



Tnemec Series 431 Perma-Shield® PL



TNEMEC

TNEMEC'S SEVERE WASTEWATER SYSTEMS

Key Value Proposition

- Tnemec manufactures various high-performance lining technologies for corrosive environments
 - Vinyl esters, polyureas, polyurethane elastomers, polyurethane hybrids (fast-sets), novolac epoxies, 100% solids epoxies, etc.
 - Various substrates (concrete, steel, cast-iron/ductile iron pipe/fittings)
- Systematic approach for product selection
 - Job, structure, substrate, exposure, contractor capabilities
- Performance-driven lining technologies
- Contractor-friendly materials
 - Greater likelihood of successful application
- Over 5,000,000 square feet in highly aggressive environments have been protected with Perma-Shield[®] epoxy.

TNEMEC'S SEVERE WASTEWATER SYSTEMS

Perma-Shield® Systems

- High-build, 100% solids modified polyamine epoxy technology designed for the protection of steel, ductile iron and concrete in severe domestic wastewater collection and treatment environments
 - Manholes
 - Lift Stations
 - Interceptors
 - Headworks
 - Treatment Structures
 - Ductile Iron Pipe and Fittings
- Versatile Product Line:
 - Series 431 Perma-Shield PL: ceramic epoxy lining for steel/DIP pipe
 - Series 434 Perma-Shield H₂S: trowel-applied polymeric mortar
 - Series 435 Perma-Glaze: high-build composite liner
 - Series 436 Perma-Shield FR: high-build, fiber-reinforced composite liner

Background

- Ductile Iron Pipe and Fittings traditionally lined with ceramic quartz filled amine epoxy for:
 - Septic Sewers
 - Acids
 - Alkali Waste
 - Pickling Brine
 - Reclaimed Water



Ceramic Epoxy Linings

- Traditional ceramic quartz filled amine cured epoxies are not providing anticipated corrosion protection.
- Competitors' "ceramic" linings use fly ash and are not truly ceramic.
- Series 431 contains ceramic hollow microspheres for greater abrasion resistance.

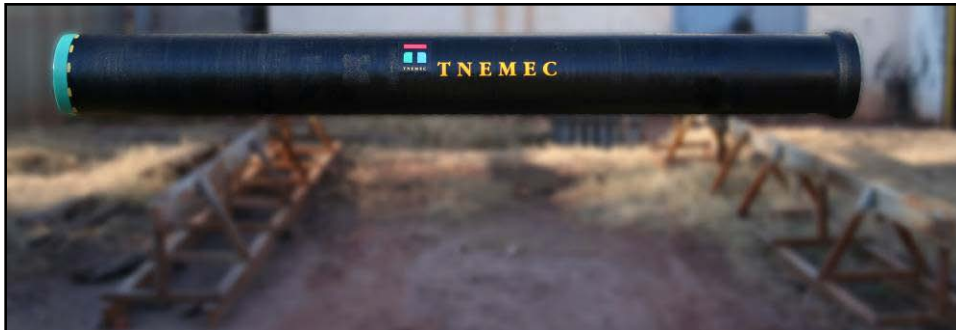


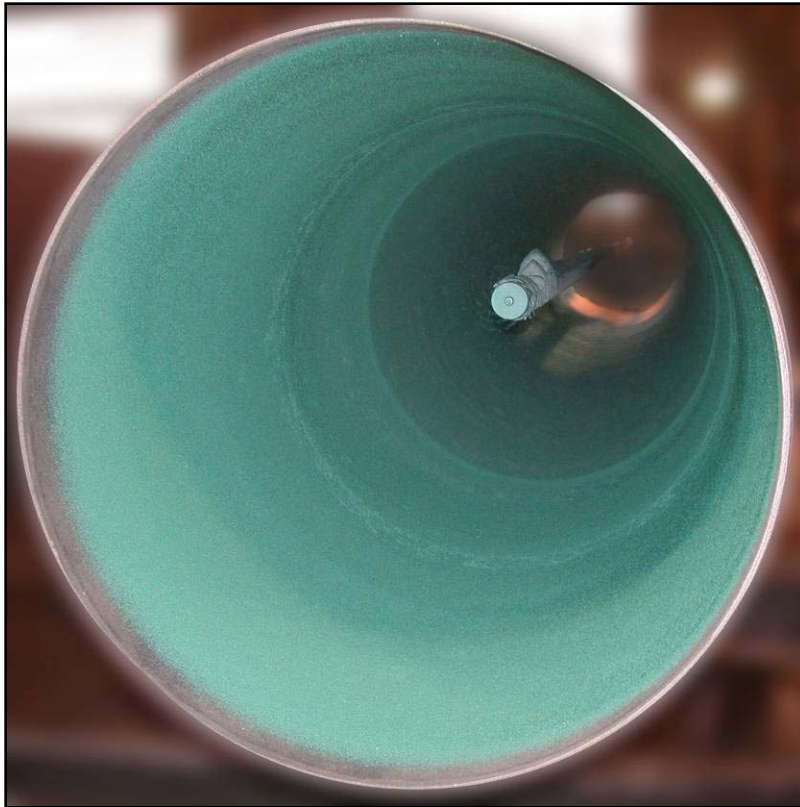
Common DIP ceramic linings

TNEMEC'S PERMA-SHIELD® SYSTEMS

Series 431 Perma-Shield PL

- 100% volume solids, ceramic modified epoxy liner for interior of steel & ductile iron pipe and fittings for domestic sewage
- Steel: 30-50 mils (762-1270 microns)
- Ductile Iron: 40 mils (1016 microns) (nominal)
- Color: 5024 Sewer Pipe Green
- Contains zero hazardous air pollutants (HAPs)
- Extended above ground storage ability





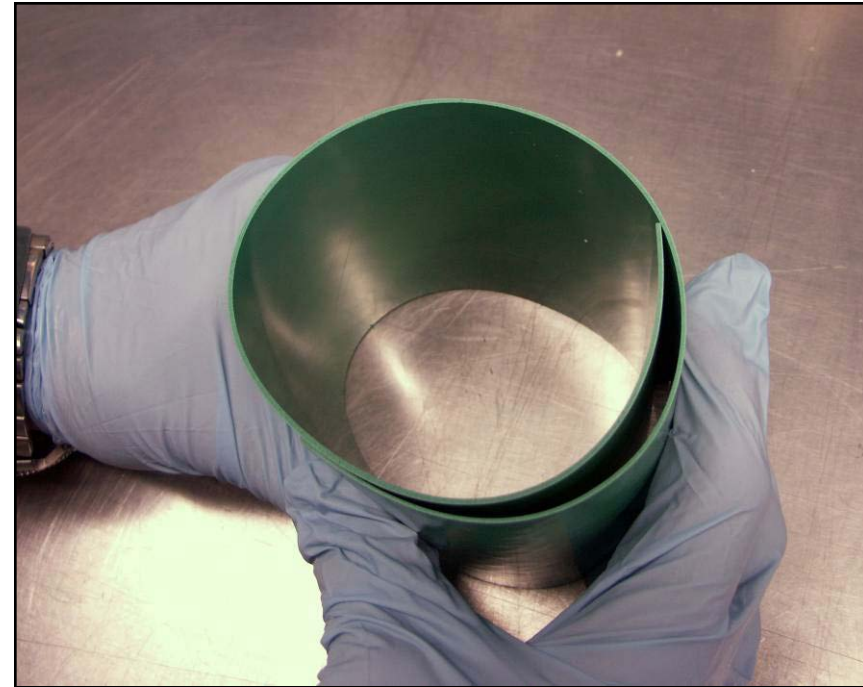
Series 431 Perma-Shield PL—
Ductile Iron Pipe



Series 431 Perma-Shield PL—Cast
Iron Fittings

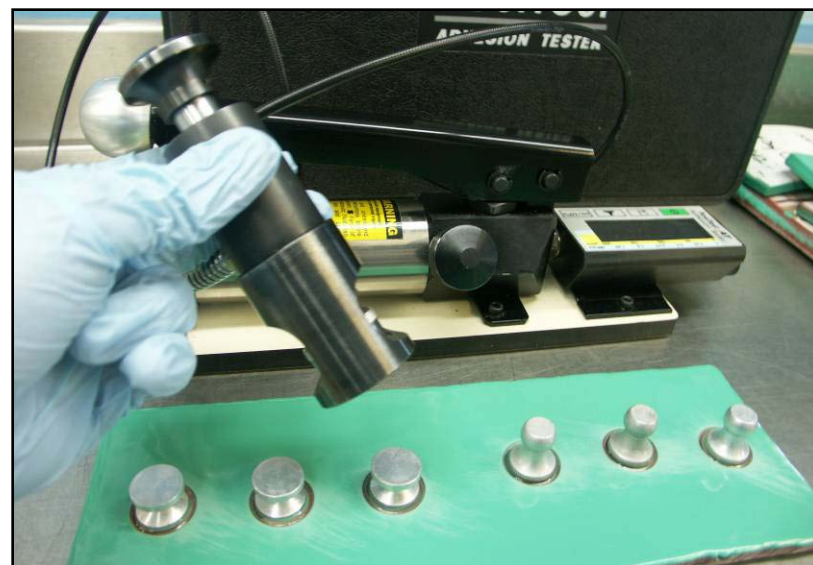
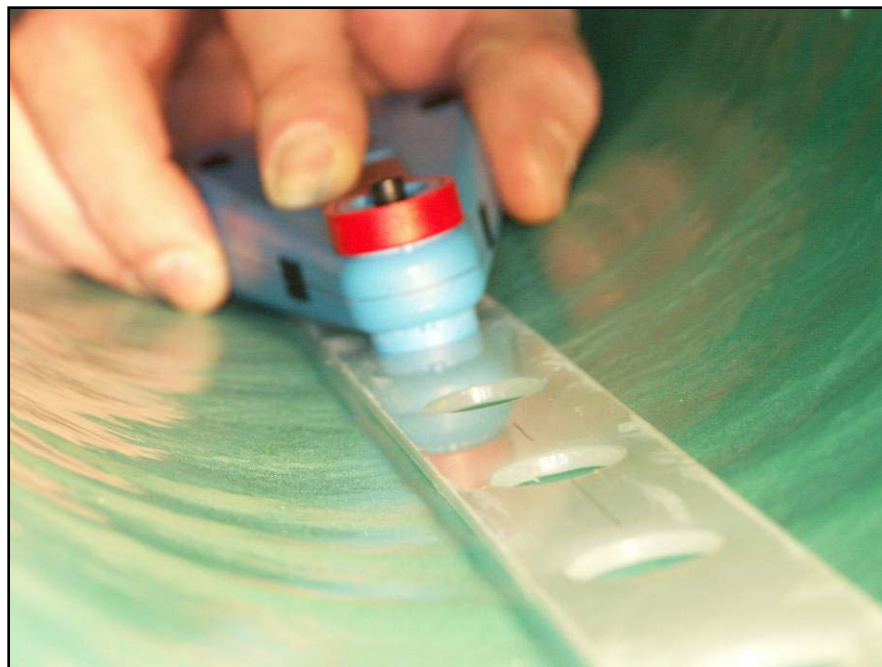
Coal Tar Free / Minimal Fillers

- Series 431 contains no coal tar, a known carcinogen which contributes to UV instability/film embrittlement.
- Series 431 is isocyanate-free
- The filler content (PVC) of Series 431 is less than 22%, about 20% of which is composed of ceramic microspheres.
- Series 431 provides superior barrier protection due to the high resin content of the film.
- Sewer Pipe Green color makes lined pipes more identifiable and inspection easier due to its increased reflectance.



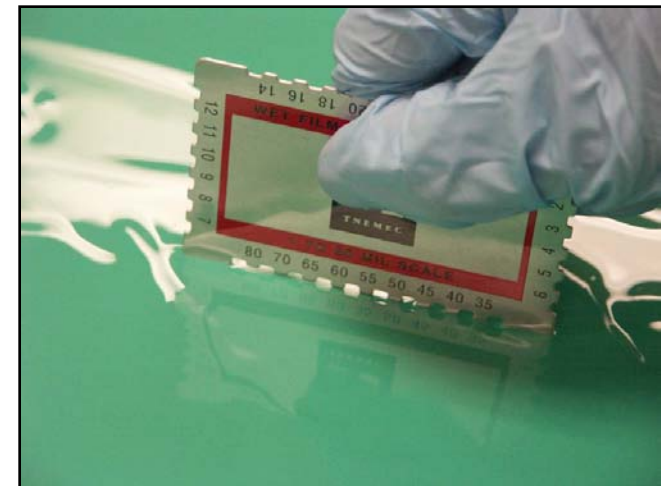
Series 431 free film @ 50 mils (1270 microns)

Series 431 Performance Testing



Performance Criteria—Series 431

- Abrasion (ASTM D 4060, CS-17, 1,000 grams)—76 mg loss
- Adhesion (ASTM D 4541)—1,131 psi on ductile, 1,769 psi on steel
- Cathodic Disbondment on steel (ASTM G 8 {1.5 V})—Group A classification. 0.00 mm disbonded equivalent circle diameter.
- Deflection—No cracking or film deformation following 5% ring deflection
- Dielectric Strength (ASTM D 149-09)—No less than 618 volts/mil
- Hardness (ASTM D 2240)—Shore D hardness 78
- Salt Fog (ASTM B 117)—5,000 hours, no blistering, cracking, rusting, delamination or rust creepage
- Water Vapor Transmission (ASTM D 1653, Method B, Wet Cup, C)—0.09 perms (0.06 metric perms) water vapor permeance
- ALL TESTING PERFORMED USING CURRENT STANDARDS/METHODS.



More Testing for DIP Linings

- British Standard (BS) EN 598: 2007 Rocking Abrasion Test
 - Lined pipe contains siliceous gravel and water and is capped on each end
 - Pipe is rocked back and forth to mimic abrasion that happens sewer system
 - Requirement is 7.9 mils (0.2 mm) max loss after 50,000 cycles
 - After 50,000 cycles, Series 431 lost just 0.57 mils (0.01 mm)
 - After 1,000,000 cycles, Series 431 lost only 5.5 mils (0.14 mm)



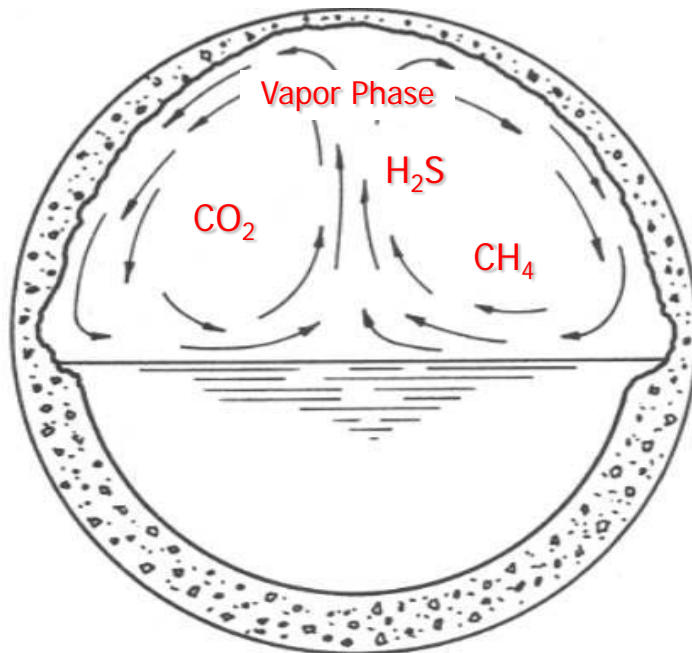
More Testing for DIP Linings

- British Standard (BS) EN 598 Chemical Resistance to Effluents
 - First pipe is filled halfway with sulfuric acid solution
 - Second pipe is filled halfway with sodium hydroxide solution
 - Flow rate and temperature of acid/caustic solutions are maintained
 - After 6 months, linings are examined for signs of cracking, blistering, and disbondment
 - Series 431 showed no effect from acid or caustic solution



Sewer Gas Attack of Ductile Iron Pipe

- Upper portion of pipe is susceptible to H₂S and other sewer gases
- Linings that allow gas permeation can fail in highly aggressive environments
- Perma-Shield products, including Series 431, are designed specifically to resist H₂S and sewer gas penetration



SEVERE WASTEWATER ANALYSIS TEST

- Developed by a coalition of industry experts to create an accelerated laboratory testing program to measure a coating's resistance to severe wastewater headspace conditions.
- Simulates & accelerates conditions characteristic of severe wastewater headspace environments
 - Eliminates the long periods of time during normal wastewater exposure
- Introduced at WEFTEC 2003 (Water Environment Federation Technical Exhibition & Conference)
- Presented at PACE 2008 (Paint And Coatings Exposition)
- Presented at UCT 2010 Conference (Underground Construction Technology)

SEVERE WASTEWATER ANALYSIS TEST, cont'd

Testing Parameters

- Temperature: 65°C (150°F)
- Duration: 28 days
- Gases: 500 ppm H₂S
- Aqueous Solution: 10% H₂SO₄, 0.4% NaCl, H₂S (saturated)
 - Other sewer gases (e.g., CO₂, CH₄) pending
- Chamber purged (recharged) with sewer gas daily
- Permeation resistance is measured before and after testing using Electrochemical Impedance Spectroscopy (EIS)



Interpreting S.W.A.T. Results

- Logarithmic impedance scale (permeation) derived from a large body of literature of laboratory and field work
- Higher and more stable the retained impedance, the better the long-term permeability resistance & overall coating performance
- Polymer degradation is easily detected by a decrease in the measured impedance
- Series 431's impedance stays in "excellent" range after 28 day S.W.A.T.
- Competitors' impedance falls below acceptable level of corrosion protection.

PERMEATION RESISTANCE

A component of the 28 day Standard Practice for Rapid Evaluation of Coatings and Linings by Severe Wastewater Analysis Test (S.W.A.T.), Electrochemical Impedance Spectroscopy (EIS) analysis is a method that uses electrical current to determine the level of coating degradation after exposure to a testing environment. Measuring a coating's resistance as impedance to an electrical current before and after provides a correlation to its overall performance. The higher the resistance, the lower its permeability to gases, liquids, chlorides and ions, thus the more protection it offers. As results from third party testing show below, the final impedance of Series 431 surpassed the competition, proving it to be the ultimate protection for steel and ductile iron pipe and fittings.

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



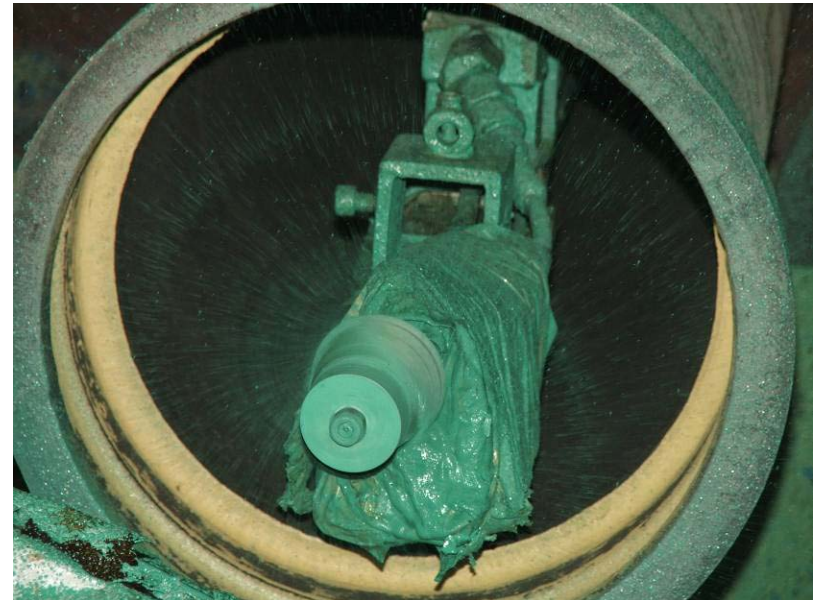
For complete testing results, contact your local TnemeC representative.

Performance Comparisons

	Series 431	Ceramic Novolac Epoxy
Volume Solids	100%	87% ($\pm 2\%$)
Color	Sewer Pipe Green -5024	Black
Ceramic content	Ceramic hollow microspheres	Fly ash
S.W.A.T. EIS Analysis	Initial: 11.2 Log Z (0.1 Hz ohms·cm ²) Post-Test: 10.7 Log Z (Excellent Protection)	Initial: 11.2 Log Z (0.1 Hz ohms·cm ²) Post-Test: 5.7 Log Z (Poor Protection)*
Abrasion (ASTM D4060, 1,000 cycles, 1,000 g load)	76 mg loss (CS-17 wheel); 2.3 mils depth of wear (H-22 wheel)	340 mg loss (CS-17 wheel); 11 mils depth of wear (H-22 wheel)
Rocking Abrasion (BS EN 598: 2007+ A1: 2009)	0.57 mils (0.01 mm) loss 50,000 cycles; 5.5 mils (0.14 mm) loss 1,000,000 cycles	2.5 mils (0.06 mm) loss 50,000 cycles; 21.3 mils (0.6 mm) loss 1,000,000 cycles*
Adhesion (ASTM D4541-09)	1,131 psi (7.8 MPa) DIP; 1,769 psi (12.2 MPa) steel	Unknown
5% Ring Deflection	Passed. No effect to film	Failed: Hairline checking and cracking detected.
High Pressure Water Cleaning	Can withstand conventional cleaning	Not recommended. Will void warranty.

Applicator Qualification

- Series 431 can only be applied by Tnemec approved applicators
- Applicators must meet several criteria, including:
 - Proper application equipment and configuration
 - Suitable application facility
 - Familiarity with preparing, handling, and applying linings to ductile iron pipe and fittings



High-Voltage Holiday Testing

- Tnemec requires each pipe lined with Series 431 be holiday tested in accordance with NACE SP0188 at 100–125 volts per mil.
- Voltage is 60% higher than current quality control recommendations for competitor ceramic epoxies.
- Proper voltage setting is critical in detecting holidays in lining system.



Touch-Up Kits

- Series 431 is packaged in a convenient, easy to use cartridge configuration for field repairs.



Summary

- Series 431 is an advanced generation ceramic epoxy for the corrosion protection of steel and ductile iron pipe and fittings for wastewater exposures.
- Increased substrate protection is derived from the key properties:
 1. Permeation Resistance
 2. Abrasion Resistance
 3. Chemical Resistance
- Series 431 outperforms all other ceramic epoxies.

Questions?

