ADVANCED POLYMER COATINGS

Mechanical Performance of a **Triple-Resin DTM Coating**

Assessing Flexibility, Impact, and Abrasion Resistance in TriFLEX®

Mechanical durability is a fundamental performance criterion for protective coatings exposed to demanding service conditions. In industrial applications, coatings must not only resist chemical degradation and environmental exposure but also maintain their integrity under physical stressors such as flexing, abrasion, and impact. This study investigates the mechanical performance of TriFLEX, an advanced direct-to-metal (DTM) coating developed by Advanced Polymer Coatings.

Traditional high-performance coating systems often rely on a multi-layer architecture that typically includes a zinc-rich primer for adhesion and corrosion protection, an epoxy midcoat for chemical resistance, and a urethane or acrylic topcoat for UV and abrasion resistance. While effective, these systems are labor-intensive, time-consuming, and prone to application inconsistencies. Moreover, achieving mechanical resilience across all layers requires precise film builds and proper inter-coat adhesion, which can be disrupted by field variability or environmental conditions during application.

TriFLEX represents a departure from this paradigm. Its formulation is built around a tri-resin architecture in which each resin plays a specific mechanical and chemical role. The primary resin promotes UV and chemical corrosion resistance, the secondary resin enhances flexibility and crack resistance, and the tertiary resin provides fast through-cure.



Customer Benefit

+ excellent adhesion
+ impact resistance
+ increased flexibility
+ one coat / DTM

These components are co-cured into a homogenous matrix, enabling single-coat application with the mechanical integrity of a multi-layer system. The following sections detail the standardized laboratory methods used to evaluate the coating's mechanical behavior and compare performance to current coating benchmarks.

Materials and Test Methods

Adhesion Testing with Surface Conditioner

To evaluate TriFLEX's adhesion to steel substrates under realistic surface conditions, carbon steel panels were prepared via dry abrasive blasting to a near-white metal finish (SSPC-SP10 / NACE No. 2). Panels were then exposed to three different pre-coating treatments:

- No submersion (control)
- Submersion in distilled water
- Submersion in a 50:1 water dilution of HoldTight® 102

HoldTight® 102 is a biodegradable, non-flammable surface preparation additive that removes soluble salts and prevents flash rusting post-blasting. Although widely used in field settings, its compatibility with high-performance coatings must be verified to ensure no adverse impact on adhesion.

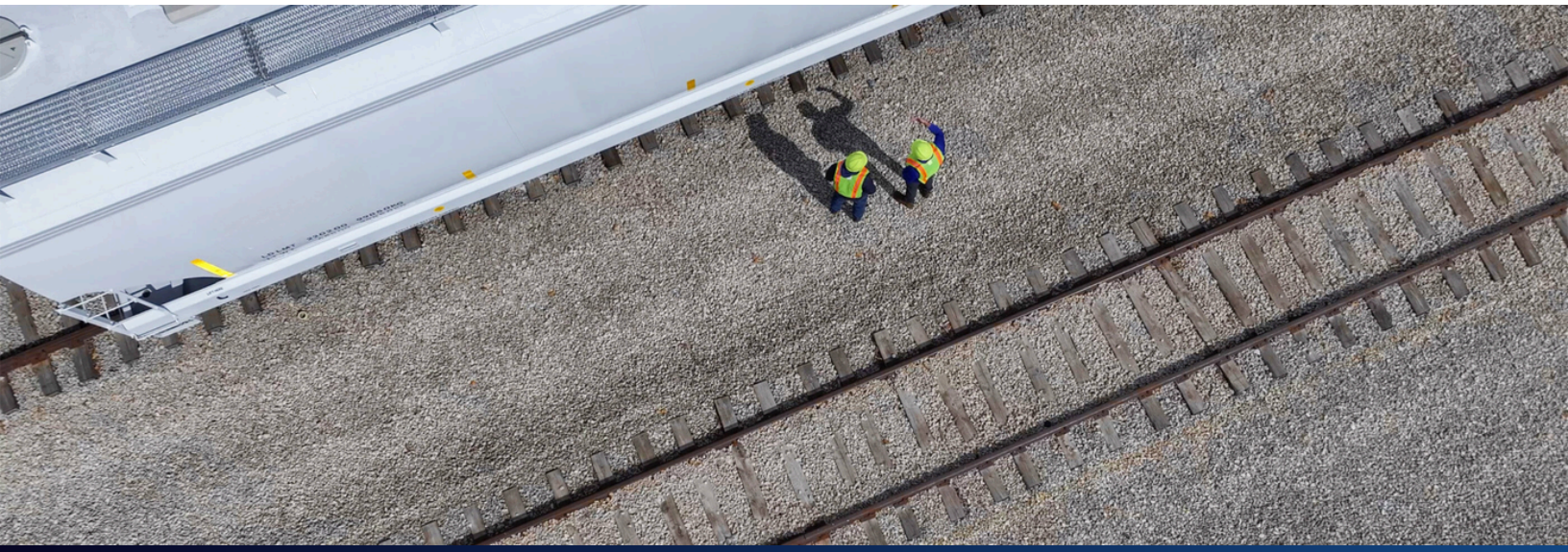
After treatment, panels were coated with TriFLEX Gray at an average dry film thickness (DFT) of 8 mils (203 microns) and cured under ambient laboratory conditions (23 ± 2°C, 50 ± 5% RH) for seven days. Pull-off adhesion was tested per ASTM D4541 using an Elcometer 510 hydraulic adhesion tester with 20 mm aluminum dollies. Failure modes were classified as adhesive (at the substrate), cohesive (within the coating), or interfacial (between coating and dolly).

Flexibility Testing

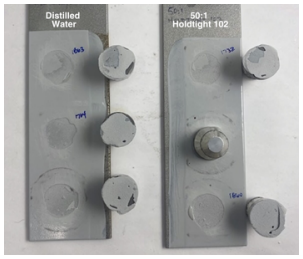
Flexural properties were assessed using the ASTM D522 Method A test for cylindrical mandrel bend. Coated panels were conditioned for 7 days post-application and then bent 180 degrees over mandrels of decreasing diameter ranging from 1 inch (25.4 mm) to 1/8 inch (3.2 mm). The smallest mandrel diameter with no observed cracking was recorded. In parallel, a qualitative assessment of the coating's crack resistance was performed by manually flexing fully cured panels back and forth to evaluate performance under repetitive bending stress, simulating flexural fatigue.

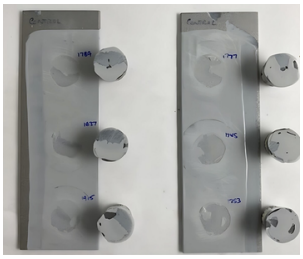
Impact Resistance Testing

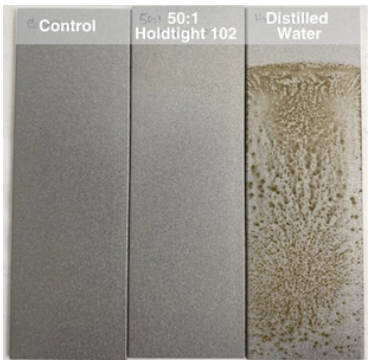
Impact resistance was evaluated by ASTM D2794, using a falling weight impact tester capable of delivering both direct and reverse impact. A hemispherical indenter was dropped from a fixed height to apply a known energy load (measured in inch-pounds) to the coated surface. For direct impact, the indenter contacted the coating directly. For reverse impact, force was applied to the uncoated backside of the panel. Failure was defined by visible cracking, delamination, or complete rupture of the coating film. TriFLEX's results were compared to reference data from standard epoxy coatings.



Results and Discussion











Adhesion Performance:

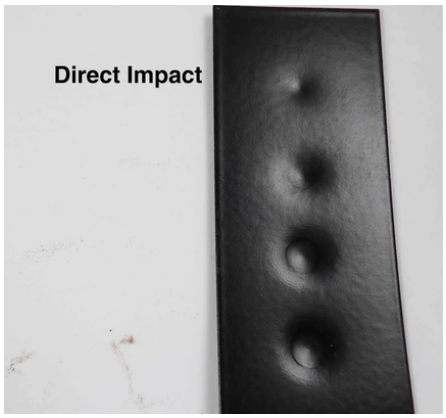
The average adhesion strength across all test conditions remained consistent. The control panel exhibited a pull-off strength of 1802 psi, while the distilled water-treated and HoldTight® 102-treated panels measured 1814 psi and 1796 psi, respectively.

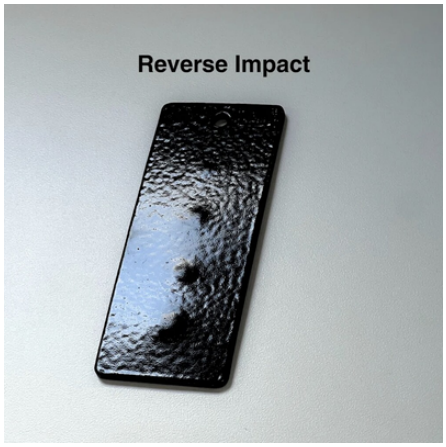
These differences are statistically negligible and fall within the expected variability of field-blasted substrates. More importantly, all tests exhibited cohesive failure within the TriFLEX film, indicating that the failure occurred in the bulk material rather than at the substrate interface. This strongly suggests that TriFLEX establishes a robust bond to carbon steel surfaces and maintains interfacial strength even in the presence of salt removal agents or residual moisture films. Field use of HoldTight® 102 as part of the surface preparation process does not compromise adhesion and may be confidently included in standard surface treatment protocols.

Flexibility Results:

TriFLEX demonstrated a high degree of flexibility, withstanding 180-degree bending over a 1/8-inch mandrel without cracking, delamination, or visible film degradation. This performance equates to an elongation threshold exceeding 30 percent, which surpasses the flexibility range typically observed in conventional epoxies (6 to 12 percent).

The triple-resin matrix appears to distribute mechanical stress across the film, reducing localized strain concentrations that would otherwise initiate cracks. When manually flexed in both directions, panels retained film integrity, supporting that TriFLEX possesses static flexibility and dynamic strain tolerance. These attributes make the coating advantageous for mechanical vibration, thermal cycling, or structural movement environments.





Impact Resistance

Results from ASTM D2794 testing showed that TriFLEX provides impact resistance values exceeding 160 in-lb for both direct and reverse impacts. Conventional epoxy coatings typically register direct impact resistance in the 70 to 90 in-lb range and show significantly diminished resistance in reverse impact due to their brittleness.

TriFLEX's ability to absorb and dissipate mechanical energy from both directions without cracking or film failure reflects the synergistic effect of its resin composition. This makes it well-suited for high-wear environments where equipment may be subjected to dropped tools or shifting loads. The dual-mode impact resistance also suggests that the coating can provide reliable protection during service and during fabrication, transport, and installation.

Conclusion

The mechanical testing results presented in this study establish TriFLEX as a high-performance DTM coating capable of withstanding a broad range of mechanical stressors. Its excellent adhesion on blasted steel confirmed even under flash rust mitigation conditions, indicates field reliability across varied surface preparation methods. Its outstanding flexibility, with elongation values above 30 percent, places it in a superior class of coatings suitable for cyclic or dynamic loading scenarios. Its impact resistance exceeding 160 in-lb in direct and reverse modes positions TriFLEX as a durable solution for equipment and infrastructure subject to physical wear.

These combined properties, achieved in a single-coat, tri-resin formulation, represent a meaningful advancement over traditional epoxy-based systems that rely on multi-layer architecture for similar performance levels.

For asset owners and applicators seeking to reduce downtime, simplify application, and improve long-term protection in physically demanding environments, TriFLEX offers a well-validated and highly effective solution.

Further validation is currently underway through comparative testing against conventional coating systems. This testing includes:

- Corrosion resistance (ISO 12944-6)
- Gloss and color retention (QUV accelerated weathering)

These studies are expected to provide quantitative benchmarks for evaluating the efficacy and potential adoption of unified resin coating systems in industrial applications.

For technical inquiries or collaboration opportunities, readers are encouraged to contact the technical services team at Advanced Polymer Coatings.

TriFLEX®