3M™ Scotchkote™ 206N Fusion Bonded Epoxy Coating

Information, Properties and Test Results

TABLE OF CONTENTS

General Information

SECTION 1

General Information

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 Coatings (FBEC) offer a significant improvement in pipeline coating technology.

2 - Description

The proposed coating is Scotchkote 206N FBEC manufactured by 3M in Austin, Texas. Scotchkote 206N FBEC 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.

3 - Application and Availability

Scotchkote 206N FBEC 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. For more complete details, see the “Coating Application” section. Coated pipe is available through numerous application plants around the world.

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. Over 62,000 miles (100,000 km) of coated pipe have been installed throughout the world, and most major users recognize the advantage of the fusion bonded epoxy coating system. Scotchkote 206N has been tested and certified to ANSI/NSF Standard 61, Drinking Water System Components.

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. All of this was carefully done during manufacture of the fusion bonded epoxy powder. The single-step electrostatic powder deposition produces a well-adhered uniformed coating, even over the mill 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.

6 - Shipping and Storage Advantages

Pipe coated with Scotchkote fusion bonded epoxy coatings can be stored for two years or more under most climactic 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.

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.

7 - Installation Advantages

Pipe coated with 3M™ Scotchkote™ 206N FBEC coating 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 206N FBEC 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 reduces coating time, materials and cost.

Scotchkote 206N FBEC 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. It is not masked by outer wraps nor does it propagate or migrate. Repair is fast and easy using liquid epoxy or hot melt compounds.

8 - In-Service Advantages

Scotchkote 206N FBEC 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 206N FBEC 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 FBEC highly resistant to moisture penetration, bacteria and fungus attack, soil acids, alkalies and salts, hydrocarbons, and other chemicals associated with pipeline use.

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 206N FBEC 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.

10 - Conclusion

Scotchkote 206N FBEC 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 206N a coating system for all your pipeline coating needs. 3M - the leading edge in coatings for over 40 years.

Coating Material

SECTION 2

Coating Material

1 - Description

3M™ Scotchkote™ 206N FBEC consists of a blend of epoxy resin and curing agent combined with additives, pigments, catalysts, leveling and flow control agents. Careful raw material selection was made by 3M to assure the coating will withstand environmental conditions encountered by underground and underwater pipelines. Scotchkote 206N coating is available in different gel and cure speeds to allow trouble-free production application on all pipe sizes in all coating plants and minimize downtime during product changeover. These variations are identified as Scotchkote 206N Fast, 206N Slow and 206N Standard FBEC.

Selection of the chemical elements for the fusion bonded epoxy coating is of prime importance. And 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 fusion bonded epoxy coating. The groups personnel have many years of experience in epoxy coating formulation and evaluation. This effort is assisted by staff laboratories 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 unusual performance and operational requirements.

2 - Manufacturing

All Scotchkote fusion bonded epoxy coating powders are made using the fusion blend process developed by 3M. Ingredients are first pulverized, properly proportioned and homogeneously dry mixed. Next, the blended materials are carefully and 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 any possibility of changes in reactivity due to separation or stratification of ingredients during transportation and application. 3M carefully selected raw materials to assure that Scotchkote 206N coating can withstand the harsh environmental conditions of underground and underwater pipelines.

3 - 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 assure uniformity of product application and performance. Among the quality control tests performed on Scotchkote 206N FBEC are: gel time, cure, flow, particle distribution, fluidization, bend, appearance and moisture content.

4 - Packaging, Storage, and Shipping

Scotchkote 206N fast, slow and standard coatings are packaged in a heavy-duty, polyethylene bag in a fiberboard carton which is clearly labeled with product number and manufacturing identification. This package protects the powder coating from humidity and contamination during shipment and storage. The net weight is 65 U.S. lbs (29.4 kilos). The sealed cartons are palletized on wooden pallets with a new weight of 1170 lbs (530 kilos) and securely banded for shipment. The packaged product must be shipped and stored at temperatures not to exceed 80°F (27°C). Alternate packaging is also available.

3M™ Scotchkote™ 206N Fusion Bonded Epoxy Coating

5-Properties of the Powder

Property	Test Method	Test Results
Classification	ASTM D 1763	Type 1, Grade 2
Color	—	Blue-Green
Specific Gravity: Powder Cured Film	 Air pycnometer Volume displacement	 1,44 ±0,03 1,36
Fluid Bed Density	—	22-25 lbs/ft^3 0,36 - 0,40 gm/cm^3
Coverage	Calculated from air pycnometer specific gravity of powder	134 ft^2/lb/mil 0,695 m^2/kg/mm
Shelf Life (in original container)	—	1 year minimum at 80°F (27°C)
Gel Time: 206N Fast 206N Slow 206N Standard	 Hot Plate 450°F (232°C)	 3-5 seconds 7-13 seconds 18-25 seconds
Cure Time: 206N Fast 206N Slow 206N Standard	 —	 See Curve, page 12 See Curve, page 13 See Curve, page 14
Moisture Content at time of manufacture	Karl Fischer	<0.3%
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/ft^3 125 kg/cm^2 / sec at 102 g/m^3
Explosion Severity	Hartmann Dust Explosibility Bomb	0.7
Glow Temperature	—	842°F (450°C)
Average Heat of Polymerization: 206N Fast 206N Slow 206N Standard	 Differential scanning Calorimeter	 Typical Value: 54 J/gm 62 J/gm 43 J/gm
Glass Transition Temperature of Cured Coating	Different Scanning Calorimeter - (midpoint)	Typical Value: 108°F/226°C

6 - Properties of the coating

All tests have been conducted at 73°F (23°C) unless otherwise noted.

6.1 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	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

6.2 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

6.3 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%

6.4 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 (-32°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

6.5 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	122°F (50°C) 0,021 g loss 176°F (80°C) 0,029 g loss 212°F (100°C) 0,036 g loss
	ASTM D 968	>15.0 liters of sand per mil (25 μm)

6.6 Adhesive Strength

Property	Test Method	Test Results
Shear	ASTM D 1002	6150 psi 433 kg/cm^2
Crosshatch	DIN 53151	Gt 0-1, no lifting of coating

6.7 Shear Creep Deformation Resistance

Property	Test Method	Test Results
Shear Adhesion	ASTM D 1002	6150 psi 433 kg/cm^2
Soil Stress	National Bureau of Reclamation 25 cycles shear	Unaffected by soil stress

6.8 Penetration Resistance

Property	Test Method	Test Results
Penetration	ASTM G 17 -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 0,005 mm
Compression Strength	ASTM D 695	11600 psi 819 kg/cm^2

3M Scotchkote™ 206N Fusion Bonded Epoxy Coating

6.9 Bendability

3M™ Scotchkote™ 206N FBEC meets the ANSI B31.4 and B31.8 pipe field bending requirements

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 mils (800 um) coating thickness			
	73°F (23°C)	15.1	3.3	3.8
	-40°F (-40°C)	57.3	0.9	1.0

6.10 Coefficient of Friction

Property	Test Method	Test Results
Coefficient of Friction	API RP5L2 -1968 Appendix 8	10.8°
	206N to 206N	19.0°
Soil Friction	U.S. Steel Corp. dry river sand. Test measures frictional resistance to longitudinal pipe movement.	Friction factor 0.619 15% higher than bare pipe. No physical effects on the coating

6.11 Thermal - Mechanical

Property	Test Method	Test Results
Thermal Conductivity	MIL-I-16923E	$6x10^{-4}$ cal/sec/cm²/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

6.12 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 Final average of all test conditions	(23°C)	$2.0x10^{14}$ ohm•cm

6.13 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

6.14 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:

Property	Test Method	Test Results
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.

6.15 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, 3% NaCl, 73°F (23°C)	Disbondment diameter 16 mm average**
	30 day, 6 volt, 3% NaCl sand crock, 176°F (80°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 8,5 mm 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.

6.15 Cathodic Disbonding (Continued)

	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.

6.16 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 at 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 6500 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

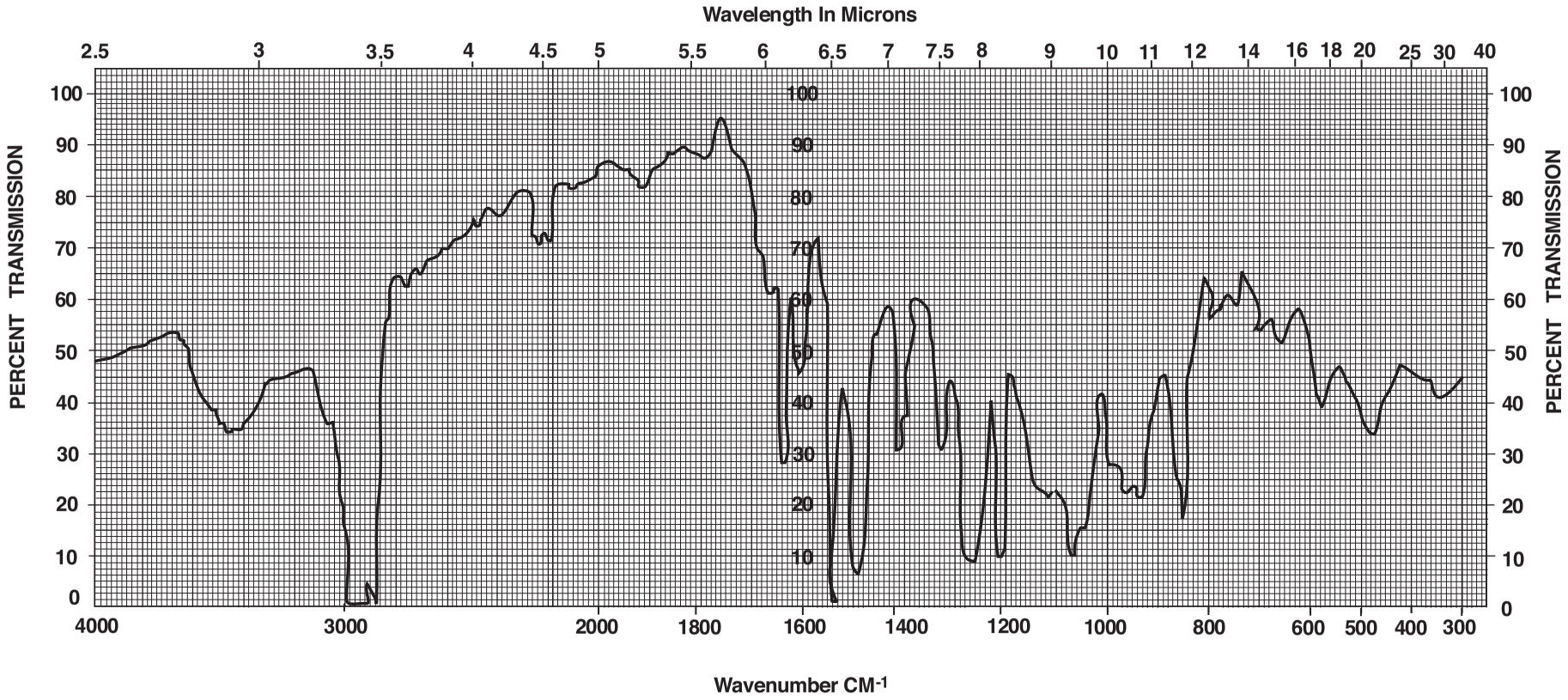
6.17 Chemical Resistance

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% CO_2 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	No effect on the coating

**Samples half submerged in liquid phase.

Instrumental Analysis Charts

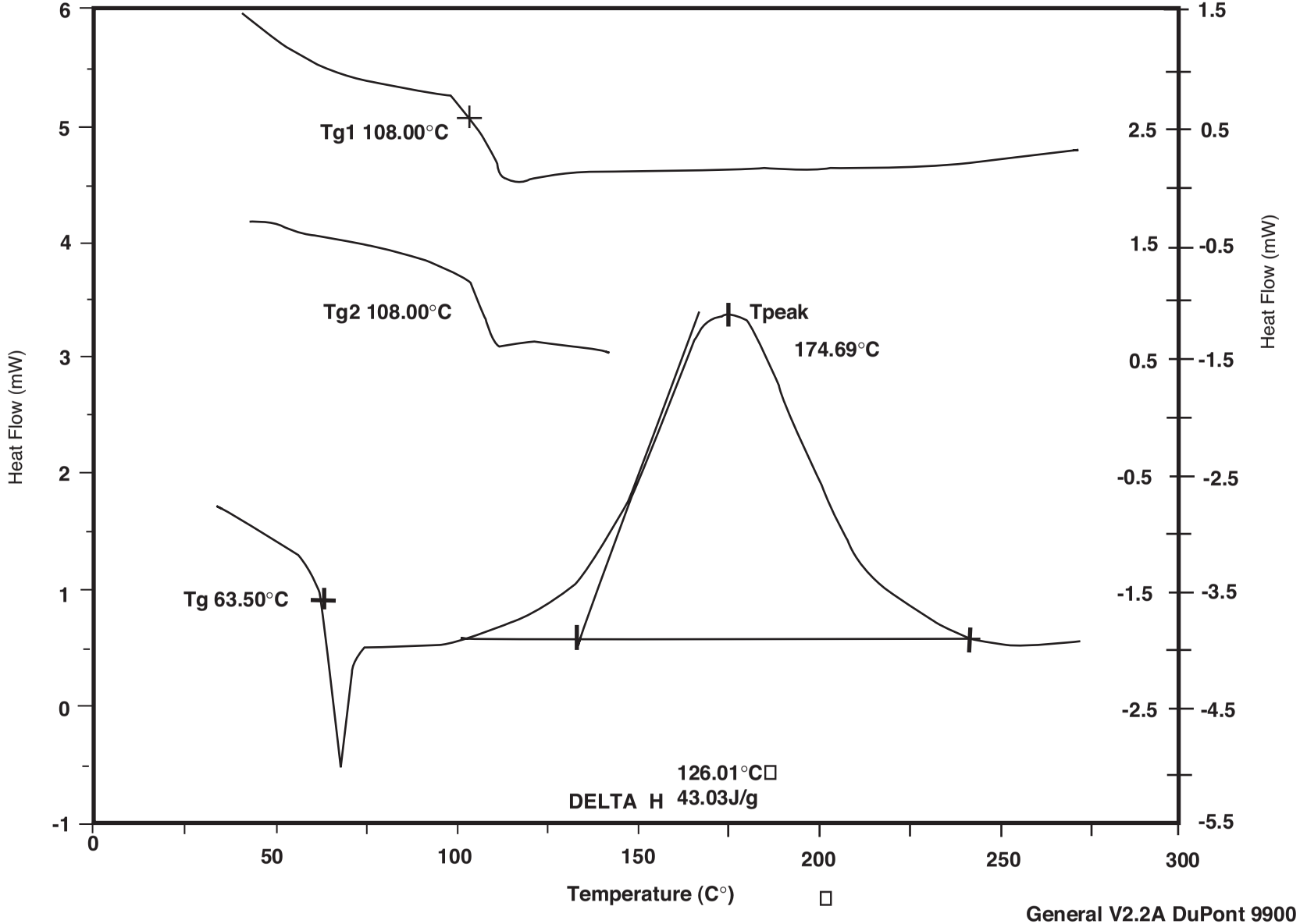
3M™ Scotchkote™ 206N Slow,Fast, Standard FBEC



DSC

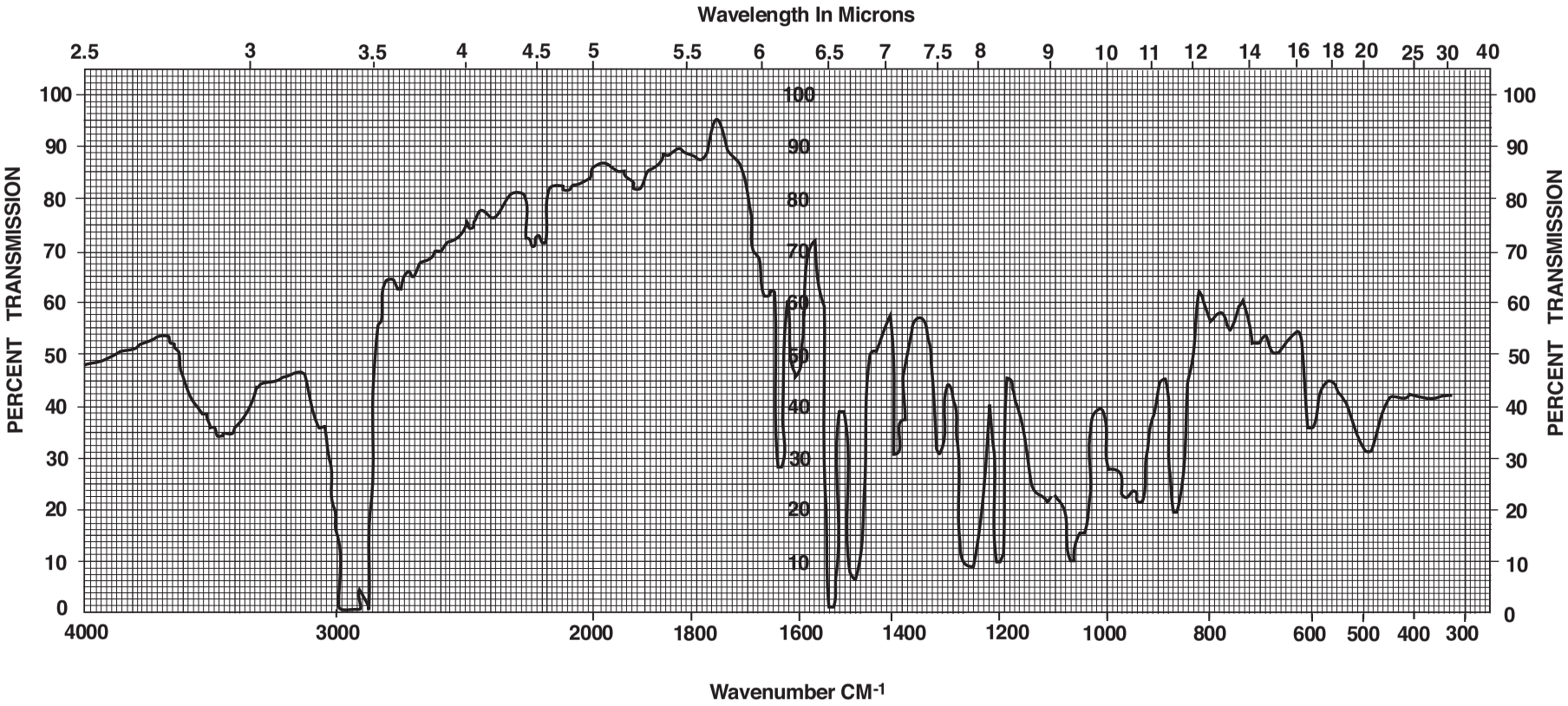
Sample: 3M™ Scotchkote™ 206N Slow FBEC
Size: 7.3000 mg
Method: 206N
Comment: 20°C/MIN-60°C, 20°C/MIN-2800°C, 20°C/MIN-280°C, 20°C/MIN-150°C, N2

File: SK206NSLOW.01
Operator: K.LAABS



General V2.2A DuPont 9900

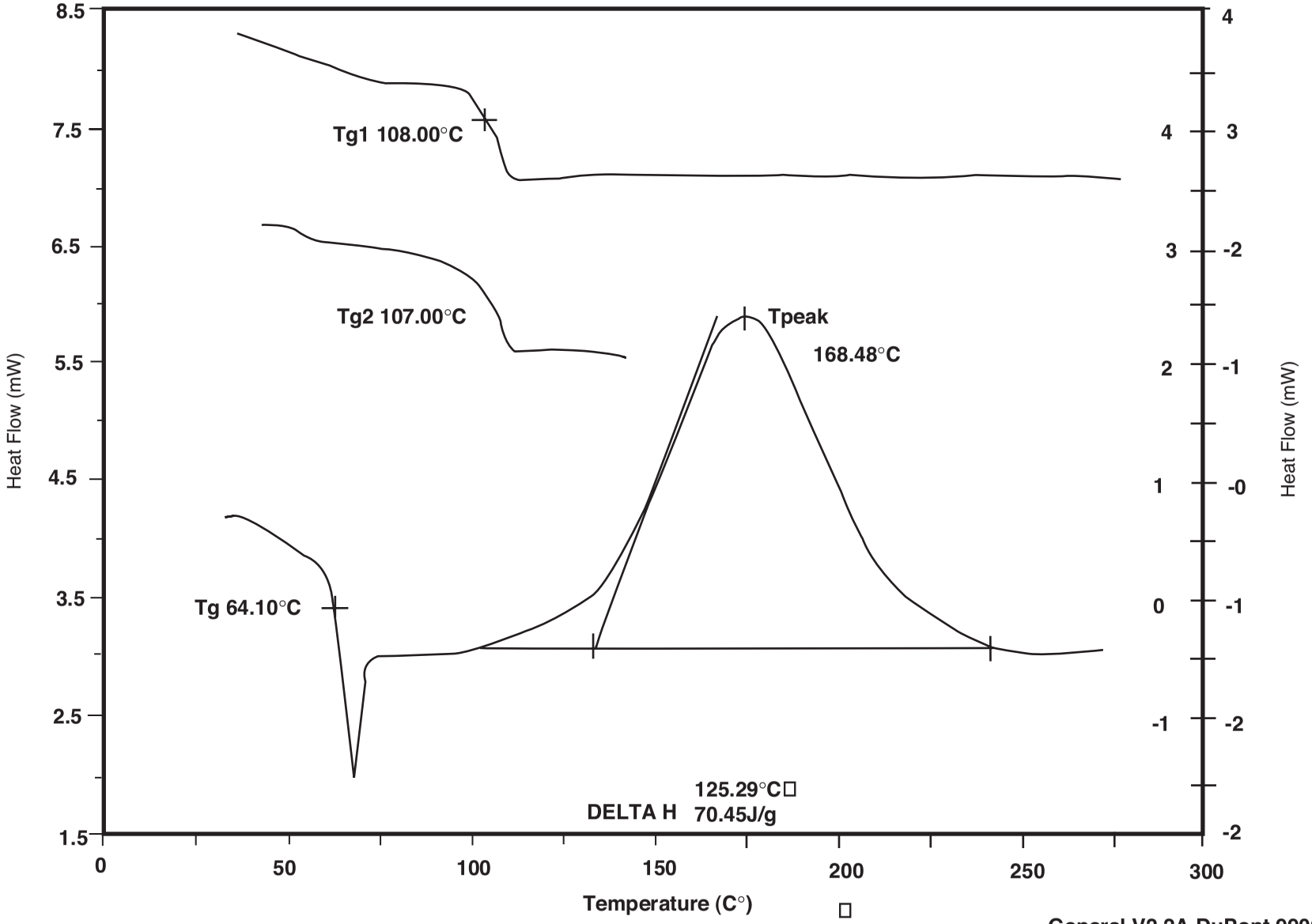
3M™ Scotchkote™ 206N Standard FBEC



DSC

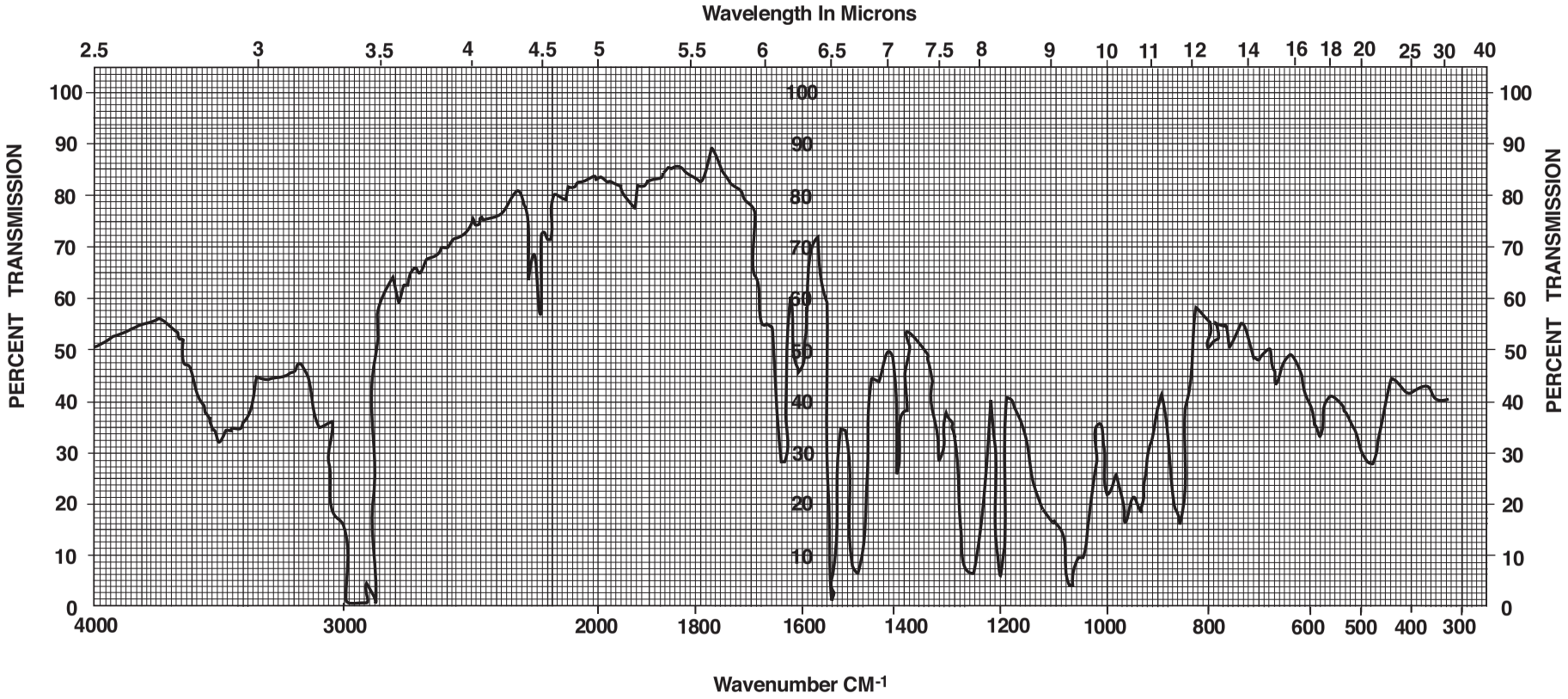
Sample: 3M™ Scotchkote™ 206N FAST FBEC
Size: 7.1000 mg
Method: 206N
Comment: 20°C/MIN-60°C, 20°C/MIN-280°C, 20°C/MIN-280°C, 20°C/MIN-150°C, N2

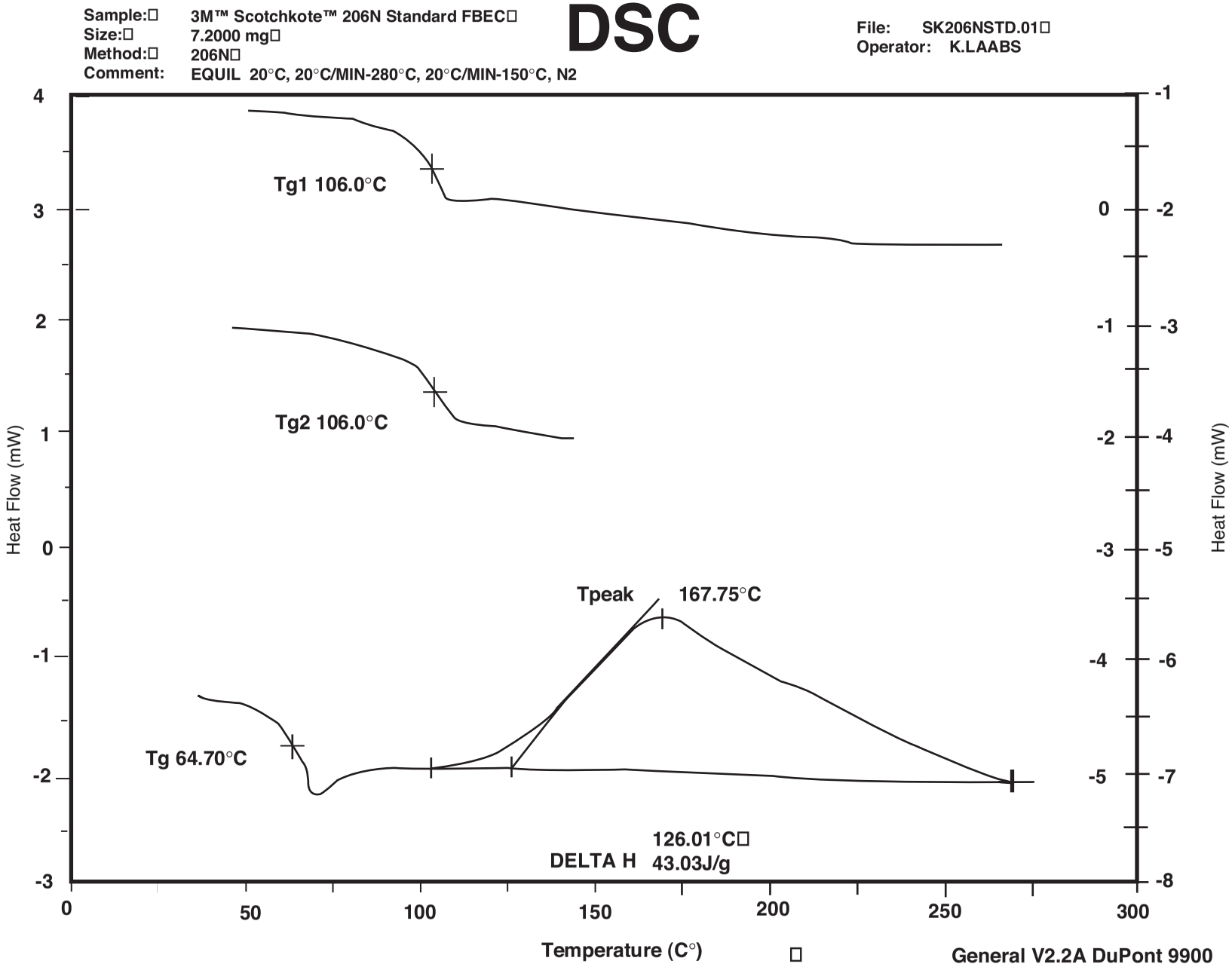
File: SK206NFAST.01
Operator: K.LAABS



General V2.2A DuPont 9900

3M™ Scotchkote™ 206N Standard FBEC

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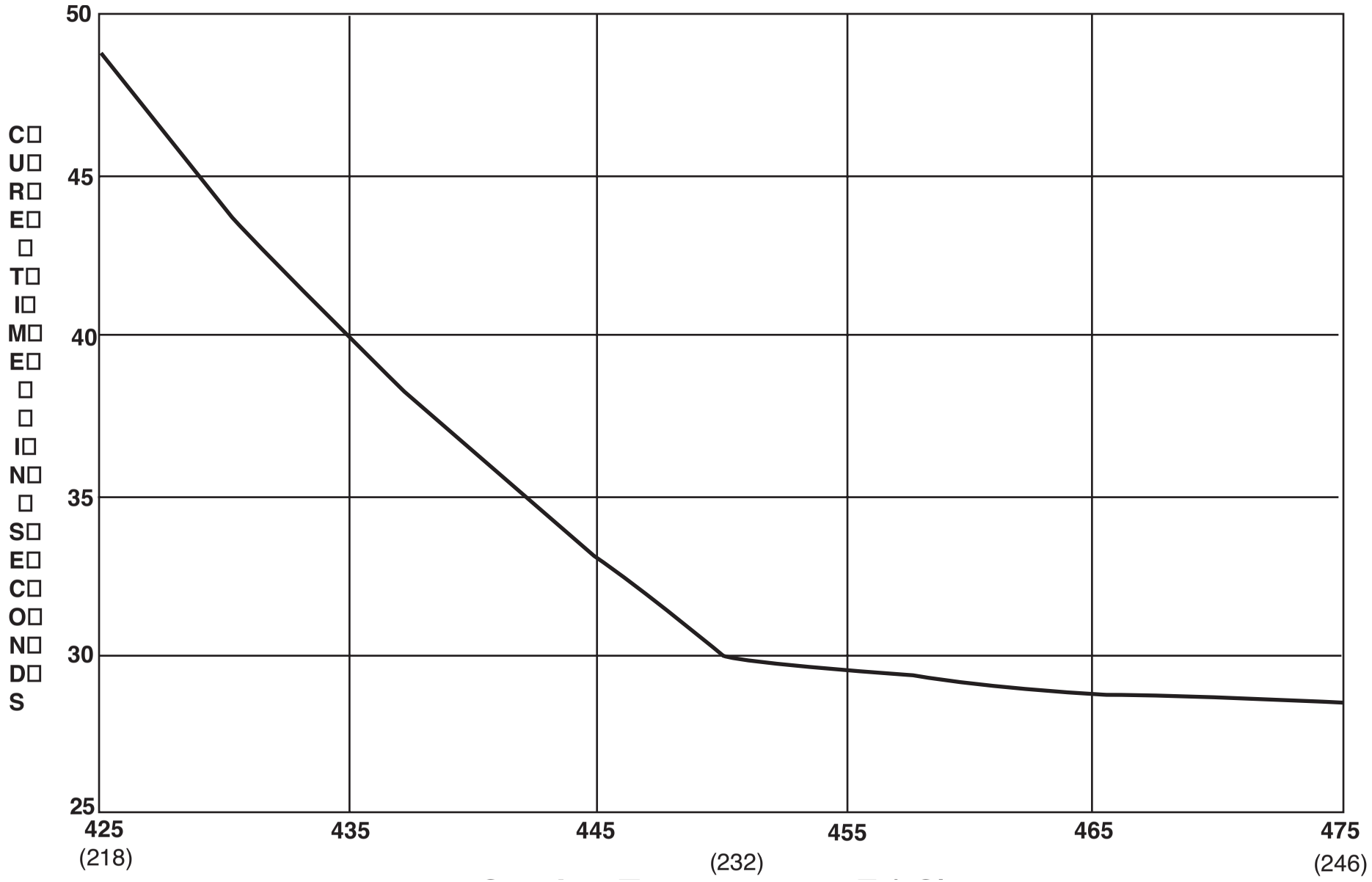
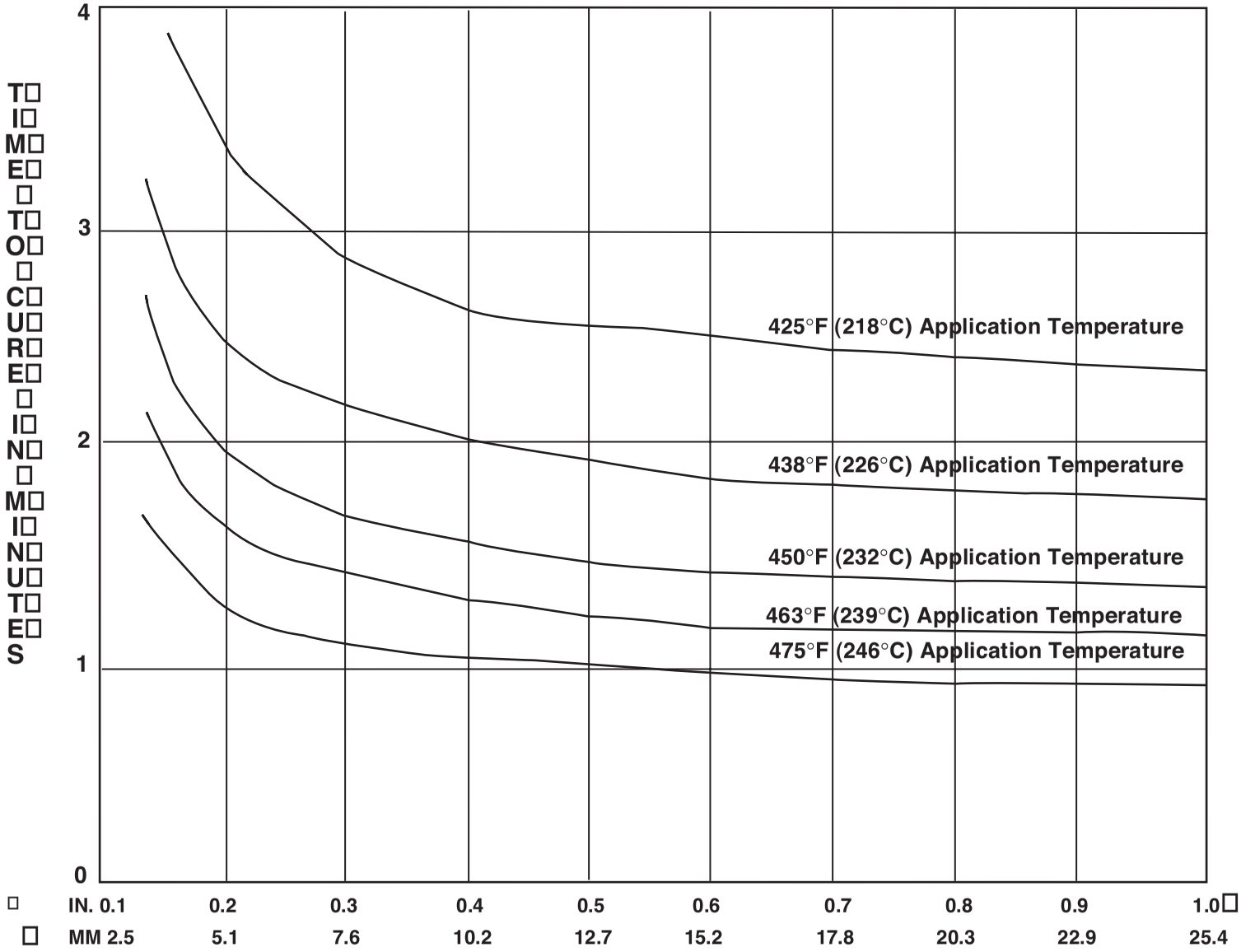
Size: 7.2000 mg
Method: 206N
Comment: EQUIL 20°C, 20°C/MIN-280°C, 20°C/MIN-150°C, N2
DSC
File: SK206NSTD.01
Operator: K.LAABS
Tg1 106.0°C
Tg2 106.0°C
Tpeak 167.75°C
Tg 64.70°C
126.01°C
DELTA H 43.03J/g
Heat Flow (mW)
Heat Flow (mW)
Temperature (C°)
General V2.2A DuPont 9900

3M™ Scotchkote™ 206N Fast FBEC – Time to Cure vs Temperature

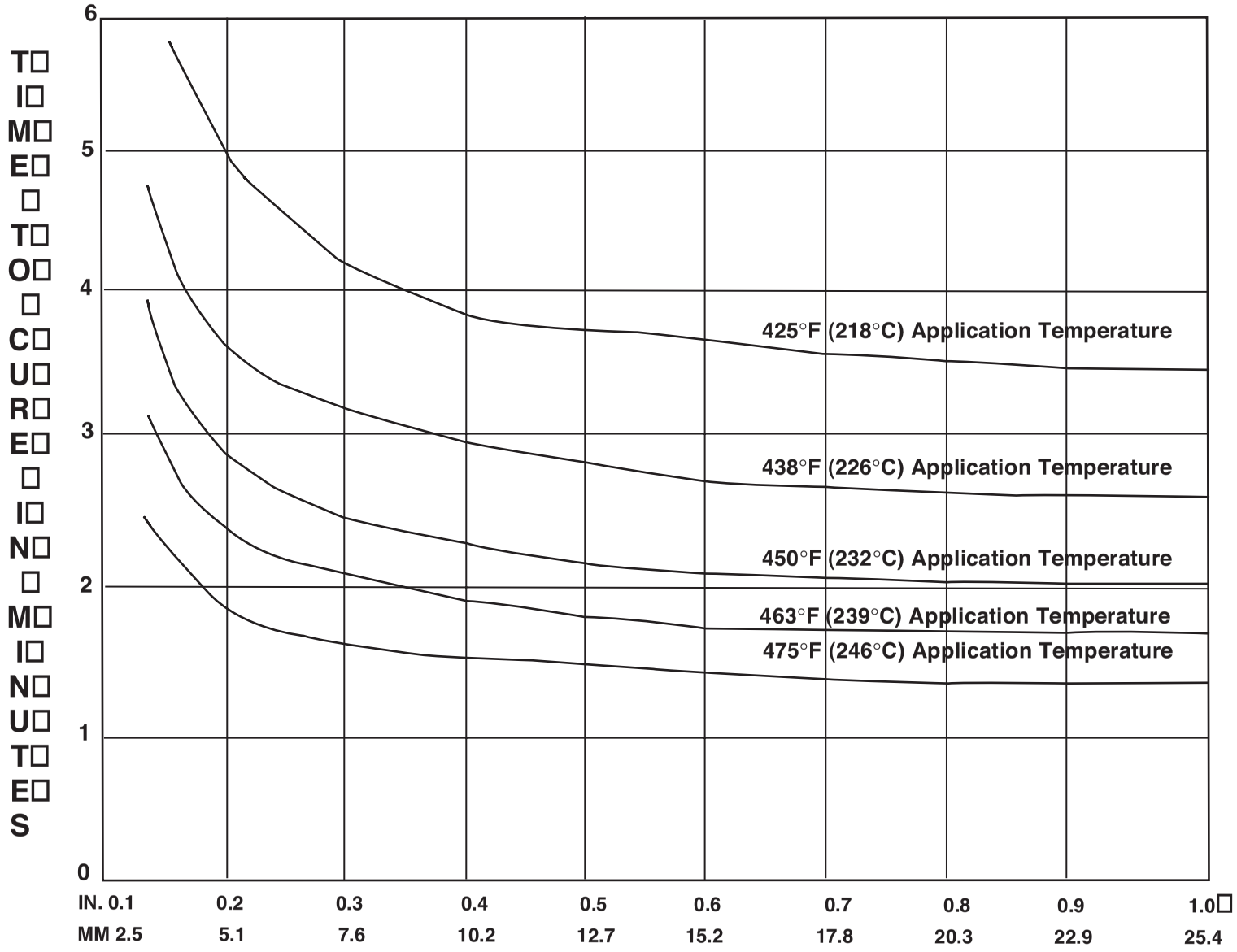


3M™ Scotchkote™ 206N Slow FBEC – Time to Cure vs Wall Thickness



Pipe Wall Thickness in inches and Millimeters

3M™ Scotchkote™ 206N Standard FBEC – Time to Cure vs Wall Thickness



Pipe Wall Thickness in inches and Millimeters

Handling and Safety Precautions

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

Ordering Information/Customer Service

For ordering technical or product information, or a copy of the Material Safety Data Sheet, call:
Phone: 800/722-6721 or 512/984-9393
Fax: 877/601-1305 or 512/984-6296

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