EXECUTIVE SUMMARY

I-35W & Mississippi River Bridge

AN OPERATIONAL EVALUATION OF THE ANTI-ICING SYSTEM

The eight-lane, 1950-ft-long bridge that spans the Mississippi River on I-35W in Minneapolis, Minnesota has been fitted with a computerized system that automatically sprays potassium acetate, an anti-icing chemical, on the bridge deck when sensor data indicates that hazardous winter driving conditions are imminent. The system was installed with the goal of increasing safety by reducing non-dry condition winter season crashes on the bridge. Boschung Company Incorporated, a Switzerland based company, was hired to design, furnish & install, and support the anti-icing system. The final cost for the system, which included the original contract as well as several additional pieces of work, was $618,450.

The bridge anti-icing system works with a combination of sensors, RWIS weather stations, a computerized control system, and a series of 38 valve units and 76 spray nozzles that apply potassium acetate. There are 13 spray programs that are activated based on the temperature and atmospheric conditions occurring on and above the bridge deck. Each of the 13 programs varies the valve unit that sprays, sequence, and the number of times the valve unit is sprayed. A small "pump house" next to the bridge houses a 3,100-gallon tank for potassium acetate storage, pumps and valves, and software for selecting spray programs. The anti-icing system can be activated manually from the pump house and via remote control in close proximity to the pump house; however, every day operations are via automatic control. That is, the system is designed to function as a stand-alone unit, with no human intervention needed.

The operational test began on December 1999 and concluded on March 31, 2001. But, because the majority of the 1999-2000 winter season was spent readying the system for full time use, the 2000-2001 winter season was chosen as the single test year for analysis. During the test year, there were seven major events (>=5.0" snow) and seventeen minor events (<5.0" snow), with 218 sprays and 137 sprays, respectively. There were also 139 preventative sprays and 7 miscellaneous sprays. An average of 34 gallons per spray was observed (12 gallons per lane mile), which translates to a total of approximately 17,000 gallons sprayed during the test year. It was found that the anti-icing system performed extremely well for minor snow events. However, the system could only address large snowfall events if the snow was low in moisture content (the system is not designed to melt heavy, wet snow). Finally, post snow event clean-up was significantly reduced on the bridge structure.

Structured performance tests were conducted on 10 randomly selected individual sprays from the 2001-2001 winter season to verify operations of all functions. These tests were conducted to verify operating pressures, temperatures, spray duration, atmospheric and environmental conditions detected, software alarms, and affects on traffic flows. The results of the structured test observations are as follows:

- The system performed well. Operating pressures, temperatures, and duration, were all within range and all functions operated within specifications;

- The software appropriately detected the environment that was present and accurately displayed the data on the dispatch workstation accurately including all alarms;

- The correct spray program was chosen and all of the correct valve units released on time;

- Traffic flow was not significantly affected by the anti-icing sprays. There existed only a very minimal amount of road spray and no unusual vehicle breaking was observed;

- All sensors were calibrated within range – that is, temperatures reported by the sensors were consistently within 2° F of temperatures determined manually;

- The chemical tracked approximately 500 feet off of the bridge deck during the winter and approximately 4000 feet during the fall and spring deployments;

- All parapet nozzles became consistently blocked by compacted ice and snow that was pushed into the parapet walls during normal snow plowing operations;

- Some disk type nozzles became partially plugged and prevented 100% lane coverage. These minor and random blockages were usually blown clear during the second spray of that unit.

A crash analysis was conducted, comparing the 2000-2001 winter season to the 1996-1997 winter season. The 1996-1997 winter season was chosen as the comparison season based on similar winter weather data characteristics obtained from National Weather Service archives. A full analysis was conducted, but the most profound result is that there was a 68% reduction in non-dry crashes from 1996-1997 (31 non-dry crashes) to the 2000-2001 winter season (10 non-dry crashes). Reducing non-dry, winter season crashes is the goal of the anti-icing system. As a result of the crash reduction, crash related congestion also was reduced.

A benefit-cost analysis revealed that the anti-icing system is cost effective for this particular location, yielding a B/C ratio of 3.4. The analysis considered costs that include construction/installation, replacement parts, routine maintenance, utilities, and chemical purchasing/delivery. Benefits included annual crash and congestion reduction savings. It should be noted that the benefit portion of the equation was calculated with a very conservative approach. Several assumptions were made in developing congestion and crash savings that were extremely conservative, in an attempt to try not to overestimate the benefits associated with the anti-icing system.

Overall, it was concluded that the anti-icing system worked extremely well and was able to increase safety and reduce crash related congestion, as advertised. This system sets an anti-icing precedent nationwide, being the first of its kind successfully installed and operated on a 1950-foot bridge structure in a metropolitan area. The following recommendations are a result of this evaluation:

1) Continue operations of the existing anti-icing system until maintenance costs out weigh replacement costs, at which time a replacement system should be considered;

2) Continue using potassium acetate because of its environmental advantages;

3) The use of parapet sprayers should be minimized because of plugging problems;

4) Additional spray disks should be installed upstream of the bridge structure for both approaches. Doing this would allow maintenance crews to approximate deck conditions by judging upstream conditions, which would limit the amount of sodium chloride applied on the deck;

5) For subsequent anti-icing system projects, additional consideration should be given to the pump house design, including tank location and size, containment structure, ventilation, addition of utility closet, and water availability;

6) Bring this anti-icing system to the attention of Mn/DOT upper management to increase awareness and comfort level;

7) Develop an internal Mn/DOT program delivery team to coordinate the deployment of future anti-icing systems. Include the development of a 5 and 10 year plan to identify funding and resources, and integrate with other new bridge construction and rehabilitation projects;

8) Develop warrants for anti-icing system installations (many bridge structures do not need anti-icing systems);

9) Develop an internal Mn/DOT Metro Division team for on-going operations of all anti-icing systems. These systems are not "humanless" and require people to coordinate summer changeovers, fine-tune operational variables, integrate software improvements and new versions, and coordinate with other anti-icing initiatives;

10) Discontinue new research in all areas of bridge anti-icing delivery techniques. Research efforts should concentrate on the following areas:

   - System effectiveness during heavy snow events – this will increase system efficiency by minimizing the amount of chemical necessary.
   - On-grade pavement anti-icing systems on mainline segments.
   - Pavement sensor networking and integrating – this will increase system efficiency by doing a better job of determining the time at which sprays should begin.

11) During the non-winter months (April – October), when potassium acetate has been replaced with water, the system should be energized on a monthly or bi-monthly basis to check piping and connections, and to help prevent small sand particles from plugging the spray nozzles.

12) In future applications, do not use Advanced Warning Flashers to alert motorists of anti-icing activity on the bridge. Roadway signing usually is used to inform motorists of actions they should or should not take. However, in this case it is not clear to the motorist what should be done differently when the flashers are active (when in fact, no action should be taken at all).