1. RAW MATERIALS

Each supplier is assessed against Quality Assurance criteria. If the supplier meets the criteria set out, then they may be included in our "Approved Supplier List". Periodic reviews take place of all of our approved suppliers to ensure that they continue to meet our criteria.

Inspection and test of raw materials, when received also enables us to assess the supplier as well as each batch of delivered raw material. Details are shown in Table 1.1.

Table 1.1

RAW MATERIAL	CHARACTERISTIC TESTED
Polyester fiber (several specifications)	Staple length Crimp level Denier Shade Supplier Certification
Polyurethane granules (several specifications)	Granularity Blocking Yellowness Supplier Certification
Tetrahydrofuran	Supplier Certification
Polyurethane film, sealing tape	Gauge Density Strength of weld – heat Strength of weld - chemical Opacity

2. PRODUCTION OF FELT (NON-WOVEN)

The sole raw material used in the production of felt is polyester staple fiber. The most suitable fiber specification for the customer's particular end-use is selected (on the basis of resin type, impregnation equipment, installation conditions and cure regime).

The process utilizes state of the art equipment and technology to ensure that the nonwoven Product is fully suited to the customer's requirements.

Continual operator inspection at each stage of the process and product, combined with the use of standard machine parameters and computerized machine monitoring ensures that the process is repeatable and consistent.

Each product is tailored to the specific customer's requirements, and a production specification is produced by the Technical Department. The felt produced is tested against the requirements of this document to concur suitable.

Process controls are described in Table 2.1.

Table 2.1

PROCESS	CONTROL	CHARACTERISTIC
Opening fiber	Operator inspection, set parameters	Even density and thickness
Carding	Operator inspection, set parameters, computer feedback	53 Even fiber distribution
Tacker needling	Operator inspection, set parameters, computer feedback, orientation of fibers	Permits controlled
Reorientation of fibers	Operator inspection, set parameters, computer feedback	Controls relative elongation moduli in length and cross directions
Needling	Operator inspection, set parameters, computer feedback	Density, strength, ability to weld

3. POLYURETHANE COATING OF FELT

The sole consumable is granular polyurethane. The polyurethane specification is selected to ensure that the coating has the correct properties to meet the requirements of the customer.

Process controls are described in Table 3.1.

Table 3.1

PROCESS	CONTROL	CHARACTERISTIC
Extrusion of polymer into flat die	Fully automatic temperature, pressure control	Homogeneity of extrudate
Formation of molten polymer film	Operator control of machine temperatures, pressures, speeds	Coating uniformity
Transfer of molten film onto felt	Operator control of machine temperatures, pressures, speeds. Continual monitoring of coating thickness	Weight distribution per unit area; weight distribution over entire roll area

4. TESTING OF PLAIN AND COATED FELTS

Each roll of plain felt and felt for coating is sampled and destructively tested against the requirements of the Production Specification as shown in Table 4.1. Each coated roll undergoes testing as Table 4.2.

Table 4.1

CHARACTERISTIC	TEST
Density and density distribution at various applied pressures	Compression measurement at increasing pressure
Load at break in machine and cross directions	Tensile testing-Maximum Resistive Force
Secant Modulus in machine and cross directions (resistance to stretch)	Tensile testing-Maximum Resistive Force vs. Extension %

Table 4.2

CHARACTERISTIC	TEST
Density and density distribution at various applied pressures	Compression measurement at increasing pressure
Load at break in machine and cross directions	Tensile testing – Maximum Resistive Force
Secant Modulus in machine and cross directions (resistance to stretch)	Tensile testing – Maximum Resistive Force vs. Extension %
Coating weight and distribution	Samples weighted to determine distribution of coating in cross direction of roll
Coating adhesion and ability to weld	Peel strength of welded tape (Standard specification)
Coating surface finish	Visual inspection

5. PRODUCTION OF LINERS

Liner requirements are collected by way of the Customer Order and customer liaison, and are confirmed to the customer on our Order Acknowledgment form.

Once all requirements are known, a liner is designed which will fulfill all the requirements.

The design is detailed to the Production department as a Manufacturing Specification. This is then entered onto the Production Schedule.

The liner may be produced by one of a number of production techniques, depending on the requirements.

6. TESTING THE FINISHED LINER

The control and test of the liner properties are detailed in Table 6.1. From each liner produced, a sample is cut from one end for QC inspection and test. This sample is destructively tested to ensure that all of the liner properties are within the Manufacturing Specification.

Table 6.1

PROCESS	CONTROL	CHARACTERISTIC
Circumference of liner	Monitored at each production stage against Manufacturing Specification	Destructive test of sample. All layers are measured
Density, Gauge of liner under various applied pressures	Selection of felt layers in order that finished density and gauge are within Manufacturing Specification	Compression test of sample of all layers
Length of liner	Monitored at each production stage against Manufacturer Specification	Inspection regime includes measurement of liners against Manufacturing Specification
Coating Integrity	Continually monitored by state-of-the-art gauge	Inspected after coating, monitored throughout liner manufacture
Metal Free	Needling process is continually monitored for alignment to prevent needle damage	Each roll passes through metal detection equipment
Felt Weld Strength	All welding equipment operates to set parameters. Overlapped thermal welded	Each weld is sampled and destructively tested. Results are compared to the Manufacturing Specification
Sealing Tape Weld Strengths	All welding equipment operates to set parameters, chemically bonded seal	Each weld is sampled, specially conditioned, and destructively tested under conditions simulating the "worst case" for that liner

Technical Information – Polyurethane Coated Liner for Hot Cure Eversion

SPECIFICATION:

Felt

- The fiber is PET Polyester staple fiber.
- The denier of the fiber for a standard hot cure eversion liner for vacuum impregnation with a polyester resin is usually selected as nominally 6 denier (+10%) (dependent on specific liner and installation details).
- The felt is manufactured to a thickness specification of ± 3 % when measured at a compressive pressure of 0.5 bar (7.4 psi) (16 ft. water head). Standard thickness of 1.5 mm, 3mm, 4.5mm, 6mm exist.

Coating

- The coating is a thermoplastic polyester polyurethane. The nominal weight may be 400 - 500, 500 - 600 or 600 - 700 grams per square meter. It is usual for the 400 - 500 gsm spec to be used. This affords an average coating thickness of 0.33mm for 400 gsm, 0.41mm for 500 gsm.
- All coating weights are applied in a minimum of two passes to ensure that pin holes are avoided.

Liner

- The liner is assembled from layers of plain felt and an outer layer of coated felt. Each inner plain layer is overlapped approximately 50mm (2”) at each joint and welded by hot fusion techniques to give the requisite weld strength to support the installation pressure (with a safety factor included). The safety factor is in excess of 2.
- The outer coated layer has a high strength felt strip fusion welded across the inside of the joint and a sealing tape of polyurethane welded over the coating to give a seal and a barrier of comparable thickness to the coating.
- The finished liner thickness is measured at the installation head and is toleranced at -0 + 5% on nominal ordered thickness.

FERRATEX
Professional Cured-In-Place wet out services built on 25 years of experience!

FerraTex Cured-In-Place Pipe Liner QA/QC

APPLIED FELTS
YOUR SUCCESS IS OUR SUCCESS

Certification

This certifies that Applied Felts manufactured tubes meet the material requirements of ASTM F1216-16. In support of ASTM D5035-04, specifically as it relates to tensile strengths, our liner tensile properties average 1100 psi. The minimum tensile strength is 750 psi as per ASTM D5813-04 item 6.1 *Fabric Tube Strength*. All our materials are tested to ensure suitability to the application. Each liner is typically tested in 28 different ways and traceable test data is available for any particular liner.

Recommendations for minimum, maximum and ideal pressures are provided for each and every liner that Applied Felts manufactures. This ensures that the installer understands the requirements for holding the tube against the existing conduit and the maximum allowable pressure so as not to damage the tube. A head pressure chart is attached as examples for various tube sizes.

Applied Felts has provided polymer coated felt tubes for use in Cured-In-Place-Pipe (CIPP) lining for more than fifteen years, and supplied materials for the CIPP industry for more than twenty years. Over 82 million feet of our liner has been successfully installed in North America. Our liners are assembled in Martinsville, VA, using only components made in the USA.

Applied Felts also certifies that all liners manufactured will meet the minimum requested finished thickness (or greater) as ordered by its customers.

Applied Felts is a registered ISO 9001:2008 company.

Recommended Handling and Storage for Liners

1 Avoid extremes of temperature.

Freezing may cause the coating structure to degrade locally, especially areas where the coating is in tension or compression, at bends and edges and immediately adjacent to seam welds.

Recommended storage temperature 5 to 35 degrees C.

Shelf life at this temperature: in excess of 1 year.

2 Avoid extremes of humidity.

Very high relative humidity (especially at high temperature such as tropical countries) will accelerate the hydrolysis of the polyurethane coating, consequently reducing the shelf life.

Recommended storage humidity 25% rh to 65% rh.

Shelf life at 65%, 35 degrees C: 1 year.

3 Avoid prolonged wet storage.

As with high humidity, the coating more susceptible to degradation at higher temperatures, and even further susceptible if pH of liquid in contact is below 7.

Wet storage is not recommended.

4 Avoid direct sunlight of incident UV radiation.

Prolonged exposure to ultra violet light will accelerate the degradation of the polyurethane.

It is recommended that liners remain in the original packaging until they are required for use. Failing this, the liner should be covered to prevent exposure.

5 Mechanical damage should be avoided.

In order to ensure that the liner is not damaged, the following recommendations should be followed:

a) Ensure that liner is not placed directly onto grit or gravel floor. Sweep and cover floor first.
b) Ensure personnel are instructed not to walk on liner.
c) Handle liner with care.
d) Ensure nip rollers clean, and liner is not in contact with any sharp edges or snags anywhere during impregnation and installation.
e) Large liners will require special handling considerations (especially when wet-out), as their weight will preclude manual handling. Cranes or conveyors may be required. If a liner is to be lifted with a crane sling, it is important that the sling should be sufficiently wide to prevent it from "biting" into the liner. It should be set up in such a way that the sling does not grip the liner (i.e. both loops of the sling onto the crane hook).

6 Styrene and Chemical Attack

Avoid prolonged contact with solvents and chemicals.

On impregnation with styrene-based resin, the solvent/monomer may start to swell the coating, giving an orange peel appearance. In time, this effect will increase to severe wrinkling (stretch by 60%).

If the contact time is sufficient, the coating will feel tacky. At this stage, the product should not be used.

Recommended shelf life after impregnation will vary dependant on the proportion of styrene in the resin, the nature and proportion of thixotropes, inhibitors, accelerators and catalysts, and the storage temperature.

As a general rule, the impregnated liner should be stored below 10 degrees C. The typical shelf life at this temperature, with a polyester resin system, is maximum 7 days. With some resin systems, this shelf life is reduced to less than 24 hours. If using an unfamiliar system, it is recommended a section of coated felt is soaked in resin and assessed periodically to determine shelf life. With experience, this may be judged visually by the degree of wrinkling.

ISO 9001 Certificate

Preferred Registrar Group Inc.

Preferred Registrar Group, Inc.

30561 Dequindre Rd. Madison Heights, MI 48071

certifies that

FerraTex Services, Inc.

Corporate-354 Eisenhower Parkway, Livingston, NJ 07039
Greenpond-1650 Greenpond Rd, Newfoundland, NJ 07435
McKenney-20520 Unico Road, McKenney, VA 23872
Ft. Pierce-4750 Magnum Drive, Fort Pierce, FL 34981
Lebanon-1420 East Toshiba Drive, Lebanon, TN 37087
Sloan-13940 Schuster Street, Sloan, NV 89054

has implemented a Quality Management System scope in accordance with:

ISO 9001:2015

The scope of this Quality Management System Governs:

Manufacture of wet out (resin impregnated) liners used for Cured In Pipe Technology, for the underground infrastructure rehabilitation for governments, cities and municipalities.

Certificate Registration Number:

17-R5998

Certified Date:
12/20/2017

~❖~

It is valid until:
12/20/2020

Denis Pecar, President

ANAB ACCREDITED ISO/IEC 17021 MANAGEMENT SYSTEMS CERTIFICATION BODY

IAF MEMBER OF MULTILATERAL RECOGNITION ARRANGEMENT

C10 Rev 1

bsi.

By Royal Charter

COPY

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2008

This is to certify that:

Applied Felts Inc.
450 College Drive
Martinsville
Virginia
24112
USA

Holds Certificate No: **FM 55735**

and operates a Quality Management System which complies with the requirements of ISO 9001:2008 for the following scope:

Manufacture of textile products used in pipeline rehabilitation.

For and on behalf of BSI:

Pietro Foschi - Strategic Delivery Director

Originally registered: 08/15/2000 Latest Issue: 03/05/2015 Expiry Date: 05/31/2018

...making excellence a habit.™

Quality Assurance/Quality Control Program

I. Summary

FerraTex has established and refined a strict Quality Control Program to ensure that all material and workmanship exceed the minimum standards and guarantee the finished product/facility performs according to design. This Program has been successfully implemented on past projects and is used on all current and future projects. The Program provides a rigid framework but is easily modified to incorporate specific requirements of the Owner.

A. Measurements made to verify the length and cross-section dimensions of the original sewer pipe prior to ordering materials and the liner thickness to be provided for each segment will be submitted.

B. Initial flexural stress will meet or exceed 4500 psi, initial flexural modulus will meet or exceed 250,000 psi and tensile strength is not applicable with gravity pipe. N/A

C. Any liner showing a split or tear, which cannot be repaired, shall be marked as rejected and immediately removed from the job site.

D. The cured-in-place pipe lining system has a minimum design service life of fifty (50) years.

E. The CIPP liner, when cured, will form a continuous, tight fitting, hard, impermeable liner that is resistant to chemicals found in domestic sewage and trace amounts of gasoline and other oil products commonly found in municipal sewage and soils adjacent to the pipe to be lined.

F. The CIPP liners will be fabricated to a size that when reformed will tightly fit the internal surface and the length of the pipe being rehabilitated. Confirm that allowances for circumferential and longitudinal expansion will be taken into account.

G. All dimensions shall be field verified prior to fabricating the liner and that the fabricator shall confirm all dimensions and installation parameters with the field superintendents prior to fabricating the tube. The tube fabricator shall certify that the tube has been fabricated to tightly fit the internal circumference of the original sewer based on the data provided.

H. To ensure that the material and workmanship involved in installing a FerraTex CIPP liner is of the highest quality, open communication pathways are maintained between the Superintendent (field operations), the QC Supervisor (project management), and the material Supplier. These communication pathways are depicted in the flow chart in Appendix A.

II. Liner Components

1 Liner Components

The history of FerraTex's operation dates back to 1989. Our Cured-In-Place Pipe Liners are Supplied by Applied Felts and comply with requirements of ASTM F1216. The wet-out tube is folded and shipped to the job site according to the installation schedule. The following table lists the components that make up the FerraTex Liner CIPP.

Table 2 – FerraTex Liner CIPP Components

	Material	Type	Product Name	Manufacturer
FERRATEX LINER (CIPP)	Tube	Polyethylene Terephthalate	Polyester Needled Felt	Applied Felts Inc.
	Outer Membrane	Polypropylene or Thermoplastic Polyurethane Polymer	Polypropylene or Polyurethane Coated Liner	Applied Felts Inc.
	Resin	Polyester Vinyl Ester Styrene Free-Vinyl Ester	COR series Aropol L7 Series	Interplastics Corp. Ashland AOC
	Catalyst (Initiator)	Peroxide	Norox 600	United Initiators
		Peroxide	TBPB	United Initiators
		Peroxide	TRIGNOX® 121 BB75	Akzo Nobel
		Peroxide	PERKADOX® 26	Akzo Nobel

* Resin System may be either polyester, vinyl ester or styrene free vinyl ester type systems, depending on the application

2 Pipe Lining System

The product description is taken from observation during the installation process. This process changes from application to application. The following notes are not intended to be complete and exhaustive descriptions, but are a brief description of the proposed construction system.

FerraTex Liner CIPP consists of polyester felt, polyester resin, and polyurethane (PU) or polypropylene PP coating. The polyester felt is overlaid on one side with a PU or PP barrier and formed into a tube with a diameter to match the pipe, and a thickness as required for

strength. The polyester felt tube is impregnated with polyester resin and the tube is inverted in place and cured.

2.1 Cured Resin Properties

The cured resin can attain physical properties as high as the following values:

Table 3 – Cured Resin Properties

Description	Value	Test Method
Initial Flexural Strength (psi)	>4,500	ASTM D-790
Initial Flexural Modulus (psi)	> 250,000	ASTM D-790
Tensile elongation (%)	< 2	ASTM D-638
Compressive Strength (psi)	15,000	ASTM D-695
Hardness (Barcol)	50 – 55	ASTM D-785

2.2 Lining System Materials & Processes

2.2.1 Material Inspection & Receiving Report

The shipping documents received at the plant in McKenney, VA or at the site with each individual load will include: (a) the shipper; (b) shipping point; (c) consignee; (d) contract and item number; (e) product identification; (f) gallons or dimensions; (g) (if shop wetout).

2.2.2 Housekeeping & Cleanliness During Manufacturing

Cleanliness is essential during the resin mixing process. Resins must not be in direct sunlight during mixing, transportation or inversion.

2.2.2.1 Resin Storage

Improper storage of the resin will cause premature exotherm. Resins are perishable materials that have a shelf and pot life. Resin storage is as recommended by the manufacturer. The tests for deterioration of resin include visual observation, gel time and/or viscosity.

2.2.2.2 Catalyst & Promoters

Catalyst and promoters are stored separately and away from other flammable material. The stock is rotated so the maximum storage time is as recommended by the manufacturer.

2.2.2.3 Solvents

Solvents are used in the tube manufacturing process for patching the coating and taping the seams. The most commonly used solvent is Tetrahydofuran (THF), which is highly flammable; only a small quantity of this solvent is needed to bond the tube coating..

2.2.3 Tube Fabrication

Liner fabrication starts with a field report of the actual length of the line to be rehabilitated. This initial record includes the diameter of the pipe, depth of each manhole structures on either side of the reach and the height of the water inversion tower. The liner length is indicated by making tic marcs, with the actual length value in 5-foot intervals, on the liner itself using a permanent ink. The thickness of the liner is made with one or many layers of felt with the outer layer coated with polyurethane.

2.2.3.1 Heat Bonding

Plain felt is joined by heat bonding. This process will be performed at the factory plant only. Only in rare cases of a liner being too long to ship, it may become necessary to field splice two or more sections together. Heated air is passed quickly between the felt layers so that only the extreme outer fibers of each felt layer are melted.

2.2.3.2 Thickness Varying

A particular liner maybe designed and constructed with varying thicknesses over a certain length, particularly if that liner is being installed through multiple pipe segments. The amount of overlying ground and water pressure loading typically varies over the length of a pipe segment and more so with multiple pipe segments. With that in mind when a liner is designed it may be beneficial to design the liner with varying thicknesses over the length of the liner. The minimum thickness of the liner is calculated (according to ASTM F1216-07b) based on the maximum ground and water pressure loading over the particular pipe length. The liner is then constructed according to the liner design with the thickness always equal to or greater than the minimum design thickness. For quality assurance the transition from one thickness to another is carried out so that the thicker of the two liner sections extends 10ft in the direction of decreasing thickness to assure that the thickness of the installed liner is never less than the minimum design thickness.

2.2.3.3 Diameter Varying

A particular liner maybe designed and constructed with varying diameter over a certain length. This is done when producing a liner that is to be installed through multiple pipe segments that do not have the same diameter sizes. Using the information from the field

reports of the measured host pipe a liner maybe constructed so that it is tapered to transition from one diameter to another.

2.2.3.4 Inspections & Reporting During Tube Fabrication.

All relevant facts about the dry tube fabrication is recorded by direct observation. Measurements of the liner in its 'lay-flat' configuration along with length numbering, bag end installation and rope installation information are indicated on the quality control report completed for each liner produced (see sample report in Appendix B). A certificate of compliance is also generated for each liner certifying its dimensions and build information (see Appendix C). Cutting and assembling of the materials is done in a well-ventilated and well lighted area.

2.3 Construction System Characteristics

The process of converting polyester resins from liquid to solid involves a chemical reaction called copolymerization. The monomer in which the polyester resin is dissolved reacts with the unsaturated groups in the polyester chains to form a cross-linked, thermoset polymer.

The specific resin formulation will depend on the following

a) Temperature of the cure
b) Rate of cure desired
c) Means of activating catalyst (heat, promoter, ultraviolet light, etc…)
d) Type of catalyst
e) Mass of resin involved
f) Pot life required
g) Inhibitor bodies present

Vipel® L713-NET-11 Polyester Resin

World Leader in Resin Technology

PRODUCT INFORMATION

Isophthalic Based Resin for Underground Sewer Pipe Liners

TYPICAL CAST MECHANICAL PROPERTIES (2) SEE BACK PAGE			
Test	**Units of Measure**	**Nominal**	**Test Method**
Tensile Strength	psi/MPa	11,600/80	ASTM D 638
Tensile Modulus	psi/GPa	600,000/4.1	ASTM D 638
Tensile Elongation	%	2.85	ASTM D 638
Flexural Strength	psi/MPa	19,000/131	ASTM D 790
Flexural Modulus	psi/GPa	560,000/3.9	ASTM D 790
Heat Distortion Temp.	°F/°C @ 264 psi	223/106	ASTM D 648
Barcol Hardness		45	ASTM D 2583
*Typical properties are not to be construed as specifications.			

TYPICAL LIQUID PROPERTIES (1) SEE BACK PAGE		
Test	**Units of Measure**	**Nominal**
Viscosity @ 25°C/77°C, RVF Brookfield Spindle #4 @ 20 RPM	cps	5,600
Thix Index 2/20	-	4.3
Color	-	Opaque
Specific Gravity @ 25°C/77°C	-	1.11
Non-Violatiles	%	62
Gel Time @ 140°F with (1.0% Di-(4-tert-butyl-cyclohexyl) peroxydicarbonate and 0.5% Trigonox® KSM	minutes	11
Pot Life @ 25°C/77°C (1% Di-(4-tert-butyl-cyclohexyl) peroxydicarbonate and + 0.5% Trigonox® KSM	hours	45

Trigonox is a trademark of Akzo Nobel Chemicals

DESCRIPTION

The Vipel® L713-NET-11 is a high molecular weight isophthalic/unsaturated polyester resin. Vipel® L713-NET-11 Series provides the corrosion resistance, durability and toughness that is required for cured in place pipe applications. Refer to the AOC Corrosion Resistant Resin Guide for corrosion resistance information listed under Vipel® F701.

BENEFITS

AOC's Vipel® L713-NET-11 molecular architecture provides an excellent balance of corrosion and physical properties.

FEATURES

- Excellent catalyzed pot life
- Superior mechanical properties
- High molecular weight
- High viscosity version

955 HIGHWAY 57 EAST • COLLIERVILLE, TN 38017 • (866) 319-8827 • FAX (901) 854-1183 • www.aoc-resins.com

Vipel® L713-NET-11 Series Polyester Resin

PERFORMANCE GUIDELINES

A. Keep full strength catalyst levels between 1.0% - 3.0% of the total resin weight.

B. Maintain shop temperatures between 18°C/65°F and 32°C/90°F and humidity between 40% and 90%. Consistent shop conditions contribute to consistent gel times and will help the fabricator make a high quality part.

STORAGE STABILITY

Resins are stable for three months from date of production when stored in the original containers away from sunlight at no more than 25°C/77°F.

During the hot summer months, no more than two months stability at 30°C /86°F should be anticipated. After extended storage, some drift may occur in gel time and viscosity.

Storage in plastic totes made out of materials such as polyethylene (PE) or polypropylene (PP), in particular translucent PE/PP, will accelerate gel formation and result in a significantly reduced storage stability.

Storage of this resin outdoors in translucent plastic totes may reduce the storage stability to only a few weeks. AOC cannot assume responsibility for gel formation under these storage conditions.

SAFETY

See appropriate Material Safety Data Sheet for guidelines.

ISO 9001:2008 CERTIFIED

The Quality Management Systems at every AOC manufacturing facility have been certified as meeting ISO 9001:2008 standards. This certification recognizes that each AOC facility has an internationally accepted model in place for managing and assuring quality. We follow the practices set forth in this model to add value to the resins we make for our customers.

FOOTNOTES

(1) The pot life times shown are typical but may be affected by catalyst, promoter and inhibitor concentrations in resin, and environmental temperature. Variations in gelling characteristics can be expected between different lots of catalysts and at extremely high humidities. Pigment and fillers can retard or accelerate gelation. It is recommended that the fabricator check the gelling characteristics of a small quantity of resin under actual operating conditions prior to use.

(2) Based on tests on Vipel® L713-NET-11 pipe at 77°F/25° and 50% relative humidity. Castings were prepared using 1.0% Perkadox 16 and 0.5 Trigonox C.

NORTH AMERICA
Toll free: +1 866 319 8827
northamerica@aoc-resins.com

LATIN AMERICA
+01 863 815 5016
latinamerica@aoc-resins.com

MIDDLE EAST
+44 1206 390415
middleeast@aoc-resins.com

EUROPE
+44 1206 390415
europe@aoc-resins.com

AOC UK LTD.
+44 01206 390400
salesUK@aoc-resins.com

INDIA
+44 1206 390415
india@aoc-resins.com

ASIA/AUSTRALIA
+44 1206 390415
asia@aoc-resins.com

Pub. No. AOC– Vipel® L713-NET-11
Effective Date: April, 2014

TEST REPORT

CLIENT: AOC, LLC
950 Highway 57 East
Collierville, TN 38017

Attention: Bill Moore Re: P.O. #8142

SAMPLES: One sample of felt laminate was submitted and identified by the client as L713-NET. The sample was received on October 31, 2007. The sample was cut into individual test coupons (each approximately 7" x 0.5") by Hauser Laboratories.

TESTING: Flexural creep testing was performed in general accordance with ASTM D2990-01, *Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics*. Five (5) test coupons were randomly selected and tested per Section 6.3 of ASTM D2990, *Flexural Creep*, using a three-point static-load configuration, a 4.25 inch span, and a 400 psi testing stress. The ASTM D2990 flexural creep testing was performed at 23±2°C and 50±5% Relative Humidity throughout the duration of the testing. The testing was started on December 12, 2007 and was completed on March 3, 2009.

The client requested determination of the 50 year modulus. This was performed by extrapolating the most linear portion of the data set (from 20 hours through 10,000 hours duration) using linear trend line analysis contained within commercially available software (Microsoft Excel).

Chemical resistance testing was performed in accordance with ASTM D543-06, *Evaluating the Resistance of Plastics to Chemical Reagents*, using the guidelines set by ASTM D5813-04, *Standard Specification for Cured-in-Place Thermosetting Resin Sewer Pipe*, Section 8.2.1. Sets of five (5) test coupons were randomly selected and exposed to the reagents below for one year at 23°C. Following the chemical exposure, the coupons were tested in accordance with ASTM D790-07, *Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*. The results of the flexural properties testing were compared to those of an additional set of five (5) coupons randomly selected and conditioned at 23±2°C and 50±5% Relative Humidity for the duration of the exposures.

Reagent	Concentration
Nitric acid	1%
Sulfuric acid	5%
ASTM Fuel C	100%
Vegetable oil	100%
Detergent	0.1%
Soap	0.1%
Sodium hydroxide	0.5%

RESULTS: The individual creep specimen dimensions are displayed in Table 1. The raw time-displacement creep data are presented in Table 2. The creep test results through 10,000 hours test duration are presented in Table 3. For each specimen, flexural modulus versus time data is displayed in tabular format. Additionally, graphical data displaying the average log modulus versus log time is presented in Figure 1, and graphical data displaying the individual log modulus versus log time is presented in Figure 2.

Using the linear trend line analysis extrapolation of the most linear portion of the data set (from 20 hours through 10,000 hours duration; See Figure 1) the 50 year (438,000 hour) modulus was calculated to be 175,000 psi.

The results of the chemical exposure testing are presented in Table 4.

DATA REVIEWED AND REPORT WRITTEN BY:

Douglas Bert
Scientist II

REPORT REVIEWED BY:

Steve Ferry
Managing Director, Hauser Laboratories

TABLE 1
INDIVIDUAL D2990 TEST SPECIMEN DIMENSIONS

Specimen Number	Width	Thickness
	in	in
1	0.530	0.266
2	0.556	0.272
3	0.554	0.252
4	0.566	0.268
5	0.558	0.269

TABLE 2
FLEXURAL DISPLACEMENT DATA

TEMPERATURE: 23°C
RELATIVE HUMIDITY: 50%
STRESS: 400psi
SPAN LENGTH: 4.25 inches

Elapsed Time	Flexural Displacement (inches)				
hours	1	2	3	4	5
0.00	0.2204	0.2191	0.2232	0.2917	0.2429
0.02	0.2104	0.2058	0.2129	0.2797	0.2370
0.03	0.2103	0.2041	0.2123	0.2793	0.2370
0.12	0.2092	0.2022	0.2123	0.2790	0.2370
0.22	0.2092	0.2008	0.2123	0.2788	0.2370
0.52	0.2091	0.1988	0.2123	0.2781	0.2368
1.0	0.2090	0.1981	0.2123	0.2777	0.2367
2.0	0.2089	0.1975	0.2122	0.2772	0.2366
4.7	0.2088	0.1972	0.2120	0.2763	0.2365
19.7	0.2086	0.1968	0.2116	0.2744	0.2362
148.2	0.2078	0.1961	0.2108	0.2670	0.2358
507.1	0.2072	0.1955	0.2102	0.2609	0.2352
1003.7	0.2057	0.1941	0.2087	0.2580	0.2340
2131.9	0.2054	0.1938	0.2084	0.2566	0.2338
2734.4	0.2050	0.1935	0.2080	0.2557	0.2335
3380.7	0.2049	0.1934	0.2079	0.2553	0.2333
4055.7	0.2047	0.1930	0.2075	0.2547	0.2331
4708.7	0.2046	0.1930	0.2075	0.2544	0.2331
5404.9	0.2045	0.1928	0.2073	0.2541	0.2328
6243.7	0.2044	0.1928	0.2072	0.2540	0.2328
6910.3	0.2044	0.1927	0.2071	0.2536	0.2327
7611.4	0.2043	0.1927	0.2070	0.2533	0.2326
8351.5	0.2041	0.1925	0.2069	0.2531	0.2325
9189.7	0.2040	0.1924	0.2068	0.2528	0.2325
9890.7	0.2040	0.1924	0.2068	0.2526	0.2324
10731.2	0.2038	0.1923	0.2067	0.2519	0.2322

TABLE 3
FLEXURAL CREEP DATA

TEMPERATURE: 23°C
RELATIVE HUMIDITY: 50%
STRESS: 400psi
SPAN LENGTH: 4.25 inches

Elapsed Time	Flexural Modulus (psi)					
Hours	1	2	3	4	5	Average
0.00						
0.02	452600	332900	464400	374400	758700	476600
0.03	448100	295200	438800	362300	758700	460600
0.12	404100	262000	438800	353800	758700	443500
0.22	404100	241900	438800	348300	758700	438400
0.52	400500	218100	438800	330400	733800	424300
1.0	397000	210800	438800	320900	722000	417900
2.0	393600	205000	434800	309900	710500	410800
4.7	390200	202200	427100	291800	699400	402100
19.7	383600	198500	412400	259700	668100	384500
148.2	359200	192500	385800	181900	630500	350000
507.1	342900	187600	367900	145900	581400	325100
1003.7	307900	177100	329900	133300	503000	290200
2131.9	301700	175000	323200	128000	491900	284000
2734.4	293900	172900	314700	124800	476200	276500
3380.7	292000	172300	312600	123400	466300	273300
4055.7	288300	169700	304700	121400	456800	268200
4708.7	286500	169600	304700	120500	456800	267600
5404.9	284700	168300	300800	119500	443200	263300
6243.7	282900	168300	299000	119200	443200	262500
6910.3	282900	167700	297100	117900	438900	260900
7611.4	281100	167700	295300	117000	434600	259100
8351.5	277700	166400	293500	116400	430400	256900
9189.7	276000	165800	291700	115500	430400	255900
9890.7	276000	165800	291700	114900	426300	254900
10731.2	272700	165200	289900	112900	418400	251800

FIGURE 1
AVERAGE LOG MODULUS VS LOG TIME
20 hours to 10,000 hours

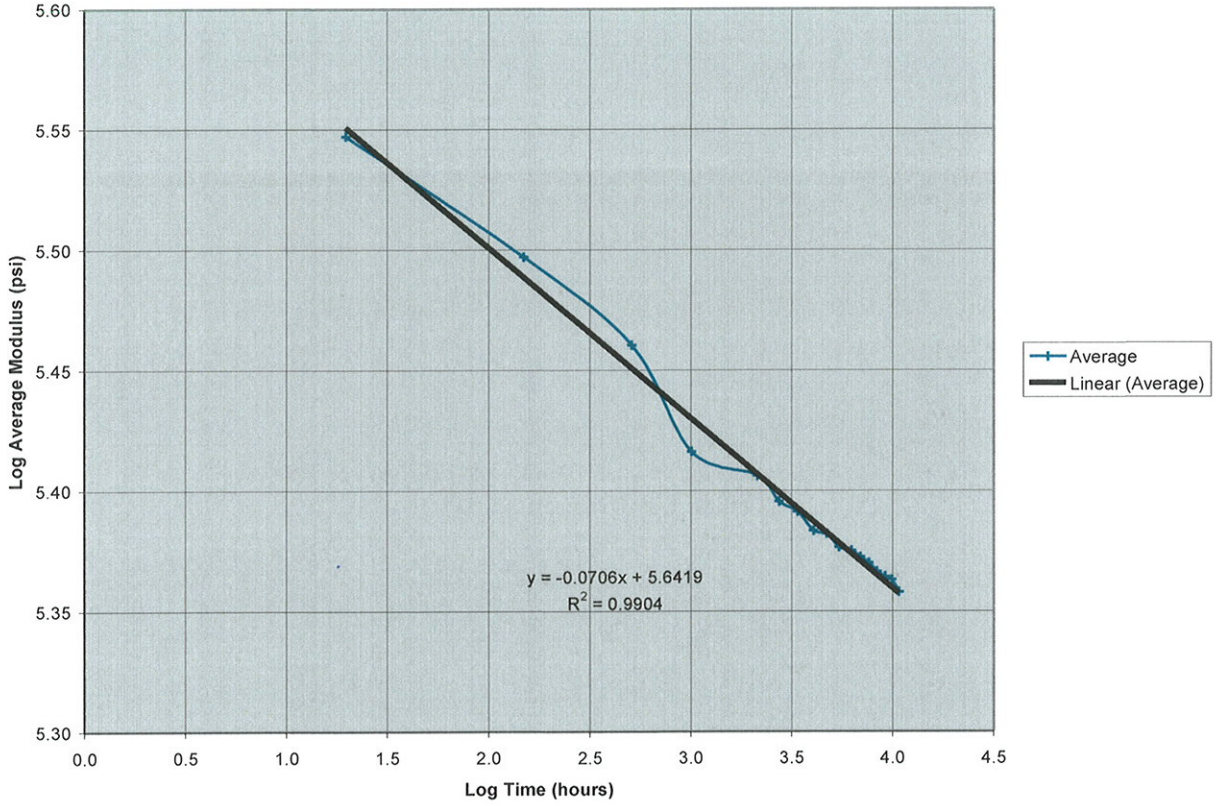

FIGURE 2
LOG MODULUS VS LOG TIME

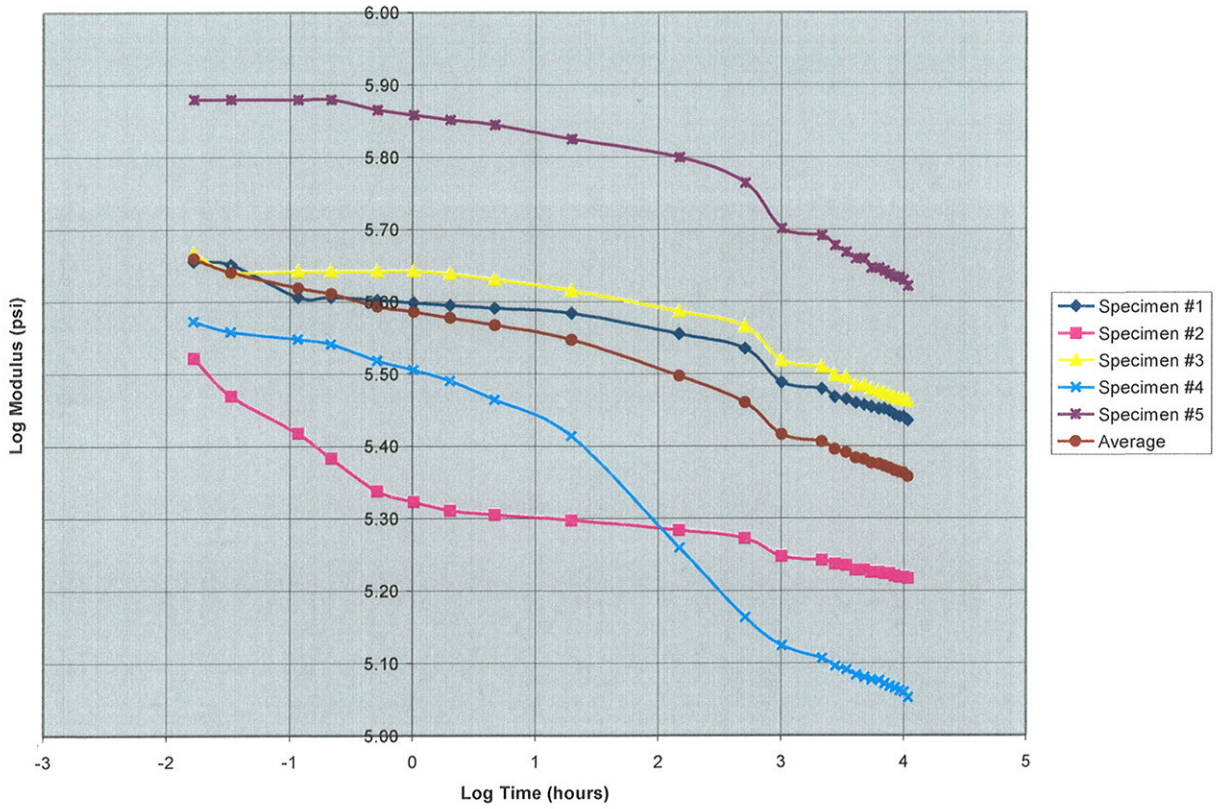

TABLE 4
CHEMICAL RESISTANCE TEST RESULTS

Specimen Number	Flexural Yield Strength	Strain @ Flexural Yield Strength	Flexural Modulus (Tangent)
	psi	in	psi
L 713-NET Unexposed			
1	7910	1.7	506000
2	7980	1.8	491000
3	8230	1.8	500000
4	8590	2.5	521000
5	8270	2.3	551000
Average	8200	2.0	514000
Std. Dev.	270	0.4	24000
L 713-NET Nitric acid			
1	7450	1.6	512000
2	8830	1.9	504000
3	7390	2.4	478000
4	7950	1.7	506000
5	6710	1.5	488000
Average	7670	1.8	498000
Std. Dev.	790	0.4	14000
Retention of Flexural Modulus (%)			96.9
L 713-NET Sulfuric acid			
1	6230	1.3	489000
2	7390	1.5	514000
3	6450	2.1	499000
4	6410	1.4	480000
5	7420	1.7	479000
Average	6780	1.6	492000
Std. Dev.	580	0.3	14000
Retention of Flexural Modulus (%)			95.7

TABLE 4 CONTINUED
CHEMICAL RESISTANCE TEST RESULTS

Specimen Number	Flexural Yield Strength	Strain @ Flexural Yield Strength	Flexural Modulus (Tangent)
	psi	in	psi
L 713-NET ASTM Fuel C			
1	6950	1.5	502000
2	7270	1.7	482000
3	8600	1.9	506000
4	7100	1.7	485000
5	7440	1.6	512000
Average	7470	1.7	497000
Std. Dev.	660	0.2	13000
Retention of Flexural Modulus (%)			96.7
L 713-NET Vegetable oil			
1	8000	1.7	505000
2	7970	1.8	503000
3	8370	1.8	515000
4	7740	1.6	500000
5	8420	1.9	503000
Average	8100	1.8	505000
Std. Dev.	290	0.1	6000
Retention of Flexural Modulus (%)			98.2
L 713-NET Detergent			
1	7960	2.9	508000
2	7840	1.8	513000
3	7940	2.2	497000
4	8120	2.5	506000
5	7930	1.7	510000
Average	7960	2.2	507000
Std. Dev.	100	0.5	6000
Retention of Flexural Modulus (%)			98.6

TABLE 4 CONTINUED
CHEMICAL RESISTANCE TEST RESULTS

Specimen Number	Flexural Yield Strength	Strain @ Flexural Yield Strength	Flexural Modulus (Tangent)
	psi	in	psi
L 713-NET Soap			
1	7060	1.5	504000
2	6740	1.5	485000
3	7180	1.6	461000
4	7630	1.7	491000
5	7130	1.7	471000
Average	7150	1.6	482000
Std. Dev.	320	0.1	17000
Retention of Flexural Modulus (%)			93.8
L 713-NET Sodium hydroxide			
1	6350	1.4	466000
2	7790	4.1	476000
3	6170	2.3	463000
4	6250	2.3	476000
5	6530	2.5	470000
Average	6620	2.5	470000
Std. Dev.	670	1.0	6000
Retention of Flexural Modulus (%)			91.4

DISCUSSION: The equation of the line used to extrapolate the 50 year modulus is:
Log(modulus in psi) = -0.0706*(Log(time in hours))+5.6419

The extrapolated 50 year modulus is 175,000 psi.

The sample passed the chemical resistance requirements of ASTM D5813-04, Section 6.4.1., which states, "The specimens shall be capable of exposure to the solutions in Table 1 at a temperature of 73.4±3.6°F (23±2°C) with a percentage retention of flexural modulus of elasticity, when tested in accordance with 8.3, of at least 80% after one-year exposure".

AOC®
World Leader in Resin Technology

March 19, 2012

To Whom It May Concern:

The following cure procedures are recommended when using the L713-NET polyester resin in Cured In Place Pipe applications. L713-NET polyester resin can be cured using either hot water or steam. The recommended post cure temperatures are a minimum of 180°F Water Temperature for water and 220°F Steam Temperature for steam cures.

Recommended post cure times, interface temperatures, and minimum cool down times are listed in the table below. Note that the shorter cure times can be used in some cases based on achieving a higher interface temperature. For steam cure on liners greater than 400 ft add a minimum of 0.5 hrs to the corresponding minimum hold time.

Liner Thickness	Water Cure Hold time	Steam Cure Hold Time	Min. Interface Temperature	Minimum Cool Down
< 10.5 mm	3 hr	1.5 hr	130°F	½ hr
< 10.5 mm	2.5 hr	1 hr	150°F	½ hr
10.5 to18 mm	3 hr	2 hr	130°F	¾ hr
10.5 to18 mm	3 hr	1.5 hr	150°F	¾ hr
19.5 to 30 mm	4 hr	3 hr	120°F	2 hr
> 30 mm	5 hr	4 hr	110°F	4 hr

Additional cure time is recommended in very cold or very wet conditions. Interface temperatures should be monitored. If interface temperatures are low, additional cure time is recommended. If the pipe to be lined contains a bituminous coating, the use of a pre-liner is recommended.

The liner shall be cooled to a minimum of 100°F using the minimum cool down period listed in the table above.

Bill Moore

Bill Moore
AOC, LLC
Product Leader - CIPP

This information is correct to the best of our knowledge; however, because of unforeseen variations in the field conditions and curing systems beyond our control, we cannot guarantee performance.

Material Safety Data Sheet

MSDS no. 13593V1

WHMIS (Canada)	NFPA (USA)	HMIS (USA)	Protective clothing
 B-2 D-2A D-2B		Health hazards 2 Fire hazard 3 Reactivity 2 Personal protection X	

Section I. Chemical Product and Company Identification

Trade name	**L713-NET-11**	**Product type**	**Polyester Resin Solution**
CAS #	Not applicable.	**Synonym**	None.
Chemical name	Not applicable.	**Chemical formula**	Not applicable.
Chemical family	Aromatic.		
Material uses	Used in the manufacture of thermoset plastic parts.		
TSCA	All ingredients are listed or compliant with TSCA.		
DSL	All ingredients are listed or compliant with the NSNR.		

Manufacturer

AOC, LLC
950 Highway 57 East
Collierville, TN U.S.A. 38017
Phone Number: (901) 854-2800
8am-5pm (CST) Mon-Fri

In case of emergency

CHEMTREC (US): 24 hours/7 days (800) 424-9300
CANUTEC (Canada): 24 hours/7 days (613) 996-6666

Section II. Information on Hazardous Ingredients

Name	CAS #	% by weight
1) Styrene	100-42-5	40.5
2) Silica, Amorphous	7631-86-9	1 - 5

Section III. Hazards Identification.

Potential acute health effects

Inhalation of spray mist or liquid vapors may cause upper respiratory irritation and possible central nervous system effects including headaches, nausea, vomiting, dizziness, drowsiness, loss of coordination, impaired judgement and general weakness. Severe eye irritant which may result in redness, burning, tearing and blurred vision. Skin irritant which may result in burning sensation. Ingestion may result in mouth, throat and gastrointestinal irritation, nausea, vomiting and diarrhea.

Potential chronic health effects

CARCINOGENIC EFFECTS:
Styrene: Classified A4 (not classifiable for human or animal) by ACGIH. Classified 2B (possible for human) by IARC. An increased incidence of lung tumors was observed in mice from a recent inhalation study. The relevance of this finding is uncertain since data from other long-term animal studies and from epidemiology studies of workers exposed to styrene do not provide a basis to conclude that styrene is carcinogenic. Lung effects have been observed in mouse studies following repeated exposure.
Silica, Amorphous: Classified 3 (not classifiable for human) by IARC.
MUTAGENIC EFFECTS
Not available.
TERATOGENIC EFFECTS
Not available.
Skin effects:
Prolonged exposure may cause dermatitis.

Section IV. First Aid Measures

Eye contact	Flush with a continuous flow of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Use of buffered baby shampoo will aid in removal. Seek medical attention.
Skin contact	Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. If irritation persists, seek medical attention.
Hazardous Skin Contact	No additional information.
Inhalation	Move the victim to a safe area as soon as possible. Allow the victim to rest in a well ventilated area.
Hazardous Inhalation	Move the victim to a safe area as soon as possible. If breathing is difficult, give oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.
Ingestion	Do not induce vomiting. Seek immediate medical attention.
Hazardous Ingestion	No additional information.

Section V. Fire and Explosion Data

The product is:	Flammable liquid, Class IC.
Auto-ignition temperature	914°F (490°C) Styrene
Flash point	87.6°F (31°C) Styrene
Flammable limits	**Lower:** 0.9% **Upper:** 6.8% (Styrene)
Products of combustion	May produce carbon monoxide, carbon dioxide, and irritating or toxic vapors, gases or particulate.
Fire hazard	Flammable in the presence of open flames, sparks, or heat.
Explosion hazard	Can react with oxidizing materials. Explosive in the form of vapor when exposed to heat or flame. Material may polymerize when container is exposed to heat (fire) and polymerization will increase pressure in a closed container which may cause the container to rupture violently.
Fire-fighting media and instructions	SMALL FIRE: Use carbon dioxide, foam, dry chemical or water fog to extinguish. LARGE FIRE: Evacuate surrounding areas. Use carbon dioxide, foam, dry chemical or water fog to extinguish. Wear self-contained breathing apparatus (SCBA) and full fire-fighting protective clothing. Cool containing vessels with water spray in order to prevent pressure build-up, autoignition or explosion. Prevent run off to sewers or other water ways.

Section VI. Accidental Release Measures

Small Spill	Absorb with an inert material and place in an appropriate waste disposal container.
Large Spill	Stop leak if without risk. Eliminate all ignition sources. Contain with an inert material, recover as much as possible and place the remainder in an appropriate waste disposal container. Warn unauthorized personnel to move away. Prevent entry into sewers or confined areas.

Section VII. Handling and Storage

Precautions	WARNING! Use only in well-ventilated areas. Store away from direct sunlight. Avoid inhalation and contact with eyes, skin, and clothing. Wear appropriate personal protective equipment for your task. Ground and bond all containers when transferring the material. Empty containers may retain product and product vapor. Do not expose to heat, flame, sparks or other ignition sources such as cutting, welding, drilling, grinding or static electricity. Do not pressurize. Provide adequate safety showers and eyewashes in the area of use. Note: If product contains metal compounds (Section II), avoid dust from dried product or grinding of articles made from this material.

Section VII. Handling and Storage

Storage	Keep away from sources of ignition. Keep away from heat and direct sunlight. Keep container tightly closed. Keep in a cool, well-ventilated place. Containers should be grounded.

Section VIII. Exposure Controls/Personal Protection

Exposure limits	1) Styrene	**OSHA PEL (United States).** TWA: 100 ppm TWA: 426 mg/m^3 **ACGIH TLV (United States).** TWA: 20 ppm TWA: 85 mg/m^3
	2) Silica, Amorphous	**OSHA PEL (United States).** TWA: 6 mg/m^3 **ACGIH TLV (United States). Notes: Total** TWA: 10 mg/m^3
Engineering controls	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective occupational exposure limits. Provide adequate safety showers and eyewashes in the area of use.	
Personal protection	Personal protective equipment may vary depending on the job being performed. **Eye/Face:** Wear eye protection such as safety glasses with side shields, splash goggles or face shield with safety glasses. **Skin:** Avoid skin contact. Impervious gloves should be worn. Other items may include long sleeves, lab coats, or impervious jackets. **Respiratory:** Determine if airborne concentrations are below the recommended exposure limits in accordance your company's PPE program and regulatory requirements. If they are not, select a NIOSH-approved respirator that provides adequate protection from the concentration levels encountered. Air-purifying respirators are generally adequate for organic vapors. Use positive pressure, supplied-air respirators if there is potential for an uncontrolled release, if exposure levels are unknown, or under circumstances where air-purifying respirators may not provide adequate protection. Reference OSHA 29 CFR 1910.134	
Personal protection in case of a large spill	Chemical resistant gloves, full protective suit, and boots. Respiratory protection in accordance with OSHA regulation 29 CFR 1910.134. A self-contained breathing apparatus should be used to avoid inhalation of the product vapors.	

Section IX. Physical and Chemical Properties

Physical state	Liquid.	**Odor**	Aromatic.
Color	Clear to Amber.	**pH (1% soln/water)**	Not applicable.
Molecular weight (g/mol)	1000 to 15000	**Boiling point**	293°F (145°C) Styrene
Melting point	Not available.	**Specific gravity**	1.1 (Water = 1)
Vapor pressure	4.5 mm Hg @ 68°F (20°C) Styrene	**Vapor density**	3.59 Styrene (Air = 1)
Odor threshold	0.14 ppm Styrene	**Water/oil dist. coeff.**	Not available.
Evaporation rate	Not available.	**Dispersibility properties**	Not dispersed in water.
Solubility in water	Slight.		

Section X. Stability and Reactivity Data

Stability	This product is normally stable, but can become unstable at elevated temperatures and undergo polymerization, which could produce heat and fumes resulting in over-pressurization and rupture in a closed container.
Instability temperature	>170°F (77°C)
Conditions of instability	Heat.
Incompatibility with various substances	Polymerizes in the presence of organic peroxides, oxidizing materials, or heat.
Corrosivity	No specific information is available in our database regarding the corrosivity of this product in presence of various materials.

Section XI. Toxicological Information

Routes of entry	Inhalation. Ingestion. Skin contact. Eye contact.	
Toxicity to animals	1) Styrene	ORAL (LD50): Acute: 2650 mg/kg [Rat]. VAPOR (LC50): Acute: 5634.2 ppm 4 hour/hours [Rat].
	2) Silica, Amorphous	Not available.
Special remarks on toxicity to animals	Lung effects have been observed in mouse studies following repeated exposure.	
Special remarks on chronic effects on humans	No additional remark.	
Special remarks on other toxic effects on humans	No additional remark.	

Section XII. Ecological Information

Ecotoxicity	Toxic to aquatic organisms. Should not be released to sewage system or other bodies of water at concentrations above limits established in regulations or permits.

Section XIII. Disposal Considerations

Waste disposal	Recycle to process, if possible. Consult your local or regional authorities. Ignitable characteristic.

Section XIV. Transport Information

DOT - Shipping description	UN1866; Resin Solution; 3; III.	**Labels** 
TDG - Shipping description	UN1866; Resin Solution; 3; III.	**Labels** 
IATA/IMDG - Shipping description	IATA: UN1866; Resin Solution; 3; III; Pkg. Inst.: Passenger - 309; Cargo - 310 IMDG: UN1866; Resin Solution; 3; III; FP=31°C; EmS No.: F-E, S-E	
Additional information	US regulations require the reporting of spills when the amount exceeds the Reportable Quantity (RQ) for specific components of this material. See CERCLA in Section 15, Regulatory Information, for the Reportable Quantities.	

Section XV. Other Regulatory Information

Other regulations

This section does not reference all applicable regulatory compliance lists.

OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Proposition 65 Warning: This product contains a chemical(s) known to the State of California to cause cancer, birth defects and/or reproductive harm.

SARA 302 component(s): None.

SARA 313 component(s): Styrene.

CERCLA RQ(s): Styrene-1000 lbs. (453.6 kg)

Section XVI. Other Information

References	-Transportation of Dangerous Goods Act - "Regulations respecting the handling, offering for transport and transporting of dangerous goods." Extract from the Canada Gazette Part II -Canada Gazette Part II, Hazardous Products Act "Ingredient Disclosure List". -Manufacturer's Material Safety Data Sheet. -29 CFR 1910.1000, Z - Tables -ACGIH 2000 TLVs for Chemical Substances and Physical Agents -Registry of Toxic Effects of Chemical Substances (RTECS) -California Code of Regulation Proposition 65
Prepared by	AOC, LLC - Corporate Regulatory Affairs. CA

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