Recommended Practice for Unprimed Internal Fusion Bonded Epoxy Coating of Line Pipe

API RECOMMENDED PRACTICE 5L7
SECOND EDITION, JUNE 1988

REAFFIRMED, MAY 2015

AMERICAN PETROLEUM INSTITUTE

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Upstream Segment

API RECOMMENDED PRACTICE 5L7
FOURTH EDITION, JUNE 1988

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FOREWORD

(a) This Recommended Practice was prepared by a Formulating Committee which included representatives of pipeline operators and line pipe manufacturers and advisors from coating manufacturers and coating applicators as well as other interested individuals.

(b) The purpose of this Recommended Practice is to present methods for qualifying coating materials, production application of such materials, and final acceptance tests of coated pipe for internally corrosive conditions.

(c) While the coating system described in this document is intended to provide a high degree of corrosion protection, the user is cautioned that operating conditions as well as the chemical nature of the product to be transported can affect the performance of the coating, and additional anti-corrosion methods, such as inhibitors, may also be warranted.

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SECTION 1
SCOPE

1.0 SCOPE

This Recommended Practice provides for UNPRIMED INTERNAL FUSION BONDED EPOXY COATING OF LINE PIPE for use in transportation pipelines in the petroleum industry. The recommendation provided herein covers:

a. Section 1 Scope
Section 2 Coating Material Specification
Section 3 Laboratory Coating Testing
Section 4 Application Practices
Section 5 Production Inspection and Acceptance Procedures

Within this Recommended Practice:

1) "Shall" is used to indicate that a provision is mandatory.

2) "Should" is used to indicate that a provision is not mandatory, but recommended as good practice.

3) "May" is used to indicate that a provision is optional.

b. The Recommended Practice is limited to the application of internal coatings on unused pipe prior to installation. It should be recognized that there may exist differences in the surface condition of pipe produced by the various pipemaking processes permitted under the latest editions of API standards. Surface conditions may preclude the coating of such pipe.

c. It is intended that the Applicator be responsible for assuring compliance with all of the provisions of this practice; however, the Purchaser may make any investigation necessary to satisfy himself of compliance by the Applicator.

1.1 DEFINITIONS

1.1.1 Applicator
The "Applicator" is the organization responsible to the Purchaser for the application of the coating.

1.1.2 Batch
A "Batch" is defined as the quantity of material produced during a continuous production run of not more than 8 hours.

1.1.3 Coating
"Coating" indicates the film of coating as applied to the substrate.

1.1.4 Coating Material
"Coating Material" indicates the material prior to application to the substrate.

1.1.5 Holiday
A "Holiday" is a discontinuity in a protective coating which exhibits electrical conductivity when exposed to a specific voltage.

1.1.6 Inspector
The authorized agent of the purchaser.

1.1.7 Purchaser
The "Purchaser" is the owner company or the authorized agency that buys the coated pipe.

1.1.8 Supplier
The "Supplier" is the manufacturer and/or distributor of the coating material and its authorized technician.

1.2 GENERAL

1.2.1 Coating Supplier Information
The coating material Supplier shall furnish to the Purchaser and/or Applicator the following information in written form upon request.

a. Specifications of the basic material properties and laboratory test results of the coating material(s) and coating(s). The basic material properties shall be within the ranges permitted in Section 2 of this Recommendation. The laboratory test results of the coating shall be within the ranges permitted in Section 3.

b. Directions for handling and storing of the coating materials.

c. Certification of compliance to the requirements of Table 2.3.

d. Infrared "analysis" of the coating material (See Appendix 1).

1.3 REFERENCED STANDARDS

1.3.1 General
This specification includes by reference, either in total or in part, other API, industry and government standards listed in Table 1.0.

1.3.2 Requirements
Requirements of other standards included by reference in this specification are essential to the safety and interchangeability of the equipment produced.

1.3.3 Equivalent Standards
Other nationally or internationally recognized standards shall be submitted to and approved by API for inclusion in this specification prior to their use as equivalent standards.

TABLE 1.0
REFERENCED STANDARDS

1. NACE TM-01-75:	*Nace Visual Standard*	Latest Edition	5. ASTM D1002:	*Test Method for Strength Properties of Adhesives in Shear by Tension Loading (Metal to Metal)*	Latest Edition
2. SSPC-Vis 1-82T SP5:	*Pictorial Surface Preparation Standards for Painting Steel Surfaces*	Latest Edition	6. ASTM G17:	*Test Method for Penetration Resistance of Pipeline Coatings (Blunt Rod)*	Latest Edition
3. SIS 05-59-00 SA3:	*Pictorial Surface Preparation Standards for Painting Steel Surfaces*	Latest Edition	7. ASTM B117:	*Method of Salt Spray (Fog) Testing*	Latest Edition
4. DIN 55928-Part 4:	*Corrosion Protection of Steel Structures by Organic, Inorganic and Metallic Coatings; Preparation and Testing of Surfaces*	Latest Edition	8. NACE TM 01-70:		Latest Edition

SECTION 2
COATING MATERIAL SPECIFICATION

2.1 PURPOSE

This Section describes material properties of coating materials to be applied under the intent of this Recommended Practice. It is the Supplier's responsibility to perform the tests referenced in this Section. The Purchaser or Applicator may also perform any or all of the referenced tests as part of a quality assurance program.

2.2 COATING MATERIAL

The coating material shall consist of a one-component, powdered, fusion-blended material consisting of epoxy resin(s), curing agent(s), pigment(s), filler(s), catalyst(s), and flow control agent(s) which, when applied to the preheated substrate, will melt, flow, and subsequently cure to produce a coating complying with the requirements of this Recommended Practice.

2.3 COATING MATERIAL PROPERTIES

Property	Value/Limits	Test Method
Specific Gravity	(1) ±0.05 g/cc	Appendix 2
Particle size	0.1% max. retained on 60 mesh (250 micron)	
Shelf Life	(1, 2)	Appendix 3
Gel Time	(1) ±20%	Appendix 4
Cure Cycle	Capable of cure at temperature below 500 F [260 C] (3) for Time: (1)	(1)
Glass Transition temperature	(1)	Appendix 5
Potential Reaction Energy	(1)	Appendix 5
Moisture Content (4)	0.50% maximum	Appendix 6
Total Volatile Content (4)	0.6% maximum	Appendix 7

(1) per supplier's specification
(2) per supplier's recommended storage conditions
(3) limitation imposed by regulations on heating of cold expanded pipe
(4) either Moisture or Total Volatile Content may be determined at supplier's discretion.

SECTION 3
LABORATORY COATING TESTING

3.1 PURPOSE

This Section describes laboratory tests required to qualify coating materials. It is the responsibility of the Purchaser and/or coating Applicator to qualify the coating material prior to production. Once qualification is established, further qualification testing is not required unless the coating material or formulation changes. The Supplier shall certify to the Applicator and/or Purchaser the results of tests performed under Section 3 for each qualified material.

3.2 PERFORMANCE TESTING STEEL PANELS

Test panels shall be mild steel. Panel dimensions for each test are given in the referenced test method. Unless otherwise agreed upon between the Supplier and the Purchaser and/or Applicator, the surface shall be blast cleaned using steel grit (G40, HRC 50-55) to any of the following standards:

a. NACE No. 1 white metal finish in accordance with NACE Visual Standard TM-01-75.

b. Steel Structures Painting Council SSPC-Vis 1-82T SP5.

c. Swedish Pictorial Standard SIS 05-59-00 SA3

d. DIN 55928 PART 4.

The surface profile shall be 1.5 to 4.0 mils [38 to 100 microns], measured from peak to trough.

3.3 COATING OF TEST PANELS

3.3.1 Coating application and curing shall be in accordance with the Supplier's recommendations.

3.3.2 Thickness of coating on the completed test panel shall be 14 ± 2 mils [356 ± 51 microns], measured by a coating thickness gauge calibrated per Par. 5.3.2.4.

3.4 PERFORMANCE OF LABORATORY COATED STEEL PANELS

3.4.1 Testing

The following tests shall be performed on test panels which have been prepared and coated in accordance with the above procedure. Tests shall be performed on duplicate panels. A coating shall be considered qualified when the results of both test panels meet the acceptance criterion for each test.

3.4.2 Additional Tests

At the option of the Purchaser or Applicator, additional qualification tests may be specified.

Test	Value/Limits	Test Method
Abrasion	20 mg max.	Appendix 8
Adhesion	5000 psi [34.5 MPa] min. or 2500 psi [17.2 MPa] min. (The 2500 psi minimum applies only when Appendix 9 Test Method is used.)	ASTM D1002 or Appendix 9.
Autoclave	Free of blisters, cracks, delaminations, or other defects exposing the steel substrate to corrosive media.	Appendix 10
Cathodic Disbondment*	0.31 in. [8 mm] maximum average radius	Appendix 11
Chemical Resistance	90 days at 73 ± 5 F [23 ± 3 C] without blistering	Appendix 12
Flexibility	3.75°/PD bend at 0 F [-18 C]	Appendix 13
Hot Water Soak	Maximum: Rating 3	Appendix 16
Impact	15 in.-lb [1.70J], minimum	Appendix 14
Penetration	Less than 10%	ASTM G17 at 200 F
Salt Fog	No blistering; no loss of adhesion	ASTM B117 for 1000 hr

*This is included as an adhesion test, not a service simulation.

SECTION 4
APPLICATION PRACTICES

4.1 PURPOSE

This Section prescribes equipment and practices used in the surface preparation of line pipe for internal fusion bonded epoxy coating and the application of this coating on the prepared surface.

4.2 GENERAL

4.2.1 Applicator

The Applicator is responsible for the quality control production tests outlined in Section 5 to ensure conformance with this Recommended Practice.

4.2.2 Plant Access

The Inspector shall have free access at all times to all parts of the application site which concern the internal coating of the pipe, while work on the contract of the Purchaser is being performed.

4.2.3 Coating Material

4.2.3.1 Selection

By agreement between the Purchaser and Applicator, a list of coating materials previously qualified by either the Purchaser or Applicator under Sections 2 and 3 shall be prepared. The Applicator and/or Purchaser shall then choose the coating material to be applied from this list subject to bidding restrictions. Approval or selection of the coating materials shall be done far enough in advance (preferably not less than 30 days) to provide material at the scheduled start of the work. Selection of alternate coating materials from the approved list may be made at any time by agreement between the Purchaser and the Applicator.

4.2.3.2 Batch Samples

It shall be the right of the Purchaser or Applicator to procure a coating material batch sample prior to or during the job for the purpose of verification of conformance to coating material specifications.

4.3 HANDLING OF PIPE

Pipe shall be handled in a manner to prevent damage to pipe walls, beveled ends, and coating. Pipe that is damaged by the coating and handling operations shall be repaired in compliance with the latest editions of applicable API standards, or replaced, at the Applicator's expense.

4.4 HANDLING OF COATING MATERIALS

4.4.1 Coating material batches shall be identified by a batch coding system devised by the Supplier. Coating materials shall be shipped and stored under cover and in such a manner that contamination or adverse effects on application or performance are avoided. Epoxy powder shall be stored in a cool, dry area; the storage temperature shall not exceed that recommended by the Supplier.

4.4.2 Shelf Life

Storage time should not exceed the maximum shelf life as recommended by the Supplier. Any batch of coating material which has exceeded the recommended shelf life shall be subject to coating material verification tests (Par. 5.3.1) prior to usage.

4.5 SURFACE PREPARATION

4.5.1 General

The cleaning must be of sufficient quality to ensure a surface that will permit firm adhesion of the coating to the pipe.

4.5.2 Degree of Cleaning

4.5.2.1 Contamination

Pipe shall be supplied to the Applicator essentially free of oil and grease.

All surfaces to be coated shall be free of oil, grease, etc., which, if present on the surface, shall be removed with a suitable solvent. All components of the cleaning machine that enter the pipe must be free of dirt, grease or other material which could contaminate the surface to be coated.

4.5.2.2 Pre-Heat

Pipes shall be pre-heated prior to blast cleaning to remove moisture from the steel. The pre-heat shall be sufficient to ensure that the internal pipe surface temperature is at least 5 F [3 C] above the dew point temperature during blast cleaning inspection, but shall not exceed the maximum pipe temperature described in Par. 4.6.2.2.

4.5.3 Blast Cleaning

4.5.3.1 Method and Degree of Cleanliness

The blast abrasive such as slag, sand, flint, or grit shall be agreed upon by applicator and purchaser. The pipe surface shall be blast cleaned to a near white no. 2 finish in accordance with the latest editions of NACE TM 01-70 or equivalent (Sa 2½ per SIS 05-59-00 or SP 10 per SSPC-Vis 1-82T), unless otherwise agreed upon between Purchaser and Applicator.

4.5.3.2 Air

All compressed air shall be stripped of oil and water before being used for blast cleaning or blow out.

4.5.3.3 Blow Out

After blast cleaning all pipes shall be blown out with clean, dry air to remove any residual contaminants from the blast cleaning operation.

4.5.4 Surface Profile

The surface profile shall be in accordance with the Supplier's recommendations. Typically coating systems will require a trough to peak height of at least 1.5 mils [38 microns] but not more than 4.0 mils [100 microns] when grit or slag is used, and a range of 0.5 to 2 mils [13 to 51 microns] when flint or sand is used.

4.5.5 Cleaning and Coating

The cleaned surface should not be allowed to deteriorate prior to coating application. The coating operation should take place within four hours of the blast cleaning operation. Where flash rusting or surface contamination has occurred, the surface shall be reblasted, regardless of elapsed time.

4.6 COATING OF PIPE

4.6.1 Equipment

4.6.1.1 Air

A source of clean, dry air with instrumentation to monitor dryness is required. The dew point of air in the fluidized bed and powder feed lines must be no higher than -20 F [-29 C].

4.6.1.2 Filters

Adequate screens (60 mesh [250 micron] or finer) shall be present in the powder handling system to ensure that large particles or agglomerates are not carried to the application equipment.

4.6.1.3 Coating Apparatus

Coating material shall be maintained in a fluidized condition during application. The apparatus used to apply the coating to the surface shall do so in a uniform manner and to the specified thickness in one coat (a single pass of the apparatus through the pipe).

4.6.2 Temperature of Pipe Surface

4.6.2.1 Application Temperature

The temperature of the pipe at time of application of the coating material shall be within the minimum and maximum limits recommended by the coating material Supplier.

Pipe may be brought up to temperature by furnace, soaking oven or induction coils which have sufficient controls to preclude exceeding the maximum allowable pipe temperature as outlined in Par. 4.6.2.2.

4.6.2.2 Maximum Pipe Temperature

Unless otherwise agreed upon, pipe surface temperature shall not exceed 525 F [274 C]. It should be recognized that elevated temperatures may have an effect on base material (steel pipe) properties such as strength, elongation and fracture toughness. The extent of any effect is dependent on steel composition and processing, application temperature, and time at that temperature. In general, similar effects may occur at ambient temperatures over a longer period of time.

4.6.2.3 Cure

a. **COATING CURE:** Coating must be cured in accordance with the time at temperature recommendations of the Supplier.

b. **POST CURE:** Pipe temperature may be raised subsequent to the powder application, subject to the limitations of Par. 4.6.2.2, in order to accelerate cure of the coating. Supplier's recommendations should be followed in such a manner as to avoid damaging or blistering the coating.

4.6.3 Thickness of Coating

The minimum, average and maximum thickness of the coating shall be specified by the purchaser at the time the order is placed. Coating thickness should be checked on every pipe with an approved gauge. The gauge is to be calibrated daily, or upon purchaser's request.

4.6.4 End Finish

Suitable means shall be used to prevent depositing coating material on bevels and lands of the pipe ends and on the cutback area specified by the Purchaser at the time the order is placed.

4.6.5 Unfavorable Operating Conditions

Coating operations shall be stopped when conditions as defined by the provisions of this recommended practice are not met.

4.7 REPAIRS TO COATING

4.7.1 General

Defective coating shall be repaired by the Applicator. This includes coating of thickness below the specified minimum, defects disclosed by the holiday detector, and obvious defects resulting from mechanical damage to the coated surface.

4.7.2 Methods and Limitations

The usual methods for repairing applied internal coatings are (a) stripping and recoating, (b) overcoating, and (c) patching. The method(s) to be used shall be determined by agreement between Purchaser and Applicator. Recommended practices and limitations for each method follow.

4.7.2.1 Stripping and Recoating

Coating shall be heated sufficiently to soften or char coating to permit removal by abrasive blasting. Subjecting pipe to the high temperatures (circa 900 F [482 C]) used for removal of internal coating, however, may not be permitted under some pipeline regulations. Other methods of stripping may be used by agreement between Purchaser and Applicator.

4.7.2.2 Overcoating

Pipe shall first be reblasted. Complete removal of the original coating is not required, but it shall be sufficiently roughened to ensure adhesion of the second coat. The pipe shall be recoated per Par. 4.6.2 and 4.6.4. Minimum coating thickness remains as originally specified, but maximum allowable coating thickness is twice that originally specified.

4.7.2.3 Patching

Only pipe of 16 inches [406 mm] diameter and larger may be repaired by patching. Smaller diameter pipe may be repaired when the area to be repaired is accessible for manual patching. Use of patch material should be used with due consideration of the possible effects of pigging.

a. Cleaning

Damaged areas and holidays are to be cleaned by removing all rust, scale, dirt or other foreign material or loose coating by using a hand or power driven sanding disc. The areas to be patched should be suitably roughened before patching. Dust generated by the cleaning is to be removed with a clean, dry cloth or brush prior to patching.

b. Patching Materials

Supplier's recommended two-part liquid epoxy or equivalent material shall be used for patching holidays and damaged coating. Such material shall be approved by Purchaser, and should be qualified under the applicable portions of Section 3.

c. Application of Patching Materials

Two-part epoxy shall be thoroughly mixed in accordance with the supplier's specification and may be applied by brush or spatula to damaged area and shall overlap the surrounding undamaged coating by a minimum of one inch [25 mm].

d. Thickness

Minimum film thickness of coating after repair shall comply with that of the basic specification.

4.8 PIPE MARKING

4.8.1 Identification

Where mill stencil information is removed during coating operations, Applicator shall maintain, in a manner acceptable to the Purchaser, traceability of each joint of pipe so that exact stencil information (including length, grade, dimensions, heat number, joint number and/or other information specified by the Purchaser) is restored after coating.

4.8.2 Restenciling

If a pipe requires rework which invalidates existing stencil information, then that pipe shall be restenciled when repairs are completed.

SECTION 5
PRODUCTION INSPECTION AND ACCEPTANCE

5.1 PURPOSE

This Section describes the acceptance criteria for pipe internally coated with fusion bonded epoxy and the methods of testing to assure compliance therewith.

5.2 GENERAL

5.2.1 Working Area

A safe working area that is suitable for the performance of their duties shall be provided by the Applicator for the Purchaser's inspectors and representatives. Inspection area shall be arranged to permit adequate time for inspection.

5.2.2 Applied Coating

The applied coating should be uniform in gloss, thickness and color and should be free of irregularities such as blisters, pinholes, fish eyes, sags or excessive "orange peel."

5.2.3 Special Requirement

Any pipe which requires closer inspection should be set aside. Purchaser may require that the Applicator set aside such pipe as the Inspector may request for testing, providing that the number of such pipe shall not exceed two joints for each eight-hour production period on a current basis, or one joint from each four-hour production period.

Pipe rings for destructive testing may be cut from such pipe upon agreement between Purchaser and Applicator. The usual width of the production test ring is 1.5 ft (.46 m); rings shall be cut in such a manner that the cut end of the remaining pipe length has a bevel configuration similar to the original.

5.3 PRODUCTION TESTS

The Applicator shall have available at the coating plant all equipment necessary for sample preparation, testing and evaluation described in this Section.

The following plant tests are recommended for quality control of the pipe coating and should be conducted by the Applicator at a specified frequency that will assure control. Minimum test frequency is given for each test.

5.3.1 Coating Material

5.3.1.1 Test Panels

Tests on Applicator coated panels shall be carried out on each batch of coating material. Test panels shall be prepared in accordance with Par. 3.2 and 3.3 at the proposed plant application temperature.

The following tests shall be done:

Test	Value/Limits	Test Method
(a) Appearance	Free of blisters, cracks, sags, etc. Appropriate gloss.	Visual
(b) Cathodic Disbondment (48 hr, 150 F [66 C])	0.31 in. [8 mm] maximum disbonded radius from edge of initial holiday.	Appendix 11
(c) Flexibility	3.75°/Pipe Dia total deflection.	Appendix 13
(d) Foam	Assess foam in cross-section.	Appendix 15
(e) Hot Water Soak	Maximum: Rating 3.	Appendix 16

5.3.1.2 Gel Test

Gel tests shall be conducted routinely on each batch of coating material before use. Testing and acceptance criteria shall be per Appendix 4 and Table 2.3, respectively.

5.3.2 In-line Inspection and Testing

The following tests are to be conducted during normal plant operation.

5.3.2.1 Surface Preparation

Surface preparation shall be monitored continually to assure compliance with Par. 4.5.3. At least once each shift, the surface profile on pipe shall be measured by a method agreed upon by Purchaser and Applicator. The profile shall be within the limits of Par. 4.5.4.

5.3.2.2 Pipe Temperature

Pipe temperature immediately prior to coating shall be monitored on a continual basis by means of temperature indicating crayons or other suitable means as agreed between Purchaser and Applicator. Coated pipe temperature shall be monitored to establish cure profile. If post cure is utilized the coated pipe temperature shall be monitored and controlled immediately following post cure. Coated pipe temperature shall be monitored by infra-red pyrometer or other suitable means as agreed between Purchaser and Applicator.

5.3.2.3 Time to Quench

The minimum elapsed time between application of coating material and quenching of the pipe shall be measured and used in conjunction with the temperature measurement in 5.3.2.2 to ensure compliance with the supplier's recommended cure schedule. The time to quench shall be monitored by means of a stop watch at start up and when line speed is changed.

5.3.2.4 Thickness Measurement

The coating thickness will be determined at a minimum of three locations near the end of each pipe, using a coating thickness gauge approved by the Purchaser. Calibration of the gauge shall be checked at least once each shift on a National Bureau of Standards non-magnetic coating standard with a thickness within 20% of the specified nominal thickness. The average coating thickness measured on each joint must fall within the limits specified by the Purchaser.

5.3.2.5 Holiday Inspection

Each length of pipe shall be inspected full length with an electrical holiday detector. A detector of circular configuration is to be pushed or pulled once through each joint at a speed between 10 and 40 feet [3 and 12 meters] per minute. Dry detectors are to be of conductive rubber, designed so that all coated surface is contacted during holiday inspection; electrical potential is to be at least 125 v per mil [25.4 microns] of nominal coating thickness. Wet detectors shall also contact all coated surface, but a potential range of 50 to 100 volts shall be used. The unit shall have both visual and audio alarms to indicate holidays. The maximum number of holidays permitted shall be agreed upon between Purchaser and Applicator. Pipe lengths with coating holidays beyond this shall be recoated per Par. 4.7.6. Those with an acceptable number of holidays may be repaired per Par. 4.7.

5.3.3 Production Test Rings

Test rings shall be cut per Par. 5.2.3 from each lot of 200 or fewer pipe lengths, unless otherwise agreed by the Purchaser and Applicator. Test rings shall be sawn into 1 in. × 8 in. [25 × 200 mm] straps, with the longer dimension parallel to the axis of the pipe, and into 4 in. [100 mm] squares.

5.3.3.1 Flexibility Tests

At least 2 flexibility tests shall be conducted with samples from each test ring in accordance with Appendix 13. Failure to pass this test shall be grounds for rejection of all coating applied before and after the coating of the tested pipe, up to the last and next passable test ring pipe. Such rejected pipe may be postcured or recoated, at the option of the Applicator, or proofs of acceptability of other portions of the rejected lot, such as additional test results from other pipe lengths, may be provided by the Applicator with the agreement of the Purchaser. The minimum flexibility requirement shall be 2.5°/PD total deflection at 0°F [-18°C]. Greater flexibility requirements or other test temperatures shall be subject to agreement between Purchaser and Applicator.

5.3.3.2 Cathodic Disbondment Test

When required by Purchaser, a cathodic disbondment test of 48 hour duration at 150 F [66 C] shall be performed on a sample from the test ring in accordance with Appendix 11 using a 3½ in. (90 mm) diameter test cell.

An average disbonded radius less than or equal to 0.47 in. [12 mm] from the edge of the original holiday shall constitute a pass.

A disbonded radius in the range 0.47 to 0.71 in. [12 to 18 mm] shall mandate a retest on an additional sample from the same ring.

A disbonded radius greater than 0.71 in. [18 mm] on any test, or greater than 0.47 in. [12 mm] on a mandatory retest shall be grounds for rejection of all coating applied before and after the tested joint, up to the last and next passable ring tests.

5.3.3.3 Other Tests

Upon agreement between Purchaser and Applicator, other tests may be required.

APPENDIX 1
INFRARED SPECTROSCOPY TEST METHOD

1.0 SCOPE
To document the coating material chemical composition.

2.0 EQUIPMENT:
Infrared Spectrophotometer
Laboratory Press
KBr Die
Vacuum Pump

3.0 PROCEDURE:
Prepare and evaluate sample per spectrophotometer Manufacturer's instructions.

4.0 REPORT
4.1 Batch number and date tested.

4.2 Printed copy of spectrum.

APPENDIX 2
SPECIFIC GRAVITY DETERMINATION

1.0 SCOPE
To determine the specific gravity of a coating material.

Two methods shall be allowed for specific gravity determination; the procedure used shall be designated on the Supplier's data sheet.

2.0 EQUIPMENT
Volumetric flask, 100 ml
Balance accurate to 0.1 gram
Mineral spirits

3.0 PROCEDURE
This method covers the determination of the specific gravity of coating material by the liquid displacement method.

3.1 PROCEDURE A

3.1.1 Accurately weigh the flask and record the weight, which shall be designated W_F.

3.1.2 Add approximately 20 grams of coating material to the flask and weigh the flask with coating material. This weight shall be designated W_{FP}.

3.1.3 Add sufficient mineral spirits to cover and wet out the coating material. Stopper the flask and agitate it for several minutes in order to ensure that there are no air pockets or lumps of dry coating material. Wash the stopper and walls of the flask down with mineral spirits until they are free of any coating materials and fill the flask to the 100 ml level. Weigh the flask, coating material and liquid together to obtain W_{FPL}.

3.1.4 Clean and dry the flask, fill with mineral spirits to the 100 ml level, and weigh it to determine the weight (W_{FL}) of the mineral spirits used.

$$\text{Density of mineral spirits} = D_L = \frac{W_{FL} - W_F}{100}$$

3.1.5 Calculate the density of the coating material according to the following equation.

$$\text{Coating material specific gravity} = \frac{W_{FP} - W_F}{100 - \frac{(W_{FPL} - W_{FP})}{D_L}}$$

3.2 PROCEDURE B

3.2.1 Specific gravity of the coating material shall be conducted using a Beckman Model 930 air comparison pycnometer or equivalent.

4.0 REPORT
4.1 Batch number and date tested.

4.2 Specific gravity calculated and procedure used.

APPENDIX 3
SHELF LIFE DETERMINATION

1.0 SCOPE

To estimate the shelf life of coating materials.

2.0 EQUIPMENT

Pint [0.5 1] Glass Jars and Lids
Oven, maintained at 110 F [43 C]
Gel Time Apparatus
Powder Application Apparatus

3.0 PROCEDURE

Record the initial gel time (Appendix 4) of the coating material. Place a sample of the coating material into each of two jars and screw on the lids. Store one sample at 75 F [24 C] and the other sample in an oven at 110 F [43 C]. Evaluate the 75 F [24 C] sample monthly and the 110 F [43 C] sample weekly. To evaluate the samples, look for evidence of hard caking of the coating material in the jar. Remove a portion of sample and check the gel time, as well as appearance on spray out onto a panel.

A significant reduction in gel time, excessive orange peel appearance of the coating on the panel, or the presence of gel particles on spray out indicate loss of shelf life.

4.0 REPORT

4.1 Batch number.

4.2 Shelf life time period in days for each test temperature.

APPENDIX 4
GEL TIME DETERMINATION

1.0 SCOPE

To determine the gel time of a coating material.

Two procedures are allowed for gel time determination; the procedure used shall be reported on the Supplier's data sheet. Tests shall be made in triplicate and averaged.

2.0 EQUIPMENT

Hot Plate
Stop Watch or Electric Timer: 0.1 second interval
Spatula
Draw down bar: gap depth 0.012-0.014 inch [300-350 microns]

3.0 PROCEDURE

3.1 Procedure A

3.1.1 Gel time shall be conducted by placing approximately 0.1 gram of coating material on a hot plate stabilized at 400 ± 5 F [204 ± 3 C]. Use a spatula to coat out at least one square inch [650 sq mm] to a uniform thickness. Start the timer as soon as the coating material becomes molten. Stir the coating with a stiff wire or spatula and stop the watch when the coating becomes an unstirrable gelatinous product. The elapsed time is the gel time.

3.2 Procedure B

3.2.1 Adjust and stabilize the hot plate to 400 ± 5 F [204 ± 3 C]. Set the draw down bar on the hot plate, quickly place a sample of coating material in front of the blade and draw a continuous film across the surface of the hot plate. Start the timer. Applying only light pressure on the spatula, draw it through the melted powder at short intervals.

3.2.2 The gel time is the length of time from when the film is applied until the spatula rides up on the gelled surface.

4.0 REPORT

4.1 Batch number and date tested.

4.2 Gel time in seconds and procedure used.

APPENDIX 5
GLASS TRANSITION AND HEAT OF REACTION DETERMINATION

1.0 SCOPE

This test determines the glass transition temperature (T_g) and the amount of exothermic heat of reaction (delta H) of a coating material.

2.0 EQUIPMENT

DSC (Differential Scanning Calorimeter)
Cooling Accessory
Analytical Balance accurate to 0.1 mg
Sample Encapsulation Press
Aluminum Pans and Covers
Knife or File
A device to measure the area under the exothermic portion of the curve.

3.0 PROCEDURE

This procedure is specific to the use of the DSC in its analysis of coating materials and coating. It does not include procedures for: start up, shut down, calibration, or problem analysis.

3.1 For coating materials, use accepted analytical sampling techniques to obtain material representative of the batch being analyzed. Sample size shall be 10 ±1 mg.

3.2 For coating use a clean knife or file to remove enough coating chips from the pipe or panel to yield a 10 ±1 mg sample.

3.3 Place the sample in a preweighed aluminum pan and put cover in place. Crimp the cover into place with the encapsulating press and obtain the sample weight by subtracting pan and cover weight from total weight. For those instruments operating on the principle of the direct contact thermocouple, it is necessary to place a small vent hole in the lid without damaging the pan.

3.4 Place sample and reference (as suggested by the instrument supplier) in the DSC cell.

3.5 Use an inert gas, such as dry nitrogen, to purge the cell.

3.6 Heat the sample to just beyond the glass transition temperature (T_{g0} for coating material; T_{g2} for coating) using a heating rate of 20 C/minute. This process stress relieves the sample and is not recorded or used for calculations.

3.7 Immediately after heating, cool the DSC to 20 C or below.

3.8 Using a programmed rate of 20 C/minute, heat the sample from 25 C to a point about 25 C beyond the end of the expected exothermic reaction region as determined from a coating material scan. Record this scan. Name the glass transition measured in this scan T_{g1}.

3.9 As in 3.7, cool the DSC cell to 20 C or below and proceed to the next run immediately.

3.10 Heat the sample at 20 C/minute, recording the second scan from 25 C to a point about 25 C past the glass transition. Name the glass transition measured in this scan T_{g2}.

4.0 CALCULATIONS

4.1 The T_g is taken as the point of intersection of the extrapolated baseline at the low temperature end and the tangent to the curve at the inflection point.

4.1.1 Draw the lines to establish the temperature for this intersection of both recorded scans.

4.1.2 The difference in temperature between the two T_g's measured before and after the maximum temperature heating cycle determines the relationship between delta T_g and degree of cure. The lower the delta T_g value the higher the degree of cure.

4.1.3 A coating which is not fully cured may show an exothermic area.

4.2 Calculate the residual exothermic heat of reaction (delta H) following the instructions provided by the manufacturer of the DSC equipment.

5.0 REPORT

5.1 Report the product and/or sample identification.

5.2 Report the batch number of material.

5.3 Report date of testing.

5.4 For coating material, report T_{g0}, T_{g1} and delta H (see Figure 1); for coating, report T_{g1}, T_{g2}, delta T_g (delta T_g = T_{g2} - T_{g1}), and residual delta H. (See Figure 2.)

5.5 Report type of apparatus used.

6.0 PRECISION

6.1 Precision limits apply to two adjacent specimens taken from the same powder sample or the same production-coated pipe. The following limits should be used for judging acceptability of results:

6.1.1 Repeatability.
Duplicate results by the same worker should not be considered suspect unless they differ by more than:

6.1.1.1 T_g (coating material): 3 C

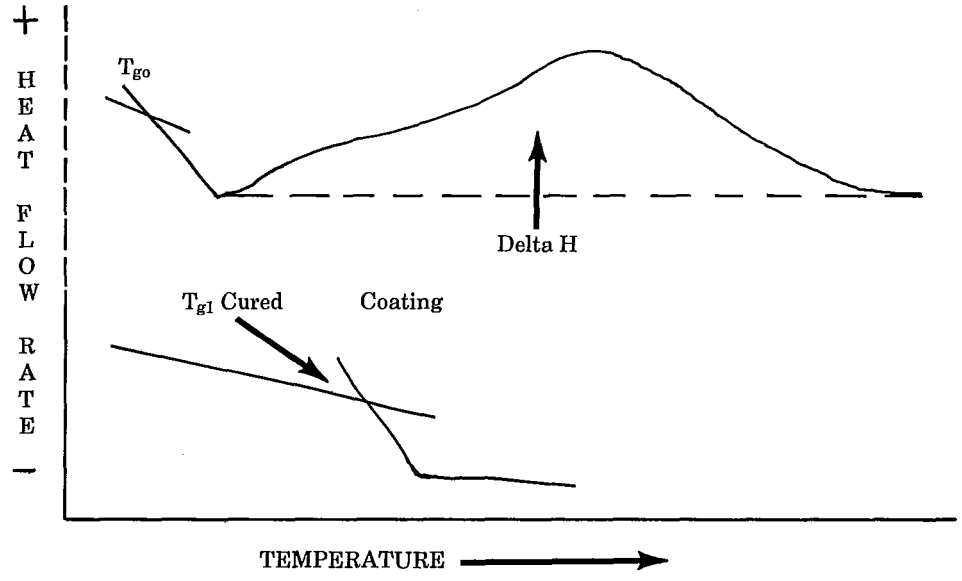
6.1.1.2 Delta H (coating material): 20% of the larger value

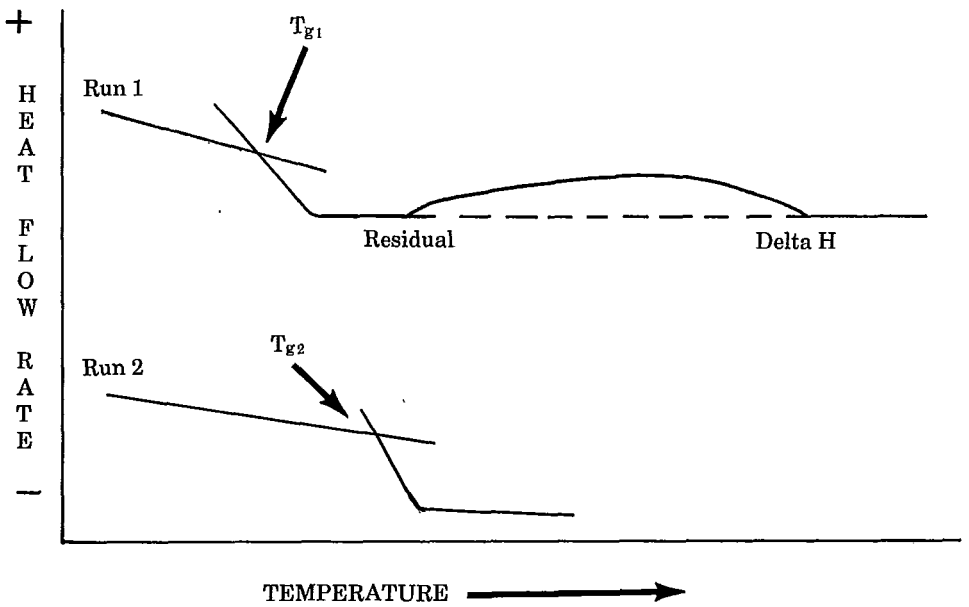
6.1.1.3 T_g (cured coating): 3 C

6.1.2 Reproducibility

Round-robin comparisons between laboratories resulted in significant variation in all parameters measured. Achieving comparable inter-laboratory results shall require strict compliance with this test procedure followed by laboratory comparison testing.

FIGURE 2
DSC SCAN ON COATING MATERIAL





APPENDIX 6
MOISTURE ANALYSIS DETERMINATION

1.0 SCOPE

To determine water content of coating materials by direct titration with Karl Fischer Reagent to an electrometric end-point.

2.0 EQUIPMENT AND REAGENTS

2.1 EQUIPMENT

Aquameter apparatus, Photovolt Aquatest IV or equivalent
Lab Mill
Analytical balance
15 ml Serum bottle and cap
Spatula
Metal Pipetting holder — 1 ml
1 ml syringe (Luer-Lok or equivalent)
4½ in. [110 mm] Hypodermic Needle
Plastic syringe — 10 ml
Automatic buret — 50 ml

2.2 REAGENTS

Chloroform
Generator solution
Vessel solution (Part A & Part B)
Neutralizing solution

2.3 SAFETY PRECAUTIONS

Karl Fischer reagent is toxic. During handling of the solutions, limit breathing of the vapors and perform all operations in a well ventilated area.

3.0 PROCEDURE

Run duplicate samples, following manufacturer's instructions.

4.0 REPORT

Report the batch number of the coating material tested, the two percentage water values and their average.

APPENDIX 7
DETERMINATION OF TOTAL VOLATILE CONTENT

1.0 SCOPE

This method covers determination of volatiles in the coating material.

2.0 EQUIPMENT

Analytical balance having weighing precision of 0.1 mg.
Vacuum oven
Aluminum weighing dishes approximately 2 in. [50 mm] in diameter
Dessicator

3.0 PROCEDURE

3.1 Place the numbered aluminum dish in the vacuum oven at 122 F [50 C] at minimum vacuum of 28 in. [710 mm] mercury for a period of 2 hours.

3.2 Place the aluminum dish in the dessicator for 20 minutes to allow return to room temperature.

3.3 Determine the mass of the aluminum dish.

3.4 Place the coating material sample (approximately 2 grams) in the aluminum dish and reweigh accurately. A minimum of two samples per batch is recommended.

3.5 Place the aluminum dish with coating material in the vacuum oven at 122 F [50 C] and vacuum of 28 in. [710 mm] of mercury for a period of 2 hours.

3.6 Condition the sample in dessicator for 20 minutes before determining the mass loss.

3.7 Place the sample in the vacuum oven at 122 F [50 C] and vacuum of 28 in. [710 mm] mercury for an additional 1 hour.

3.8 Determine the mass loss, as per Par. 3.6.

3.9 If necessary, continue the test until the sample reaches constant weight (i.e., zero mass loss between two successive weighings).

4.0 CALCULATIONS

Calculate the percent total volatiles as follows:

$$\% \text{ TV} = \frac{\text{PWP} - \text{PDP}}{\text{PWP} - \text{EP}} \times 100$$

Where:

PWP = part "wet" coating material
PWL = part "dry" coating material
EP = mass of empty pan

5.0 REPORT

5.1 The batch number and date tested.

5.2 The three percentage volatile values and the average.

APPENDIX 8
ABRASION TEST METHOD

1.0 SCOPE

This test procedure describes the evaluation of fusion bonded epoxy coatings for resistance to abrasion in the laboratory.

This test method is the latest edition of ASTM D4060-81, "*Abrasion Resistance of Organic Coatings by the Taber Abraser.*" Parameter values shall be as stipulated below.

2.0 EQUIPMENT

Taber Abraser Model 503, or equivalent
Analytical balance

3.0 PROCEDURE PARAMETERS

3.1 Duplicate specimens (4 in. [100 mm] square × 0.25 in. [6.3 mm] thick) of each coating shall be tested.

3.2 The abrasive wheels shall be CS-17.

3.3 The test shall be run for at least 1000 cycles.

4.0 REPORT

4.1 Batch number and date tested.

4.2 Number of cycles and mass loss in milligrams per 1000 cycles.

APPENDIX 9
ADHESION TEST METHOD

1.0 SCOPE

To determine the force required to remove coating from a steel substrate.

2.0 EQUIPMENT:

Adhesion Tester — Such as the Elcometer Adhesion Tester 106-0-4000 or equivalent.
Aluminum Dollies — Round disc, one inch [25 mm] diameter, supplied by the Manufacturer.
Glue — Epoxide type capable of 3000 psi [21 MPa] when completely cured.

3.0 TEST SPECIMEN

The test specimen shall be 4 in. [100 mm] square by 0.25 in. [6 mm] thick, prepared and coated in accordance with Paragraphs 3.2 and 3.3 of the body of this Recommended Practice.

4.0 PROCEDURE

Glue three aluminum dollies to the coating to be tested. Let cure for 24 hours at approximately 75 F [24 C]. Cut the coating completely away from the external edge of the dollies all the way down to the steel substrate. Zero the adhesion tester and position it onto the dollies one at a time and record the force required to remove the coating from the substrate.

5.0 REPORT

5.1 Batch number and date tested.

5.2 Force in psi [MPa] required to remove coating from substrate.

NOTE: *In the event that the failure occurs in the glue, this mode of failure should be recorded and reported.*

APPENDIX 10
AUTOCLAVE TEST METHOD

1.0 SCOPE

To determine if the coating is compatible with a given environment.

2.0 EQUIPMENT

The autoclave vessel should be rated for a minimum working pressure of 2,000 psi and a temperature of 200 F with adequate pressure gauges, indicating temperature controllers and a rupture disc pressure relief system. Suitable materials to withstand the corrosive test media shall be used. The rupture disc vent and all other vents shall be piped to a caustic scrubber designed to neutralize H_2S discharges.

3.0 TEST SPECIMEN

The test specimen shall be 1 in. [25 mm] × 8 in. [200 mm] × 0.25 in. [6 mm] thick. The steel substrate shall be left exposed on the 8 in. [200 mm] × 0.25 in. [6 mm] faces. Specimens shall be prepared and coated in accordance with Paragraphs 3.2 and 3.3 of this Recommended Practice.

Test specimens shall be inspected for runs, pinholes, blisters, and coating thickness recorded before testing. Multiple coating systems should be included and compared in a single test run. A control sample with known performance in the test environment should be included in each test.

4.0 PROCEDURE

Water with 5% NaCl by weight should cover approximately 50% of the surface of the coated specimen. A gas mixture of 0.5% (by volume) H_2S, 5% CO_2, and 94.5% CH_4 (methane) should be used to pressurize the autoclave. Where expected service conditions may have a higher H_2S or CO_2 concentration, the gas composition should be altered accordingly.

4.2 The autoclave is filled to the middle of the test specimens with 5% brine, sealed, flushed with CO_2, pressurized with the gas mixture, and heated to 200 F [93 C]. Gas should be vented to the scrubber to prevent pressures over 2,000 psi [14 MPa] as the autoclave is heated. The pressure and temperature shall be maintained for 16 hours before the heaters are turned off. The gases shall be vented rapidly after four hours of cooling.

4.3 The coatings are rated in the vapor and fluid zones. They are rated for color change, swelling, softening, blisters, cracks, delamination, and loss of adhesion using the latest edition of NACE Test Method TM-01-85, Evaluation of Plastic Coatings by Autoclave Testing. A blister rating can be developed following the latest edition of ASTM D714.

5.0 REPORT

5.1 Batch number and date tested.

5.2 Whether test specimen exhibited blisters, cracks, delaminations or defects exposing the steel substrate.

APPENDIX 11
CATHODIC DISBONDMENT TEST

1.0 SCOPE

This test provides an accelerated adhesion assessment of the coating.

2.0 EQUIPMENT

D. C. Power supply unit (Figure 1)
Platinum or platinum-coated anode wire
Electrolyte solution consisting of 3% by weight sodium chloride (NaCl) in distilled water
Plastic tubes 3½ in. [90 mm] diameter, 4 in. [100 mm] long
High resistance volt/amp meter
Hot Plate or oven capable of maintaining ± 5 F [±3 C]
Calomel reference electrode
Utility knife

3.0 TEST SPECIMEN

3.1 QUALIFICATION SPECIMEN

The test specimen shall be 4 in. [100 mm] square by 0.250 in. [6 mm] thick, prepared and coated in accordance with Paragraph 3.2 and 3.3 of this Recommended Practice.

3.2 TEST RING SPECIMEN

The test specimen shall be 4 in. [100 mm] square segment cut from the test ring.

3.3 Drill a ⅛ in. [3 mm] hole through the coating to expose the substrate, ensuring that the hole does not go through the substrate. This holiday should be drilled at the center of specimen.

3.4 Glue plastic tube onto specimen with holiday at center of tubing (Figure 2).

4.0 PROCEDURE

4.1 Pour approximately 350 ml of electrolyte into the plastic tubing.

4.2 Assemble the test cell as shown in Figure 2. When testing specimens cut from pipe it is necessary to employ a heat transfer medium (e.g., steel shot or grit) in order to provide uniform heating of the specimen. Use of a metal pan partially filled with the heat transfer medium into which the specimen is implanted (as shown in Figure 3) is preferable. Place on a hot plate or in an oven to maintain the substrate temperature at 150 F [66 C] for 48 hours.

4.3 Connect the negative lead from power supply to specimen and positive lead to anode.

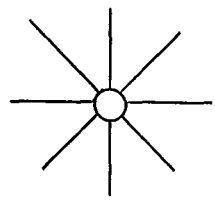
4.4 Turn on power supply and apply voltage to the test specimen: negative 1.5 volts with respect to the calomel reference electrode.

4.5 Monitor the voltage, temperature, and electrolyte level 4, 24, and 48 hours from start.

4.6 EVALUATION PROCEDURE

4.6.1 At the 48-hour point, remove test cell from the hot plate or oven, immediately drain electrolyte from the cell, dismantle the test cell, and air cool the sample to room temperature. The evaluation shall be performed within 1 hour of removal from hot plate.

4.6.2 Using a utility knife, make radial cuts through the coating to the substrate as indicated below. The radial cuts are to be at least 0.8 in. [20 mm] in length.



Test specimen with radial cuts

4.6.3 Insert the blade of a utility knife under the coating. Using a levering action, chip off the coating. Continue until the coating demonstrates a definite resistance to the levering action.

4.6.4 Measure the radius of the disbonded area from the holiday edge along each radial cut and average the measured results.

5.0 REPORT

Report the average disbonded radius.

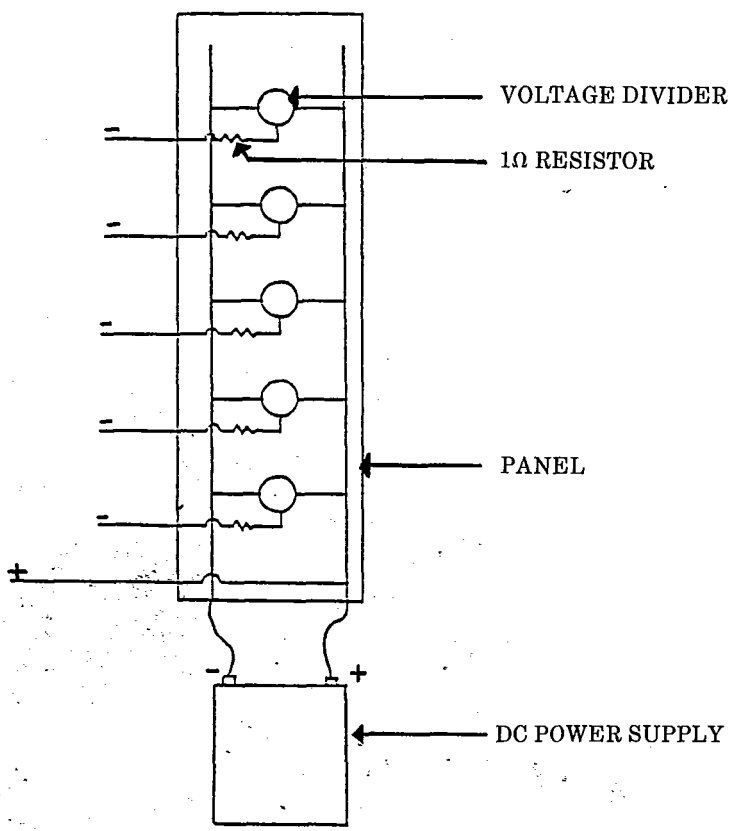
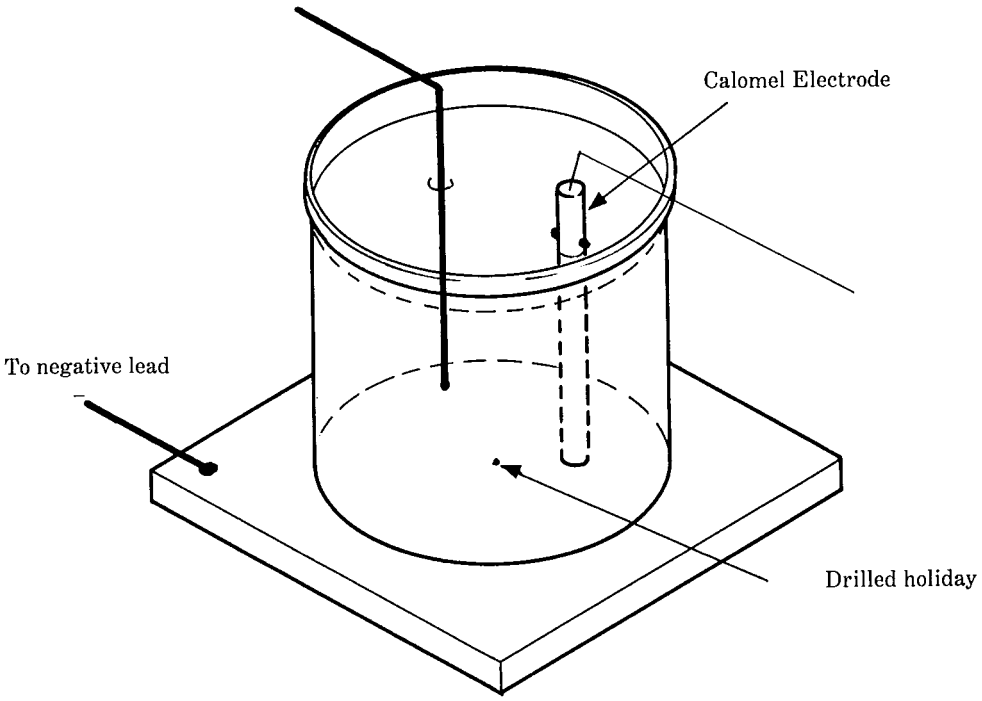


FIGURE 1 — POWER SUPPLY ASSEMBLY



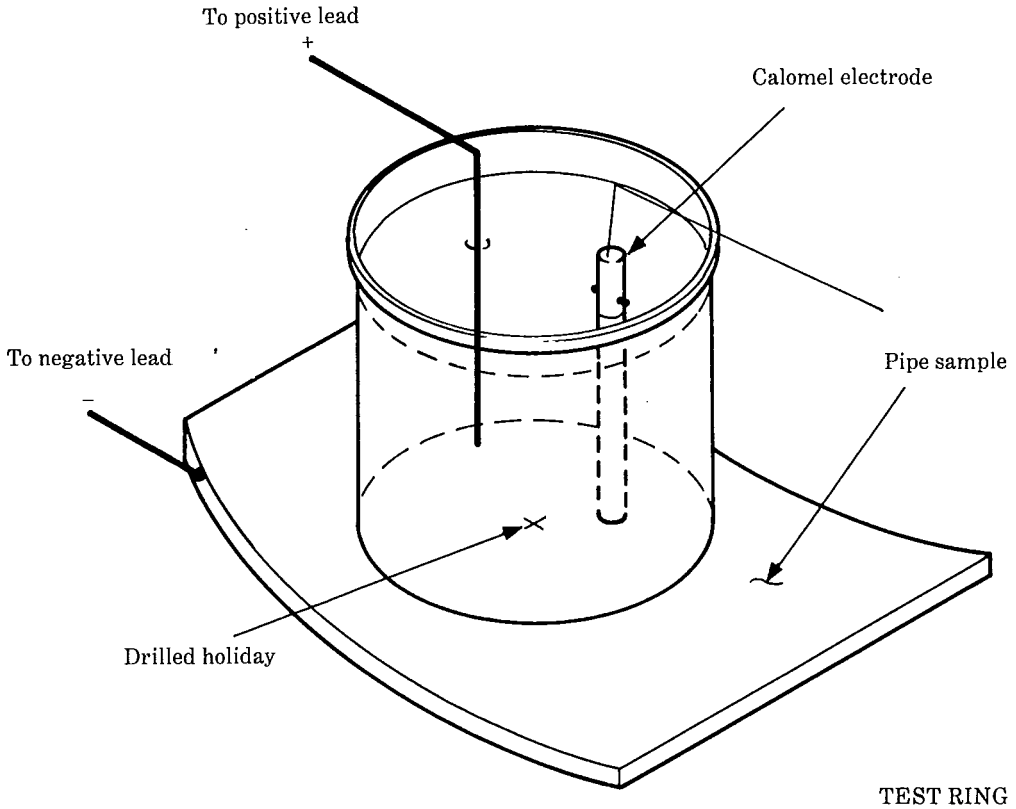


FIGURE 2
SCHEMATIC OF APPARATUS FOR CATHODIC DISBONDMENT TEST

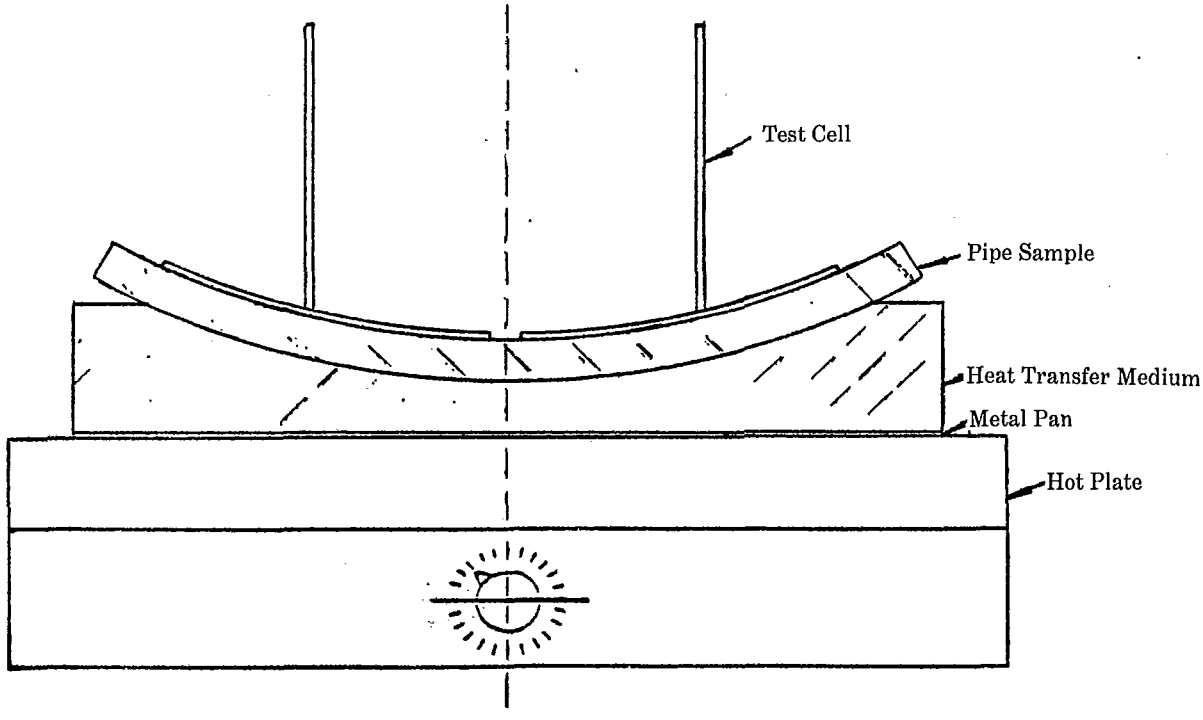


FIGURE 3
CATHODIC DISBONDMENT TEST SET UP FOR PIPE RING SAMPLES

APPENDIX 12
CHEMICAL RESISTANCE TEST

1.0 SCOPE
To evaluate the resistance of coating to various reagents.

2.0 EQUIPMENT
Quart [1 liter] Glass Jars and Vented Lids

MEDIUM	CONCENTRATION	pH VALUE
HCl in water	.....	2.5 - 3.0
HF in water	.....	2.5 - 3.0
H_2SO_4 in water	.....	2.0
NaCl + H_2SO_4 in water	100,000 ppm chlorides	3.0
NaCl in water	10.0%	
Distilled water	100%	

3.0 TEST SPECIMEN
Each test specimen shall be 1 in. [25 mm] × 8 in. [200 mm] × 0.25 in. [6 mm] thick. All sides of the test specimen shall be coated.

Specimens shall be prepared and coated in accordance with Paragraphs 3.2 and 3.3 of this Recommended Practice.

4.0 PROCEDURE

4.1 Pour enough medium into the jar so half the length of the test specimen is immersed in the medium and half the specimen is in the vapor phase of the medium.

4.2 Place the vented lid on the jar and ensure the medium level remains constant for 90 days.

4.3 After 90 days immersion, examine the test specimen for bleaching, swelling, softening, blisters, cracks, delamination and loss of adhesion.

5.0 REPORT
The condition of the sample after 90 days immersion of both the liquid and vapor phase portions of the sample.

APPENDIX 13
FLEXIBILITY TEST

1.0 SCOPE
To assure the coating has adequate flexibility for field bending or reeling.

2.0 EQUIPMENT
Hydraulic Press
Bending Mandrels of Fixed Radii
Freezer
Microscope

3.0 TEST SPECIMEN

3.1 QUALIFICATION SPECIMEN
Each test specimen shall be 1 in. [25 mm] × 8 in. [200 mm] × 0.25 in. [6 mm] thick. The specimen shall be prepared and coated in accordance with Paragraphs 3.2 and 3.3 of this Recommended Practice.

3.2 TEST RING SPECIMEN
Each specimen shall be 1 in. [25 mm] × 8 in. [200 mm] × pipe wall thickness, with the 8 in. [200 mm] dimension parallel to the axis of the pipe.

4.0 PROCEDURE

4.1 Ensure the test specimen edges have all stress raisers removed. Place the test specimens into the freezer and cool them to 0 F [-18C] and hold for one hour.

4.2 Calculate the required mandrel radius with the following formula:

$$R = \frac{57.3\,t}{s} - \frac{t}{2}$$

R = mandrel radius
t = substrate thickness
s = strain (deflection) in degrees per pipe diameter (°/PD)

4.3 Where a mandrel of the calculated radius is not available, the mandrel of next *smaller* radius shall be used.

4.4 Bend the test specimens over the radius, completing the bend in approximately 30 seconds.

4.5 Visually inspect the specimens under 40 power magnification for cracking and disbonding after the specimens have warmed to room temperature.

5.0 REPORT

5.1 Specimen thickness, mandrel radius, and deflection.

5.2 Whether the specimen has any crack, fissure, or delamination of the coating; the presence of any such defect within 0.1 in. [2.5 mm] of the strap edge does not constitute failure.

APPENDIX 14
IMPACT TEST

1.0 SCOPE
To provide a method for assessing coating resistance to damage.

2.0 EQUIPMENT
Gardner Impact Tester, or equivalent
Holiday Detector

3.0 TEST SPECIMEN
Each test specimen shall be 4 in. [100 mm] square by 0.25 in. [6 mm] thick. Specimens shall be prepared and coated in accordance with Paragraphs 3.2 and 3.3 of this Recommended Practice.

4.0 PROCEDURE

4.1 The Gardner Impact Tester shall be modified as follows:

A tup shall be used which can accommodate a 0.625 in. [15.8 mm] diameter ball bearing. The tup shall have a hardness of Rockwell C [HRC] 50-55.

4.2 The modified impact tester shall be screwed to a block of laminated wood. The wood block should measure approximately 24 in. [610 mm] on each side and have a top facing of hardwood.

4.3 Impact test shall be carried out with 2.2 lb. [1 kgf] weight in a 39 in. [1 m] graduated slotted tube. The ball bearing shall be rotated every 10 impacts to a new location and replaced after 200 impacts.

4.4 Allow the weight to fall onto the tup and ensure the point of impact is supported on a base which does not permit the metal substrate to deform or bend. If a specimen has undergone any form of substrate deformation, then the result obtained from that specimen is invalid.

4.5 Check each impact indentation on the test specimen for substrate exposure with a holiday detector. The detector shall have a wet sponge search electrode set at 67.5 volts.

5.0 REPORT
The maximum amount of energy the coating may absorb without substrate exposure in in.-lb. or J.

APPENDIX 15
VISUAL EXAMINATION OF COATING

1.0 SCOPE
To identify the amount of voids in the coating through film.

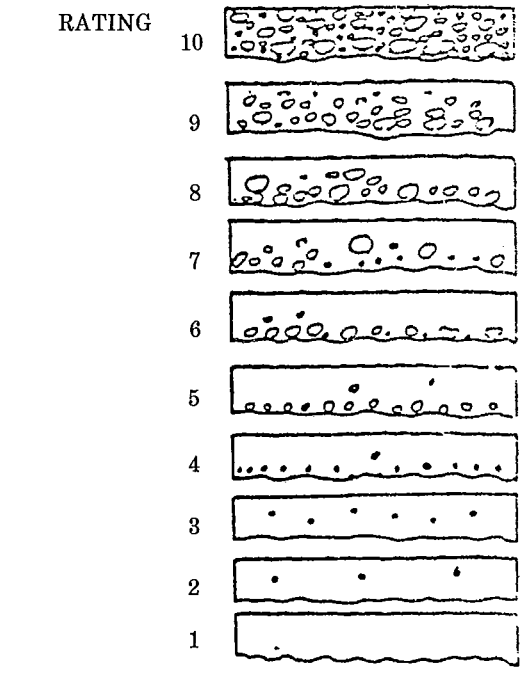
2.0 EQUIPMENT
40 power microscope.

3.0 TEST SPECIMEN
Cut a 1 in. [25 mm] × 8 in. [200 mm] × wall thickness test specimen from the test ring. The 8 in. [200 mm] dimension shall be parallel to the axis of the pipe.

4.0 PROCEDURE

4.1 Freeze sample to -76 F [-60 C] and bend the test specimen 180 degrees to snap off a piece of coating from the substrate.

4.2 Examine coating film cross-section under 40 power magnification. Rate the presence of voids as follows:



5.0 REPORT
Void Rating.

APPENDIX 16
HOT WATER SOAK

1.0 SCOPE

This test provides an accelerated assessment of the coating's adhesion to the substrate.

2.0 EQUIPMENT

Slow cooker
Thermometer
Utility knife

3.0 TEST SPECIMEN

Each test specimen shall be 4 in. [100 mm] square by 0.25 in. [6 mm] thick. Test ring specimens shall be 4 in. [100 mm] square × pipe wall thickness.

4.0 PROCEDURE

4.1 Put enough tap water into the cooker to fully submerge the test specimen and heat water to 167 ± 5 F [75 ± 3 C].

4.2 Place the specimen in the cooker. The water temperature shall be checked every 24 hours with a thermometer.

4.3 After 48 hours of immersion, and while the sample is hot, use a utility knife to scribe a rectangle approximately 1 in. [25 mm] × 0.5 in. [12 mm] through the coating to the substrate. Cool sample to room temperature.

4.4 The specimen shall be evaluated within two hours of the removal of the sample from the hot water. Insert a utility knife under the coating at a corner of the scribed rectangle and use a levering action to remove the coating. Continue inserting the knife and levering under the coating until all of the coating in the rectangle is removed or the coating demonstrates a definite resistance to the levering action.

4.5 Evaluate the coating and substrate within the rectangle using the following ratings.

Rating 1: Coating chips shall not be removed cleanly at any point in the rectangle.

Rating 2: Some coating in the rectangle comes off in chips when the knife point is levered under the coating. Over 50 percent of the rectangle has coating which shall not be removed. Note that the removed coating does not entirely expose the substrate.

Rating 3: Most of the coating in the rectangle comes off in chips when the knife point is levered under the coating. Some chips cannot be removed from the substrate. Visual examination with the naked eye shows a substantial amount of the coating was not removed cleanly to expose the substrate.

Rating 4: The coating comes off in chips when the knife point is levered under the coating. No coating remains on the substrate. Visual examination with the naked eye shows that the coating was removed cleanly to expose the substrate.

Rating 5: All coating shall be removed without chipping.

5.0 REPORT

5.1 Batch number or pipe number.

5.2 Dates of application and testing.

5.3 The rating obtained.

PUBLICATIONS LIST

The following publications are under the jurisdiction of the API Committee on Standardization of Tubular Goods and are available from the American Petroleum Institute, Publications and Distribution Section, 1220 L Street, Northwest, Washington, DC 20005, (202) 682-8375.

SPECIFICATIONS

Spec 5CT: Specification for Casing and Tubing.
Covers seamless and welded casing and tubing, couplings, pup joints and connectors in all grades. Process of manufacture, chemical and mechanical property requirements, methods of test and dimensions.
NOTE: *The first edition of Spec 5CT includes the requirements for casing and tubing previously detailed in last editions of discontinued Specifications 5A, 5AC, 5AX and 5AQ as well as items approved at the 1987 Standardization Conference.*

Spec 5D: Specification for Drill Pipe.
Covers all grades of seamless drill pipe. Process of manufacture, chemical and mechanical property requirements, methods of test and dimensions are included.
NOTE: *The first edition of Spec 5D includes the requirements for drill pipe previously detailed in the last editions of discontinued Specifications 5A and 5AX as well as items approved at the 1987 Standardization Conference.*

Std 5B: Specification for Threading, Gaging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads.
Covers dimensional requirements on threads and thread gages, stipulations on gaging practice, gage specifications and certification, as well as instruments and methods for the inspection of threads of round-thread casing and tubing, buttress thread casing, and extreme-line casing, and drill pipe.

Spec 5L: Specification for Line Pipe.
Covers seamless and welded steel line pipe in various grades. It includes standard-weight threaded line pipe, and standard-weight, regular-weight, special, extra-strong, and double-extra-strong plain-end line pipe. Processes of manufacture, chemical and physical requirements, and methods of test are included, as well as requirements on coupling and thread protectors.
NOTE: *The thirty-third edition of Spec 5L includes the spiral weld process and grades X42 through X70 previously specified in Specs 5LS and 5LX.*

RECOMMENDED PRACTICES

RP 5A5: Recommended Practice for Field Inspection of New Casing, Tubing, and Plain End Drill Pipe.
Provides a uniform method of inspecting tubular goods.

RP 5B1: Recommended Practice for Thread Inspection on Casing, Tubing and Line Pipe.
The purpose of this recommended practice is to provide guidance and instructions on the correct use of thread inspection techniques and equipment.

RP 5C1: Recommended Practice for Care and Use of Casing and Tubing.
Covers use, transportation, storage, handling, and reconditioning of casing and tubing.

RP 5L1: Recommended Practice for Railroad Transportation of Line Pipe.
Provides a recommended procedure for loading line pipe on railroad cars.

RP 5L2: Recommended Practice for Internal Coating of Line Pipe for Gas Transmission Services.
Covers coating materials, application practices and inspection of internal coatings on new pipe.

RP 5L3: Recommended Practice for Conducting Drop-Weight Tear Tests on Line Pipe.
Describes a recommended method for conducting drop-weight tear tests on line pipe 20 in. OD and larger with wall thicknesses 0.750 in. and less.

RP 5L5: Recommended Practice for Marine Transportation of Line Pipe.
Provides recommendations for transportation of line pipe in sizes 10¾ in. OD and larger by seagoing vessels.

RP 5L6: Recommended Practice for Transportation of Line Pipe on Inland Waterways.
Provides recommendations for transportation of line pipe in sizes 10¾ in. OD and larger on inland waterways.

RP 5L7: Recommended Practices for Unprimed Internal Fusion Bonded Epoxy Coating of Line Pipe.
Covers recommendations for coating materials, application, testing, and inspection of internal fusion bonded epoxy coatings on unused line pipe prior to installation.

BULLETINS

Bul 5A2: Bulletin on Thread Compounds.
Provides material requirements and performance tests for two grades of thread compound for use on oil-field tubular goods.

Bul 5C2: Bulletin on Performance Properties of Casing and Tubing.
Covers collapsing pressures, internal yield pressures, and joint strengths of casing and tubing and minimum yield load for drill pipe.

Bul 5C3: Bulletin on Formulas and Calculations for Casing, Tubing, Drill Pipe, and Line Pipe Properties.
Provides formulas used in the calculations of various pipe properties, also background information regarding their development and use.

Bul 5C4: Bulletin on Round Thread Casing Joint Strength with Combined Internal Pressure and Bending.
Provides joint strength of round thread casing when subject to combined bending and internal pressure.

Bul 5T1: Bulletin on Imperfection Terminology.
Provides definitions in English, French, German, Italian, Japanese, and Spanish for a number of imperfections which commonly occur in steel pipe.

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