S.6 Chassis Study Group Information Report: 2002-1

Road Chemical Induced Corrosion

Developed by the Technology & Maintenance Council's (TMC)
Ice-Clearing Chemical Induced Corrosion Task Force
Under the Auspices of the S.6 Chassis Study Group

ABSTRACT
Aggressive corrosion, caused by new formulations of road ice clearing chemicals, has recently become 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. In order to reduce this problem, the Technology & Maintenance Council (TMC) of the American Trucking Associations (ATA) is calling 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. If this is not possible, then TMC is asking that manufacturers of vehicles make design and/or material changes to their product to resist road ice clearing chemical induced corrosion.

INTRODUCTION
A new form of aggressive corrosion on commercial vehicles has recently come to the attention of fleet managers in certain areas of North America, specifically in areas of the United States and Canada where new technology chemicals are used to clear roadways of ice and snow. 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 fleets, however, is that its use has recently become a serious maintenance problem for many equipment users. Use of magnesium chloride- and calcium chloride-based products by certain

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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.

Other areas affected include 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 problem has been reported at recent meetings of the Technology & Maintenance Council (TMC) of the American Trucking Associations (ATA). Examples of failed parts attributed to this phenomenon were displayed at a special Failure Analysis session of TMC's Shop Talk, and during a technical session on the same topic. The pictures that appear at the end of this paper, and in the special appendix, 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 solve the problem as it pertains to electrical connectors, brake components, and many other affected systems, just because the components are not readily accessible.

Based on member concern, TMC has launched a Task Force 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.

TMC is, therefore, recommending the following action to solve this serious durability and safety problem.

1. TMC is calling 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. If this is not possible, then TMC is asking that states stop using these chemicals to clear road ice.

3. If states will not agree to do this because of the advantages of these new formulations, then TMC is asking that manufacturers of vehicles make design and/or material changes to their product to resist road ice clearing chemical induced corrosion.

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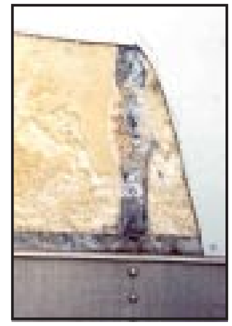
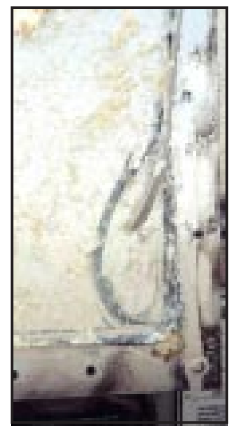
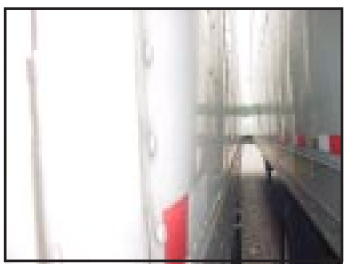
APPENDIX

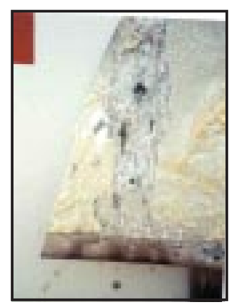
The following photos are examples of corrosion caused by new road ice clearing chemicals as described in this information report. What also follows are reprints from TMC's *Maintenance Manager Magazine* and *The Trailblazer*, also describing the problem.





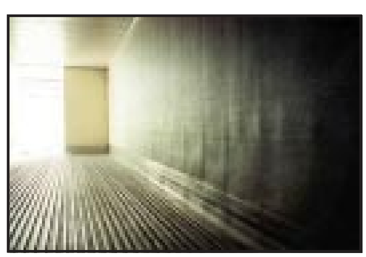













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Are Ice-Clearing Chemicals Killing Your Trucks?

BY JIM STARLING, TMC STUDY GROUP COORDINATOR

Some maintenance managers are reporting increased nstances of corrosion on their tractors and trailers. Many of them say increased corrosion is the result of states using calcium chloride and magnesium chloride for snow and ice clearance. Can it be beaten? Some think it can by inspecting trucks and washing them more often, using sealed components and protective lubricants, and, where appropriate, using components made of resistant materials.

For decades, the substance of choice for highway ice removal was rock salt, but now many state transportation departments are taking long looks at different chemicals, and a few DOTs are using them in big ways. These new chemicals — calcium chloride and magnesium chloride — offer a number of benefits, but trucking companies contend they eat through truck components almost as fast as they melt ice and snow.

"It's a more hostile world today than it was five years ago," said Nick Stone, director of maintenance for Con-Way Transportation Services in Ann Arbor, Mich. He said he sees more corrosion on trailer frames, dollies, spring hangers and aluminum web fuel separators held in place with steel brackets.

"Where ever moisture can get in, we get corrosion. If anything isn't sealed, corrosion is worse," said Bruce Beill, director of maintenance for Sysco Food Services in Grand Rapids, Mich. "I think it's because sand and calcium chloride is clumping on the vehicle."

Calcium chloride is significantly more corrosive than salt — sodium chloride. In some circumstances, magnesium chloride is too.

One fleet maintenance manager said that if magnesium chloride seeps through a crack in paint to reach steel or aluminum surface, it quickly begins to corrode the metal. Jerry Whitehead of Western Trailer Co. said his customers are saying similar things.

According to Mr. Whitehead, if surface paint is chipped by rocks or other road debris, and bare metal exposed, then corrosion attacks the uncovered steel or aluminum and continues eating away at metal still covered by paint. No one can tell corrosion is present until the paint starts blistering. He said the corrosion "is like cancer on aluminum rivet heads and cast aluminum parts."

Mr. Whitehead said the corrosion problem has grown worse during the last few years than at any other time in his 30-year career. However, he notes that companies with active trailer-washing policies don't have corrosion problems.

Western Trailer assembles several different types of specialty heavy-duty trailers, including flat beds and hopper bottoms.

The American Trucking Associations Foundation collects reports from maintenance managers who contend that magnesium chloride and the medium in which it is spread has a greater tendency to stick to vehicle surfaces, and increase the potential for corrosion, than brine or sodium chloride.

Increased Maintenance Costs

ATAF conducted a preliminary survey to determine the effect of magnesium chloride use on trucking firms. It found that several trucking companies based or operating in Colorado believe they are suffering increased maintenance, parts replacement and cleaning costs.

According to Dr. Patricia Olsgard, Ph.D., of ATAF, magnesium chloride is used in most Rocky Mountain states. And Ed Fink of the Colorado Department of Transportation reported that his state alone uses four million gallons a year. ATAF, the Colorado Motor Carriers Association, and CDOT are sponsoring a University of Colorado laboratory research study on the effects of mag-

The articles in this reprint appeared as a three-part series in the First, Second and Third Quarter 2000 issues of TMC's *Maintenance Manager*. © 2001 Maintenance & Technology Council - The American Trucking Associations

nesium chloride on truck components. (*See sidebar below.*).

Mr. Fink said Colorado is happy with the road-clearing effectiveness of the natural substance. "We're getting a much better level of service" with liquid magnesium chloride. Dr. Olsgard said CDOT treats roads up to 72 hours before a storm arrives. Mr. Fink acknowledged the early application, but said roads are much clearer now than they were several years ago. "People forget what it was like eight years ago," he said.

According to Mr. Fink, traffic can move at normal highway speeds on the Interstate 70 corridor — even in below-freezing temperatures — without any ice or packed snow problems. "We've come a long way in improving mobility," he said. "No one has to drive at 10 or 20 miles an hour on packed and rutted snow anymore to get to a ski resort. And drivers don't see a car off the road around almost every turn either."

Before CDOT began using magnesium chloride, the state agency soaked examples of different metals in magnesium chloride and saw no unusual corrosion problems. Mr. Fink said he is interested in finding a solution.

He speculates that untested combinations of sodium chloride, which is still used, and magnesium chloride may be contributing to increased corrosion, and he acknowledged that trucking companies may have a greater corrosion problem. "There's no doubt something is happening," he said. "I've met with truckers with nice trucks and they've shown me the corrosion on chrome, aluminum and even stainless steel."

According to some trucking maintenance directors, the evidence or greater corrosion is found most frequently on trailer longitudinal rails, electrical connectors, and exposed aluminum and chrome components.

"Electrical connectors are real bad," Mr. Whitehead said.

Clarence Levens, service manager at Rush Truck Centers of Colorado in Denver,

Looking for Solutions

ATA Foundation, CSU, CDOT And Colorado Carriers Test Different De-Icing Materials

Dr. Patricia Olsgard, Ph.D., of the American Trucking Association Foundation, is working with Yunping Xi of the University of Colorado at Boulder and Werner Hutter of the Colorado Department of Transportation (CDOT) to investigate whether the ice-clearing materials used by CDOT is damaging trucks in unexpected ways.

They are seeking to pin down the problems trucking companies attribute to de-icer use, document and analyze the de-icing costs to the trucking industry, and identify the costs and benefits of de-icers used by CDOT.

There are essentially three studies, and the final results won't be available until June or July. The first is the laboratory testing of two grades of aluminum and three of steel commonly used in the truck=ing industry. The second is real-world testing of strips of metals — coupons — attached to vehicles frequently exposed to de-icing chemicals.

Soak and Dry Testing

The first phase of three of cyclic corrosion testing according to soak-and-dry method specified by SAE testing protocol J2334 and the continuous salt spray test defined by ASTM B117 began Aug. 3, 1999 and ended Oct. 3. The corrosion mediums were pure solutions of sodium chloride and pure magnesium chloride, respectively.

The second phase began Oct. 28 and ended Dec. 28. The corrosion mediums were two solutions commonly used on Colorado highways.

The third phase begins in January and ends in February. The corrosion mediums will be combined salts of sodium chloride and magnesium chloride which simulate Colorado's winter road environment.

After all tests are completed, the test samples will be analyzed with chemical and optical tests for a final determination of corrosion severity.

'Real World' Exposure

The second study involves real-world exposure tests carried out on Colorado highways on the trucks of two companies and CDOT vehicles. In October, strips of metal — coupons — were prepared by Dr. Yunping Xi of the University of Colorado at Boulder and fixed to license-plate-size plexiglass panels placed on the exterior of selected vehicles.

The two companies involved are CAST Transportation and HVH Transportation. They are operating a total of 10 trucks equipped with test coupons on the I-70 corridor. The trucks will stay within Colorado's borders for the duration of the test. CDOT de-icing trucks and supervisor vehicles will also carry the coupons. The test ends in mid-April or when CDOT decides to end de-icing operations.

The ATA Foundation will collect the coupons at the end of the test period. Test logs — containing operating statistics on each truck such as driving and weather conditions, location, maintenance performed, days, mileage, times, and highways used — kept by drivers will be matched with CDOT de-icer application records to compare the results of exposure to differing de-icers.

ATAF will document anecdotal information and examine vehicle maintenance logs, safety statistics, and other data to back up those reports. It will then use the laboratory results provided by the University of Colorado to determine exactly what factors are contributing to increased corrosion, how much the use of magnesium chloride costs trucking companies, and identify alternatives to magnesium chloride or different ways of applying it. The foundation will also develop recommendations on ways trucking companies can reduce corrosion.

A third study, if it may be called a separate study, involves surveys of Colorado trucking companies and an ongoing literature review of other studies. A two-page survey was faxed to all Colorado trucking companies in February 1999, but a more detailed version is slated to be sent out in January or February to a select group of Colorado trucking companies. It will be used to examine trucking companies de-icing costs in more detail.

said that even though electrical connectors are better made than they were several years ago, he still sees evidence of corrosion, and he attributes the damage to magnesium chloride. "Magnesium chloride is able to get into ECM and headlight connectors. Even if shrink tubing is used, it still gets inside connectors."

"We've especially noticed more corrosion on radiator fins made of aluminum. They decay after three to four years. We also see more corrosion on fuel tank straps. We now spec stainless steel straps because of the decay issue," said E.W. "Pete" Johnson, director of maintenance for Matlack, Inc. in Swedesboro, New Jersey. He sees more corrosion on trucks that travel in Wisconsin, Minnesota, Canada, and Michigan's Upper Peninsula.

"Minnesota used to use salt, but now they use a chemical and pour it on like crazy," said Bill Quimby, vice president of Maintenance for Berger Transfer and Storage in Roseville, Minn. He doesn't believe he is seeing more corrosion than before, but said "cabs rot right off the frame."

Countering Corrosion

Those fleet maintenance managers who report finding more corrosion now than in the past also report finding it in very specific components or areas, usually splash-prone areas on the front, underside and lower portions of tractors and trailers, and on foot pedal linkages in cabs.

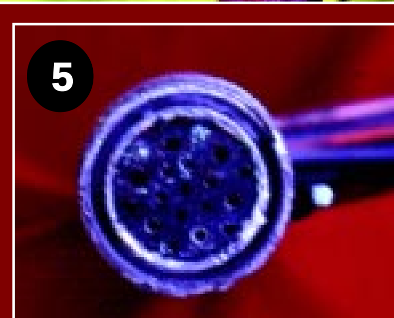
More frequent washing may be one of several methods that can be used to reduce the problem. Norm Dixon, maintenance manager for Beaufort Transfer Co. in Gerald, Mo., said he has seen more corrosion on his trucks — electrical connectors, tail lights and firewalls — since Missouri began using calcium chloride. But he sees it mostly on trucks that operate from one terminal in an area that gets more frozen precipitation than others and where truck-washing isn't as rigorously performed as at other terminals.

"Those customers that wash their trailers

Corrosion Takes Its Toll

The following examples were all taken from late model vehicles.

1. **Pedal hinge corroded**
2. **Bracket rusted through**
3. **Spring Hanger severely rusted**
4. **Trailer I beam rusted through**
5. **Corrosion in electrical socket**



regularly summer and winter, not just twice a year or just in the summer time, never have warranty or corrosion problems," Mr. Whitehead said.

Jerry Sheehan, vice president of Leprino Foods in Denver, and Steve Hochmiller, vice president of maintenance for Don Ward and Company in Denver would probably agree with Mr. Whitehead.

"We wash our trucks frequently. I hear a lot of bitching, but we are only seeing a little more corrosion, mostly pitting on aluminum wheels," said Mr. Sheehan. Mr. Hochmiller also has a frequent washing program and has not noticed a larger corrosion problem.

According to fleet managers, electrical connectors from the headlights back must be sealed in some manner or coated with dielectric grease or similar substances. Ronald Szapacs, Air Products and Chemical in Allentown, Penn., said, "Dielectric grease has had a dramatic effect in reducing connector corrosion. We use it in trailer junction boxes and on Packard connectors as well."

Although Mr. Johnson sees more corrosion on his trucks, his electrical connectors are holding up well. "Connectors are fine because we use a dielectric grease on them," he said.

Because of the susceptibility of connectors to moisture penetration and corrosion, Western Trailers is changing from plug harnesses to molded.

Refine Equipment Spec's

Bob Flesher, fleet maintenance manager for AGA Gas in Ohio, said fleet managers can combat corrosion by refining specifications for tractors and trailers. He said corrosion isn't a big problem for his fleet because he specs premium components and appropriate protective coverings and coatings.

Increased dissimilar metals corrosion in areas where magnesium chloride and calcium chloride are used can be reduced by either making greater use of stainless steel or placing an intervening protective material between dissimilar metals. However, stainless is more brittle than most grades of steel used in trucking.

Resistant materials may be more difficult to specify, but they are out there. While Mr. Johnson said that aluminum radiator fins are very susceptible to corrosion, another fleet manager specifies resistant materials for his radiators — plastics — and says he has no corrosion problems.

Fighting Corrosion

Prevention Is More Important Than Ever

Your trucks are exposed more frequently to potentially corrosive conditions than ever before. Today's fleet manager must be concerned about the early and frequent use of ice-clearing chemicals on highways, use of corrosive chlorides for dust control at construction sites and on unpaved roads, and steel-eating atmospheric pollutants. But the operational environment wasn't always so hostile.

Fifty years ago corrosion wasn't much of an issue for fleet managers. Back then, no one used salt of any kind on roads and there was less sulfur dioxide and nitrous oxide in the atmosphere. Oil was used for dust control and trucks were less susceptible to corrosion. "The sheet metal on a 1940s truck was so thick," said Jerry Warmkessel, manager of fleet service engineering at Mack Truck Company, that "you could take a hammer and hit and hit it and it wouldn't bend."

Road-clearing wasn't as important as it is today, although local governments used cinders and sand to improve traction, because trains were the prime means of travel and commerce. However, greater affluence, interstate highways, and more efficient trucks led to increased consumer demand for year-round road service. Municipalities and state highway departments began using sodium chloride.

Every year the amount of salt spread across North American roads increased, and chloride-induced corrosion became a concern for American and Canadian fleets. It started slowly at first, but within a dozen years, the operating environment was radically changed. It was something all manufacturers had to address.

"Corrosion was a problem in the '70s when we were getting perforation," said Mr. Warmkessel. This was also the period when truck manufacturers began using thinner-gauge sheet metal in order to save weight. Many fleets experienced serious corrosion on their trucks, especially those vehicles used in sever applications. According to Mr. Warmkessel, chairman of TMC's Commercial Vehicle Paint Adhesion and Durability Task Force, this created warranty issues with customers until the mid-1980's when Mack and other manufacturers implemented solutions.

"Customer expectations are a major force. (Corrosion) awareness increased, and we responded to their concerns," said Nirmal Tolani, manager of metallic materials and specifications for International Truck and Engine Corp.

In 1965, four million tons of sodium chloride were used for ice clearing. In 1979, usage jumped to 12 million tons. Salt usage has leveled off at about 15 million tons, but last year alone, Colorado used six million tons of magnesium chloride and many states are using more calcium chloride for both ice-clearing and dust control.

According to corrosion expert Robert Baboian, former head of Texas Instruments' electrochemical and corrosion laboratory in Attleboro, Mass., degradation is generally classified into structural (inside-out) and cosmetic (outside-in) corrosion. Structural deterioration in the truck or cab frame leads to perforation, usually from the inside out. This corrosion occurs at crevices, corners and other locations on the vehicle — entrapment areas — where road and environmental debris can build up. Rust also forms at spots where protective coatings are lacking or have been penetrated by chlorides or moisture.

Cosmetic corrosion is usually associated with cab or engine housing paint faults. Paint coating failure can occur from a variety of causes including cathodic disbondment, filiform corrosion, galvanic (bimetallic) effects, and fretting.

The chassis and underside are most likely to suffer damage caused by stone or road debris impact which removes paint or other protective coatings. Crevice corrosion and pockets of debris (poultices) in entrapment areas are more likely to be found on the underside too.

Trim and hardware accessories provide mechanical damage protection and cosmetics (styling, hiding welds), but they are vulnerable to pitting, crevice corrosion, and discoloration if composed of stainless steel or anodized aluminum. Stainless steel trim materials can lead to galvanic corrosion of painted steel, but some trim materials, such as aluminum and zinc die cast, don't affect body steel; they corrode instead.

Although corrosion problems became more frequent in the 1960s and 70s, they didn't increase uniformly across the continent for a simple reason — conditions varied greatly throughout North America. Thus, even today the severity of external corrosion varies considerably across the continent. Variables include differences in environmental conditions, application, and highway practices. Corrosion is found most often where ice-clearing and dust-control chemicals see the heaviest use, the concentrations of certain atmospheric pollutants are highest and in warm, humid, marine environments (southern coastal areas and Gulf Coast off-shore oil platforms).

The Northeast and Great Lakes states have traditionally had the greatest occurrences of corrosion. "North of the Mason-Dixon line, calcium chloride is put down even before it snows. It plays hell with trucks," said Mr. Warmkessel.

Heavy use of chlorides in those regions means fighting corrosion is an important part of truck maintenance, but calcium chloride is the most destructive of the three used of ice clearance — calcium chloride, sodium chloride and magnesium chloride.

"Chloride is the most destructive force," said Dr. Baboian. "Chlorides disrupt a protective film that naturally forms on metals. The chloride ion is a really bad actor.

"Calcium chloride is worse than other chlorides because it attracts moisture more easily (greater deliquescence)," said Dr. Baboian. "It absorbs water vapor from the air at 40 percent humidity whereas sodium chloride absorbs water vapor at 75 percent. You could lay it on a dry bench and it would become wet."

Dr. Baboian said that calcium chloride's property of drawing moisture is why it is used for dust control. "If you see someone spraying liquid on a dirt road, chances are its calcium chloride. I stay away from dirt roads with my own car because of that (increased corrosion risk)."

Adding to the corrosivity of today's operational environment are atmospheric pollutants such as sulfur dioxide and nitrogen oxides (NOx). Through oxidation and hydrolysis, atmospheric sulfur dioxide becomes sulfuric acid when it comes in contact with steel. Byproducts of the reaction include increased conductivity and a lower pH. The creation of hygroscopic sulfate corrosion products, according to Dr. Baboian, lowers the critical humidity required for corrosion reaction.

Nitric acid is created when nitrogen oxides come into contact with steel. Nitrogen oxides, which are found in diesel emissions, also promote the conversion of sulfur dioxide to sulfuric acid. Since truck emissions contain NOx, nitric acid is always going to be present on every truck.

Steel corrodes faster In the presence of both sulfur dioxide and nitrous oxides. The reaction is synergistic.

Other atmospheric pollutants can damage metal too. "Acid rain and other airborne pollutants can cause aluminum blush and bloom; the surface of anonized aluminum turns milky," said Dr. Baboian. "But there is not a lot you can do about it because attempting to shine it with abrasives will result in the removal of protective coatings and may lead to serious corrosion."

According to Craig Kendall, national customer service manager, Peterbilt Motors Company, a common industry practice may be paving the way for corrosion — the addition of electrical accessories and customization after delivery. Imperfect grounding can lead to stray charges and ion pathways that promote corrosion. He cautioned that the grounding issue is unproven, but it may be something a fleet should consider if it has a corrosion problem, or wishes to prevent one.

Then there are application-specific corrosion issues. According to Mr. Kendall, corrosivity issues are common on oil-drilling platforms and in the transport of certain

Your Corrosion Fighting Checklist

- Find out exactly what your OEM does for corrosion prevention and compare with what other OEMs do.
- Wash off road salts frequently.
- Make sure vehicle is washed properly on a regular basis.
- Don't use recycled water (Check salt content first if you must.).
- Don't attempt to seal off problem areas.
- Avoid unpaved roads and construction areas where chlorides are used for dust control.
- Check and clean entrapment areas of debris.
- Replace chipped paint as soon as possible.
- Spec' premium paints and clear coat.
- Do not accept trucks from OEM if paint application is subpar.
- Spec premium sealed electrical connectors from OEM.
- Inspect and spray connectors with a moisture inhibitor.
- Use dielectric grease.
- Spec' primer on frame components before assembly.
- Don't attempt to scour surface corrosion from aluminum wheels.
- If truck is used in severe application, pay close attention to most affected areas and wash thoroughly daily. Rinse entire vehicle.
- Periodically check control pedals and linkages.

explosive ingredients, salt, livestock and refuse ("garbage juice" is acidic).

Concrete mixers are also prone to corrosion because companies use muriatic acid, a form of hydrochloric acid, to clean off mix remains. If the truck isn't thoroughly and totally rinsed off, corrosion will quickly become a problem. The vehicle's finish can be marred in as little as two months; serious corrosion can appear in as little as two years.

The OEMs started addressing corrosion issues almost 20 years ago. During an almost continuous improvement process since then, they've learned to reduce the risk of corrosion through design changes and increased use of coatings, sealants and corrosion-resistant materials.

Designers reduced corrosion by eliminating entrapment areas where moisture and poultice can be trapped or retained; they reduced the number of sharply angled meeting surfaces, "dead ends" and narrow openings; and they closed unneeded holes in body panels and provided better drainage. They also improved access for pretreatment, extended primer coverage and strived to reduce contact between dissimilar metals.

According to Mr. Tolani, International changed joint designs to improve sealing and reduced the number of panel joints. International now galvanizes both sides of sheet metal panels and the cab structure. The cab painting preparation process includes 14 steps, and more components are made of stainless steel. International now requires that all driveline, axle and suspension components be painted before assembly.

Mr. Kendall said simple changes, such as improved drainage, help greatly. "We had a horn corrosion problem caused by the collection of water, so we just changed the design so it faced down instead of up."

In addition to designing out likely corrosion and poultice pockets, Peterbilt uses better component sealing, multiple coatings, clear coat on threaded fasteners and more aluminum and non-corroding materials such as fiberglass. The company uses epoxy, dielectric grease, neoprene and double seals for electrical connectors.

Western Star, according to Tony McParland, the company's quality assurance manager, now uses Deutsch-type electrical connectors with silicone rubber seals. "Thermoplastic is used everywhere moisture can get in a vehicle," he said.

According to Mr. Warmkessel, Mack uses galvanized steel cabs and interior panels. All frame components are primed prior to assembly. "You must coat a part entirely before assembly because if you wait until after assembly, some portion of the joined surfaces will not be covered and will eventually be subject to corrosion. When our components are assembled, it's prime-to-prime instead of metal-to-metal."

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Manufacturers are also looking for ways to make their products better and more corrosion resistant.

"We're testing for corrosion all the time," said Mr. Kendall.

International has a cyclic corrosion chamber large enough to test two cab assemblies at the same time. "With this chamber, we can test new and old technologies side-by-side to get accurate comparisons," said Mr. Tolani, who added that International is also testing non-traditional materials.

"We've investigated carbon epoxies and other non-metallic composites, but the cost for the buyer would be too high if we used some of these materials now. We must balance cost, performance and durability. The cost of a composite frame is too high to make it practical. And there is a problem with durability at the joints," he said.

According to Mr. Kendall, Peterbilt is also studying composites.

Since the manufacturers are not capable —yet— of designing a truck that is impervious to corrosion, fleets must do their part to keep vehicles corrosion-free. But corrosion prevention requires cooperation among fleet managers, drivers and those who clean the vehicles. Corrosion prevention starts with specification.

Electrical connectors are where corrosion often takes an early hold. Dr. Baboian said that fleets should specify sealed electrical systems. If opened for inspection purposes, connections must be sprayed heavily with a moisture inhibitor and resealed. Many fleets use dielectric grease on connectors to good effect. Dr. Baboian advised fleets against trying to seal systems equipped with standard connectors. "Attempting to self-seal may do more harm than good because if even a pinhole opening remains, moisture can still get in through capillary action; you could end up sealing moisture in rather than out."

According to Mr. Kendall, some types of primers and paint used by manufacturers, many water-based because of environmental concerns, don't perform as well as others. "It's a problem for the whole industry. Adhesion and corrosion resistance is not as good as we would like."

Mr. Warmkessel recommended that fleets specify a quality, solvent-based primer, paint and clear coat for proper protection. Mr. Kendall agreed and added that fleets should make sure of product compatibility first.

Dr. Baboian said anti-corrosion coatings have their place, but he favors application by the manufacturer at the assembly plant. However, if a fleet decides it must apply an aftermarket undercoating or clear coat, the fleet manager should ensure that application is properly performed and that the coating used is compatible with other coatings (e.g., paint and primer) already on the truck. "Don't apply a coating to something if it will not adhere to it properly. To get maximum performance from an anticorrosive coating, research what is available and make sure of the bond. Prevent disbondment," he said.

If repairs make repainting necessary, Dr. Baboian said the metal must be thoroughly cleaned and properly primed. "You must follow specific steps if you are going to paint aluminum or galvanized steel. Some of them are complex," he said.

Basic vehicle care is important too.

"Make sure the vehicle is washed properly," said Dr. Baboian. "The importance of washing off road salts should not be underestimated. Entrapment areas—areas that may retain debris, sand, dirt, vegetation, or chemicals— must be inspected and cleaned regularly. Wheel wells must be stripped out regularly. A buildup of debris attracts moisture and increases the probability of corrosion.

"Underneath is where problems occur. There are a number of entrapment areas. But don't try to block them off because if even a crack remains, moisture could get in and corrosion could get a start and remain unnoticed. It's better to keep them open and washed out," said Dr. Baboian. Drain holes should be checked frequently and cleaned out as needed.

Drivers should avoid driving—or walking — through seawater or road deicing puddles. Liquid chlorides dripping from footwear promote corrosion on flooring and brake, throttle and clutch linkages and pedals.

Chipped paint must be replaced as soon as possible to keep corrosion from getting a foothold on bare metal surfaces.

In addition to paying attention to inspection, painting, and cleaning, fleets must know their cleaning resources.

"If the truck-washing system you are using uses recycled water, you could be adding to the potential for corrosion. Recycled water often contains a higher percentage of sodium chloride than does water straight from the normal water supply; salt builds up in recirculated water. Lots of people don't think about it," he said.

"Because of system pressure, cleaning with recirculated water may result in sodium chloride being forced into inaccessible spaces and crevices where moisture would not normally have easy access."

"Pay attention to rinsing after washing," Mr. Kendall said. "Be aware of corrosion causes and the places corrosion is likely to take root. Search them out and clean and maintain them. Don't short-change your anti-corrosion campaign."

Fighting Corrosion

States Are More Willing To Use Chemicals To Improve Road Service

Ice control strategies are growing more sophisticated as state highway departments, and the half-dozen or more local districts under each department, become increasingly dedicated to keeping roadways passable during winter. During the past 40 years, they've learned that sodium chloride has its limitations and are seeking to overcome them with different substances. As a result, it's likely that during the coming winter, trucks that travel any distance at all in winter will come in contact with each of the major chlorides almost every time they leave the terminal or cross a state line (*See map on page 8.*).

More than 30 states still use rock salt—sodium chloride — as the primary solid ice-control substance because it's stable, familiar, cheap and easy to apply. But many states — about 20 — also use calcium chloride (usually about three parts to 97 of sodium chloride) to pre-wet rock salt and make it easier to spread and to keep ice from forming when temperatures are below the effective limits of sodium chloride.

A few states use it for ice control on roadways in ecologically sensitive watersheds or on potentially dangerous hills and curves, and a few others, such as Colorado, use it in solid or liquid form as a primary ice preventative.

Although magnesium chloride is very effective and its use is becoming more common despite cost and corrosion issues, its employment is selective in most states. However, Louisiana is in a long-term process of switching to it from salt.

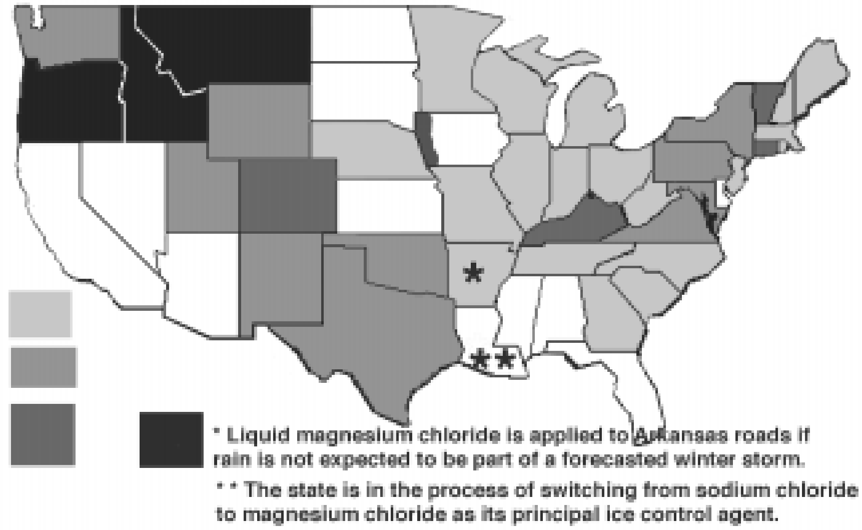
Oregon, Idaho and Montana make heavy use of magnesium chloride, but with a corrosion inhibitor included in the compound. The version of magnesium chloride used is 70 percent less corrosive than salt and conforms to the so-called Northwest Show-fighter specification. It addition to the states above, it's also provided to British Columbia and Washington.

The primary traction-enhancing abrasive used nationally is sand. Cinders, ash and stone aggregate are also used, but not nearly as extensively.

The substances which are more expensive, effective and least damaging to roadways are most likley to be used on particularly costly or important bridges

On the following page is a list of the chemicals used for snow and ice clearing in the 48 contiguous states. More than 30 states still use rock salt as a primary agent, 28 make some use of calcium chloride and 21 employ magnesium chloride.

Winter Road Treatment by State



Arkansas — Rock salt mixed with fine crushed rock. Some calcium chloride is at temperatures below 20°F. Some liquid magnesium chloride pretreatment is applied to major roads if the forecast includes snow without liquid precipitation first.

California — Rock salt is the state's primary ice control agent. Sand is the primary traction enhancer.

Colorado — Colorado makes very heavy use of calcium chloride and is generally pleased with the results.

Connecticut — Calcium chloride is used for ice control on roads in watershed areas. A sand and salt (7/2 mix) is used everywhere else.

Delaware — Rock salt is the state's primary ice control agent. Sand is the primary traction enhancer, but is used in the southern part of the state only.

District of Columbia — Rock salt and magnesium chloride are the ice control agents of choice and sand is the primary traction enhancer.

Florida — Sand is the only substance Florida uses for traction improvement, and then generally on bridges only.

Georgia — Rock salt is the primary ice control agent except when conditions are extreme. Then calcium chlorideis used. Aggregate is the primary traction enhancer.

Idaho — Magnesium chloride (with corrosion inhibitors) is the primary ice preventative. The traction enhancer of choice is a mix of rock aggregate and rock salt.

Illinois — Rock salt and calcium chloride are the chemicals of choice. Solid calcium chloride is preferred in the southern part of the state, and liquid calcium chloride is used around Chicago. Choice of which is used is dependent upon district preference. Salt brine is used as an anti-icing agent on bridges.

Indiana — Rock salt, calcium chloride and Iceban are most likely to be found on Indiana roads. Fine aggregate is used for traction control. Magnesium chloride is used on the new Vincennes bridge only.

Iowa — Rock salt is used in Iowa except in the western tier of counties. There the chemical of choice is calcium chloride.

Kansas — Rock salt and sand are used together in Kansas. The state also uses salt brine.

Kentucky — Liquid calcium chloride is the state's primary ice control chemical except near Cinncinati, Ohio. Roads on the south side of the Ohio River are coated with liquid magnesium chloride.

Louisiana — Rock salt is used on bridges only, however the state is in the process of switching to magnesium chloride.

Maine — Rock salt and sand are used on most roads in Maine. Calcium chloride is applied to interstate highways.

Maryland — Rock salt is the primary solid applied to roads, but flake calcium chloride, Iceban and CMAK (Calcium-Magnesium Acetate with potassium) are also used. The primary liquid anti-icing agent is magnesium chloride. Use of this substance is expected to increase, but salt brine is also used.

Massachusetts — Rock salt is the state's solid anti-icing substance; liquid calcium chloride is the liquid. Massachusets also uses a pre-mix of rock salt and flake calcium chloride, small amounts of CMA, and as little sand as possible.

Michigan — Rock salt is the main substance applied to Michigan roads, but limited amounts of calcium chloride, CMA solid, and potassium acetate (Ziwaukee Bridge only) are employed. In the future, Michigan will use the same standards as Illinois.

Minnesota — Rock salt and calcium chloride (relatively small amounts) are the solids of choice. Liquid magnesium chloride is applied in metropolitan areas. Potassium acetate is used on a few select bridges.

Mississippi — Rock salt is the state's solid anti-icing agent. Sand and fine aggregate (crushed rock) are the traction enhancers used.

Missouri — Rock salt is heavily used. Missouri also applies salt brine and calcium chloride (liquid and flake).

Montana — Inhibited magnesium chloride liquid (70 percent less corrosive than sodium chloride and in compliance with Northwest Snowfighter ice control specification standards) is applied to roads. Sand is used for traction control.

Nebraska — In order of amounts applied: Rock salt, salt brine, calcium chloride, iceban, and some magnesium chloride are used for ice control. Sand is used to improve traction.

Nevada — Rock salt and salt brine are used on Nevada roads.

New Hampshire — Rock and solar salt is employed for ice control. Calcium chloride is used to treat salt loads to keep it spreadable. Sand is used to improve traction.

New Jersey — Rock salt, calcium chloride, and CMA are applied to New Jersey roads.

New Mexico — Rock salt and cinders together are spread on roadways. Magnesium chloride is also used to a lesser degree.

New York — Rock salt and an alcohol/magnesium chloride mix are the agens of choice.

North Carolina — Rock salt is the primary substance applied. Calcium chloride is used to treat the rock salt and for anti-icing in limited applications, such as mixing it in flake form with salt. Use of abrasives — sand and a little aggregate — is limited to the western part of the state.

North Dakota — Rock salt and brine are the anti-icing agents used. One district will be experimenting with Iceban on freeway ramps.

Ohio — Traction control is preserved with the application of grit to roadways. Small amounts of Iceban, rock salt and salt brine, and calcium chloride are used when needed. On theOhio Turnpike, rock salt and small amounts of calcium chloride are applied to roadways.

Oklahoma — Rock salt is the primary substance used. Liquid and solid magnesium chloride are used to to treat salt before application to roadways. Sand is the primary abrasive in use.

Oregon — The state uses sand, CMA, potassium acetate (often mixed with calcium chloride), and magnesium chloride compliant with the Northwest Snowfighter specification.

Pennsylvania — Rock salt and brine are the primary anti-icing agents. Liquid magnesium chloride and liquid calcium chloride, both with corrosion inhibitors, are used in smaller amounts as prewetting or anti-icing agents. Use depends on county manager preference.

Rhode Island — Rock salt, treated with small amounts of calcium chloride, is what you will see on Rhode Island roads.

South Carolina — Rock salt and brine. Liquid calcium chloride is also used.

South Dakota — The state relies on abrasives such as sand and cinders.

Tennessee — Salt brine is applied to roads above 23ºF; rock salt is used at colder temperatures. Iceban is also used.

Texas — Rock salt is used for ice control, as is liquid and solid magnesium chloride. Abrasives used include sand and bottom ash mixed, sand alone, and aggregate gravel.

Utah — Rock salt, followed by magnesium chloride, is used for ice control.

Vermont — Calcium chloride pellets or a 45 percent calcium chloride solution is applied to Vermont roads.

Virginia — Rock salt, calcium chloride, magnesium chloride, and Iceban are used on Virginia roads.

Washington — Rock salt, magnesium chloride (inhibited in accordance with the Northwest Snowfighter specification), calcium chloride (also inhibited according to specification), and Iceban are used in Washington state.

West Virginia — Rock salt mixed with cinders or calcium chloride mixed with cinders (temperature dependent) is used most often. CMA is used on the bridge over the New River Gorge. Pure rock salt or calcium chloride (temperature dependent) is applied on interstates or treacherous portions of roadways.

Wisconsin — Rock salt treated with calcium chloride liquid is most often used. Some bridges are treated with calcium chloride or magnesium chloride depending on conditions. Abrasives (sand) are used in the western third of the state only.

Wyoming — Wyoming uses a 95 percent sand, 5 percent salt mix on roadways. Liquid magnesium chloride is used as an anti-icing agent on problematic portions of urban roads and highways. Some mixing of mag chloride and sand may be done to keep sand from blowing off roadway.

PRESENTATION HIGHLIGHTS

S.6 Chassis Study Group

Mini-Technical Session —
"New Corrosion Problems: Are Your Fleet's Brakes Rusting Away?"

Moderator: Joe Fleming, Falcon Transport Company

Speakers: Roy Gambrell, Truck It, Inc.
Patti Olsgard, Colorado Motor Carriers Association
Rod Russell, Dana Corporation
Alan Matsumoto, Carlisle Corporation
Darry Stuart, Quickway Transportation

Rust jacking of brakes and corrosion from liquid deicers in general is a larger problem to our industry than is generally realized. Moderator Fleming, Falcon Transport Company, presented an overview of the problem and what the industry is doing about it.

No Problem? Take a Closer Look

"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 they have the problem, they had better take a closer look at the brakes on their equipment, he said.

The problem is caused partially by the use of calcium chloride on roadways. Calcium chloride is used not only for ice and snow treatment, but also for dust control. 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 becomes 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 show, 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 —** causing 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 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.

Deicers: A Leading Cause of Rust Jacking

One of the leading causes of rust jacking is the use of corrosive chemicals to control the snow and ice on the roadways. Thirty states are now using rock salt on their rods, but that is changing. Twenty states use calcium chloride along with the rock salt, but that list is also growing. Some states have started using sodium chloride.

Oregon, Montana and Idaho use magnesium chloride, a very aggressive compound and possibly the most corrosive of all the deicers. Those states 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 are like an acid when contacting with metal parts of our vehicles.

"This has become a huge problem in our industry and we must all work together to find a solution," said Mr. Gambrell.

How Colorado Works Through the Problem

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

In 1996 and 1997, the State of Colorado began to hear complaints about corrosion from some of the fleets in Colorado. Ms. Olsgard explained they classify winter road maintenance in two categories: anti-icing and deicing. 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 with each other to provide a more effective deicing solution, Ms. Olsgard said.

In Colorado, the main solution used in snow and ice control is magnesium chloride, whether they are treating the roads for anti-icing or deicing. Ms. Olsgard went on to say that 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.

In addition to the magnesium chloride and salt/sand mixture, Colorado is experimenting 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.

Alcohol-Based Solutions Considered Cutting Edge

Colorado is also using 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 explained.

Because Colorado uses mainly the highly corrosive magnesium chloride on its roads, complaints come regularly from the trucking industry concerning the corrosion factor on their vehicles during the wintertime. 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.

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. Lastly, it can make road surfaces slick or slippery on certain conditions.

Why Use Magnesium Chloride?

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, Ms. Olsgard noted. 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 75 cents per gallon for Calabran M 1000 and $75 per ton for the dehydrated product called Ice Slicer. Magnesium chloride is relatively easy to use, requiring little training to use the equipment to apply it. Its use cuts down on personnel time needed and the effort used to apply it.

Today, fleets can expect their vehicles to encounter deicers almost everywhere, but there are some areas where it is more prevalent than others. The mountain states, northeastern states and plains states all use deicers as winter road treatments, Ms. Olsgard said. In the Sunbelt, mainly in Arizona and New Mexico, the same type compounds are used as a release agent on asphalt trucks. These products are also used in Canada and Europe to a large degree.

“Because this is a very serious issue for the trucking industry, we must find solutions to some of the issues,” Ms. Olsgard said. She has been working with the State of Colorado for three years on solutions to the problems, and there are things fleet users can do on their own. For instance, working with local transportation departments on product selection, corrosion inhibitor additives and application methods are all examples of being proactive.

There has been some progress made in Colorado, Ms. Olsgard said. 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 on 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 is also considering reducing its application time before an anticipated storm to 24 hours from 96 hours. Lastly, be sure the local municipalities have adequate testing and quality control procedures to be sure the products they are purchasing and applying to the roadways meets the specifications mandated.

What Fleets Can Do

In the way of vehicle maintenance, there are also several things fleet operators can do, Ms., Olsgard noted. Keeping vehicles clean and restoring any pitted or damaged metal components will go a long way toward reducing costs related to corrosion. Also, apply wax to a vehicle's finish to act as a buffer and sealants to electrical systems for the same purpose. Additionally, several companies are working on soaps and cleaners to take the deicers off without the use of acids in a fleet's cleaning solutions.

Ms. Olsgard said the trucking industry should not feel alone in its fight against these compounds. The school bus industry has many of the same concerns and issues as the trucking industry when it comes to corrosion problems. And in the ski industry, the shuttles used on the roadways are prone to the same corrosion as heavy trucks and trailers. Utility companies have found that the deicers coat insulators and promote utility pole fires as a result. "We all have an interest in this, not just the trucking industry," she concluded.

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.

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.

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.

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 pushing up 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 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 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.

Types of Paint Used on Brake Shoe Tables

Several different paint processes are used on both OEM and aftermarket brake shoe tables, Mr. Russell explained. Solvent-based paints consist of a solvent plus a higher volatile organic compound. Water-reducible paints are made up of water, solvent and a lower volatile organic compound. Water-based paints are made up of water and emulsifiers. All of these paints have endured a 100- to 200-hour life range in an environmental chamber. E-coat paints are an epoxy dip that is electrostatically charged. E-coating provides a 200- to 500-hour life range in an environmental chamber. E-coating is the process used on most new OEM shoes being produced today.

Brake shoes are tested to the guidelines established by the ASTM. Test method B 117-97 provides a controlled corrosive environment that will help predict component performance. To perform the test, component samples are placed in an environmental chamber and exposed to a mist of corrosive fog for a specified time period.

There are a number of things currently being pursued by the HDBMC in an effort to learn more about the rust jacking phenomenon and how to fight it. Additional shoe and lining assembly samples are being collected from several fleets for further evaluation. Mr. Russell reminded the fleet users that it is critical to provide complete supporting documentation when returning any samples for analysis.

He said baseline and exploratory laboratory tests are being conducted on corrosive compounds such as rock salt, calcium chloride and magnesium chloride in an effort to find shoe table coatings that are impervious to these solutions.

He said it is also recommended the HDBMC work with TMC's S.6 Study Group to conduct a formal survey of its members to better quantify rust jacking issues. Mr. Russell said the plan would be to present the results of the survey as well as any laboratory test results at a future TMC meeting.

There are several conclusions that can be drawn, Mr. Russell noted. States and provinces are likely to continue to use existing deicing and anti-icing compounds. However, if the use of calcium chloride and magnesium chloride are proven to significantly accelerate the corrosion of vehicles and vehicle components, municipalities should be pushed to provide updated cost/benefit studies.

It is not practical to expect fleet users to wash equipment to the extent needed to flush the corrosive compounds out of the brake systems, said Mr. Russell. This type of washing has not been proven to be a solution to the problem.

He stressed that new shoes should have a quality corrosion resistant coating. Relined shoes should also be focused on in the areas of shoe table coating and proper coining, he said. Higher quality relined shoes using good cores are an important component in fighting the rust jacking phenomenon.

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 lines 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 lignin 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 a shoe table that has a different drill patter on the rivet holes that 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 assures 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.

Seeing is Believing

Darry Stuart, Quickway Transportation, presented a series of pictures depicting corrosion on all parts of tractors and trailers. He said rust jacking that occurs in brakes is certainly an issue, but equally as important are the parts that are rusting away that fleet users are not supposed to have to replace— things like frame rusting and flaking are expensive problems to have and happen in today's vehicles.

There are no components on today's vehicles that are immune from the corrosion caused by the chemicals being used as deicers today, Mr. Stuart said. He showed examples of various components all over the vehicle from shock absorbers to air tanks to underhood components that are victims of premature corrosion. Fleets generally do not budget for the types of repairs caused by corrosion, he observed. He asked if a fleet did budget for some of this type of maintenance, would that make it okay for it to occur?

Wheel maintenance is something that is very important to a fleet's operation and can be budgeted for, however road deicers can eat through even powder coating on wheels as Mr. Stuart showed with several photographs. Trailer corners and other parts on the trailer are not immune to the corrosion, either. A series of pictures showed everything from suspension brackets to the underside of the trailer corroded. Electrical components are particularly susceptible to corrosion and wicking of liquid deicers, Mr. Stuart observed. These problems can be particularly annoying and very difficult to find.

What Fleets *Can* Do

There are some things a fleet user can do to prevent some of the corrosion damage happening on vehicles today. Mr. Stuart said that fleets should specify corrosion resistant materials such as stainless steel where appropriate, cost effective and practical. Where painted surfaces or chrome is used, be sure the surface preparation is properly prepared. Frequent vehicle washing to remove the residue the corrosive materials leave is key to longer life and better appearance. Lastly, fleets should consider whether repainting parts of the vehicle affected by the corrosives is the right thing to do. Mr. Stuart advised that the problems fleets are seeing from corrosive deicing solutions are not going away any time soon.

Questions and Answers

Q. *About heavy metals in vehicle was water - are they from additives in the liquid deicers or leaking from vehicles?*

A. Both. Molybdenum, zinc and lead are additives you will find in deicers.

Q. *Would bonding the shoes to the table help eliminate some of the problems associated with rust jacking?*

A. It might have a better effect, but there is a question of if it is a cost effective method. Bonding may end up being a stopgap method. In 1984, there was a bonded shoe manufactured, but the industry did not accept it because of cost. The bus industry uses some of these types of things, but the maintenance is very high. The shoes used in bus brake applications are typically cast iron.

Q. *How often should a "drum removed" inspection be done to look at brake linings?*

A. If you see a crack where you can put a business card in between the table and lining, you have cracked shoes.

Q. *Does this make a case for or against dust shields?*
A. If you have dust shields and maintain them, they are good. If you have dust shields and do not maintain them, they are worse than not having them.

Q. *How long have liquid agents been used?*
A. In some states, liquid agents have been used as long as 8-10 years. In the last five years there has been heavier use in more areas.

Q. *Are the effects of liquid deicing agents working their way into electrical systems a spotty or a more prevalent problem?*
A. The effects of liquid deicing agents on electrical systems is more prevalent in vehicles that run mainly in the eastern states.