

Research Report  
KTC-03-02/UI 4-02-1F

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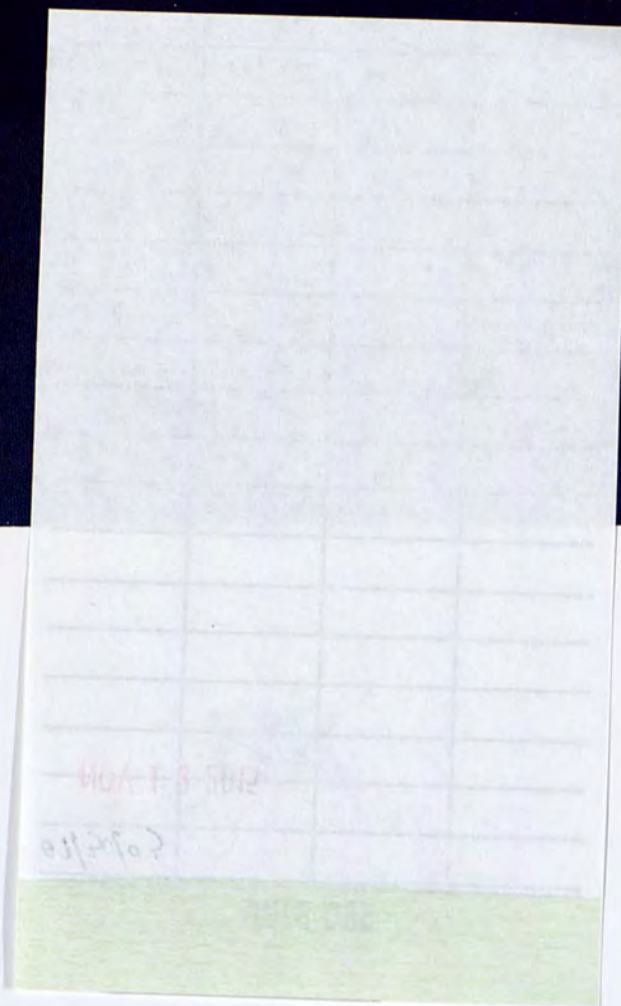
*College of Engineering*

INVESTIGATION OF SOLUBLE SALTS  
ON KENTUCKY BRIDGES



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**Research Report**  
**KTC-03-02/UI 4-02-1F**

**INVESTIGATION OF SOLUBLE SALTS  
ON KENTUCKY BRIDGES**

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in cooperation with

**Kentucky Transportation Cabinet  
Commonwealth of Kentucky**

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**January 2003**

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## Executive Summary

Invisible soluble salts present on steel highway structures can act to promote corrosion even after maintenance painting. Soluble salts include chloride, nitrate and sulfate ions. Soluble salts found on bridge decks and roadways are the result of usage of deicing salts (chlorides), and the deposition of atmospheric pollution (nitrates and sulfates) on exterior surfaces. Typical pollution-related sources of soluble salts are coal-fired power plants, refineries, farming operations, vehicle emissions, and chemical plants. Sites for soluble salt damage on bridges include:

- Beam ends under open or leaking expansion joints,
- Flanges and lower portions of webs of overpass structures,
- Lower chords and connecting members (end posts, portals, vertical posts and diagonals), and guard rails of truss bridges near roadway level, and
- Outside faces of fascia girders and other bridge elements constantly exposed to the environment.

Maximum acceptable concentrations of soluble salts are very low (e.g. 10  $\mu\text{g}/\text{cm}^2$  for chlorides).

Several state highway agencies are looking at ways to increase the durability of their bridge maintenance painting projects and are using/investigating various chemical neutralizers/soluble salt removers to preclude problems caused by soluble salts. KYTC (Kentucky Transportation Cabinet) officials initiated this study to investigate presence of soluble salts on Kentucky bridges and to determine if they posed a significant problem to bridge paint durability. This work was undertaken by Kentucky Transportation Center (KTC) under study KYP 02-0056 "Unforeseen Investigations". The objectives of the study were to:

- 1) Determine the levels of soluble salts on KYTC bridges.
- 2) Study the effect of various cleaning methods (pressure washing, power and hand tool cleaning, etc.) on soluble salts on bridges.
- 3) Establish whether commercially available chemical neutralizing/soluble salt removing agents are capable of reducing salt levels to where they will not damage new paint nor cause early "rust back".

KTC researchers selected a field test method developed by **CHLOR\*RID International, Inc.**, a firm that supplies soluble salt testing materials and a chemical salt remover sold under the trade name **CHLOR\*RID™**. The firm also markets a field test kit (i.e., **CHLOR\*TEST™CSN™** **SALTS™**) that extracts soluble salts from bridge surfaces and analyzes the extract to provide a measure of salt concentration.

KYTC officials chose three bridges located on different routes that they anticipated to be subject to differing amounts of deicing-salt applications (and consequently differing amounts of chloride contamination for testing). Those were the I-471 Bridge over the Ohio River in Campbell Co. (tied arch and urban area), I-71 N Bridge over I-75 S in Boone Co. (deck girder and main line overpass in a rural area) and KY 355 Bridge in Owen Co (through truss in a rural area).

Tests were conducted at different areas on the bridge where corrosion or rusting was evident. Readings were taken in the existing condition, after hand tool/power tool cleaning, and, in some instances, after pressure washing at approximately 3500 psi with and without **CHLOR\*RID™**.



The tests of the three bridges revealed low levels of soluble salts in most instances, even in the untreated or "existing conditions". Pressure washing with potable water was effective in reducing the amounts of soluble salts as was pressure washing with **CHLOR\*RID™**. The testing did not reveal a significant problem related to soluble salts, but the testing was too limited to make a determination about all Kentucky bridges.

Recommendations are provided for future testing of bridges for soluble salts prior to maintenance painting along with recommendation for performing washing tests on structures with high soluble salt levels (i.e., above  $30 \mu\text{g}/\text{cm}^2$  for any types of soluble salt), and adding contract requirements for reducing the surface salt level to about  $10 \mu\text{g}/\text{cm}^2$  prior to painting (with the contractor having the choice of method to treat the surfaces to that level).

## Introduction

### Background

Chloride, sulfate and nitrate salts are soluble in water. Typically, deposits of those salts on bridges not readily visible. When combined with moisture, they initiate electrochemical reactions on the surfaces of steel bridges and other highway structures that often result in extensive corrosion and premature coating failures.

Small amounts of soluble salts can act to promote corrosion on structures even after maintenance painting. Soluble salts result from the use of deicing salts (chlorides) on bridge decks and roadways, and the deposition of atmospheric pollution (nitrates and sulfates) on exterior surfaces. Typical sites for soluble salt damage include:

- Beam ends under open or leaking expansion joints,
- Flanges and lower portions of webs of overpass structures,
- Lower chords and connecting members (end posts, portals, vertical posts and diagonals), and guard rails of truss bridges near roadway level, and
- Outside faces of fascia girders and other bridge elements constantly exposed to the environment.

The first three typical sites are usually subjected to chloride-induced damage. Besides flow of chloride-contaminated moisture through joints, the other transport mechanism for chlorides is in contaminated aerosols generated by vehicular traffic driving on wet roadways and bridge decks. Those aerosols can be carried to steel surfaces above roadways and be deposited on exposed elevated portions of bridges. Exterior elements of bridges can also be subjected to salt-contaminated precipitation (1). Such precipitation contains sulfur- and nitrogen bearing compounds such as sulfates and nitrates which act as soluble salts (2). The sources for those compounds are typically coal-fired power plants, refineries, farming operations, vehicle emissions, and chemical plants. While refinery, farming, and chemical plant pollution may be local phenomena, power plant generated pollution can carry hundreds of miles before it is removed from the atmosphere. As the common transport mechanisms for those salts are wind and rain, exposed portions of structures are the anticipated sites for their deposition.

Soluble salt contaminants are hygroscopic which promotes corrosion on surfaces not visibly wetted or otherwise exposed to water. When salt-contaminated surfaces are painted over, the salts generate osmotic pressure to pull moisture through an otherwise sound coating and promote corrosion beneath it. These soluble salts are not consumed during the corrosion process, but are regenerated by oxygen. If salts contaminate an existing coating that is being overcoated, the osmotic forces will still exist and result in blistering, poor adhesion, and disbonding.

Due to the ability of salt ions to be regenerated, a small concentration of any of the soluble salts on a metal surface (beneath a coating) can cause corrosion and coating failures. Their severity depends upon:

- The amount and type of contaminants on the surface,
- The amounts of water and oxygen,
- The permeability of the coating,
- Coating thickness, and

- Ambient temperature levels on both the coating and the steel substrate.

As previously noted, very low amounts of soluble salts are able to generate or exacerbate corrosion and coating performance problems. Chlorides are the most corrosive followed by nitrates and sulfates. In part, that is due to the electro negativity of the respective elements and, in part, to their solubility. For atmospheric exposures, the generally accepted permissible limits for soluble salts are 15, 20, 30  $\mu\text{g}/\text{cm}^2$  for chlorides, nitrates, and sulfates respectively per ISO (International Organization for Standardization) 15235. Chlorides are the most common soluble salts encountered on highway structures and are usually the only soluble salt of concern.

Often times, the soluble salts are invisible on surfaces and can only be detected by special tests. Those tests are composed of two parts – extraction and chemical/electrochemical quantitative analyses. The extraction is typically performed by wetting a test surface (of predetermined area) for a fixed time to dissolve and extract a surface/near surface salt with a fixed volume of solute. The extraction efficiencies of various methods range from 25% to 75% (3). The extract is subsequently tested chemically, by titration or precipitation, or electrochemically by measuring its conductivity. Perhaps the most accurate test for soluble salts involves extracting surface materials (e.g. existing coatings and rust) and boiling those to more completely agitate and dissolve the soluble salts. Some tests can be conducted entirely in the field, while others require laboratory apparatus.

Typical field tests use deionized water in conjunction with contact to a test substrate such as existing paint or rust. The deionized water can be agitated, swabbed or retained in contact with the test substrate to dissolve the surface-retained salts and to collect them in a suitable manner for quantitative analyses. The one test is known as the sleeve retrieval method. It uses a special extraction liquid to collect the surface salts in a manner that provides for quantitative analysis. The manufacturer claims an extraction efficiency of about 60%. The quantity of soluble salts in the extract is subsequently measured by titration. SSPC (Society for Protective Coatings) and NACE (National Association of Corrosion Engineers) are currently in the process of developing a joint document for evaluating and specifying non-visible soluble salts on steel and other non-porous surfaces prior to coating application.

When testing reveals unacceptable concentrations of soluble salts present on ferrous or coated ferrous surfaces, there are several actions that may be taken to reduce their levels to the extent that they will not cause problems with subsequent coatings. If abrasive blasting is used, the substrate areas with high salt concentrations will “flash rust” when left overnight and then the contaminated areas can be blasted. If dry abrasive blasting is not employed, a wet method such as wet abrasive blasting or high pressure water jetting at pressures of about 10,000 to 35,000 psi are considered effective in removing soluble salts (op. cit. 3). Mechanical surface preparation using power tools does not provide an adequate means of reducing soluble salts to acceptable levels for painting (op. cit. 3). Another means of reducing soluble salts is to add a dilute (1:100) mixture of a chemical neutralizer/soluble salt remover to water and pressure wash the substrate at normal pressures (3,000 to 7,000 psi). The chemical neutralizer binds the soluble salts and facilitates their removal by washing at these low pressures (as compared to water jetting). Several manufacturers have proprietary soluble salt removers/neutralizers.

## State Highway Actions Regarding Soluble Salts

The soluble salts commonly associated with highway bridges are chlorides, typically resulting from application of deicing salts, though marine exposure may also be severe in coastal states. The severity of salt contamination on inland applications is related to the frequency and extent of deicing salt applications. To a certain extent, the quantity of deicing salt used is a function of the northerly location of states. Use of deicing salts in states north of Kentucky such as Ohio, Indiana, Illinois, Michigan and Wisconsin are greater than Kentucky (op. cit. 1).

Several state highway agencies are looking at ways to increase the durability of their bridge maintenance painting projects and hence are using/investigating various chemical neutralizers/soluble salt removers to preclude problems caused by soluble salts (i.e. Minnesota DOT, New York State DOT, West Virginia DOT, and the Wisconsin DOT). The Wisconsin DOT has used a chemical soluble salt remover in water to routinely give its bridges a spring washing to remove chlorides built-up over the preceding winter (4). Those agencies believe that the chemical neutralizing agents can be used as treatments to provide a potential low-cost solution for increasing the durability of the maintenance projects and preventing corrosion due to chloride build-up.

KYTC officials wished to investigate presence of soluble salts on Kentucky bridges to determine if they posed a significant problem to bridge paint durability. This work was undertaken by Kentucky Transportation Center under study KYP 02-0056 "Unforeseen Investigations". The objectives of this investigation were to:

- Determine the levels of soluble salts on KYTC bridges.
- Study the effect of various cleaning methods (pressure washing, power and hand tool cleaning, etc.) on soluble salts on bridges.
- Establish whether commercially available chemical neutralizing/soluble salt removing agents are capable of reducing salt levels to where they will not damage new paint nor cause early "rust back".

## Soluble Salt Testing/Treating

In March 2001, prior to the onset of this study, KYTC officials and KTC researchers met with a representative of **CHLOR\*RID International, Inc.**, a firm that supplies soluble salt testing materials and a soluble salt remover, a chemical sold under the trade name **CHLOR\*RID™**.

The firm markets a field test kit (i.e., **CHLOR\*TEST"CSN" SALTS**) that uses chemical extraction to remove soluble salts from surfaces such as rust, steel and paint. The kit uses a proprietary extraction fluid to remove soluble salts from surfaces. A pre-measured amount of the extraction fluid is placed in a rubber sleeve with a pre-set area for salt extraction/testing. The sleeve has a adhesive/sealant coated rim that allow the test to be conducted on a variety of surfaces and surface orientations. The adhesive seals the rim to the surface and permits the user to manipulate the sleeve in a manner that agitates the extraction fluid which is in contact with the test surface. After two minutes of agitation, the sleeve is removed from the test surface. The extract is filtered and returned to its original container. Thereafter a variety of tests, titration, litmus, and precipitation/light transmission are used to measure three common soluble salts (chlorides, nitrates,

and sulfates). The tests were engineered to provide direct contamination readings in  $\mu\text{g}/\text{cm}^2$ . That information could be compared with allowable contamination levels established by others to determine whether special actions were needed to reduce salt concentration levels.

KTC researchers had already used swabbing and patch extraction test methods in previous research and after the field demonstration they considered the CHLORID International field soluble salt test kit to be most suited to KTC test requirements. The firm also had significant experience with its soluble salt remover. The material was a liquid that could readily be added to a water tank for use in pressure washing or added to the water line by means of a dosing pump. After a field demonstration of the field soluble salt measuring kit, KYTC officials authorized KTC researchers to purchase the test kits, salt remover, and a dosing pump to be used in the study. KTC already possessed a 4,000 psi pressure washer and mechanical surface preparation equipment for use in this study.

## Field Tests on KYTC Bridges

KYTC painting officials worked with KTC researchers to identify candidate bridges for soluble salt testing. Those officials wanted to assess bridges located on a variety of routes that might be subject to differing amounts of deicing salt applications and consequently differing amounts of chloride contamination. Also, there were some differences in the bridge types selected. Initially, the tests were performed on three bridges in Central Kentucky in KYTC District 6. Those were I-471 in Campbell Co. (tied arch), I-71 N over I-75 S in Boone Co. (deck girder) and KY 355 in Owen Co (through truss).

The tests were conducted in April 2002. This is of note as some experts believe that acid rain in the late spring and/or summer decreases soluble salt concentrations that build up on structures during winter months. They believe that extraction tests conducted in late spring and/or summer do not reflect the actual levels of soluble salt that coatings and steel have experienced due to application of deicing salts. The KTC tests were performed prior to any flushing of soluble salts by spring rains and therefore provided a good indication of the maximum levels of soluble salts on the structure at any time.

### **I-471 (Dan Beard Twin Bridges) - B39 in Campbell Co.**

Tests were conducted on the 760-ft. long tied-arch spans of these structures on the south end of those spans. The test areas chosen were at the end of the bridges where ladder permitted access to the pier. Three sites were selected for testing. Two of those were on the northbound structure: the other was on the southbound structure. One site was on the northbound structure on a floor beam under a modular expansion joint (Test Area 1). A second site was also on the northbound structure was at the end of the arch on the arch box upper flange (Test Area 2). The third site was on the southbound structure at the end of the arch on the arch box upper flange (Test Area 3). The second and third sites were similar, but on different structures. They were slightly below bridge deck level and were exposed to aerosols generated by traffic during rainy weather. There was extensive coating deterioration and corrosion at those sites. The second area was under a leaking floor beam and there was a slight amount of corrosion of the upper face of the floor beam lower flange with

some additional corrosion on several beam stiffeners. Those locations represented some of the worst corrosion existing on the bridges and were considered likely sites for undesirable concentrations of soluble salts.

**CHLOR\*TEST\*CSN\* SALTS** tests were performed prior to cleaning on the test surface (See "Existing Condition" Tests Data in Table I Below). In Test Area 1, a second test was performed on a vertical stiffener 9 inches above the lower flange. After determining that salts were present on the test areas, KTC personnel power-tool cleaned the rusted areas using a needle gun and/or 3M soft pad to remove excess surface rust and the general areas were re-tested (See "After Power Tool Cleaning" Data in Table I Below). Then, due to access limitations, only one location, Test Area 1 was pressure washed with a 0° spinner tip held at normal and about 6 to 12 inches away from the surface using plain potable water. The washing pressure was 3500 psi. The area was wiped with paper towels to remove ponding water and left to dry before subsequent re-testing (See "After Pressure Washing" Data in Table II Below).

### **I-71 N over I-75 S Bridge - B42 N in Boone Co.**

Tests were conducted on the northbound overpass of I 71 over I 75 Southbound on a fascia girder and on an angle that comprised part of the transverse bracing over a pier located off the right side of the I-75 roadway. The two test areas were: 1) under the bottom flange of the fascia girder over the travel lane of I-75 Southbound (Test Areas A, C, and D), and 2) on the web and flange of a transverse bracing angle facing the roadway (Test Area B). Those areas were where soluble salts could be anticipated from vehicle aerosols and salt seepage from the compression seal on the joint above the diaphragm. The girder had some freckle rusting on both the web and lower flange indicative of localized coating failures. The compression seal above the angle had failed and as a consequence much of the coating on the angle had deteriorated and there was significant corrosion on both the angle web and flange.

Salt tests were performed at the four sites in the in the untreated condition (See the "Existing Condition" Data in Table II Below). There after, the transverse bracing angle was power tool cleaned and tested both in the web and flange areas (See Test Area B "After Power Tool Cleaning Data in Table II Below). On Test Areas A and C of the girder, the areas previous tested in the "Existing Condition" were pressure washed at 3500 psi with a 0° spinner tip held at normal and about 6 to 12 inches away from the surface using plain potable water and subsequently were re-tested. In Test Area D, on the lower portion of the girder web, the test sites were hand-tool cleaned with a wire brush and a putty knife (to clean off loose edges of paint). That area was re-tested for soluble salts, washed and re-tested again. The test results for this phase of work were recorded for inclusion in this report under Table II (Below).

### **KY 355 Bridge – B6 in Owen Co.**

The portion of this bridge that was tested was a 147 foot long span steel thru truss on vertical and end posts on the west truss at points between 2 to 5 feet above the bridge deck. The coating on the vertical posts was severely deteriorated with spot corrosion as was the end post. Tests were conducted in those areas on surfaces with intact paint for the "Existing Condition". The rusted areas were hand-tool cleaned to remove loose rust and those were also tested for soluble

salts. Then, Test Area C was pressure washed at 3500 psi with a 0° spinner tip held at normal and about 6 to 12 inches away from the surface. The wash water was treated with a dilute (100:1 mixture of potable water and **CHLOR\*RID™**). Thereafter, Test Area C was re-tested for soluble salts. The test results for this phase of work were recorded for inclusion in this report under Table III (Below).

## Conclusions

The tests of the three bridges revealed low levels of soluble salts in most instances, even in the untreated or "Existing Condition". The testing did not reveal a significant problem on Kentucky bridges related to soluble salts. However, not enough tests were conducted to arrive at firm conclusions that could be applied to all Kentucky bridges. Where used, regular pressure washing reduced the salt levels significantly. The **CHLOR\*RID™** did eliminate soluble salts in the one instance where it was used. The **CHLOR\*TEST"CSN" SALTS™** test proved simple to use and provided consistent results. Based upon our field results, no laboratory work was undertaken to determine the efficacy of the **CHLOR\*RID™** soluble salt remover.

What is problematic is that all of the test bridges had at least some locations with moderate corrosion (rusting). The cause of this problem has not been definitely answered, but some evidence exists pointing to moisture exposure (time-of-wetness). Bridge steel located directly under deck joints is sheltered, but it can be wetted by leaking or open joints. Another location where corrosion and coating deterioration is commonly observed is on girders of overpass bridges directly above traffic lanes (due to aerosol pickup). The KY 355 was a rural truss bridge that probably did not experience significant deicing salt applications. Yet, it had significant corrosion throughout the truss including areas along the upper chords and transverse members. The likely cause of that degradation is the high humidity levels experienced in Kentucky resulting in high time-of-wetness of the bridge steel. The atmosphere in Kentucky has daily condensation-evaporation cycles throughout much of the year pumping moisture in and out of coatings, breaking them down and providing moisture at the paint/steel interface to promote corrosion.

The amount of work performed during these tests was limited. The following actions are recommended for further work in evaluating soluble salts:

- KYTC officials that conduct preliminary evaluations of bridges should be equipped with **CHLOR\*TEST™** kits to test bridges that are candidates for maintenance painting. A record of the test results should be made along with digital photographs and other documentation locating test sites and test results. This data should be available for long-term records and analysis.
- In cases where extreme coating deterioration is encountered, testing should be performed using the **CHLOR\*TEST"CSN" SALTS™** test kit to ensure that no unusual conditions exist.
- If high soluble salt levels are encountered (i.e., above 30  $\mu\text{g}/\text{cm}^2$  for any types of soluble salt), the bridge should be given a washing test to ensure that the salt level can be reduced to about 10  $\mu\text{g}/\text{cm}^2$  prior to painting. That salt removal level should be stipulated as a contract requirement for the project. The contractor should have his options for salt removal to that target value.

<b>I-471 North Bound Lane @ Upstream Floor Beam on 4/23/2002 in Campbell Co.</b>			
<b>Test area 1A- Upper face of bottom flange @ down stream side of floor beam (rusted area)</b>			
	Existing Condition	After Power Tool Cleaning	After Washing
	µg/ml	µg/ml	µg/ml
Chloride	30	45	15
Nitrate	2.5	0	2.5
Sulfate	24	3	0
<b>Test area 1B- Stiffener (side 9" from upper face of bottom flange)</b>			
	Existing Condition		
	µg/ml		
Chloride	30		
Nitrate	2.5		
Sulfate	0		
<b>Test area 2A- Upper flange of northbound arch</b>			
	Existing Condition	After Power Tool Cleaning	
	µg/ml	µg/ml	
Chloride	0	7	
Nitrate	2.5	2.5	
Sulfate	0	0	
<b>Test area 3A- Upper flange of southbound arch</b>			
	Existing Condition	After Power Tool Cleaning	
	µg/ml	µg/ml	
Chloride	10	5	
Nitrate	2.5	2.5	
Sulfate	0	0	

**Table 1 I-471 North Bound Lane @ Upstream Floor Beam on 4/23/2002 in Campbell Co.**



**I-71 over I-75 South Bound Lane on 4/24/2002 in Boone Co.**

**Test Area A- Bottom face of lower flange of fascia girder over southbound I 75**

Existing Condition	1A	2A	3A	4A	Average
	µg/ml	µg/ml	µg/ml	µg/ml	µg/ml
Nitrates	0	0	0	0	0
Chloride	23	7	7	25	15.5
Sulfate	0	0	0	2	0.5

After washing	1A	2A	3A	4A	Average
	µg/ml	µg/ml	µg/ml	µg/ml	µg/ml
Nitrates	0	0	0	0	0
Chloride	1	7	0	0	2
Sulfate	1	0	0	0	0.25

**Test Area B – Transverse Bracing Angle**      **1B,2B-Web**    **3B,4B-Bottom Flange**

Existing Condition	1B	2B	3B	4B
	µg/ml	µg/ml	µg/ml	µg/ml
Nitrates	0	0	0	0
Chloride	9	0	0	0
Sulfate	0	0	0	1

**After power tool cleaning and washing**

	5B	6B	7B
	µg/ml	µg/ml	µg/ml
Nitrates	0	0	0
Chlorides	8	6	10
Sulfate	0	0	3

**Test Area C - Bottom face of lower flange of fascia girder over southbound I 75**

Existing Condition	1C	2C	3C	4C	Average
	µg/ml	µg/ml	µg/ml	µg/ml	µg/ml
Nitrate	0	0	0	0	0
Chloride	7	5	11	15	9.5
Sulfate	0	0	3	0	0.75

**After washing**

	µg/ml	µg/ml	µg/ml	µg/ml	µg/ml
Nitrate	0	0	0	0	0
Chloride	0	0	0	3	0.75
Sulfate	0	0	0	2	0.5

**Test Area D – Outer face of fascia beam web over southbound I 75**

Hand Tool	1D	2D	3D	Average
	µg/ml	µg/ml	µg/ml	µg/ml

Nitrate	0	0	0	0
Chloride	5	0	0	1.67
Sulfate	0	0	0	0
After washing				
	µg/ml	µg/ml	µg/ml	µg/ml
Nitrate	0	0	0	0
Chloride	0	0	0	0
Sulfate	0	0	1	0.33

Table 2 I-71 over I-75 South Bound Lane on 4/24/2002 in Boone Co.

KY 355 on 4/25/2002 in Owen Co.				
Test Area A - Vertical Post		1A,2A - Above Guardrail, 3A,4A - Below Guardrail		
	1A - Hand tool	2A - Existing Condition	3A - Hand tool	4A Existing Condition
Nitrate	0	0	0	0
Chloride	0	0	8	8
Sulfate	2	0	4	2
After wash				
			3A	4A
Nitrate			0	0
Chloride			5	0
Sulfate			1	0
Test Area B - End Post		1A,2B Above Guardrail		
	Hand tool	Existing Condition		
Nitrate	0	0		
Chloride	0	0		
Sulfate	1	0		
Test Area C - Vertical Post		1C,2C - Above Guardrail, 3C,4C - Below Guardrail		
	1C Paint surface	2C Hand tool	3C Hand tool	4C Painted Surface
Nitrate	0	0	0	0
Chloride	0	0	8	0
Sulfate	0	0	0	0
After washing with CHLOR-RID Solution				
			3C	4C
Nitrate			0	0
Chloride			0	0
Sulfate			0	0

Table 3 KY 355 on 4/25/2002 in Owen Co.

## References

1. C. H. Hare, "The Painting of Steel Bridges", Published by Clive H. Hare, Inc., Holbrook, MA 1987.
2. Herbert H. Uhlig, "Corrosion and Corrosion Control", Second Edition, Chapter 8. Published by John Wiley & Sons, Inc.
3. B.R. Appleman, "Advances in Technology and Standards for Mitigating the Effects of Soluble Salts", Journal of Protective Coatings and Linings, May 2002.
4. Personal communication between Bruce Karow, Wisconsin DOT and Theodore Hopwood, KTC on December 5, 2002.
5. M. Morcillo, S. Feliu, J.C. Galvan, and J.M. Bastidas, "Some Observations of Painting Contaminated Rusty Steel", Journal of Protective Coatings and Linings, September 1987.
6. Mitschke, Howard, "Effects Of Chloride Contamination On Performance Of Tank And Vessel Linings", SSPC 2000 Proceedings, p 304. Published in JPCL.
7. J.M. Bastidas, M. Morcillo, F.J. Rodriguez, "Mild Steel Corrosion in Saline Solutions. Comparison Between Bulk Solutions and Steel-Coating Interfacial Solutions", Journal of Coatings Technology, July 1998.
8. J. Colehan, "Allowable Salts and Frequency of Testing Survey for Year 2002-2003", Chlor\*rid International, Inc., Chandler, AZ.



Figure 1 CHLOR\*RID Test sleeve mounted on southbound arch flange (test area 3A).



Figure 2 Technician installing sleeve on upper face of lower flange on floor beam (test area 1A).



Figure 3 Test kit from CHLOR-RID for performing salt analysis.

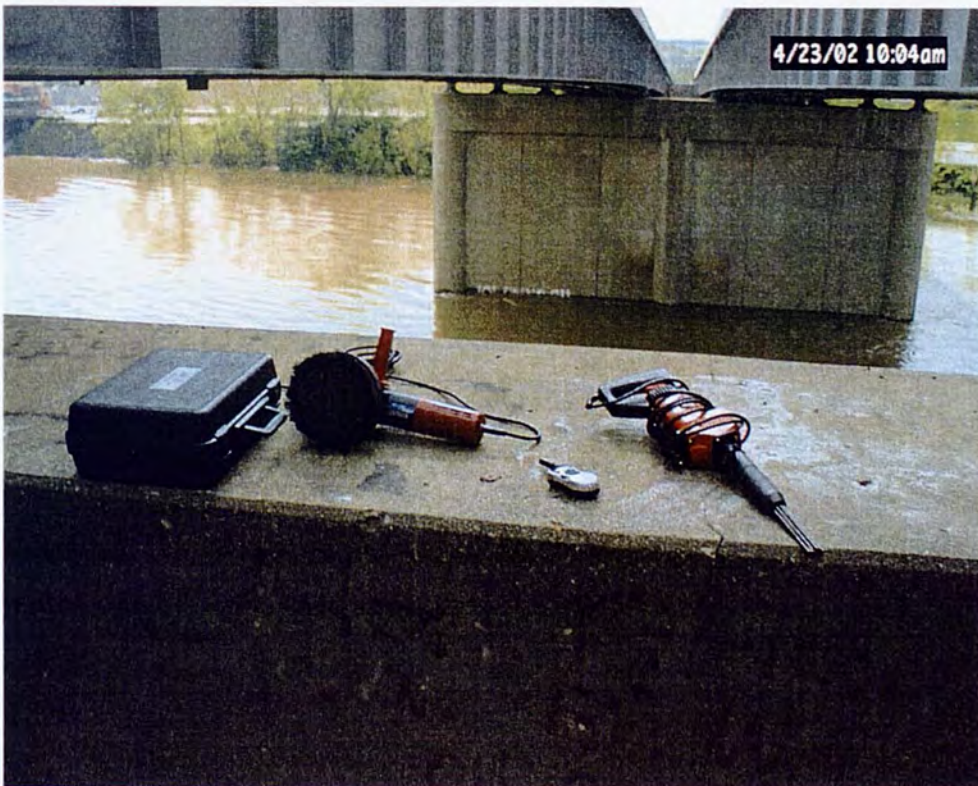


Figure 4 Power tools used in preparing a test area.



Figure 5 Equipment from CHLOR-RID that pumps the solution for removing invisible salts during pressure washing operation.



Figure 6 Testing in progress on KY 355 in Owen Co. for obtaining a sample using CHLOR-RID kit for analysis.

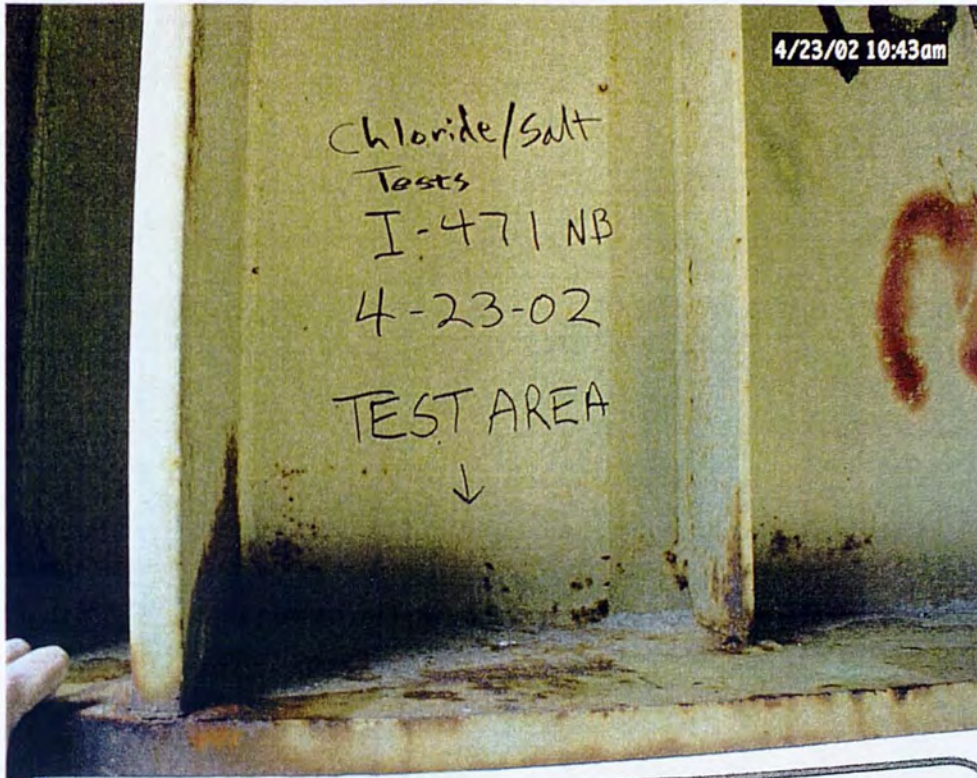


Figure 7 Test area power tool cleaned for collecting a sample on I-471N.



Figure 8 Pressure washing test area on I-71 N overpass over I-75 S.

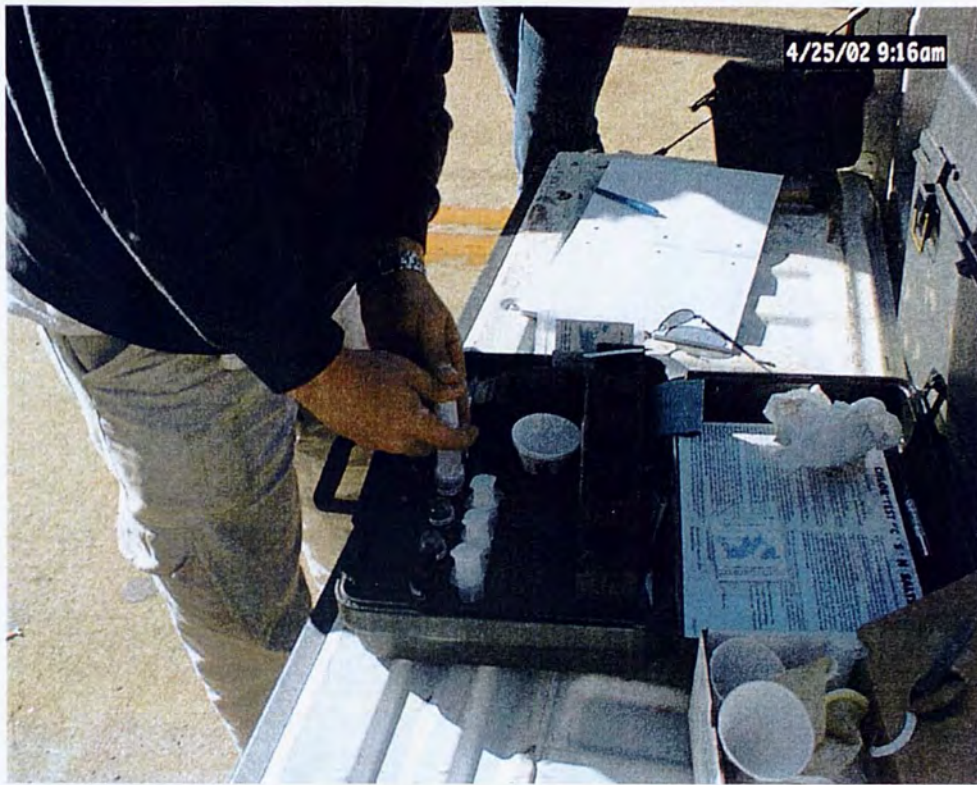


Figure 9 Analyzing a sample collected from I-71 N overpass over I-75 S.



Figure 10 Performing analysis on a sample for presence of nitrates.