



NAPCA Bulletin 12-78-04 (Revised August 2022)

EXTERNAL APPLICATION PROCEDURES FOR PLANT APPLIED FUSION BONDED EPOXY (FBE) COATINGS AND ABRASION RESISTANT OVERLAY (ARO) COATINGS TO STEEL PIPE

1. General

- a) These specifications may be used in whole or in part by anyone without prejudice, if recognition of the source is included. The National Association of Pipe Coating Applicators (NAPCA) assumes no responsibility for the interpretation or use of these specifications.
- b) The intended use of these coatings is to provide corrosion protection for buried pipelines. Above ground storage of coated pipe in excess of 6 months without additional Ultraviolet protection is not recommended.

2. Scope

- a) The Applicator shall furnish all labor, equipment and material required, shall prepare all surfaces to be coated and shall apply the coating to all surfaces to be coated.
- b) Corrosion protection, as provided under this specification, is furnished by the application of fusion bonded epoxy to the exterior of pipe to be placed underground.

3. Definitions

- Applicator – The company responsible for the actual application of the coating.
- Company – The purchaser of the coated pipe or the entity for whom the Applicator coats the pipe.
- SSPC – Steel Structures Painting Council
- NACE/AMPP – National Association of Corrosion Engineers
- Manufacturer – The company that makes the coating materials which are applied to the pipe
- FBE – Fusion bonded epoxy pipe coating applied directly on steel for the purpose of corrosion protection
- ARO – Abrasion resistant overlay coating, a fusion bonded epoxy coating applied over a FBE coating for the purpose of abrasion or damage resistance
- Batch – The quantity of epoxy powder produced during a continuous production run of not more than 8 hours.
- Holiday – A discontinuity in the applied coating that exhibits electrical conductivity when exposed to a specific voltage.
- Test ring – A sample taken from production-coated pipe

4) Pipe Conditions

- a) Pipe delivered to the Applicator for coating shall be free of protective oils, lacquers, mill primer, dirt or any other deleterious surface contamination which may affect the application of the

coating. The pipe surface shall be as free as possible from scabs, slivers and laminations. Removal of such contaminants shall be as agreed between the Applicator and the Company.

- b) Any paint markings or stenciling of the pipe surface shall be of the type and thickness that can be removed easily during normal surface preparation.

5) Handling of Bare Pipe

- a) Proper equipment for unloading, handling, and temporary storage of bare pipe shall be used to avoid any damage to the pipe or pipe ends.
- b) If internally coated pipe is received at the Applicator's plant, care shall be taken to avoid damage to the internal coating or the obliteration of the internal pipe markings during any phases of work covered by this specification. Internal coatings must be capable of withstanding the processing conditions necessary for the application of the external coating.
- c) The Applicator shall visibly inspect the pipe upon receipt for damage such as dents, flat ends, and bevel damage. Any damage observed at this point shall be noted on the inbound tally, and the Company shall be informed within 24 hours of receipt of the pipe. Any non-visible defects such as slivers, scabs, laminations, burrs, dents, etc. will be observed after the pipe is blast cleaned and at the Company's request, removed as an extra work item.
- d) When the roughness of the pipe surface is such that the normal coating rate will be impaired or will result in coated pipe that will be in non-conformance with these specifications, at the Company's option, the Applicator shall take whatever steps necessary to rework the pipe surface and/or add additional coating thickness to the pipe so as to provide coated pipe which can be processed at a normal rate and which will comply with these specifications. The cost of reworking the pipe surface and/or applying additional coating thickness will be agreed upon in advance by the Applicator and Company and paid for by the Company.

6) Materials and Workmanship

- a) All material furnished by the Applicator shall be of the specified quality. All work shall be done in a thorough workmanlike manner. The entire operation of pipe receiving, stockpiling, surface preparation, coating application, storage and loadout shall be performed under the supervision of and by experienced personnel skilled in the application of protective coating.
- b) The applicator shall use epoxy powders that are certified by the powder manufacturer. This certification shall be supplied with each batch of material;
 - I. Powder manufacturer's name;
 - II. Product description;
 - III. Mass of material;
 - IV. Batch number;
 - V. Location of manufacturer;
 - VI. Manufacturing identification number;
 - VII. Temperature requirements for transportation and storage;
 - VIII. Year and month of manufacture

7) Equipment

The Applicator's equipment shall be in such condition as to permit the Applicator to follow the procedure and obtain results prescribed in these specifications.

8. Coating Material

- a. All coating materials, including repair or patch materials, purchased or used under these specifications, shall be packaged in suitable and approved containers. The containers shall be plainly marked with the name of the Manufacturer, type of material and batch or lot number where applicable. Bulk shipments shall be allowed provided the above information is included in the bill of lading.
- b. The coating material shall be packaged in containers suitable to keep the contents clean and dry during handling, shipping and storage. Storage and handling conditions shall be in accordance with the Manufacturer's recommendations.
- c. Precautions shall be taken during the handling, shipping and storage of all materials to prevent damage to the containers that would result in contamination of the coating materials. All contaminated, or otherwise damaged materials shall be discarded.
- d. Time/temperature limitations for FBE Powders shall be in accordance with the Manufacturer's recommendations.

9. Surface Preparation

- a. Before blasting, all oil, grease, mill lacquer and other deleterious material on the surfaces of the metal to be coated shall be removed by suitable means.
- b. In cold weather or any time when moisture tends to collect on the steel, the pipe shall be uniformly warmed for sufficient time to dry the pipe prior to cleaning. The pipe temperatures shall be maintained at least 5 degrees F above the dew point during the cleaning and coating operations. Pipe temperature shall not exceed 160 degrees F as a result of preheat.
- c. Pipe surfaces shall be blast cleaned to a Near-White metal finish in accordance with SSPC-SP-10 or NACE #2 requirements.
- d. NACE, Swedish Pictorial, SSPC or other mutually agreed upon standards shall be used to judge the degree of cleaning.
- e. A consistent abrasive working mix shall be maintained by frequent additions of small quantities of new abrasive commensurate with consumption. Infrequent large quantity additions of abrasive shall be avoided.
- f. Following cleaning and prior to coating the pipe, abrasive remaining on the outside and/or inside of the pipe shall be removed by air blast, vacuum or other suitable methods. If air is used, the air should be dry and free of contaminants, and all particles removed from the surface shall be collected in such a manner as not to contaminate clean pipe.
- g. Following cleaning and prior to coating, the pipe surface shall be inspected for adequate cleaning and surface condition. Pipe not properly cleaned shall be rejected and recleaned.
- h. Blast cleaned pipe surfaces shall be protected from conditions that would allow the pipe to flash rust before coating. If flash rusting occurs, affected pipe shall be recleaned.
- i. Surface imperfections such as slivers, scabs, laminations, burrs and weld spatter shall be removed by hand filing or light grinding as long as such removal does not:

- Adversely affect the quality of pipe cleaning.
- Adversely affect the normal production rate of the plant.

10. Coating Application (FBE)

- The pipe shall be heated to a temperature within the tolerances recommended by the Manufacturer of the coating material to be applied. The pipe shall not be heated to a temperature in excess of 600 degrees F at any time during the process. Blue oxide formation shall not be used as an indicator that maximum temperature has been exceeded or that damage to steel properties has occurred.
- The pipe shall be monitored for proper temperature prior to coating by use of a temperature sensitive crayon (used at a minimum) or calibrated pyrometers.
- Coating material shall be applied uniformly utilizing the best commercial practices and in such a manner so that the minimum cured film thickness is that specified by the Company.
- The coating shall be applied to the full length of each pipe except for a "cutback" of not less than 0.5 inches (1.27 cm).
- Use of recycled coating material is permitted if adequate recovery and screening equipment is used and maintained. An adequate recycle system must properly blend recycled and virgin coating material into the delivery system.
- The Applicator shall supply samples of the coating material to the Company, at any time requested, for such test as the Company may wish to run, to assure that the quality of the coating material is being maintained. Company inspection and acceptance of coating materials must be completed prior to application of said materials. Subsequent testing may be conducted to confirm that the coating material has not suffered from improper handling or storage.
- During coating and curing periods, the coated pipe shall be handled so as to avoid any damage to the coating.
- After the coating is cured, the pipe may be force cooled to facilitate coating inspection and repair, provided care is taken to avoid any damage from thermal shock to the newly applied coating. The maximum temperature for inspection and repair is 250 degrees F.

11. Coating Application (ARO)

- The corrosion barrier and the abrasion resistant overlay shall utilize a separate fluidized bed.
- Two separate spray booths are preferred. Reclaimed FBE and ARO powder may be used if they are applied in two separate spray booths, but may not be used if they are applied in the same booth. Powder from the topcoat shall not be recycled into the base coat powder except as directed by the ARO powder manufacturer.
- The ARO topcoat shall be applied in accordance with the coating manufacturer's recommended procedure and prior to gelling of the FBE corrosion base coat.

12. Inspection and Testing

a. The entire procedure of applying the protective coating material as herein specified will be rigidly inspected from the time the bare pipe is received until the coated pipe is loaded on the carrier for shipment.

b. If the Company designates an Inspector, the Inspector shall be provided free access to the Applicator's plant at any time during any operation involving the pipe, with the right to inspect and to accept or reject work performed.

c. The Applicator's Quality Control Inspector shall be responsible for stopping operations when conditions develop which could adversely affect the quality of the completed work.

d. Although the principal purpose of the coating inspection by the Company and Applicator is to insure compliance of the coating with these specifications, such inspection shall also include examination for previously undetected defects in the pipe, pipe surface or on the pipe ends. Pipe having such defects shall be set aside for subsequent repair or replacement by the pipe supplier and for any necessary coating repair. Recoating or coating repair that may be necessary by reason of these defects in the pipe which do not involve fault on the part of the Applicator shall be done at the Company's expense.

e. When Company's Representative exercises Company's right of approval at the Applicator's plant, the Company's Representative shall conduct final inspection on the Applicator's out-bound rack. Accepted pipe shall be presumed to be produced as specified unless test results indicate a discrepancy.

f. Coating Thickness Measurements

- An appropriate film thickness gauge, calibrated to the National Bureau of Standards' Certified Coating Thickness Calibration Standards shall be used to perform coating thickness measurements on FBE and ARO coatings. A tooke gauge or grinding/filing down the ARO to the base FBE shall be used to perform measurements of base coat and the top coat or a piece of masking tape can be applied to the FBE before the ARO is applied and the measurements can be taken with an appropriate dry film thickness gauge.
- The agreed upon coating specification shall state the absolute minimum thickness to be applied. All thickness readings measured at or above the absolute minimum shall be accepted for both FBE and ARO coatings.
- The range of coating thickness measurements shall be recorded for each joint of pipe.
- NAPCA recommends that no milage be specified below 10 mils minimum.

g. Electrical Inspection

- Holiday inspection of the entire coated surface shall be performed with an approved high voltage Holiday Detector to indicate any flaws, holes, breaks or conductive particles in the protective coating.
- The Holiday Detector shall have sufficient D.C. voltage and be equipped with a positive signaling device. The search electrode shall be made of conductive rubber, or other applicable material. The Holiday Detector shall be operated in such a way as to audibly and/or visually detect the presence of all holidays.
- The voltage to be used shall be per the guidelines of NACE RPO490 or the ARO powder manufacturer.

h. Adhesion

- Adhesion of the cured coating shall be checked by pushing a sharp knife blade through the cured coating to the pipe surface. The coating will not strip or peel when the knife is moved in a "whittling" motion against the steel surface, if proper adhesion of the cured coating to the pipe surface has been attained.

13. Production Ring Test - FBE

Test	Test type	Acceptance Criteria	No. of test specimens	Test method
Cathodic disbondment: 24 hours @ 65 +/- 3°C. 3.5 V, 3% NaCl solution	A	Max. radius: 8 mm (0.3 in)	1	NACE SPO 394 Appendix F
Flexibility: 2.5°/PD permanent strain @ - 30°C or 0°C (32°F)	A	No cracks, tears, or delamination (unaided visual)	3	NACE SPO 394 Appendix H
Hot-water soak (24 hours @ 75 +/- 3°C	A	Rating of 1-3, inclusive	1	CSA Z245.20-18 Clause 12.14
Interface contamination	B	Max: 30%	1	NACE SPO 394 Appendix K
Cross section - porosity	B	Rating of 1-3 inclusive	1	NACE SPO 394 Appendix G
Thermal characteristics	C	△ Tg of 5°C max. or 95% conversion minimum	1	NACE SPO 394 Appendix D
Impact resistance: 1.5J (13 in/lb) minimum	C	No holidays	1	NACE SPO 394 Appendix I
<p>A) Failure to meet the acceptance criteria for Type A tests shall be grounds for rejection of all pipe coated after the previous acceptable test result and before the next acceptable test result. Additional Type A testing of the affected day's production may be conducted in an attempt to reduce the amount of rejected pipe. Failure to meet the acceptance criteria for Type B or C tests shall be grounds for requiring changes to the application process parameters. Type C tests are required only when specified by the purchaser.</p> <p>B) The purchaser may specify more stringent requirements for specific applications. These requirements must be clearly documented and agreed by the purchaser and the applicator before production.</p> <p>C) See appendix D of NACE SPO 394.</p>				

14. Production Ring Test – ARO (when applicable)

Test	Test type	Acceptance Criteria	No. of test specimens	Test method
Cathodic disbondment: 24 hours @ 65 +/- 3°C. 3.5 V, 3% NaCl solution	A	Max. radius: 8 mm (0.3 in)	1	CSA Z245.20-18 Clause 12.8
Flexibility: 1.5°/PD permanent strain @ - 30°C or 0°C (32°F)	A	No cracks, tears, or delamination (unaided visual)	3	CSA Z245.20-18 Clause 12.11
Hot-water soak (24 hours @ 75 +/- 3°C	A	Rating of 1-3, inclusive	1	CSA Z245.20-18 Clause 12.14
Interface contamination	B	Max: 30%	1	CSA Z245.20-18 Clause 12.9
Cross section - porosity	B	Rating of 1-3 inclusive	1	CSA Z245.20-18 Clause 12.10
Thermal characteristics	C	△ Tg of 5°C max. or 95% conversion minimum	1	CSA Z245.20-18 Clause 12.7

Impact resistance: 3.0J minimum	C	No holidays	1	CSA Z245.20-18 Clause 12.12
<p>A) Failure to meet the acceptance criteria for Type A tests shall be grounds for rejection of all pipe coated after the previous acceptable test result and before the next acceptable test result. Additional Type A testing of the affected day's production may be conducted in an attempt to reduce the amount of rejected pipe. Failure to meet the acceptance criteria for Type B or C tests shall be grounds for requiring changes to the application process parameters. Type C tests are required only when specified by the purchaser.</p> <p>B) The purchaser may specify more stringent requirements for specific applications. These requirements must be clearly documented and agreed by the purchaser and the applicator before production.</p> <p>C) See appendix D of NACE SPO 394.</p>				

15. Repair Procedures

- a. All defects disclosed by the Holiday Detector and other obvious defects shall be repaired by the Applicator.
- b. Holidays which are the result of slivers, scabs, laminations, or other steel conditions beyond the control of the Applicator shall be repaired at the Company's expense.
- c. Areas of repair to the coating shall be holiday inspected by the Applicator on a 100 percent basis.
- d. Pinhole type holidays may be patched using the hot melt patch stick method. Abrade the adjacent coating surface with either a hand file or coarse sand paper. The abrasion should be on the surface only and should not remove a significant thickness of the coating. The surface to be touched up will be heated with a small torch until the stick starts to melt, then the stick should be rubbed over the heated surface, building up a small puddle of patching compound over the entire area being patched. Such holidays may also be patched by use of a two part, 100% solids, liquid epoxy compound specified by the Manufacturer using the method set forth in the following paragraph. Liquid epoxy repairs of pinhole type holidays shall be considered an extra work item to be performed at a price agreed upon between the Company and Applicator.
- e. Where larger areas of damaged coating are to be repaired and the use of patch sticks is not practical, a two part, 100% solids, liquid epoxy compound specified by the Manufacturer shall be used. The damaged area shall be abraded by hand filing or use of carborundum cloth. Application shall be made to a minimum thickness of 25 mils (0.64mm) and shall overlap the undamaged area a minimum of 0.5 inches (1.27cm).
- f. The liquid patch compounds shall not be applied when the pipe temperature is below 50 F unless provisions are made for heat curing the patch material using methods and temperatures in accordance with procedures recommended by the coating Manufacturer.
- g. All repairs performed on ARO coatings shall be made with an accepted 100% solids liquid epoxy compound.

16. Coated Pipe Handling, Storage and Loading Requirements

- a. Pipe shall be stored, handled and transported in a manner to prevent damage to the pipe walls, beveled ends and the coating.

b. Storage racks shall be so designed as to protect the coated pipe from standing water, direct soil contact, and sharp or hard objects that might damage the coating.

c. All individual coated pipe, that is handled, stored, or shipped, shall be protected by padding, separators or dividers. These separators shall be affixed to the exterior surface of the pipe. Suggested separators consist of 1) polypropylene rope rings for larger and smaller diameters of pipe joints, with rope thickness varying from 3/8 to 5/8-inches in diameter depending on pipe wall thickness; 2) spiral cardboard rings with waxed outside surface for 4 inches nominal and smaller diameter pipe joints, with ring being 2 inches wide and 0.25 inch thickness; 3) 0.25 inch minimum thickness rubber; or 4) other material approved as separators and acceptable to the Company.

- Each 40 foot joint of coated pipe shall have affixed to its exterior surface a minimum of three (3) separators, randomly spaced, but spaced relatively close to the ends of each joint and near the center of the pipe. The minimum number of separators for nominal 60 foot pipe shall be four (4); and for nominal 80 foot pipe, the minimum number of separators shall be five (5).
- The type and thickness of separators shall be chosen to prevent joints of pipe from coming in contact with each other.

d. The coated pipe shall be shipped using sufficient and proper dunnage to adequately protect the pipe and coating.

e. All pipe shipped by rail shall be loaded in accordance with API Specifications RP 5L1, Latest Edition.

17. Supplementary Details Supplied by the Company

When possible, the Company shall supply the following supplemental information:

- Length and diameter of pipe.
- Grade, wall thickness and/or weight per foot of pipe.
- Source and approximate shipping date from the pipe mill.
- Method of shipment from the mill.
- Approximate shipping date to the destination.
- If pipe is to be stored, the approximate length of time it is to be stored.
- Length, style and post preparation of cutback.
- Minimum weight per car or truck required to protect lowest outbound rate.
- Name and type of carrier.
- Stacking and/or loading instructions.
- Pipe manifest, preferably electronic.

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Revision History

Date revised	Change history
August 30, 2022	Complete format; Tables added for production test requirements; references added to NACE SPO 394 and Can/CSA Z245.20-18
July 14, 2023	Released for use