

# Deicing Technology and the Effects of Deicers on Infrastructure and Equipment

Prepared for Iowa Freight  
Advisory Council

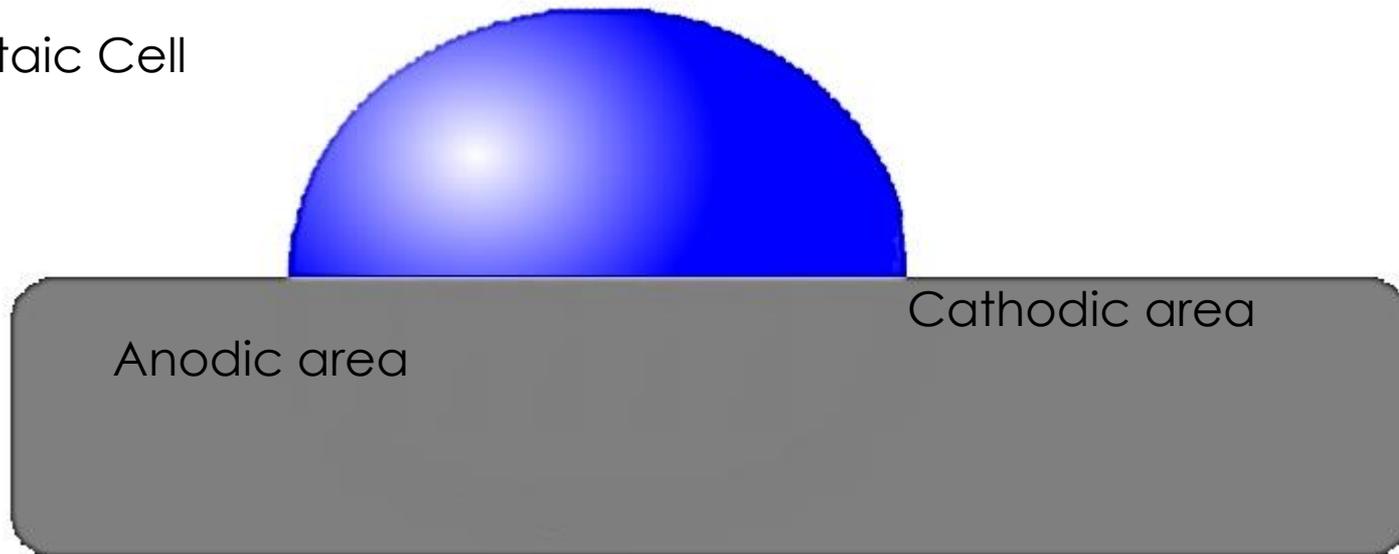
December 1, 2017

# Background

- **Roadway deicer use is estimated to reduce crashes by 75-90% & prevent significant economic losses due to closures.**
- **Deicing accounted for 44% of the 42,000,000 metric tons of salt produced in US.**
- **This has led to concerns about damage to transportation infrastructure, the natural environment, and motor vehicles.**
  - Recent literature suggest estimated costs of road salt damage range from \$803 to \$3,341/ton to vehicles, bridges, and the environment.

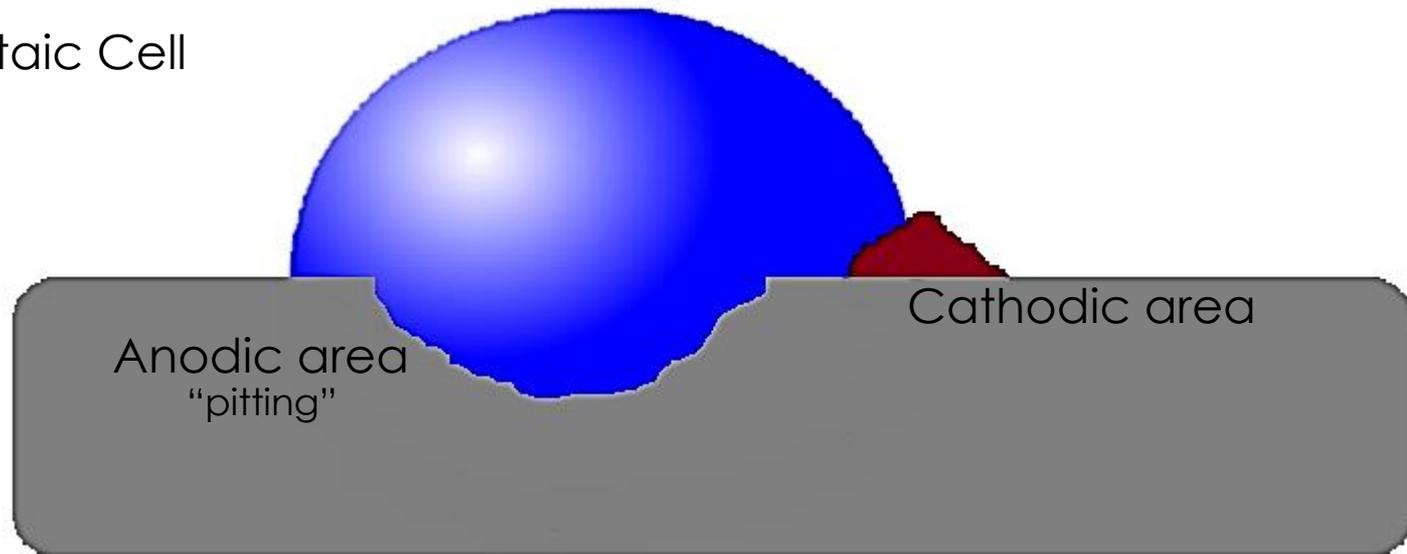
# Iron Corrosion Chemistry

Voltaic Cell



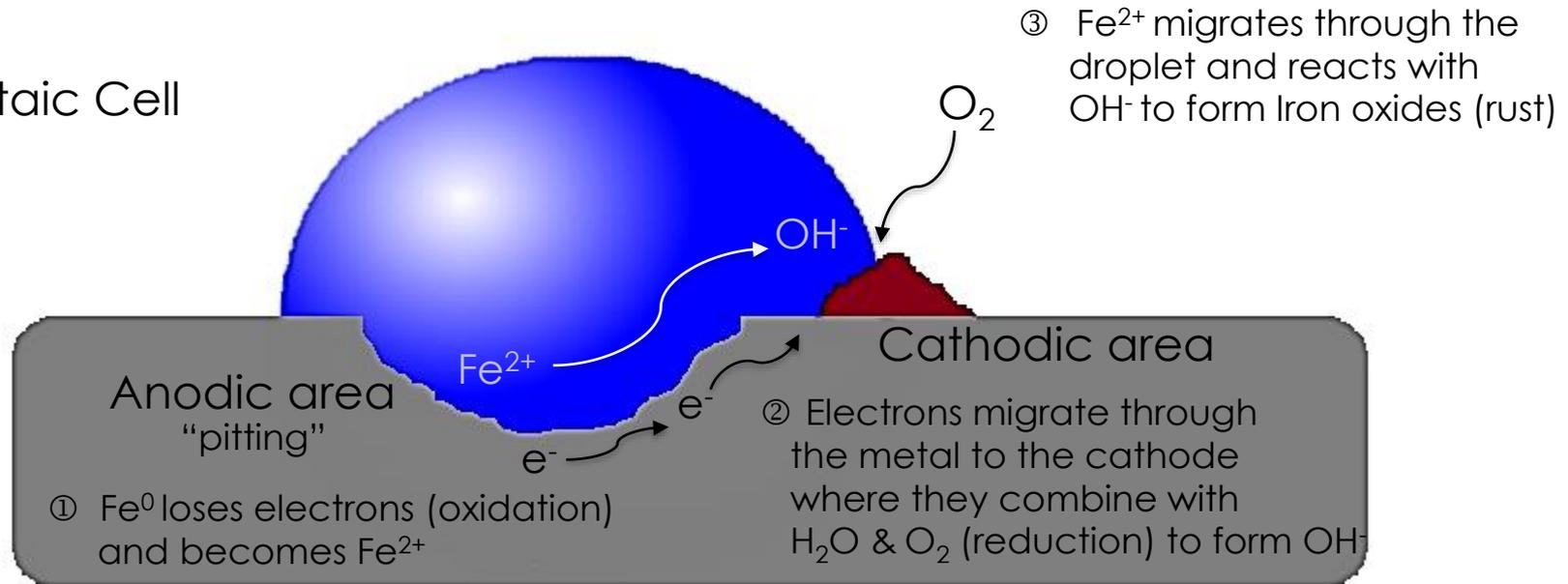
# Iron Corrosion Chemistry

Voltaic Cell

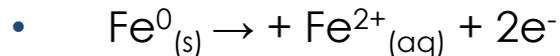


# Iron Corrosion Chemistry

Voltaic Cell



At the anode:

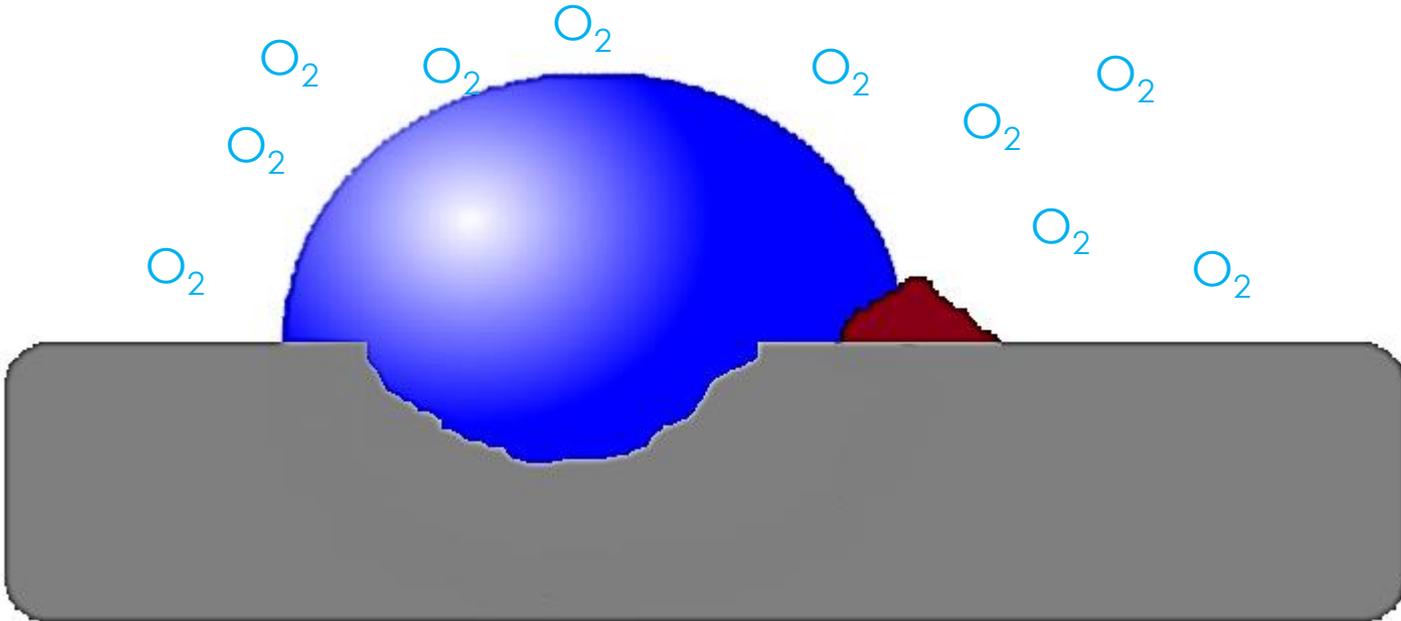


At the cathode:

- $\text{O}_{2(g)} + 2\text{H}_2\text{O}_{(l)} + 4e^- \rightarrow 4\text{OH}^-_{(aq)}$
- $\text{Fe}^{2+}_{(aq)} + 2\text{OH}^-_{(aq)} \rightarrow \text{Fe}(\text{OH})_{2(s)}$
- $4\text{Fe}(\text{OH})_{2(s)} + \text{O}_{2(g)} \rightarrow 2\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}_{(s)} + 2\text{H}_2\text{O}_{(l)}$
- ...and other oxides

*The technical bit just in case you were interested...*

# Iron Corrosion Chemistry



## Rust has three requirements:

- Iron
- Oxygen
- Moisture

*All you really  
need to know...*

# What makes corrosion worse?

- **Corrosion is exacerbated by:**
  - Sometimes by dissimilar metals in contact in an aquatic solution (galvanic corrosion)
  - Higher temperatures
  - Acidic conditions
  - Persistent wetness
  - Presence of  $\text{Cl}^-$



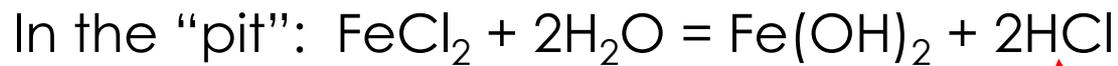
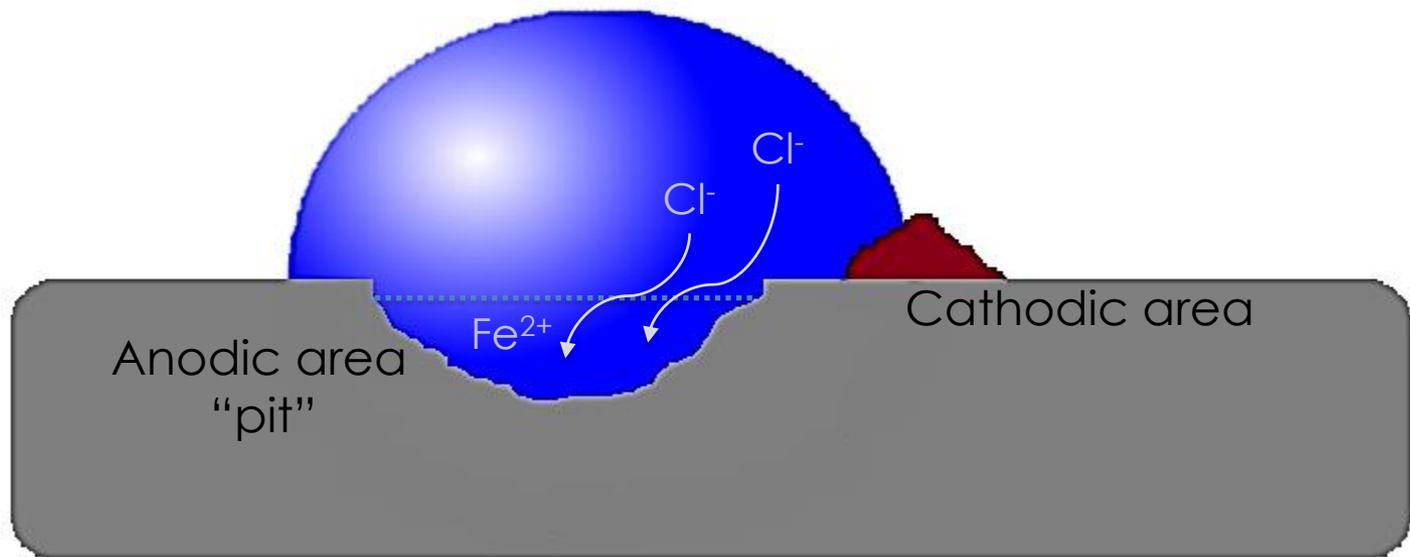
# What protects against corrosion?

- **Corrosion is lessened by:**
  - Sometimes by dissimilar metals in contact in aq. solution (galvanizing)
  - Passivation (formation of a protective oxide layer)
    - Oxide insulates & impedes oxygen diffusion
  - Painting/coating metal surfaces prevents  $O_2$  and  $H_2O$  from contact
  - Removing as much deicer as possible from vehicles
    - Pay special attention to crevices and areas where salt can get trapped
  - Periodic application of corrosion inhibitor



# What effect does road salt have?

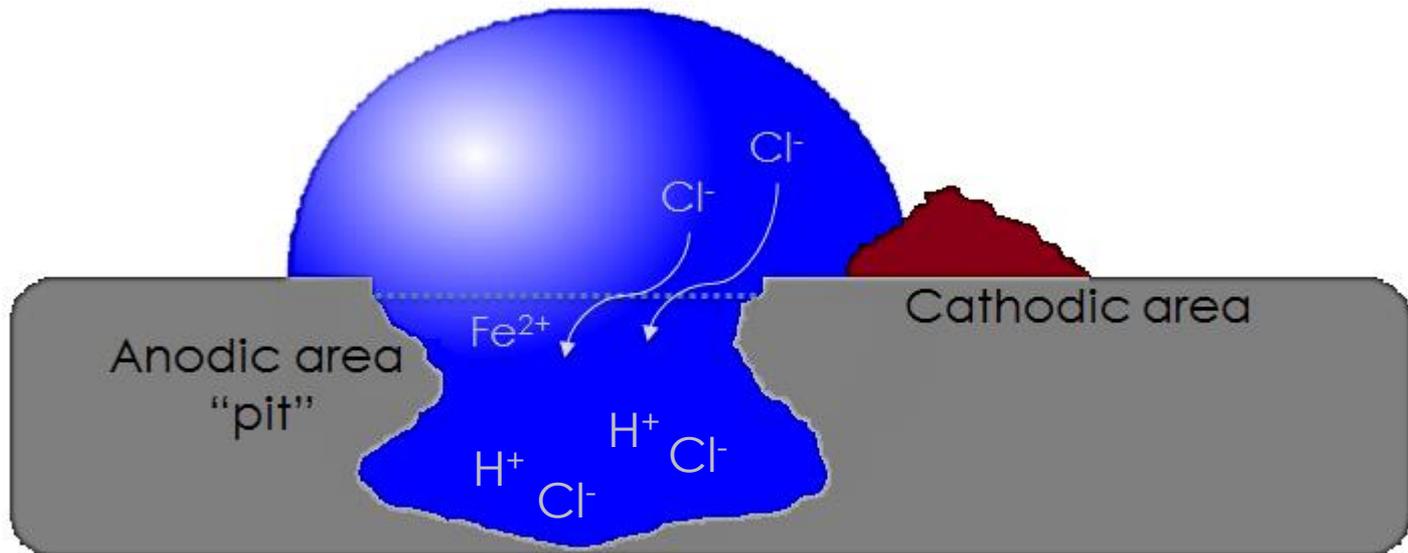
- Salt increases electrical conductivity, prevents formation of protective oxide films (passivation) & catalyzes corrosion.



*yikes!*

# What effect does a chloride salt have?

...Rate of corrosion then increases exponentially



# Understanding concrete—it's really hard

- **What effects do deicers have on pavement?**
  - Concrete damage from spalling from freeze/thaw cycles



- Deicers are hygroscopic (i.e., attract moisture).

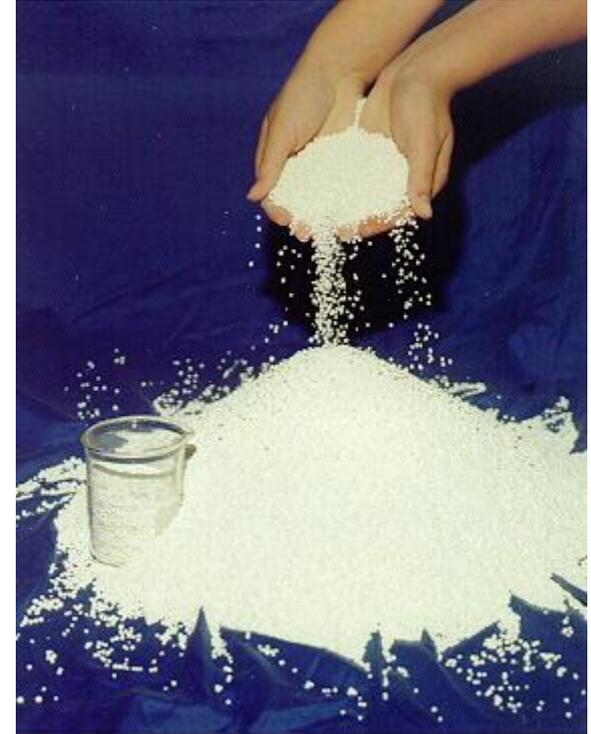
# Salt in the environment

- **Growing environmental concerns about increasing chloride concentrations in lakes, rivers, reservoirs, wells**
  - Chloride salts are not biodegradable; salinity is accumulative
  - EPA is concerned that rising salinity can cause problems both in human health (drinking water) and fish toxicity.
  - Trend toward more local restrictions on chloride salt use



# Deicing Options

- **Mechanical Removal**
- **Sand**
- **Sodium Chloride (solid or brine)**
- **Calcium Chloride (solid or brine)**
- **Magnesium Chloride (solid)**
- **CMA (solid)**
- **Sodium Acetate (solid)**
- **Potassium Acetate (liquid)**
- **Formates (similar to acetates)**
- **Urea**
- **Alternative Products: Beet Juice, Cheese Whey, etc.**



# Trends for Winter Maintenance

- **Tool box approach**

- Use of better technology (weather forecasting, RWIS, pavement temperature sensors, etc.)
- Sharing on best management practices (pre-wetting, proactive anti-icing, training, monitoring, calibration, etc.)
- Targeted use of non-chloride deicers



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