

MANAGING THE CORROSION AND TOXICOLOGICAL EFFECTS OF ROADWAY DEICERS

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Outline

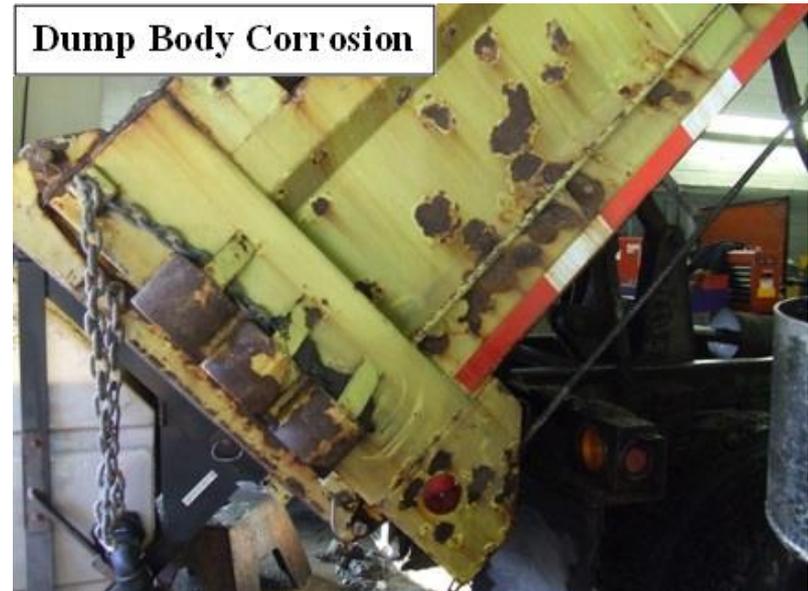
- Materials Used for Snow and Ice Control
- Corrosion Definition
- Causes and Effects of Corrosion
- New Equipment Specification
- Repair, Rehabilitation, and Retrofitting of Existing Equipment
- Preventive Maintenance Practices for Equipment
- Training and Facility Management
- Toxicity due to chloride based deicers and mitigation strategies
- Concluding Remarks

Materials Used for Snow and Ice Control

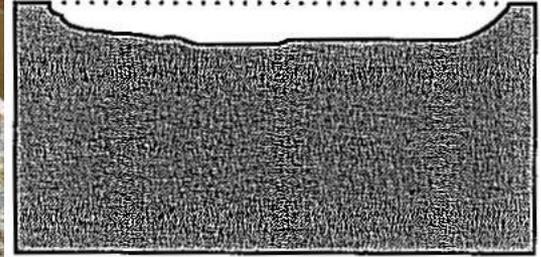
- ❑ *Inert materials*, such as sand, have no de-icing properties; simply provide temporary traction on icy pavement.
- ❑ *Chemically active* de-icing materials are:
 - Chlorides such as sodium chloride, calcium chloride and magnesium chloride;
 - Acetates such as potassium acetate, calcium magnesium acetate and sodium acetate;
 - Formates such as potassium formate;
 - Glycols
 - Urea and agro-based

Corrosion Definition

- Corrosion is deterioration of materials due to the reaction with environment.
- All of the metallic components used in DOT fleet are prone to corrosion.
- The corrosion forms can be divided into:
 - General corrosion
 - Localized corrosion



General Corrosion



- Surface area is corroded at the same rate.
- It can be included in design calculations by **increasing wall thickness.**

Localized Corrosion



- Localized corrosion can cause unexpected failures.
- It has different forms.

Causes and Effects of Corrosion

- Chloride deicers are easily available, relatively inexpensive, and easier to use than non-chloride deicers despite their higher risk to vehicles and equipment.
- The average estimated annual costs per agency for corrosion management:
 - ✓ Training programs (\$190,938)
 - ✓ Materials selection (\$320,667)
 - ✓ Design improvements (\$45,000)
 - ✓ Corrosion monitoring and testing (\$10,000)
 - ✓ Proactive maintenance (\$171,424)
 - ✓ Reactive maintenance (\$325,000)

Cost-Benefit Analysis of Mitigating Deicer Corrosion to DOT Equipment

- You can reduce the current cost of corrosion risk related to deicer exposure by 80% × 25%, if the agency can increase its current investment in equipment corrosion control by 20% (Shi et al 2013).
- **The benefit/cost ratio** of further mitigating corrosion from deicers to DOT fleet equipment:

$$(80\% \times 25\% \times \$14,050,368) / (20\% \times \$1,063,029) = 13.2$$

New Equipment Specification; Build to Last

1.Metal Materials Selection

2.Design Improvements

3.Considerations for welded joints

4.Coatings for Corrosion Protection

Metal Materials Selection

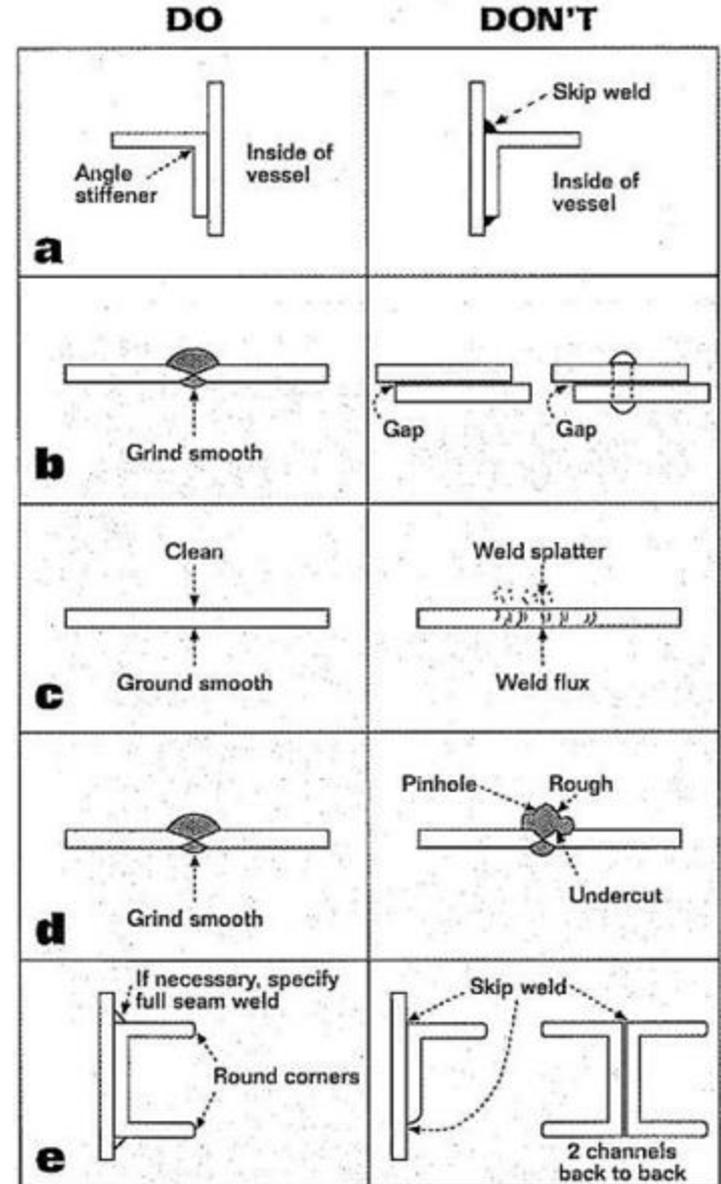
- Magnesium alloys and mill product forms of aluminum alloys 2020, 7079, and 7178 should not be used for structural applications.
- In SCC of austenitic stainless steel (300 series stainless steel) by chlorides, substitution of duplex stainless steels will often eliminate the problem.
- Using steels containing molybdenum such as stainless steel 316 can reduce pitting corrosion.
- Intergranular corrosion can be reduced by using the stabilized (321 or 347) or low-carbon (304L or 316L) stainless steels.

Design Improvements

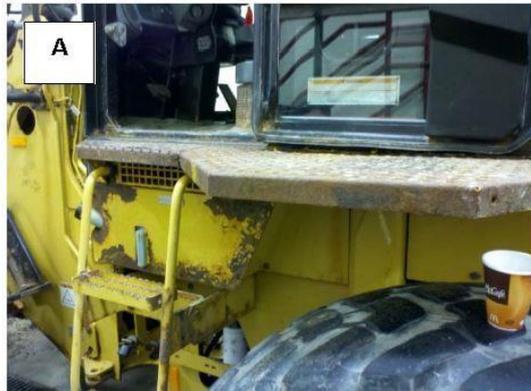
- Where water may accumulate, include holes for drainage (Min. D. 0.375 inches).
- Avoid sharp corners that make it difficult for protective coatings to function.
- Remove notches and other stress-concentrating features by using rounded filets and angles.
- Minimize the crevices or seal them.
- Contact between dissimilar metals should be avoided. Where it is not possible, both metals should be coated.

Considerations for welded joints

- Eliminate the weld splatter.
- Rough welding should be ground smooth.
- If feasible, welds should be double coated.
- Where corrosion is possible, use continuous welds instead of discontinuous welds.
- Remove brackets and extra metal.



Protect Your Asset by a Professional Coating!



Coatings for Corrosion Protection

- ❑ Coatings must meet many requirements including long-lasting, easy application, environmentally friendly, cost-effective, and high performance.
- ❑ An ordinary coating that is applied to a well prepared surface may perform better than a high-quality coating which is installed over a substrate with an inappropriate surface.
- Use of salt remover (rust remover) effectively increases coating performance.
- In situations where grit blasting is prohibited or unusable for safety and environmental reasons; rust removers should be used for surface preparation prior to coating.

Repair, Rehabilitation and Retrofitting of Existing Equipment

Evaluation Process for Fleet

- A thorough inspection of each unit;
- An initial itemized list of repair/maintenance work;
- A general assessment rating (alpha-numerical or defined term);
- A priority ranking for each item, for example: Critical, Urgent, Needed, Recommended;
- A detailed cost estimate for each vehicle;
- A determination of expected service life if repairs/rehab is done;
- A decision for the course of action for each unit; and
- Final cost estimate based on evaluation.

Repair and Restoration

- Restoration means replacing a component.

Modifications

- Such as replacing strobe warning lights mounted on the cab roof with ones mounted on a cross-bar.



Preventive Maintenance Practices for Equipment

- ❑ **Reactive methods** are used to deal with existing corrosion by cleaning corroded parts, or replacing them if the parts are easy to clean, or easily replaced and fairly inexpensive.
- ❑ **Preventive methods** may involve the use of corrosion resistant materials, dielectric grease, enclosed wiring connections, the use of sacrificial anodes, the use of coatings, the use of corrosion inhibited products, and frequent and regular washing.

Protect Equipment Assets by Preventive Maintenance!



Relocating junction boxes into the cab.



Sealed connections and plugs and use of dielectric grease on them.



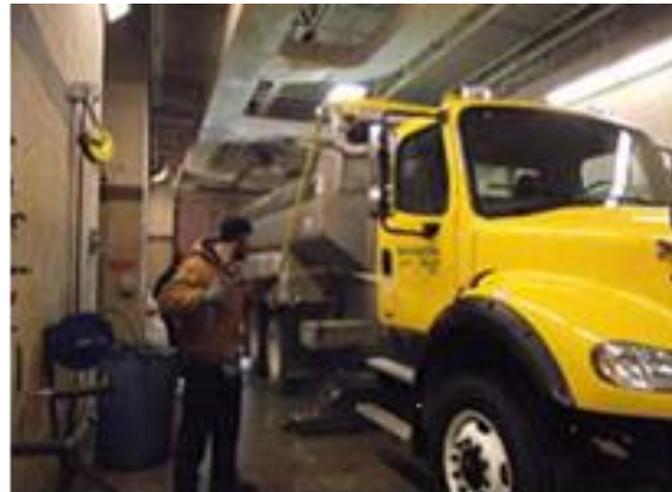
Installing modified protective cover for battery.

In-field success of some proactive maintenance methods (a) aluminum fuel tank, (b) stainless steel hydraulic pipes, (c) poly tandem fender guards, (d) E-coated frame rail.





Wash Vehicle Daily!



Washing

- **Concentrate on trouble spots** such as frame rails, brake components, and underneath of the chassis.
- **Use hot water** and then **fast drying**.
- **Do not use a pressure washer**, because water can be forced into crevices and cannot escape which leads to corrosion.
- **Use low pressure wash** and **high flow rate** (300 psi/300 gpm).
- **Use physical action together with washing**.
- **Use salt removers (neutralizers)** to remove the salt captured in crevices.
- **Once active corrosion of metals is started, apply spray-on corrosion inhibitor**.

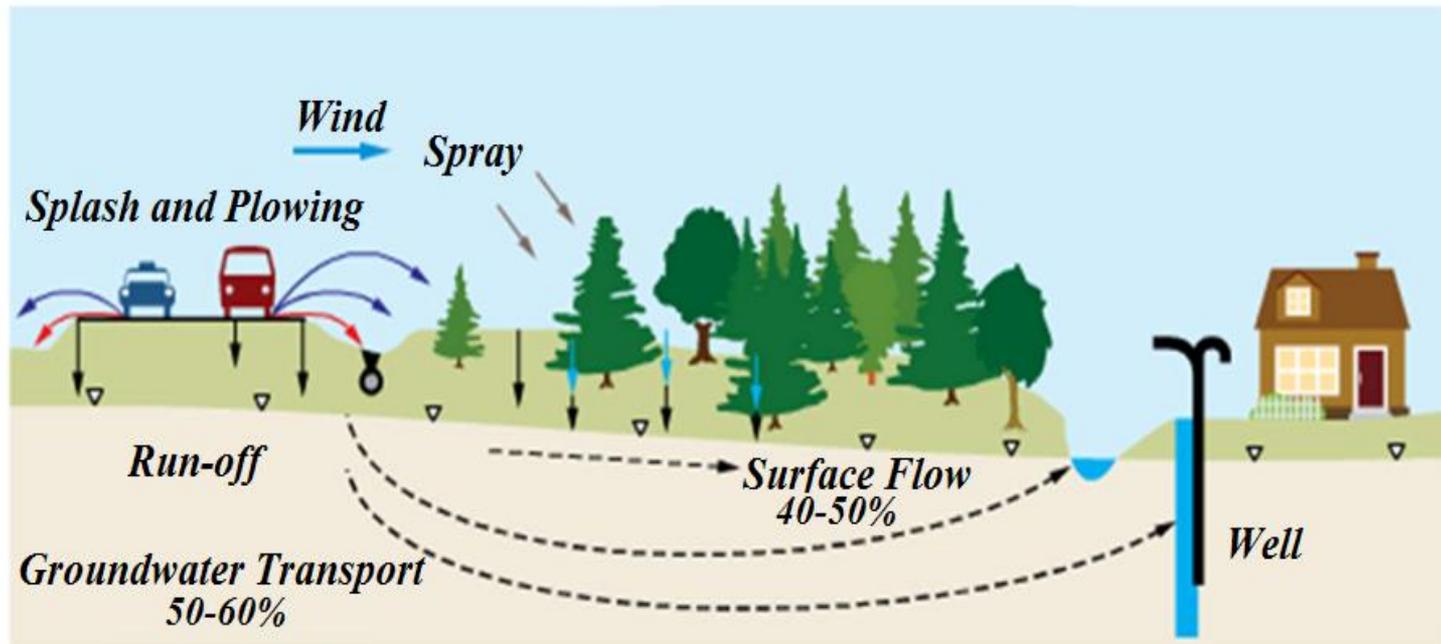
Training and Facility Management

- ❑ **Operators** need to know the basic characteristics of each product.
- ❑ **Mechanics** need to understand the corrosiveness of each chemical.
- ❑ **Supervisors** are responsible for making sure that the staff involved in transporting, handling, and storing materials have the proper training.
- ❑ **Good housekeeping** should be an every-day standard at any agency facility where materials are stored and handled.

Toxicity due to chloride based deicers and mitigation strategies

- Information on **impacts of chlorides on aquatic species** is needed to enable fully-informed decisions by stakeholders.

Pathways of deicers into the environment



(adapted from Rubin et al., 2010 and Ratkevičius et al., 2014)

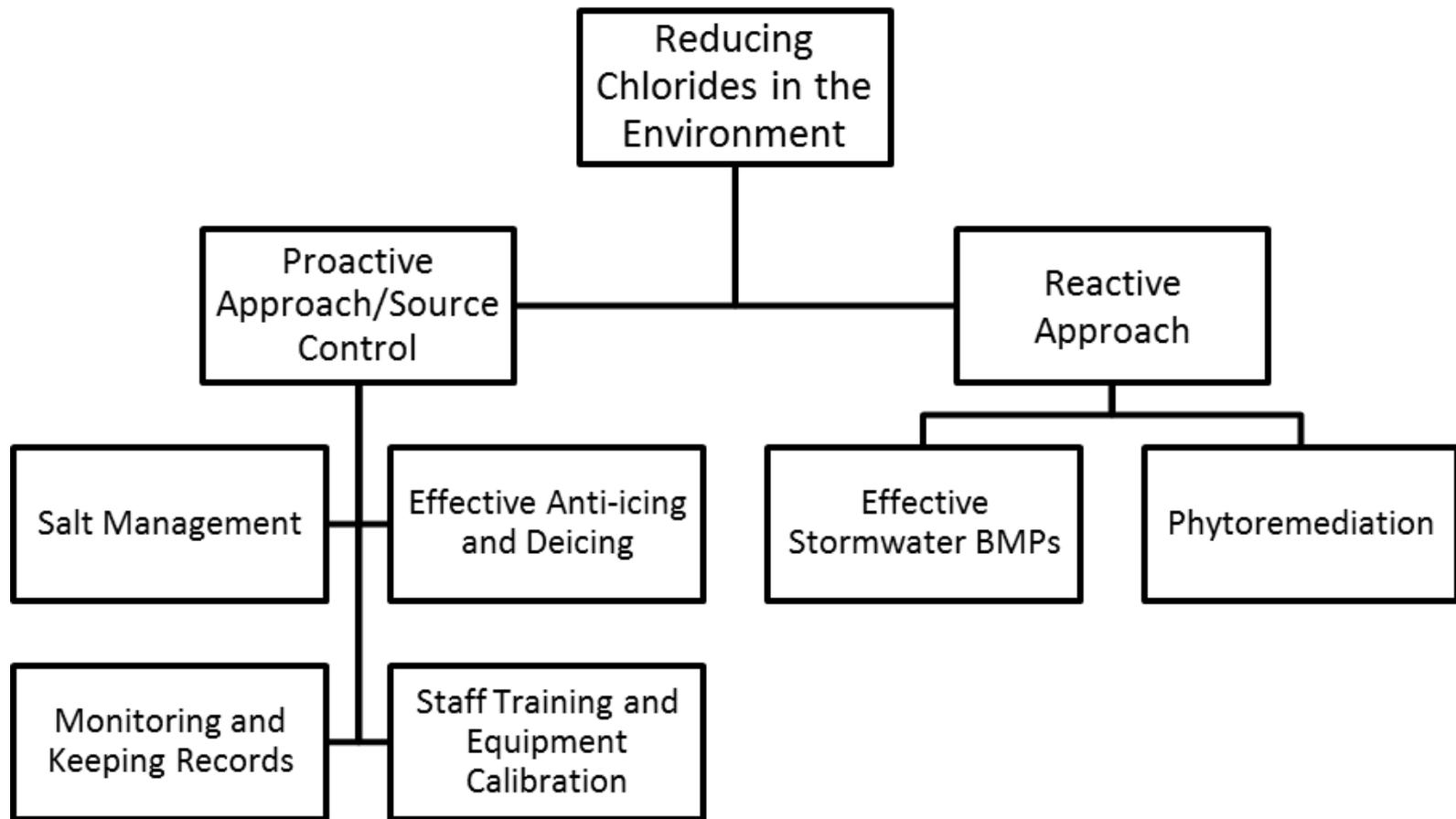
Impacts of Chloride Based Deicers on Aquatic Species

- Amphibian toxicity
- Benthic species toxicity
- Invertebrate species toxicity
- Fish toxicity



- ❖ Increasing species acclimation and diluting water hardness reduces the toxic effects of chloride by 1.4 to 1.5 times.

❑ Heavy Metal Leaching by Deicers



Overview of strategies to reduce chloride based deicers in the environment (Jungwirth et al. 2015)

Concluding Remarks

- ❖ Existing knowledge about the anti-corrosion performance of various materials and design configurations in various deicer-laden service environments should be utilized to refine the equipment purchasing specifications developed by the transportation agencies.
- ❖ Agencies should implement an extensive preventive maintenance program which can be supplemented by corrective maintenance practices to minimize the negative impact of deicer corrosion to equipment asset.
- ❖ The density of road networks and the application rates used can directly influence the chloride concentrations observed in surface and groundwater.
- ❖ The use of various proactive strategies combined with effective reactive strategies will ultimately reduce the environmental impacts related to chloride based deicers.

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Q&A

