# Research Problem Statement

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## I. TITLE

17-003 Guidelines for using sacrificial coatings to protect ODOT equipment assets from deicer corrosion

## II. PROBLEM

Field observations and recent studies have confirmed that DOT equipment used for the application of chemical deicers corrodes at a much accelerated rate. Over the last decade or so, ODOT has used magnesium chloride ($MgCl_2$) products to help maintain safe mobility on winter highways. Relative to rock salt and salt brine, $MgCl_2$ products tend to migrate more into hidden areas and are more difficult to be cleaned from the vehicles. The exposure to these products poses a significant cost to the hundreds of separate pieces of ODOT maintenance equipment.

The costs associated with corrosion to ODOT equipment are substantial as metallic corrosion increases maintenance and repair costs, reduces vehicle life, and results in downtime to equipment. The ODOT's estimated Fleet Equipment replacement cost is $400 million, in which deicer exposure contributes a significant portion. In a recent study (Shi et al., 2013), for agencies that report deicer corrosion to equipment as a significant issue, the total cost of current corrosion management and corrosion risks related to deicer exposure was estimated to average $1 million and $14 million per year, respectively. On average, deicer exposure leads to risks in six areas: 17.3% depreciation in equipment value, 8.5% increase in equipment downtime, 11.9% reduction in equipment reliability, 17.3% reduction in equipment service life, 19.6% increase in premature repair and replacement, and 1.5% risk in safety from faulty parts on equipment.

For an “average agency” (a northern state DOT with an average size of fleet asset), the benefit/cost ratio of further improving deicer corrosion control of DOT equipment fleet can be estimated to be 13.2 (Shi et al., 2015). Laboratory studies have suggested that preventative maintenance (frequent washing, anti-corrosion coatings, corrosion inhibitors, salt removers) can preserve the quality and life of metals in chloride-laden environments (Jungwirth et al., 2014; Li et al., 2013; Shi et al., 2013). Preliminary field trials by ODOT Fleet Services section have demonstrated the benefits of using sacrificial anodes to mitigate the corrosion of deicer tanks, even though the mitigation was isolated to a small area. It is envisioned that the same principle of cathodic protection could be extended to using sacrificial coatings to protect ODOT equipment, with a more comprehensive outcome. Applying a sacrificial coating to specific high-deicer-exposure areas on vehicles may be more cost-effective than the normal practice of frequent washing followed by vehicle storage in dry garage.

In this context, there is an urgent need to identify various sacrificial coating options and evaluate their performance and cost benefits as a function of typical equipment and exposure scenarios of interest to ODOT. The goal is to develop guidelines for ODOT to adopt the cost-effective sacrificial coating treatments to reduce the corrosion effects of deicers to ODOT equipment assets and extend their service life.

## III. PROPOSED RESEARCH, DEVELOPMENT, OR TECHNICAL TRANSFER ACTIVITY

This research project will mainly consist of laboratory investigation and field validation. It will start with the identification of *typical equipment and exposure scenarios* of interest to ODOT, followed by a *design of experiments* for the laboratory testing program. The candidate equipment to be protected by sacrificial coating may include: plow trucks, slip-in deicer tanks, liquid deicer applicators, hoppers, and front end loaders. The candidate areas of coating application may include: metal deicer tank skids, sander, dump bed or frames components. The effectiveness of the coating treatments will be evaluated in terms of their ability to slow down the metallic corrosion, in the presence of $MgCl_2$ applications, wet–dry cycling, and abrasion. The simulation of service conditions (e.g., amount of annual rainfall and temperature cycles in various ODOT districts) will be incorporated to be part of the testing program. Other variables to explore will include: the type and condition of metal to be protected (aluminum alloys, low-carbon formable steels, high-strength steels, etc.), the level and frequency of deicer exposure, climatic conditions (time of wetness, temperature, etc.), washing frequencies, and exposure to abrasives. A *service life model* of various vehicle parts will be developed to link the results of accelerated laboratory tests to field performance of selected coating treatments. Subsequently, the model will be used to establish *acceptance tests* for selected sacrificial coatings and to predict the beneficial life of selected coatings and their life cycle cost. For various selected scenarios, the most cost-effective coating treatment will be identified. With the assistance of ODOT Fleet Services section, the key findings from the laboratory investigation will be preliminarily *validated on selected maintenance trucks in the field* over at least 12 months. All the findings from the project will be leveraged to develop *guidelines* for preserving new and old ODOT maintenance equipment exposed to magnesium chloride deicers.

## IV. POTENTIAL BENEFITS

By identifying cost-effective sacrificial coatings, the service life of ODOT equipment assets will be prolonged and repairs can be reduced, resulting in cost savings to the Department and less downtime to equipment fleet. Without this research, ODOT will continue to bear the costs due to premature equipment failure and the associated safety risk, reliability risk and environmental footprint. This research is urgently needed in light of the increasing reliance on chloride deicers for highway winter operations and the challenge of maintaining a state of good repair with limited equipment maintenance budgets.

## V. IMPLEMENTATION

This research will modify the approach to equipment preservation by ODOT Fleet Services section and enable ODOT to make informed and better choices on preserving the quality and life of equipment assets. The findings will help ODOT revise the requirements for coatings products to be included in the QPL and relevant sections in the Equipment Management Manual.

## VI. LIST OF REFERENCES *(optional)*


Jungwirth, S., Shi, X., Seeley, N., Fang, Y. (2014). Proactive Approaches to Preserving Maintenance Equipment from Roadway Deicers. *ASCE Journal of Cold Regions Engineering*, DOI: 10.1061/(ASCE)CR.1943-5495.0000085.

Li, Y., Fang, Y., Seeley, N., Jungwirth, S., Jackson, E., Shi, X. (2013). Corrosion of Chloride Deicers on Highway Maintenance Equipment: Renewed Perspective and Laboratory Investigation. *Transportation Research Record* 2361, 106-113.

Shi, X., et al. (2013). Identification and Laboratory Assessment of Best Practices to Protect DOT Equipment from the Corrosive Effect of Chemical Deicers. Final report prepared for the Washington State DOT.

Shi, X., Hansen, G., Mills, M., Jungwirth, S., Zhang, Y. (2015). Preserving the Value of Highway Maintenance Equipment against Roadway Deicers: A Case Study and Preliminary Cost Benefit Analysis. *Anti-Corrosion Methods and Materials*, in press.


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