TRENCHCOAT™ Protective Film

An Engineered Solution for Storm Drain/Culvert Systems



Development

TRENCHCOAT™ Protective Film was developed by The Dow Chemical Company in 1974 to marry the light weight and high strength characteristics of galvanized corrugated steel pipe (CSP) with the excellent chemical resistance and toughness of polymer technology. The end result is a more economical storm drain/culvert composite pipe suited to aggressive environmental conditions and longer service life.

End Use Benefits

- Why laminate CSP with TRENCHCOAT™ Protective Film?
  - Long-term durability
  - Structural capacity
  - Hydraulic capacity
  - Economics

Physical Properties

Properties		Test Method	Value[1]
Color	—	—	Black
Film Thickness, mm (minimum)	—	ASTM D 1005	0.254
Yield Tensile Strength, N/mm^2	MD	ASTM D 882	10.7
	TD		10.3
Ultimate Tensile Strength, N/mm^2	MD	ASTM D 882	20.7
	TD		19.3
Ultimate Elongation, %	MD	ASTM D 882	470
	TD		490
2% Secant Modulus, N/mm^2	MD	ASTM D 882	160
	TD		165
Elmendorf Tear Strength, g	—	ASTM D 1922	2800-3200

[1] Values are averages of typical film; not to be construed as specifications.

Coating Process

- Current lamination companies:
  - Advanced Coil Industries (USA)
  - Precoat Metals/U.S. Coaters (USA)
  - Metal Koting (Canada)
  - BlueScope Steel (Australia)
  - Wuppermann AG (Germany)
- Galvanized steel (G210) is stored in a climate-controlled environment

Coating Process

The coil sheet proceeds through an alkaline cleaning tank to remove surface contamination and may then proceed through a four-brush Scotch-Brite machine if the coil contains contamination such as white rust or a pre-treatment.

The sheet moves through a double freshwater rinse tank that is continuously filtered. The coil then passes through squeegee rolls to remove the excess water.

Coating Process

The sheet goes through the Chem-Coater, which applies a thin layer of pre-treatment. This adds yet another layer of corrosion resistance to the laminated CSP product.

The pre-treatment also provides additional reactive sites for the adhesive polymer of the coating to chemically bond to the steel substrate.

Coating Process

The pre-treated sheet passes through a series of heating units to cure the pre-treatment and assure adequate adhesion to the galvanized steel.

The sheet then goes through a 100-foot-long gas-fired oven to heat the sheet to 400°F.

Coating Process

As the sheet exits the oven and enters the lamination area, infrared process controllers continuously measure the temperature of both sides of the steel sheet to assure that a constant 400°F temperature is maintained throughout the lamination process.

Coating Process

The sheet then enters the laminating stage, where two separate webs of 12-mil-thick TRENCHCOAT™ Protective Film are automatically laminated to the top and bottom of the steel sheet. The film webs are pressed against the hot steel sheet using 60-inch-wide Neoprene nip rolls.

The nip roll pressure is held at 100 psi. The combination of the heat of the steel sheet and the pressure from the nip rolls produces an excellent chemical and mechanical bond of the TRENCHCOAT Film to the galvanized steel.

Coating Process

Next, the sheet moves through a quenching area where cold water is jet-sprayed onto the sheet to quickly reduce the temperature of the sheet to 100°F.

During this process, the sheet is supported by idler rolls that are coated with water to prevent the molten polymer from sticking to the support rolls.

Coating Process

The sheet is continuously stenciled with the proper information per the ASTM and AASHTO specifications (i.e., specification numbers, heat number of the steel, galvanized coating weight, coating date, etc.).

Coating Process

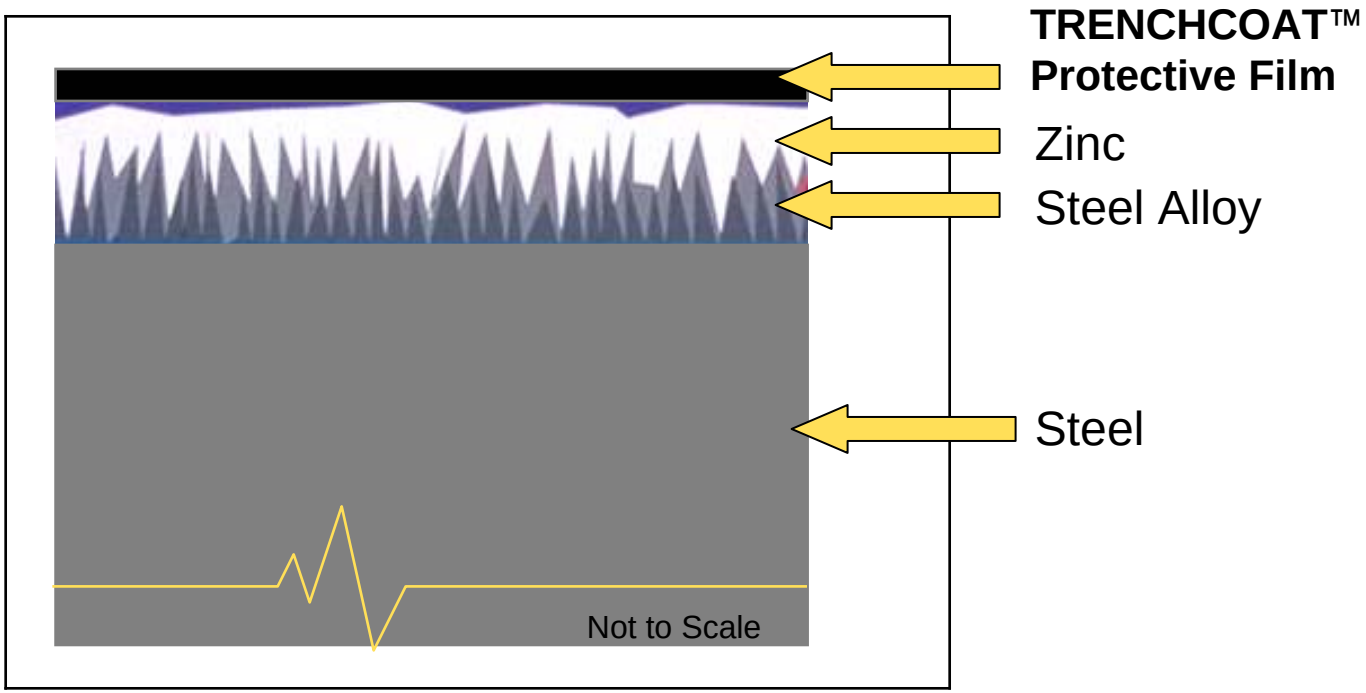
Before the sheet is re-coiled, a sample is cut to perform ASTM- and AASHTO-described tests including those for adhesion, impact, thickness of coating, holidays, abrasion resistance, imperviousness, freeze-thaw, weatherability, salt fog, and resistance to microbial attack.

Coating Process

After quenching, the sheet is rewound into coil form, banded, and shipped to the fabricators. The fabricators will subsequently form the coated steel sheet into polymer laminated corrugated steel pipe products.

Excellent Adhesion

TRENCHCOAT™ Protective Film bonds chemically and physically to galvanized steel, and resists delamination.



Physical/Chemical Resistance

Properties of CSP Laminated with TRENCHCOAT™ Protective Film

Properties	Test Method	Value[1]
Dielectric Strength, volts/mil	ASTM D 149	2200
Resistance to Acid, 10%, HCl	ASTM D 1308(2)	No change
Resistance to Acid, 10%, HNO_3	ASTM D 1308(2)	No change
Resistance to Base, 10%, NH_4OH	ASTM D 1308(2)	No change
Resistance to Base, 10%, NaOH	ASTM D 1308(2)	No change
Resistance to Acid, 30%, H_2SO_4	ASTM D 543, A742	No change
Resistance to Base, 10%, NaOH	ASTM D 543, A742	No change
Resistance to Salt, 10%, NaCl	ASTM D 543, A742	No change

[1] Values are averages of typical film; not to be construed as specifications.
[2] Exposure to the coated surface for 1400 hours at 73°F (23°C).

Physical/Chemical Resistance

Properties of CSP Laminated with TRENCHCOAT™ Protective Film

Properties	Value[1]
Resistance to chloroform (tricholoromethane)	No Change
Resistance to DMSO (dimethylsulfoxide)	No Change
Resistance to methylene chloride (dichloromethane)	No Change
Resistance to THF (tetrahydrofuran)	No Change

Test method: ISO 175, 28 days exposure at room temperature

[1] Values are averages of typical film; not to be construed as specifications.

Physical/Chemical Resistance

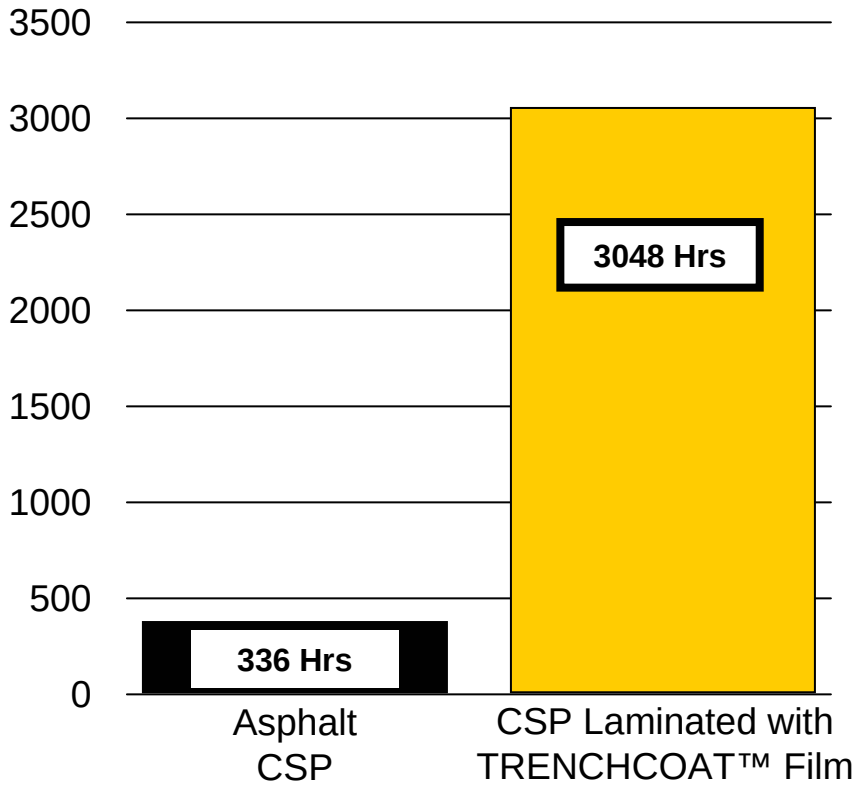
Properties of CSP Laminated with TRENCHCOAT™ Protective Film

Properties	Test Method	Value[1]
Microbial Resistance	AASHTO M246	No attack
Adhesion, at 73°F (23°C)	ASTM D 903	Exceeds tensile strength of the film
Imperviousness, 48 hours Reagent Exposure	ASTM A742	No change
Resistance to Moist SO_2 Attack, 40 cycles	Kesternich Method DIN 50018.2.0L	No attack or adhesion loss
Cleveland Condensing Humidity Cabinet, 6 months exposure at 130°F (54°C)	ASTM D 2247-68	No attack or adhesion loss
Weatherability, 3000 hours	ASTM D 3361	No cracking or delamination
Hardness, Shore D, 10 sec	ASTM D 2240	46

[1] Values are averages of typical film; not to be construed as specifications.

Salt Spray Test (ASTM B 117)

Test specimens were scribed per ASTM D 1654. Edges of the test specimens were protected per ASTM B 117.

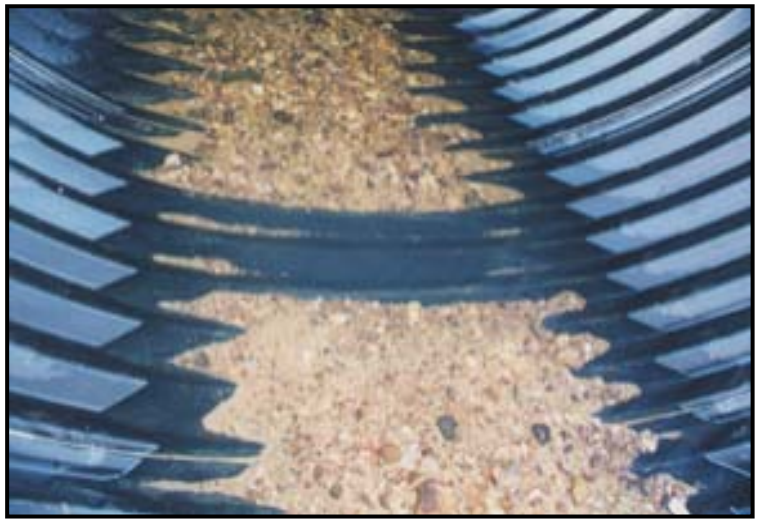


Excellent Corrosion Resistance

Corrugated steel pipe laminated with TRENCHCOAT™ Protective Film resists corrosive attacks found in aggressive end-use environments with high concentrations of acids, salts, and alkalis.

Excellent Abrasion Resistance

Corrugated steel pipe laminated with TRENCHCOAT™ Protective Film is better able to withstand sandy clay runoff and gravel bed loads without losing adhesion to metal. Abrasion Resistance Testing (ASTM A 926-03 for Coarse Particles) showed no coating loss after 36 hours.

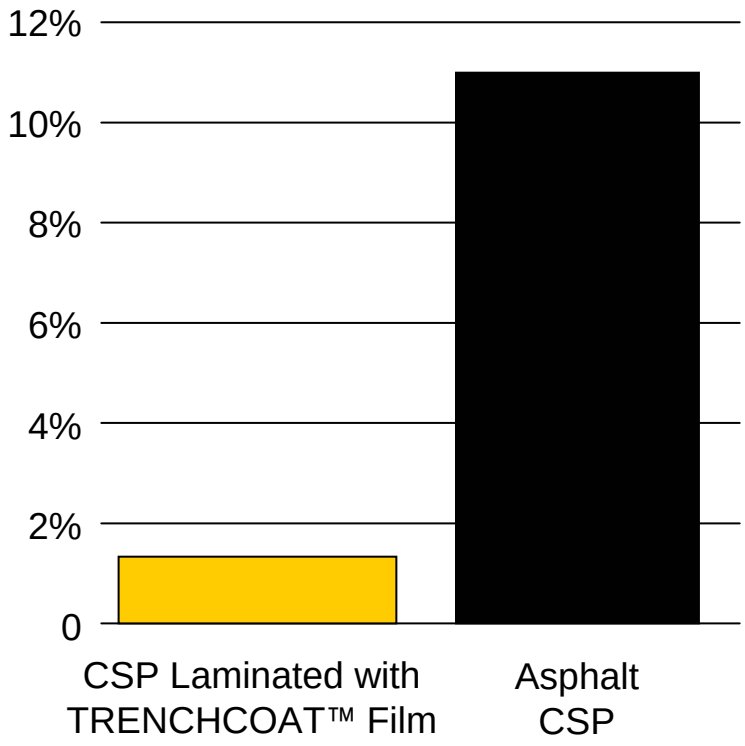


Imperviousness/Water Barrier

A percentage of the total thickness was calculated for comparing organic coatings of varying thicknesses.

The benchmark penetration level was chosen to be approximately two times the average of the organic coatings tested, or about 10% penetration for the 30-day test.

As shown, CSP laminated with TRENCHCOAT™ Film displays 22 times greater moisture barrier vs. the conventional asphalt coatings.



Weatherability

- Asphalt
  - The asphalt specimens begin to show signs of weathering at approximately 500 hours into the QUV test.
- TRENCHCOAT™ Protective Film
  - The specimens of CSP laminated with TRENCHCOAT Film begin to show signs of weathering at approximately 4000 hours into the QUV test.

Microbial Resistance

- ASTM G22 Procedure B
- 21 days exposure
- No evidence of attack

Performance Validation

- The excellent performance of CSP laminated with TRENCHCOAT™ Protective Film is validated by:
  - Dow lab and field studies
  - National Corrugated Steel Pipe Association studies
  - Independent corrosion firm
  - Fabricators
  - State Departments of Transportation

California Field Study

- Orville, California, Test Site Results
- Comparing CSP laminated with TRENCHCOAT™ Protective Film with concrete pipe

California Field Study

Environmental Conditions

• Soil pH	2.6
• Soil Resistivity	1297 ohm.cm
• Water pH	2.4
• Water Resistivity	466 ohm.cm

California Field Study

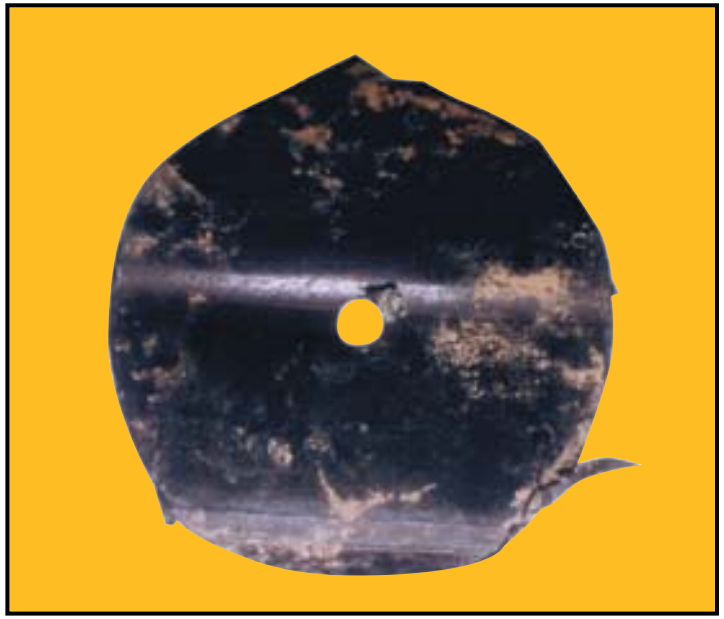
Concrete Pipe Results

The inside of the concrete pipe shows corrosion to the extent that the cement is eroded.

California Field Study

CSP Results

The specimen of CSP laminated with TRENCHCOAT™ Protective Film is intact and has an excellent appearance. No delamination or abrasion concerns were noted.



Louisiana Performance Tests

- 19 sites throughout Louisiana
- Pipes in service 4 to 21 years
- pH 5.84 to 8.0
- Resistivity of 150 to 10,000 ohm.cm
- CSP laminated with TRENCHCOAT™ Protective Film was in excellent condition

NCSPA/Corrpro Performance

Tier 1 - Qualification Tests	Water Penetration Cathodic Disbondment Chemical Resistance Freeze-Thaw Impact Resistance
Tier 2 - Abrasion Tests	Bedload Abrasion Apparatus Rotating Disk Exposure Apparatus
Tier 3 - Accelerated Tests	Accelerated Abrasion Test Apparatus

Ocean City Research tested eight different coating systems to the Tier 1 and Tier 2 methodology listed above. **Of the coatings tested, CSP laminated with TRENCHCOAT™ Film showed the best abrasion resistance.** Subsequent tests conducted by Ocean City Research using Tier 3 testing at a Level 3 abrasion condition prove that TRENCHCOAT Protective Film has excellent abrasion resistance.

PSG Corrosion Study

- Field performance of corrugated steel pipe laminated with TRENCHCOAT™ Protective Film, conducted by PSG Corrosion Engineering, Inc., San Diego, California.
- Don Waters, P. Eng., Vice President of Corrpro Companies, Inc., quotes on the performance of CSP laminated with TRENCHCOAT Film:

"We cannot find any data to suggest that this pipe coating would not provide at least 100 years of service life."

PSG Corrosion Study

Current requirement test measurements are used by corrosion engineers to determine what amount of protection will be needed to prevent a metal structure from corroding. They can also be used to determine how much the metal structure is corroding during the test. The data presented below shows that CSP laminated with TRENCHCOAT™ Protective Film can provide corrosion resistance many times better than non-coated pipe.

Culvert Description	**Current Requirement**
Galvanized CSP	0.22 (mA/ft^2)
Galvanized CSP w/ TRENCHCOAT™ Film	0.000058 (mA/ft^2)

0.22 (mA/ft^2) ÷ 0.000058 (mA/ft^2) = 3793 times better corrosion performance

Environmental Guidelines

TRENCHCOAT™ Protective Film may extend the environmental limits and life expectancy of pipe where CSP can be used.

Environmental Guidelines

- Soil / Water pH 3.0 - 12.0
- Soil / Water Resistivity > 100 ohm.cm
- Abrasion guidelines stand alone in Levels 1 – 3
- Use invert treatments in Level 4

Service Life Expectancies

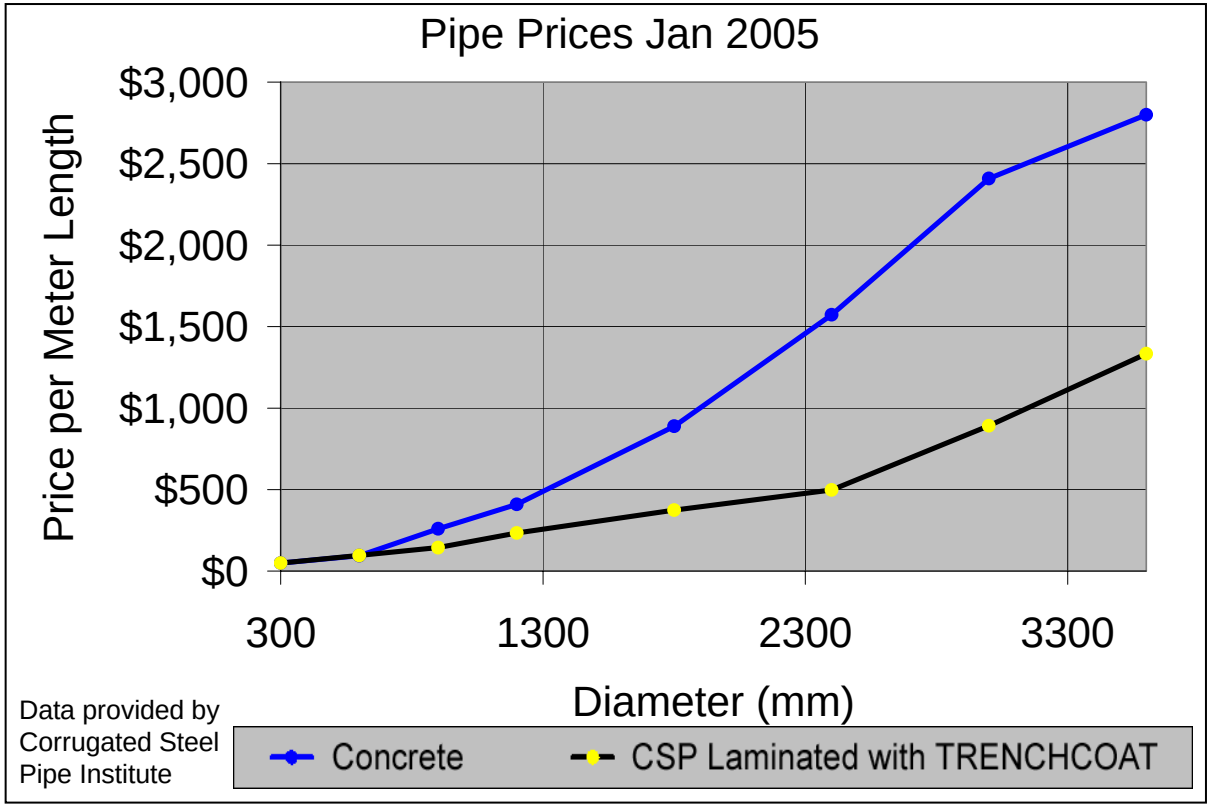
CSP Laminated with TRENCHCOAT™ Protective Film

Estimated Service Life[1]	pH Levels	Resistivity
100 years	5 - 9	> 1500 ohm.cm
75 years	4 - 9	> 750 ohm.cm

[1] When handled as recommended.

Can Offer Savings Over Concrete

CSP Laminated with TRENCHCOAT™ Protective Film Can Offer Savings Throughout the Diameter Range



Data provided by Corrugated Steel Pipe Institute

Durability and Cost Advantages

- CSP laminated with TRENCHCOAT™ Protective Film offers long-term durability and excellent performance in:
  - Corrosive environments
  - Abrasive environments
- Combined with improved cost savings through:
  - Longer lengths
  - Lighter weights
  - Customized sizes and fabrications

For more information, visit the
TRENCHCOAT™ Protective Film web page
(part of the Dow Plastics web site).

Contact information and disclaimers are on the next slide.



TRENCHCOAT™
Protective Film

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