3M™ Scotchkote™ Fusion Bonded Epoxy Coating 206N

Information, Properties and Test Results

Handling and Safety Precautions: Read all Health Hazard, Precautionary and First Aid, Safety Data Sheet, and / or product label prior to handling or use.

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1.0 General Information

1.1 Introduction

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

1.2 Description

Scotchkote coating 206N is a primerless, one-part, heat curable, thermosetting powdered epoxy coating designed to provide maximum corrosion protection to pipeline systems.

A fusion bonded coating utilizes heat to melt adhere the coating material to the metal substrate. As a pipeline coating, the term means a one-hundred percent solids, thermosetting, epoxy coating applied from the powdered state onto preheated pipe. The powder, when applied to the hot pipe, melts, flows and cures to a uniform, continuous, corrosion resistant coating.

1.3 Application and Availability

Scotchkote coating 206N 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, and air spray techniques.

1.4 History

Scotchkote fusion bonded epoxy coatings have been used extensively in the oil, gas, and water industries to coat the exterior and interior of pipe. Coated pipes have been installed throughout the world, and most major users recognize the advantage of the fusion bonded epoxy coating system.

1.5 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 inclement weather doesn't stop the coating operation and the process is ecologically controlled.

No proportioning, metering or mixing is required at the coating plant as this was carefully done during manufacture of the fusion bonded epoxy powder. The single-step electrostatic powder deposition produces a welladhered uniformed coating, even over the mill weld seam, which is often hard to coat using other coating systems.

High 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 are part of the permanent coating record.

1.6 Shipping and Storage Advantages

Because of the Scotchkote fusion bondeded epoxy 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.

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.

1.7 Installation Advantages

Pipe coated with 3M Scotchkote coating 206N can be installed easier, faster and at a competitive cost under widely varying temperature and weather conditions from arctic cold to tropical heat. Contour bends up to 3.2 degrees per diameter length can be made using conventional padded bending machines without damage to the external or internal coating.

Scotchkote coating 206N 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 has no effect on the coating.

Because of the coatings resistance to the heat of welding, only a small cutback is necessary. The small field joint helps reduce coating time, materials and cost.

Scotchkote coating 206N 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 3M Scotchkote Liquid Epoxy Coatings.

Field damage, should it occur, is easy to spot. It is not masked by outer wraps nor does it propagate or migrate. Repair is fast and easy using scotchkote liquid epoxy coatings for all applications or 3M Scotchkote Hot Melt Patchstick 226P (for non-potable water applications).

1.8 In-Service Advantages

Scotchkote coating 206N requires very low levels of supplementary cathodic protection even after extended periods of time. The coating does not shield protection currents so the cathodic protection system can operate at optimum efficiency and effectiveness.

Scotchkote coating 206N is designed to provide maximum corrosion protection under widely varying pipeline operating conditions.

The coating is unaffected by 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 coating 206N highly resistant to bacteria and fungus attack, soil acids, alkalies and salts, hydrocarbons, and other chemicals associated with pipeline use.

1.9 Cost Comparison

The “in-the-ground” cost of a coating includes not only the initial cost of application on pipe, but the transportation, handling and installation costs 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 coating 206N permits the contractor to employ cost saving construction practices and equipment. The coating will not strip off during plowing or river boring operations. Roller cradles and padded cinching devices are completely compatible with the coating.

1.10 Conclusion

Scotchkote coating 206N is used by many major oil, gas, and water companies as external and internal corrosion protection for pipeline systems up to 64 inches (1625 mm) in diameter. It meets the unusual storage, construction and service conditions which are encountered around the world. Its excellent in-service history makes Scotchkote coating 206N a coating system for all your pipeline coating needs.

2.0 Properties

Properties of the Powder		
Property	Test Method	Test Results
Classification	ASTM D 1763	Type 1, Grade 2
Color	—	Blue-Green
Fluid Bed Density	—	22-25 lbs/ft^3 0,36 - 0,40 gm/cm^3
Shelf Life (in original container)	—	12 Months when stored @ 80°F (27°C)
Particle Size	Alpine Air Sieve	>177 µm 1% or less < 44 µm 45%-60%
Angle of Response	—	38°
Minimum Explosion Concentration	Hartmann Dust Explosibility Bomb	0.10 oz/ft^3 102 g/m^3
Ignition Temperature	—	986°F (450°C)
Maximum Explosion Pressure	Hartmann Dust Explosibility Bomb	75 psig at 2.0 oz/ft^2 5,3 kg/cm^2 / sec at 204 g/m^3
Maximum Rate of Explosion Pressure Rise	Hartmann Dust Explosibility Bomb	1785 psi/sec at 1.0 oz/ft3 125 kg/cm2 / sec at 102 g/m3
Explosion Severity	Hartmann Dust Explosibility Bomb	0.7
Glow Temperature	—	842°F (450°C)
Average Heat of Polymerization: 206N	Differential Scanning Calorimeter	Typical Value: 43 J/gm
Glass Transition Temperature of Cured Coating	Differential Scanning Calorimeter - (midpoint)	Typical Value: 108°F/226°C

Property of the Coating

Hardness		
Property	Test Method	Test Results
Hardness	Buchholz DIN 53153	90 minimum
	Knoop, ASTM D 1474 25 g load, 18 cycles, 16 mil (400 µm) coating thickness	20
	Rockwell L	90
	Rockwell M	57
	Barcol ASTM D 2583	18
	Shore D	18
		32°F (0°C) 84 68°F (20°C) 84 140°F (60°C) 84 176°F (80°C) 84 212°F (100°C) 79

Property of the Coating Continued

Tensile Strength		
Property	Test Method	Test Results
Tensile Strength	ASTM D 2370 free film, 16 mil (400 µm) coating thickness	-49°F (-45°C) 11750 psi 823 kg/cm^2
		-18°F (-28°C) 10200 psi 715 kg/cm^2
		73°F (23°C) 9330 psi 654 kg/cm^2
		113°F (45°C) 5800 psi 406 kg/cm^2
		194°F (90°C) 2700 psi 191 kg/cm^2

Elongation		
Property	Test Method	Test Results
Elongation	ASTM D 2370 free film, 16 mil (400 µm) coating thickness	-49°F (-45°C) 3.4%
		-18°F (-28°C) 6.4%
		73°F (23°C) 6.9%
		113°F (45°C) 8.0%
		194°F (90°C) 52.0%

Impact Resistance		
Property	Test Method	Test Results
Impact	ASTM G 14, 5/8 in (1.6 cm) diameter tup, 15 mil (380 µm) coating on 0.125 in (3.2 mm) panel	-76°F (-60°C) 20 in-lbs 2,3 J
		-26°F (-60°C) 40 in-lbs 4,5 J
		32°F (0°C) 80 in-lbs 9,0 J
		73°F (23°C) 160 in-lbs 18,1 J

Abrasion Resistance		
Property	Test Method	Test Results
Abrasion	ASTM D 4060, CS-17 wheel, 1000 g load, 5000 cycles 73°F (23°C)	0,114 gram loss
	ASTM D 4060, CS-10 wheel, 1000 g load, 1000 cycles 73°F (23°C)	0,025 gram loss
	ASTM D 4060, CS-17 wheel, 1000 g load, 1000 cycles 73°F (23°C)	122°F (50°C) 0,021 gram loss 176°F (80°C) 0,029 gram loss 212°F (100°C) 0,036 gram loss
	ASTM D 968	>15.0 liters of sand per mil (25 µm)

Abrasion Strength		
Property	Test Method	Test Results
Shear	ASTM D 1002	6150 psi 433 kg/cm
Crosshatch	DIN 53151	Gt 0-1, no lifting of coating

Property of the Coating Continued

Shear Creep Deformation Resistance		
Property	Test Method	Test Results
Shear Adhesion	ASTM D 1002	6150 psi 433 kg/cm
Soil Stress	National Bureau of Reclamation 25 cycles shear	Unaffected by soil stress

Penetration Resistance		
Property	Test Method	Test Results
Penetration	ASTM G 17 0 -40° to 240°F (-40° to 116°C) 5.5 lb (2,5 kg) 0.1875 in (.475 cm) diameter blunt indentor	0
Chisel Penetration	Tennessee Gas Pipeline Company	55400 psi 382 MPa
Penetration	DIN 30670 at 194°F (90°C), 5.5 lb (2,5 kg), 0.072 in (.18 cm) diameter blunt indentor	0.2 mils
Compression Strength	ASTM D 695	11600 psi 819 kg/cm

Bendability				
Property	Test Method	Test Results		
Bend	Mandrel bend 15-19 mil (380-480 µm) coating thickness	Pipe Diam.	Elongation	Angle of Deflection (%PDL)
	72°F (22°C)	13.9	3.6	4.1
	20°F (-7°C)	18.5	2.7	3.1
	-3°F (-19°C)	18.5	2.7	3.1
	-17°F (-27°C)	18.5	2.7	3.1
	-40°F (-40°C)	23.1	2.2	2.5
	Mandrel bend 31 mil (800 µm) coating thickness			
	73°F (23°C)	15.1	3.3	3.8
	-40°F (-40°C)	57.3	0.9	1.0

Thermal - Mechanical		
Property	Test Method	Test Results
Thermal Conductivity	MIL-I-16923E	$6x10^{-4}$ cal/sec/cm^2/C°/cm
Thermal Shock	3M 10 cycles -100° to 300°F (-70° to 150°C)	Unaffected by thermal shock
Thermal Expansion Resistance	90 days in ice, 16 hours freeze, 8 hours heat, temperature range -80° to 250°F (-60° to 120°C) Test method: Tennessee Gas Pipeline Company	Unaffected by thermal cycling

Property of the Coating Continued

Volume Resistivity		
Property	Test Method	Test Results
Volume Resistivity	ASTM D 257	73°F (23°C) $1.3x10^{15}$ ohm•cm
		130°F (54°C) $5.0x10^{13}$ ohm•cm
		180°F (32°C) $1.0x10^{12}$ ohm•cm
	After 15000 hours immersion in 3% NaCl solution	73°F (23°C) $9.5x10^{13}$ ohm•cm
	1000 hours 3% NaCl with and without ±6 volt polarization	73°F (23°C) 2.0x1014 ohm•cm Final average of all test conditions

Electric Strength		
Property	Test Method	Test Results
Electric Strength	ASTM D 1000	73°F (23°C) 1150 v/mil 45 kv/mm
		180°F (82°C) 690 v/mil 27 kv/mm

Weathering Resistance		
Property	Test Method	Test Results
Weathering	ASTM G 53 QUV cyclic U.V weathering tester 1000 hours	Initial Gardner 60° specular gloss 36; final Gardner 60° specular gloss 2
Salt Fog	ASTM B 117 1000 hours ASTM G 53	No blistering, no discoloration, no loss of adhesion
Effects of Outdoor Weathering: Production coated pipe with a coating thickness of 16-18 mils (400-450 µm) was weathered outdoors for two years in a temperature climate having a temperature fluctuation range of -30° to 100°F (-35° to 40°C). Original samples and weathered samples were compared using cathodic disbonding and mandrel bend. The test results are as follows:		
Cathodic Disbondment	90 day, 5 volt, 5% NaCl 73°F (23°C)	33 mm - original 34 mm - weathered
Bend	Mandrel 73°F (23°C)	>4.0° per diameter length - original >4.0° per diameter length - weathered
The results indicate little, if any, change in the coating during the exposure period.		

Property of the Coating Continued

Cathodic Disbonding		
Property	Test Method	Test Results
Cathodic Disbondment	90 day, 5 volt, 5% NaCl 73°F (23°C)	Disbondment diameter 29 mm average**
	90 day, 1.5 volt, 3% ASTM G 8 salt solution, 73°F (23°C)	Disbondment diameter 24 mm average**
	90 day, 6 volt, 3% ASTM G 8 salt solution, 73°F (23°C)	Disbondment diameter 31 mm average**
	30 day, 6 volt, 5% NaCl 73°F (23°C)	Disbondment diameter 16 mm average**
	30 day, 6 volt, 3% NaCl sand crock 73°F (23°C)	Disbondment diameter 34 mm average**
	30 day, 5 volt, 3% NaCl sand crock 230°F (110°C)	Disbondment diameter 26 mm average**
	180 day, 1.5 volt, 3% ASTM G 8 salt solution, sand crock, 230°F (110°C) panel temperature, 26 mil (660 um) coating thickness	Disbondment diameter 39 mm average**
	7 day, 5 volt, 5% NaCl, 73°F (23°C) after bending at 3° per diameter length	Disbondment diameter 8,5m average**
	British Gas Corporation Specification PS/CW6 3% NaCl, 1.5 volt, 73°F (23°C)	Disbondment radius 1,4 mm after 28 days 2,5 mm after 56 days
	** Value includes 3,2 mm diameter of initial opening.	
	British Gas Corporation Specification PS/CW6 3% NaCl, 1.5 volt, 73°F (23°C) Coupon bent at 3°/PD	Disbondment radius 5,0 mm after 28 days no coating cracks
Soil Burial	12 months at 194°F (90°C) in 1000 ohm•cm water saturated soil, 1.5 volt cathodic protection	Disbondment diameter 29 mm average, good knife “X” adhesion.

Moisture Resistance		
Property	Test Method	Test Results
Moisture Vapor Transmission	MIL-I-16923E	$4.5x10^{-7}$ g/hr/cm/cm^2
	Tap water at 212°F (100°C) 1000 hours	Crosshatch adhesion per DIN 53151 Gt 0-1, no lifting of coating, good knife “X” adhesion
	DIN 53151, 10 cycles t 212°F (100°C), 20 hours in water, 20 hours in air.	Gt 0, no loss of gloss
Water Absorption	Immersion 24 hours at 73°F (23°C) ASTM D 570 DIN 53495 Process CL	0.83%
	10 mil (254 µm) coating on steel 500 hours at 73°F (23°C)	2.3%
	Immersion 672 hours ASTM D 570 10-12 mil (250-300 µm) thickness (free film) 140°F (60°C)	<3.0%
Synthetic Sea Water Resistance	Immersion 1 year at 212°F (100°C) production coated at 16 mil (400µm) thickness	Crosshatch adhesion per DIN 53151 Gt 0-1 no lifting of coating, good knife “X” adhesion

Property of the Coating Continued

Chemical Resistance		
Property	Test Method	Test Results
Chemical Resistance	30 day immersion at 100°F (38°C) a) HCL in water pH 2.5-3.0 b) HF in water pH 2.5-3.0 c) H_2SO_4 in water pH 2.8 d) NaCl, H_2SO_4 in water pH 3.0 (105 ppm chloride) e) NaCl in water, 10% concentrate f) Distilled water	No effect under all test conditions
	60 day immersion at 122°F (50°C) a) 5% NaOH b) 5% NaCl c) 1% Nitric Acid d) Saturated Magnesium Sulfate e) Calcium Carbonate Solution	No blistering, cracking, or disbonding under all test conditions
Sour Gas Resistance	50 day autoclave 180°F (82°C) 1900 psi (12.9 MPa) 3 rapid decompressions Test composition: Natural gas 92.24 mole % H_2S 0.62 mole % CO_2 4.97 mole % H_2O 0.014 mole %	No change, excellent “X” adhesion
Chemical Pressure Resistance	24 hour autoclave 200°F (93°C) 500 psi (3.4 MPa) Gas Phase 10% CO2 90% Nitrogen Liquid Phase (pH at 6.8)** 1570 ppm Sodium 618 ppm Calcium 94 ppm Magnesium 1248 ppm Sulfate 2755 ppm Chloride 195 ppm Bicarbonate Total: 6480 ppm **Samples half submerged in liquid phase	No effect on the coating

2.1 Service Temperature Range

Scotchkote coating 206N, when properly applied, should perform in a satisfactory manner on pipelines operating between -75° and 150°F (-60C and 65°C). For temperatures between 120° and 150°F (50° and 65°C), laboratory tests indicate thicker coatings may improve the service capability of the coating. However, it is difficult to accurately predict field performance from laboratory data due to the wide variation in actual field conditions. Soil types, moisture content, temperatures, coating thickness and other factors peculiar to the are all influence the coating performance and the upper temperature operating limit.

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