ALPHALINER PROPERTIES AS INSTALLED

Quality Assurance Testing Results – Manufacturer	Alphaliner 500	Alphaliner 1500
Circumferential Flexural Modulus (psi) (DIN EN 1228)[1]	1,377,500	1,740,000
Curved Beam Flexural Modulus (psi) (ISO 178)[2]	1,218,000	1,653,000
Curved Beam Flexural Strength (psi) (ISO 178)[2]	26,110	30,460
Porosity of finished liner (APS Water Tightness Standard)[3]	Insignificant (0%)	Insignificant (0%)
Wall thickness of the finished liner (mm) (ISO 7685)[4]	"per design"	"per design"
CIPP Design Properties & Qualification Testing Results		
Chemical Resistance [5]		
Corrosion Resistance Enhanced Polyester Resin	See note 5	See note 5
Vinyl ester Resin System	See note 5	See note 5
Strain Corrosion Resistance (ISO 10952) [6]	0.68%	0.68%
Conformance with Host Pipe [7]	Excellent	Excellent
Fiber Reinforcement [8]	E-CR Fiberglass	E-CR Fiberglass
50-year Strength Retention Factor [9]	0.625	0.750
Liner rinsing performance qualification test [10]	Pass	Pass
Wicking at cuts in finished liner [11]	Insignificant (0%)	Insignificant (0%)

[1] DIN EN 1228 is a test method that determines the initial ring stiffness which is a measure of the ring's response to bending immediately upon loading. The initial ring stiffness returns a more accurate stiffness than the three-point bend test method (ISO 178 or ASTM D790) because it is measured on a complete ring, which represents a more realistic sample than a sample cut out from a ring. Modulus values obtained from complete hoops (rings) are in the range of 5-15% higher than those obtained from curved beam samples per ISO 178 (three-point bending test). This is most likely attributable to the complete hoop's ability to carry some of the loading in thrust similar to the actual in place liner's response to a bending load. DIN EN 1228 is quite similar to the ASTM D 2412 parallel plate deflection test which takes the specimen to the point of cracking. ISO 7685 appears to have replaced this test in the current version of ISO 11296-4.

[2] The ISO 178 and ASTM D 790 test methods are designed to measure the flexural strength of flat specimens using three-point bending. Because of the Alphaliner's isotropic design, a curved beam specimen must be substituted for the flat beam specimen. ISO 11296-4, Annex B, provides the specific changes necessary to use adapt the ISO 178 test method to perform the required quality assurance testing on field samples of liners with an isotropic glass fiber reinforced liners. Further, per the Note 2 therein, the engineer is advised that this modification to the testing has demonstrated that the curved specimen will generally deliver modulus values that are in the range of 10-15% lower than that of the flat beam specimen with the same matrix (resin and orientation of the glass fibers). (While the ASTM D 790 could be similarly modified for the curved beam specimen, Reline America is still investigating the wisdom of using this test method.)

[3] DIN EN 1610 is the installation standard for new pipe construction. Section 13 of this standard covers the procedures and requirements for testing gravity pipelines using either pressurized air or water. The allowable leakage rate, or drop in pressure, is based upon the diameter of the pipe being tested and the differential pressure created by the slope of the pipe. This is analogous to the ASTM F 1216 and F 1743 allowable leakage rates being based on new pipe installation standards. Reline America promotes the testing of the pipe wall itself to determine whether the liner is "tight" or "not tight".

[4] The wall thickness is calculated using an approved engineering approach. The installer should always submit the calculated minimum value and not the nominal thickness manufactured for the installation. The quality assurance testing is based upon the minimum required finished thickness. The wall thickness together with the physical properties of the finished liner establishes the factor of safety achieved by the installer in the field. Reline America previously issued a calculator to its installers which use the design appendix X.1 in ASTM D1216. Ed Kampbell has designed a new calculator for Reline America that allows one to use a more technically sound approach to this design appendix; and also contains a new and much improved design approach that takes proper advantage of the Alphaliner material properties, especially with non-circular shaped pipes.

RELINE AMERICA®

[5] The chemical corrosion resistance performance of the enhanced orthophthalic polyester resin used by Reline America is quite superior to the standard isopthalic polyester resins used by most CIPP system manufacturers. Recent, unpublished test results done by an independent lab in accordance with Reline America's "Greenbook pickle jar testing" effort have demonstrated that this enhanced polyester resin reaches the performance levels previously only attainable with vinyl ester resins. Once Reline America has fully digested the data from this testing, it is highly likely that this will begin to blur the line between when our standard polyester resin is required versus our vinyl ester resin system. That being said, corrosion resistance performance is only part of the equation when selecting the appropriate resin system for a particular application.

[6] Strain corrosion testing must be performed on liners containing reinforcing fibers other than the standard polyester fibers. The specified ISO 10952 determines the resistance to chemical attack of a liner in deflected, or strained, condition. A range of estimated deflections is selected such that the times to failure of at least 18 test pieces will be distributed between 0.1 hours and over 10,000 hours; with 4 failures occurring between 10 and 1000 hours, 3 failures occurring between 1000 and 6000 hours, and 3 failures occurring at greater than 6000 hours (at least one of which must exceed 10,000 hours). The interior of each of these full ring test pieces is exposed to a corrosive test fluid maintained at the specified concentration while being maintained in a fixed diametrically deflected condition. The results are plotted in a graph that is used to fit a curve that can be used to calculate an extrapolated defection value for a specified period of time greater than that of the test. The greater the deflection after a set time, the better the liner is in its resistant against chemical attack. The minimum failure strain level after 50 years is set in ISO 11294-4 at 0.45%. Alphaliner came in considerably better at a 0.68% strain.

[7] Both Alphaliner 500 and 1500 are dimensioned and designed to conform to the contours of the host pipe's geometry very tightly. Alphaliner 500 and 1500 both have at least a 10% expansion capability built into their design. With the ID of the host pipe measured for each and every reach of pipe prior to its manufacture, the Alphaliner glass fiber tubes have the ability to expand differentially to the demands of any localized deviations from the pipe's global geometry (jogs, offsets, damage, etc.) making for an unrivaled fit compared with other UV cure liners.

[8] The fiberglass reinforcements in both the Alphaliner 500 and 1500 systems are of a corrosion resistant E-glass, commonly referred to as E-CR glass. The use of glass fibers meeting this class designation is essential to the finished liner's performance in the types of environments into which it can be installed. In addition to the fibers themselves, it is the sizing that is put onto the fibers to create the mechanical lock or bond between the resin and the fiber that assures the long-term composite action of this system. The selection of the fibers, the choice of the resin system, and the coordination of the type of sizing are tightly controlled by the materials design process.

[9] Sustained external hydrostatic loading on a liner can over time exact a circumferential shortening of the liner which, in turn, can lead to localized bending in the region of the liner where the radius is the greatest (most flattened). Using the test method described in the DIN EN 761 the Alphaliner systems have been subjected to a ring deformation of three percent and the amount of pressure or load to maintain this deformation is then recorded over a time period up to 10,000 hours at prescribed points along this timeline. These data points are then plotted in a graphical format where a line can be fitted to them that allow an engineer to extrapolate what the value would be at the end of the stated design life of the liner. Typically this design point is 50 years (or 438,000 hours). The value estimated at this design life point (i.e. 50 years) is compared to the initial or short-term value derived from the ISO 178.The ratio of the long-term estimated value to the initial value is the percentage retained. Given the stability of the glass fiber reinforcement, the retention factors for the Alphaliner systems are much higher than the standard felt fiber and resin CIPP.

[10] The liner firmness in rinsing is a qualifications testing process to assure that the finished liner can stand up to the powerful jetting used today to remove debris and obstructions that will be a part of the service life of the CIPP liner. The level of the cleaning pressures, the angle of the hydraulic jets, and the cleaning actions (speed of retrieval) normally used are applied to the liner to simulate the level of hydraulic action the hardened liner must endure throughout its proposed 50 year life cycle. This is used to evaluate the toughness of the liner materials in this very real world requirement.

[11] Reinstating branch connections to the new liner presents an opportunity for the fluid in the pipe to enter the liner matrix via the fibers if they have not been properly sized to hold tight to the resin matrix. If this were to happen the structural integrity of the liner wall could become compromised. Testing for the potential for wicking action of water through any cut edges in the liner is an essential part of the design validation (qualification) process.

RELINE AMERICA®