1/1000-inch. According to ASTM A123 for a piece of steel with a thickness of 1/4-inch or greater, the minimum mil thickness requirement is 3.9 mils.

Hot-dip galvanizing typically produces coatings that are greater than the minimum requirement. A good average coating thickness is probably between 5 and 7 mils. A 5 mil coating provides approximately 120 years to five percent surface rust. This does not mean the material will rust away in 120 years, but rather that in 120 years, five percent of the coating has corroded away leaving red rust, or blushing. Ninety-five percent of the coating is still intact and working as a barrier and cathodic protection system. At five percent surface rust there is no loss of steel integrity. Five percent surface rust indicates that it is time to think about coating the galvanized surface by brush- or spray-applied corrosion protection method if disassembly for regalvanizing is not an option for extending the life of protection.

Other Zinc Coatings

Metallizing (or zinc spraying) is accomplished by feeding the zinc in either wire or powder form to a spray gun, where it is melted and sprayed onto the steel surface by using combustion gases and/or auxiliary compressed air to provide the necessary velocity. Metallizing allows coating of fabricated items which cannot be galvanized because of their size or because the coating must be performed on the job site.

Abrasive cleaning of the steel to white metal is required before metallizing. The zinc coating is normally sealed with a thin coating of a low-viscosity polyurethane, epoxy or vinyl resin. There are some limitations as to the thorough coverage because of structure inaccessible areas such as recesses, hollows and cavities.

Coating consistency is dependent on operator experience, thus coating variation is a possibility and the coatings may be thinner at corners and edges. Metallizing does provide cathodic protection, but there are no zinc-iron alloy layers.

Zinc painting consists of zinc dust in organic or inorganic binders. Zinc-rich coatings are barrier coatings which also provide limited cathodic protection. The binder must be conductive or the zinc particles must be in contact to provide cathodic protection. Suitable zinc-rich paints provide a useful repair coating for damage galvanized coatings. However, surface preparation by abrasive blast cleaning is necessary. Uneven film coats may develop if applied by brush or roller, and mud cracking may occur if the paint is too thickly applied.

Another coating option, although usually limited to steel mill operations, is continuous galvanizing which is a hot-dip process. The process consists of coating sheet steel, strip or wire on machines at speeds of over 300 feet per minute. While barrier and cathodic protection is provided the mil thickness is minimal compared to that of hot-dip galvanizing after fabrication.

Electroplating, or electrogalvanizing, generally refers to zinc coatings applied to steel sheet and strip by electrodeposition in a steel mill facility. Barrier and cathodic protection is provided, but there are no zinc-iron alloy layers.

Design and Repair

Protection against corrosion should begin in the

design phase of the product, said Irving. Adopting design practices in conjunction with ASTM A385, "Practice for Providing High Quality Zinc Coatings (Hot-Dip)," will produce optimum quality galvanizing, reduce coating costs, assist with timely processing of the product, and ensure the safety of galvanizing personnel.

Guidelines for repair of hot-dip galvanized coatings are provided in ASTM A780, "Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings." This document provides guidance for repair using zinc-based alloys, paints containing zinc dust and sprayed zinc.

Effects of Corrosion on Equipment

Trailer manufacturers are designing equipment to combat the effects of harsh road chemicals, according to Jeff Bennett, vice president of engineering and product development for Utility Trailer Manufacturing Company. Trailers are manufactured using stainless steel and galvanizing is done where appropriate and rust prevention coatings are utilized to replace many of the paints that were once used. [At TMC's 2011 Fall Meeting,] Bennett showed photographs of results from a salt spray test performed by a trailer OEM.

The test compared a buck plate coated with three different types of coatings; a wet coat, galvanized coating and the OEM's powder coating. The results showed that while the powder coating appeared to out perform the other coatings, the test was performed using a non stainless steel trailer.

Bennett then showed a series of photographs highlighting the effects of corrosion on various areas of the trailer and compared them with trailers that have received rust prevention coatings, specifically the wax-type compound used by Utility. The manufacturer immerses each assembly in this wax-type compound, making sure material gets into all crevices to shrugs off road salts.

A Fleet's Approach

Lori Coleman, fleet manager for Gordon Food Services (GFS), said her fleet is thorough in its efforts to minimize corrosion effects on its 1,100 day-cab tractors and 1,700 multi-temperature refrigerated trailers. As its main service area is through several Rust Belt states, the equipment is continually exposed to the corrosive effects of harsh road chemicals. Tractors are washed daily and trailers are washed at least twice a week in an effort to fight corrosion.

The fleet has experienced severe effects of corrosion of equipment purchased as recently as 2007. Coleman explained that common corrosion problems occur in trailer cross members, upper couplers, electrical plugs and wiring. In an effort to abate corrosion, the fleet has over the last five years worked with the trailer manufacturer on the coatings used, changed the detergents used in the wash bays and have begun to install underbody jets into the wash bay area. She said that while these practices have helped, the fleet continues to see the detrimental effects of corrosion.

GLOSSARY OF TERMS

Amorphous—Pertaining to a solid, which is noncrystaline, having neither definite form nor structure.

Amorphous Silica Thickener—Silica (Si02) that has been chemically converted from a hard, abrasive, non-crystalline form to a light, fluffy, non-crystalline powder with a large surface area to make a very efficient thickener.

Asperities—Roughness of surface, tiny projections or peaks on a surface.

Conductive Path—Corrosion cannot occur unless the dissimilar metals are electrically connected. For example, a bolt that holds pieces of aluminum and steel together is the most common conductive path. There must also be a path for ions to flow from the anode to the cathode. This is usually provided by the electrolyte.

Corrosion—Gradual destruction of a metal or alloy due to a chemical process such as oxidation.

Crystalline—Pertaining to, resembling or composed of crystals.

Dielectric—A material, which is an electrical insulator.

Dispersion—A distribution of finely divided particles in a medium.

Dropping Point—The temperature point at which grease changes from a semisolid to a liquid state. Defined by ASTM D566 and ASTM D2265, as the temperature when a drop of material falls from the orifice of the test devise. **NOTE:** Of limited use in defining the upper temperature limit of grease because the base oil stability is more important.

Electrolyte—A substance that, when dissolved in a suitable solvent or when it facilitates fusing, becomes an ionic conductor. Salt is a typical electrolyte.

Fluorinated Oil—Oil that has been manufactured by a chemical reaction in which fluorine is introduced into the compound, replacing all hydrogen atoms. Also a common name for PEPE oils.

Fretting Corrosion—Surface oxidation and build-up of metal oxides between two metal surfaces in close contact under pressure and subject to micro- motion. External vibrating forces or thermal expansion and contractions due to temperature extremes can cause micro-motion.

Galling—Surface damage on mating, moving metal parts due to friction and adhesive wear.

Galvanic Couple—A pair of dissimilar conductors capable of acting together as an electrical source when brought into contact with (or through) an electrolyte.

Metallic Soap—Thickener system made of soaps or complex soaps with metals such as Lithium, Sodium, Calcium, and Aluminum

Neat Grease—Lubricating material that is 100 percent grease, not diluted by any solvent carriers.

Noble Plating—A metal or alloy such as gold, silver, or platinum having high resistance to corrosion and oxidation.

Organo-Clay Thickener—Clay material treated to make it reject water and attract oil. An activator is used to increase the surface area to bind the oil into a grease.

Oxidation—A chemical reaction that increases the oxygen content of a material. Any reaction in which a chemical joins with oxygen, such as occurs in rusting or combustion.

PAO—PolyAlphaOlefin

Pour Point—The lowest temperature at which oil will flow under the force of gravity. Note: Helps define the lower temperature limit of a lubricant.

PPE—PolyPhenyl Ether

PFPE—PerFluoroPolyEther

PTFE—PolyTetraFluoroEthylene

Tensile Strength—The maximum stress a material subjected to a stretching load can withstand without tearing.

APPENDIX

CORROSION SOLUTIONS PROVIDER DIRECTORY

This **Appendix** contains a directory of TMC member companies who report offering various solutions to address component and vehicle corrosion. TMC has not evaluated the claims of these companies, and TMC cannot possibly know, evaluate, or advise the transportation industry of all conceivable ways in which a practice may be undertaken or of the possible consequences of each such practice. Other practices or methods may be as good, or better, depending upon the particular circumstances involved. All who use the providers listed below must first satisfy themselves thoroughly that neither the safety of their employees or agents, nor the safety or usefulness of any products, will be jeopardized by any method selected. The following is not intended nor should it be construed as an endorsement of any particular person, organization, or product.

Alcoa Wheel Products
1600 Harvard Ave.
Cleveland, OH 04105
(814) 226-7386
www.alcoawheels.com
We have created a Dura-Bright wheel. This wheel is resistance to corrosion and will clean with soap and water. This process to the wheel will keep corroding from calcium chloride, road salt , magnesium chloride and brine water. We have done extensive testing at our Technical Center in New Kensington, PA on the Dura-Bright wheel.

Anthony Liftgates, Inc.
1037 West Howard St
Pontiac, IL 61764-0615
(610) 326-0106
www.anthonyliftgates.com
Anthony Liftgates has recently upgraded its entire product line to Prp-Mp Metal Polymerization finish. The Prp-Mp Polymerization process provides an affordable, effective, alternative to galvanizing. The process provides a finish that performs and protects Anthony products against harsh anti-icing chemicals, rock chipping, and rust creep. The Prp-Mp finish has provided galvanizing type performance and results on over one million vehicle parts in service today.

Automotive International
8855 Blue Ash Rd.
Cincinnati, Ohio 45242
800-543-7156
www.valugard.net
Automotive International has been providing corrosion prevention products and solutions to the transportation industry for over 30 years, including soft coatings such as cavity wax and various types of under coatings for use on all types of vehicles. We also offer cleaners such as a mag chloride remover. We are OEM approved and an ISO 9001:2008 registered company.

Counteract Balancing Beads
13029 8th Line
Georgetown, Ontario L7G4S4
USA Location—
5555 N Tacoma Ave Suite 2551
Indianapolis ,IN 46220
(800) 572-8952
www.counteractbalancing.com

Recently the Government and tire industry have recommended cleaning all
studs with a wire brush. Studs can become rusted and corroded, cleaning 10 studs with a wire conventional brush is messy and time consuming.
THE SOLUTION: Counteracts Stud Cleaning Tool allows you to clean 10 stud in under three minutes or less, thoroughly, making them look brand new.

APPENDIX

Cummins Filtration
Circuito Exportación 222
Parque Industrial Tres Naciones
San Luis Potosi, 78395 Mexico
52 444 870 4950
ww.fleetguard.com
Fully formulated coolants and additives for the cooling system. SCA additives liquid or water filters with DCA or SCA active or slow-release formulas to prevent corrosion in the cooling system. Fuel additives to prevent corrosion of fuel injection systems due to the use of water contaminated fuel or biodiesel and FWS filters and processors.

Daubert Chemical Company
4700 S. Central Avenue
Chicago, IL 60464
(708) 496-7350
www.daubert.com
Rust preventive undercoats and cavity waxes for extended protection of truck and trailer components.

DSX Equipment Technologies LLC
PO Box 8766
Jacksonville, FL 32239
(904) 744-3400
www.dsxequiptech.com
DSX Defender II is a fluoropolymer-based protective wax. Our trucking customers tell us ice, snow and sodium chloride do not stick or is easy to remove. Our racing customers — Formula 1, endurance racing (24 hours of Lemans) and boating — report that track rubbish does not stick to the undercarriage of their cars with boats; river slime does not stick.

E-ZOIL
234 Fillmore Avenue
Tonawanda, NY 14150
(716) 213-0106
www.ezoil.com
Diesel Aid, our best selling diesel fuel additive, prevents corrosion of the fuel system. Air Brake Anti-Freeze prevents corrosion of the air brake system. HD-5000, our supplemental coolant additive, prevents corrosion of the cooling system.

Elisha Technologies LLC
1177 North Morley
Moberly, MO 65270
(660) 263-4377
www.elisha.com
Elisha Technologies offers an environmentally friendly corrosion solution that replaces trivalent and hexavalent chromium passivation on zinc and zinc alloy plating. It is free of heavy metals, including cobalt. The Elisha system offers superior heat and deformation tolerance compared to chromates.

Flaming River
800 Poertner Dr.
Berea, OH 44017
(800) 648-8022 x132
www.flamingriver.com
We offer battery terminal covers designed to fit our manual battery disconnect switch. The switch is often mounted near the battery box in direct weather area for easy access. The covers reduce corrosion buildup on battery cable ends often caused by road salt spray.

Fontaine Trailer Company
430 Letson Rd
Haleyville, AL 35565
(615) 772-7743
www.fontainetrailer.com
As a flatbed OEM, we have seen a huge change in the buying habits of many flatbed fleets. Fleets that have traditionally purchased all steel or steel/aluminum combo trailers in the past are making the move to all aluminum products. Our Revolution flatbed sets the industry standard in strength and durability. All aluminum Revolution trailers, in combination with optional galvanized suspension components, give the end user the most corrosive resistant flatbed on the market today.

Fuel Savvy, LLC
5075 Central Highway
Pennsauken, NJ 08109
(856) 425-3899
www.fleetfuelsaver.com
ECO-FLAPS. Reduce road spray that normally splashes onto the trailer frame and undercarriage AIRTABS. Reduce road spray between tractor and trailer and what normally gets plastered on rear doors Both products reduce road salt being blasted back onto vehicle surfaces at highway speeds.

GatorHyde/Chemline
401 Adelle Dr
5151 Natural Bridge, St. Louis, MO
Sagamore Hils, OH 44067
(330) 283-1429
www.gatorhyde.com
GaorHyde is a manufacturer of fast set polyurea coatings used to prevent corrosion due to MgCl and CaCl. GatorHyde CG offers extreme durability and chemical resistance, all weather performance, flexible 275 percent elongation, extreme corrosion resistance, washable, will not cut, peel, crack or ship under road conditions and has a wide service temperature range (- 4°F to + 450°F).

Hendrickson Intl.
501 Canton Farm Road
Joliet, IL 60434
(800) 356-6737
www.hendrickson-intl.com
Aero Clad material provides a lightweight alternative to traditional chrome plated steel by combining stainless steel with aluminum to produce a mirror like finish that is 10 times thicker. Thus, Aero Clad bumpers provide superior resistance to cracking, peeling, fading, pitting and corrosion and are backed by a five-year warranty.

Hutchens Industries
215 North Patterson
Springfield, MO 65801
(417) 862-5012
hutchensindustries.com
Hutchens Industries offers two methods of corrosion prevention for our sliding and fixed frames. Hot-Dip Galvanization provides a corrosion protection system that greatly extends the life of the unit. Scharpf Coating is a soft, tacky, pliable, self-healing, waxy finish coat available on all subframes up to 100" long.

Hyundai Translead
8880 Rio San Diego Dr.
Suite 600
San Diego, CA 92108
(800) 251-0871
www.translead.com
Standard galvanizing package includes the rear frame, rear impact guard, wing plate and "K" bracing, mid-turn signal brackets and mud flap bracket. Additional components that are offered hot dipped galvanized include the full upper coupler, all crossmembers, threshold plate, slider rails, external upper landing leg tubes and suspension slider box.

LGM Company, LLC.
1780S County Road 850E
Greensburg, IN 47240
(812) 222-0222
www.lgmcoupler.com
We offer corrosion prevention plus pressure/vacuum inspection for the upper coupler. Our company now offers the Encapsulated Upper Coupler for the tanker market, All types of semi trailer types can be fitted with this design from the OEM. This superior concept has a trustworthy inspection, corrosion control, safety improvement, longer life, higher resale value, less maintenance cost, down time and peace of mind. (Patent Pending)

Maxi-Seal Harness Systems, Inc.
13312 5th Street
Suite B
Grandview, MO 64030
(816) 841-6700
www.maxisealharness.com
We offer the Defender Harness System. It was designed from the ground up to be corrosion proof. We incorporate our Integrated Moisture Barrier (IMB) at every crimp connection, a long life silicone seal in our power distribution module, integrally molded strain relief on all cable exits from overmolds, our patented hardshell J560 molded connector, and engineering grade resins to ensure 100 percent bond between the overmolds, the connectors, and the cables. This system is by far the most innovative harness system on the market and has proven to be a true Defender against corrosion.

Meritor Heavy Vehicle Systems, LLC
7975 Dixie Highway
Florence, KY 41091 USA
(859) 525-3462
Meritor.com
PlatinumShield™ II - brake shoe coating with three-year guarantee against corrosion and rust-jacking PlatinumShield™ Hydraulic Brake Rotors - rotors with anti-corrosion coating, one-year / 100,000-mile warranty.

MGM Brakes
8530 Cliff Cameron Drive
Charlotte, NC 28269
(800) 527-1534
(704) 547-7411
www.mgmbrakes.com
MGM Brakes developed a technology to reduce "corrosive" attacks on your brakes by changing the spring guide to a non-conductive material. MGM also offers severe service models with extra protection of "epoxy coating" on the upper piston plate, steel piston guide and center flange case, designed for severe operating environments.

Parker Hannifin
148 Waterstone Way
Montevallo, AL 35115
(205) 668-4134
www.parker.com
www.phtruck.com
Telescopic Eject Cylinders: NG Series cylinders are coated with a nano coating. The nano coating monecular structure is smaller than the air that penetrates the material that creates rust. Given that the nano coating has smaller particles than the air, it becomes a tremendous protectant to any rust formation. Various test results are available. Hydraulic Hoses: Parker Tough Cover Hose Products are abrasion resistant in addition to being made with a synthetic outer cover that will reduce corrosion, as this product protects the steel wire inside the hydraulic hose. This coupled with a stainless steel fittings will reduce the effects of corrosion. Thermoplastic Hoses: Will not rust as no steel components are present.

Philatron Wire and Cable
15315 Cornet Street
Santa Fe Springs, CA 90670
(800) 421-3547
www.philatron.com
Philatron's Stallion Coiled Electrical Trailer Cables with corrosion proof Xenoy Polycarbonate 7-way Plugs are virtually indestructible; they are lightweight, do not drag, and offer smart cable management. These corrosive-proof, Xenoy plugs offer a pull force up to 420 lbs. They are non-metal, not plastic, but made to last. The Stallion Coiled Electrical Trailer Cables with corrosion proof Xenoy Plugs come with a seven-year warranty. Virtually indestructible, Xenoy® plugs with sure-fitting "D" contacts. The plugs are corrosion proof and are much tougher than the standard semi metal plug parts. Temperature range is -70°F to +400°F. Heavy duty in service, these semi parts are lightweight.

PPG Industries, Inc.
19699 Progress Drive
Strongsville, OH 44149
(618) 407-8109
www.ppgcommercialcoatings.com
PPG Industries manufactures and distributes corrosion prevention coatings Globally that include zinc, epoxy, urethane primers, alkyd, urethane topcoats and polyurea bedliner coatings. Materials can be applied by conventional spray, airless and brush or roll. Audit Services available to determine root cause analysis and best practice for repairs.

PRP Industries, Inc.
1854 Industrial Blvd.
Muskegon, MI 49442
(231) 767-9799
www.prpindustries.com
PRP metal polymerization, CORSOL metal treatment. The alternative to galvanizing.

Sherwin-Williams Automotive Finishes
4440 Warrensville Center Rd
Warrensville Center Rd., OH 44128
(412) 580-1992
www.sherwin-automotive.com or http://genesis.sherwin-automotive.com/home/
Sherwin-Williams Genesis® Primers and Topcoats provide optimum corrosion protection, long term durability and a high gloss finish. Our Genesis® Primers are offered in both Epoxy and Urethane technologies and are available in numerous VOC ranges. Use in conjunction with our Genesis® Topcoats for the ultimate Fleet finish.

Spraydown USA
2141 Fairwood Ave
Columbus, OH 43230
(614) 754-3750
www.spraydownusa.com
Spraydown is the industry's best scientifically tested spray suppression mud flap. Its design improves visibility and corrosion resistance by dramatically reducing the amount of corrosive road spray striking the "corrosion hot zones" on tractors and trailers. Spraydown also generates fuel savings through improved aerodynamics and drag reduction.

STEMCO
6200 Industrial Blvd.
Longview, TX 75602
(903) 232-3561
http://www.stemco.com/
STEMCO LP offers B-Lock, a patented rust preventative technology that eliminates early deterioration of brake shoes, known in the industry as "rust jacking." B-Lock forms a barrier between the brake shoe table and the brake lining which blocks out elements such as moisture and salt that cause brake shoe corrosion.

Syner-Co International
12526 High Bluff Drive, Suite 300
San Diego, CA 92130
(760) 512-0553
www.syner-co.com
Our Power Barrier Technology is an OEM-applied anticorrosion coating and equipment paint system. It replaces standard old paint systems. Reduces production costs for manufacturers and greater efficiency. Move to a variable cost with No capital equipment expense. Sixteen (16) year corrosion warranty. Non-toxic, easy repairs using (weld like) process Don't waste money and weight on galvanizing or stainless steel — Power Barrier Technology has you covered.

Tectran
330 Greene St.
Buffalo, NY 14206-1025
(800) 776-5549
www.tectran.com
Tectran offers a wide range of solution-oriented products designed for corrosion resistance in today's chemical environment. Seven-pin tractor-trailer connectors with Weatherseal, anodized gladhands, wide-lipped poly gladhand seals, and much more. Tectran's Pendilube penetrating dielectric lubricant spray fights corrosion by creeping into crevices and wiring connections as a pretreatment, before road chemicals and moisture can do their damage. Pendilube also works as a dielectric penetrant on parts damaged by corrosion.

APPENDIX

Truck-Lite Company, Inc.
310 E. Elmwood Avenue
Falconer, NY 14733
(800) 562 - 5012
(716) 665 - 6403 FAX
www.truck-lite.com
Truck-Lite offers a variety of corrosion prevention products, including:

- NYK Dielectric Grease
- Multi-Purpose Maintenance Spray
- Full line of sealed, LED Lifetime Lighting products
- Sealed wiring harness assemblies

For additional product information or to locate a distributor near you, please contact our Customer Service Department at 800-562-5012

Webb Wheel Products, Inc.
2310 Industrial Drive
Cullman, AL 35055
(256) 775-7535
www.webbwheel.com
http://www.webbwheel.com/pdfs/literature/2011RotorBrochure-websized.pdf
All Webb Wheel hydraulic rotors with ABS teeth are now equipped with a new high temperature, corrosion resistant coating. This coating is designed to combat corrosion, even at the elevated temperatures seen during braking events. This protection will extend ABS functionality in corrosive environments.

Whiting Systems, Inc.
9000 Highway 5 North
Alexander, AR 72002
(501) 847-9031
www.whitingsystems.com
Whiting Systems, Inc. founded in 1974, manufactures automated large vehicle washes, pressure washers, cleaning detergents and provides maintenance services to the commercial vehicle industry.

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