SETTING A NEW STANDARD

ASTM F3430 For Structural Foam Arch-Shaped Stormwater Chambers

Polymeric arch-shaped chambers, like those produced by CULTEC, have been in existence for over 30 years. Through their existence, plastic chambers have evolved from solely being utilized for backyard septic leachfields to intrinsic construction components predominantly used in large industrial stormwater systems (Figure 1).

Now a commodity, these chambers require proof of long-term performance in applications with deep burial dead soil loading and shallow burial heavy traffic loading. International standards exist that define the design and structural performance requirements of polymeric arch-shaped chambers. One such standard developed is the ASTM International Standard.. Manufacturers use these standards as tools to design and manufacture products that meet the demands of the industry.

Engineering plans, contracts, and government standards incorporate ASTM standards for consumer protection. Consumers of products manufactured to ASTM specifications can rest assured that they meet the highest standard in design, testing, and manufacture.

Figure 1: Stormwater Chamber Installation

Recharger® 360HD Chambers

ASTM International, previously known as American Society for Testing and Materials, is a consensus-based forum for the development of product, design, and testing standards that provide industries with a technically sound method of validating the performance and safety of their products. In an effort to create a comprehensive new chamber product standard, CULTEC pioneered the industry's testing of structural foam construction products. CULTEC's endeavor fell within the scope of the ASTM F17 committee on Plastic Piping Systems and subcommittee F17.65 for Land Drainage.

ASTM product and design standards exist for polypropylene stormwater chambers. The chamber classifications included in that standard are manufactured by a high-pressure injection molding process producing a solid wall. CULTEC used the guidance of these standards to design new chambers that met and exceeded the performance requirements as defined.

CULTEC's product line historically consisted of polyethylene thermoformed chambers. However, CULTEC chose the low-pressure injection molding (also known as structural foam) manufacturing process to ensure the new products met the strict requirements of these ASTM standards.

Although CULTEC demonstrated the ability of the chambers to meet the rigorous performance requirements, the structural foam process received extra scrutiny by the subcommittee. Because of this, CULTEC decided to move forward with the development of a new chamber standard, specifically for cellular polypropylene chambers, now published as ASTM F3430 Standard Specification for Closed-Cell Cellular Polypropylene (PP) Corrugated Wall Stormwater Collection Chambers, while still meeting the performance requirements of the original ASTM F2418. The challenge lay in determining proper qualification of the internal cellular structure and ongoing non-destructive quality inspection techniques thereafter.

The structural foam injection molding process produces a wall with solid outer layers and a cellular core layer (Figure 2). The process introduces nitrogen gas and a blowing agent into the plastic melt stream that aids in packing out the mold. The mold is made of aluminum, and the cost of entry into the marketplace is significantly less than steel molds required for high-pressure injection molding. Compared to their solid counterparts, structural foam products typically require 10-20% less plastic and have less molded-in stress and warpage due to the low-pressure process.

Figure 2: Cross-section showing Solid Skin Outer Layers & Cellular Core

CULTEC spearheaded the validation of structural foam, large span structural chambers. Although these chambers met the end-use performance requirements for material and structure, further testing and validation was necessary for a complete technical standard. The existing ASTM chamber standard, ASTM F2418 Standard Specification for Polypropylene (PP) Corrugated Wall Stormwater Collection Chambers, served as a template for the new standard, as the required performance and end use was the same as solid-walled chambers.

ASTM F2418 demands short and long-term material and structural performance. The cellular-walled chambers meet and exceed material requirements for cell classification, tensile stress, flexural modulus, and IZOD impact resistance. The cellular polypropylene meets the required 50-year creep modulus and creep rupture strength, and accelerated weathering. A third-party engineering firm verified the structural design of the chamber geometry and installation configuration via finite element analysis. Large-scale in situ live and dead load testing, where strain gauges and deflectometers were applied to the chambers, verified the finite element analysis and concluded that the chambers exceeded the performance requirement of the standard (Figure 3).

Figure 3: CULTEC Recharger 902HD Chamber with Strain Gauges & Deflectometers

The major difference between the two standards is the addition of qualification of the cellular wall and ongoing quality inspections. The problem this posed was that affordable, non-destructive flaw detection techniques were not prevalent in the industry at that time. CULTEC needed to demonstrate the chambers performed as intended, however, a non-destructive standardized test did not yet exist. How could CULTEC verify that these parts' internal structure was consistent?

Through process control, and weight and visual inspections, a skilled manufacturer can verify proper molding of a part. The end-use performance of a chamber is unique in that it must withstand heavy traffic and soil loads over a long period. If the porosity of the cellular structure within the chamber wall is greater in an area of high stress, it is possible that the chamber could not meet the demands in the field. After unsuccessful attempts at non-destructive inspection techniques, including light table and ultrasonic imaging, CULTEC discovered that thermal imaging detected heavily porous sections within a part if imaged soon after removal from the mold. The heat variation between the plastic and the gas within the part at this moment in time allowed for successful imaging. The next task was relating these images to conforming and non-conforming parts and substantiating these findings with structural testing.

CULTEC worked with Stress Engineering of Mason, OH to find a solution. CULTEC created a production trial with the intention of producing a set of chambers manufactured with typical conditions and settings per specifications and another set with settings that would produce elevated porosity levels. Void inspection via light table was required to confirm the validity of the thermal imaging, so all parts were manufactured without colorant. Thermal imaging successfully allowed detection of large clusters of voids shown as mottling within the chamber wall (Figure 4).

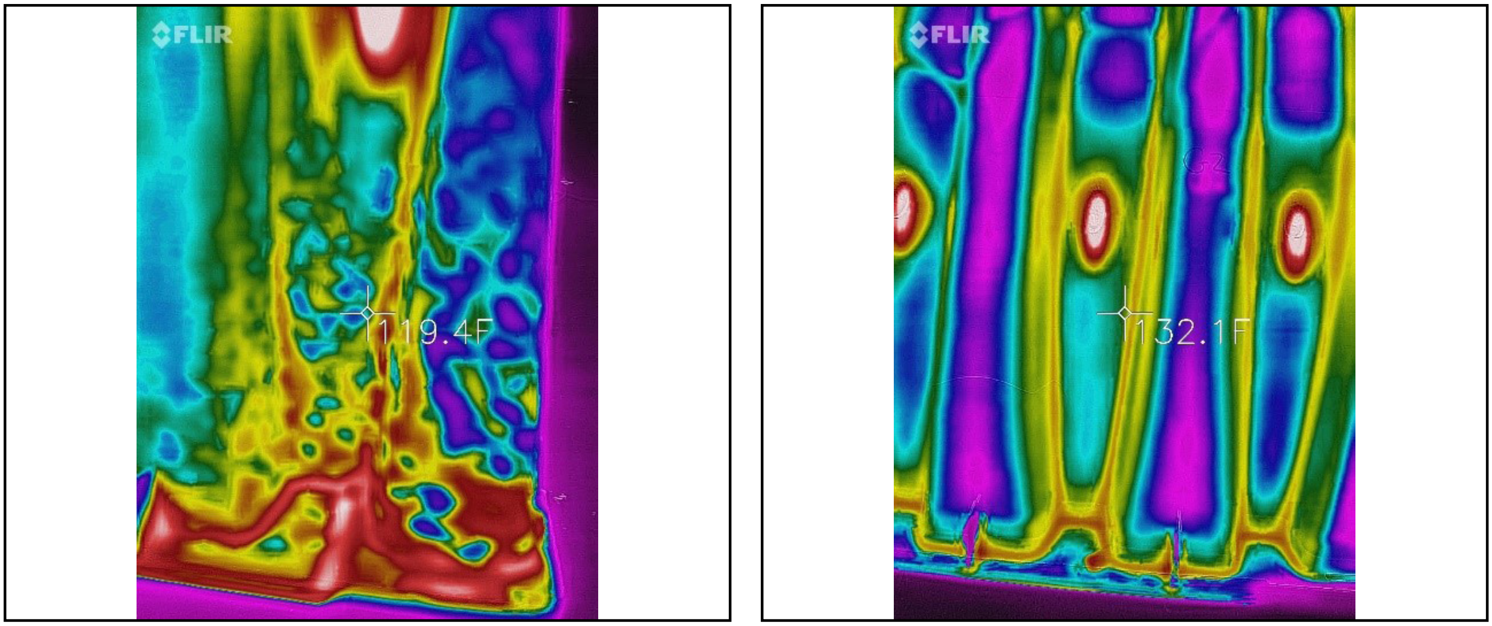


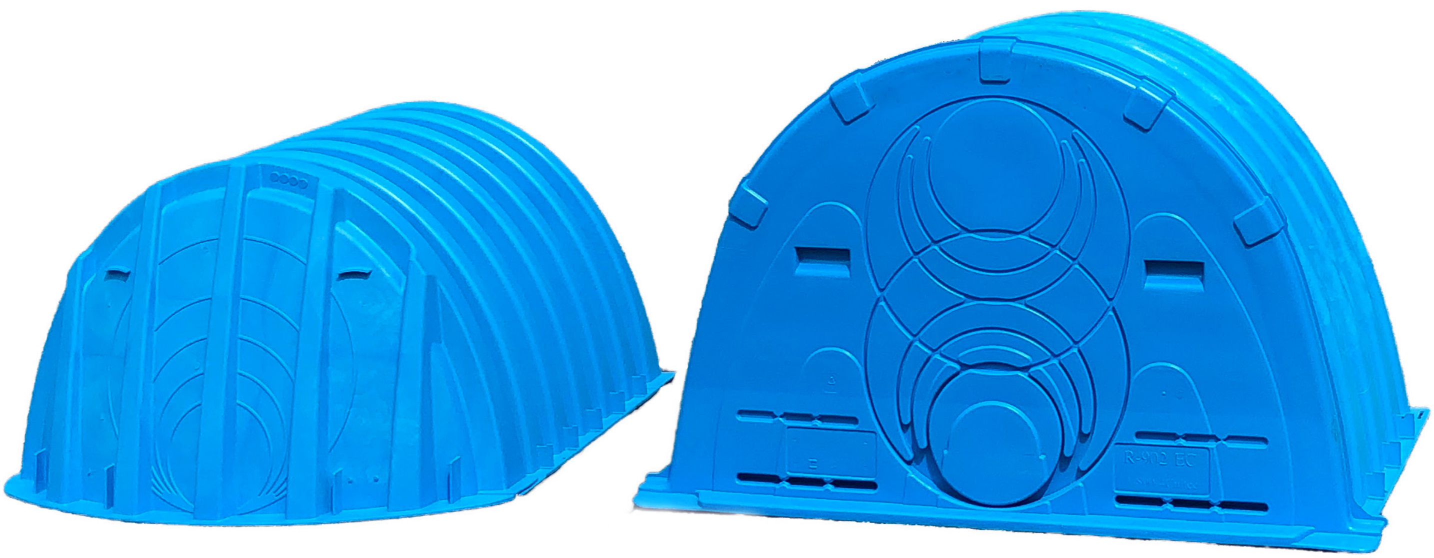
Figure 4: Thermal Imaging Trial. Heavily-Porous Chamber Section (left). Typical Production Chamber (right).

Viewing the part through a light table confirmed this finding. In contrast, typical production parts resulted in a smooth appearance through the thermal imaging camera. Major porosity clusters were marked as inspected, and these parts were shipped to Stress Engineering for arch stiffness testing and density measurements.

Arch stiffness testing, as required by the ASTM standard, measures the chamber's ability to resist deflection under specific loads. Arch stiffness was used to qualify the chamber's performance in a laboratory setting. The two sets of chambers tested displayed no significant difference in arch stiffness, confirming the global performance of the chamber as a whole. Chamber wall density testing in areas of high porosity compared to areas of typical porosity proved that high porosity sections are slightly less dense. This provided the manufacturer with a set minimum density value for use during typical production. The results proved that material distribution throughout the part is balanced despite variations in foaming. Essentially, even when higher porosity is present, solid material is still in the immediate area. This is an important fact, as the amount of plastic is directly related to the amount of load that section can resist. The insensitivity of the density shows the robustness of the molding process, and overly clustered porosity can be identified using the thermal imaging method.

standard for structural foam chambers. Thanks to these testing efforts, the stormwater industry now has another option to specify products that meet ASTM standard requirements. Prior to the publication of this standard, only chambers manufactured with high-pressure injection molding had the ability to meet ASTM standard requirements. Entry into the marketplace was difficult for small businesses without the capital for the upfront costs of high-pressure injection molding.

Given the growing need for stormwater management systems for infrastructure and public safety, the marketplace requires a variety of options to ensure availability, cost-competitiveness, and site condition suitability. Applying thermal imaging to the production process as an affordable and reliable quality inspection technique allowed for non-destructive validation of continued product performance.



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