Research Report
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EVALUATION OF AUTOMATED BRIDGE DECK ANTI-ICING SYSTEM

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EVALUATION OF AUTOMATED BRIDGE DECK ANTI-ICING SYSTEM

KENTUCKY HIGHWAY INVESTIGATIVE TASK NO. 36

by

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in cooperation with

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16. Abstract

Driving in snow and ice can be dangerous. This is especially true on bridges. Under certain cold weather conditions, moisture on bridge decks freeze because of the open air flow under them while the adjacent roadway is unaffected. This creates potentially hazardous driving situations for motorists who may not be expecting a change of condition from the road to the bridge surface.

To combat this problem, a bridge deck anti-icing system was installed on a bridge on southbound Interstate 75 at the north interchange to Corbin, Kentucky in October 1997. This system can be actuated early before ice and snow form on the bridge to create hazardous driving conditions. The eleven parapet-mounted/ bridge rail-mounted spray nozzles per side treat the two travel lanes and the approach plate with an anti-icing agent. The system uses calcium chloride as the anti-icing agent and sprays eight gallons during each application for the entire bridge. This early chemical application prevents the formation of icy conditions on the bridge deck.

After four winter seasons, the anti-icing system located in Corbin, Kentucky had minimal problems associated with it. The system worked efficiently and as expected. However, because of the location on an interstate which is one of the first areas treated during snow maintenance operations and because the bridge is located in a part of the state that does not receive an abundant amount of precipitation, the system was not as effective as first anticipated. It is recommended that this system be used in the following areas and/or conditions: (1) crash prone areas, (2) isolated structures that require the deicing truck to travel an unreasonable distance to treat, (3) remote areas that are difficult to reach in bad weather, or (4) bridges over water which may be more susceptible to freezing moisture.

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EXECUTIVE SUMMARY

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Perry Cogburn	Virginia Department of Transportation
Carl Baumgardner	Odin Systems

1.0 BACKGROUND

Driving in snow and ice can be dangerous. This is especially true on bridges. Under certain cold weather conditions, moisture on bridge decks freeze because of the open air flow under them while the adjacent roadway is unaffected. This creates potentially hazardous driving situations for motorists who may not be expecting a change of condition from the road to the bridge surface.

It is not feasible to dispatch road maintenance crews strictly to treat bridges throughout the state. Therefore, a system was developed to spray bridges prior to or during the onset of icy conditions. This is referred to as a bridge deck anti-icing system.

Anti-icing involves the early application of deicing chemicals to a surface prior to freezing precipitation adhering to that surface. The chemical application prevents formation of a bond between the snow or ice and a pavement surface, such as a bridge deck. In contrast, deicing operations are performed to break the bond of already bonded snow and ice. "Preventing the bond is approximately three times as efficient as breaking the bond between frozen precipitation and pavement."(1) By applying the deicing chemical before this bonding effect occurs, the snow/ice removal process is accomplished more efficiently. Often the removal process requires only the tracking action of traffic moving over the chemicals.

2.0 THE ODIN SYSTEM

Odin Systems was chosen as the company to supply the anti-icing bridge deck system. This system includes a nozzle and spray system mounted on the bridge rail and bridge walls (Figures 1-3).

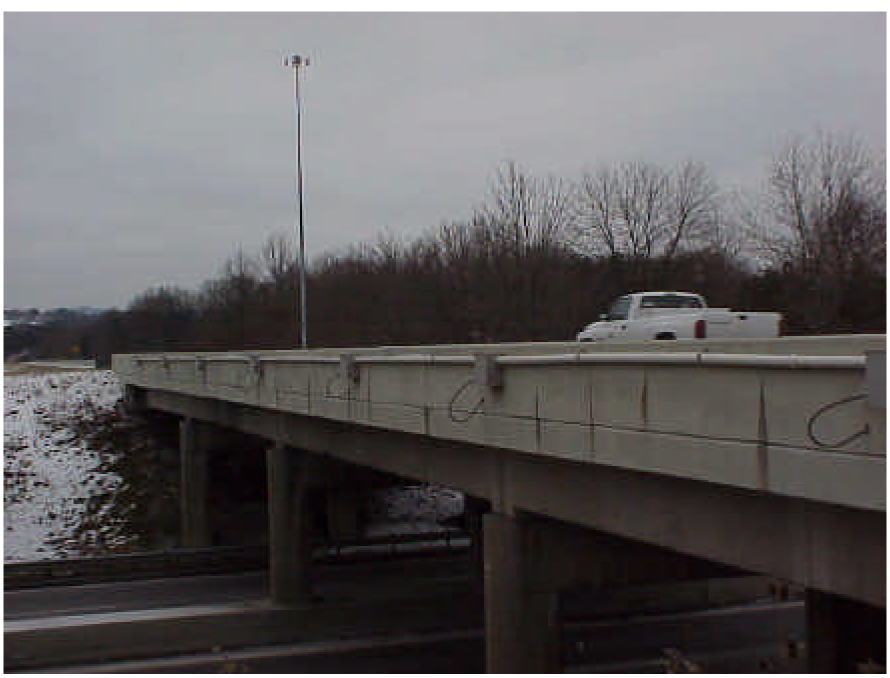

Figure 1. Spray System Mounted on Bridge

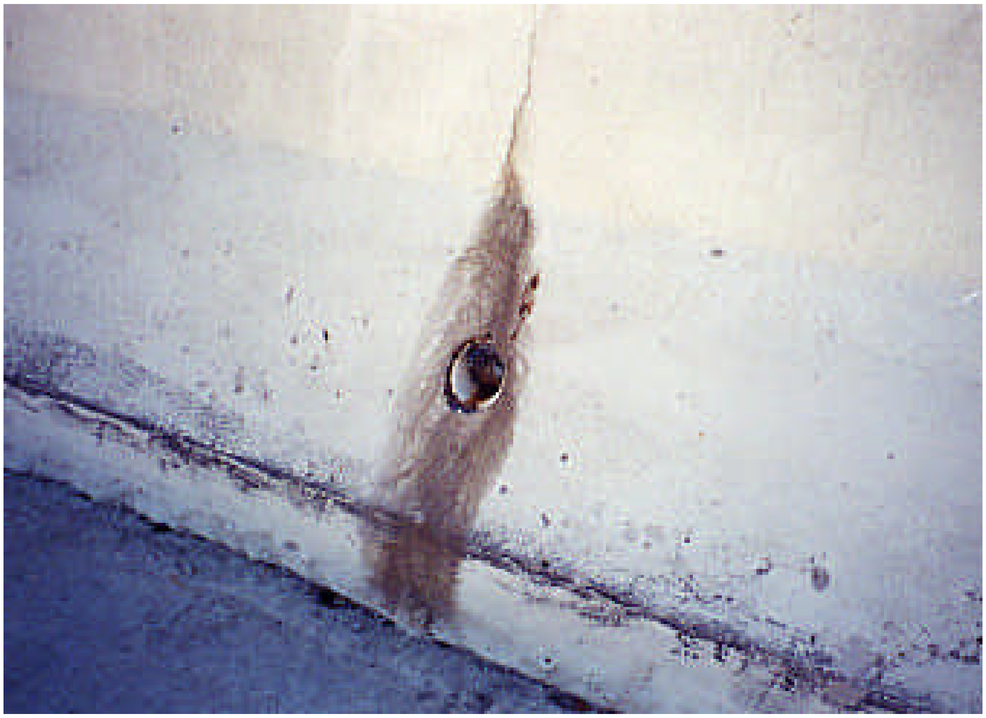

Figure 2. Spray Nozzle in Bridge Wall

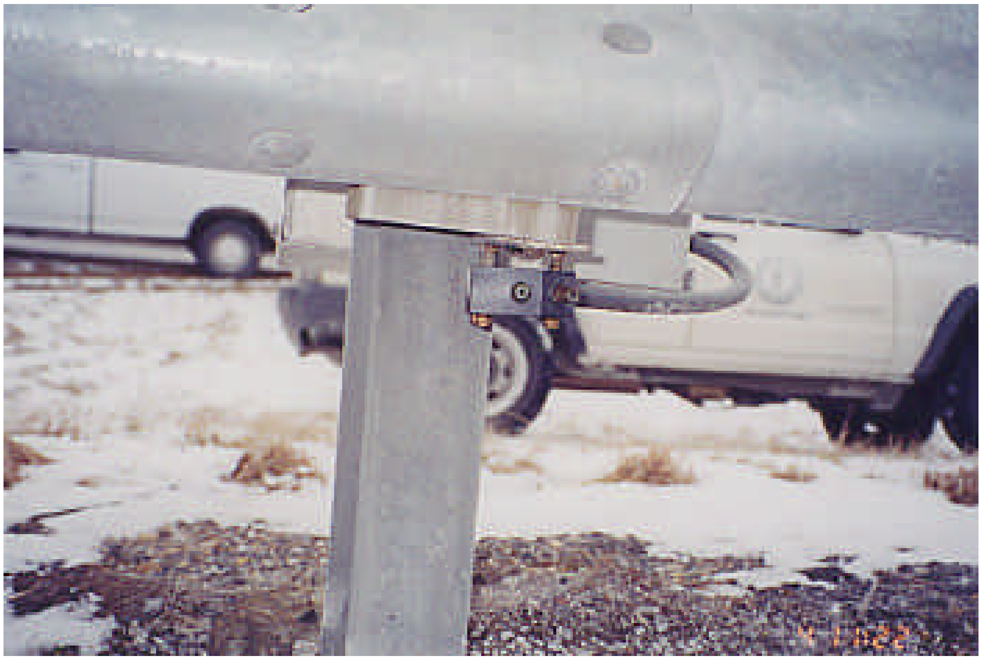

Figure 3. Spray Nozzle under Bridge Rail

A fluid storage tank, pump, and delivery system installed at one end of the bridge deck will deliver the anti-icing fluid to the nozzles (Figures 4, 5).

Figure 4. Storage Building that Houses System

Figure 5. Inside Storage Building

Two telephone lines are used for the system, one for the video camera transmission and the other for the actuation of the system. A video camera system is used to monitor the site conditions and system operations. The Kentucky Transportation Cabinet (KYTC) personnel activate the spray system after they have reviewed the Road Weather Information System (RWIS) information and conducted visual observations via the camera. Odin systems have the capability of being activated while at the bridge, remotely through a dial-up connection, or automatically by linkage to the RWIS. In this application, the bridge can only be activated through a dial-up connection.

The anti-icing agent is pumped to the deck surface through a system of pipes and nozzles placed along the structure. Once activated, the system builds up pressure and starts spraying the farthest nozzle from the tank first (Figure 6). As pressure builds up, the sprayers continue spraying while moving upstream towards traffic until all the nozzles have sprayed (Figure 7). Each nozzle sprays two streams of the deicing chemical at a time. The entire activation cycle takes approximately four minutes and uses a total of eight gallons of deicing chemical for the entire bridge.

Figure 6. First Nozzles Spraying

Figure 7. Nozzles Spraying Upstream

3. 0 PROJECT DESCRIPTION

A bridge deck anti-icing system was installed on a bridge on southbound Interstate 75 at the north interchange (milepost 28.9) to Corbin, Kentucky in October 1997. This bridge is approximately 600 feet in length and 3-lanes wide. There are eleven parapet-mounted/ bridge rail-mounted spray nozzles per side to treat the two travel lanes and the approach plate. The system uses calcium chloride as the anti-icing agent and sprays eight gallons at a time for the entire bridge. The system cost approximately $65,000 not including the RWIS.

4.0 EVALUATION

4.1 Weather Conditions

The bridge system was installed during October 1997. Since that time, there have been four winter seasons to evaluate the effectiveness of the system. The snowfall for that time is shown in Table 1. The table shows only the months that had measurable snowfall. The total snowfall for all four seasons was 25.5 inches. The bridge system was activated a total of five times for winter conditions.

Winter Season	Month	Snowfall (inches)	Total Snowfall / Season (inches)	Number of Times Bridge System Activated
1997-1998	December	5.5	10.0	3
	February	4.0		
	March	0.5		
1998-1999	December	1.2	1.4	2
	January	0.2		
1999-2000	December	0.4	5.6	0
	January	5.2		
2000-2001	December	7.0	8.5	0
	January	1.5		

Table 1. Snowfall and Bridge Activation

4.2 System Activation

There are three different means to activate an Odin bridge system: (1) push-button at the bridge location, (2) a dial-up connection, and (3) automatically by input from the RWIS. However, for this installation, only the dial-connection can activate the bridge anti-icing system. The dial-up connection allows the KYTC personnel to activate the system remotely. Only authorized personnel can activate the system since a password is required. The bridge has only been activated 10-12 times for actual use, cleaning, and displaying how the system works.

Decisions on activation of the system are made from a combination of the RWIS information and visual observations from the video camera.

4.2.1 Anti-Icing Material

The deicing chemical used for the bridge system is calcium chloride. This chemical was chosen because the entire state already uses this chemical for snow/ice maintenance activities except for one district so it was the most practical selection. The chemical is removed from the tank after the winter season and replaced with water during the summer.

4.2.2 Fluid Rate

The Odin system applies the chemical in small quantities directly onto the travel paths. The amount of chemical applied to the surface can be adjusted as necessary. This anti-icing system sprays eight gallons of calcium chloride per activation. Vehicles track the chemical over the bridge surface for complete coverage of the bridge deck.

4.3 Equipment Performance

4.3.1 Reliability of Camera

The original video camera system installed at the bridge was a fixed black/white system. The camera image was not sufficiently clear to accurately monitor the bridge surface. Therefore, a maintenance worker was dispatched to visually inspect the bridge before the anti-icing activation took place. This method was inefficient from the standpoint that remote activation capabilities were not used.

The camera system was replaced in 2001 with a higher resolution black/white camera system. The new camera gives a clearer picture of the bridge surface area than the original camera system. Because of the new camera, a maintenance worker does not have to visually inspect the bridge surface before activation is initiated. Figure 8 shows the location of the mounted camera.

Figure 8. Camera System

4.3.2 Roadway Weather Information System

A Roadway Weather Information System (RWIS) is located adjacent to the bridge (Figure 9). The RWIS collects such information as air temperature, precipitation, wind velocity, and pavement temperature. The RWIS is not automatically linked to the activation of the anti-icing system; however, the information collected, is used to determine whether the bridge system is activated.

Figure 9. RWIS

4.3.3 Dynamic Message Sign

During the first two winter seasons after the installation of the anti-icing system, three dynamic message signs (DMS) were used to alert drivers of snow/ice removal and the anti-icing activity on the bridge. One sign was placed on the northbound side before the bridge and two were placed in the southbound direction before the bridge. The DMS would read “Caution Snow/Ice Removal Trucks Ahead” and “Caution Anti-icing Spraying on Bridge.” Since those first two seasons, no DMS have been used for this purpose.

4.4 Driver Reaction

There was no noticeable driver reaction to the spraying as it occurred. The nozzles are less than a foot above the ground and do not interfere with the driving task. The spraying lasts approximately 10 seconds per nozzle so few drivers encounter the spraying.

4.5 Traffic Volume / Crash Rate

The average daily traffic volumes for that bridge section on southbound Interstate 75 are shown in Table 2.

Year	Average Daily Traffic Volume on Bridge
1997	16,550
1998	19,050
1999	18,100
2000	17,925
2001	18,575

Table 2. Average Daily Traffic Volumes for Years 1997-2001

Crash summaries for that section of interstate were not prepared because it was assumed that the infrequency of use would have no impact on crashes.

4.6 Adjacent Control Bridge

The existence of twin bridge structures allowed for test and control bridge deck conditions. There was no noticeable difference recorded between the deterioration of the anti-icing test bridge over the control bridge. This may have been related to the limited use of the anti-icing system. Also, both bridges were salted by the maintenance trucks during snow/ice conditions so no observations could be made as to the effectiveness of the system.

Figure 10. Twin Bridge Structures

4.7 Reduction in Maintenance Activities and Related Cost

Due to the limited use of the anti-icing bridge system, no noticeable reduction in maintenance activities was recorded. However, it is possible that this system would be an added cost due to the manner in which it was operated. This is based on the fact that the routine deicing truck must cross over this bridge during interstate applications, thus doubling the coverage at this location if the bridge is activated.

4.8 Training

Odin Systems provided a four-hour training session, along with an Operations Manual, when the bridge was installed. However, several of the originally trained Transportation Cabinet employees have taken different jobs which has reduced the number of employees with training experience. Further training would be desirable; however, no additional training has been conducted due to cost. Therefore, maintenance of the system is limited by the small number of employees who are trained in that area.

4.9 Problems Encountered

During the winter season of 1998-1999, several nozzles were not working properly and the operation of the pump would occasionally cause the electrical circuitry to close. An Odin representative made a service visit to the bridge anticipating dirty solenoid valves from chemical contamination; however, they were found to be clean and further analysis found that the 2-amp fuses servicing the inoperative nozzles were open. The system operated as designed upon replacing the 2-amp fuses with 5-amp fuses. Regarding the occasional circuit breaker operation, the pump was operating against closed nozzles, which loaded the motor to the point where the additional amps were tripping the breaker. To overcome this problem, the overpressure switch was reduced from 225 psi to 200 psi. The overpressure switch diverts pump output back to the tank.

The original video camera did not provide adequate picture quality and the bridge surface was not clearly visible through the camera system. The transmission rate for the camera was too slow and the images were stored on a computer at the site and then later accessed remotely. These camera problems led to the need of dispatching a maintenance worker to visit the bridge before activation was initiated. This proved to be an inefficient operation with no practical value. The camera was replaced in 2001 with a higher resolution black/white camera system that provides a clearer picture than the original camera system.

5.0 OTHER STATES' RESULTS

Several other states have similar bridge deck anti-icing systems. Through personal correspondence with Mr. Perry Cogburn of the Virginia Department of Transportation, comments from other States were reviewed regarding their systems. There are 11 other states with similar systems. These states include Colorado, Kansas, Maryland, Minnesota, Nebraska, New York, North Carolina, Pennsylvania, Utah, Virginia, and Wisconsin. Most of these states had Odin Systems installed; however, some of the other companies included Boschung and Numetrics. Comments will be limited to only the Odin Systems.

Some of the comments include:

- Technical problems and system has never functioned as anticipated
- Works best in non-snow events and in light snow storms
- Works well in semi-automatic mode (remote phone or remote dispatch)
- First year of use and are pleased with the results
- Pleased with results although two mild winters
- Operated throughout winter after waiting on initial repairs
- Battery for control circuit, nitrogen gas for pushing PA. Minor bugs still being worked out
- Use limited due to down time and changes made by vendor

Most of these systems were fully automated. The deicing chemicals varied between potassium acetate, calcium magnesium acetate, brine, calcium chloride, iceban and magnesium chloride, magnesium chloride, and a solid deicing material.

6.0 RECOMMENDATIONS

The anti-icing system located in Corbin, Kentucky had minimal problems associated with it. The system worked efficiently and as expected. However, because of the location on an interstate which is one of the first areas treated during snow maintenance operations and because the bridge is located in a part of the state that does not receive an abundant amount of precipitation, the system was not as effective as first anticipated. It is recommended that this system be used in the following areas and/or conditions: (1) crash prone areas, (2) isolated structures that require the deicing truck to travel an unreasonable distance to treat, (3) remote areas that are difficult to reach in bad weather, or (4) bridges over water which may be more susceptible to freezing moisture.

It is also recommended that adequate training be given to the maintenance personnel in charge of the bridge since this is necessary to operate and maintain the anti-icing bridge system in a manner that makes the system effective and efficient.

7.0 CONCLUSIONS

An advantage of the automated bridge anti-icing system is that it can substantially reduce the number of salt applications and the application rate. Direct application of the anti-icing chemicals in the wheel paths, while maintaining an acceptable level of service, should minimize crash rates and traffic delays. Another advantage of this system is that the anti-icing chemical can be applied quickly. When the need arises, the bridge system can be activated remotely with a phone call.

The Odin bridge system worked as the Kentucky Transportation Cabinet had desired. Except for the inadequate camera system and the fuse problem discussed earlier, the system encountered no major problems. However, because of the location of the bridge, the anti-icing system was not as efficient as anticipated. More consideration should be given to the location if future installations are desired.

8.0 REFERENCES

1. Ask, Berney, Odin Systems International, Inc. "New Anti-Icing Technologies Include Automated Chemical Sprayers on Bridges." APWA Reporter. August 1996.