

ABRASION

METHOD:	ASTM D 4060-14 (CS-17 Wheel, 1,000 cycles, 1,000 gram load).
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	No more than 41 mg loss, average of three tests. (TR6742)
METHOD:	BS EN 598: 2007+A1: 2009 (Rocking Abrasion).
SYSTEM:	Series 431 Perma-Shield PL applied to NAPP 500-03-04 Abrasive Blast Cleaned ductile iron pipe.
REQUIREMENT:	No more than 0.01 mm (0.6 mils) thickness of coating loss after 50,000 cycles. (TR6207-B)
METHOD:	BS EN 598: 2007+A1: 2009 (Rocking Abrasion).
SYSTEM:	Series 431 Perma-Shield PL applied to NAPP 500-04-03 Abrasive Blast Cleaned ductile iron pipe.
REQUIREMENT:	No more than 0.14 mm (5.5 mils) thickness of coating loss after 1,000,000 cycles. (TR6206-B)
METHOD:	ASTM D 968-15.
SYSTEM:	Series 431 Perma-Shield PL applied to SSPC-SP5/NACE No. 1 White Metal Blast Cleaned steel.
REQUIREMENT:	No more than 500 Liters/mil (25 microns) loss. (TR6596)

ADHESION

METHOD:	ASTM D 4541-09e1 (Method E, Type V Tester, 20mm).
SYSTEM:	Series 431 Perma-Shield PL applied to SSPC-SP5/NACE No. 1 White Metal Blast Cleaned steel.
REQUIREMENT:	No less than 2,909 psi (20.6 Mpa) following Thermal Cycling, average of three tests. (TR6941-A)
METHOD:	ASTM D 4541-09e1 (Method E, Type V Tester, 20mm).
SYSTEM:	Series 431 Perma-Shield PL applied to NAPP 500-03-04 Internal Pipe Surface Condition (full removal of annealing oxide layer) cleaned ductile iron.
REQUIREMENT:	No failure. Adhesion strength greater than 3,000 psi (20.68 MPa), average of three tests. (TR6597)

CATHODIC DISBONDMENT

METHOD:	ASTM G 8-96 (2003) e1.
SYSTEM:	Series 431 Perma-Shield PL applied at 37 mils average DFT.
REQUIREMENT:	Classification Group A. No more than 0.00 inch (0.00 mm) disbanded equivalent circle diameter, average of two tests. (TR6210)

CHEMICAL IMMERSION

METHOD:	NACE TM 0174-2002.
SYSTEM:	Series 431 Perma-Shield PL applied to SSPC-SP5/NACE No. 1 White Metal Blast Cleaned steel.
REQUIREMENT:	No blistering, cracking, checking, erosion or delamination of film after one year continuous immersion at 72°F (22°C). (TR6211)

Reagents:

Hydrochloric Acid 5%	Sulfuric Acid 5%
Hydrochloric Acid 10%	Sulfuric Acid 25%
Sodium Hypochlorite 13%	Sulfuric Acid 50%
Sodium Potassium Acetate 50%	Urea Liquid

NOTE: This is a partial list of chemical data. Please refer to Tnemec's online Chemical Resistance Guide for a comprehensive list of chemicals and exposures.

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CHEMICAL RESISTANCE

METHOD: BS EN 598: 2007+A1: 2009 (Chemical Resistance to Effluents).
SYSTEM: Series 431 Perma-Shield PL applied to NAPF 500-04-03 Abrasive Blast Cleaned ductile iron pipe.
REQUIREMENT: No blistering, checking, disbonding, softening, discoloration or loss of gloss following six months immersion, recirculated at 1.0 l/min and maintained at 64°F (18°C). (TR6217-A)

Reagents:

Sulfuric acid solution, pH 3
Sodium hydroxide solution, pH 13

DIELECTRIC STRENGTH

METHOD: ASTM D 149.
SYSTEM: Series 431 Perma-Shield PL.
REQUIREMENT: Not less than 618 V/mil dielectric strength, average of five tests. (TR6183-B)

HARDNESS

METHOD: ASTM D 2240-05.
SYSTEM: Series 431 Perma-Shield PL.
REQUIREMENT: No less than a Shore Type D hardness of 78, average of five tests. (TR6185-A)

IMMERSION

METHOD: ASTM D 870-09.
SYSTEM: Series 431 Perma-Shield PL applied to NAPF 500-04-03 Abrasive Blast Cleaned ductile iron pipe.
REQUIREMENT: No rusting, cracking, checking, or delamination of film after 4,000 hours continuous immersion in 140°F deionized water. (TR6209-A)

IMPACT

METHOD: ASTM D 2794-93 (2010) (modified)
SYSTEM: Series 431 Perma-Shield PL applied to SSPC-SP5/NACE No. 1 White Metal Cleaned steel.
REQUIREMENT: No visible cracking or delamination of film after 160 inch-pounds direct impact to 1/8 inch steel panel. (TR6243)

METHOD: ASTM D 2794-093 (2010) (modified)
SYSTEM: Series 431 Perma-Shield PL applied to NAPF-500-04-03 ductile iron pipe panel.
REQUIREMENT: No visible cracking or delamination of film after 160 inch-pounds direct impact to Class 350 ductile iron pipe panel. (TR6243)

SALT SPRAY (FOG)

METHOD: ASTM B 117-09.
SYSTEM: Series 431 Perma-Shield PL applied to ductile iron.
REQUIREMENT: No blistering, cracking or delamination of film after 10,000 hours exposure. (TR6241)

SEVERE WASTEWATER ANALYSIS TEST (S.W.A.T.)

METHOD: ASTM G 210.
SYSTEM: Series 431 Perma-Shield PL applied to SSPC-SP5/NACE No. 1 White Metal Blast Cleaned steel.
REQUIREMENT: Initial impedance of 11.18 log-Z at 0.001 Hz (ohms cm²). No blistering, cracking, checking or delamination. No less than 88.7% EIS retention or not more than 1.26 ohms cm² reduction in log-Z electrochemical impedance at 0.001 Hz after 28 days exposure. No less than 2,363 psi (16.30 MPa) adhesion or no loss of adhesion after 28 days in S.W.A.T., average of three tests. (TR6733)

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SPECIAL QUALIFICATIONS

METHOD:	Ductile Iron Pipe Research Association (DIPRA).
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	Ceramic filled amine epoxy containing 20% ceramic microspheres suitable for use in 120-150°F operating temperature septic sewers.
NOTE:	Contact your Tnemec representative for additional information on specific uses and maximum operating temperatures.
METHOD:	High-Velocity Jet Sewer Cleaning (Hydrocleaning).
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	Compatible with 2,500 psi (172 bar) water pressure. 80 gpm (302 Lpm) flow rate, 0° fixed jet nozzles, 60s stationary time (hold time).
NOTE:	Reference Tnemec Technical Bulletin No. 11-86, <i>Series 431 Perma-Shield PL High-Velocity Jet Cleaning (Hydrocleaning) Guidelines</i> .
METHOD:	Above Ground Storage Life.
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	Up to 3 years (exposure) with only minor chalking, no cracking, checking, rusting, undercutting or disbondment of the film.
NOTE:	Interior of steel or ductile iron pipe fittings. Contact your Tnemec representative for additional information.
METHOD:	AWWA C 210.
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	Meets the requirements set forth in AWWA C210-15 testing.

TENSILE STRENGTH, ELONGATION, MODULUS OF ELASTICITY

METHOD:	ASTM D 2370-98 (2010)
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	No less than 3,400 psi (23.4 MPa) tensile strength, 3.5% elongation at break, and 152,000 psi (1,048 MPa) tensile modulus of elasticity, average of ten tests. (TR6242-A)

WATER ABSORPTION

METHOD:	ASTM C 413-01 (2006).
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	No water absorption, average of three tests. (TR6188-C)

WATER VAPOR TRANSMISSION

METHOD:	ASTM E 96/E96M-2013 (Method A, Condition A).
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	No more than 0.104 perms (0.068 metric perms) water vapor permeance (WVP). (TR6613)
METHOD:	ASTM D 1653 (2008) (Method A, Condition A).
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	No more than 0.71 g/m ² per 24h water vapor transmission (WVT) and no more than 0.104 perms (0.068 metric perms) water vapor permeance (WVP). (TR6598-A)
METHOD:	ASTM D 1653-03 (2008) (Method B Wet Cup, Condition C).
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	No more than 1.25 g/m ² per 24h water vapor transmission (WVT), and no more than 0.09 perms (0.06 metric perms) water vapor permeance (WVP), average of three tests. (TR6186-D)
METHOD:	ASTM E 96/E96M-05 (Procedure D).
SYSTEM:	Series 431 Perma-Shield PL.
REQUIREMENT:	No more than 0.09 perms (0.06 metric perms) water vapor permeance (WVP), average of three tests. (TR6208)

This product will meet or exceed the above test requirements established for the coating systems listed. Test performance results were obtained in a controlled environment and Tnemec Company makes no claim that these tests or any other tests accurately represent all environments. As application, environmental and design factors can vary significantly, due care should be exercised in the selection and use of the coating. Published technical data is subject to change without notice. The online catalog at www.tnemec.com should be referenced for the most current technical data and instructions. For additional performance criteria and specific test results, contact Tnemec Company or its representative.

