



Advanced Piping Products

CryoTek Pipe Shoe

Compression Test – Mechanical Property

The CryoTek Pipe Shoe compression test was requested for the Gulf Pascagoula LNG Terminal project. Compression testing demonstrates our CryoTek Pipe Shoe's ability to withstand large compressive loads, even in extreme conditions.

Product Tested: 5 (8" X 5" X 18") CryoTek Pipe Shoes.

Test Set Up: The CryoTek Pipe Shoes were subjected to compressive testing after submersion in a -320°F liquid nitrogen bath. 4 shoes were submerged for 20 minutes and 1 shoe was submerged for 40 minutes. An 8-inch schedule 160 carbon steel pipe was used to apply the vertical compressive load.

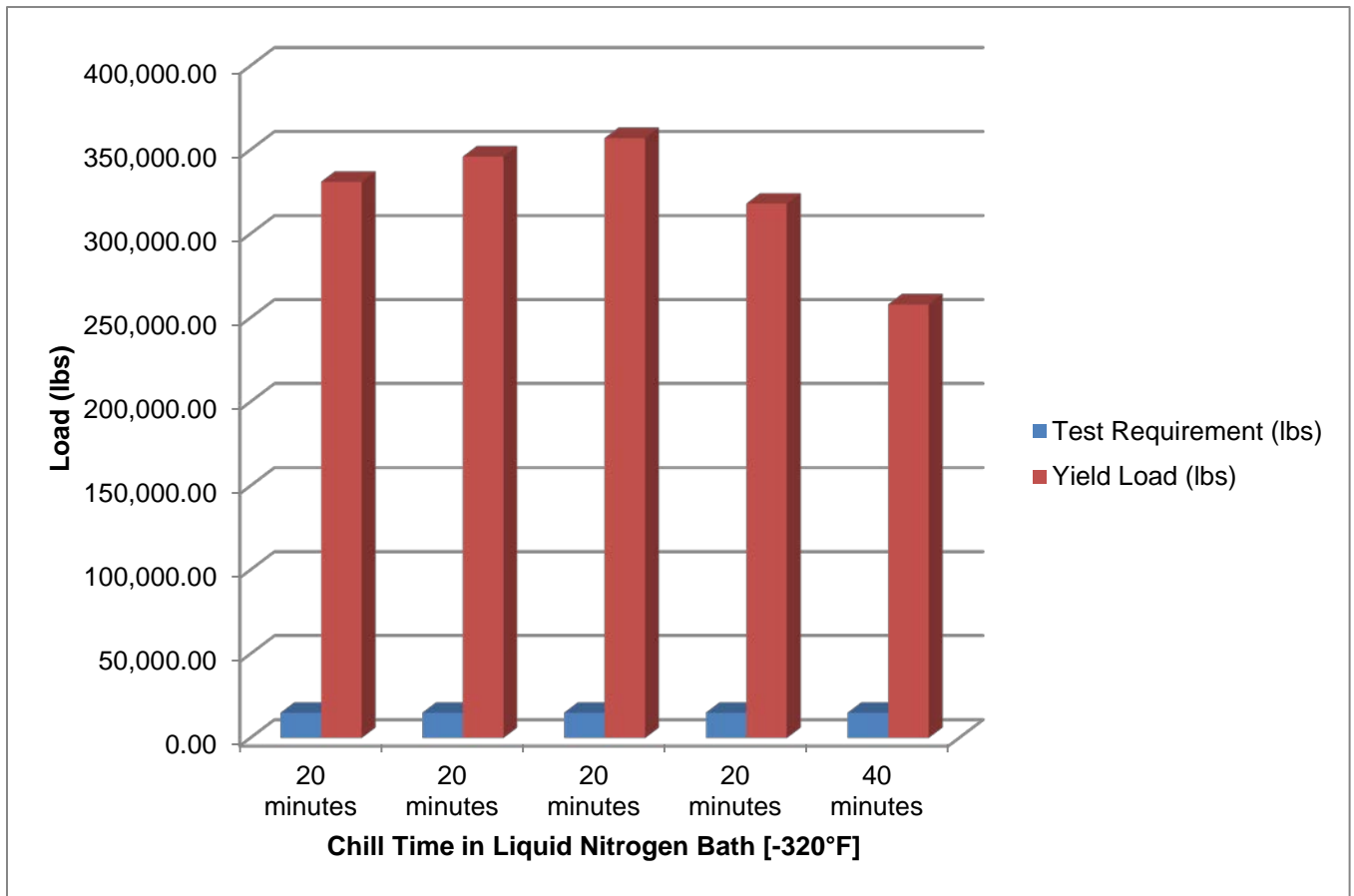
Below is a picture of the test set up:





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Compression Test Results: For the Gulf LNG project, the design vertical compressive load was 3,000 pounds and there was a safety factor of 5, meaning the test requirement was a vertical compressive load of 15,000 pounds. The CryoTek Pipe Shoe exceeded the load requirements in each test.



Chill Time in LN Bath (-320°F)	Test Requirement	Yield Load	Exceeded Test Requirement
20 minutes	15,000 lbs.	331,000 lbs.	316,000 lbs.
20 minutes	15,000 lbs.	346,000 lbs.	331,000 lbs.
20 minutes	15,000 lbs.	357,000 lbs.	342,000 lbs.
20 minutes	15,000 lbs.	318,000 lbs.	303,000 lbs.
40 minutes	15,000 lbs.	258,000 lbs.	243,000 lbs.



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Chemical Resistance Test – Chemical Property

Liquid nitrogen resistance testing of our CryoTek Pipe Shoe was also requested for the Gulf Pascagoula LNG Terminal project. These test results are an indicator of material performance in harsh environments.

Testing Specification: ASTM C581.

Test Set Up: A CryoTek Pipe Shoe was immersed into a -320°F liquid nitrogen bath for more than 10 minutes. The CryoTek Pipe shoe was tested for presence of material cracks after a varied number of immersions.

Chemical Resistance Test Results: Below is a chart outlining the test results:

CryoTek IPN Composite Technology: Chemical Resistance				
Number of Immersions	0	1	10	100
Number of Cracks Present	0	0	0	0

The CryoTek IPN Composite material exhibits no cracks in the laminate surface even after repeated immersions. The exceptional material performance is due to the flexibility of the resin matrix (8%) and the material's high impact strength (40 kJ/m²).



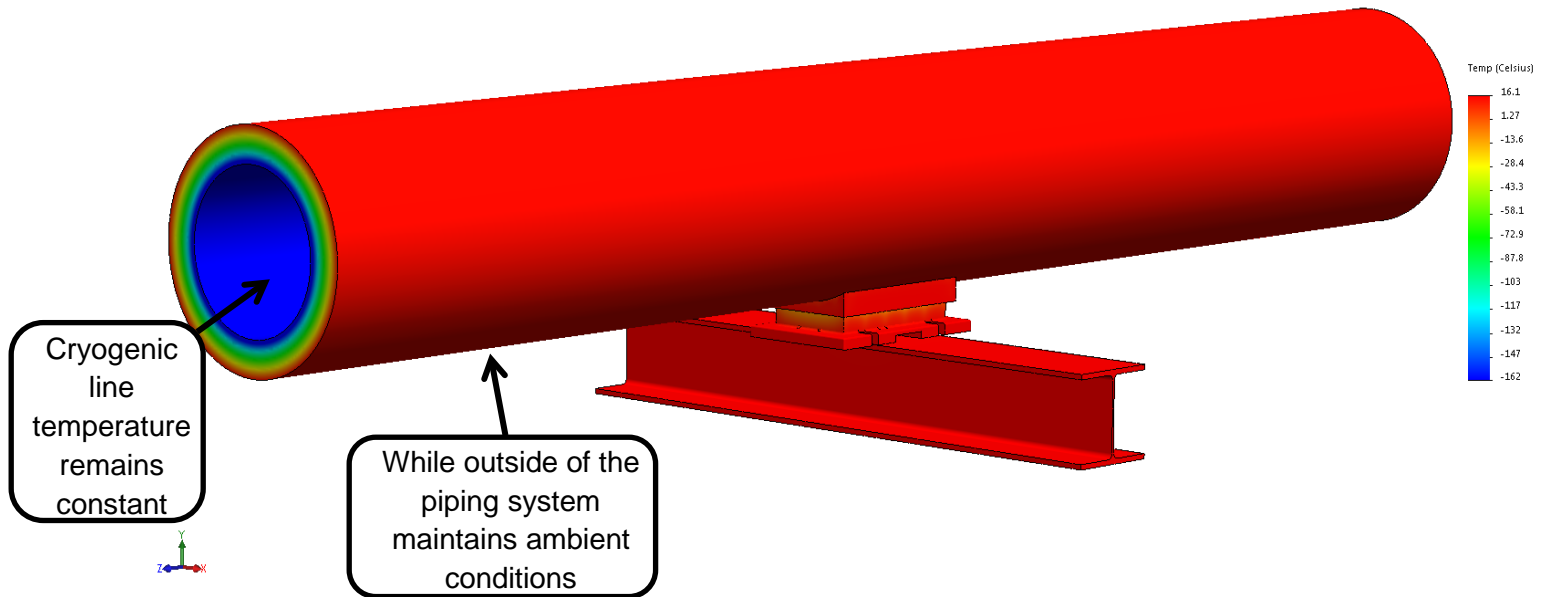
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Finite Element Analysis – Thermal Property

Finite element analysis on the CryoTek Pipe Shoe was requested for the Dominion Cove Point LNG Project. The simulation demonstrates how the CryoTek VEFR technology does not promote temperature transfer.

Test Set Up: Simulation of the CryoTek Pipe Shoe with Aerogel Cryogel insulation. Pipe flow was simulated to be at cryogenic conditions.



Test Results: The FEA results demonstrate the CryoTek Pipe Shoe's excellent performance at extreme temperature conditions.



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Shear Testing – Mechanical Property

Shear tests were performed to demonstrate our CryoTek Pipe Shoe and Epoxy's ability to withstand large loads in multiple directions, even in cryogenic temperatures.

Product Tested: Two CryoTek Pipe Shoes (12" X 8" X 18")

Test Set Up: Transverse and longitudinal shear tests were performed in cryogenic conditions. The CryoTek Pipe Shoes were connected to 12-inch stainless steel pipes with APP Epoxy (see page 7) and stainless steel banding (standard installation). The pipes were chilled to -320°F using liquid nitrogen. For the longitudinal test, a load was applied coming down on the edge of the bottom of the pipe shoe. The failure load was noted.

Below is a photo of the longitudinal test set up:



Load
Location



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For the transverse test, the load also was applied coming down on the edge of the bottom of the pipe shoe. The failure load was noted.

Below are photos of the transverse test set up:



Load
Location





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Test Results: For the longitudinal shear test, the CryoTek Pipe Shoe withstood loads up to 45,000 pounds before experiencing cracking of the epoxy interface between the pipe and the pipe shoe. For the transverse shear test, the CryoTek Pipe Shoe withstood loads up to 15,600 pounds before experiencing this epoxy cracking.

Test	Load
Longitudinal Shear	45,000 lbs.
Lateral Shear	15,600 lbs.



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APP Epoxy Adhesive

Shear Strength Test (Tensile) – Mechanical Property

In addition to using stainless steel banding, the CryoTek Pipe Shoe is also epoxied to the pipe. The epoxy we use was developed for aerospace applications and is specifically formulated to bond lightweight composites to metallic materials. These shear testing results demonstrate our epoxy's ability to withstand large loads in multiple directions without losing its adhesion integrity.

Test Specification: ASTM E8.

Test Type: Lap shear tensile test.

Test Set Up: APP ProTek composite material was connected to a flat piece carbon steel using APP Epoxy. The overlap section was 1 square inch.

Below is a photo of the test sample:



A tensile testing machine was used to determine the lap shear tensile strength of APP Epoxy.

Below is a photo of the tensile testing machine:



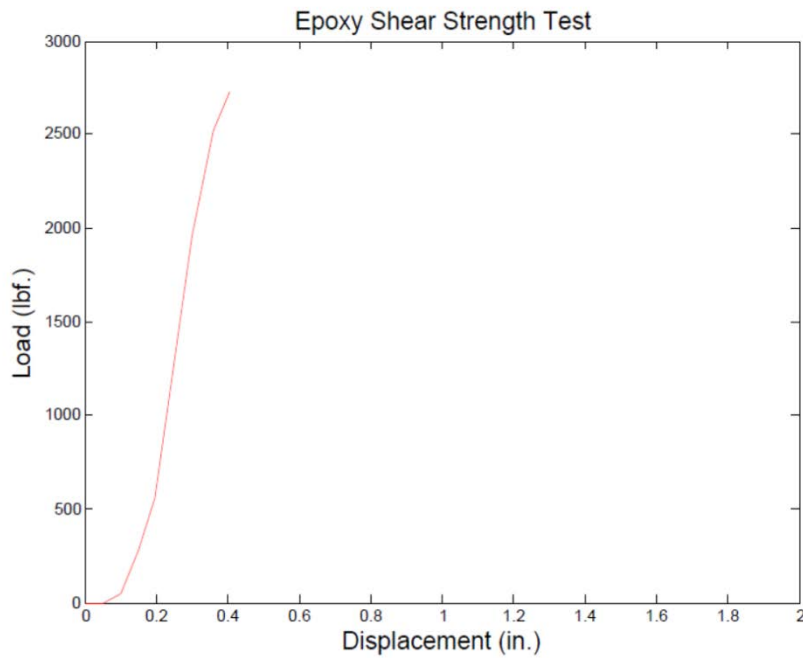


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Test Results: The glue failed at a load of 2,730 pounds. The sample section was 1 square inch, meaning APP Epoxy exhibits a shear strength of 2730 psi. The test also demonstrated the epoxy's ability to expand more than 40 percent, meaning the material will flex with the piping system as opposed to failing upon loading and pipe expansion and contraction.

Tensile Test Results	
Ultimate Strength	2730 psi
Modulus	7300 psi
Tensile Elongation	41.3%

Below is the load vs. displacement graph for the shear strength test:





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APP Epoxy Adhesive

Shear Strength Test – Mechanical Property

Product Tested: 180 degree coverage ProTek Wear Pad epoxied to a 14 inch pipe. The wear pad had a raised 1" X 3" integral band. The client was using ProTek Wear Pads with a band as anchor points on their ships.

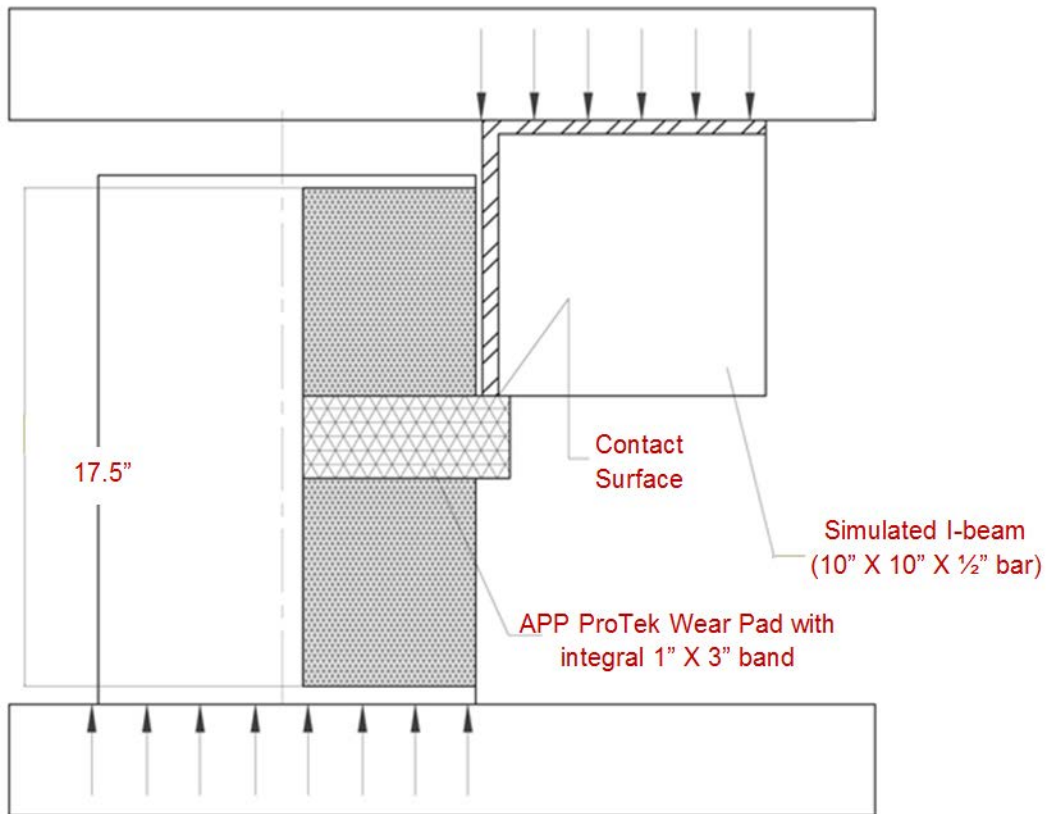


Test Set Up: Compression test machines were used to apply a load to the raised ring. This applied load simulated the force of an I-beam coming down on the integral band.



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Below is a diagram of the test set up:



Test Results: The epoxy was found to be able to handle overlap shear loads in excess of 44,000 pounds. The test was ended at a load of 44,437 pounds because the raised ring had been point loaded and had begun to crack, but even at this high load, there was no epoxy failure or separation of the pipe from the wear pad.