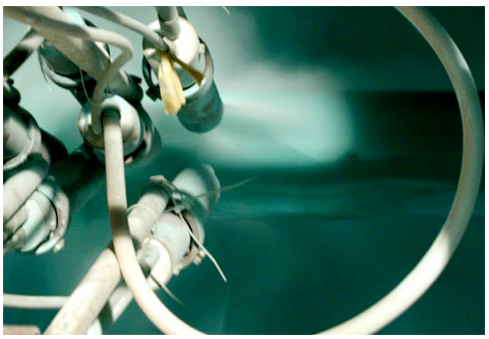
Scotchkote™

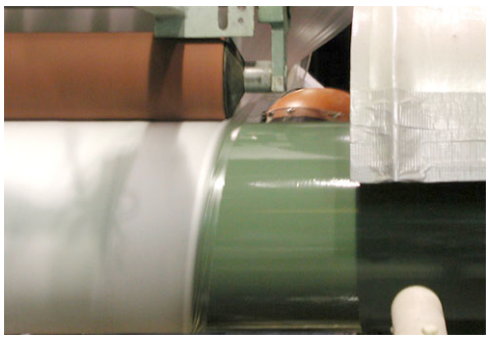
Fusion Bonded Epoxy Coating 226N+
Datasheet Addendum

Information, Properties and Test Results



Single Layer

Dual Layer



3 Layer

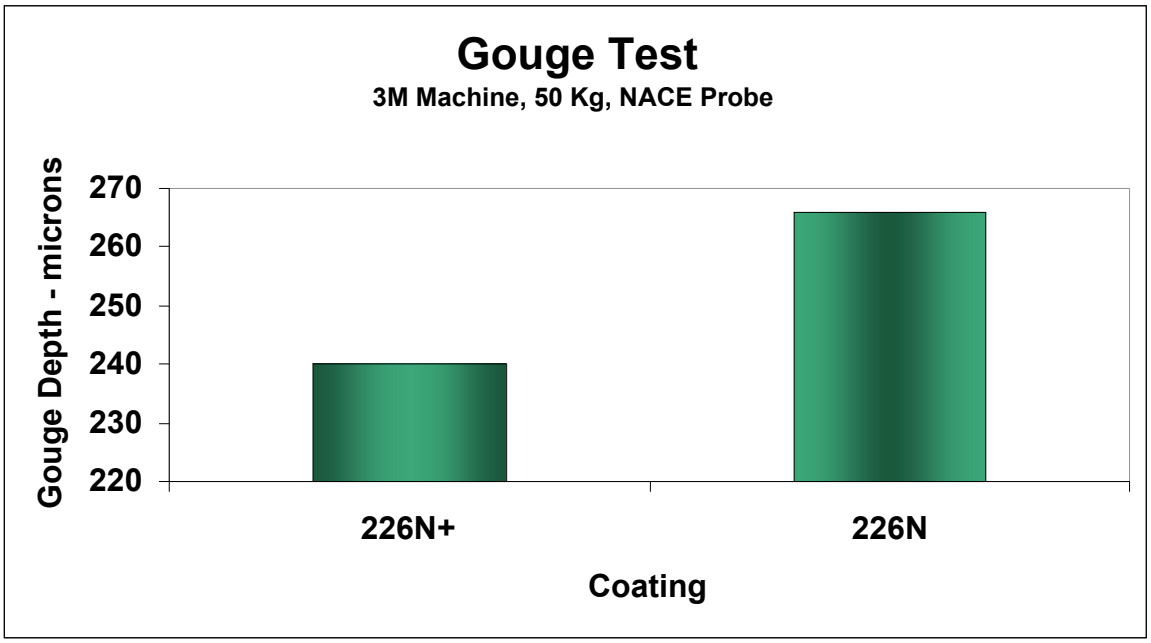


Table of Contents

Pipe with Scotchkote FBE

General Information

Introduction

The cost of the coating is only a small fraction of the coat of a pipeline system, yet the coating is the major means of assuring long-term operation by preventing pipeline deterioration and service disruption due to corrosion loss. 3M™ Scotchkote™ Fusion-Bonded-Epoxy Coatings are a significant improvement in pipeline coating technology.

Description

The proposed coating is Scotchkote 226N^{+} Fusion-Bonded-Epoxy Coating manufactured by 3M. Scotchkote 226N^{+} coating is a primerless, one-part, heat curable, thermosetting powdered epoxy coating designed to provide maximum corrosion protection to pipeline systems. It represents a breakthrough in fusion-bonded-epoxy (FBE) coating technology, providing an improvement in resistance to handling damage. It also provides an improvement in hot, wet adhesion retention and cathodic-disbondment resistance.

Application and Availability

Scotchkote 226N^{+} coating is applied to clean, preheated pipe using electrostatic deposition on the external surface of pipe and air-powder spray on the interior of the pipe. Fittings and fabrications are coated using fluid bed, electrostatic, or air spray techniques. Coated pipe is available through numerous application plants around the world.

History

Scotchkote FBE coating has been used extensively in the oil, gas, and water industries to coat the exterior and interior of pipe. Over 100,000 miles (160,000 km) of Scotchkote coated pipe have been installed throughout the world and most major users recognize the advantage of the FBE coating system.

Application Advantages

Scotchkote Fusion-Bonded-Epoxy Coatings are plant applied where excellent surface preparation can be achieved by grit blasting. Additionally, the blast cleaning has been found to improve the stress-corrosion-cracking resistance of the pipe itself. Pipe handling and processing can be rigidly controlled. Plant application means coating operations don't stop for inclement weather. No proportioning, metering or mixing is required at the coating plant. All of this was carefully done during manufacture of the FBE powder. The single-step electrostatic powder deposition produces a well-adhered uniform coating, even over the pipe weld seam, which is often hard to coat using other coating systems. Highest quality standards can be maintained during plant application. Inspection of both pipe and coating provides quality assurance for the pipe owner. The smooth epoxy coating mirrors the pipe surface, making pipe and coating flaws easy to detect. Electrical inspection, thickness, adhesion, and other quality checks become part of the permanent coating record.

Shipping and Storage Advantages

Pipe coated with Scotchkote Fusion-Bonded-Epoxy Coatings can be stored for two years or more under most climatic conditions without deterioration of the coating. Because of the coating's high compression strength and cold flow resistance, stacking heights during storage are limited only by pipe ovality distortion and safety considerations. The coating does not soften or flow even at high storage or operating temperatures. Scotchkote coated pipe can be shipped throughout the world with minimal coating damage using all common modes of transportation. Thus, quality, plant-applied coating is available even at remote, inhospitable construction sites. The coating is lightweight and adds little to shipping costs; yet the pipe is protected from the elements during shipping and storage.

Installation Advantages

Pipe coated with Scotchkote 226N^{+} coating can be installed easily, efficiently, and at a competitive cost under widely varying temperature and weather conditions from arctic cold to tropical heat. Contour bends up to 3 degrees per diameter length can be made using conventional padded bending machines without damage to the Scotchkote external or internal coating. Scotchkote 226N^{+} coating handles easily in the field. It does not ravel, tear, split, or compress under load from

slings or cribbing. Flexing of the pipe during handling does not damage the coating. Because of the resistance of Scotchkote 226N^{+} to the heat of welding, only a small cutback is necessary. The small field joint reduces coating time, materials and cost. Scotchkote™ Fusion-Bonded-Epoxy Coating 226N^{+}, applied to the weld area in the field, can provide the same quality coating on the field weld as on the main body of the pipe. The process of blast clean, induction heat, and coat takes just a few minutes. The field application requires minimal equipment and manpower and is almost independent of weather conditions. Field welds can also be protected with most conventional joint coating materials such as tape, shrink sleeves, or liquid epoxy coatings. Field damage, should it occur, is easy to spot. Outer wraps do not mask it nor does it propagate or migrate. Repair is fast and easy using liquid epoxy or hot-melt compounds.

In-service Advantages

Scotchkote 226N^{+} coating requires very low levels of supplementary cathodic protection even after extended periods of time. The Scotchkote FBE coating does not shield protection currents so the cathodic-protection system can operate at optimum efficiency and effectiveness. Scotchkote 226N^{+} coating, with enhanced adhesion and cathodic-disbondment performance, is designed to provide maximum corrosion protection under widely varying pipeline operating conditions. Scotchkote FBE coating resists soil compaction and soil forces, which can be detrimental to the dimensional integrity of many other types of coatings especially on large diameter pipe. Chemical inertness makes Scotchkote 226N^{+} coating highly resistant to moisture penetration, bacteria and fungus attack, soil acids, alkalis and salts, hydrocarbons, and other chemicals associated with pipeline use.

Cost Comparison

The “in-the-ground” cost of a coating includes not only the initial coat of application on pipe, but transportation, handling and installation coats, which can be attributable to the coating system as well: i.e., coating of external and internal welded joints, special handling, speed of installation, coating repair, etc. Use of Scotchkote FBE coating permits the contractor to employ cost-saving construction practices and equipment. Scotchkote 226N^{+} coating does not strip off during plowing or river boring operations. Roller cradles and padded cinching devices are completely compatible with the coating. Scotchkote FBE coating is cost competitive and the often preferred pipe-coating alternative.

Conclusion

Many major oil, gas, and water companies use Scotchkote materials as corrosion protection for pipeline systems up to 80 inches (2000 mm) in diameter. It meets the unusual storage, construction, and service conditions that are encountered around the world. Its excellent in-service history makes Scotchkote coating a system for your entire pipeline coating needs. 3M has established the leading edge in pipeline coatings for over 45 years.

Information, Properties and Test Results

Description

3M™ Scotchkote™ Fusion Bonded Epoxy Coating 226N+ consists of a blend of epoxy resin and curing agent combined with additives, pigments, catalysts, leveling, and flow control agents. Careful product design assures the coating will withstand environmental conditions encountered by underground and underwater pipelines. Scotchkote 226N+ coating is available in different gel and cure speeds to allow trouble-free application on all pipe sizes in coating plants and minimize downtime during product changeover. These variations are identified as Scotchkote coatings 226N+ 4G, 8G, and 11G.

Selection of the chemical elements for the FBE coating is of prime importance. The molecular structure of the epoxy resin, the type and reactivity of the curing agent and catalyst, and the additives all play an important role in the ultimate coatability and performance of the coating. 3M maintains a laboratory group dedicated to the research and development of FBE coating. Personnel in the CPP laboratory have many years of experience in epoxy-coating formulation and evaluation. Staff laboratories assist this effort with broad-based expertise in the scientific disciplines applicable to coating and surface technology. In addition, 3M synthesizes and manufactures specialized epoxy resins, curing agents, catalysts, and additives used to formulate Scotchkote coatings to meet performance and operational requirements.

Manufacturing

All 3M Scotchkote fusion-bonded-epoxy coating powders are made using the fusion-blend process developed by 3M. Incoming materials are pulverized, proportioned, and homogeneously dry mixed. The blended materials are thoroughly mixed in the molten state using a continuous melt mixer. The fused blend is cooled and then pulverized into the final powdered form. The fusion-blend process assures that each particle of the coating powder contains all active ingredients, thus eliminating changes in reactivity due to separation or stratification during transportation and application. 3M carefully selected raw materials to assure that Scotchkote 226N+ coating withstands the harsh environmental conditions of underground and underwater pipelines. 3M has Scotchkote Fusion-Bonded-Epoxy manufacturing sites located around the world.

Process and Quality Control

Process control is essential to the quality of the finished product. 3M maintains rigid incoming quality inspection of raw materials, precise measurement and metering of critical components, controlled environmental conditions and processing temperatures for the chemical constituents, and a discerning outgoing inspection of the finished coating powder to provide uniformity of product application and performance. Among the quality control test performed on Scotchkote powder are: gel time, cure, flow, particle distribution, fluidization, bend, cathodic disbondment, hot-water adhesion, appearance, and moisture content.

Packaging, Storage and Shipping

Scotchkote 226N+ coating is packaged in a heavy-duty, polyethylene bag in a fiberboard carton that is clearly labeled with product number and manufacturing identification. This package protects the coating from humidity and contamination during shipment and storage. The net weight is 65 U.S. lbs (29.4 kg). The sealed cartons are palletized on wooden pallets with a net weight of 1170 lbs. (530 kg) and securely banded for shipment. The packaged product must be shipped and stored at temperatures not to exceed 80°F (27°C). Alternate packaging sizes are available, e.g., 1700 lb or 2205 lb (1000 kg) sacks.

Properties of the Powder

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

Classification and Color

Property	Test Method	Value
Classification	ASTM D 1763	Type 1, Grade 2
Color	Federal Standard 595B	14272/Green

Fluid-Bed Density

Property	Test Method	Value
Fluid Bed Density		29 lbs/ft^3 0.46 gm/cm^3

Shelf Life

Property	Test Method	Value
Shelf Life		1 year minimum (In original container) at 80°F (27°C)

Density and Coverage

Property	Test Method	Value
Density	Air Pycnometer, CSA Z245.20-02, 12.6	1.44 g/cm^3 (film) 1.57 g/cm^3 (powder)
Coverage		134 ft^2/lb/mil based on film density 0.695 m^2/kg/mm

Particle Size

Property	Test Method	Value
Particle size large than 250 µm Larger than 150 µm	Screen analysis, CSA Z245.20-02, 12.5	<0.2% <3.0%

Moisture Content

Property	Test Method	Value
Moisture content	Mass loss, CSA Z245.20-02, 12.3	<0.3%

Gel Time

Property	Test Method	Value
Gel Time at 205˚C (400˚F) 226N+ 4G 226N+ 8G 226N+ 11G	CSA Z245.20-02, 12.2	 6-11 seconds 17-23 seconds 24-36 seconds

Cure Time

Property	Test Method	Value
Cure Time at 232˚C (450˚F) 226N+ 4G 226N+ 8G 226N+ 11G		 30 seconds 90 seconds 110 seconds

Angle of Repose

Property	Test Method	Value
Angle of Repose		35˚– 40˚

Minimum Explosion Concentration – Lower Explosive Limit

Property	Test Method	Value
Minimum Explosion Concentration	ASTM E1515 – for dust/air mixture	35 - 55 g/m^3 (Determined on a range of typical FBE powders)

Auto-ignition Temperature

Property	Test Method	Value
Auto-ignition Temperature – Dust Cloud	ASTM E1515	450 – 550˚C (Determined on a range of typical FBE powders)
Auto-ignition Temperature – Dust Layer	ASTM E1515	325 – 375˚C (Determined on a range of typical FBE powders)

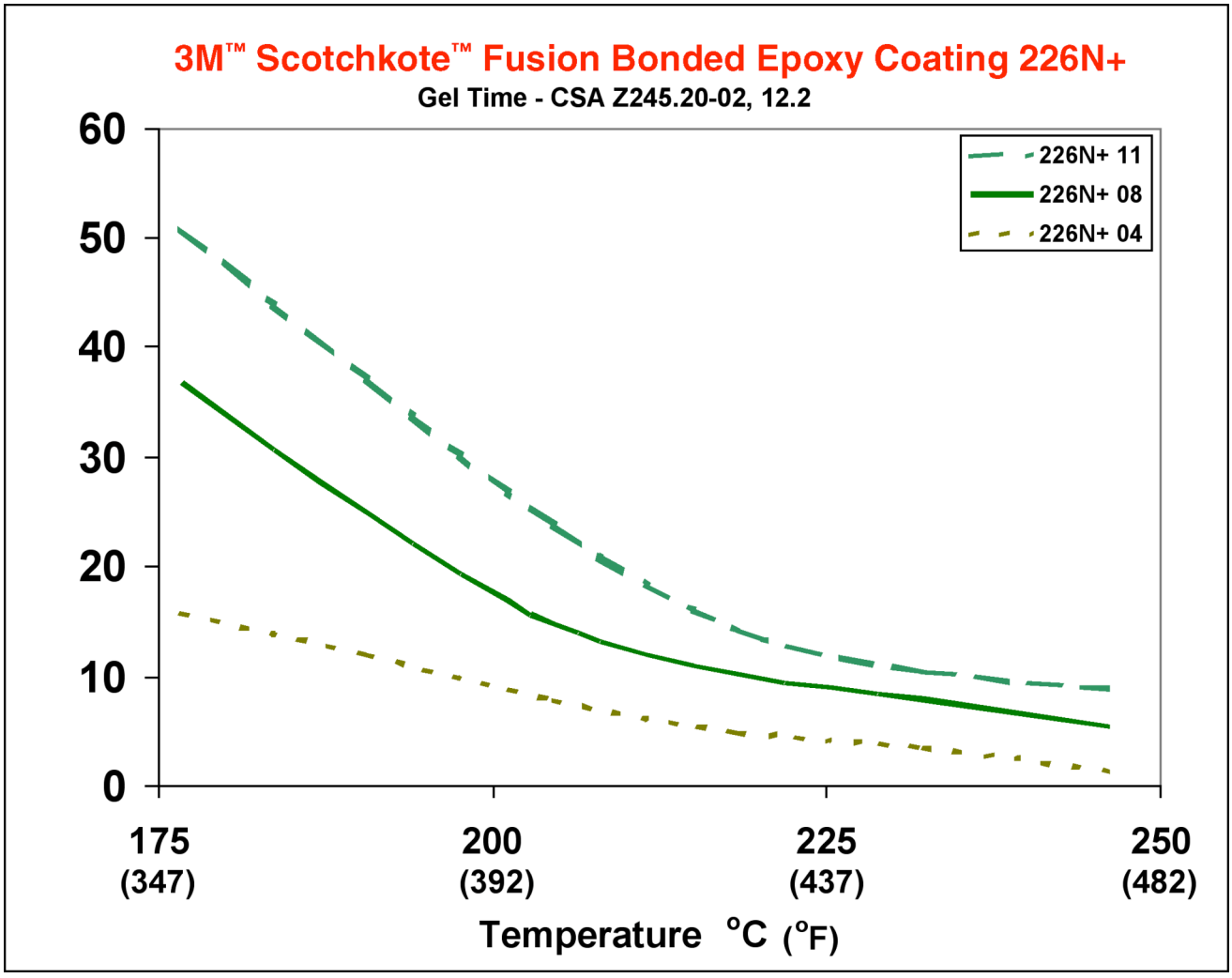
Minimum Ignition Energy

Property	Test Method	Value
Minimum Capacitor Energy	ASTM E1515	30 – 42 mJ (Determined on a range of typical FBE powders)
Minimum Ignition Spark Energy	ASTM E1515	2.2 – 3.5 mJ (Determined on a range of typical FBE powders)

Maximum Rate of Explosion Pressure Rise

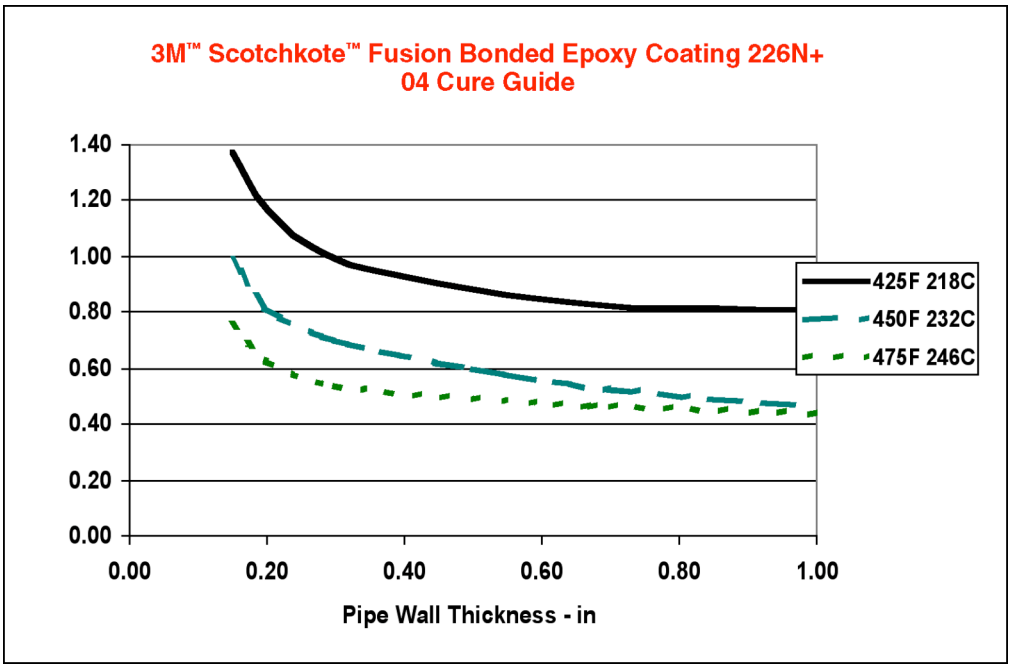
Property	Test Method	Value
Maximum Rate of Explosion Pressure Rise	ASTM E1515	7500 – 9800 psi/sec 51.7 – 67.6 MPa (Determined on a range of typical FBE powders)

3M™ Scotchkote™ Fusion Bonded Epoxy Coating 226N+ – Gel Time vs. Temperature

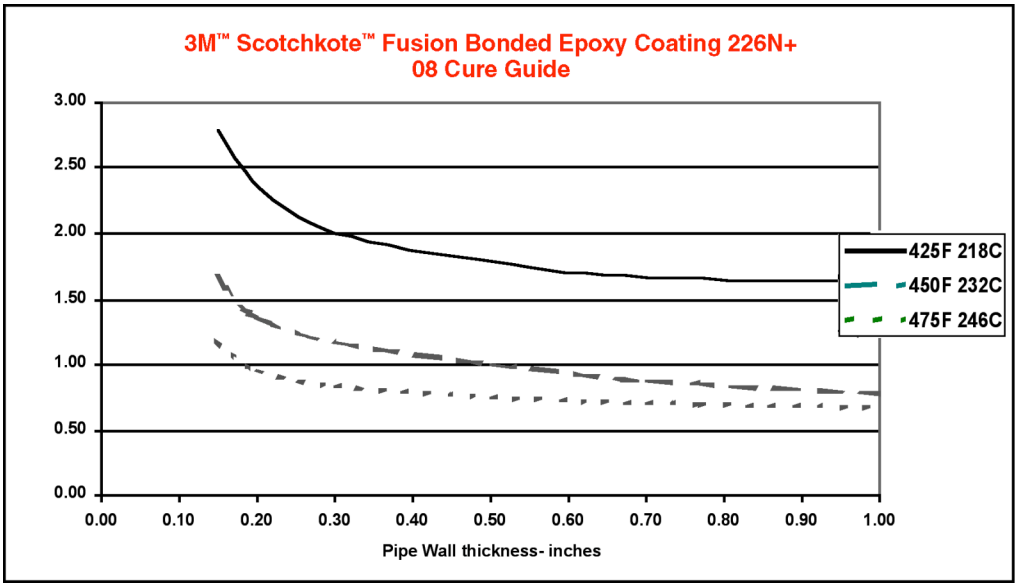


Powder gel time is dependent on temperature and technique. Different temperature measuring devices used to set hot plate temperature result in different surface temperatures and different gel times for a given "temperature". The above curves are based on data from one powder sample, on one piece of equipment tested by one individual.

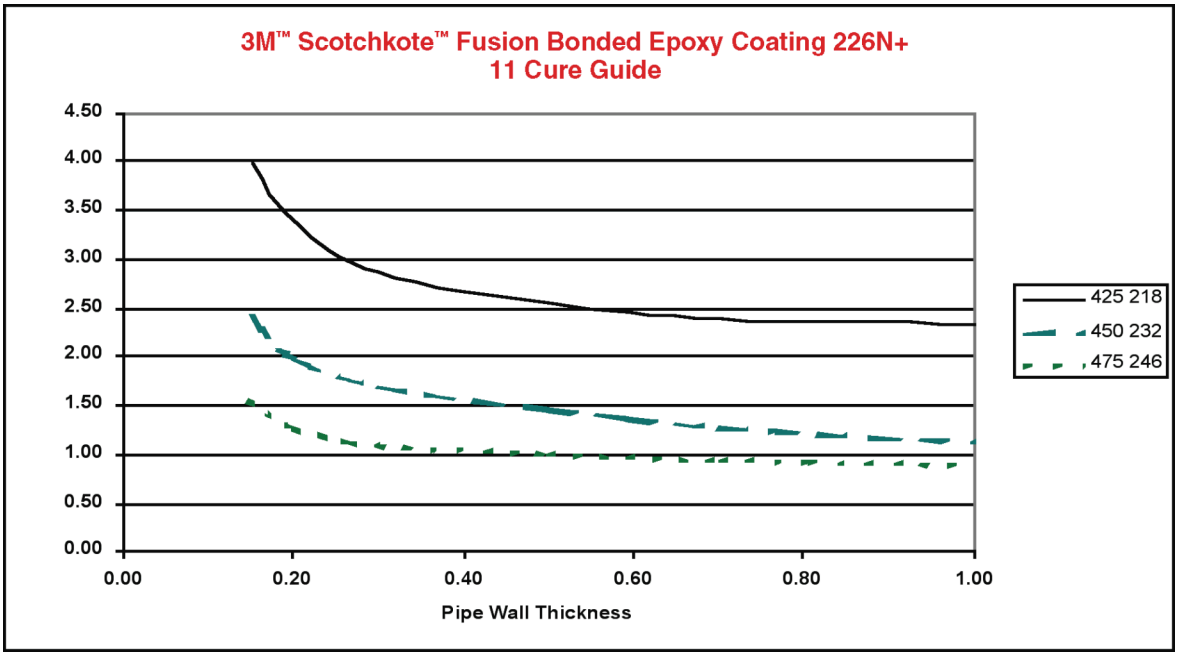
3M™ Scotchkote™ Fusion Bonded Epoxy Coating 226N+ Cure Time vs. Application Temperature



Scotchkote 226N+ Coating 4G – Cure Time vs. Temperature

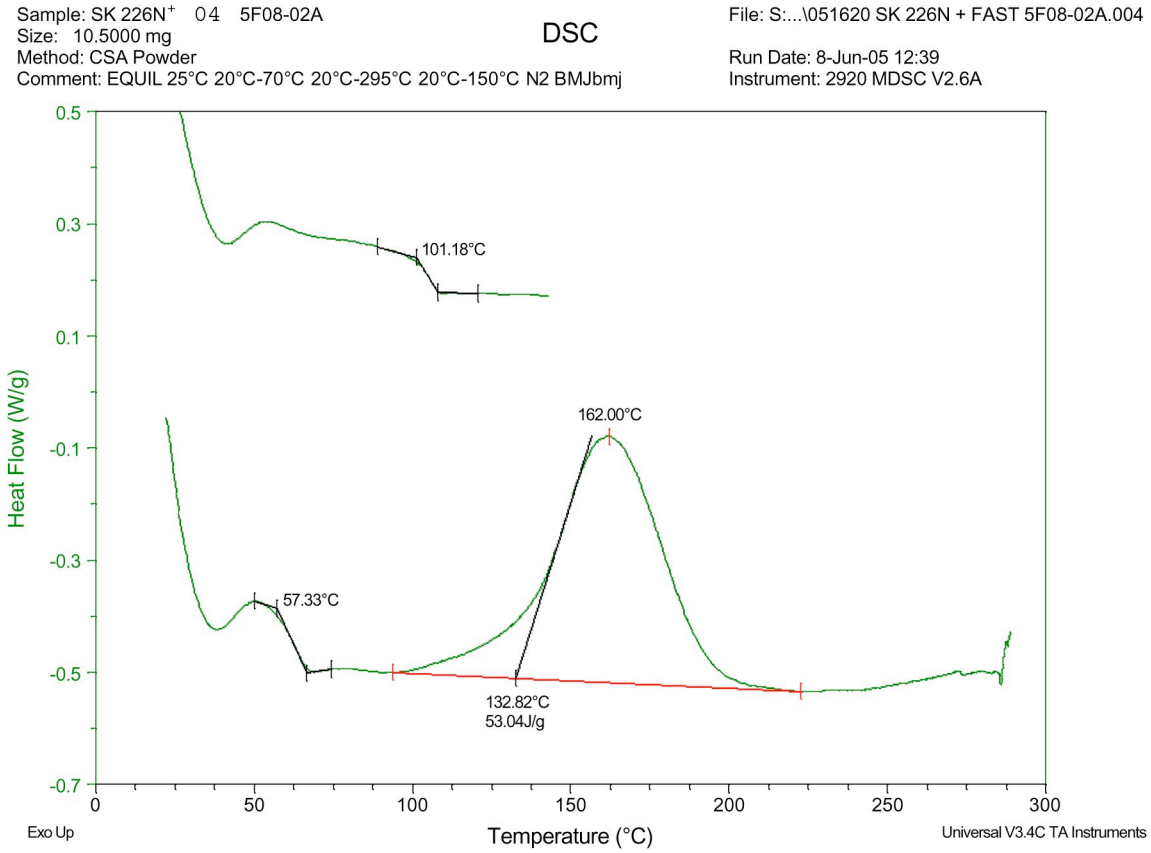


Scotchkote 226N+ Coating 8G – Cure Time vs. Temperature

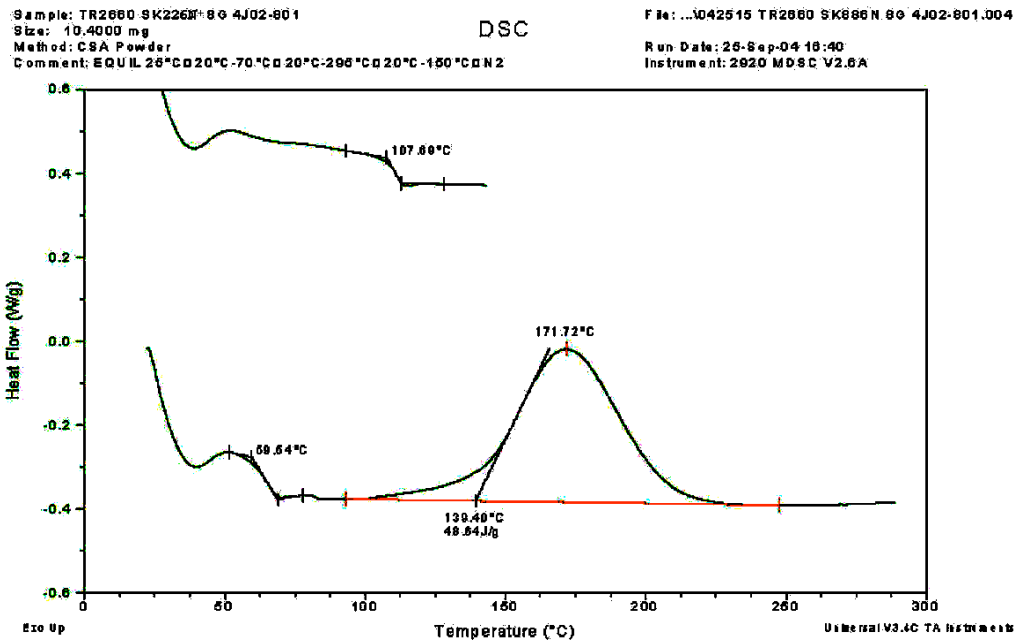


Scotchkote 226N+ Coating 11G – Cure Time vs. Temperature

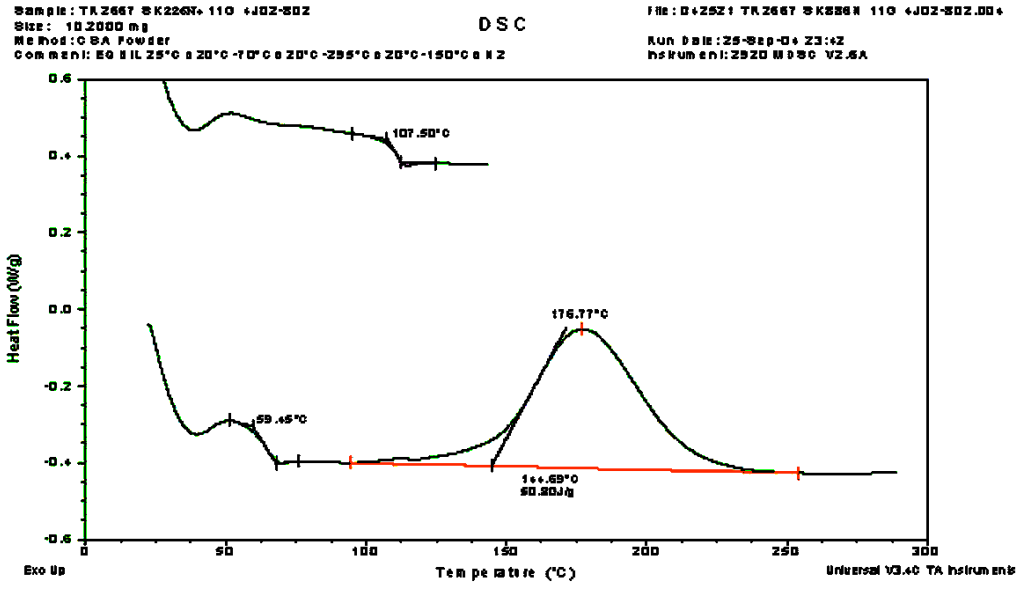
3M™ Scotchkote™ Fusion Bonded Epoxy Coating 226N+ – DSC Scans



Scotchkote 226N+ Coating 4G – DSC Scan

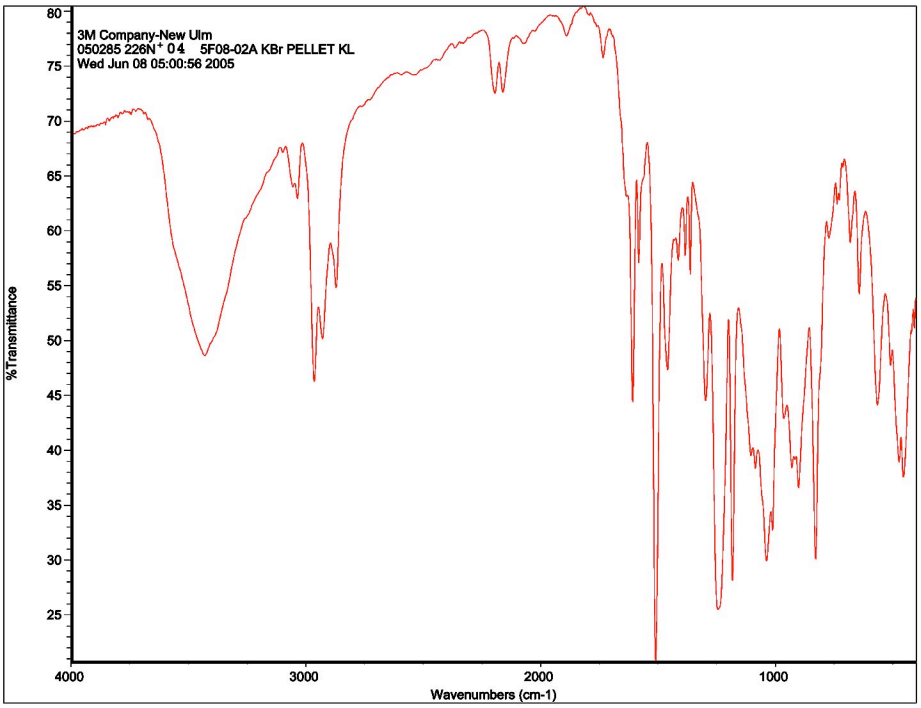


3M™ Scotchkote™ Fusion Bonded Epoxy Coating 226N+ 8G – DSC Scan

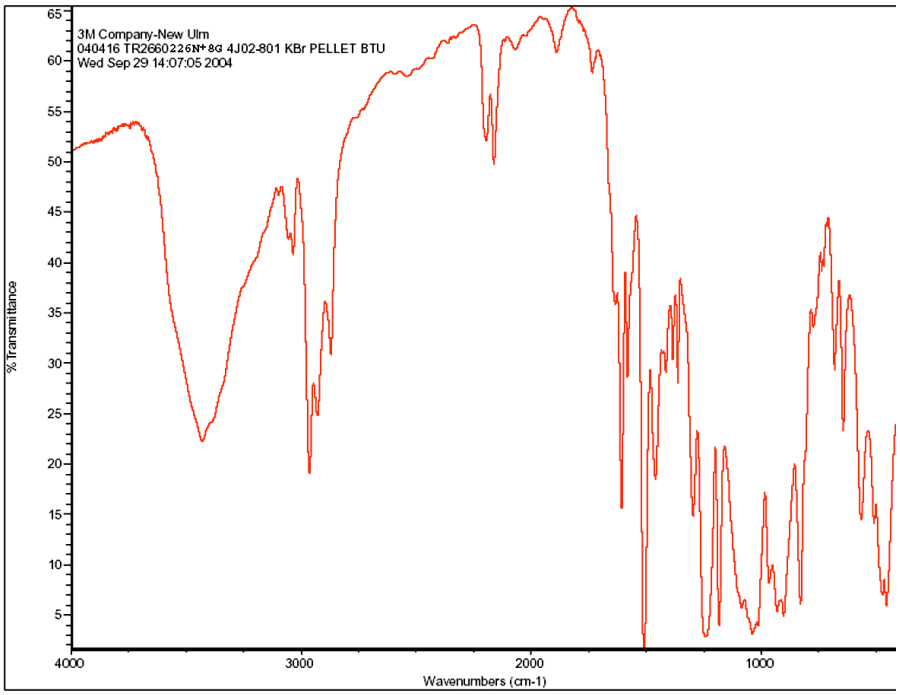


Scotchkote 226N+ Coating 11G – DSC Scan

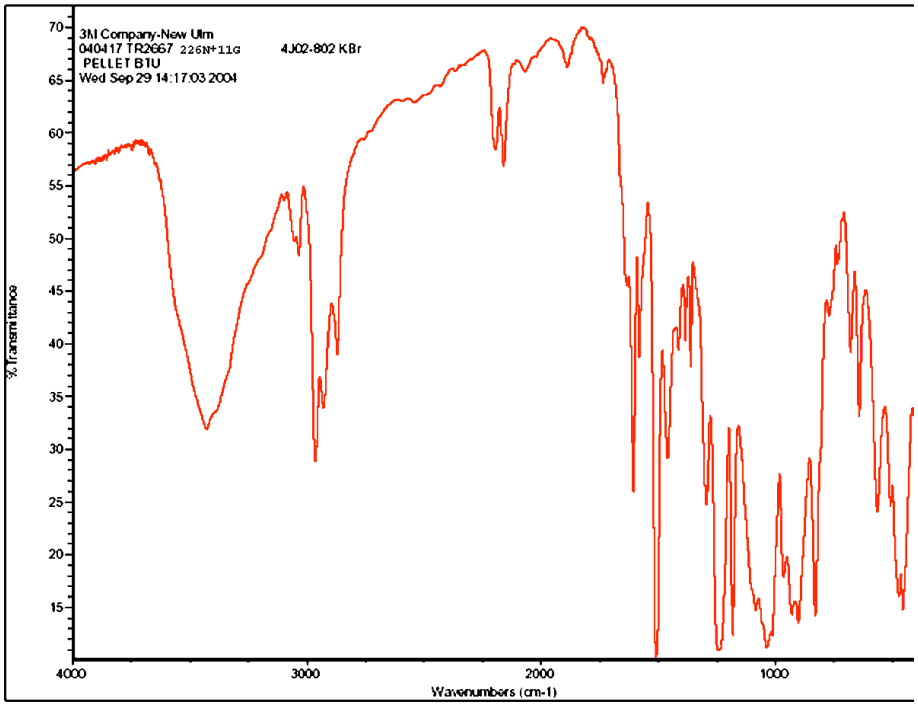
3M™ Scotchkote™ Fusion Bonded Epoxy Coating 226N+ – IR Scans



Scotchkote 226N+ Coating 4G – IR Scan



3M™ Scotchkote™ Fusion Bonded Epoxy Coating 226N+ 8G – IR Scan



Scotchkote 226N+ Coating 11G – IR Scan

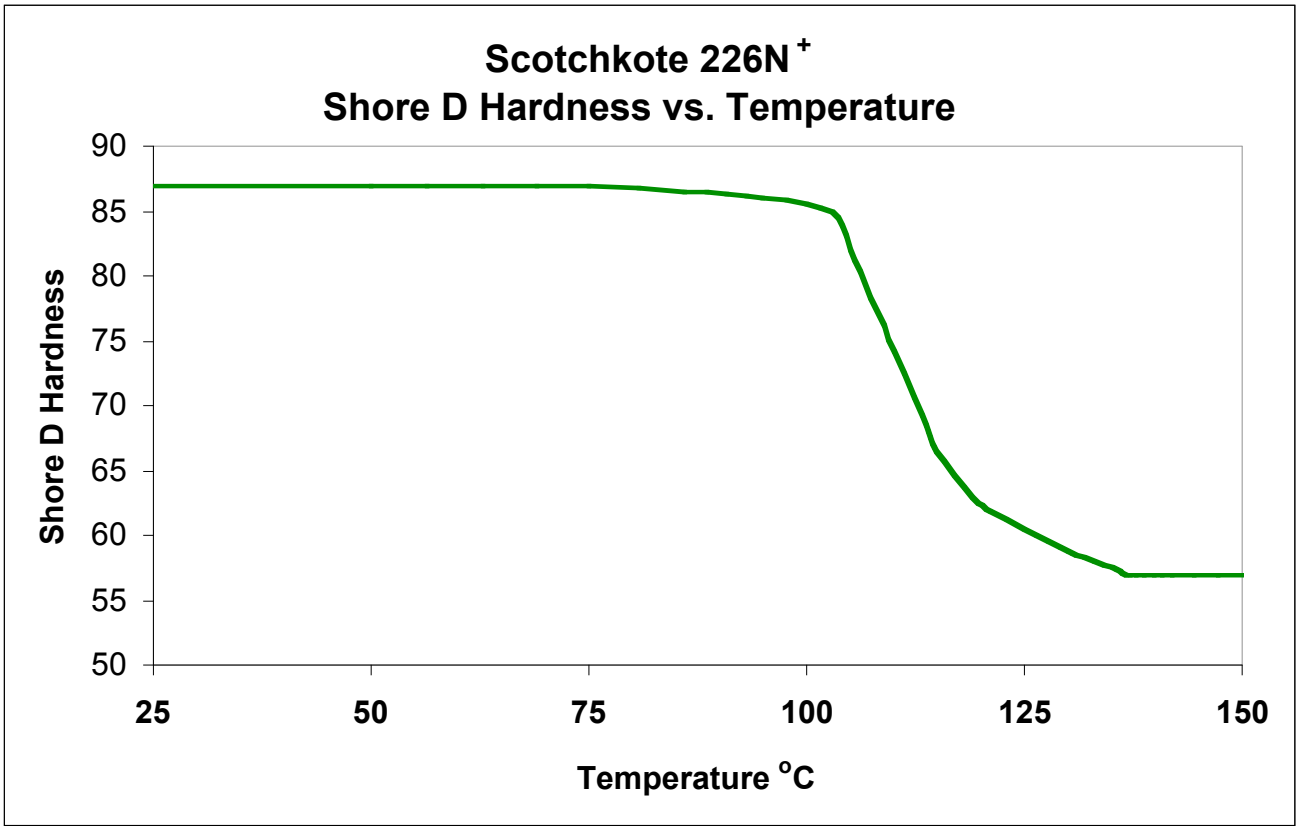
Properties of the Coating

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

Tests conducted at 23±2˚C (73±3˚F) unless otherwise noted. Average values – not for specification purposes.

Hardness

Property	Test Method	Value
Hardness	Shore D	87
	Buchholz DIN 53153	>90
	Barcol	34



Compression Strength

Property	Test Method	Value
Compression Strength	ASTM D 695	13476 psi 947.5 kg/cm^2 92.91 MPa

Flexibility

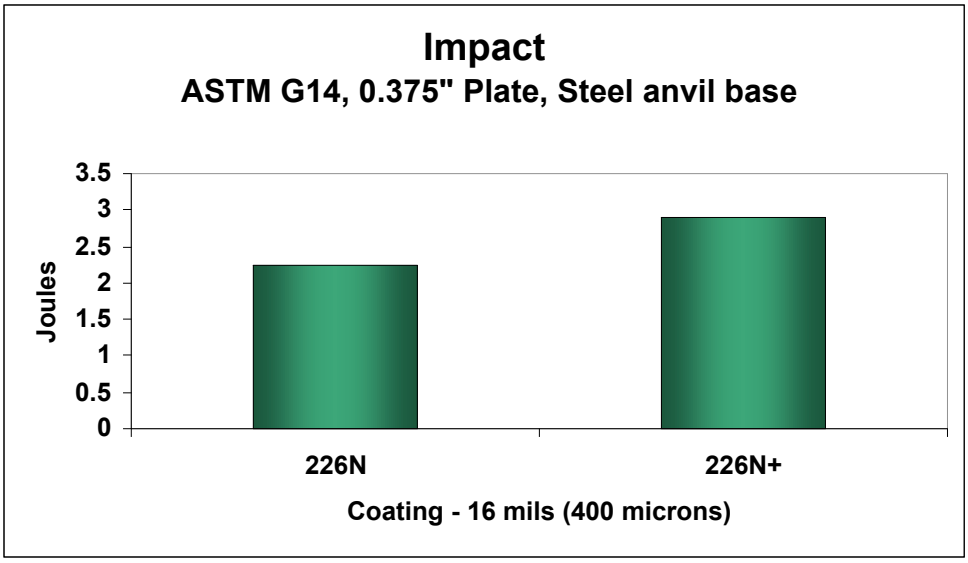
Property	Test Method	Value		
Flexibility	-30˚C, CSA Z245.20-02, 12.11	>3˚/PD		
Mandrel Bend – Tests on laboratory prepared samples – no hard crack		Pipe Dia. PD	% Elongation	˚/PD
	-30˚C (-22˚F)	>19.1	>2.6	>3
	0˚C (32˚F)	>13	>3.8	>4
	23˚C (73˚F)	>7.8	>6.4	>7
	GBE/CW6	Pass 23.5 PD @ -2°C (28˚F) > 2% Strain		
	GBE/CW6	Pass 15.2 PD @ 20°C (68˚F) > 3% Strain		

Tensile/Elongation

Property	Test Method	Value
Tensile Strength	ASTM D 882	8047 psi 565.8 kg/cm^2 55.48 MPa
Elongation	ASTM D 882 – % strain at Max load	5.0%

Impact

Property	Test Method	Value
Impact	ASTM G 14, 5/8 in (16 mm) diameter Tup, 15 mil (380 µm) coating on 0.375 in (9.6 mm) panel, steel anvil base.	2.9 J
	ASTM G 14, 5/8 in (16 mm) diameter Tup, 15 mil (380 µm) coating on 0.375 in (9.6 mm) panel, laminated wood base.	6.0 J
	CSA Z245.20-02, 12.12	
	-40°C	>1.5 J
	-30°C	>1.5 J
	-10°C	>1.5 J
	0°C	>1.5 J
	RT	>1.5 J
	50°C	>1.5 J



Electrical Properties

Property	Test Method	Value
Volume resistivity	ASTM D 257	1.2 X 10^{15} ohm•cm
Electrical Strength (Electric breakdown voltage)	ASTM D 1000	45.2 kV/mm 1148 V/mil

Adhesion/Adhesion Retention

Property	Test Method	Value
Hot-water Resistance	CSA Z245.20-02, 12.14, 75˚C, 24 hours	1 adhesion rating
	CSA Z245.20-02, 12.14, 75˚C, 48 hours	1 adhesion rating
	CSA Z245.20-02, 12.14, 75˚C, 14 days	1 adhesion rating
	CSA Z245.20-02, 12.14, 75˚C, 28 days	2 adhesion rating
	CSA Z245.20-02, 12.14, 95˚C, 24 hours	1 adhesion rating
	CSA Z245.20-02, 12.14, 95˚C, 14 days	2 adhesion rating
	CSA Z245.20-02, 12.14, 95˚C, 28 days	2 adhesion rating
Crosshatch Adhesion	DIN 53151	Gt 0 – 1, no lifting of coating
Adhesion	GBE/CW6	<1 MM
Salt Spray Resistance	ASTM B 117 – 1000 hours	No blistering, no discoloration, no loss of adhesion

Overlap Shear Adhesion

Property	Test Method	Value
Adhesion	ASTM D 1002 Polished steel plates	Cohesive failure – FBE retained on both plates >5188 psi >35.88 MPa

Chemical Resistance

Property	Test Method	Value
Chemical resistance	90 days, 24˚C, CSA Z245.20-98, 12.9 ∞ Hydrochloric acid in distilled water at pH 2.5 to 3 ∞ 10% NaCl with sulfuric acid in distilled water at a pH of 2.5 to 3 ∞ 10% NaCl in distilled water ∞ Distilled water ∞ 5% NaOH in distilled water ∞ Saturated solution mixture of equal parts by mass of magnesium carbonate and calcium carbonate in distilled water	No sign of bleaching, swelling, softening, blisters, cracks, delamination, or loss of adhesion

Thermal Shock Resistance

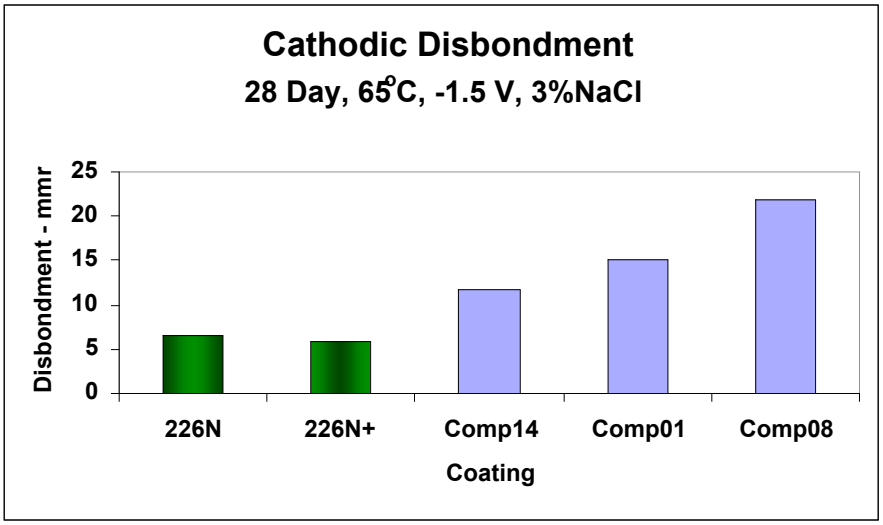
Property	Test Method	Value
Thermal Shock Resistance	3M – 10 cycles -100°to 300°F (-70°to 150°C)	Unaffected by thermal shock

Strain Polarization

Property	Test Method	Value
Strain Polarization	CSA Z245.20-02, 12.13	No Cracking

Cathodic Disbondment

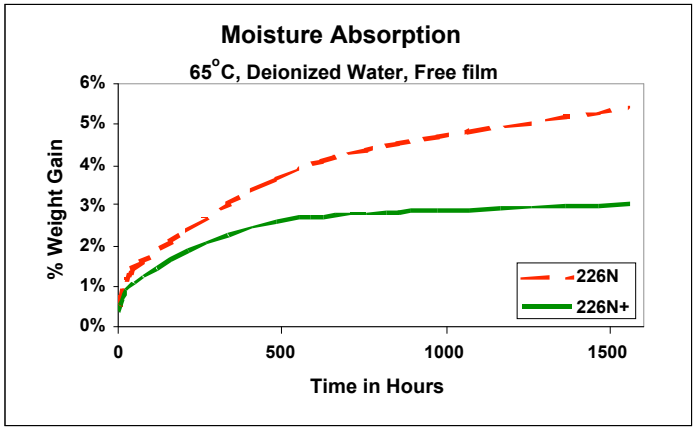
Property	Test Method	Value
Cathodic disbondment	28 Day, 23˚C, 1.5V, 3% NaCl	2.4 mmr
	14 Days, 50˚C, 1.5V, 3% NaCl	2.6 mmr
	28 Days, 50˚C, 1.5V, 3% NaCl	2.4 mmr
	48 Days, 50˚C, 1.5V, 3% NaCl	6.7 mmr
	24 hours, 65˚C, 3.5V, 3% NaCl, CSA Z245.20-02 clause 12.8	2.5 mmr
	14 Days, 65˚C, 1.5V, 3% NaCl	3.0 mmr
	28 Days, 65˚C, 1.5V, 3% NaCl	5.8 mmr
	28 day, 65˚C, 3.5V, 3% NaCl	6 mmr
	14 day, 80˚C, 1.5V, 3% NaCl	4.6 mmr
	28 day, 80˚C, 1.5V, 3% NaCl	12.8 mmr

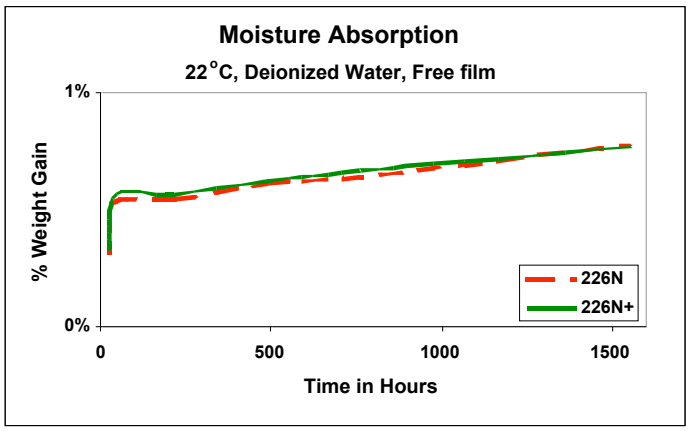


Abrasion Resistance

Property	Test Method	Value	
Abrasion Resistance	ASTM D 968	>15.0 liters of sand per 25 µm (mil)	
Abrasion Resistance	ASTM D 4060 CS 10 wheel 5000 cycles	Wear index	0.032
		Weight loss	0.160 gm
		Wear cycle/mil	2250
Abrasion Resistance	ASTM D 4060 CS 17 wheel 5000 cycles	Wear index	0.066
		Weight loss	0.330 gm
		Wear cycle/mil	1547

Moisture Absorption



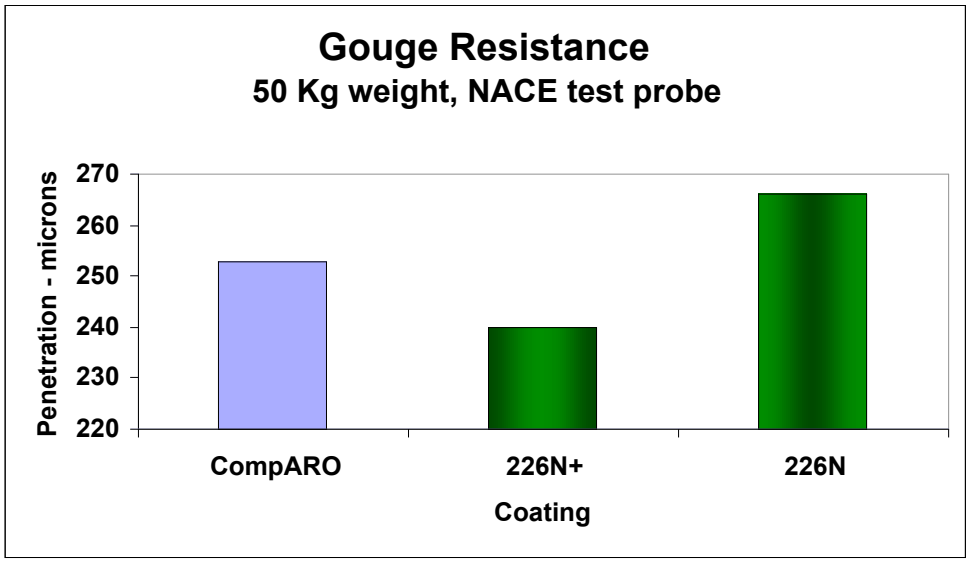


Moisture Vapor Transmission (MVT)

Property	Test Method	Value
MVT	Mil I 16923E	6.8 x 10^{-7} g/hr/cm/cm^2

Gouge Resistance

Property	Test Method	Value
Gouge Resistance	50 kg weight, NACE probe	240 m



Soil-Stress Resistance

Property	Test Method	Value
Soil Stress	National Bureau of Reclamation: 25 cycles of shear	No observable effect

Indentation Resistance

Property	Test Method	Value
Penetration	ASTM G 17: -40° to 116°C (-40° to 240°F), 2.5 kg (5.5 lb), 4.78 mm (0.187 in) diameter blunt indentor	0 mm (0 in)
	DIN 30670: 90°C 194°F, 2.5 kg (5.5 lb), 1,8 mm (0.071 in) diameter blunt indentor	0.05 mm (2 mils)

Coefficient of Friction

Property	Test Method	Value
Coefficient of Friction	API RP5L2 – 1968 Appendix 8	16°
Soil Friction	U.S. Steel Corp dry river sand. Test measures frictional resistance to longitudinal pipe movement	Friction factor 0.6 – 15% higher than bare pipe. No physical affects on the coating.

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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.

Important Notice

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B&W Distributors, Inc.
PO Box 21960
Mesa, AZ 85277

P: 480-924-8883
F: 480-924-9100

info@bwdist.com
www.bwdist.com

3M

Corrosion Protection Department
6801 River Place Blvd.
Austin, TX 78726-9000
www.3M.com/corrosion

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