WJE | ENGINEERS
ARCHITECTS
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Wiss, Janney, Elstner Associates, Inc.
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Via Email: mkaler@k3capitalpartners.com

December 20, 2011

Mark Kaler
Managing Partner
K3 Capital Partners LLC
130 S. Canal St., Suite 226
Chicago, IL 60606

Re: Proposal for Dowel Bar Corrosion Testing using ASTM A955 Annex A2 Rapid Macrocell Test
WJE No. 2011.5982

Dear Mr. Kaler:

Wiss, Janney, Elstner Associates, Inc. (WJE) is pleased to provide this proposal to perform corrosion tests of your unique dowel bars having fusion-bonded epoxy coated ends. We understand you are interested in comparing the corrosion performance of your dowel bars that are powder coated on all surfaces to that of dowel bars with ends that are uncoated or coated using only a spray-applied repair material.

We propose to conduct this testing based on a modified version of the rapid macrocell test method specified for the evaluation of stainless steel bars in ASTM A955-09 *Standard Specification for Deformed and Plain Stainless-Steel Bars,* Annex A1.2 *Evaluation of Corrosion Resistance*. This method is designed to assess performance of highly corrosion-resistant bars intended for use in transportation structures and is standardized in ASTM A955-09 Annex A2 *Rapid Macrocell Test*.

In this test, the sample bars are tested in conditions conducive to chloride-induced corrosion and intended to simulate steel embedded in concrete. The bars are tested in sets of three, with two bars designated as the cathode, and the remaining bar designated as the anode. Each set constitutes one test cell. A single test cell is pictured schematically in the figure below. In each cell, the two cathode bars are submerged to a depth of approximately 3 in. in a simulated concrete pore solution produced by mixing 974.8 g of distilled water, 18.81 g of potassium hydroxide and 17.87 g of sodium hydroxide. The single anode bar is submerged to a depth of approximately 3 in. in the same simulated concrete pore solution modified by the addition of 172.1 g of sodium chloride, to produce a 15% sodium chloride concentration. A salt bridge provides an ionic path between the containers used for each solution. The corrosion circuit in each cell is completed by electrical connections between the anode bar and the cathode bars made across a 10-ohm resistor, allowing the corrosion current of the anodic bar to be measured. To ensure that sufficient oxygen is available to support cathodic reactions, air is continuously bubbled through the solution around the cathode bars. This air is "scrubbed" to remove carbon dioxide, which would promote carbonation of the simulated concrete pore solution, by passing the air through a solution of 1M sodium hydroxide solution.

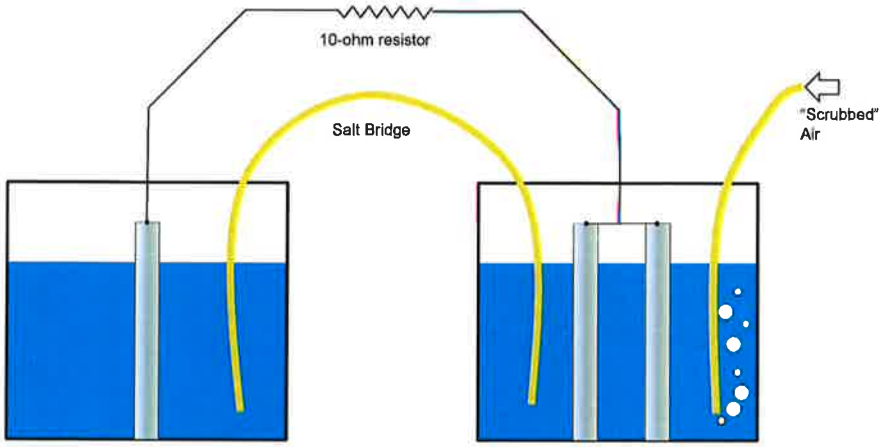

Figure - Schematic of the test setup.

For each sample configuration tested, six sets of bars will be exposed to these test conditions for 15 weeks. The test is run at room temperature (68-76°F) and solutions are replaced every five weeks. The bars will be cleaned of oil and contaminants with acetone before testing.

The development of corrosion during testing is evaluated by measuring the voltage drop across resistors separating the anode and the cathode bars. When measured according the procedure outlined in ASTM A955, a positive voltage corresponds to a positive conventional current moving from the cathode to anode, as would be expected in a typical corrosion reaction. The corrosion rate for each sample set will be determined based on the voltage drop across the resistor.

We propose to conduct this testing on dowel bars in the following three conditions:

- Powder coated on all surfaces
- Powder coated on sides with ends coated with spray-applied repair material
- Powder coated on sides with ends uncoated

We anticipate that you will provide the coated bars to our laboratories, and that we will evaluate coating thickness and holidays on the sides and ends of the bars before testing. At the conclusion of testing, photographs of the bars will be taken to characterize their corrosion condition.

We propose to perform the scope of work described above on a fixed fee basis. The cost of this proposed testing will be $25,000 ($12,500 for the first test condition and $6,250 for each additional condition tested at the same time). We request that half of this budget be submitted now and the remainder at the completion of the testing. This budget includes all testing equipment, set up, data collection and preparation of a report.

Additional work at your request will be billed based on our standard hourly rates. A copy of our Terms and Conditions for Professional Services, dated October 1, 2009, is attached for your review and is part of this proposal. Since the sample materials have potentially multiple end uses, a signed Limitation of Liability is required before beginning work. A copy is attached for your signature.

We look forward to undertaking these studies for you, and thank you for giving us the opportunity to submit this proposal to you. If this proposal is satisfactory, please issue your standard Work Authorization for our execution or sign in the space provided below and return one copy as authorization to proceed. Please contact me if you have any questions.

Sincerely,

WISS, JANNEY, ELSTNER ASSOCIATES, INC.

John Lawler, P.E., Ph.D.
Project Manager

Attachments: Terms and Conditions for Professional Services
Limitation of Liability

Agreed and Approved (WJE No. 2011.5982)

Name: MARK KALER (please print)

Signature: Mark Kaler

Title: DIRECTOR

As Agent or Principal For: JC SUPPLY & MANUFACTURING

Date: 1/17/12

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AGREEMENT FOR LIMITATION OF LIABILITY

In consideration of the performance of services under Job No. ___________ (hereinafter referred to as the "Job"), Wiss, Janney, Elstner Associates, Inc. (hereinafter "WJE") and its employees will exercise the degree of skill and care expected by customarily accepted practices and procedures. WJE makes no warranties, expressed or implied, with respect to its performance, unless agreed to in writing. WJE may rely upon information supplied by Client (company or entity signing this form) or the contractors or consultants involved, or information available from generally accepted reputable sources, without independent verification. WJE is not responsible for acts or omissions of the client, or for third parties not under its direct control.

The Client hereby agrees that the total of WJE's liability (including without limitation, by reasons of negligence, warranty, strict liability, tort, contract or otherwise) arising out of or in connection with Job services shall not exceed $50,000 or fees actually paid for services, whichever is greater. (If Client wishes a higher limit, WJE will attempt to obtain insurance. Client agrees to bear the cost of the insurance.)

Except to the extent that claims, losses, costs, attorney's fees, expenses, awards, actions, judgments or other liabilities are solely caused by the gross negligence or willful misconduct of the indemnified party, the Client further agrees to fully indemnify and hold harmless WJE and its officers, directors, employees, agents, representatives and subcontractors from any and all claims, losses, costs, attorney's fees, expenses, awards, actions, judgments or other liabilities of whatever type, including any negligence of WJE, arising out of or in connection with WJE's employment for and performance of Job services.

In no event shall WJE be liable (including without limitation, by reason of negligence, warranty and strict liability) for any special, indirect or consequential damages including without limitation loss of profits or revenue, loss of full or partial use of any equipment or facility, cost of capital, loss of goodwill, claims of customers or creditors, or similar damages.

The provisions of this Agreement for limitation of or indemnification against liability shall apply to the full extent permitted by law and shall continue in full force and effect during, as well as after, the completion or termination of WJE's employment for Job services. If any provision of this Agreement shall be held or deemed to be or shall in fact be illegal, inoperative or unenforceable, the same shall not affect any other provision or provisions contained herein or render the same invalid, inoperative or unenforceable to any extent whatever.

For JC SUPPLY & MANUFACTURING (Company)	For Wiss, Janney, Elstner Associates, Inc.
By Mark Kalen (Signature)	By ______________ (Signature)
MARK KALEN (Printed)	______________ (Printed)
DIRECTOR & AGENT (Title)	______________ (Title)
Date 1/17/12	Date ______________

Note: The WJE Job No. should be shown on accompanying documents. Please execute and return the form to **Mr. Thomas Oczkowski, Vice President, Wiss, Janney, Elstner Associates, Inc., 330 Pfingsten Road, Northbrook, Illinois 60062** for completion by WJE. A copy of the completed form will be returned to the client.

January 3, 2001

WJE

Terms and Conditions for Professional Services

October 1, 2009

Wiss, Janney, Elstner Associates, Inc. or **WJE Engineers & Architects, P.C. (WJE)** has been requested to perform certain professional and other services. The parties agree that these services shall be performed under the following Terms and Conditions, and that Client's acceptance of WJE's proposal or its direction for WJE to commence any services constitutes acceptance of these Terms.

1. Independent Contractor. WJE is an independent contractor, and all persons employed to furnish services hereunder are employees of WJE or its subcontractors/subconsultants and not of the Client. WJE and Client agree to be solely responsible for compliance with all federal, state, and local laws, rules and regulations, and ordinances that apply to their own respective employees.

2. Performance. The standard of care for all professional services performed or furnished by WJE will be the skill and care ordinarily used by members of WJE's professions performing similar services and practicing under similar circumstances at the same time and in the same locality. WJE makes no guarantees or warranties, express or implied, with regard to the performance of its services. WJE shall not have control over or be in charge of and shall not be responsible for construction means, methods, techniques, sequences or procedures or for construction safety precautions and programs since these are the responsibilities of others. WJE agrees to perform its services in as timely a manner as is consistent with the professional standard of care and to comply with applicable laws, regulations, codes and standards that relate to WJE's services and that are in effect as of the date when the services are provided.

3. Client Duties. In order for WJE to perform the services requested, the Client shall, at no expense to WJE, (1) provide all necessary information regarding Client's requirements as necessary for the orderly progress of the work; (2) designate a person to act as Client's representative for the services who shall have the authority to transmit instructions, receive instructions and information, and interpret and define Client's policies and requests for WJE's services; and (3) provide access to and make all provisions for WJE to enter, without cost, limitation, or burden to WJE, the subject property as required to perform the work, including the use of scaffolds or similar mechanical equipment. WJE is entitled to rely upon the information and services provided by the Client.

4. Safety. Field work will be performed only under conditions deemed safe by WJE personnel. Charges may be made for safety or security measures required by hazardous job conditions that WJE may encounter. Client understands that WJE is only responsible for the safety of its own employees and those of its subconsultants and is not responsible for the safety of other persons or property.

5. Compensation and Expenses. Client agrees to pay for WJE's requested services in accordance with WJE's standard hourly rate schedule or negotiated fee. Charges generally will be billed in monthly intervals with applicable taxes included. Travel, subsistence, and out-of-pocket expenses incurred; communications; reproduction; and shipping charges will be billed at cost plus 5 percent and invoiced as an expense service fee. Use of vehicles will be billed at $0.60 per mile. Expended materials for field and laboratory work, rental equipment, and any fees advanced on Client's behalf will be billed at cost plus 10 percent and invoiced as an expense service fee. WJE equipment used in field or laboratory work is billed at WJE's equipment usage rate schedule in effect at the time the work is performed, subject to adjustment for minimum or extended usage. Portal-to-portal equipment usage rates are comparable to prevailing commercial rental rates (if available). Billing rates may be increased annually. Any subcontracted service will be billed at cost plus 10 percent providing the subcontract firm has in place adequate insurance coverage determined by WJE; otherwise, the cost will be marked up 20 percent and invoiced as an expense service fee. Client agrees to pay WJE's then-current time charges, attorneys' fees, and other expenses resulting from required attendance at depositions, administrative proceedings, or responding to subpoenas or court orders relating to the Project, but not for such expenses attributed to WJE's negligent performance of its services.

Payment for WJE's services is expected in full in US dollars upon receipt of the invoice. Invoices considered past due are subject to any related attorneys' fees and collection expenses. WJE reserves the right to suspend its services if the Client fails to make payment when due providing that WJE gives seven calendar days' notice to Client as practicable. In such an event, WJE shall have no liability to the Client for delay or damage caused the Client because of such suspension.

6. Termination. Both the Client and WJE have the right to terminate WJE's services for convenience upon seven calendar days' written notice to the other party. In the event the Client terminates without cause, WJE shall be entitled to compensation for its services and expenses up to the time of such notification, including fees for any transition services, and shall have no liability for delay or damage to Client because of such termination.

7. Reports, Drawings, and Work Product. WJE retains ownership of reports, drawings, specifications, test data, techniques, photographs, letters, notes, and other work product, including those in electronic form, it has created. These documents or parts thereof may not be reproduced or used by the Client for any purpose other than the purpose for which they were prepared, including, but not limited to, use on other projects or future modifications to this Project, without the prior written consent of WJE. Upon request, WJE will provide Client with a copy of documentation for information and reference purposes and bill for such reproduction in accordance with Paragraph 5 above. Any unauthorized use of WJE's work product shall be at the Client's sole risk and Client shall indemnify WJE for any liability or legal exposure to WJE. To the extent WJE terminates its services due to non-payment of fees by Client, Client shall not be entitled to use the documents described herein for any purpose whatsoever.

8. Environmental Hazards. Client acknowledges that WJE's services do not include the detection, investigation, evaluation, or abatement of environmental conditions that WJE may encounter, such as mold, lead, asbestos, PCBs, hazardous substances, or toxic materials that may be present in buildings and structures involved in this Project. The Client agrees to defend, indemnify, and hold WJE harmless from any claims relating to the actual or alleged existence or discharge of such materials through no fault of WJE's employees. WJE reserves the right to suspend its services, without liability for consequential or any other damages, if it has reason to believe that its employees may be exposed to hazardous materials and will notify the Client in such event.

9. Dispute Resolution. Prior to the initiation of any legal proceedings, WJE and the Client agree to submit all claims, disputes, or controversies arising out of or in relation to the services provided by WJE to mediation. Such mediation shall be conducted under the auspices of the American Arbitration Association or such other mediation service or mediator upon which the parties agree.

10. Governing Law. The laws of the state where WJE performs its services shall govern.

11. Successors and Assigns. These Terms shall be binding upon Client and WJE and their respective successors, assigns and legal representatives. Neither party may assign, subcontract, or otherwise delegate its responsibilities without the prior consent of the other party, which consent shall not be unreasonably withheld.

12. Insurance. WJE maintains commercial general liability, automobile, workers' compensation, and employers' liability and professional liability coverages under policies written by national insurance carriers rated by the A.M. Best Company, evidence of which will be provided upon request. Endorsements are not allowed. No waiver of subrogation is allowed on WJE's professional liability policy. Upon written request, WJE agrees to name the Client as an additional insured to the commercial general liability and automobile coverages. Any request to add other parties as additional insureds must be made in writing and is subject to certain limitations. All policies are subject to annual renewal, and WJE will not undertake to guarantee continued coverage beyond the individual policy term. Excess coverage is available for exposures over primary policy limits except for professional liability.

13. Indemnity. To the fullest extent permitted by law, Client and WJE each agree to indemnify and hold the other harmless, and their respective agents, officers and employees, from and against liability for all direct claims, losses, damages, and expenses, including reasonable attorneys' fees, to the extent such claims, losses, damages, or expenses are for bodily injury, sickness, disease, death, or property damage and to the extent they are caused by the negligent acts, errors, or omissions of the indemnifying party, and/or the indemnifying party's agents, officers, employees, independent contractors, or subcontractors of any tier. In the event such claims, losses, damages, or expenses are caused by the joint or concurrent negligence of Client and WJE, or their respective agents, officers, employees, independent contractors, or subcontractors of any tier, they shall be borne by each party in proportion to that negligence.

14. Agreed Remedy. To the fullest extent permitted by law, the total liability, in the aggregate, of WJE and WJE's officers, directors, employees, agents, and consultants to Client and anyone claiming by, through, or under Client, for any and all injuries, claims, losses, expenses, or damages, including, without limitation, attorneys' fees, arising out of or in any way related to WJE's services, the Project, or these Terms, from any cause or causes whatsoever, including but not limited to, negligence, strict liability, indemnity or breach of contract shall not exceed an amount equal to the proceeds obligated to be paid under WJE's applicable insurance policy for such claims. If, for any reason, the applicable insurance policy does not provide coverage for any particular claim described herein, then the liability amount shall not exceed WJE's fees for the services performed hereunder.

In no event shall WJE be liable in contract, tort, strict liability, warranty or otherwise, for any special, incidental or consequential damages, such as, but not limited to, delay, disruption, loss of product, loss of anticipated profits or revenue, loss of use of equipment or system, non-operation or increased expense of operation of other equipment or systems, cost of capital, or cost of purchase or replacement equipment systems or power.

15. Third-Party Beneficiaries. Nothing contained in these Terms shall create a contractual relationship with, or a cause of action in favor of, a third party against either the Client or WJE. WJE's services hereunder are being performed solely for the benefit of the Client, and no other entity shall have any claim against WJE because of these Terms or WJE's performance or non-performance of services hereunder.

16. Entire Agreement. These Terms together with any written proposal shall constitute the entire understanding of the parties concerning the Project and supersede all prior negotiations and written agreements between them, and any amendment or modification to either WJE's proposal or these Terms may be made only by a written instrument expressly stated to be an amendment and signed by WJE.

17. Severability. If any provisions of these Terms, or portions thereof, are determined to be unenforceable, the remainder shall not be affected thereby and each remaining provision or portion thereof shall continue to be valid and effective and shall be enforceable to the fullest extent permitted by law.

National Concrete Pavement Technology Center

IOWA STATE UNIVERSITY
Institute for Transportation

Project Title: Evaluation of the Corrosion Resistance of a New Generation Epoxy Coating Process for Dowel Bars

Team Members: Tom Cackler, Brent Phares, Justin Dahlberg, ISU Lab Staff

Proposed Starting Date: January 1, 2012

Project Duration: Up to 27 months

Estimated Project Cost: $31,900

A new process for encapsulating the ends of dowel bars using a fusion bonded epoxy system has been developed. Although there is speculation that this process may be superior to conventional processes, there is a desire to evaluate the corrosion resistance through independent testing. Corrosion resistance performance is generally evaluated by accelerating the corrosion process in laboratory specimens. For this work, it is proposed to conduct several accelerated tests on the new generation epoxy-coated dowel bars, current generation epoxy-coated dowel bars, and uncoated dowel bars to determine changes in corrosion potential and relative corrosion rates.

The ASTM G 109 accelerated corrosion test (ACT) is the test first developed to study the corrosion protection provided by chemical admixtures. While the ASTM ACT was originally developed to evaluate admixtures intended to inhibit chloride-induced corrosion of steel in concrete, over the past two decades, the test method has been most notably used to evaluate the corrosion response of steel reinforcement. Although the ASTM ACT typically requires one to two years for completion, the test method provides a severe corrosion environment that is believed to simulate 30 to 40 years of exposure. The test specimen consists of a small beam constructed with two layers of steel. The top layer consists of one bar, while the bottom layer consists of two bars placed side-by-side. The layers are connected electrically by a 10-ohm resistor and the sides of the concrete are sealed with epoxy. A reservoir is secured to the top of the beam to allow pooling of liquid on the upper surface. The test subjects 229 mm (9 in.) of reinforcement below the surface to alternate cycles of wetting and drying with a 3 percent sodium chloride solution. The cycles of wetting allow for chloride ingress to the reinforcement level while the cycles of drying allow for oxygen to replenish. The half-cell corrosion potentials for the top and bottom layers are measured as an indicator of the onset of corrosion. The corrosion rates are determined by measuring the voltage drop across the resistor.

The Rapid Macrocell ACT was originally developed under the SHRP program and updated under the NCHRP-IDEA program. The goal of the test is to obtain a realistic measure of the performance of corrosion protection systems over a shorter period of time than traditional accelerated corrosion tests (i.e., the ASTM ACT). The basic test system requires two containers and consists of either bare or mortar-clad steel reinforcement. The contact surface between the mortar and the bar simulates the concrete-reinforcement interface in actual structures. A single bar, either bare or mortar-clad, is placed in a 1-quart container with a simulated pore solution containing a 3 percent concentration of sodium chloride. Two bars are placed in a second 5-quart container and immersed in simulated pore solution with no chlorides added. The solution in both containers places 76 mm (3 in.) of reinforcement below the solution surface. The solutions in the two containers are connected by a salt bridge and the test specimen in the pore solution containing sodium chloride (anode) is electrically connected through a single 10-ohm resistor to the two specimens in the simulated pore solution (cathode). Air is bubbled into the pore solution surrounding the cathode to ensure that an adequate supply of oxygen is present for the cathodic reaction. The air causes some evaporation, which is countered by adding distilled water to this container to maintain a constant solution volume. Similar to the ASTM ACT, half-cell corrosion potentials for the anode and cathode are measured to establish corrosion initiation. The corrosion current and the rate of corrosion are determined by measuring the voltage drop across the resistor.

Half-cell potentials are measured using a reference electrode. The steel layers are isolated (i.e., each bar is disconnected from the resistor) before the measurement of half-cell potential to avoid interference from the other steel elements. After the measurements are performed, the steel elements are again electrically connected through the resistor. The half-cell corrosion potential of the anode and cathode were measured using a saturated calomel electrode. The half-cell is maintained in accordance with ASTM C 876 for the stabilization of corrosion potential. The associated corrosion condition with varying half-cell corrosion potentials from the saturated calomel electrode established in ASTM C876.

Work Plan

To complete this evaluation, it is proposed that both types of accelerated corrosion tests be completed. A total of 18 specimens (6 with new generation bars, 6 with current generation bars, and 6 with uncoated bars) will be fabricated for testing following ASTM G109 and 9 specimens will (3 with new generation bars, 3 with current generation bars, and 3 with uncoated bars) be fabricated for Rapid Macrocell testing. For ASTM G109 testing, 9 of the specimens will be fabricated with an artificial crack. This artificial crack will further accelerate the ingress of chlorides, water, and air.

The ASTM ACT chloride exposure condition used in this study will be based upon a weekly cycle. The beams will subjected to a seven day ponding and drying regime. For the first 4 days of each week. the test surface will be ponded with a depth of approximately 38 mm (1-1/2 in.) of 3 percent sodium chloride solution in the laboratory. During this period, the reservoir will be covered with a plastic sheet to minimize evaporation. Following this 4 day exposure, the sodium chloride solution will be removed, and the test surface rinsed with distilled water and drained. These unponded beams will remain dry for three days. After this exposure, the test surface will be immediately reponded with the 3 percent sodium chloride solution. The ponding and drying regime will be repeated for 12 weeks when the test surface will be subject to continuous ponding for 12 weeks. Following the 12 week period of continuous ponding, the alternating ponding and drying regime will be resumed and continued alternatively for the remainder of the test period.

For the Rapid Macrocell ACT, the mortar-clad specimen will be placed in a 1-quart container, along with a simulated pore solution containing a 3 percent concentration of sodium chloride for the duration of the test period. When needed, simulated pore solution will be added to maintain the 76.2 mm (3 in.) of reinforcement below the surface.

At the conclusion of each test period, the testing procedures and results will be given to the client.

Project Budget

The estimated cost for this work is $31,900. In preparing this budget it has been assumed that the client shall provide the research team with all needed dowel bars.

National Concrete Pavement Technology Center

IOWA STATE UNIVERSITY
Institute for Transportation

Project Title: **Field Reevaluation of Elliptical Steel Dowel Performance**

Team Members: Tom Cackler, James Cable, Pavana Vennapusa, ISU Lab Staff

Proposed Starting Date: February 1, 2012

Project Duration: 5 months

INTRODUCTION/BACKGROUND:
In the field of concrete paving, joints are always a subject of great concern both in the construction and long-term performance of concrete pavements. Research has demonstrated the need for some type of positive load transfer across transverse joints. The same research has directed pavement designers to use round dowels spaced at regular intervals across the transverse joint to distribute the vehicle loads both longitudinally and transversely across the joint. The goal of this effort is the reduction in bearing stresses on each dowel and the reduction in stress on the two pavement slab edges and erosion of the underlying surface. The result should be improved long term performance of the joints and the pavement structure.

Doweled joints have been shown to deteriorate in terms of metal corrosion from road salts, hollowing of the concrete at the dowel ends due to excessive bearing stresses on the dowel, and pavements cracking at the end of the dowels usually associated with construction processes. Dowels are also a cost factor when joint spacings are reduced in an effort to control curling and warping distress in pavements. The designer wants a plan to place adequate but not excessive numbers of dowels spaced at the proper locations to handle the anticipated loads and bearing stresses for the design life of the pavement.

LITERATURE SEARCH:
The literature search for this project has been completed as part of the project on "Dowel Bar Optimization: Phases I and II". *Table 3.4 in that document provided an average concrete bearing stress for several types of dowels tested, based on limited laboratory testing.*

Dowel Bar Description	*Concrete Bearing Stress in psi*
1-1/4 inch round epoxy coated steel	*2,084*
1-1/2 inch round epoxy coated steel	*1,568*
Large elliptical steel	*1,147*
Medium elliptical steel	*1,611*
Small elliptical steel	*2,637*

The decisions made on the dowel bar arrangements for the field test in this project were based on the relationship of the elliptical bar spacing and bearing stresses to that of the 1-1/2 inch round epoxy coated steel bar used in the laboratory tests.

RESEARCH PROBLEM STATEMENT: In 2001. the National Concrete Pavement Technology Center in conjunction with the FHWA developed a project to field test the constructability and performance of conventional steel dowels vs three types of elliptical bars. This came as a result of previous research entitled "Dowel Bar Optimization: Phases I and II" which provided information in laboratory testing regarding spacing and bearing stresses for installation of conventional steel dowels and three types of elliptical dowels. Field evaluation of those same bars and calibration of the results was important to the application of the results into the design process for pavements.

A series of test sections were constructed in 2001 on Iowa Highway 330 in central Iowa to measure the performance of the various types of elliptical dowel bars. Those sections were evaluated for five years and a final report was written in 2008. The test sections are now 10 years old and this research would revisit the project and conduct one more field evaluation to determine any changes in performance of the dowel types .

RESEARCH OBJECTIVES:
The research will revisit the project in attempt to answer the following questions:

1. What is the relative performance over time, of the medium (major axis = 1.654 inches, minor axis = 1.115 inches and area = 1.473 inches^2) and large (major axis = 1.969 inches, minor axis = 1.338 inches and area = 2.084 inches^2) elliptical dowels as compared to that of the conventional steel dowels, 1.50 inches in diameter with an cross section area of 1.767 inches^2, in terms of deflection, joint faulting and joint openings?
2. What is the impact of dowel spacing on the relative performance of the elliptical and round dowels in field conditions?
3. What is the impact on performance of the various dowel shapes when placed in cut or fill sections of the roadway?

PROPOSED RESEARCH:
The research will include one additional monitoring of three types of dowels placed at three different conventional spacings across the transverse joints of the concrete pavement. A fourth layout will investigate the potential for placing dowels primarily in the wheel paths. The variables are:

1. Uniform dowel bar spacings of 12, 15 and 18-inch c-c.
2. One special dowel spacing of four bars each at 12-inch c-c in each wheel path and a single bar between the wheel paths.
3. Dowel sizes of 1.5 inch diameter round, and both medium and heavy elliptical dowels.
4. Three replicate sections of each dowel size and spacing placed in cut and fill roadway sections.
5. Each test section consists of 20 transverse joints of a particular combination of dowel shape and spacing separated from the next test section be a minimum of 5 conventional 1.5 inch round steel doweled joints.

The research involves monitoring of full width (26 foot) transverse joint dowel baskets (12 and 14 foot sections). Approximately 520 joints contain the medium sized elliptical dowels, 390 joints of heavy elliptical bars, and 390 joints of conventional 1.5 inch diameter round dowels. The joints were constructed as rectangular or perpendicular to the centerline of the pavement. The heavy and medium sized elliptical bars were coated with an epoxy that meets ASTM-934 standard vs. the Iowa DOT required ASTM-777 standard. The proposed epoxy has demonstrated to be more resistant to abrasion and deicing chemicals than those presently required for highway work.

The bars were placed in a construction project in Jasper/Story/Marshall County (NHSX-330-1(19)—3H-50), by the contractor, Fred Carlson Co. in the summer of 2002. The project site provided the needed cut and fill sections to fulfill the needs of this research.

EVALUATION and TESTING:
Testing for this project will be accomplished with the aid of the Iowa DOT Special Investigations Unit and the CP Tech Center research staff.

1. FWD deflection testing of ten joints (outside wheel path, both lanes) in each of test sections one time in the spring of 2012.
2. Visual distress surveys of the test sections one time in the spring of 2012.
3. Measurement of faulting and joint openings along the outside edge of the pavement at ten joints in each test section one time in the spring of 2012.

RESEARCH PERIOD:
The research period will extend from February 1, 2012 through June 30, 2012.

REPORTS:
The project report will document the results of the deflection and visual distress surveys as they relate to the first five years of research data. It will be developed to estimate the long-term performance of the various dowel configurations and sizes.

PROJECT STAFFING:
The research will be conducted under the administration of the CP Tech Center and the supervision of Dr. James K. Cable P.E.

It is anticipated that the Iowa DOT Office of Special Investigations team will do the Profile measurement work in cooperation with the ISU research team.

FWD. faulting, joint opening and visual surveys will be done by the CP Tech Center staff members.

BUDGET:

Salaries/Benefits		$5,119
Cable Concrete Consultant		$28,216
Testing		
Travel		$200
Materials		$1,000
FWD testing		$10,000
High Speed profiler		$5,600
Lab Testing (Jeremy, Bryan)		
Final report editing/printing		$500
TOTAL DIRECT COSTS		$50,635
ISU Indirect Costs	26%	$12,329
TOTAL COSTS		$62,964

IMPLEMENTATION:
The final report resulting from this project will be distributed to the sponsor, the Iowa DOT, and other sponsoring agencies such as the dowel bar manufacturers. Presentations on this research will be made at various workshops including concrete paving association and material supplier conferences and workshops.

References:

Field Evaluation of Elliptical Steel Dowel Performance, Final Report, May 2008: Center for Transportation Research and Education: James K. Cable, Jason M. Walker, Max Porter. Stacia L. Totman, Nathan Pierson.

Field Evaluation of Elliptical Steel Dowel Performance, Interim Report, December 2006; National Concrete Pavement Technology Center: James K. Cable, Stacia L. Totman, Nathan Pierson.

Field Evaluation of Elliptical Steel Dowel Performance, Construction Report, December 2002; Center for Portland Cement Concrete Pavement Technology; James K. Cable, Lee Edgar and Jera Williams.

Dowel Bar Optimization: Phases I and II, Final Report, Sponsored by the American Highway Technology, Max L. Porter, Robert J. Guinn Jr., and Andrew L. Lundy, October 2001, produced by CTRE and the PCC Center

mark kaler

To: pkrauss@wje.com
Subject: independent lab test

Paul,

I left you a VM today regarding some independent test program. I am work with JC Supply and Manufacturing. We are a manufacture of load transfer and associated pavement materials. We have developed a new process for fusion bonded epoxy ends for dowel bars that we believe has superior performance to the traditional method of bare end or 2 component spray epoxy system. We are looking to get independent testing to verify. Would your group provide a proposal of the appropriate test program and cost of the elements of the proposed test program. We would like to have comparison testing vs patched ends. We would also like to have an option for comparative testing vs stainless – under the same test protocol as stainless is tested – ie no drilled hole.

We may elect to fund this project prior to year end for tax purposes so if you could expedite this proposal it would be of great help.

Thanks and any questions my contact info is below

Mark Kaler
Managing Partner

K3 Capital Partners LLC
130 S. Canal St.
Suite 226
Chicago, IL 60606
PH - 815-263-3300
Fax - 815-464-3256
mkaler@k3capitalpartners.com
www.k3capitalpartners.com

mark kaler

To: Cackler, E. T [ITRNS]
Subject: RE: Dowels

On the dowels really looking at corrosion comparison – the new process we have developed provides for fusion bonding of epoxy on the ends of dowels vs either bare ends or the 2 part spray on epoxy. The study that Roger Larson and kurt Smith completed showed epoxy to have some problems – my hypothesis is that the exposed ends create a corrosion current that accelerates corrosive activity with any holiday or damage area of the dowel. If you have seen dowels that have been in the open environment waiting to be placed for more than 3 months the ends start to rust and the epoxy is compromised – this is without any road salt.. I am also a firm believer that we need a higher thickness on the bar to eliminate most all of holidays.

Let me know your thoughts

From: Cackler, E. T [ITRNS] [mailto:tcackler@iastate.edu]
Sent: Thursday, December 15, 2011 8:39 AM
To: mark kaler
Subject: RE: Dowels

On the dowel bar testing, I assume you are wanting pullout tests. Anything else. Also can you tell me how many different dowels coatings you are wanting to test. I am trying to understand how big the test matrix is. I'm sure this is something we can easily do, just need the detail so we can put the proposal together.

The proposal to monitor the performance of the 330 project is underway.

Thanks for the opportunity.

Tom

From: mark kaler [mailto:mkaler3@comcast.net]
Sent: Wednesday, December 14, 2011 11:22 AM
To: 'Cackler, E. T [ITRNS]'
Subject: RE: Dowels

Tom,

Could you develop a proposal for an updated evaluation.

We also have a new process to encapsulate the ends of dowel bar with a fusion bonded epoxy system. We believe this is a far superior system to either plain ends or the patching system used today. We are looking to verify this with independent testing. Would you be able to provide this type of work? if so we would like a comparison test program with our bar vs traditional patched ends and stainless. Develop a proposal for this as well.

We may want to fund this work yet this year for tax purposes so if you could expedite the proposals that would help.

Thanks

Mark

mark kaler

To: Cackler, E. T [ITRNS]
Subject: RE: Dowels

Tom,

Could you develop a proposal for an updated evaluation.

We also have a new process to encapsulate the ends of dowel bar with a fusion bonded epoxy system. We believe this is a far superior system to either plain ends or the patching system used today. We are looking to verify this with independent testing. Would you be able to provide this type of work? if so we would like a comparison test program with our bar vs traditional patched ends and stainless. Develop a proposal for this as well.

We may want to fund this work yet this year for tax purposes so if you could expedite the proposals that would help.

Thanks

Mark

From: Cackler, E. T [ITRNS] [mailto:tcackler@iastate.edu]
Sent: Thursday, December 08, 2011 1:46 PM
To: mark kaler
Subject: RE: Dowels

It would need to be a sponsored project. We just don't have the funds unfortunately that are not fully allocated to specific projects.

Thanks, Tom

From: mark kaler [mailto:mkaler3@comcast.net]
Sent: Wednesday, December 07, 2011 11:14 AM
To: 'Cackler, E. T [ITRNS]'
Cc: 'Wagner, Denise F [ITRNS]'; Connie Lightcap
Subject: RE: Dowels

Tom,

we do think it would be valuable to update the performance of the elliptical dowels. Would there be funding available for this type of study?

Thanks for the help

Mark

From: Cackler, E. T [ITRNS] [mailto:tcackler@iastate.edu]
Sent: Tuesday, December 06, 2011 2:04 PM
To: mark kaler
Cc: Wagner, Denise F [ITRNS] (dfwagner@iastate.edu)
Subject: RE: Dowels

Hi Mark,
I saw you across the room at the task force meeting but missed the chance to talk to you. I had to leave on Thursday so was not around for much of the meeting this year. Anyway trust all is well with you and your family.

I will email you a couple of the reports that Mark Snyder mentions as we don't have them posted on line yet but will before long. Mark Snyder was the primary author on these for us.

I agree, it would be good to get another set of data on the performance of the elliptical dowels on highway 330. There is a good start on a data set and continuing this would be very good to get actual field data. Let me know if you would like to pursue this as we plan for next year.

Thanks, Tom

From: mark kaler [mailto:mkaler3@comcast.net]
Sent: Tuesday, December 06, 2011 11:27 AM
To: tcackler@iastate.edu
Subject: Dowels

Tom,

I didn't get a chance to catch up with you at the ACPA event but wanted to talk with you on an item. We had a report completed by the tech center on the performance elliptical dowels from the test section on IA 330. It will be 10 years next year and thought it would be beneficial to update that report. This product has lost interest in the industry but I think it provides greatly improved cost effectiveness. Let me know your thoughts.

Also Dr. Snyder in his presentation indicated that this was part of publication of pooled study I thought completed under the CP center but couldn't find it on the website – can you lead me to it?

thanks

Mark Kaler
Managing Partner

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Fax - 815-464-3256
mkaler@k3capitalpartners.com
www.k3capitalpartners.com

Thurman Cancer ⇒ December Mtg.

Business Cards

Email Address Forward

WJE – Ends testing for Patch ⇒

Rhino Ctg ⇒ 3-M

3-M

Jennifer Pratt

Developmental engineer

6352 ⇒ Abrasion Pipe Ctg – overcoat. Not applied ~~to~~ to steel directly not Flexible

Rhino Ct ⇒ pipeline ctg w/ improved corrosion

RMLABRADOR@MMM.COM

3M™ Scotchkote™ Fusion-Bonded Epoxy Coating 6233

Data Sheet

Product Description

3M™ Scotchkote™ Fusion-Bonded Epoxy Coating 6233 is a one-part, heat curable, thermosetting epoxy coating powder designed for corrosion protection of pipe.

Properties

Property	Value
Specific Gravity	
Film	1.36
Powder	1.44
Coverage based on film	141 ft²/lb/mil (0.735 m²/kg/mm)
Color	Govt. Color 14272/Green
6233-4G	
Gel Time @ 400°F/205°C	9.5 seconds ± 20%
Cure Time @ 450°F/232°C	30 seconds
6233-8G	
Gel Time @ 400°F/205°C	17 seconds ± 20%
Cure Time @ 450°F/232°C	90 seconds
6233-11G	
Gel Time @ 400°F/205°C	25 seconds ± 20%
Cure Time @ 450°F/232°C	110 seconds
Shelf life @ 27°C/80°F	12 months

Temperature Operating Range

The Scotchkote 6233 coating, when properly applied, should perform in a satisfactory manner on pipelines operating between -100°F/-73°C to 230°F/110°C. For temperatures between +170°F/77°C to 230°F/110°C , laboratory tests indicate that the thicker coatings may improve the service capability. However, it is difficult to accurately predict field performance from the laboratory data due to the wide variation in actual field conditions. Soil types, moisture content, temperatures, coating thickness and other factors specific to the area all influence the coating performance and the upper temperature operating limit.

Scotchkote 6233 meets the requirements of AWWA C213 and C550.

3M™ Scotchkote™ Fusion-Bonded Epoxy Coating 6233 Test Data

Property	Test Description			Typical Value
Impact	ASTM G14 (modified)			
	1/8 in (3.2 mm) thick plate			160 in•lbs (18.1 J)
	3/8 in (9.5 mm) thick plate			59 in•lbs (6.7 J)
Cathodic Disbondment	CAN/CSA-Z245.20-12.8			
	48 hours, 1.5 volt, 3% NaCl 149°F/65°C			2.3 mm r
	28 day, 1.5 volt, 3% NaCl 73°F/23°C			2.5 mm r
	28 day, 1.5 volt, 3% NaCl 149°F/65°C			4.9 mm r
Hot Water Resistance	24 hours, CAN/CSA-Z245.20-12.14, 203°F/95°C			1 rating
	48 hours, CAN/CSA-Z245.20-12.14, 167°F/75°C			1 rating
Bendability (Mandrel Bend)	Temperature	Pipe Diameters	°/PD	% Elongation
	73°F/23°C	<10.5	5.5	4.8
	-22°F/-30°C	<19.1	>3.0	>2.6
Compressive Strength	ASTM D 695			>10,000 psi (705 kg/cm²)
Penetration	ASTM G 17 -40° to 200°F/-40° to 93°C			0
Thermal Shock	-320° to 310°F/-195° to 154°C Coated pipe			No visible effects 10 Cycles
Dialectric Strength	1180 V/mil/46 kV/mm			

Note: The typical values in this data sheet are based on lab prepared samples. Values shown are not to be interpreted as product specifications.

3M

3M™ Scotchkote™ Fusion-Bonded Epoxy Dual Coating System 6352

Product Description

3M Scotchkote Fusion-Bonded Epoxy Dual Coating System 6352 is a hard, mechanically strong top coating for all Scotchkote fusion-bonded epoxy pipeline corrosion protection coatings. When applied at greater thickness, Scotchkote 6352 also enhances the hot, wet performance of the first layer of corrosion coating. It is applied to the base coating to form a tough outer layer that is resistant to gouge, impact, abrasion and penetration. Scotchkote 6352 coating is specifically designed to protect the primary corrosion coating from damage during pipeline directional drilling applications, bores, river crossing and installation in rough terrain.

It is thermosetting, integrally bonded to the base coating and does not shield from cathodic protection. Excellent flexibility provides an added service advantage over other top coating systems.

Properties		
Color	Brown	
Specific Gravity - Film Powder	 1.57 1.64	
Coverage based on film	122 ft2/lb/mil kg/mm	0.636 m2/
Gel Time at 400°F/204°C 6352-04 6352-08	 9.5 seconds ± 20% 16 seconds ± 20%	

Temperature Operating Range

The Scotchkote 6352 coating, when properly applied, should perform in a satisfactory manner on pipelines operating between -100°F/-73°C and 230°F/110°C. For temperatures between 170°F/77°C and 230°F/110°C, laboratory tests indicate that the thicker coatings may improve the service capability. However, it is difficult to accurately predict field performance from the laboratory data due to the wide variation in actual field conditions. Soil types, moisture content, temperatures, coating thickness and other factors peculiar to the area all influence the coating performance and the upper temperature operating limit.

Suggested Thickness

Thickness requirements depend on service conditions. Normally, the following thickness is used: 8 mils/200 µm to 16 mils/400 µm of Scotchkote 6233 and 226 FBE coatings, and 15 mils/380 µm to 35 mils/900 µm of Scotchkote 6352 FBE coating.

Scotchkote 6352 meets the requirements of AWWA C213.

Scotchkote 6352 Fusion Bonded Epoxy Coating Test Data

Property	Test Description	Typical Value
Impact	ASTM G14 (modified) Except with 1" x 1/2" x 7" bars	142 in•lbs/16 J
Bendability (Mandrel Bend)	see below	
Hot Water Resistance	24 hours, CAN/CSA-Z245.20-12.14, 203°F/95°C 48 hours, CAN/CSA-Z245.20-12.14, 167°F/75°C	1 rating 1 rating
Hardness	ASTM D 2240-97 Shore D, run on pucks ASTM D 2583-95 Barcol, run on pucks	86 50
Gouge Resistance	TISI with R33 bit 30 kg load 40 kg load 50 kg load	 203 µm/8 mils gouge depth 279 µm/11 mils gouge depth 330 µm/13 mils gouge depth
Abrasion Resistance	ASTM D 4060 CS17 1000 g wt 5000 cycles	0.091 g loss
Cathodic Disbondment	28 day, 1.5V, 3% NaCl, 176°F/80°C	4.8 mmr 226N/6233

Bendability (Mandrel Bend):

Thickness - mils (microns)	First Layer/ Second Layer	Source	Temperature	Pipe Diameter	°/PD*	% Elongation
30 (762)	15 (381/15 (381)	Lab	-22°/-30°	28.7	>2.0	1.7%

* Plant application could vary test results

Note: The typical values in this data sheet are based on lab prepared samples. Run on steel bars coated with 381 µm/15 mils of Scotchkote 226N/6233 overcoated with 508 µm/20 mils of Scotchkote 6352 coating. Values shown are not to be interpreted as product specifications.

3M

Curing Specifications

After application, 3M™ Scotchkote™ Fusion-Bonded Epoxy Dual Coating System 6352 shall be allowed to cure in accordance with Figure 1 or 2. The indicated temperature is that of the outer surface of the corrosion coating primer layer. A properly calibrated IR measuring device shall measure the temperature. Alternatively, an estimate of the surface temperature shall be calculated by multiplying the primer coating thickness in mils by 2 and subtracting that value from the pipe temperature in ˚F (thickness in microns by 0.04 and subtracting that value from the pipe temperature: 475˚F (246˚C). Estimated temperature of coating surface = 475 - (16 x 2) = 443˚F.

(In ˚C, 246 - (400 x 0.04) = 230˚C)

Coating Repair

Areas of pipe requiring small spot repairs shall be cleaned to remove dirt and damaged coating using surface grinders or other suitable means. All dust shall be wiped off.

3M™ Scotchkote™ Liquid Epoxy Coating 323 or 3M™ Scotchkote™ Liquid Epoxy Coating 352 shall be applied in small areas to the thickness as specified. The freshly coated area shall be allowed to properly cure prior to handling and storage. Liquid epoxy shall not be applied if the pipe temperature is 41°F/5°C or less, except when manufacturer's recommended heat curing procedures are followed. Alternatively, for pinhole areas, the heat bondable polymeric 3M™ Scotchkote™ Hot Melt Patch Compound 226P shall be applied in small areas to a minimum thickness of 16mils/400 µm in addition to the parent coating. Abrade the area with sandpaper. A non-contaminating heat source shall be used to heat the area to be repaired to approximately 350°F/177°C. When the Patch Compound sticks to the hot surface, it is hot enough. While continuing to heat the cleaned and prepared area, the patch compound shall be applied by rubbing the stick on the area to be repaired in circular motion to achieve a smooth, neat appearing patch. The patch shall be allowed to cool before handling.

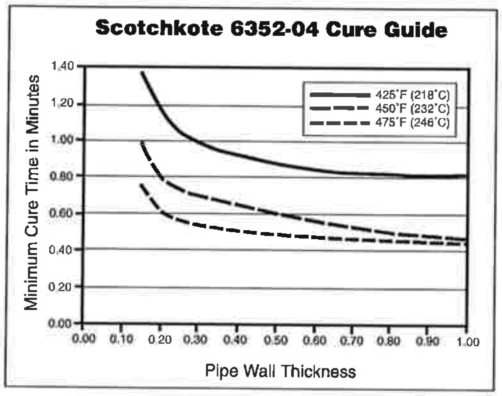

Figure 1

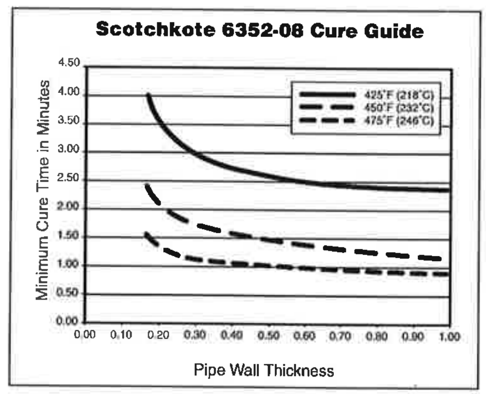

Figure 2

Handling & Safety Precautions

Read all Health Hazard, Precautionary, and First Aid statements found in the Material Safety Data Sheet, and/or product label prior to handling or use.

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80-6111-8349-4 Rev. G

3M™ Scotchkote™ Fusion-Bonded Epoxy Coating 226N

Product Description

The 3M™ Scotchkote™ Fusion-Bonded Epoxy Coating 226N, is a one-part, heat curable, thermosetting epoxy coating. It is designed to provide superior performance and adhesion to the metal substrate, and to provide excellent cathodic disbonding properties without the use of a chromate pretreatment.

Scotchkote 226N Test Data

Property	Value
Color Federal Standard 595B	14272/Green
Specific Gravity	1.36 g/cm³ (film) 1.57
Shelf Life at 27°C	12 months
Particle size larger than 250 µm larger than 150 µm	<0.2% <3.0%
Moisture Content	<0.3% at manufacture
Gel Time at 205°C 226N 4G 226N 8G 226N 11G	 6-11 seconds 17-23 seconds 24-36 seconds
Cure Time at 232°C 226N 4G 226N 8G 226N 11G	 30 seconds 90 seconds 110 seconds

Temperature Operating Range

Scotchkote 226N, when properly applied, should perform in a satisfactory manner on pipelines operating between -100°F/-73°C and 230°F/110°C. For temperatures between 170°F/77°C and 230°F/110°C, laboratory tests indicate that the thicker coatings may improve the service capability. It is difficult to accurately predict field performance from laboratory data, due to the wide variation in actual field conditions. Operating temperature performance depends on the whole system, not only the FBE coating. Soil types, moisture content, temperature and other factors peculiar to the area all influence the coating performance and the upper temperature operating limit.

Test Data

Coating performance is affected by the degree of surface preparation, application temperature, film formation and curing conditions.

Scotchkote 226N Test Data - Coating

Property	Test Method	Value
Impact	-30°C	6J
Cathodic Disbondment	24 hours, 65°C, 3.5V, 3% NaCl CSA Z245.20-02, Clause 12.8 14 day, 65°C, 1.5V, 3% NaCl 28 day, 23°C, 1.5V, 3% NaCl 28 day, 65°C, 3.5V, 3% NaCl	2.5 mmr 3.0 mmr 2.3 mmr 6.0 mmr
Hot Water Resistance	24 hours, CAN/CSA-Z245.20-12.14, 203°F/95°C 48 hours, CAN/CSA-Z245.20-12.14, 167°F/75°C	1 rating 1 rating
Flexibility (Bendability) (Mandrel Bend)	-30°C CSA Z245.20-02, Clause 12.11 Temperature: -22°F/-30°C; Pipe Diameters: >19.1	>3PD °/PD: >3.0; % Elongation: >2.6
Penetration	ASTM G 17 -40° to 200°F/-40° to 93°C	0
Volume Resistivity	ASTM D 257	1.2×10^{15} ohm*cm
Electrical Strength	ASTM D 1000	1160V/mil / 45.2kV/mm

Note: The typical values in this data sheet are based on lab prepared samples. Values shown are not to be interpreted as product specifications.

3M

3M™ Scotchkote™
Spray Grade Fusion Bonded Epoxy Coating 413

Product Description

3M™ Scotchkote™ Spray Grade Fusion Bonded Epoxy Coating 413 is a one-part, heat curable, thermosetting epoxy coating designed for corrosion protection of reinforcing steel. The epoxy is applied to preheated steel as a dry powder which melts and cures to a uniform coating thickness. This bonding process provides excellent adhesion and coverage on concrete reinforcing bar, wire fabric, piling, tensioning hardware and other steel members of any size or shape. Scotchkote 413 is resistant to corrosive agents such as deicing salts, airborne salt spray, sea water, harsh chemicals, acid rain, carbonation, contaminated aggregate and concrete additives.

Features

- Superior flexibility, exceeds ASTM A 775 and ASTM A 884 bending requirements for rebars
- No primer required
- Economical
- Improved UV resistance
- Fast curing for high-speed application
- Protects over wide temperature range
- Resists deicing salts
- Can be shipped with minimum damage
- Is not damaged by concrete embedment
- Resistant to cathodic disbondment
- Lightweight for lower shipping costs
- Will not sag, cold flow, or become soft in storage
- Easy visual inspection of coated articles
- Meets FHWA requirements
- Meets ASTM A 775/A 775M
- Meets AASHTO M 284 and AASHTO M 254
- Meets ASTM A 884

General Application Steps

1. Remove oil, grease and loosely adhering deposits.
2. Abrasive blast clean the surface to SSPC-SP10 or NACE No. 2 near-white, or ISO 8501 Sa2.5.
3. Preheat metal to 300° to 460°F (149° to 238°C).
4. Deposit Scotchkote 413 Spray Grade coating by electrostatic spray to the thickness required.
5. Cure by post baking according to cure guide below.
6. Electrically inspect for holidays after coating has cooled to 250°F (121°C) or lower.

Cure Specifications

Scotchkote 413 coating must be cured to achieve maximum performance properties. Suggested application temperatures and cure times are listed in the cure guide. Post bake is required. Cure time can vary because of differences in heating systems. Applications at lower temperatures or on lightweight material may require additional cure.

3M™ Scotchkote™ Spray Grade Fusion Bonded Epoxy Coating 413 Cure Guide

Metal Temperature	Cure Time
350°F (177°C)	20 minutes
375°F (191°C)	12 minutes
400°F (204°C)	8 minutes
425°F (218°C)	6 minutes
450°F (232°C)	5 minutes

3M™ Scotchkote™ Spray Grade Fusion Bonded Epoxy Coating 413

Property	Value
Color	Green
Specific Gravity - Powder (Air Pycnometer)	1.21
Coverage	159 ft^2/lb/mil (0,83 m^2/kg/mm)
Gel Time	15 to 20 seconds at 400°F (204°C)
Minimum Explosive Concentration	0.03 oz/ft^3 (30,6 g/m^3)

3M

3M™ Scotchkote™ Spray Grade Fusion Bonded Epoxy Coating 413 Test Data

Property	Test Description	Results
Impact	ASTM G 14 1/8" x 3" x 3" (0,32 cm x 7,6 cm x 7,6 cm) steel panel, 5/8" (1,6 cm) radius tup	160 in•lbs 1,8 kg•m
	ASTM A 775	80 in•lbs 0,9 kg•m
Abrasion Resistance	ASTM A 775 CS-17 1000g weight / 1000 cycles	5 mg loss
Penetration	ASTM G 17 -40° to 240°F (-40° to 116°C)	0
Hardness	Knoop Hardness	≥ 16
Cathodic Disbondment	ASTM A 775, 1.5 volt 168 hours at 75°F (24°C), 3% NaCl 0.12 in (3 mm) intentional holiday	3.0 mmr
Chemical Resistance	ASTM A 775 45 days at 70°F (21°C) immersed in: 3 molar (25% CaCl) 3 molar (10.7% NaOH) Saturated $Ca(OH)_2$	No blistering, cracking or peeling No blistering, cracking or peeling Slight reduction in adhesion No blistering, cracking or peeling
Bendability	Rebar bend, #5 rebar around 3.13" (79,5 mm) diameter mandrel 180° at 20°F (-7°C)	No cracks or tears
Chloride Permeability	FHWA-RD-74-18	$< 2.86 \times 10^{-5}$
Salt Spray Resistance	ASTM A 775/A 775M ASTM B 117, coated rebar 5% NaCl 800 hrs at 95°F (35°C) 0.12 in (3mm) intentional holiday	2.0 disbondment radius average
Relative Bond Strength to Concrete	FHWA-RD-74-18	>88% of mean strength for uncoated bar

Handling & Safety Precautions

Read all Health Hazard, Precautionary, and First Aid statements found in the Material Safety Data Sheet, and/or product label prior to handling or use.

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3M™ Scotchkote™
Fusion-Bonded Epoxy Dual Coating System 6352

Product Description

3M Scotchkote Fusion-Bonded Epoxy Dual Coating System 6352 is a hard, mechanically strong top coating for all Scotchkote fusion-bonded epoxy pipeline corrosion protection coatings. When applied at greater thickness, Scotchkote 6352 also enhances the hot, wet performance of the first layer of corrosion coating. It is applied to the base coating to form a tough outer layer that is resistant to gouge, impact, abrasion and penetration. Scotchkote 6352 coating is specifically designed to protect the primary corrosion coating from damage during pipeline directional drilling applications, bores, river crossing and installation in rough terrain.

It is thermosetting, integrally bonded to the base coating and does not shield from cathodic protection. Excellent flexibility provides an added service advantage over other top coating systems.

Properties		
Color	Brown	
Specific Gravity -		
Film	1.57	
Powder	1.64	
Coverage based on film	122 ft2/lb/mil kg/mm	0.636 m2/
Gel Time at 400°F/204°C		
6352-04	9.5 seconds ± 20%	
6352-08	16 seconds ± 20%	

Temperature Operating Range

The Scotchkote 6352 coating, when properly applied, should perform in a satisfactory manner on pipelines operating between -100°F/-73°C and 230°F/110°C. For temperatures between 170°F/77°C and 230°F/110°C, laboratory tests indicate that the thicker coatings may improve the service capability. However, it is difficult to accurately predict field performance from the laboratory data due to the wide variation in actual field conditions. Soil types, moisture content, temperatures, coating thickness and other factors peculiar to the area all influence the coating performance and the upper temperature operating limit.

Suggested Thickness

Thickness requirements depend on service conditions. Normally, the following thickness is used: 8 mils/200 µm to 16 mils/400 µm of Scotchkote 6233 and 226 FBE coatings, and 15 mils/380 µm to 35 mils/900 µm of Scotchkote 6352 FBE coating.

Scotchkote 6352 meets the requirements of AWWA C213.

Scotchkote 6352 Fusion Bonded Epoxy Coating Test Data

Property	Test Description	Typical Value
Impact	ASTM G14 (modified) Except with 1" x 1/2" x 7" bars	142 in•lbs/16 J
Hot Water Resistance	24 hours, CAN/CSA-Z245.20-12.14, 203°F/95°C 48 hours, CAN/CSA-Z245.20-12.14, 167°F/75°C	1 rating 1 rating
Hardness	ASTM D 2240-97 Shore D, run on pucks ASTM D 2583-95 Barcol, run on pucks	86 50
Gouge Resistance	TISI with R33 bit 30 kg load 40 kg load 50 kg load	 203 µm/8 mils gouge depth 279 µm/11 mils gouge depth 330 µm/13 mils gouge depth
Abrasion Resistance	ASTM D 4060 CS17 1000 g wt 5000 cycles	0.091 g loss
Cathodic Disbondment	28 day, 1.5V, 3% NaCl, 176°F/80°C	4.8 mmr 226N/6233

Bendability (Mandrel Bend):

Thickness - mils (microns)	First Layer/ Second Layer	Source	Temperature	Pipe Diameter	°/PD*	% Elongation
30 (762)	15 (381/15 (381)	Lab	-22°/-30°	28.7	>2.0	1.7%

* Plant application could vary test results

Note: The typical values in this data sheet are based on lab prepared samples. Run on steel bars coated with 381 µm/15 mils of Scotchkote 226N/6233 overcoated with 508 µm/20 mils of Scotchkote 6352 coating. Values shown are not to be interpreted as product specifications.

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Curing Specifications

After application, 3M™ Scotchkote™ Fusion-Bonded Epoxy Dual Coating System 6352 shall be allowed to cure in accordance with Figure 1 or 2. The indicated temperature is that of the outer surface of the corrosion coating primer layer. A properly calibrated IR measuring device shall measure the temperature. Alternatively, an estimate of the surface temperature shall be calculated by multiplying the primer coating thickness in mils by 2 and subtracting that value from the pipe temperature in °F (thickness in microns by 0.04 and subtracting that value from the pipe temperature: 475°F (246°C). Estimated temperature of coating surface = 475 - (16 x 2) = 443°F.

(In °C, 246 - (400 x 0.04) = 230°C)

Coating Repair

Areas of pipe requiring small spot repairs shall be cleaned to remove dirt and damaged coating using surface grinders or other suitable means. All dust shall be wiped off.

3M™ Scotchkote™ Liquid Epoxy Coating 323 or 3M™ Scotchkote™ Liquid Epoxy Coating 352 shall be applied in small areas to the thickness as specified. The freshly coated area shall be allowed to properly cure prior to handling and storage. Liquid epoxy shall not be applied if the pipe temperature is 41°F/5°C or less, except when manufacturer's recommended heat curing procedures are followed. Alternatively, for pinhole areas, the heat bondable polymeric 3M™ Scotchkote™ Hot Melt Patch Compound 226P shall be applied in small areas to a minimum thickness of 16mils/400 µm in addition to the parent coating. Abrade the area with sandpaper. A non-contaminating heat source shall be used to heat the area to be repaired to approximately 350°F/177°C. When the Patch Compound sticks to the hot surface, it is hot enough. While continuing to heat the cleaned and prepared area, the patch compound shall be applied by rubbing the stick on the area to be repaired in circular motion to achieve a smooth, neat appearing patch. The patch shall be allowed to cool before handling.

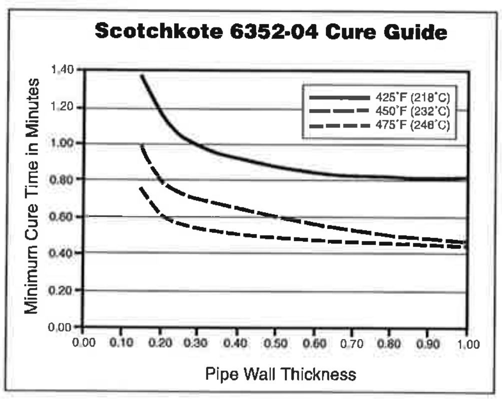

Figure 1

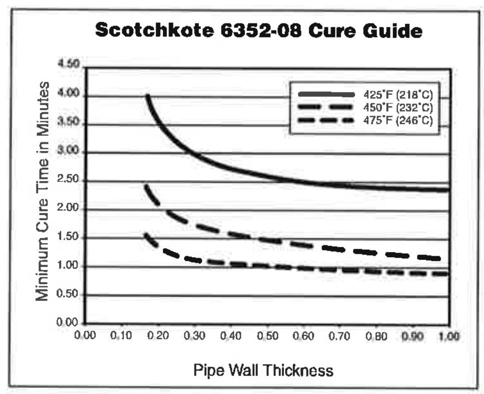

Figure 2

Handling & Safety Precautions

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80-6111-8349-4 Rev. G

3M™ Scotchkote™
Fusion-Bonded Epoxy Dual Coating System 6352

Product Description

3M Scotchkote Fusion-Bonded Epoxy Dual Coating System 6352 is a hard, mechanically strong top coating for all Scotchkote fusion-bonded epoxy pipeline corrosion protection coatings. When applied at greater thickness, Scotchkote 6352 also enhances the hot, wet performance of the first layer of corrosion coating. It is applied to the base coating to form a tough outer layer that is resistant to gouge, impact, abrasion and penetration. Scotchkote 6352 coating is specifically designed to protect the primary corrosion coating from damage during pipeline directional drilling applications, bores, river crossing and installation in rough terrain.

It is thermosetting, integrally bonded to the base coating and does not shield from cathodic protection. Excellent flexibility provides an added service advantage over other top coating systems.

Properties		
Color	Brown	
Specific Gravity - Film Powder	 1.57 1.64	
Coverage based on film	122 ft2/lb/mil kg/mm	0.636 m2/
Gel Time at 400°F/204°C 6352-04 6352-08	 9.5 seconds ± 20% 16 seconds ± 20%	

Temperature Operating Range

The Scotchkote 6352 coating, when properly applied, should perform in a satisfactory manner on pipelines operating between -100°F/-73°C and 230°F/110°C. For temperatures between 170°F/77°C and 230°F/110°C, laboratory tests indicate that the thicker coatings may improve the service capability. However, it is difficult to accurately predict field performance from the laboratory data due to the wide variation in actual field conditions. Soil types, moisture content, temperatures, coating thickness and other factors peculiar to the area all influence the coating performance and the upper temperature operating limit.

Suggested Thickness

Thickness requirements depend on service conditions. Normally, the following thickness is used: 8 mils/200 µm to 16 mils/400 µm of Scotchkote 6233 and 226 FBE coatings, and 15 mils/380 µm to 35 mils/900 µm of Scotchkote 6352 FBE coating.

Scotchkote 6352 meets the requirements of AWWA C213.

Scotchkote 6352 Fusion Bonded Epoxy Coating Test Data

Property	Test Description	Typical Value
Impact	ASTM G14 (modified) Except with 1" x 1/2" x 7" bars	142 in•lbs/16 J
Hot Water Resistance	24 hours, CAN/CSA-Z245.20-12.14, 203°F/95°C 48 hours, CAN/CSA-Z245.20-12.14, 167°F/75°C	1 rating 1 rating
Hardness	ASTM D 2240-97 Shore D, run on pucks ASTM D 2583-95 Barcol, run on pucks	86 50
Gouge Resistance	TISI with R33 bit 30 kg load 40 kg load 50 kg load	 203 µm/8 mils gouge depth 279 µm/11 mils gouge depth 330 µm/13 mils gouge depth
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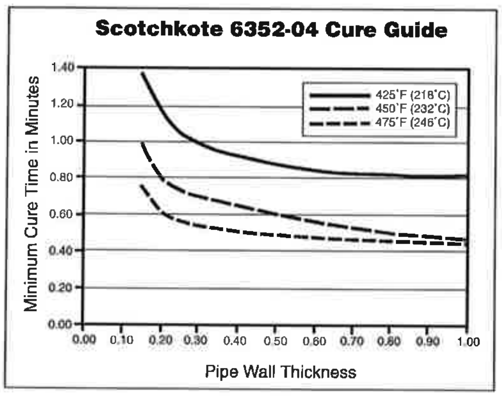

Figure 1

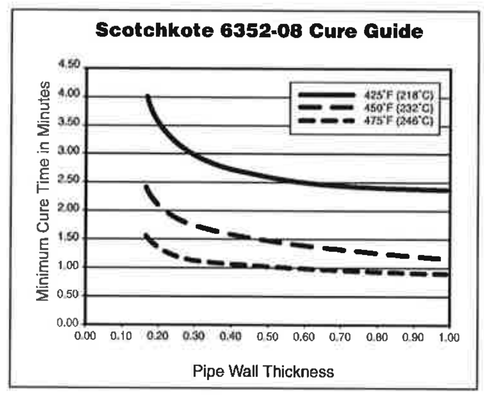

Figure 2

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80-6111-8349-4 Rev. G

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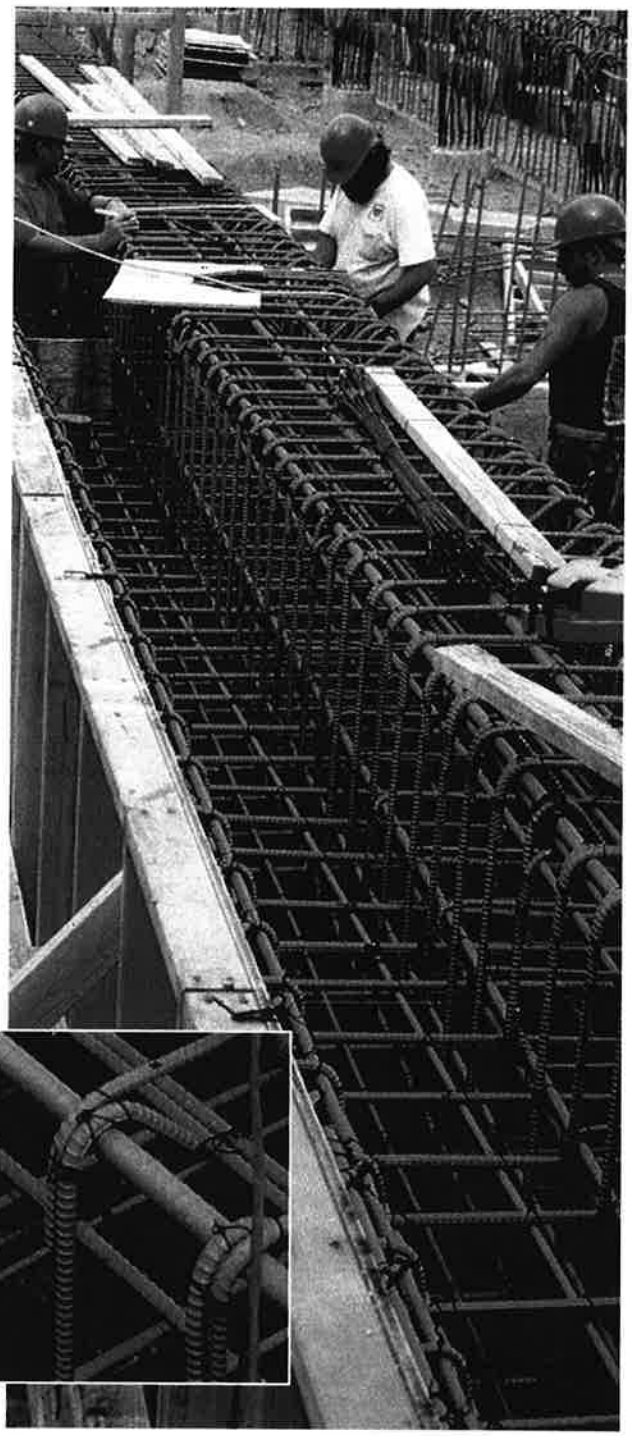
Scotchkote™

Fusion Bonded Epoxy Coating 426



Product Description

3M™ Scotchkote™ Fusion Bonded Epoxy Coating 426 is a one-part, heat curable, thermosetting epoxy coating designed for improved corrosion protection of reinforcing steel in severe marine and corrosive environments. The epoxy is applied to preheated steel as a dry powder which melts and cures to a uniform coating thickness. This bonding process provides excellent adhesion and coverage on concrete reinforcing steel bar and other steel members which have been prefabricated to any size or shape. Scotchkote 426 coating is resistant to cathodic disbondment and corrosive agents such as deicing salts, airborne salt spray, sea water, harsh chemicals, acid rain, carbonation, contaminated aggregate and concrete additives.

Features

- Provides superior resistance from disbondment without pretreatments.
- Superior for prefabricated steel reinforcement.
- Good corrosion protection, even under hot, wet, salty conditions.
- Easy visual inspection of reinforcement surfaces.
- Color coded for easy identification of prefabricated reinforcement.
- Storage in all climatic conditions with minimal damage.
- Consistent performance test results under all application conditions.
- Resistance to cathodic disbondment and hot-water immersion adhesion loss.
- Improved UV resistance.
- Resists deicing salts.
- Meets CAN/CSA-Z 245.20-M92 and British Gas GBE/CW6 without pretreatment.
- Meets ASTM A 775/A 775M and AASHTO M 284, AASHTO M 254, and ASTM A 884, except flexibility.
- Meets ASTM A 934/A 934M.

Test Data - Coatings

Hot Water Immersion Resistance
167°F (75°C), 48 hours

Scotchkote 426 rebar coating
British Gas GBE/CW6 0 mm
CSA Z 245.20 1 Rating

Flexible Rebar Coating with Surface Treatment
British Gas GBE/CW6 6 mm
CSA z 245.20 3 Rating

Flexible Rebar Coating
British Gas GBE/CW6 12 mm
CSA Z 245.20 5 Rating

Cathodic Disbondment (Salt Crock) Resistance
150°F (66°C), 40 hours, 3% NaCl, 3 volts

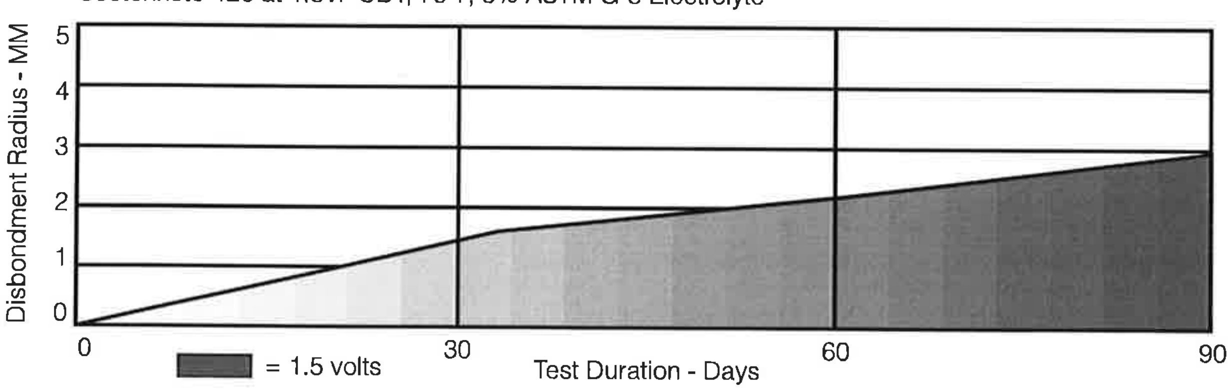
Scotchkote 426 rebar coating
2 mmr disbondment

Flexible Rebar Coating with Surface Treatment
5 mmr disbondment

Flexible Rebar Coating
15 mmr disbondment

Cathodic Disbondment

Scotchkote 426 at 1.5V: CDT; 73°F, 3% ASTM G-8 Electrolyte



Test Data - Coatings

Property	Test Description	Results
Chemical Resistance	ASTM A 934/A 934M 45 days at 75° F (24°C); 3 molar (25%) $CaCl_2$; 3 molar (10.7%) NaOH; Saturated $Ca(OH)_2$	No blistering, softening, bond loss or holidays.
Resistance to Applied Voltage (Cathodic Disbondment or Salt Crock)	Modified ASTM G-95, 175°F (79°C); 3V, 3% NaCl, 14 days	9.5 mmr
	ASTM A 934 150°F (66°C); 3V, 3% NaCl, 48 hours	4.3 mmr
	ASTM A 934 74°F (23°C); 1.5 V, 3% NaCl, 168 hours	0.8 mmr
Salt Spray Resistance	ASTM A 934 95°F (35°C); 5% NaCl, 800 hours	< 1 mm
Chloride - Permeability	ASTM A 934 75°F (24°C), 45 days	1.41 x 10^{-5} molar
Coating Flexibility	ASTM A 934 No. 6 (No. 20) Rebar, 6° around a 6 in. (150 mm) diameter mandrel, completed within 5 seconds. 75°F (24°C)	No cracking visible on outside radius
Relative Bond Strength in Concrete	ASTM A 944	> 80% of mean strength for uncoated bar
Abrasion Resistance	ASTM D 1044 CS-17, 1000 g weight, 5000 cycles	0.1 g. loss
	ASTM A 934, 1000 g weight, 1000 cycles	19 mg.
Impact	ASTM A 934/A 934M	No shattering, cracking or bond loss outside impact area
Water Immersion	British Gas GBE/CW6 122°F (50°C)	7 days, 1.0 mm disbondment 28 days, 2.2 mm disbondment
Hardness	Knoop Hardness	> 20

General Application Steps

A. Remove oil, grease and loosely adhering deposits.

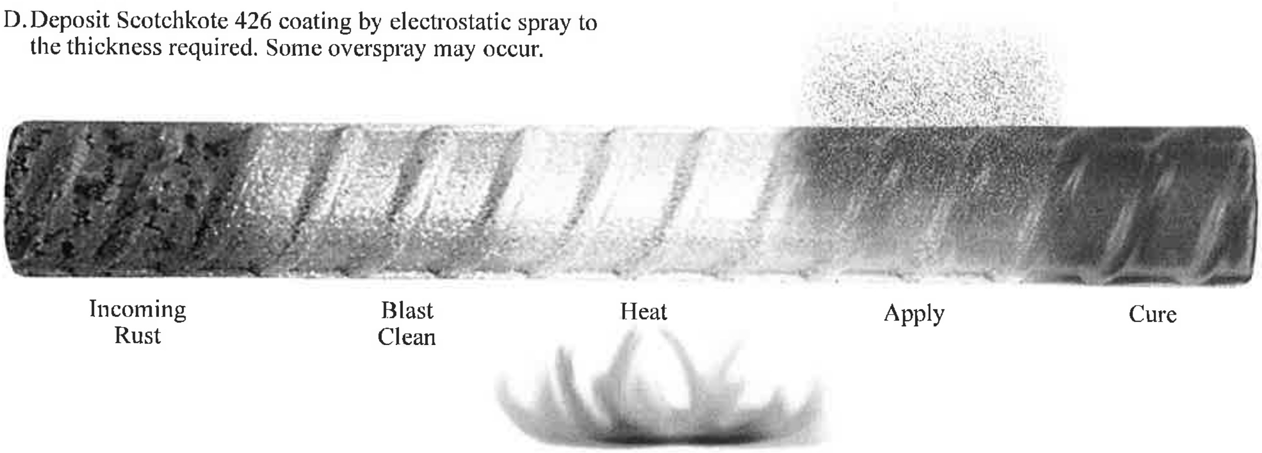
B. Abrasive blast clean the surface to NACE No. 2/SSPC-SP10 ISO 8501:1, Grade SA 21/2 near white finish.

C. Preheat metal to approximately 450°F (232°C).

D. Deposit Scotchkote 426 coating by electrostatic spray to the thickness required. Some overspray may occur.

E. Allow to cure according to Cure Specifications.

F. Electrically inspect for holidays after coating has cooled to 250°F (121°C) or lower.



Cure Specifications

Scotchkote 426 coating must be cured according to the following schedule in order to achieve maximum performance properties. Cure time is based on metal temperature.

Application Temperature	Minimum Time to Cure
450°F/232C	
Scotchkote 426 Fast	30 seconds
Scotchkote 426 Long Gel	90 seconds

Properties

Property	Value	
Color	Violet	
Specific Gravity Powder	1.47 ± .03	
Coverage based on specific gravity	131 ft^2/lb/mil (0,681 m^2/kg/mm)	
Gel Time	400°F(204°C)	450°F(232°C)
Scotchkote 426 Fast	4-10 seconds	2-5 seconds
Scotchkote 426 Long Gel	13-20 seconds	6-10 seconds

Handling and Safety Precautions

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3M™ Scotchkote™ Pipe Coatings

3M has been the primary global supplier of fusion bonded epoxy coatings for pipelines since 1960, and Scotchkote materials have been used to coat more pipelines worldwide than any other fusion bonded epoxy product. Since 1960, the Scotchkote brand of products have changed significantly with major improvements in flexibility, adhesion, high temperature performance and damage protection. New systems are available that provide more choices to handle specific operating conditions than ever before. Application standards and overall quality of the applied coating have also increased substantially, and 3M has been intimately involved in this ongoing process at every step through extensive technical service activities, involvement in industry associations, and end user support. Take advantage of this expertise by using Scotchkote products on your next pipe coating project.

The Alliance Pipeline in Minnesota, coated with 3M™ Scotchkote™ 6233. 7

Scotchkote 6233

Scotchkote 6233 is a significantly advanced, high-performance fusion bonded epoxy coating. It incorporates 3M's latest formulation technology, utilizing special adhesion promoting agents to enhance cathodic disbondment resistance in all conditions, especially elevated temperatures/wet environments. Scotchkote 6233 adheres under the stress of changing temperatures and soil compaction. It bonds to line pipe, girth welds and associated fittings, and provides one of the best coatings available for use in corrosive soils, hydrocarbons, harsh chemicals and sea water.

Another important benefit of the coating is its ability to provide consistently high quality control test results under a broad range of application conditions. Comparative test results from The Alberta Research Council* confirm Scotchkote 6233 passes specification test requirements with uniformly higher marks on cathodic disbondment and water immersion testing than other available fusion bonded epoxy coating evaluated in a 1998 study. These special characteristics provide a substantial upgrade in performance expectations not only from the application but from field performance as well. Scotchkote 6233 meets the requirements of CAN/CSA-Z245.20/06.

Scotchkote 226N/226N+

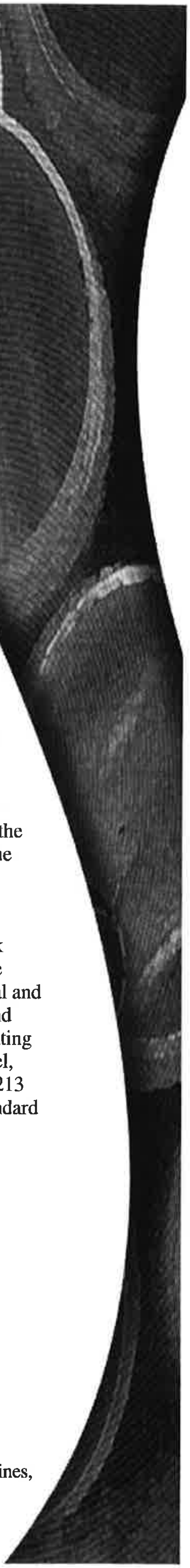
Scotchkote 226N/226N+ provides the same advanced properties as Scotchkote 6233. It meets the requirements of CAN/CSA-Z245.20/06, BG PS/CW6 without pretreatment.

Scotchkote 6258

Scotchkote 6258 is a one part, heat curable, thermosetting fusion bonded epoxy coating designed for corrosion protection of pipes. Scotchkote 6258 utilizes special ingredients that promote superior adhesion to steel and epoxy novolak resins that significantly raise the glass transition temperature of the coating. These benefits make this a suitable standalone coating and as a liner for downhole tubing.

Scotchkote 206N

Scotchkote 206N, has been a pipe coating benchmark since 1974. It is available in a variety of gel/cure time ranges for automatic or manual application to external and internal surfaces of pipe, associated appurtenances and field joints. The coating exceeds all industry pipe-coating standards. Scotchkote 206N Standard, Extra Long Gel, and Fluid Bed Grade products conform to AWWA C213 and 550, and they meet the requirements of NSF Standard 61 for use as a coating in contact with potable water.



* "Laboratory Evaluation of Seven Fusion Bond Epoxy Pipeline Coatings", December 23, 1998, prepared for Enbridge Pipelines, Inc. and 3M Canada by Alberta Research Council, Advanced Industrial Materials and Process Group, Edmonton, Alberta.

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