Evaluation of Epoke Bulk Spreader for Winter Maintenance

State Job Number: 134651

William H. Schneider, IV
Christopher M. Miller
William A. Holik
Mallory Crow
Research Objectives

1. Evaluate existing data reports with the Epoke unit,
2. Assess the in-field performance of the Epoke,
3. Perform a cost benefit analysis of the Epoke, and
4. Propose a deployment strategy for the Epoke consistent with current ODOT practices.
Project Setting

Winter 2011 - 2012

State Route 8
Summit County, Ohio

Winter 2012 - 2013

Interstate 271
Summit County, Ohio
Project Data Flow

- Data Collection

  Equipment
  - Labor – Same for Each Truck
  - Initial Cost
  - Maintenance Costs – Parts and Labor
  - Pretreat
  - Light Snowfall
  - Moderate Snowfall
  - Heavy Snowfall

  Weather
  - Normalized to Storm Severity

  Salt
  - Epoke Salt Applied
  - Standard Truck Salt Applied

  Travel Speeds
  - Direction Maintained by Epoke
  - Direction Maintained by Standard Truck

  Determine Difference in Vehicle Speeds (LOS)

Deployment Optimization
- Short Term – Each event
- Each Season – Move equipment as needed, and
- Long Term – Purchase Epoke spreaders to incorporate into fleet.

Education and Training will be needed to best utilize the Epoke system.

Conduct Overall Cost Benefit Analysis based on Optimal Deployment
Epoke Equipment

- S4902 Spreader: $110,000
- Tanker Spreader: $56,500
- EpoSat Controller: Included with spreader purchase.
Epoke Theory

- Crush salt and apply liquid to reduce bounce and scatter.
- Use higher liquid to solid ratio to reduce amount of salt used.
- Spread material up to three lanes in one pass.

Figure provided by Epoke
Epoke System

- Epoke Sirius AST Combi S4902 is the spreader evaluated.
- Tanks store brine, while hopper stores salt.
Epoke System

- The EpoSat is capable of recording routes and spreader controls on the route.
- EpoSat programs allows changes to be made to recorded route.
- Allows the operators to focus on roadways and plowing.
Epoke System

• The controller allows the operators to:
  – adjust the amount of salt and liquid being applied.
  – the number of lanes and direction of the spreading.
  – record and navigate routes
Epoke Used with Tanker Truck

- Placed Epoke on tanker truck used for pretreatment.
- Tanker holds 5000 gallons of brine.
Weather Data Collection

- Two weather stations utilized for study: Cuyahoga Falls and Macedonia.
- Storms were characterized to evaluate the Epoke in various weather conditions.
- Categories are created from observations of mild winters.

<table>
<thead>
<tr>
<th>Pretreatment</th>
<th>Anti-icing activities before a storm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Snowfall</td>
<td>Less than two inches of total accumulation or peak snowfall less than 0.25 inches/hour</td>
</tr>
<tr>
<td>Moderate Snowfall</td>
<td>Two to six inches of total accumulation or peak snowfall between 0.25 and 0.75 inches/hour</td>
</tr>
<tr>
<td>Heavy Snowfall</td>
<td>Greater than six inches total accumulation or peak snowfall greater than 0.75 inches/hour</td>
</tr>
</tbody>
</table>
Snow Plow Truck Data Collection

• In order to compare Epoke and standard truck, several categories of data were collected for each truck:
  – Salt Usage – is used to determine the difference in the amount of salt applied by each truck.
  – Brine Usage – is used to determine the difference in the amount of brine applied by each truck.
  – Mileage – Record the start and end mile markers of the routes traveled.
  – Lanes treated – Unique to Epoke, which can treat multiple lanes.
  – Plowing – Recorded so that any maintenance actions besides applying material may be accounted for.
Technique One

- M&R 661 Form – operators fill out periodically during event.
- Unsafe to have operators fill in the forms as frequently as needed for research purposes.
Technique Two

- Placing students in the snow plow trucks along with the operators to fill out forms, increased the resolution of the data.
- Multiple students filling out forms created increased time for data interpretation, since there is little consistency amongst the forms.
Technique Three

- Utilized in second winter season.
- Students fill out a data collection form programmed on laptop while riding in trucks.
- Research team created a simple, offline computer based program for data collection.
- Data is more organized and consistent.
GPS Data

• Used to ensure the integrity of the salt application data and to validate the route optimization model.

• Two formats – Google Earth (.kml file) and Microsoft Excel (.csv file), which can be imported into ArcGIS.
Speed Data Collection

• Bluetooth nodes were placed alongside the study area.

• Bluetooth nodes consist of:
  – Bluetooth radio
  – Computer board with USB interfaces
  – Bluetooth Antennae
  – 3G wireless card
  – Power regulator
  – Batteries

• Maintained weekly
Speed Data Collection

- Records the MAC address and timestamp.
- Calculate space mean speed.
- Motorists travel at speeds they feel comfortable.
Speed Data Collection – Winter 2011/2012
Speed Data Collection – Winter 2012/2013

Weather and Speeds during 12/26/2012 Event

2/16/2013 Speed and Weather
Weather Event Summary

- Over the two winter seasons of this study, 39 winter events occurred.
- Epoke route was changed to I-271 in middle of second winter season to facilitate data collection.
Total Salt Use Calculation

- Epoke’s pre-wetted salt has a salt to liquid ratio of 70:30
- Standard truck applies brine at rate of 7 gallons per ton of salt.
- ODOT uses brine for liquid = 23.3% salt

From this point forward, comparisons are made on total salt applied regardless of application type or vehicle.
Salt Calculation Equations

Total Material Applied (lbs)

\[ = \text{Application Rate} \left( \frac{\text{lbs}}{\ln - ml} \right) \times \text{Number of Lanes Treated} \times \text{Length of Application (miles)} \]

Total Liquid Applied (gallons)

\[ = \text{Application Rate} \left( \frac{\text{gal}}{\ln - ml} \right) \times \text{Number of Lanes Treated} \times \text{Length of Application (miles)} \]

**Standard Truck**

Total Salt Used = (Total Material Applied) + (Total Material Applied \times 0.008)

**Epoke**

Total Salt Used

\[ = (\text{Total Pre-wetted Material Applied} \times 0.7) \]
\[ + (\text{Total Pre-wetted Material Applied} \times 0.3 \times 0.233) \]
\[ + (\text{Total Liquid Applied} \times 0.233) \]
Factors of Salt Loss

Initial Loss
- Bounce/Scatter Related
  - Pre-wetted has Less Initial Loss than Dry

Salt Dissolution
- Time, Traffic and Moisture Content Related
  - Pre-wetted Dissolves Faster than Dry

Loss after Application
- Spray Off - Dissolved Salt Sprayed by Traffic
- Blow Off - Removal of Solid Grains by Traffic Related
- Run Off - Gravity and Time Related
  - Is dependent on dissolution rate.
Factors of Salt Loss

- **Dry Salt = 30 - 40% of Initial Loss**
- **Pre-wetted = 4 - 8% of Initial Loss**

Initial Loss

Bounce/Scatter Related

Pre-wetted has Less Initial Loss than Dry

Ref: Wisconsin Transportation Information Center, 2005
Factors of Salt Loss

Salt Dissolution

- Time, Traffic and Moisture Content Related
- Pre-wetted Dissolves Faster than Dry
- For salt to be effective it must dissolve.
  - Pre-wetted will dissolve more quickly because of the higher amount of water and smaller grain size.
  - Decrease in particle size will result in an increased dissolution rate.

Initial Loss

- Run Off - Gravity and Time Related
- Blow Off - Removal of Solid Grains by Traffic Related
- Spray Off - Dissolved Salt Sprayed by Traffic

Salt Dissolution Time, Traffic and Moisture Content Related

- Pre-wetted has Less Initial Loss than Dry

Ref: Wisconsin Transportation Information Center, 2005

For salt to be effective it must dissolve.
Factors of Salt Loss

- Caused primarily from traffic spray off.
- Is a factor of dissolution rate. More liquid will result in more spray off.

Loss after Application

Spray Off - Dissolved Salt Sprayed by Traffic

Blow Off - Removal of Solid Grains by Traffic Related

Run Off - Gravity and Time Related

Is dependent on dissolution rate.

Ref: Lysbakken, 2010
Results – Salt Usage

• Research team tracked the salt applied by Epoke and standard truck during all snow events using the computer based data collection platform, as previously discussed.
  – Subsection One – Salt Usage on Good Comparison Days
  – Subsection Two – Salt Usage on Days when Epoke is Out of Service
Salt Usage on “Good” Comparison Days

- 12 days which Epoke and standard truck were both operational and treated exclusively opposite directions of the study zone.
- Epoke total salt usage in study zone is 9,757 lbs.
- Standard truck total salt usage in study zone is 11,103 lbs.
- Epoke used 12% less salt per event on good comparison days.
Salt Usage when Epoke/Truck is Out of Service

- 7 days during which the Epoke or truck is out of service for maintenance issue and a snow event occurred. The standard truck maintains both directions of travel in the study zone.
- Northbound standard truck total salt usage in study zone is 12,968 lbs.
- Southbound standard truck total salt usage in study zone is 12,388 lbs.
Vehicle Speeds: Speed Trends

- Compare the speeds in the northbound direction to the southbound direction. This comparison may indicate a difference in the quality of treatment between the two treatment systems.

<table>
<thead>
<tr>
<th>Direction</th>
<th>Baseline Average Speeds (mph)</th>
<th>Weather Event Average Speeds (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>67</td>
<td>61</td>
</tr>
<tr>
<td>SB</td>
<td>67</td>
<td>61</td>
</tr>
</tbody>
</table>
Vehicle Speeds: Regain Time

- The amount of time required to return vehicle speeds to within ten mph of the baseline conditions after a winter storm has ended.
- Used Bluetooth data and weather data to determine the regain time.

<table>
<thead>
<tr>
<th>Direction</th>
<th>Average Regain Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>26</td>
</tr>
<tr>
<td>SB</td>
<td>18</td>
</tr>
</tbody>
</table>
Tanker Pretreatment

- ODOT placed an Epoke spreader on 5,000 gallon tanker truck for pretreatment.
- Previously took 12 – 14 hours, now 6 – 8.
- 11 events where exclusively pretreatment is preformed with tanker.
Tanker Pretreatment – December 6, 2012

• Tanker truck:
  – Traveled 69 miles
  – Treated 152 lane miles with 1253 gallons of brine
  – Time: one hours and 50 minutes

• By using the tanker, ODOT has the capability to spread material over multiple lanes which presents a time savings.
## Epoke Cost Analysis – Labor Savings

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Route</th>
<th>Boston</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison Evaluation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimization Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epoke to Standard Labor Savings</td>
<td>1.6:1</td>
<td>1.3:1</td>
<td>2.1:1</td>
</tr>
<tr>
<td>Number of Events per Year</td>
<td>56</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>Duration of Event (hr)</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Labor Rate Straight Time ($/hr)</td>
<td>$17.60</td>
<td>$17.60</td>
<td>$17.60</td>
</tr>
<tr>
<td>Labor Savings ($/year)</td>
<td>$7,096</td>
<td>$3,548</td>
<td>$13,010</td>
</tr>
</tbody>
</table>

Note: The number of events, duration of events, and labor rate is set in accordance to discussions with ODOT.
# Epoke Cost Analysis – Salt Savings

<table>
<thead>
<tr>
<th></th>
<th>20K Tons</th>
<th>10K Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salt Savings from Epoke (%)</strong></td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td><strong>Salt Used by Epoke</strong> (tons)</td>
<td>3333</td>
<td>1667</td>
</tr>
<tr>
<td><strong>Total Salt Saved</strong> (tons)</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td><strong>Price of Salt</strong></td>
<td>$37.13</td>
<td>$37.13</td>
</tr>
<tr>
<td><strong>Salt Savings</strong></td>
<td>$14,852</td>
<td>$7,426</td>
</tr>
</tbody>
</table>

*Note: For a garage with 1 Epoke and 5 Standard Trucks, using an equal amount of salt.*
Epoke Cost Analysis – Payback Period

<table>
<thead>
<tr>
<th>Inflation Rate of 4%</th>
<th>Expenses of $77,000 and $580 for Maintenance per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Savings of 16%</td>
<td>1.6 Standard Trucks are equivalent to 1 Epoke</td>
</tr>
<tr>
<td>Labor Rate of $17.60 per hour</td>
<td>Garage with 1 Epoke and 5 Standard Trucks</td>
</tr>
<tr>
<td>56 Winter Events at 12 Hours Each</td>
<td></td>
</tr>
</tbody>
</table>
# Epoke Tanker Cost Analysis – Payback Period

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost of $56,000</td>
<td></td>
</tr>
<tr>
<td>Fuel cost of $4 per gallon</td>
<td></td>
</tr>
<tr>
<td>Labor Rate of $17.60</td>
<td></td>
</tr>
<tr>
<td>Tanker fuel efficiency of 5 miles per gallon</td>
<td></td>
</tr>
<tr>
<td>Inflation rate of 4%</td>
<td></td>
</tr>
</tbody>
</table>
Training

- Operators have ability to apply at desired rates.
- Potentially over treating with Epoke.
  - Relaxed through communication and training.
- Implementation strategy:
  - Most economical route to utilize Epoke.
  - Operator input on routes and test runs to ensure they are feasible.
February 16, 2013 Event

<table>
<thead>
<tr>
<th></th>
<th>Epoke Salt Used in Study Zone (lbs)</th>
<th>Standard Truck Salt Used in Study Zone (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>0</td>
<td>3,326</td>
</tr>
<tr>
<td>SB</td>
<td>6,554</td>
<td>0</td>
</tr>
</tbody>
</table>

2/16/2013 Salt Applied

2/16/2013 Speed and Weather
February 16, 2013 Event

Epoke Route

Standard Truck Route
Route Optimization

- Developed route optimization model in ArcGIS.
- Validated model with GPS units in trucks.
- Use model to determine the optimum deployment of Epoke.

- Epoke saves most time when implemented on I-271.
Implementation

• Tanker – Pretreatment,
• Route Optimization – Validate routes, determine best route for Epoke.
• Epoke best suited for light snow.
  – Becomes plowing event not spreading event as snowfall increases.
Implementation Strategies

- Move Epoke South during heavy snowfall in Summit County.
- Move standard truck north to replace Epoke in fleet.
Conclusions

• Salt savings by Epoke:
  – reducing bounce and scatter.
  – 70:30 salt to water ratio being applied

• Studies show that higher water content and accumulating traffic will result in quicker salt removal.

• Epoke best suited for pretreatment and light snow events.

• Epoke presents time savings over standard spreader based on treatment of multiple lanes.
Conclusions: Salt Savings

• Savings based on application process.

<table>
<thead>
<tr>
<th></th>
<th>Salt Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced on Good Comparison Days</td>
<td>12%</td>
</tr>
<tr>
<td>Maximum Possible for ODOT</td>
<td>18%</td>
</tr>
</tbody>
</table>

• Maximum possible savings if currently using dry material is 23% with brine as liquid, as well as 30% – 40% savings from bounce and scatter.

• Salt savings based on limited number of events.
Thank you