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16. ABSTRACT

Though this study did not include replication, the preponderance of the data from field and simulated-field experiments indicates that Cured-in-Place Pipe (CIPP), with some care in enforcing the Caltrans specification and delaying the reintroduction of natural flow, will result in concentrations of Volatile Organic Compounds (VOCs) that will not likely impact downstream receiving waters.

Some measured concentrations were above the toxicity threshold for sensitive aquatic species, however, all concentrations were below all other known toxicity thresholds (e.g. trout). To be protective of water flowing through the CIPP, enhancements may be necessary to protect the most sensitive aquatic species.

Cure method had a clear benefit to the most concerning constituent, styrene. Ultraviolet (UV) curing was clearly superior and the other volatile concentrations detected were all measured at levels below known environmental thresholds.

The water quality results, in terms of protection of aquatic species, can be categorized by soil conditions. For unsaturated soil conditions, UV-cured resin, styrene-free resin, and steam-cured, styrene-base resin with forced heated air treatment would be protective of all aquatic species without the need to divert flow. For all other scenarios, water cannot be allowed to flow through the pipe until 96 hours after CIPP installation. For saturated soil conditions, UV-cured and non-styrene CIPP met all water quality criteria. For styrene-based CIPP in saturated conditions, forced heated air appears to be a contributing factor to bring concentrations below environmental thresholds by Day 4. Additional enhancements may be necessary for saturated soil conditions that are presumably causing a heat sink that may be inhibiting the curing process.

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WATER QUALITY OF FLOW THROUGH CURED-IN-PLACE PIPE (CIPP)

WATER PROGRAMS
SACRAMENTO STATE

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Executive Summary

To conservatively measure the water quality impacts of CIPP methods, a small volume of water was introduced immediately after CIPP installations of 11 pipes. Minimizing the volume of water used to flush the pipes theoretically results in higher concentrations of chemical residuals from the CIPP installation materials. Water quality analysis for volatile organic compounds in samples taken from the induced flows demonstrated that adherence to the Caltrans specification for CIPP installation is sufficient to avoid fish kills. Some measured concentrations were above the no observable effect concentration (NOEC) for algae within 4 days; however, all concentrations were below all other known toxicity thresholds for other test species (e.g., trout). The most protective CIPP curing method was UV, where the concentrations of volatile organic compounds in all samples analyzed were below all known environmental thresholds. Potential specification improvements may be helpful to further reduce the risk to sensitive species such as algae.

For locations requiring protection of the most sensitive species immediately at the point of discharge, several CIPP options appear feasible for pipe rehabilitation. The present study was not designed to determine optimum enhancements to CIPP specifications, so duration of water diversion, duration of forced heated air post-cure treatment, and minimum steam temperature are not specified here. While not tested in this study, enforcement of the maximum cool-down rate for steam-cured CIPP per the Caltrans specification may reduce the need for specification enhancements. Tested CIPP specification options from the present study that were protective of known environmental thresholds can be organized according to field conditions.

For dry site conditions that require protection of aquatic species at the pipe outfall, consider a CIPP specification that restricts the contractor to the following options:

- UV cure,
- Pull-through or inversion installation, steam cure, and a water diversion, or
- Pull-through or inversion installation, steam cure, and forced heated air post-cure treatment.

For wet soil site conditions that require protection of aquatic species at the outfall, consider a CIPP specification that restricts the contractor to the following options:

- UV cure, or
- Pull-through or inversion installation, minimum steam temperature of 240^{o} F, water diversion, and forced heated air post-cure treatment.

Introduction

Culverts are a vital part of California's transportation system because they prevent flooding and erosion by channeling stormwater beneath highways. There are an estimated 205,000 culverts in the state highway system. Caltrans rates these culverts using three categories: good, fair, and poor. Current assessments predict that 62 percent are in good condition, 25 percent are in fair condition, and 13 percent are in poor condition. The culverts rated fair (approximately 51,000) require corrective maintenance that may include trenchless repair methods (Caltrans 2016). Open trench replacement of these culverts is expensive, causes significant impacts to the traveling public using the highways above, and produces sediment management challenges. Some trenchless replacement techniques, such as pipe jacking, also require sediment management (Caltrans 2013).

Numerous trenchless methods are available to rehabilitate these culverts with minimal impact to the public. Rehabilitation is usually less intrusive than other trenchless replacement techniques. One trenchless method used to rehabilitate pipe is cured-in-place pipe (CIPP). Installed correctly, CIPP technology represents not only cost savings, but could have less sediment-based environmental impacts than other methods. However, the environmental impacts of this method have been questioned by California Regional Water Quality Control Boards (Regional Water Boards; CTC 2012). Because of concerns about styrene, in particular, and its potential environmental impacts and behavior (Donaldson and Baker 2008), there is a resulting need to understand the environmental impacts of CIPP installed according to the Caltrans specification and to compare the results with California's environmental regulations and known toxicity thresholds. The purpose of the present study is to determine if the current Caltrans specifications are adequate or if modifications are necessary to protect water quality. The relevant Caltrans specifications used in this study are Standard Special Provisions (SSP) 15-6.11-A04-19-13 and SSP 15-6.02 (Caltrans 2010). Caltrans now uses the 2015 version of this specification under the identification number 71-3.08 (Caltrans 2015). Both versions reflect recent updates to the SSP designed to reduce styrene releases to the environment, namely the capture of all condensate and use of additional liner material to capture any resin that might fall to the ground during installation, curing, and cutting operations.

A previous study by the Virginia Department of Transportation (VDOT) showed that there were residual styrene concentrations in the receiving waters at levels that would be toxic to fish (Donaldson and Baker 2008). Elevated styrene concentrations were generally attributed to poor installation and resin curing practices (Donaldson and Baker 2008) and not necessarily an inherent flaw with the product itself. Since the 2008 study, VDOT has revised its specifications, increasing the requirements for performance-based specifications and capturing the resin and process water (Donaldson and Wallington 2013). Subsequent study of steam-cured, styrene-based resins following the revised specification were not found in the literature. So, to address concerns regarding the water quality resulting from styrene-based culvert rehabilitation following specifications designed to protect water quality, a pilot study was proposed to measure water quality resulting from CIPP installations following the Caltrans SSP.

Though not always applicable to end-of-pipe discharges, toxicity thresholds are used as conservative points of comparison for discharges from CIPP. In addition to toxicity thresholds, the state has established a maximum contaminant level (MCL) for styrene in drinking water at 100 µg/L. Environmental studies have shown that styrene biodegrades and volatilizes quickly in the environment (Fu and Alexander 1992), so the threat to the environment is reduced with time and distance to receiving waters. Fate and transport to the receiving water is an important factor that was not addressed in this study. Because CIPP in California is more often used on culverts with ephemeral flows, fate and transport to receiving waters could be an important consideration when selecting culvert rehabilitation methods. A programmatic scientific approach was recommended to address these potential water quality concerns (CTC 2012).

A systematic study based on the Caltrans specification can also reduce project-specific costs. For example, the regulating agency required discharge concentrations to be verified for up to 60 days after installation of the Caltrans project under expenditure authorization (EA) 04-264900. In addition to this requirement, a flushing procedure was imposed (CTC 2012). These requirements add substantial cost and time to CIPP projects.

The lack of water quality data from Caltrans CIPP installations prompted the present study. Data from this study could reduce the need for project-specific analysis in the future. Data could also inform improvements to the Caltrans CIPP specification.

Water Quality Standards and Toxicity Thresholds

Thresholds for all volatile organic compounds (VOCs) found in reportable quantities are listed in Appendix B. Among these thresholds, limits for styrene were of principle concern.

For styrene, known toxicity lethal concentration (LC), effect concentration (EC), and no observable effect concentration (NOEC) thresholds may be appropriate for comparison to discharge from CIPP to nearby receiving waters depending on transport, flow, and beneficial uses of the receiving waters. In the following list, species and threshold (EC, LC, or NOEC) are listed from highest to lowest concentration and the ranges represent values from different studies, as summarized by Donaldson and Baker (2008).

- Amphipod 96-hr LC50—9.5 mg/L
- Fathead minnow 96-hr LC50—5.2 to 10 mg/L
- Water flea 48-hr EC50—4.7 mg/L
- Amphipod 96-hr NOEC—4.1 mg/L
- Fathead minnow NOEC—2.6 to 4 mg/L
- Rainbow trout 96-hr LC50—2.5 mg/L
- Freshwater green algae 96-hr EC50—0.72 mg/L
- Freshwater green algae 72-hr NOEC—0.53 mg/L
- Freshwater green algae 96-hr NOEC—0.063 mg/L

The California Office of Environmental Health Hazard Assessment (OEHHA) set a public health goal (PHG) of 0.5 ppb for drinking water, based on carcinogen effects in test species (OEHHA 2010). PHGs are not regulatory standards and their application to surface waters is not appropriate. Surface water standards are available in the basin plans approved by the Regional Water Boards.

The drinking water MCL is 100 ppb (CA Title 22 §64444) and this value is referenced in many California basin plans such as the Los Angeles Region Plan (Los Angeles Water Board 2014). Further, basin plans in California have narrative objectives for receiving waters that may be applicable to CIPP, particularly the prohibition of discharge materials that cause "visible film" in receiving waters (Central Valley Water Board 2016).

Problem Statement

Prior to this study, pollutant discharge concentrations at CIPP installations that followed the allowable CIPP installation methods in the Caltrans specification were not available. One of the notable challenges of implementing this trenchless culvert rehabilitation method using styrene-based resins is the leaching of styrene, a VOC, into water that flows through the culverts. Thorough curing theoretically immobilizes styrene, but the degree of effectiveness in Caltrans installations should be assessed to ensure the Caltrans specifications are adequately protective of water resources.

Study Design

This study investigates discharge concentrations of VOCs and tests additional procedures that may be adopted to minimize potential impacts to water quality. The study was designed to replicate a worse-case scenario of runoff from a small storm flowing through a recently installed CIPP (within the same day). To obtain conservative (higher) water concentrations, a very low volume of water was used at a relatively high flow rate for that volume of water. A high rate increases the flow depth and the surface washing of the sides of the CIPP. A low volume minimizes the concentration dilution. Flow was selected based on Manning's flow calculations to obtain a target flow depth of three to four inches. To ensure the target depth was achieved throughout the length of the pipe, the target flow duration was estimated based on the travel time of the target flow down the length of each test pipe. In practice, the flow was shut off at the occurrence of flow at the downstream end of the pipe. The resulting volume used varied from approximately 200 to 300 gallons. The project budget allowed for five flushing events. Then, to capture the predicted greatest change in concentrations immediately after a CIPP installation, an increasing geometric series was used to schedule the induced flows. However, for the field scenarios, additional samples were collected until the concentrations reached non-detect levels.

The test scenarios were designed to study the most commonly implemented CIPP techniques within the Caltrans specifications, along with some of the methods in the specification that were assumed to be more protective of water quality. An inversion placement of a styrene-based polyester resin with a preliner cured with steam is the most commonly used method. UV-cured polyester and steam-cured low VOC resins were considered the most environmentally benign alternatives (Donaldson and Whelton 2013), but cost considerations often prompt contractors to select other methods.

After the start of this project, Whelton et al. (2015) proposed a more predictive, laboratory-based analysis approach and future field studies should consider whether augmentation with similar laboratory experiments could lead to the development of predictive models of water quality.

The CIPP scenarios, setup, and sampling and analysis methods related to the present study are discussed in the sections that follow.

CIPP Test Scenarios

A series of scenarios were developed to test a variety of the steam- and UV-cured CIPP techniques allowed by the Caltrans specification. A few post-cure enhancements were also considered to measure any improvement in post-cure water quality. In addition, the effect of an extra preliner was tested. Post-cure treatments and an extra preliner are enhancements to (not requirements of) the specifications. The scenarios are described in this section and in Table 1. They are organized by host pipe variation, installation technique, liner variation, resin variation, cure methods, and post-cure treatment.

Host Pipe Variation

Corrugated metal pipe (CMP) and reinforced concrete pipe (RCP) were selected as host pipe materials. Only one CIPP variation in the simulated field experiment used RCP host pipe. The remaining simulated field pipes and all the culverts in the field were CMP.

CIPP Installation Techniques

Inversion and pull-in-place were the two installation methods used in this study. The contractors reported that inversion is the preferred method because it reduces the risk of liner damage that sometimes results when pulling the liner through host pipe. All liners, once installed within the host pipe, were pressurized with air introduced into the liner to conform the liner to the host pipe and ensure proper fit during the curing process.

Inversion

CIPP liners were placed into position in the host pipes by inverting them using air pressure following procedures outlined in ASTM F2019-11. This involved impregnating (off-site wet out process) and storing the liners in refrigeration prior to installation. Once inverted and in position, the liners were in the correct orientation and ready to begin the curing process.

Pull-in-place

CIPP liners were pulled into place using a system of cables and a winch following procedures outlined in ASTM F2019-11. Pulled-in-place liners were impregnated and refrigerated prior to installation into the host pipe.

Liner Variations

Liners are used to prevent excess uncured resin from leaving the host pipe and pooling in areas that are not adequately cured. Uncured resin outside of the host pipe could present a risk to groundwater. It could also travel along the exterior of the host pipe and discharge to the surface.

Preliner

The Caltrans specification requires a preliner for inversion installations. All inversion installations in the present study, except one, used a preliner and select installations used an extra preliner.

Extra Preliner

The extra preliner variation was used for two of the inversion installations.

No Preliner

A preliner was not installed for the pulled-in-place variation as allowed in the Caltrans specification. A preliner is not typically used because the liner used for pull-in-place applications is installed with an outer impermeable membrane to protect the resin-impregnated felt liner during placement of the liner into the host pipe. In addition, a preliner was not used on one of the non-styrene resins.

Resin Variations

Two resins were used. Additives are used to reduce resin viscosity and improve uniform impregnation of the felt liner in a process called wet-out.

Polyester-Styrene Resin

CIPP liner felt tubes were impregnated with styrene-based polyester resins during wet-out operations prior to installation. These resins were used in all CIPP liners except for the low VOC variations.

Vinyl Ester (Low VOC) Resin

The low VOC resin variations selected used non-styrene monomers in a vinyl ester resin. The wet-out process performed was similar to the styrene-based polyester resin variations process.

Curing Methods

Curing is critical to achieve the strength requirements of the liner. Curing also reduces the environmental impacts of uncured resin.

Steam Catalyst

Steam is used to raise the temperature of the liner to a level that will initiate a catalyst reaction in the liner resin. Steam was used in all but one of the CIPP installations.

Ultraviolet Light Catalyst

Ultraviolet light (UV) is used to initiate the curing process of the light reactive liner. UV-cured liners are considered more environmentally friendly due to their shortened cure time and the lack of styrene liquid byproduct waste (condensate) that results from traditional steam-cured installations. This technology does incur increased cost due to the required installation equipment and UV blocking film that protects the impregnated liner prior to installation and curing.

UV curing requires sophisticated computer-controlled curing and monitoring equipment. The ultraviolet light required to catalyze the UV reactive resin impregnated liner is supplied by a light train as shown in Figure 1. Parameters, such as light intensity and pull-through speed for the light train, were specified by the liner manufacturer initially and speed was monitored and adjusted on the fly during curing to ensure recommended curing temperatures were achieved. The Caltrans specification does not specify a cool-down period for UV cure.

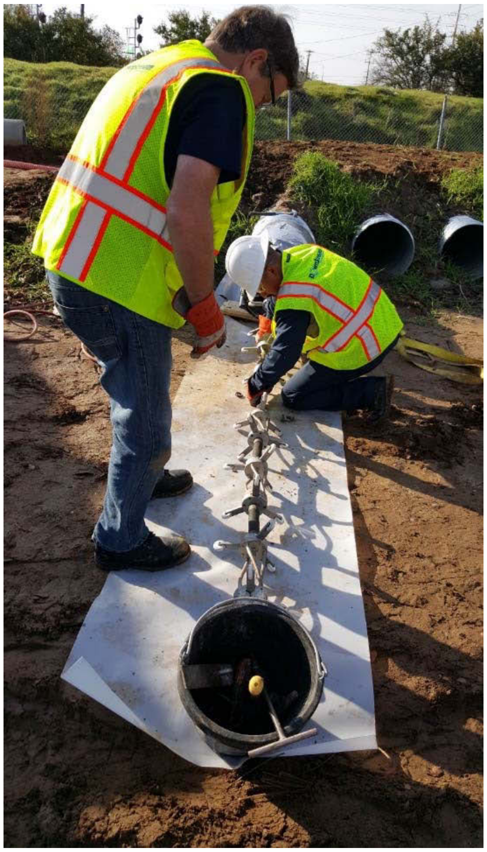

Figure 1. UV-Cured CIPP Light Train Installation

Post-Cure Treatments

Post-cure treatments were proposed as methods to further the curing process or to increase volatilization of styrene. In either case, this treatment should reduce concentrations of styrene in subsequent water flushing events. Note that post-cure treatment is not required in the Caltrans specification, however it was included in this study to determine if it resulted in a measurable change in water concentrations.

Forced Ambient Air Treatment

A fan forced ambient temperature air through the rehabilitated pipe after cool down. The fan operated for six hours. Figure 2 shows the field study forced ambient air post-cure treatment.

Forced Heated Air Treatment

A shop furnace circulated heated air through the rehabilitated pipe after cool down. The fan operated for six hours. A heated air fan was placed for Pipe 11, which followed the post-curing schedule for Pipe 10. The heated air fan used for this post-cure treatment can be seen in Figure 3.

Figure 2. Forced Ambient Air Fan Post-Cure Treatment

Figure 3. Forced Heated Air Fan Post-Cure Treatment

Field vs Simulated Field

A combination of field and simulated field water quality tests were performed on the CIPP rehabilitation system and covered several installation and post-cure treatment scenarios. Because field studies are more expensive and difficult to identify, they were augmented by simulated field studies. Field studies are preferable as a test of actual conditions. Simulated studies in a more controlled environment are better suited to comparing test scenarios while controlling all other parameters. Agreement between field and simulated field results indicates that the simulated field results may be extrapolated to field conditions. Three field studies and eight simulated field studies were conducted, as presented in Table 1. The field studies followed test scenarios 1, 3, and 4. The simulated field studies followed all eight test scenarios. All test scenarios used 18-in-diameter pipe. Field Pipes 1, 10, and 11 had lengths of 37-, 47-, and 59-ft, respectively.

Table 1. CIPP Test Scenarios for Field and Simulated Field Experiments

Test Scenario No.	Simulated Field Test Pipe No. (all lengths 20 ft.)	Field Test Pipe No.	Resin	Curing Method	Pipe Type	Preliner	Post-Cure Treatment	Placement Method
1 control	Pipe 1	Pipe 1	Polyester Styrene	Steam	CSP	Yes	None	Invert
2	Pipe 2	NA	Polyester Styrene	Steam	CSP	No (Impermeable on both sides of tube)	None	Pulled
3	Pipe 3	Pipe 10	Polyester Styrene	Steam	CSP	Yes	Blown air*	Invert
4	Pipe 4	Pipe 11	Polyester Styrene	Steam	CSP	Yes + Extra Preliner*	Blown Warm Air*	Invert
5	Pipe 5	NA	Polyester Styrene	Steam	RCP	Yes	None	Invert
6	Pipe 6		Polyester Styrene	UV	CSP	No (Impermeable on both sides of tube)	None	Pulled
7	Pipe 7		Low VOC Vinyl Ester	Steam	CSP	Yes (Same as Scenario 1)	None	Invert
8	Pipe 8		Low VOC Vinyl Ester	Steam	CSP	No	None	Invert

*Signifies an enhancement that is not required in the Caltrans specification.

Due to contracting issues, the field studies and simulated field studies were performed over different seasons and with different contractors. The contractor variation, shown in Table 2, introduced unintended variables that, fortunately, provide additional insight into water quality outcomes, as will be discussed later in this report. Field study installations and sampling were performed during the month of September 2014. The simulated field studies were carried out from January to August 2016.

Table 2. Contractor Variations for CIPP Test Scenarios

Contractor	Pipe/Culvert Nos.	Research Type
A	1, 10, and 11	Field (SR-50)
B	1 and 7	Simulated Field
C	6	Simulated Field
D	2, 3, 4, 5 and 8	Simulated Field

Simulated field tests were performed to document pollutant discharge concentrations for current Caltrans CIPP installation materials and curing methods. The tests included steam and UV curing methods using styrene and non-styrene resins.

Originally, field tests were to be performed at sites where CIPP installations took place to corroborate prior simulated field test results. However, due to project scheduling, the field tests occurred first.

The research coincided with a field project on SR-50 in Kyburz using steam-cured CIPP liners (the most commonly used method) where field sample collection was feasible. The simulated field experiments were conducted in an outdoor test environment on the California State University, Sacramento campus.

Three culverts of uniform liner type, liner thickness, and pipe diameter were selected from the referenced CIPP project on SR-50. Additionally, the culverts selected had similar slopes and lengths to minimize variations in flow dosing equipment that would be required if slope and length varied substantially. The three culverts selected were numbered 1, 10, and 11 in the contract documents.

Setup

The setup for inducing flow was designed so that sufficient water could be introduced into the pipe to create a flow depth of three to four inches. The setup varied between field and simulated field test conditions due to access and target flow rate, as described later. For both field and simulated field tests, a containment system was constructed to eliminate any discharge of dry weather flow from the experiment. The discharge collected in the containment system was pumped to a collection vehicle and disposed of offsite.

Simulated Field Dosing System

A gravity flow dosing system (Figure 5) was designed and built to facilitate sample collection for the simulated field experiments. This system consisted of a 275-gallon tank connected to 4-inch flexible hose with a 4-inch ball valve to control flow. A 90-degree fitting was used at the end of the flexible hose to reduce in-pipe velocities and increase depth of flow in the host pipe with installed CIPP liner. The dosing system was tested prior to the experiments to ensure the minimum depth of flow was achieved

(Figure 3). The dosing tank was placed on top of another 275-gallon tank to attain sufficient pressure head to achieve the desired in-pipe flow depth (Figure 4).

Figure 4. Simulated Field Depth of Flow Verification Testing

Figure 5. Simulated Field Dosing Tank Configuration

Because of the lack of an available water supply at the simulated field experiment project site, the dosing system tanks were transported to the site on a flatbed equipment trailer (Figure 6 and Figure 7).

Figure 6. Simulated Field Dosing System

Figure 7. Simulated Field Dosing System Equipment Trailer

Field Dosing and Containment Systems

Pipe access, uneven terrain, and relative distance to uncontrolled traffic presented challenges during the field study. A gravity-fed dosing system was originally conceived but mountainous terrain did not allow vehicle access to the upstream side of the culverts. Alternately, a dosing system utilizing pumps and an assembly of pipes and hoses was devised to introduce flow at the upstream end of the culverts from the culvert outfall. The dosing system consisted of 4-inch pipes placed in the host culverts from the downstream end. Hoses connected the 4-inch pipes, pumps, and water tanks. Analysis of pipe slope and length was used to estimate the flow and volume needed to reach the specified depth of flow in each pipe. The target flow calculation had to account for the presence of the 4-inch pipe within the host pipe. The first week of sampling used two 2-inch, gas-powered trash pumps in parallel drawing from a 2000-gallon water truck as shown in Figure 8. The third week of sampling used one 3-inch trash pump drawing from one 275-gallon tote stored on a utility trailer. Figure 9 shows the 4-inch pipe used for dosing in the field study as placed for sample collection.

Figure 8. Water Truck and Field Study Dosing System

Figure 9. Four-Inch Dosing System Pipe Placed In Rehabilitated Host Pipe

To prevent dry weather flow discharges during the field study, a capture system was constructed downstream of the culverts. Pipes 1 and 10 discharged to lined cofferdams that could capture approximately 1000 and 500 gallons of water, respectively (Figures 10 and 11). Pipe 11 discharged to a rectangular 200-gallon tank that was abutted to the headwall of Pipe 11 (Figure 12). Water was transported in two 275-gallon totes for offsite disposal (Figure 13).

Figure 10. Field Pipe 1 Containment System

Figure 11. Field Pipe 10 Containment System

Figure 12. Field Pipe 11 Containment System

Figure 13. Effluent Recovery Totes

Water Quality Sampling and Analysis Methodology

Grab samples were collected from turbulent flow as water discharged from the pipes. Each grab sample was collected in triplicate, as requested by the laboratory. Induced flow was performed on a schedule based on an increasing geometric progression in an attempt to weight the samples toward the period just at the end of the curing process. To start the schedule, the first sample was taken six hours after cool down. Subsequent sampling for each pipe occurred at 12 hours, 24 hours, 48 hours, and 96 hours after cool down for both field and simulated field studies.

Simulated Field Experiment Sampling Variation

A single condensate sample was collected and analyzed for each steam-cured installation during the simulated field experiment. Condensate samples were collected from stagnant liquid so they are not considered well-mixed.

The UV-cured liner did not yield any condensate so a condensate sample was not collected for this variation. In lieu of a condensate sample, the UV-cured liner was flushed two hours after final cool down using the same protocol as used on the experimental runs previously described.

Field Experiment Sampling Variation

Initially, samples were collected in the downstream containment systems immediately after flows subsided for Pipes 1, 10, and 11 during Run 1 and Pipes 1 and 10 during Run 2. This was performed to analyze a well-mixed sample from all the water that was exposed to the CIPP. However, it was observed that an oily sheen quickly developed after flushing the CIPP and that the sheen was not uniformly distributed across the containment. This quick separation of volatiles from the water column was later confirmed by the sample concentrations that were near or below the reporting limit. For the remaining three runs for Pipes 1 and 10 and the four runs for Pipe 11, samples were collected from the turbulent flow as it left the pipe.

Additional samples were collected at 13 days, 15 days, and 17 days, when sample results verified that concentrations reached non-detect levels.

Sample Handling Procedures

Prior to introducing flow, sample containers supplied by the laboratory were prepared for each sample collection. This involved affixing proper labeling to sample containers, placing sample containers inside a sealable plastic bag to prevent contamination, and storing sample containers in ice chests.

A strict protocol was followed during experiment runs to ensure a high standard of sample integrity. This required a minimum of three people to conduct experiment runs and sample collection as follows:

- Two team members were required to wear appropriate personal protection equipment including safety glasses, nitrile gloves, work boots, long pants, safety vests, and hard hats during liner installation operations or while working near traffic.
- One team member held the sealable bag containing prepared sample containers during sample collection while a second team member retrieved individual sample containers. The sample container was opened by the second team member, a sample was collected, and the sealed sample container was placed back in to the sealable bag. This process ensured that only one team member handled sample containers during collection, minimizing the risk of contamination.

- The remaining team members were in position at the dosing rig to introduce flow to the host pipe and facilitate sample collection at the pipe outfall.
- Once samples were collected, they were stored and transported with ice. Specified hold times for samples were never exceeded during the field experiment.

Analytical Methods

In December of 2010, CalEPA and the Office of Environmental Health Hazard Assessment established a public health goal (PHG) of .5 ppb or 0.5 µg/L for styrene. This is not an enforceable regulation, but it was considered as a potential minimum reporting level when selecting an analytical method and laboratory. The analytical method used for both simulated field and field experiment sample analysis was EPA 8260B (Volatile Organic Compounds by Gas Chromatography/ Mass Spectrometry). The same analytical laboratory was used for both simulated field and field experiments. The laboratory was certified by the Environmental Laboratory Accreditation Program (ELAP). For non-styrene CIPP, additional parameters that were not covered by the VOC analysis were not available upon inspection of the Material Safety Data Sheets (MSDS), so the full suite of VOCs was again analyzed for the sake of comparison to styrene-based CIPP. Available information was limited on proprietary constituents, so further exploration of the types of allowable styrene substitutes and consequent concentrations may be useful.

Experience and Visual Observations

After each test, the perimeter of the project area was inspected for any discharge. In all cases, the containment systems were effective and all field and simulated field tests were conducted without discharge of water from the test areas. Samples were successfully taken without observation of any contamination issues during the collection process.

Field

Three CIPP culvert rehabilitation installations that occurred on the same day within a 1.2-mile section of roadway on State Route 50 (SR-50) between Silverfork and Kyburz, CA, constituted the field experiment. Each test used approximately 200 to 300 gallons of water at a flow rate of approximately 300 gallons per minute.

Sampling teams noted the presence of chemical odors. Throughout the field trials, Pipe 11 had the most consistent odor. Pipe 11 was observed to have water weeping from the sides of the highway embankment, which is an indication of saturated conditions around the exterior of the pipe. A small quantity of fluid was also observed dripping from the exterior of the CIPP at a rate of a few drips per minute. However, the flow was so low that it could not be determined whether the flow was seeping along the outside of the host pipe or between the host pipe and the CIPP. An exact flow measurement could not be obtained because the flow was small and adhered to the headwall of the pipe. The flow was not sampled. Downstream containment systems collected an oily sheen throughout the experiment (Figure 14).

Further downstream, a sheen was also observed (Figure 15), but that could be due to decaying vegetation. Odors at Pipes 1 and 10 dissipated substantially faster and were nearly undetectable by the fourth day. Odor was not detected at any location during the final week of sample collection.

The sampling teams also noted that an oily sheen developed within seconds of the end of flow into the containment systems.

Figure 14. Oily Sheen Immediately Downstream of Field Pipe 11, 48 Hours After Final Cool Down

Figure 15. Oily Sheen 20 Yards Downstream of Field Pipe 11, 48 Hours After Final Cool Down

Simulated Field

Eight pipe rehabilitation installations occurred on the California State University, Sacramento campus. These installations consisted of one control experiment and seven variations (Table 1). The experience with the contractors varied substantially. For the UV-cured installation, the contractor was well-prepared and a consultant was onsite to observe the installation and ensure all the appropriate submittals were received by the study team. For Pipes 2, 3, 4, 5, and 8, the contractor was equally prepared and professional.

In contrast, the contractor that installed liners at Pipes 1 and 7 mobilized without bringing a preliner. After some questioning, it was determined that the contractor was not very experienced in complying with the Caltrans specification. The contractor rescheduled the installation. Then, during the installation of Pipe 7, the liner punched through the preliner during the inverted installation process. This may have been due to the preliner slipping in the pipe during inversion installation of the uncured CIPP tube. This occurred when the rollers and clamp assembly that held one end of the tube fell toward the pipe during the inversion process. Because the preliner was already held in place on the side receiving the inverted liner, it did not slip into the pipe when the assembly fell. However, when the assembly was put back in place, it pulled the preliner with it from the downstream side. This was evidenced by a reduction in length of preliner extending past the downstream end of the host pipe. This could have allowed the preliner to double over on itself and, then, when the inversion installation continued, the preliner was pinched and the liner could not proceed down the pipe without bursting through the liner. This was partially remedied by putting a short section of preliner in the downstream section of the pipe. After consultation with Caltrans, the experiment was allowed to proceed for the sake of the budget and schedule. The lack of a full preliner was not likely to have a substantial impact on an installation of new host pipe that does not have any joints or voids. While the preliner issues may not have been important in this case, it may indicate that inexperienced contractors may provide lower quality installations that in turn effect water quality and long term costs. In practice, this installation would have been rejected as not following the Caltrans specification.

Results

This section includes water quality data for styrene, materials testing results, meteorological data, and temperature logs. Results for all other constituents and QA/QC data is contained in Appendix B. Constituent detection frequencies are also shown in Appendix B. Besides styrene, no VOCs were measured at concentrations above known toxic thresholds.

Styrene Data

CIPP Effluent

Styrene results from the field study are presented in Figure 16. Results are not presented here for the 6-hour samples for field Pipes 1, 10, and 11, or for the 12-hour samples of Pipes 1 and 10 because they are not representative of the well-mixed flow typically found in culverts and streams. All results are reported in Appendix B.

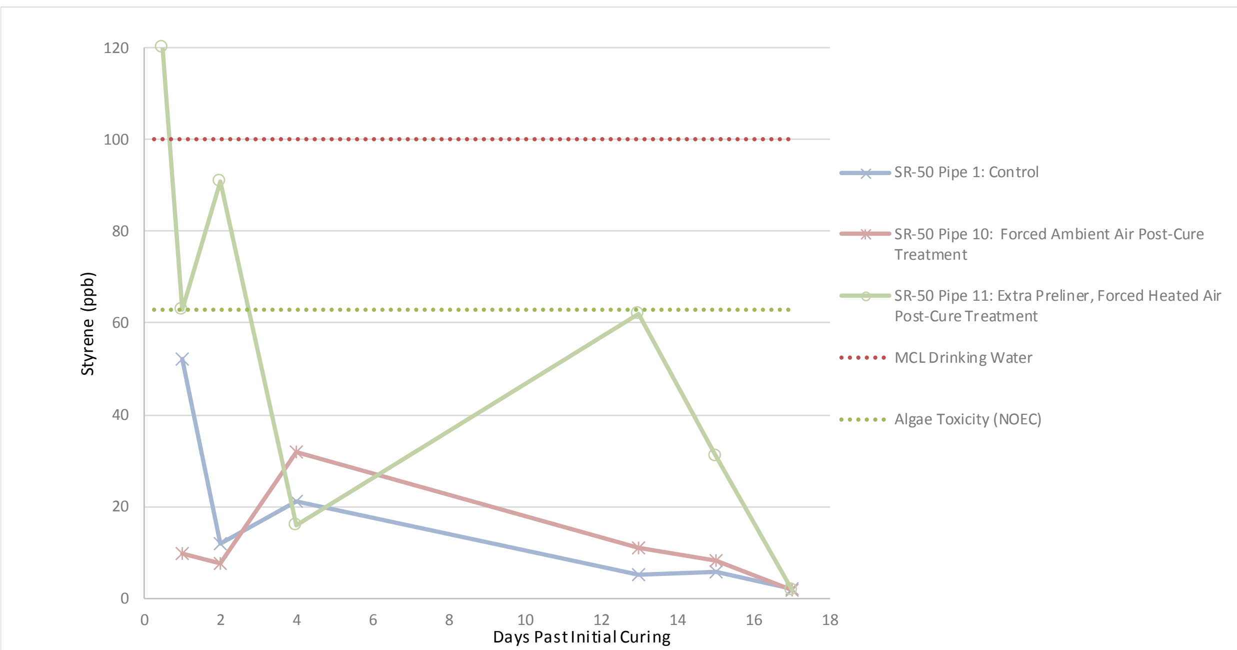

Figure 16. Field Experiment Styrene Results

Styrene results from the simulated field study are presented in Figures 16 and 17. Samples were taken up to 96 hours after curing. Additional sampling was not required because the simulated field pipes did not actually convey stormwater and there would be no lingering environmental impact. Figure 17 shows laboratory results for styrene from the simulated field study.

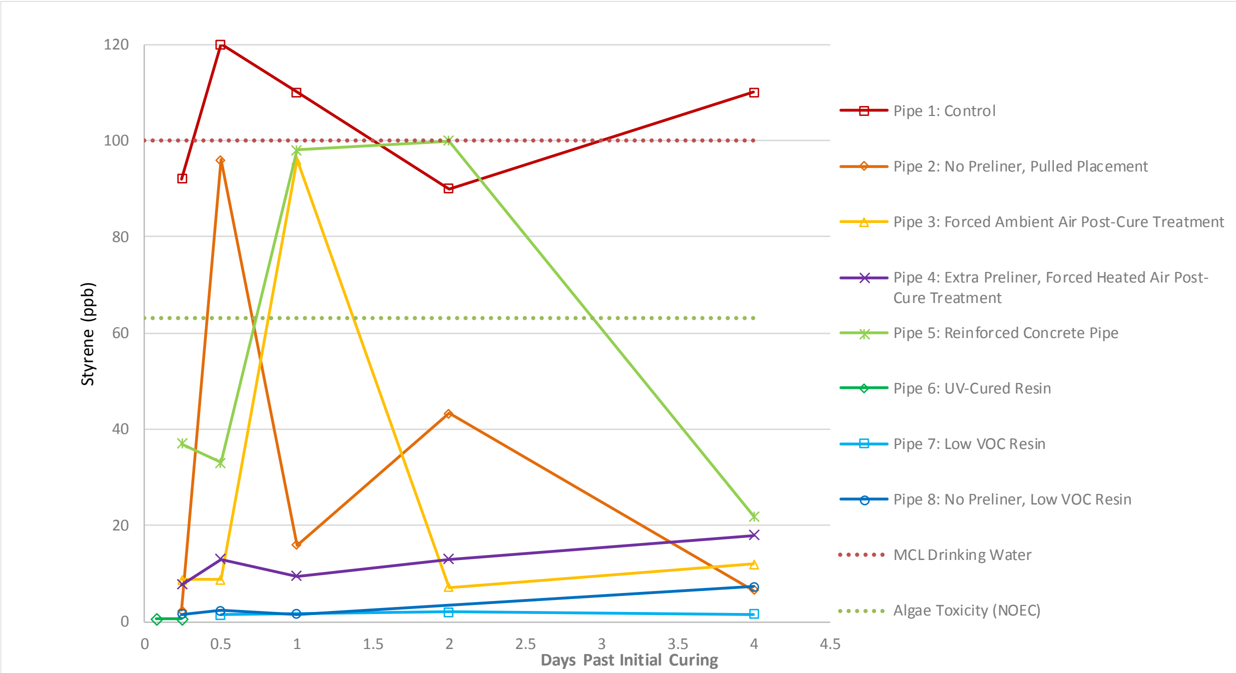

Figure 17. Simulated Field Experiment Styrene Results

Simulated Field Condensate

The results of the condensate analysis are not relevant to water quality of flow through CIPP because the condensate should not be permitted to escape into the environment during typical steam-cured CIPP installations. Though they are not discussed in this report, the condensate sample results appear in Appendix B.

Water Source and Dosing System

Figure 18 shows a comparison of simulated field influent, water source, and experiment water quality sample results for styrene. The simulated field influent represents water that flows from the dosing tank and through the hose to the CIPP. The simulated field hose bib results are for water taken as it enters the dosing system tank. The analysis results of both were so dominated by non-detect values that the box plot displays as a single line, which indicates that both 25th percentile and 50th percentile concentrations are the non-detect value. The field background concentrations at the SR-50 project location had more detectable concentrations, but were still not high enough to impact the analysis. So, background styrene concentrations for both field and simulated field experiments were considered low enough that they were not major contributors to water quality sample results and, therefore, were considered negligible for analysis.

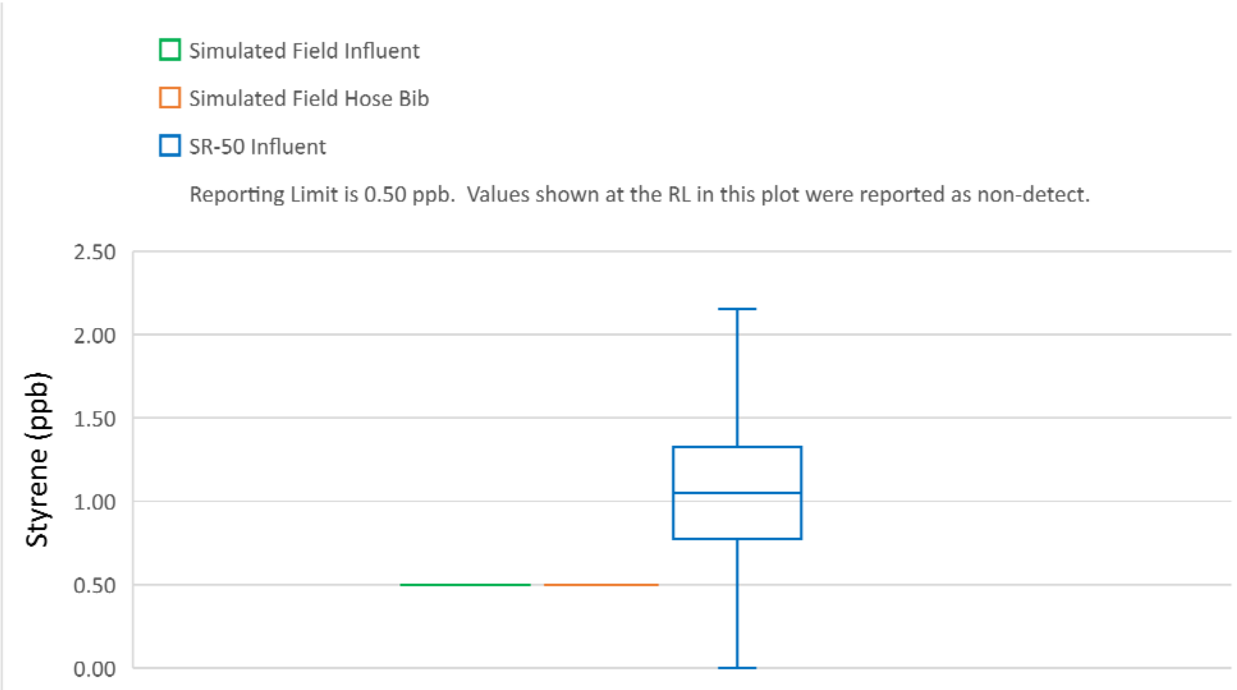

Figure 18. Box Plot Comparing Styrene Concentrations for Dosing Systems and Source Water

Meteorological Data

Figure 19 shows a comparison of average daily atmospheric temperatures for the field and simulated field studies. Ambient temperature does not appear to be an important factor. Though the simulated field control (Simulated Field Pipe 1) was constructed in a cooler environment and had higher concentrations compared to other simulated experiments, the ambient temperature was similar to the field conditions and concentrations of styrene were all lower than the simulated control at Day 4.

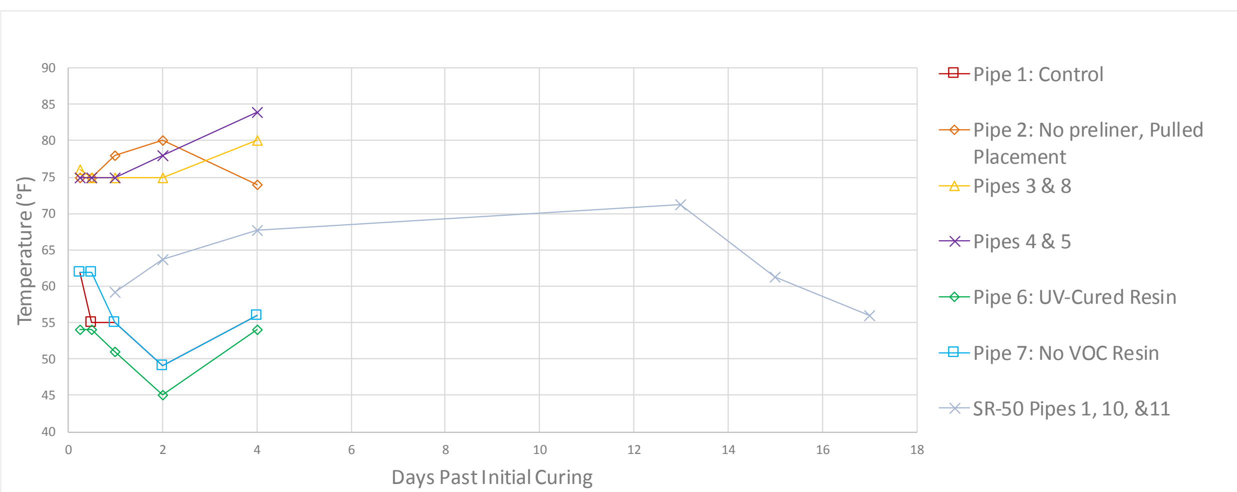

Figure 19. Comparison of Daily Mean Temperatures During Sampling Activities

Precipitation and humidity varied substantially as demonstrated in Figures 20 through 23. These figures include data from days prior to installation where precipitation was reported. Precipitation increases soil moisture, especially at the simulated field test site where soils were exposed to direct precipitation. In contrast, soils at the field test sites were almost completely covered with pavement, so soil moisture in the field was driven by sub-surface hydrology.

In the simulated field test, there was considerable contrast in soil moisture due to precipitation. Cumulative precipitation for simulated field Pipes 1 and 7 (Figure 20) totaled over 2 inches. Relative humidity was always 70 percent or higher. Cumulative rainfall was even higher just prior to installation of simulated field Pipe 6 (Figure 21), but pre-installation humidity was lower. Simulated field Pipes 2, 3, 4, 5, and 8 were constructed in dry conditions with much lower humidity (Figure 22). The field study installations occurred in dry weather (Figure 23), but there was some precipitation during the last week of sampling.

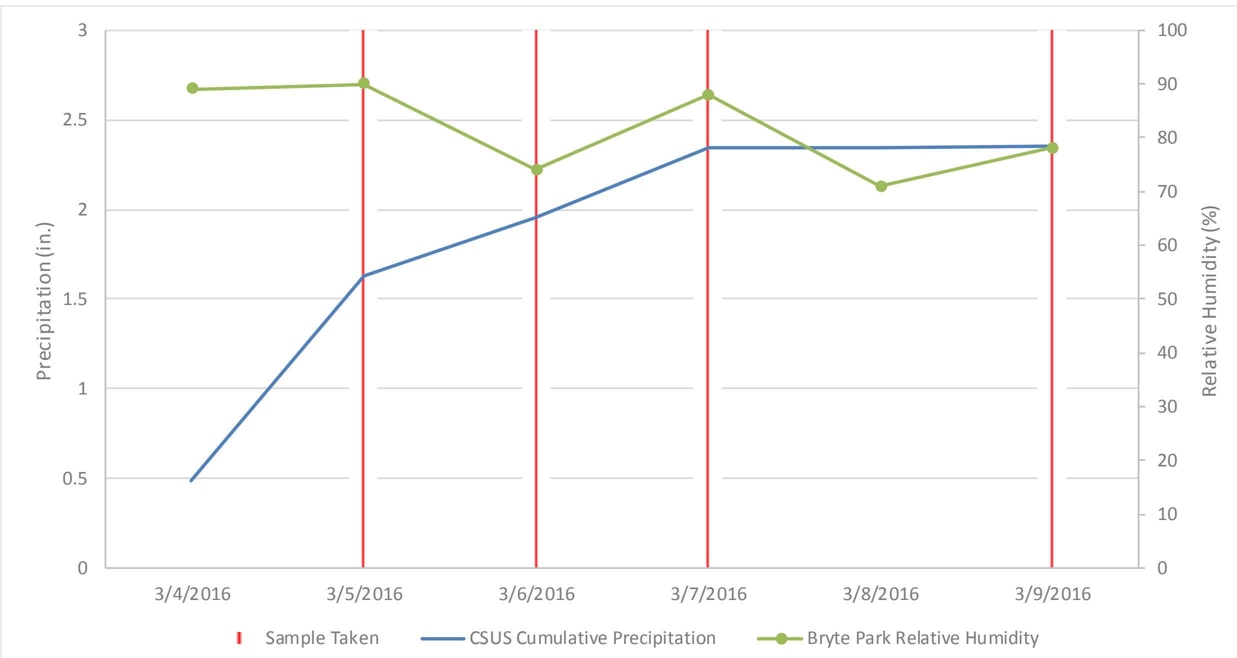

Figure 20. Simulated Field Pipes 1 & 7 Cumulative Precipitation and Relative Humidity Data

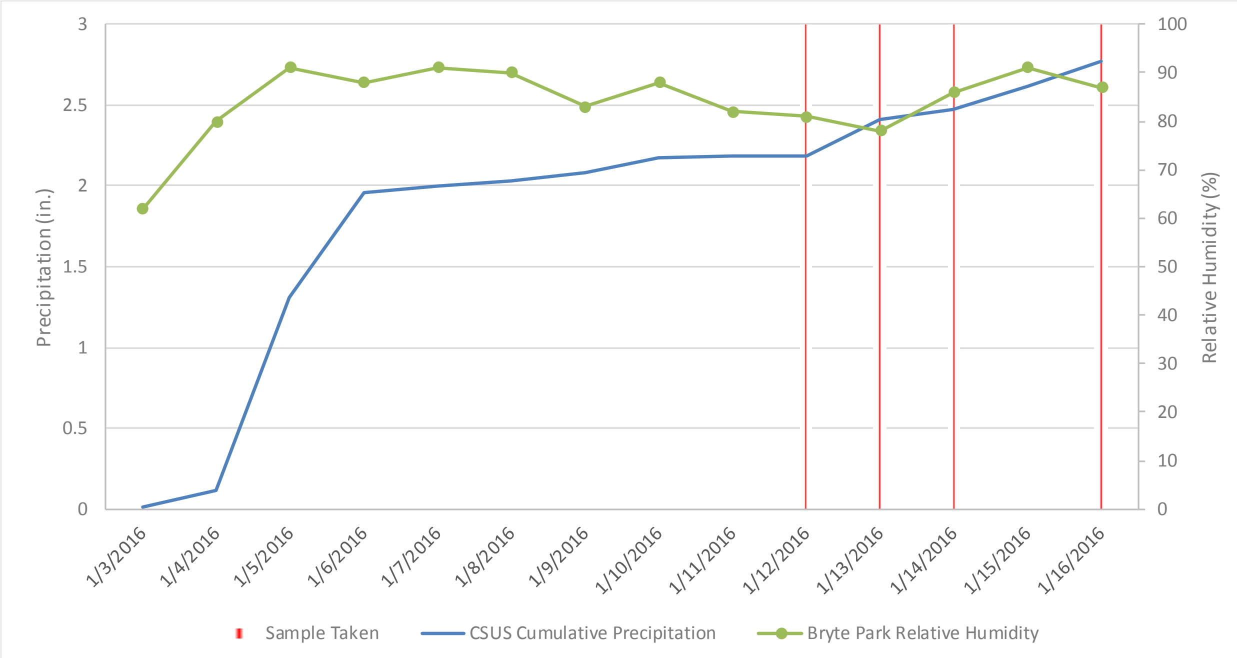

Figure 21. Simulated Field Pipe 6 Cumulative Precipitation and Relative Humidity Data

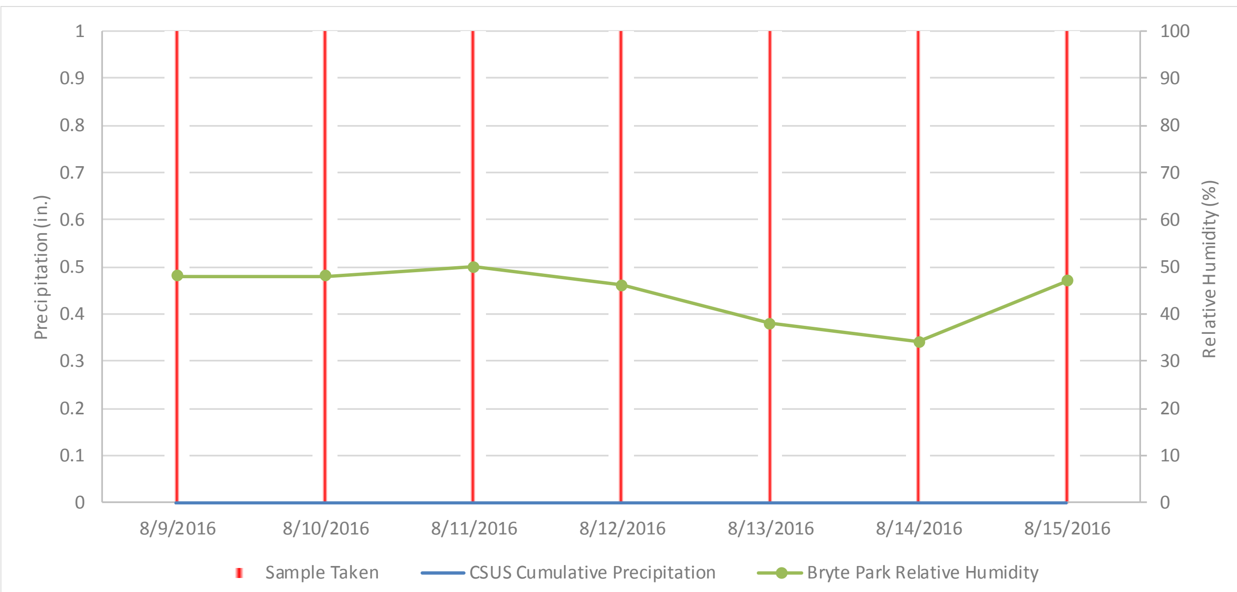

Figure 22. Simulated Field Pipes 2, 3, 4, 5 & 8 Cumulative Precipitation and Relative Humidity Data

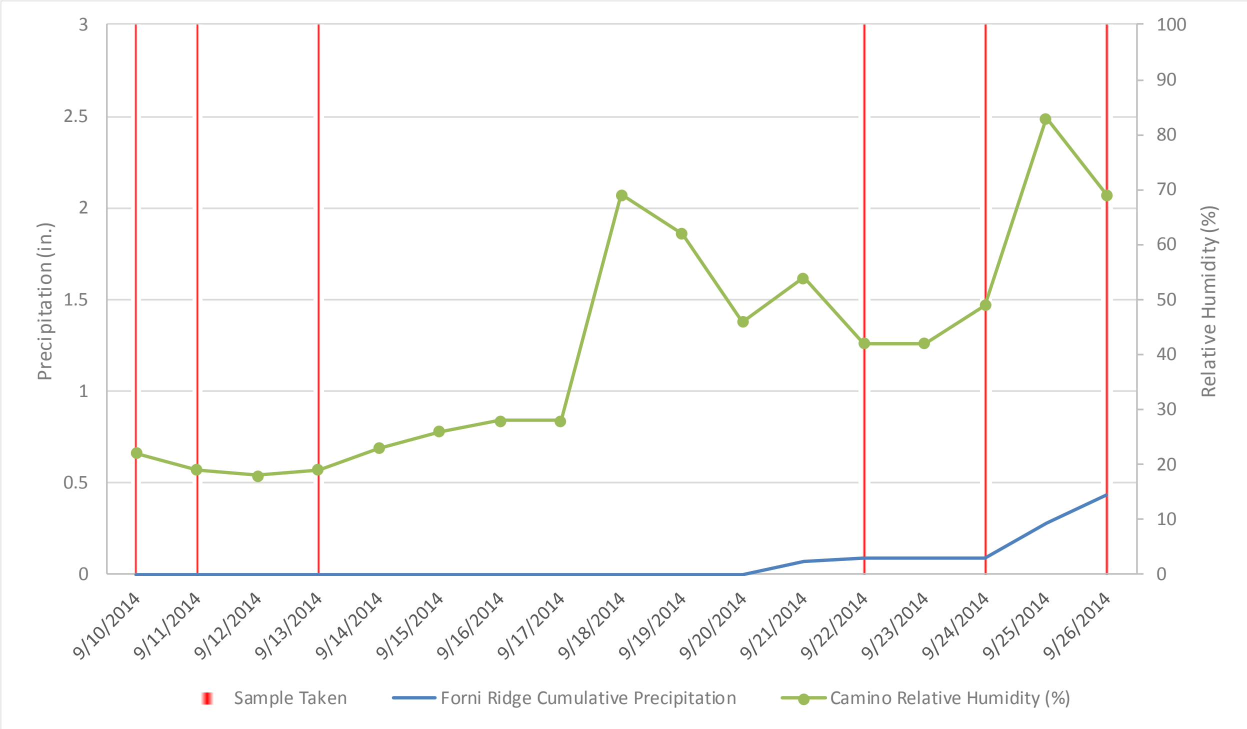

Figure 23. Field Pipes 1, 10 & 11 Cumulative Precipitation and Relative Humidity Data

Temperature Cure Log Data

Cure log data including steam temperatures and thermal couple temperatures were recorded during steam-cured installations. Temperatures at the individual sections of the light train were recorded for the UV-cured installation. The data for simulated field cure logs are presented in Figure 24. While the temperature data for both steam-cured and UV-cured installations are presented in Figure 24, a direct comparison between the two is not appropriate due to vastly different catalyzing methods and technologies. Figure 25 shows field study cure log data. Data for thermal couple and steam temperature data are shown in Figures 26 and 27, respectively, for both field and simulated field CIPP. UV-cured Pipe 6 is not included in these figures because steam curing was not used.

The Caltrans specification requires the contractor to follow the cure temperature and schedule provided in a work plan submitted in advance of the CIPP installation. All contractors complied with this requirement, however, in all cases the contractors did not describe in their work plans a cool-down period that is compliant with the Caltrans maximum cool-down rate of 15 to 20° F/hr. The cool-down rates were 3 and 10 times the maximum allowed rate as observed in Figure 26. This requirement does not apply to UV-cured installations.

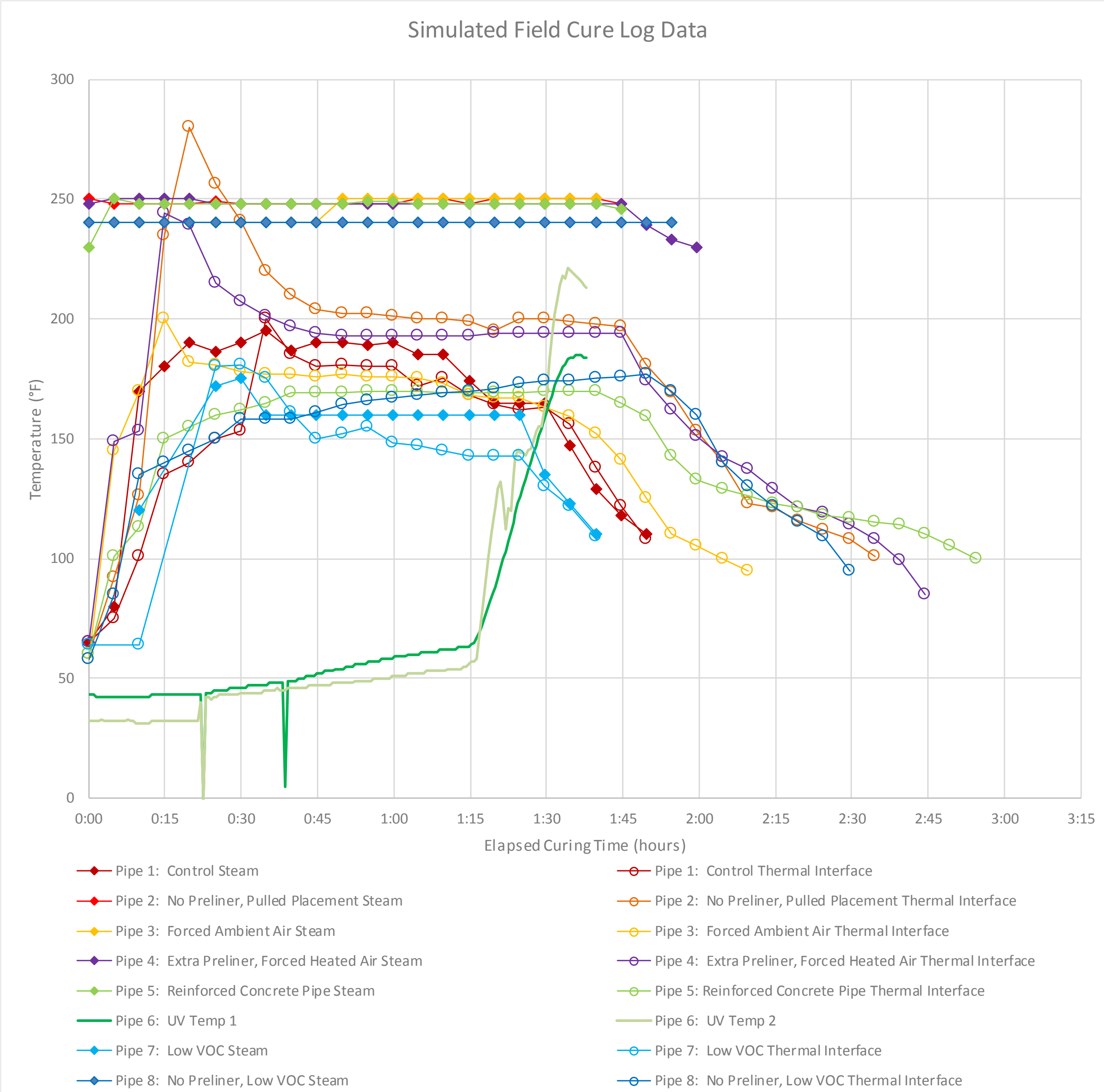

Figure 24. Simulated Field Cure Log Data

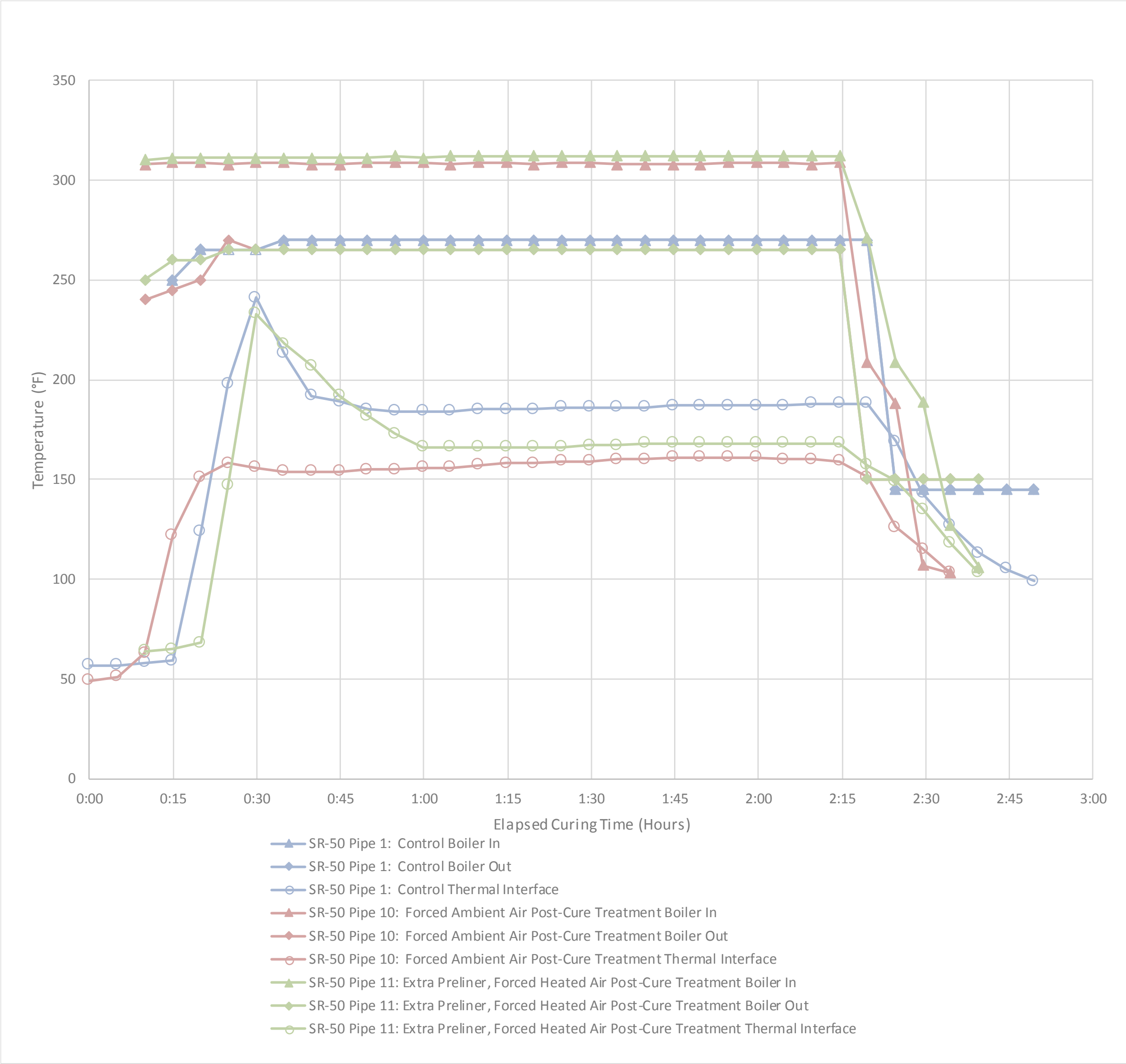

Figure 25. Field Cure Log Data

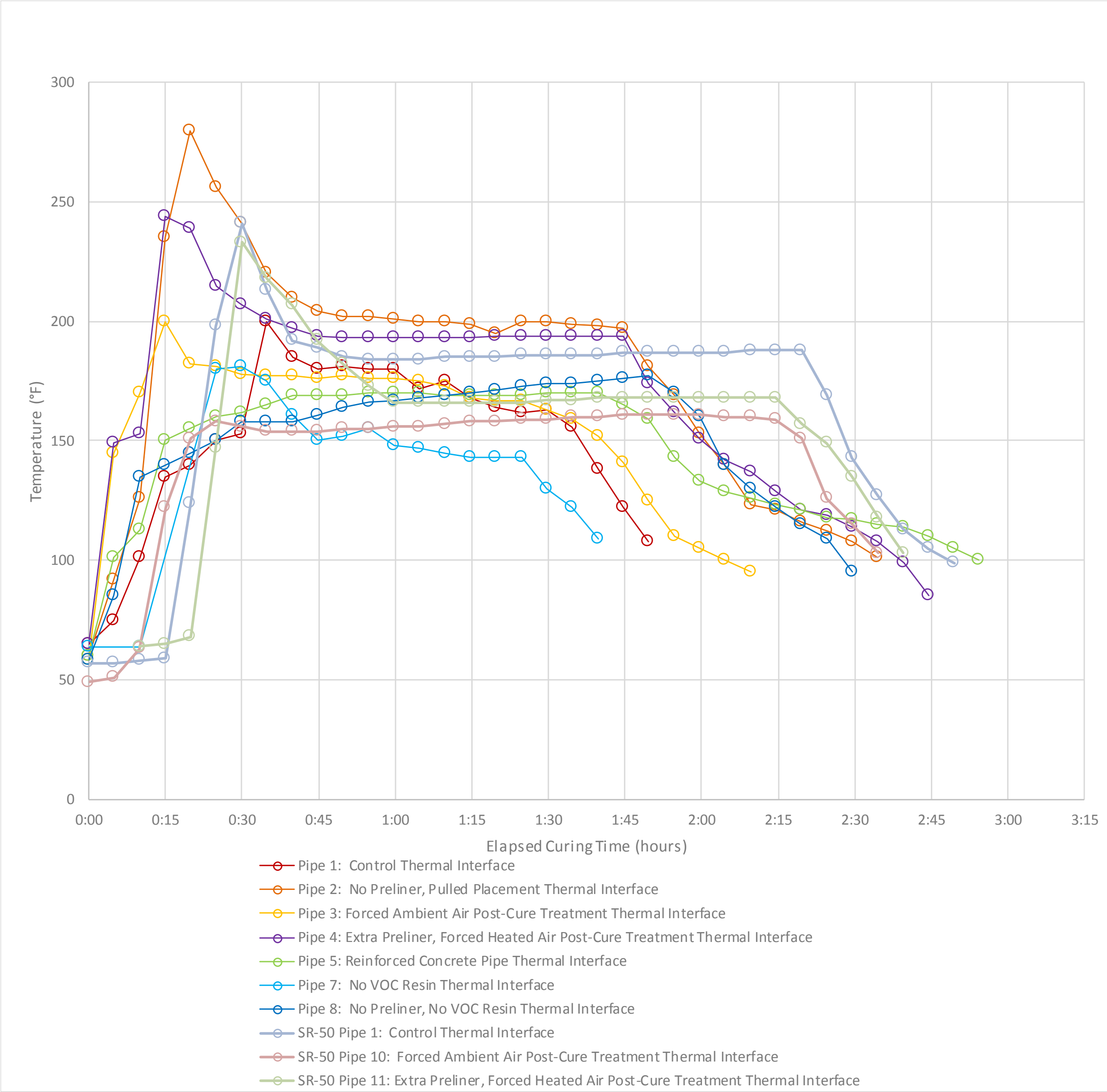

Figure 26. Field and Simulated Field Thermal Couple Data

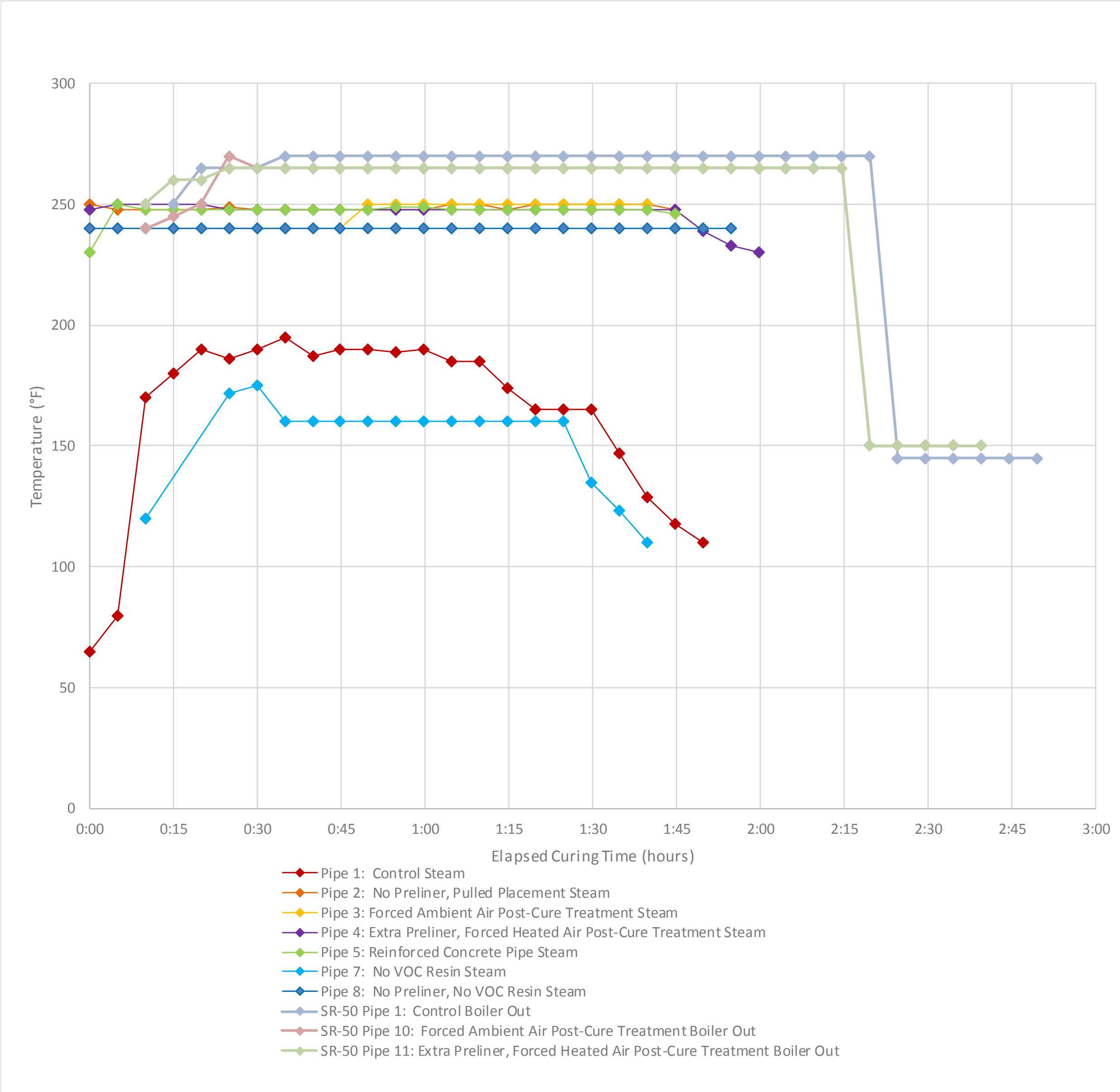

Figure 27. Field and Simulated Field Steam Temperature Data

Discussion

Concentrations of most volatile organic compounds were below reporting limits for most water quality samples taken during the field study and simulated field study. The present study focused on styrene results. Figure 28 compares the field and simulated field styrene concentrations for the styrene-based CIPP. Six and twelve-hour results were excluded since this data was not collected in a consistent manner between field and simulated field test runs. The median values are nearly identical. The upper percentile is much higher for the simulated field tests, but this is driven by unique installation characteristics for Pipe 1, which will be explored more thoroughly later in this report. Since both field and simulated field tests experienced both saturated and unsaturated soil conditions and the resulting concentrations are comparable for the styrene CIPP (Figure 28), both data sets are considered in the discussion of the effects of CIPP installation test scenarios on styrene concentrations. A general discussion of results is followed by a discussion of the control installations and the effects of the individual test scenarios.

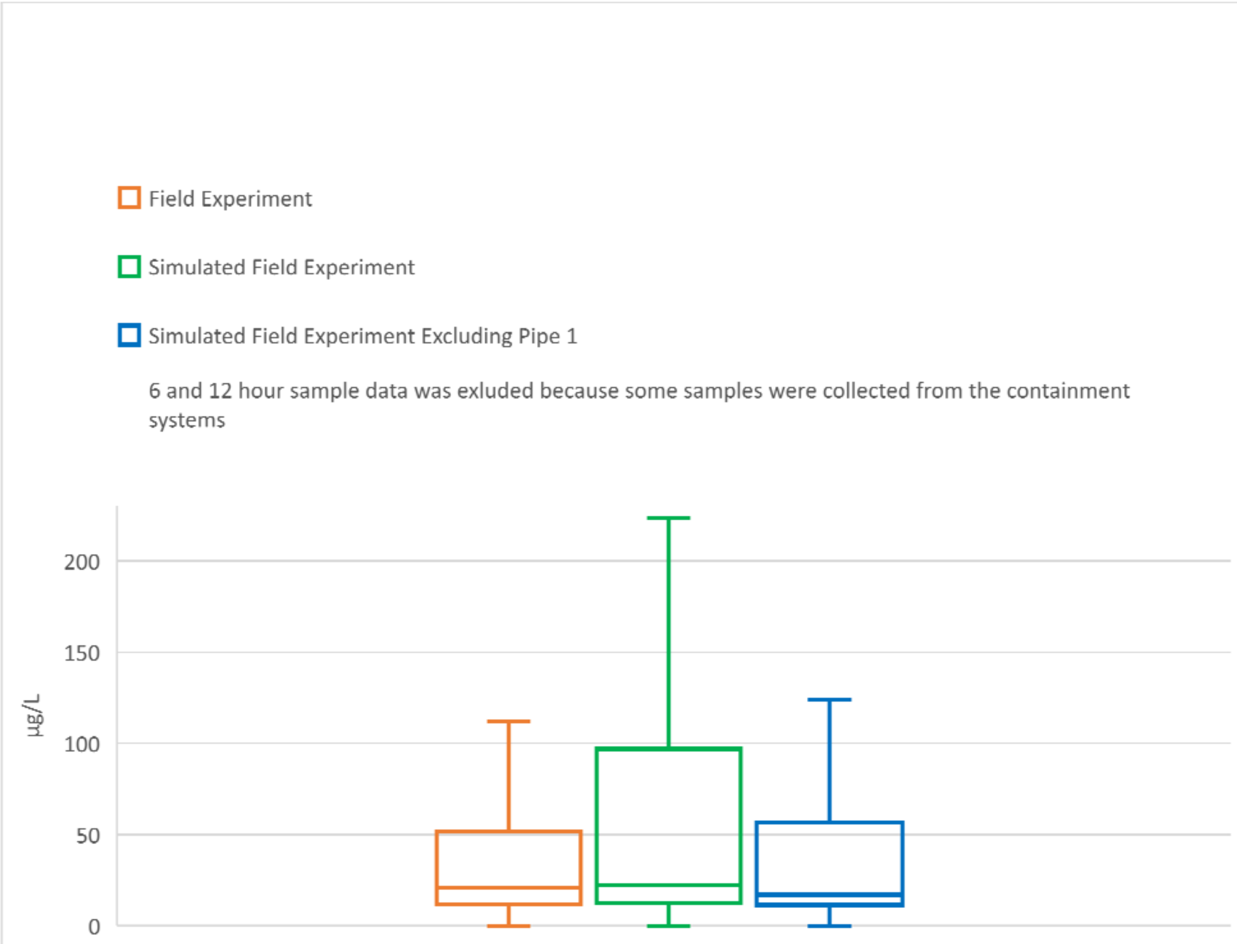

Figure 28. Box Plots Comparing Field and Simulated Field Styrene Data from Styrene-Based CIPP Installations for 24-, 48-, and 96-hour Samples

General Trends

Figure 29 compares all results for styrene in the first 96 hours. Theoretically, a rapid decline is expected as curing completes and subsequent water flushing events remove accumulated styrene. However, both field and simulated field test results indicate that styrene continues to diffuse across the inner liner as evidenced by increasing concentrations after flow was induced for the water quality tests. The increase in concentration is expected. After the initial sample, the geometric time series sampling interval doubles the period of time elapsed for each subsequent sample. This allows more time for styrene to diffuse and accumulate on the interior of the CIPP. Then as the reservoir of styrene is depleted the diffusion across the membrane becomes negligible compared to the rate of volatilization and concentrations in water samples decrease. Humidity will negatively affect volatilization, but this study does not quantify the relationship between humidity, styrene concentration in water, or volatilization into the air within the pipe. Although some variability can be attributed to sampling technique, the variation would be random among events. Instead, each pipe followed a similar trend in concentration spike sometime prior to the 48th hour, which further supports the theory that the resin is not completely cured at final cool down and curing continues over several days.

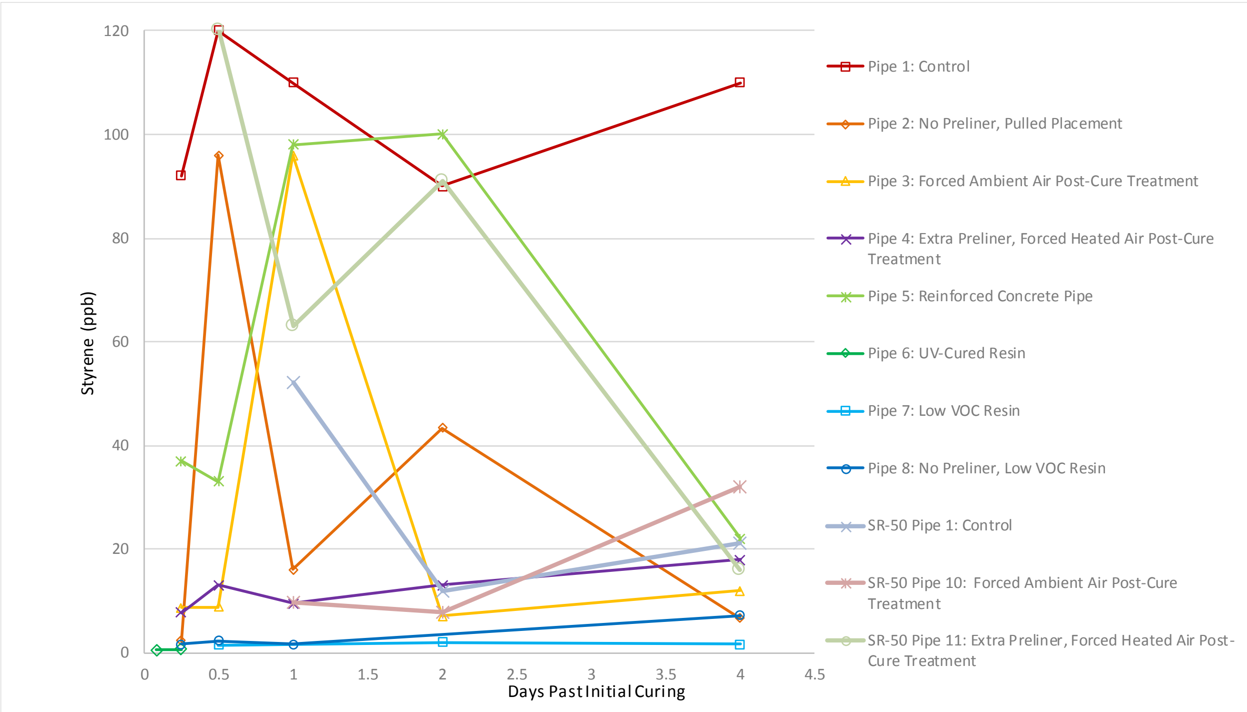

Figure 29. Field and Simulated Field Styrene Results through Day 4

Field

All field experiments resulted in concentrations that were immediately (without dilution or fate and transport losses) protective of the most sensitive species (algae) within four days. Concentrations varied for Pipe 11 through the 13th day. After Day 13, the concentrations in Pipe 11 decreased linearly to a non-detect value at Day 17. For Pipes 1 and 10, concentrations varied until Day 4. After Day 4, the concentrations in Pipes 1 and 10 decreased in a fairly linear fashion to a non-detect value at Day 17. The reason for increased variability in Pipe 11 may be due to high groundwater that caused a greater heat sink during the curing process than what was experienced at Pipes 1 and 10. Similar to Pipe 11, Pipe 10 had dry weather flow that was diverted, however, Pipe 10 did not show evidence of high groundwater. Dry weather flow in the pipe may be from a spring located off the roadway.

Initial 6-hour samples for all pipes and the 12-hour samples for Pipes 1 and 10 were at or near reporting limits (Appendix B) due to collection of samples in the quiescent containment systems. Comparison of water samples from turbulent and non-turbulent flow indicates that concentrations in quiescent flow may be much lower than concentrations in fully turbulent flow. This may have implications in assessing environmental risk based on the flow regime of downstream receiving waters.

Simulated Field

All simulated field experiments resulted in concentrations that would be immediately protective of the most sensitive species (algae) within four days, except for the control (simulated field Pipe 1). The simulated field Pipe 1 had the following combination of site characteristics that was unique among the polyester resin CIPP for both field and simulated field tests:

- Low ambient air temperature (<62°F compared to >75°F for all other styrene-based, steam-cured CIPP),
- Saturated embankment and soil moisture (lack of impervious pavement above Simulated Field Experiment), and
- Lower steam temperature (<200°F compared to >240°F for all other styrene-based, steam-cured CIPP)

Lower steam temperature, lower maximum thermal couple temperature, and shorter duration above recommended minimum cure temperature (hold time) may have been factors contributing to elevated styrene concentrations in simulated field Pipe 1. Steam temperature in Pipes 2, 3, 4, 5, and 8 were in the 240 ˚F to 250 ˚F range for the duration of the curing hold time while the steam temperature in simulated field Pipe 1 ranged from 165 ˚F to 195 ˚F, approximately, during the curing hold time (Figure 27).

Ambient air temperatures were also cooler during the installation of simulated field Pipe 1 (Figure 28). This difference was due to seasonal air temperature variations as a result of installation schedules. Simulated field Pipe 1 was installed in March 2016, while the remaining styrene-based resin impregnated liners were installed in August 2016 when daily mean temperatures are much higher and daily maximum temperatures are regularly near 95˚F.

While ambient air temperatures may have contributed to the elevated styrene detection in simulated field Pipe 1, lower steam temperatures and saturated soils are likely more important factors because similarly low ambient air temperatures for the field control (Pipe 1) did not result in similarly high styrene concentrations.

Reconsidering Appropriate Control Test Scenarios

The unique environmental and curing conditions for simulated field Pipe 1 discussed in the previous section were not anticipated in the study design. Because of these conditions, simulated field Pipe 1 is an inappropriate control to compare against other CIPP variations in the simulated field study. Consequently, the other CIPP variations in the simulated field study should be compared to alternative controls. Figure 30 shows a comparison of styrene concentrations for both control installations and simulated field Pipes 2 and 5. Simulated field Pipe 1 concentrations remained above the drinking water MCL at Day 4 due to the unique conditions previously discussed. The simulated field pull-in-place variation Pipe 2 may be a better control for dry conditions in the simulated field tests because it represents the closest replication of simulated field Pipe 1, but without the host of differing conditions. The only variable is installation method and this should have little effect unless the pull-in-place method caused liner damage or uneven installation and it did not. In this case, damage was not likely because the host pipe was a single (no joints) piece of new pipe and so there were no sharp edges along the interior of the pipe.

Simulated field Pipe 1, however, may be the most appropriate control for field Pipe 11 because they share the same environmental condition of high soil moisture. The notable difference is Pipe 1 was cured with a lower steam temperature, so simulated field Pipe 1 does not control for all parameters in the Pipe 11 scenario. An imperfect control limits the conclusions that can be drawn for the Pipe 11 scenario.

Pipe 5 was also considered as a potential control since the only difference between simulated field Pipe 1 and Pipe 5 is host pipe. The question is whether a difference in host pipe has a greater effect on curing compared to the pull-through installation method used in simulated field Pipe 2. Since the results for simulated field Pipe 1 and field Pipe 11 indicate soil moisture affects curing—presumably by causing a heat sink—a difference in host pipe could also affect curing effectiveness due to differing thermal properties. Examination of results in Figure 30 indicates that simulated field Pipe 5 did not cure as quickly or completely as simulated field Pipe 2. So RCP is not an appropriate control scenario since all other scenarios use CMP. Pipe 2 is considered the most appropriate control for comparing CIPP specification enhancements in dry soil conditions.

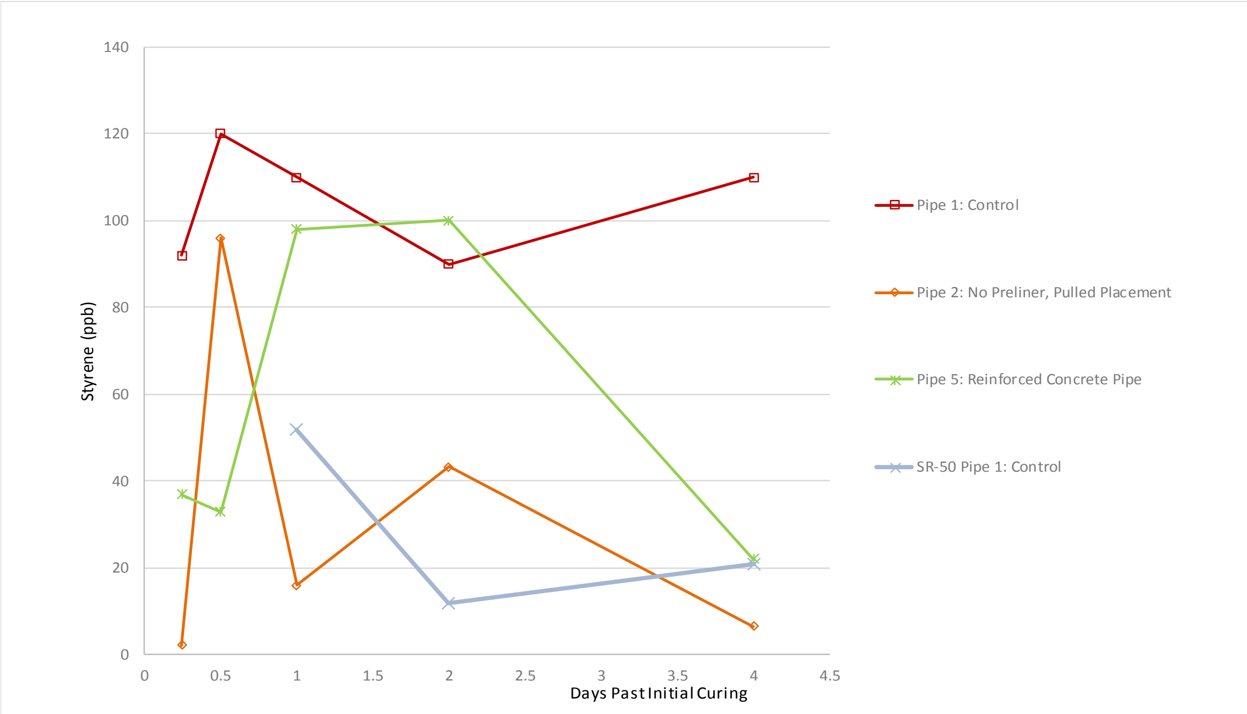

Figure 30. Comparison of Styrene Results for Field Control, Simulated Field Control, and Control Alternatives

Where appropriate, simulated field Pipe 2 will replace simulated field Pipe 1 in figures to compare to a control that does not have high soil moisture.

Effects of CIPP Test Scenarios

Post-Cure Treatments

Post-cure treatments did not appear to have noticeable effects on styrene concentrations in field tests.

For field Pipe 11, this may be due to the larger effect of other factors such as saturated soil conditions. Continual diffusion across the inner liner minimizes the benefit of rinsing or blown ambient air because these practices do not reduce the amount of uncured resin behind the liner that will continue to diffuse after the post-cure treatment is removed.

Figure 31 shows a comparison of forced ambient air post-cure treatment styrene results to results from control conditions. In simulated field trials, forced ambient air appeared to delay the increase in styrene concentration, but the magnitude was unaffected. Forced ambient air did not effect when concentrations fell below the NOEC for algae (63 ppb). In field trials the control was always below the algae NOEC, so any improvement offered by forced ambient air would not have practical implications. In consideration of both field and simulated field test results, it cannot be concluded that forced ambient air applied for a period of 6 hours after final cool down provided any benefit to subsequent styrene concentrations in flow through the CIPP.

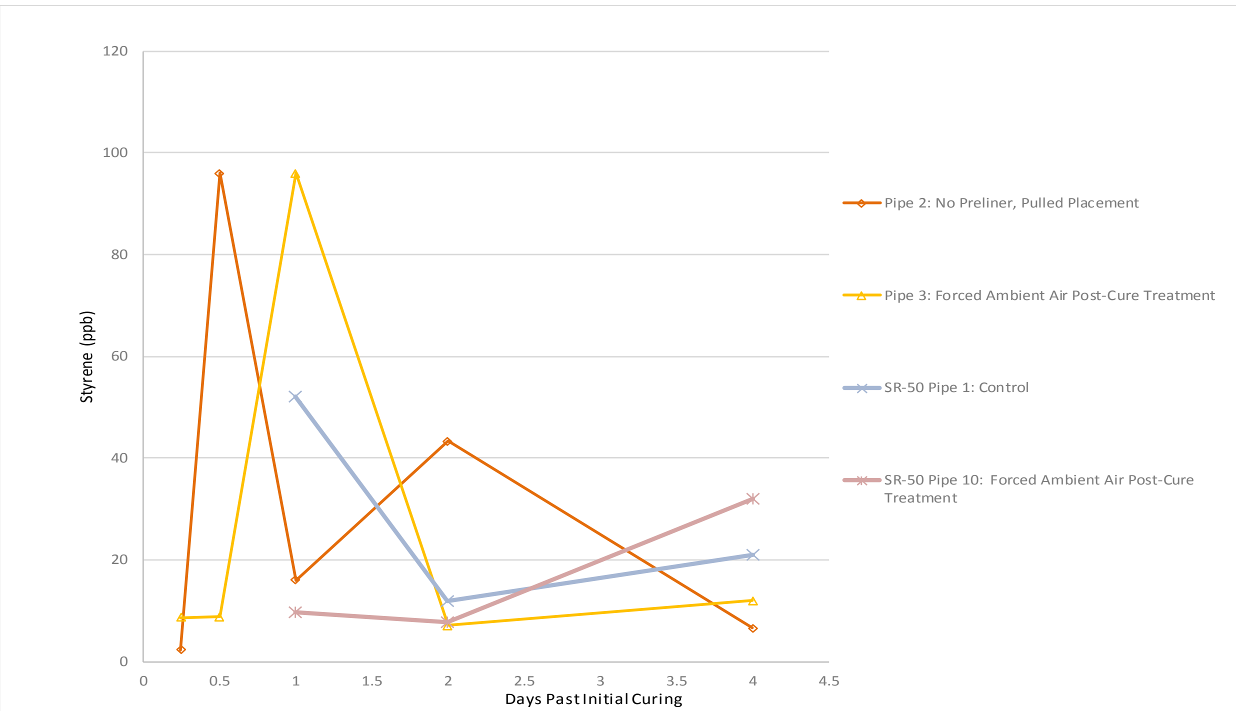

Figure 31. Comparison of Styrene Results for Forced Ambient Air and Control Conditions

Figure 32 shows a comparison of styrene concentrations from simulated field control and forced heated air post-cure treatment for CIPP in unsaturated soil conditions. Forced heated air resulted in all concentrations below the NOEC for algae. In this case, water diversions are not needed to be protective of all aquatic species.

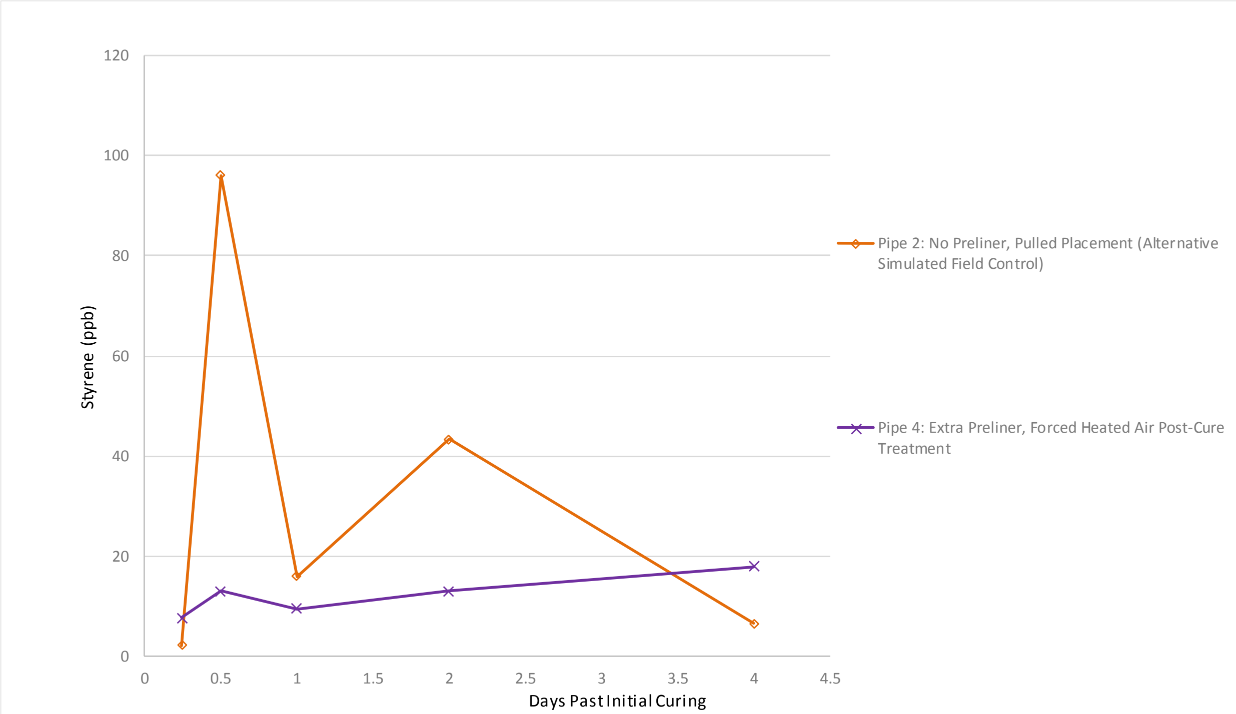

Figure 32. Comparison of Styrene Results for Forced Heated Air in Dry Control Conditions

Styrene results in Figure 33 compares the control for saturated soil conditions (simulated field Pipe 1) to the forced heated air post-cure treatment (field Pipe 11). The concentrations in the field forced heated air scenario were substantially lower at Day 4, but because the control had substantially lower steam temperatures that could have caused the concentration on Day 4 to remain high, the results are not conclusive.

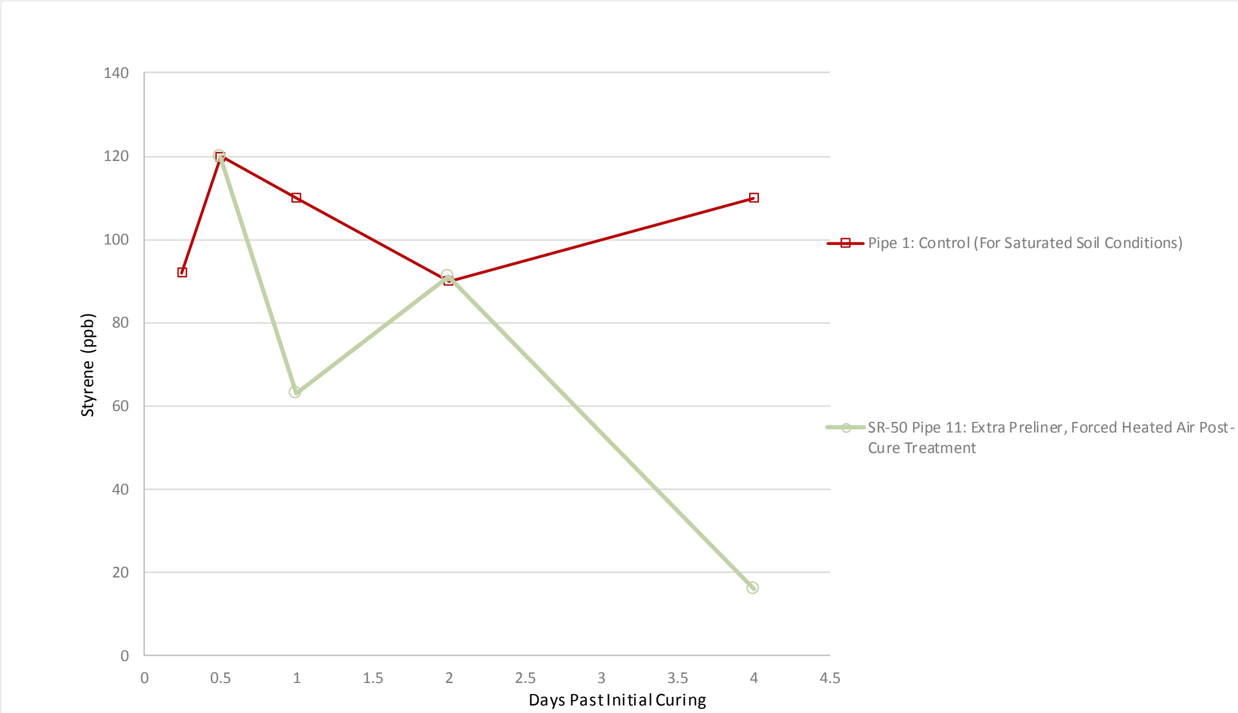

Figure 33. Comparison of Styrene Results for Forced Heated Air Post-Cure Treatment and Saturated Soil Control Conditions

Extra Preliner

Figures 32 and 33 compare styrene from CIPP with an extra preliner to control scenarios. The effect of an extra preliner on the results is difficult to assess because forced heated air was also used in both scenarios using a preliner and thus obscures any benefit of the extra preliner. The extra preliner, being on the exterior of the CIPP material, would presumably help reduce diffusion of volatiles toward the host pipe and surrounding soils, but this study was not designed to test that effect. The field scenario with the extra preliner was on Pipe 11 where saturated soils were observed. Though it was observed that low flow (drips per minute) occurred along the outside of the CIPP, it could not be determined whether the flow was outside of the host pipe or inside the host pipe between the host pipe and the CIPP.

Resins

Non-styrene resins clearly will have an impact on styrene concentrations, as shown in Figure 17. The concern with non-styrene resin was whether there were other constituents in the water that would be measured at concerning concentrations. For the measured constituents, no known environmental thresholds were exceeded (all data can be found in Appendix B). However, the MSDS product information on the alternative monomer used was redacted for proprietary purposes, so the exact monomer used may not have been tested within the suite of analysis used in this study. Practically, because the alternative resin is not specified in the Caltrans specification, site-specific testing may be required. To enable sufficient time to find a capable laboratory, manufacturers will need to submit a complete MSDS months in advance of the CIPP work. Because the current standard lead time is two weeks, requiring proprietary information and an increased lead time for MSDS submittal may limit the likelihood that this approach is used.

Cure Method

Cure method had a clear benefit to the most concerning constituent, styrene. UV curing was clearly superior and the other volatile concentrations detected were all measured at levels below known environmental thresholds. The only detectable concentrations occurred in the samples taken 2 and 6 hours after curing.

Host Pipe Material

Examination of the data in Figure 17 shows that RCP may impede complete curing as evidenced by higher concentrations compared to simulated field Pipe 2 (the presumed control for the simulated field study).

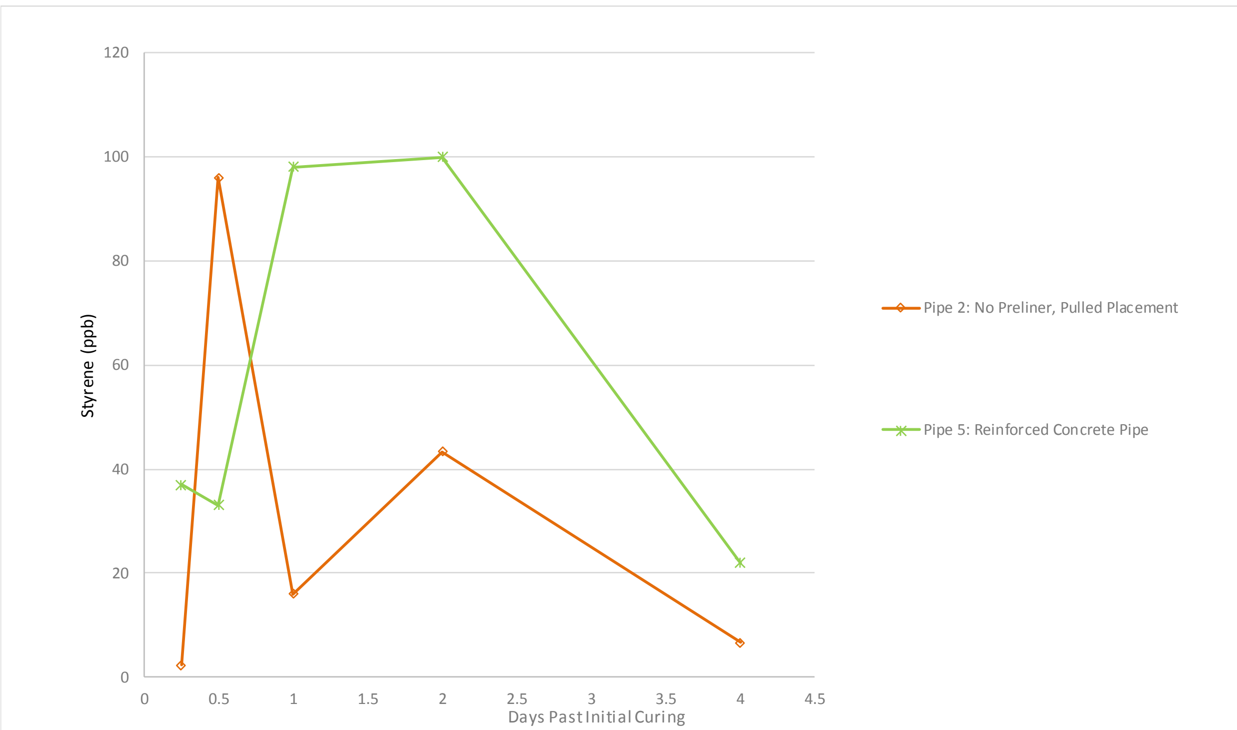

Figure 34. Comparison of Simulated Field Pipes 2 & 5

Liner Installation Method

There is no evidence in this study that installation method affects water quality results. Figure 35 shows that, at each of the common sample times, concentrations are similarly variable in magnitude and range of values. However, the inversion installation seems to be preferred to minimize damage to the liner during the installation process.

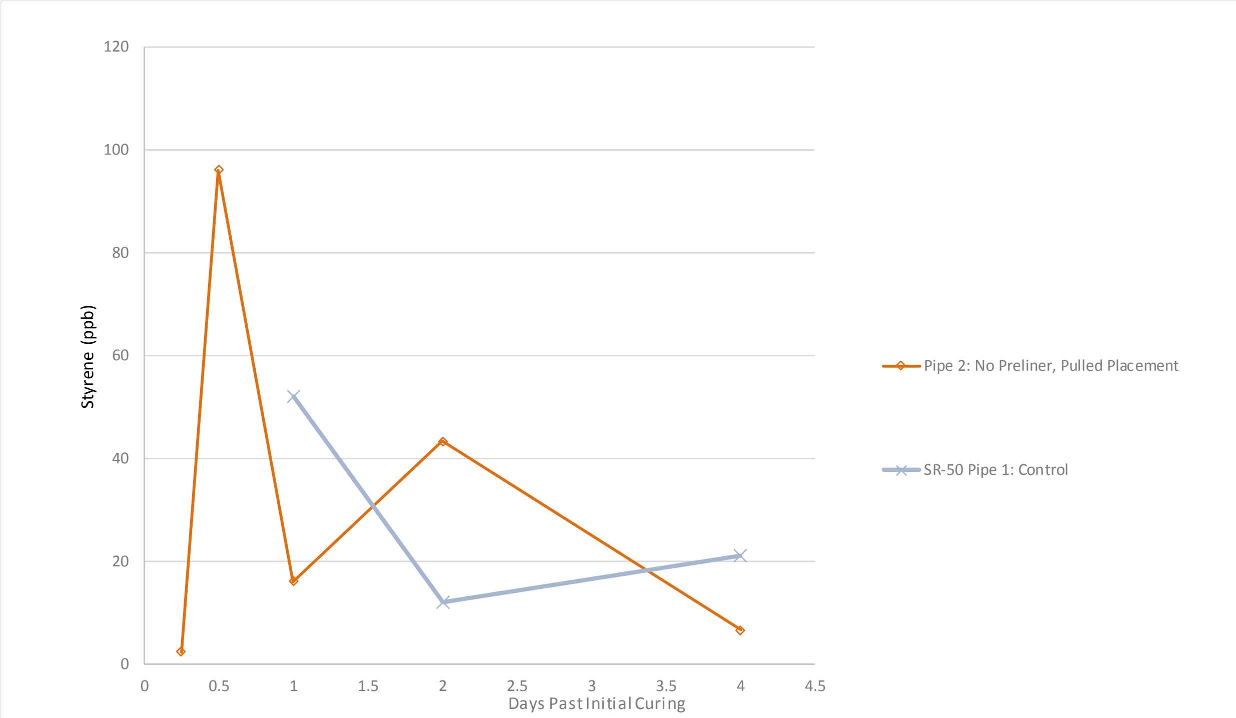

Figure 35. Comparison of Field Pipe 1 and Simulated Field Pipe 2

Overall Data Observations

Though this study did not include replication, the preponderance of the data from field and simulated-field experiments indicates that CIPP, with some care in enforcing the Caltrans specification and delaying the reintroduction of natural flow, will result in concentrations of VOCs that will not likely impact downstream receiving waters. To be protective of water flowing through the CIPP, enhancements may be necessary to protect the most sensitive aquatic species. Additional enhancements may be necessary for saturated soil conditions that are presumably causing a heat sink that may be inhibiting the curing process.

The water quality results, in terms of protection of aquatic species, can be categorized by soil conditions. For unsaturated soil conditions, UV-cured resin, styrene-free resin, and steam-cured, styrene-base resin with forced heated air treatment would be protective of all aquatic species without the need to divert flow. For all other scenarios, water cannot be allowed to flow through the pipe until 96 hours after CIPP installation. For saturated soil conditions, UV-cured and non-styrene CIPP met all water quality criteria. For styrene-based CIPP in saturated conditions, forced heated air appears to be a contributing factor to bring concentrations below the algae NOEC by Day 4. The limited experience gained in this study may be cause for study of additional CIPP scenarios in saturated conditions.

Potential Impact on CIPP Specifications

Generally, the Caltrans specifications for UV and steam-cured CIPP are sufficiently protective of the most sensitive aquatic species (algae) after a four-day waiting period before allowing flows through the CIPP. By Day 4, all water flowing through the CIPP, without dilution into a receiving water, was below the NOEC for algae in all but one of the 11 tests in this study. Concentrations never exceeded toxicity thresholds for any other test species. Consequently, enhancements to the specification is discussed in this report for cases where impacts to algae are a concern for water immediately discharging from CIPP. For applications where immediate algae toxicity is not a concern, a possible relaxation of the Caltrans specification concerns the maximum cool-down rate. All 10 steam-cured CIPP exceeded the maximum rate by at least 3 times. Conversely, where algae effects are a concern, enforcement of the cool-down specification may eliminate the need for other specification enhancements due to prolonging the curing process under active heating, but this was not tested. Extending the cure time is another possible enhancement that was not tested. Where algae toxicity is a concern, several enhancements to the specification are discussed in this section.

Specification enhancements are presented according to soil moisture conditions since this appears to be the most critical site condition identified by this study. Consequently, soil moisture testing should be considered during planning stages. Project timing may dictate that soil moisture testing be performed in a prior year during the proposed time of year for the CIPP work. Alternatively, soil moisture testing could also be added to the CIPP specification as a requirement prior to developing the CIPP work plan.

CIPP specification enhancement may not be appropriate for all receiving water conditions. As discussed earlier, sample collection was switched from sampling the capture volume to sampling the pipe flow. The phenomena of rapid separation of volatiles in quiescent water, as observed in the initial field samples taken from the containment system, was previously concluded by Fu and Alexander (1992), who report almost complete volatilization of styrene in the environment within 40 hours. Consequently, distance to receiving waters may be a consideration in determining the risk of CIPP to vulnerable species and the need for enhancements to the CIPP specification. For example, culverts at ephemeral crossings where the discharge water may not support aquatic life until a receiving water is reached further downstream may merit different treatment than other culverts. In contrast, fate and transport losses may not be an appropriate consideration for culverts that carry stream flow that is considered a receiving water.

The CIPP specification enhancements suggested in this report are also conservative because the high flow conditions relative to very low volumes compared to storm volumes should result in conservative (high) concentrations. Higher storm or stream flow volumes should increase dilution.

Unsaturated Soils

To be immediately protective of the most sensitive aquatic species for CIPP installed in unsaturated soils, stream flows should be diverted for at least four days after CIPP installation for culverts that discharge directly to receiving waters. For dry culverts that do not have a diversion in place, the specification should prohibit installation when rainfall is predicted within four days. Scheduling installations during the dry season is already common to avoid the need to bypass large storm flows, but a specification requirement for dry season work will also help minimize saturated soil conditions. In cases where diversions are impractical, the results of this study indicate~~s~~ that UV-cured resin or steam-cured resin with forced heated air methods are protective of water quality without the need to divert flows after curing.

Saturated Soils

Additional specification enhancements may be necessary to be protective of the most sensitive aquatic species for CIPP installed in saturated soils because the simulated field control (simulated field Pipe 1) still had concentrations that would impact algae at Day 4. Sampling stopped at Day 4 for the simulated field tests, so it is not possible to estimate an appropriate period to maintain flow diversions. The field test with saturated soils at Pipe 11 was protective of algae within four days but it had two mitigating factors: an extra preliner and forced heated air post-cure treatment. Of those two mitigations, it is not possible to distinguish which factor may have been more helpful merely by considering the water quality results because the simulated field tests applied the same combination of treatments on the same pipe (Pipe 4). However, on a theoretical basis, an extra preliner offers very few insulation qualities to prevent heat loss to saturated soils during the curing process. Conversely, forced heated air should enhance residual curing after final cool down. Consequently, a potential specification change would require forced heated air treatment in addition to a flow diversion if precipitation is likely. Also, extending the cure time should result in lower concentrations, but quantifying an appropriate time extension may require additional study.

Another potential mitigation for cases with saturated soils is to require the contractor to use non-styrene resin or UV-cured polyester resin. UV-cured polyester resin had no observable environmental effects and its use would eliminate need to divert flow. The environmental effects of non-styrene resins are less clear. Non-styrene resin suppliers commonly redact proprietary resin information and the current specification does not identify the specific alternative. Adding a post-cure water testing requirement to the specifications for these alternatives could help build an approved list of styrene alternatives based on test results. In addition, disclosure of all additives must be strictly enforced to ensure the correct chemical is being tested. After sufficient testing and identification of viable alternatives, testing would not be required. Instead, the specification could be modified to identify the exact alternatives to styrene. Because of redacted information, this study could not conclude that alternative resins are protective of aquatic species.

CIPP Options for Locations Requiring Immediate Protection of Sensitive Aquatic Species

For locations requiring protection of the most sensitive species immediately at the point of discharge, several CIPP options appear feasible for pipe rehabilitation. The present study was not designed to determine optimum enhancements to CIPP specifications, so duration of water diversion, duration of forced heated air post-cure treatment, and minimum steam temperature are not specified here. While not tested in this study, enforcement of the maximum cool-down rate for steam-cured CIPP per the Caltrans specification may reduce the need for specification enhancements. Tested CIPP specification options from the present study that were protective of known environmental thresholds can be organized according to field conditions.

For dry site conditions that require protection of aquatic species at the pipe outfall, consider a CIPP specification that restricts the contractor to the following options:

- UV cure,
- Pull-through or inversion installation, steam cure, and water diversion, or
- Pull-through or inversion installation, steam cure, and forced heated air post-cure treatment.

For wet soil site conditions that require protection of aquatic species at the outfall, consider a CIPP specification that restricts the contractor to the following options:

- UV cure, or
- Pull-through or inversion installation, minimum steam temperature of 240^{o} F, water diversion, and forced heated air post-cure treatment.

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Appendix A: Literature Review

This literature review was conducted in 2014 prior to the initiation of the field and simulated field tests described in the Final Report. This appendix contains a summary of key findings from the preliminary investigation (CTC and Associates 2012) and it reviews additional literature that was published since the preliminary investigation. This review also summarizes information on styrene characteristics, non-styrene alternatives, and environmental thresholds. The additional literature was reviewed to check the proposed study approach and make any necessary adjustments. Other literature relative to the results of this study are contained in the Final Report.

Preliminary Investigation

In the preliminary investigation of this study several states were contacted to determine their use of CIPP and document any known issues related to styrene. Eleven of the 15 states contacted had used CIPP for pipe rehabilitation. Nine of those did not report water quality issues or regulatory concerns (CTC and Associates 2012).

Four states reported water quality issues: New York, Oregon, Virginia, and Washington. The New York Department of Transportation found concerning amounts of styrene and consequently revised their specifications. Oregon reported extremely high concentrations (174 ppm), but those were attributed to failure to divert incoming water. Virginia initially found reported concentrations at potentially toxic levels. Water quality issues in the Virginia study were proposed to be related one or more of the following observations: 1) condensate was not contained, 2) uncured resin not contained, 3) insufficient curing time, and 4) some relative permeability of the liner. Virginia DOT has also since strengthened their CIPP specifications. Washington DOT did not have a CIPP specification and experienced water quality issues that resulted in regulatory action. Consequently, they generally recommend culvert replacement over relining.

Additional Literature since the 2012 Preliminary Investigation

Styrene concentrations are found to vary among CIPP projects. In a follow up to the 2008 Virginia DOT study, Donaldson explored the water quality impacts other CIPP and coatings that were installed following improved installation specifications. The different determinants were the type of curing that was conducted (UV or steam), and the type of resin or coating material (fiber sock or polyuria spray-on coating). The research concluded that styrene levels from UV CIPP installation were lower than that of conventional water based curing, but some levels occurred that would be toxic to water fleas (Donaldson and Whelton 2013).

Donaldson (2013) evaluated vinyl ester as a non-styrene alternative CIPP material. UV curing of traditional styrene-based CIPP was also analyzed. Vinyl ester was found to cause toxicity when samples were soaked for up to 120 days. UV-cured CIPP showed more promise in field tests, but one of the soaked samples exceeded toxicity thresholds. Traditional steam cure was not retested following the Virginia DOT specification.

Whelton et al. (2013) provides a summary of environmental impacts from several pipe rehabilitation methods, including cement mortar, polymer-enhanced cement mortar, epoxy, polyurethane, polyuria, and polyurethane and polyuria blends. The paper elaborates that alternatives to CIPP can also have potential environmental impacts due to elevated COD and TOC and alterations to pH. Further research is suggested.

The results of the literature reviewed since the preliminary investigation does not offer any changes to this study since the most promising technology, UV curing of traditional CIPP, is already being addressed in the simulated field tests.

Styrene Characteristics

Styrene is a monomer which is used for multiple applications where plastics are needed. Styrene has a strong smell which can be detected at low levels in the air. Styrene arises as a colorless or yellowish viscous liquid with a sweet-smelling odor. It has a flash point of 34°C (closed cup), a lower explosive limit of 0.9% to 1.1% v/v, an upper explosive limit of 6.1% to 6.8% v/v, and an auto ignition temperature of 490°C. (DHHS 2011)

Styrene has the following properties:

- Molecular weight—104.2
- Specific gravity—0.906 at 20°C
- Melting point—31°C,
- Boiling point—145°C
- Log K—2.95 ow
- Water solubility—310 mg/L at 25°C
- Vapor pressure—6.4 mm Hg at 25°C
- Vapor density relative to air—3.6 (DHHS 2011)

Non-Styrene CIPP Alternatives

In the CIPP industry there are alternatives to styrene-based resin. The most common alternatives are polyester and vinyl ester resins (Moore 2011). Moore also reports that styrene-based CIPP is safe and reliable, but there may be situations where due to client request or specification non-VOC resin is required. Non-VOC technology is relatively new, and companies are reluctant to divulge the exact composition of styrene-free resin to protect trade secrets. In the case of vinyl ester resin, Moore reports that many non-VOC chemicals may be suitable, but specific chemicals are not listed (2011).

Industry Health Standards for Air Concentrations

Federal OSHA standards dictate a time weighted exposure level of 100 ppm of styrene exposure is allowable for a safe eight-hour period (CFR 2016). CalOSHA has set a lower exposure level of 50 ppm (CalOSHA 2011).

Water Quality Standards and Toxicity Thresholds

The NASSCO CIPP committee suggests that discharge of water from steam curing to downstream water ways can be allowed if the concentration of styrene is less than 25 ppm (NASSCO 2008), but this concentration is substantially higher than known toxicity lethal concentration (LC), effect concentration (EC), and no observable effect concentration (NOEC) thresholds. The following toxicity thresholds, as summarized by Donaldson and Baker (2008), may be appropriate for comparison for discharge from CIPP to nearby receiving waters, depending on transport, flow, and beneficial uses of the receiving waters. Species and test (EC, LC, or NOEC) are listed from highest to lowest concentration. The ranges represent values from different studies.

- Amphipod 96-hr LC50—9.5mg/L
- Fathead minnow 96-hr LC50—5.2 to 10 mg/L
- Water flea 48-hr EC50—4.7mg/L
- Amphipod 96-hr NOEC—4.1 mg/L
- Fathead minnow NOEC—2.6 to 4 mg/L
- Rainbow trout 96-hr LC50—2.5mg/L
- Freshwater green algae 96-hr EC50—0.72mg/L
- Freshwater green algae 72-hr NOEC—0.53 mg/L
- Freshwater green algae 96-hr NOEC—0.063 mg/L

The California Office of Environmental Health Hazard Assessment (OEHHA) has set a public health goal (PHG) of 0.5 ppb for drinking water based on carcinogen effects in test species (http://oehha.ca.gov/water/phg/122810styrene.html). PHGs are not regulatory standards and application to surface waters is not appropriate. Surface water standards are available in the Basin Plans approved by the California Regional Water Quality Control Boards.

The drinking water MCL is 100 ppb (http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/dwdocuments/MCLsEPAvsDWP-2014-07-01.pdf) and this value is also referenced in many California Basin Plans, such as the Los Angeles Region

(http://www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/).

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Appendix B: Data Tables and Graphs

This appendix presents all the discharge water quality measurements for detected VOC constituents. The data are organized into the following sections:

1. Environmental Thresholds
2. Water Quality Results
3. Background Concentrations
4. Meteorological Data
5. Soil Moisture
6. Temperature Cure Logs
7. Field Experiment QA/QC
8. Simulated Field Experiment QA/QC

Environmental Thresholds

The known water quality threshold values for all VOCs measured at detectable levels in this study are presented in Environmental Thresholds. Sample results for the constituents in Table 1 are represented in the subsequent tables and graphs in this appendix.

Table 1. Drinking Water Standards for VOCs Detected in Reportable Quantities

Constituent	Limit	Units	Source
Acetone	100	µg/L	USEPA Integrated Risk Information System (IRIS)
Benzene	1	µg/L	CalEPA
Bromodichloromethane	80	µg/L	EPA
Bromoform	80	µg/L	EPA
Bromomethane	1	µg/L	USEPA Integrated Risk Information System (IRIS)
Chloroform	80	µg/L	EPA
Chloromethane	4	µg/L	USEPA Integrated Risk Information System (IRIS)
Dibromochloromethane	80	µg/L	EPA
Isopropyl Benzene	100	µg/L	USEPA Integrated Risk Information System (IRIS)
n-Propylbenzene	260	µg/L	California Department of Public Health Notification Level
Styrene	100	µg/L	EPA
tert-Butyl alcohol	12	µg/L	California Drinking Water Action Level (DHS)
tert-Butylbenzene	260	µg/L	California Drinking Water Action Level (DHS)
Toluene	150	µg/L	CalEPA
Trihalomethanes	80	µg/L	EPA
Xylenes (total)	1750	µg/L	CalEPA
1,2,4-Trimethylbenzene	330	µg/L	California Public Health Goal (OEHHA)
1,3,5-Trimethylbenzene	330	µg/L	California Public Health Goal (OEHHA)

Water Quality Results

Table 2. Detection Frequency of Results Above Reporting Limit (Excluding Condensate Sample Results)

	Detection Frequency (Results Above Reporting Limit)													
	Acetone	Benzene	Bromodichloromethane	Chloroform	Chloromethane	Dibromochloromethane	Isopropyl Benzene	n-Propylbenzene	Styrene	tert-Butyl Alcohol	Toluene	Xylenes (total)	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene
CSUS Dosing System			1	8					2					
Pipe 1	1		5	5					5			1		
Pipe 2				5	1				5					
Pipe 3			1	5					5					
Pipe 4				5					5					
Pipe 5	1			5					5					
Pipe 6				5					1					
Pipe 7			5	5				1	3			3		
Pipe 8	1			5			3		4	1				
SR-50 Pipe 1			4	5		4			8		1	1	1	1
SR-50 Pipe 10		1	4	5		4		2	6		3	2	2	1
SR-50 Pipe 11	1		4	5		4	3	3	7		1		3	3

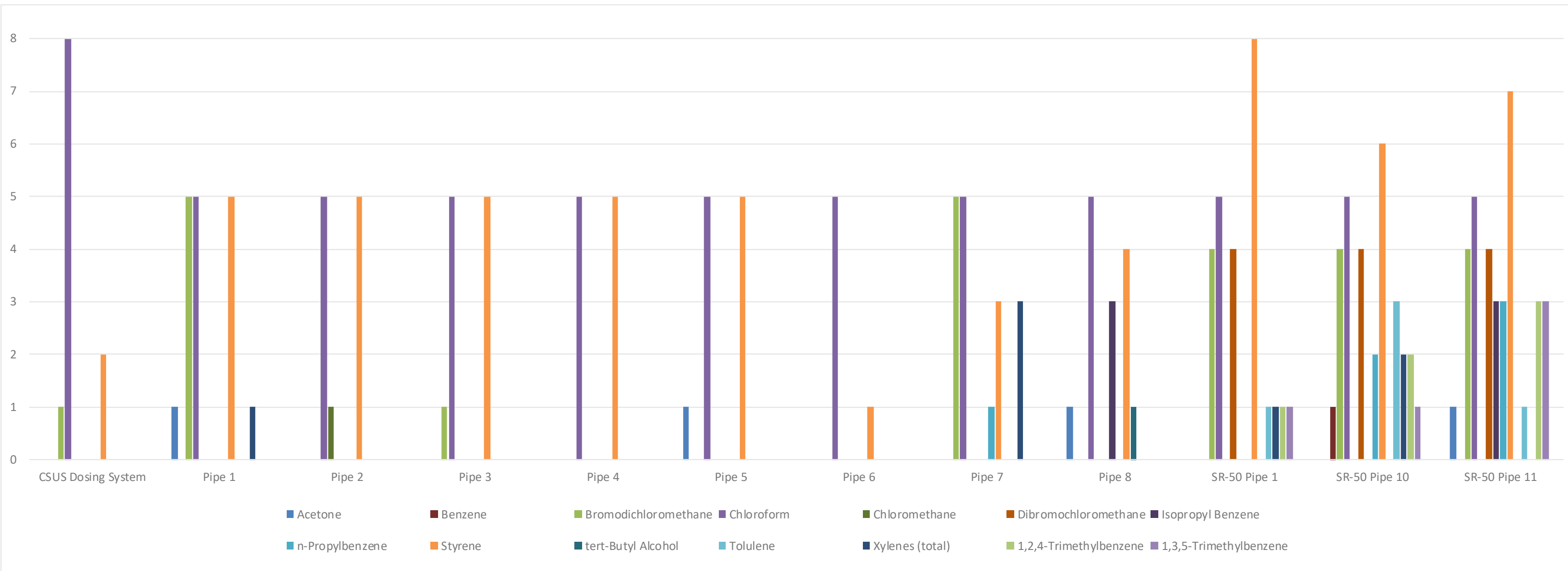

Figure 1. Detection Frequency of Results Above Reporting Limit

Table 3. Acetone Results

Analyte	ND Value	Units	Environmental Threshold
Acetone	10	µg/L	100 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	110	22	71	ND	ND	ND	33	110			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	0.5	11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	11.5	ND	ND	25.5	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

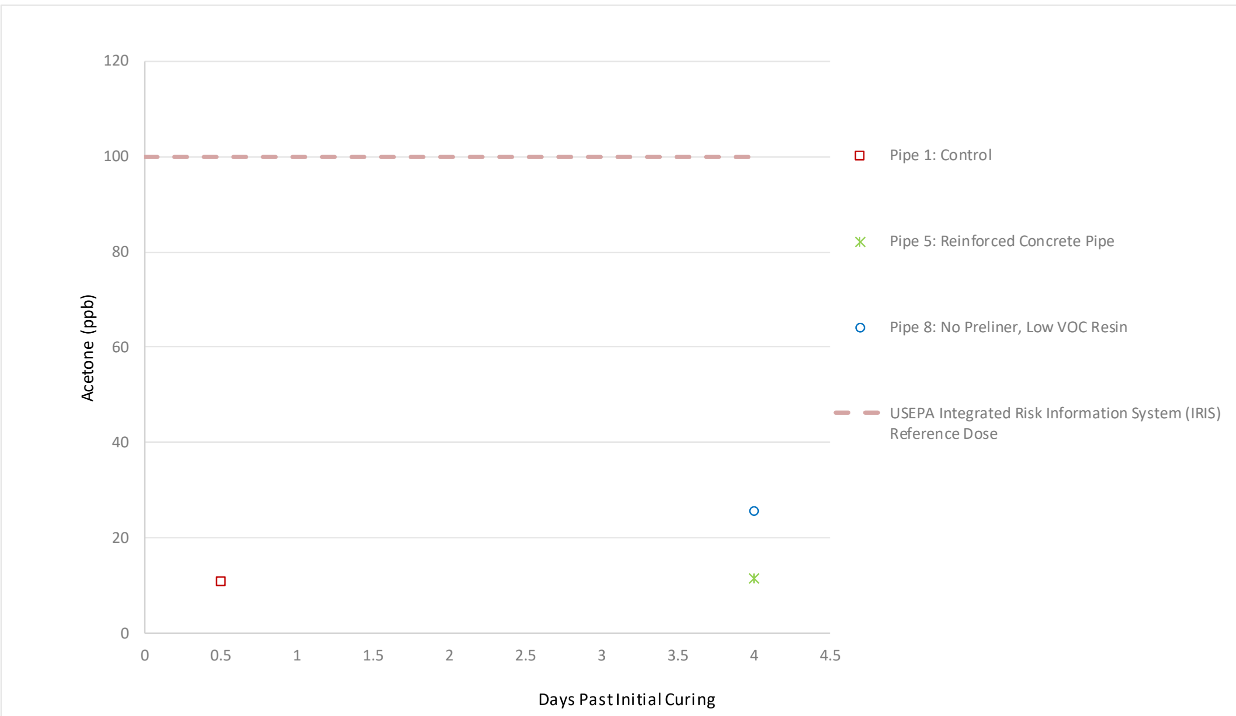

Figure 2. Simulated Field Experiment Acetone Results

Table 4. Benzene Results

Analyte	ND Value	Units	Environmental Threshold
Benzene	0.50	µg/L	1 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	1.2			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.58	ND
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

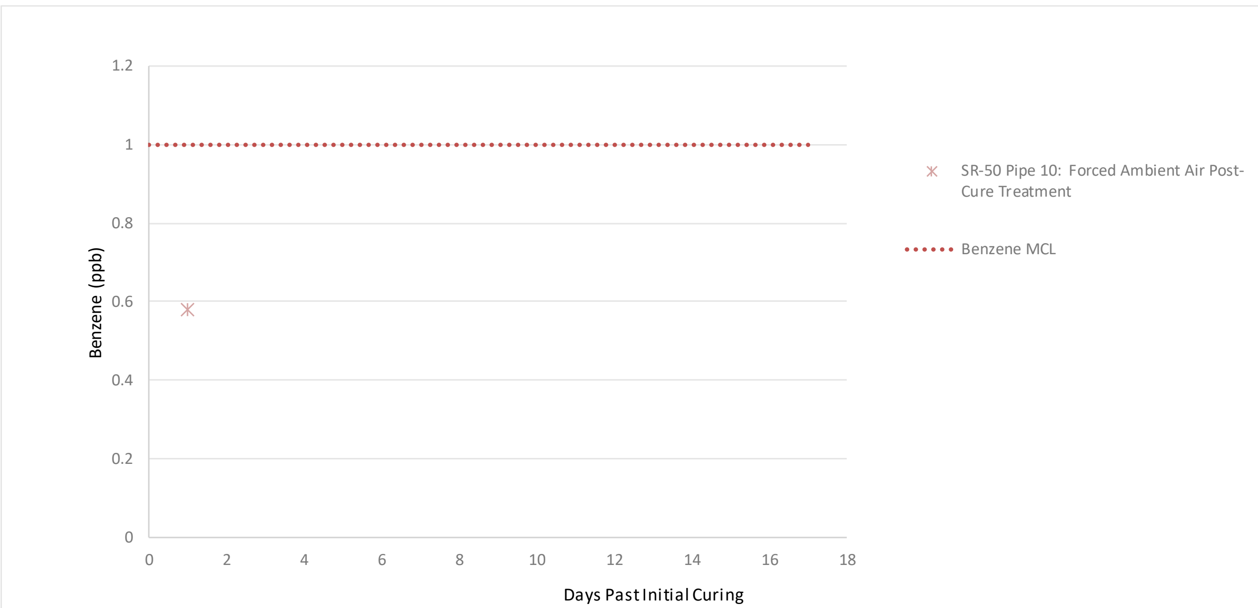

Figure 3. Field Experiment Benzene Results

Table 5. Bromodichloromethane Results

Analyte	ND Value	Units	Environmental Threshold
Bromodichloromethane	0.50	μg/L	80 μg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	ND			
1	0.25	3.3	ND	ND	ND	ND	ND	3.3	ND	3.8	4	4.5
2	0.5	2.8	ND	0.55	ND	ND	ND	3.3	ND	4.5	5.1	1.9
3	1	3.4	ND	ND	ND	ND	ND	4.3	ND	2.1	2.1	2.2
4	2	2.4	ND	ND	ND	ND	ND	2.8	ND	1.2	1.2	1
5	4	3.0	ND	ND	ND	ND	ND	2.7	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

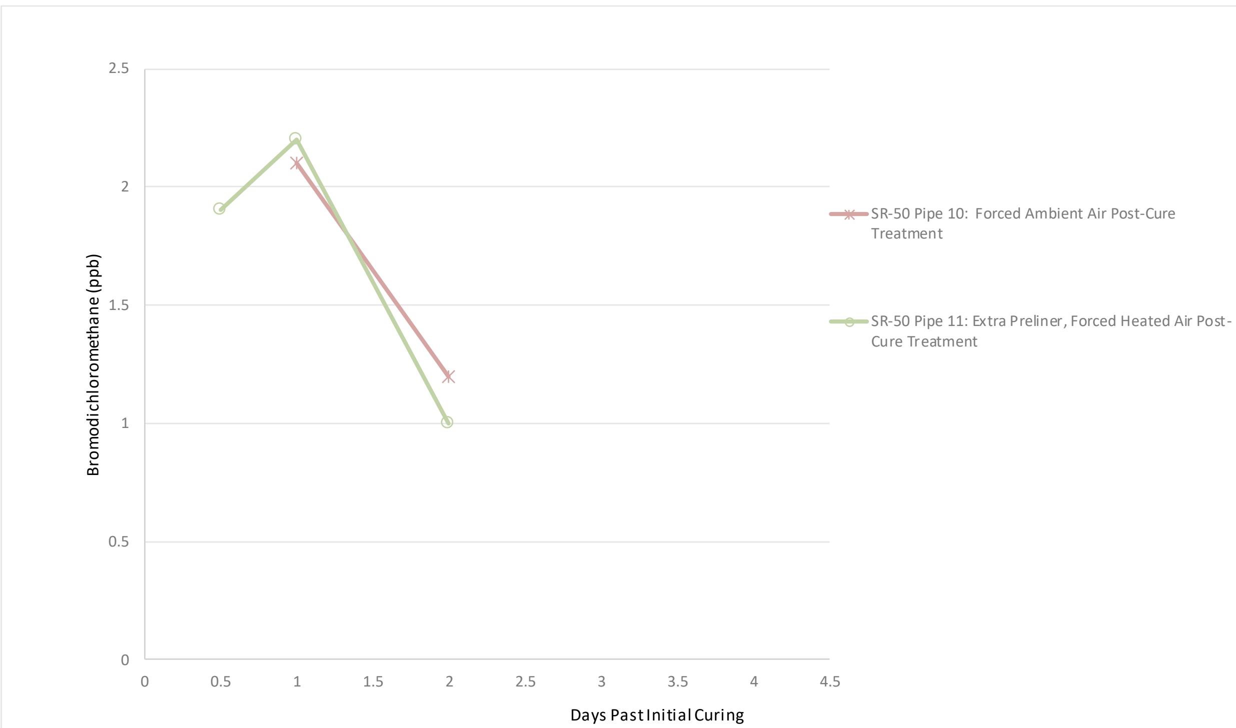

Figure 4. Field Experiment Bromodichloromethane Results

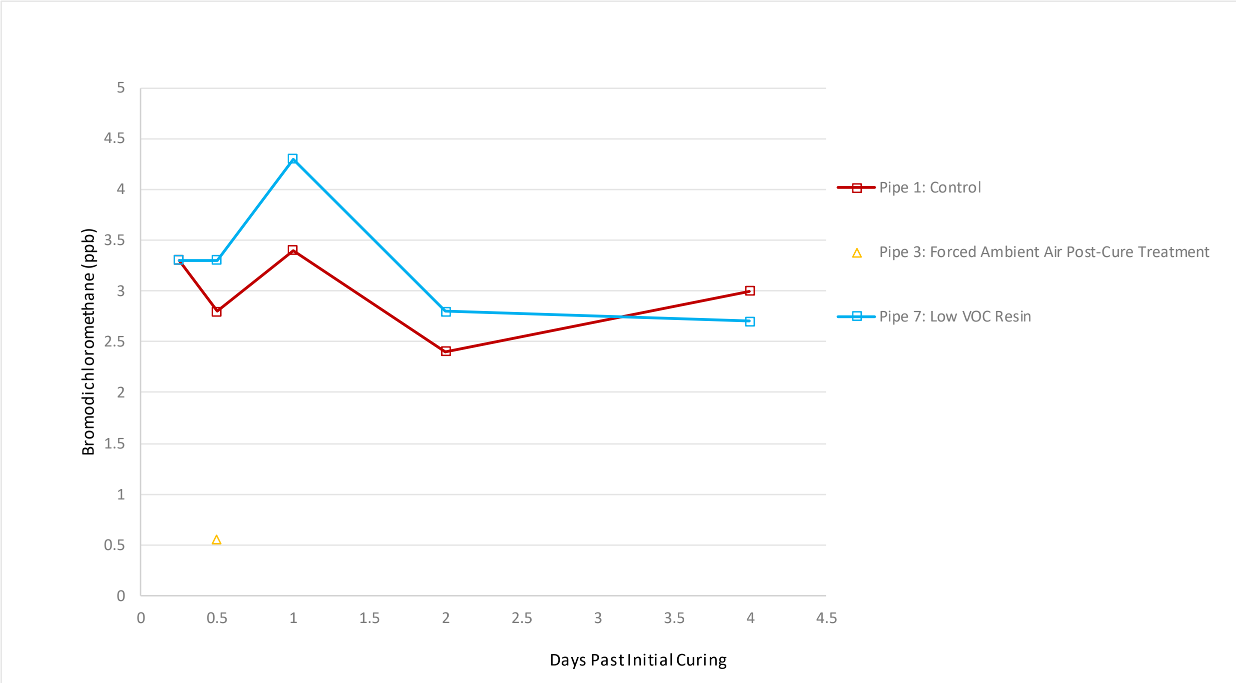

Figure 5. Simulated Field Experiment Bromodichloromethane Results

Table 6. Bromomethane Results

Analyte	ND Value	Units	Environmental Threshold
Bromomethane	1	µg/L	1 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	1.4	ND	ND	ND	ND	ND	ND	ND			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

Table 7. Chloroform Results

Analyte	ND Value	Units	Environmental Threshold
Chloroform	0.50	µg/L	80 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	4.3	ND	ND			
1	0.25	49	6.9	6.85	6.5	4.7	3.7	46	7.4	20	17	16
2	0.5	41	5.8	8.0	6.7	7.0	4.0	49	6.0	18	19	4.0
3	1	48	5.6	6.4	7.4	5.9	3.8	65	7.5	5.4	4.8	5.8
4	2	36	5.6	7.6	5.2	4.8	3.8	42	7.3	6	5.8	4.9
5	4	47	4.0	6.8	5.5	5.75	4.0	42	5.35	2	2	1.8
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

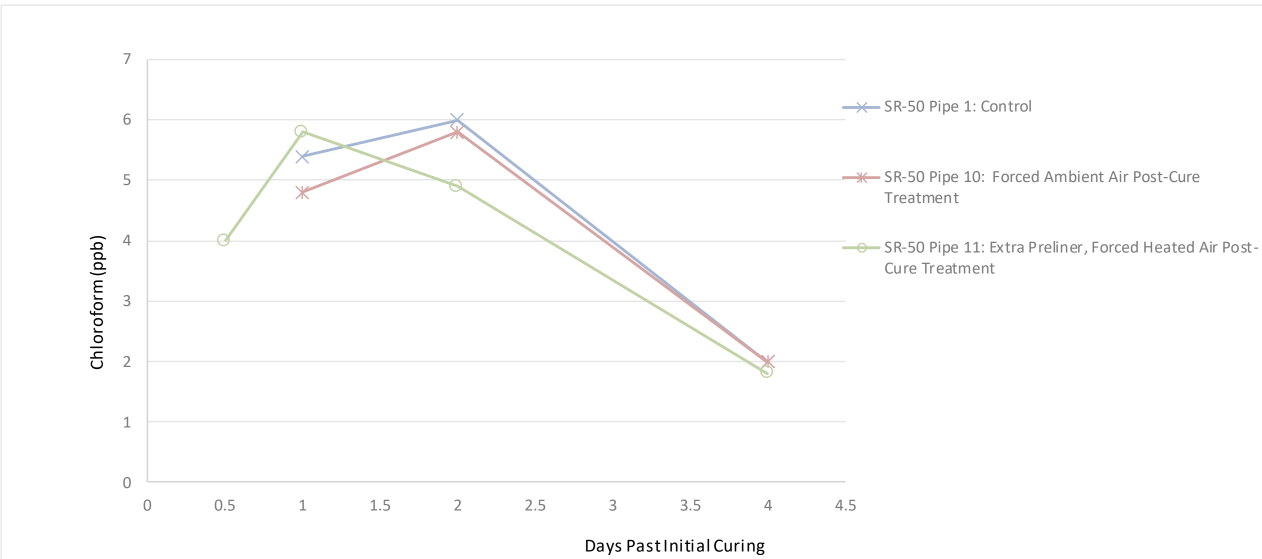

Figure 6. Field Experiment Chloroform Results

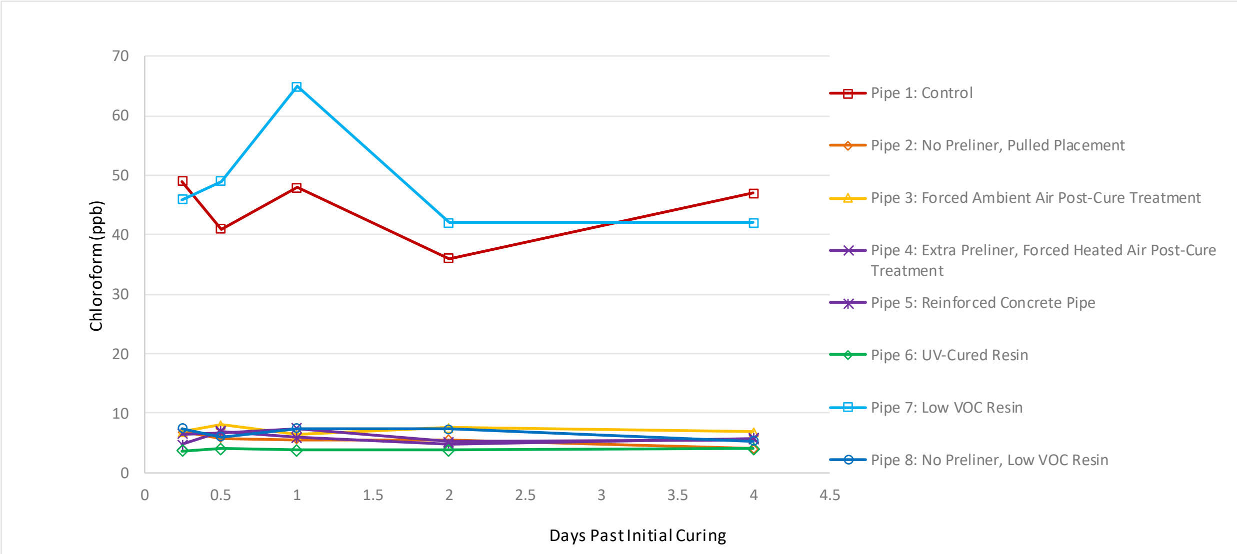

Figure 7. Simulated Field Experiment Chloroform Results

Table 8. Chloromethane Results

Analyte	ND Value	Units	Environmental Threshold
Chloromethane	1.0	µg/L	4 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	ND			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	0.5	ND	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

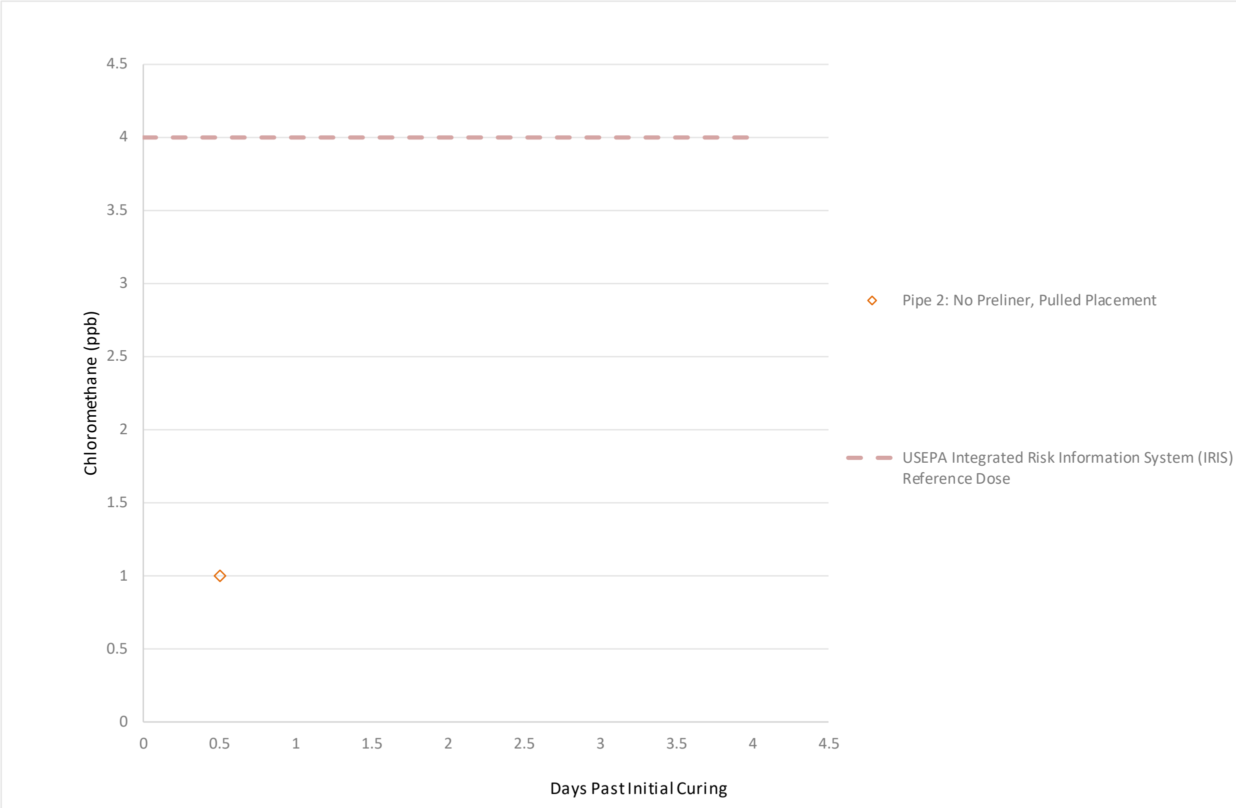

Figure 8. Simulated Field Experiment Chloromethane Results

Table 9. Dibromochloromethane Results

Analyte	ND Value	Units	Environmental Threshold
Dibromochloromethane	0.50	µg/L	80 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	ND			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	2.3	2.7	3.1
2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	3	3.5	1.7
3	1	ND	ND	ND	ND	ND	ND	ND	ND	1.9	1.8	1.9
4	2	ND	ND	ND	ND	ND	ND	ND	ND	0.54	0.62	0.57
5	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

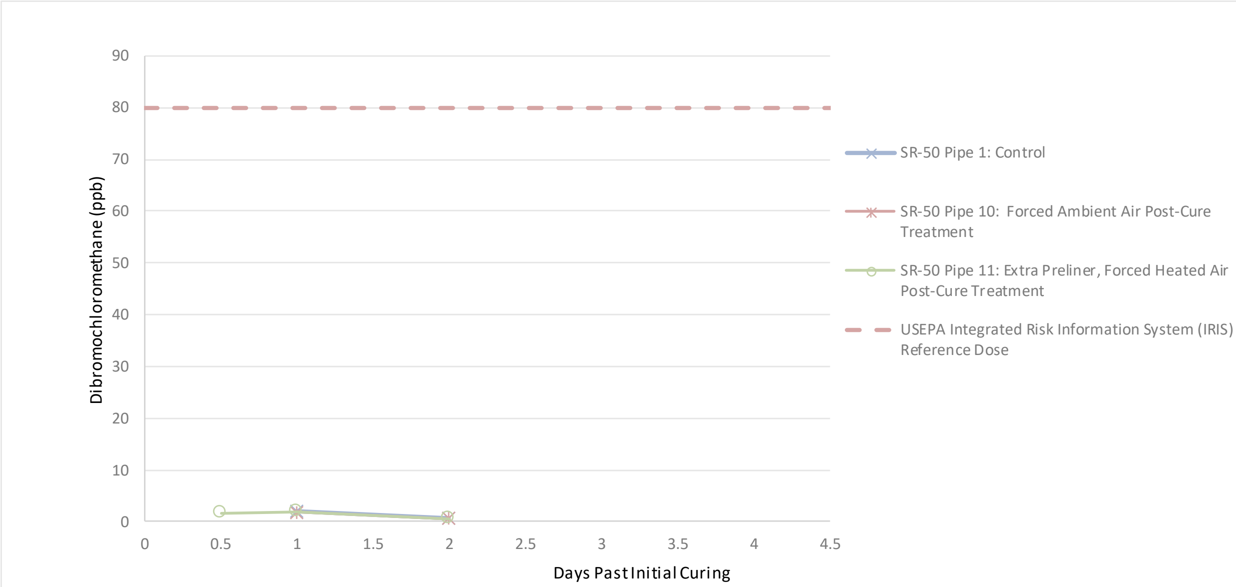

Figure 9. Simulated Field Experiment Dibromochloromethane Results

Table 10. Isopropyl Benzene Results

Analyte	ND Value	Units	Environmental Threshold
Isopropyl Benzene	0.50	µg/L	100 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	0.90			
1	0.25	ND	ND	ND	ND	ND	ND	ND	1.6	ND	ND	1.5
2	0.5	ND	ND	ND	ND	ND	ND	ND	2.2	ND	ND	1.5
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.5
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	4.15	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

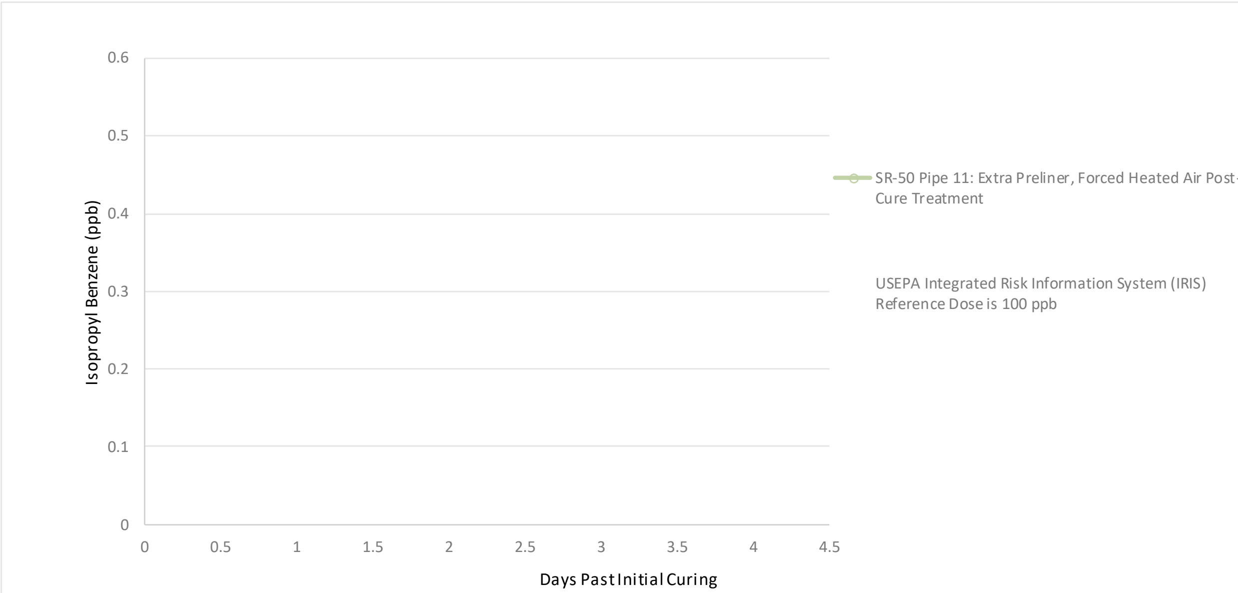

Figure 10. Field Experiment Isopropyl Benzene Results

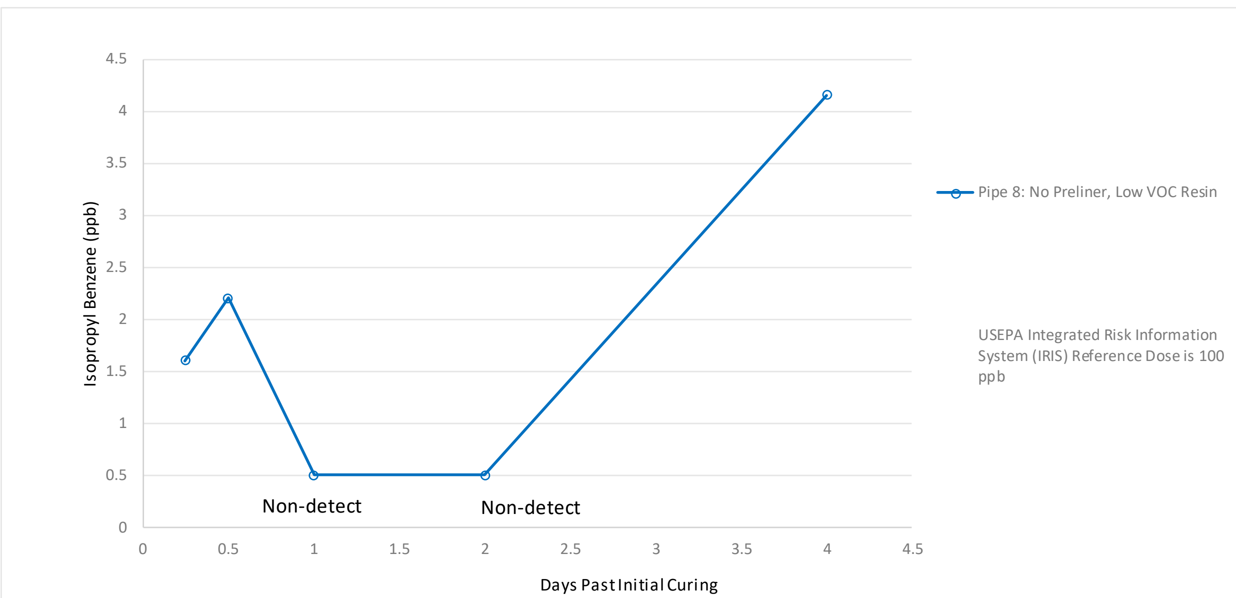

Figure 11. Simulated Field Experiment Isopropyl Benzene Results

Table 11. n-Propylbenzene Results

Analyte	ND Value	Units	Environmental Threshold
n-Propylbenzene	0.50	µg/L	260 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	1.4	ND	ND	ND	ND	ND	1.4	ND			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.4
2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.3	1.3
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.3	1.3
4	2	ND	ND	ND	ND	ND	ND	1.3	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

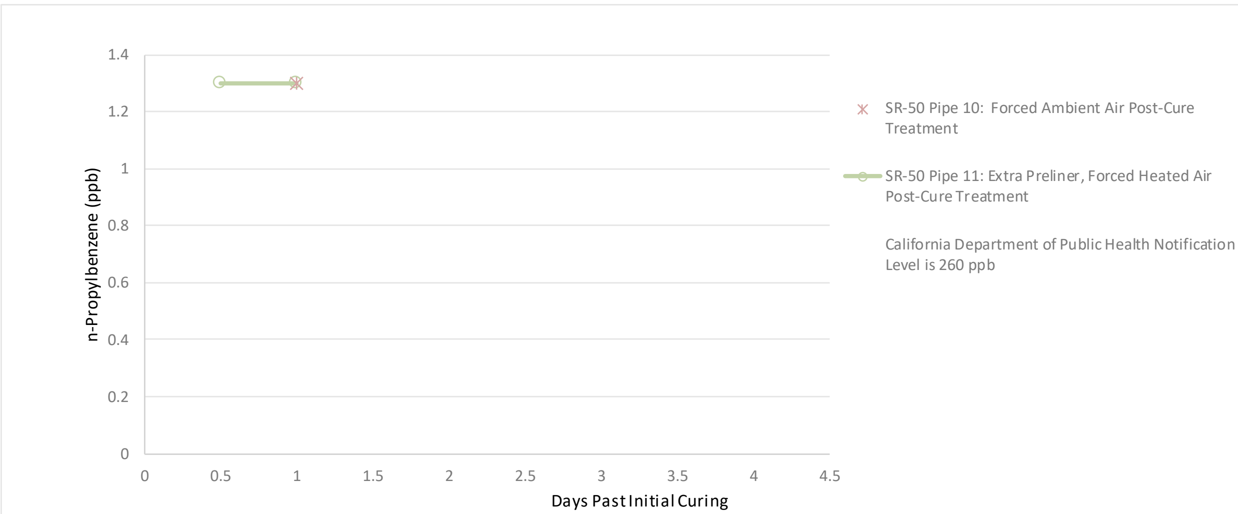

Figure 12. Field Experiment n-Propylbenzene Results

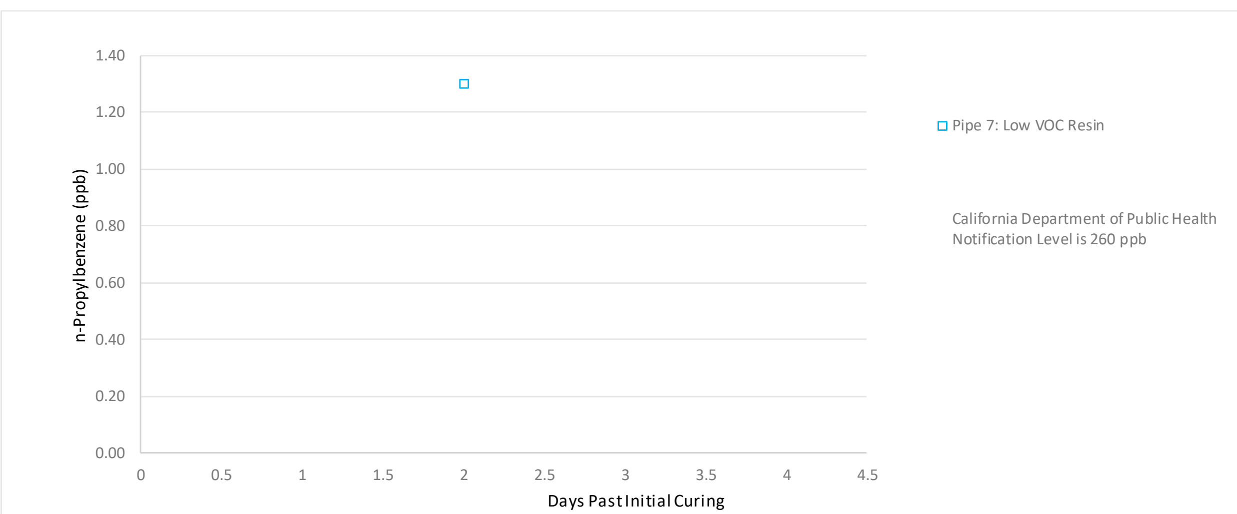

Figure 13. Simulated Field Experiment n-Propylbenzene Results

Table 12. Styrene Results

Analyte	ND Value	Units	Environmental Threshold
Styrene	0.50	µg/L	100 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	20000	110	2100	100	110	0.5	100	20			
1	0.25	92	2.3	8.7	7.7	37	0.62	ND	1.6	1.7	ND	ND
2	0.5	120	96	8.8	13	33	ND	1.5	2.3	2.6	ND	120
3	1	110	16	96	9.5	98	ND	ND	1.6	52	9.6	63
4	2	90	43.35	7.1	13	100	ND	2.0	ND	12	7.7	91
5	4	110	6.6	12	18	22	ND	1.6	7.25	21	32	16
6	13									5.2	11	62
7	15									5.7	8.3	31
8	17									2.2	1.7	1.6

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

Refer to Figures 16 and 17 in the main report for graphs displaying Styrene data.

Table 13. tert-Butyl Alcohol Results

Analyte	ND Value	Units	Environmental Threshold
tert-Butyl Alcohol	5.0	µg/L	12 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
1	0	ND	ND	ND	ND	ND		ND	34			
2	0.25	ND	ND	ND	ND	ND		ND	ND			
3	0.5	ND	ND	ND	ND	ND		ND	ND			
4	1	ND	ND	ND	ND	ND		ND	ND			
5	2	ND	ND	ND	ND	ND		ND	ND			
6	4	ND	ND	ND	ND	ND		ND	11			
7	13											
8	15											
9	17											

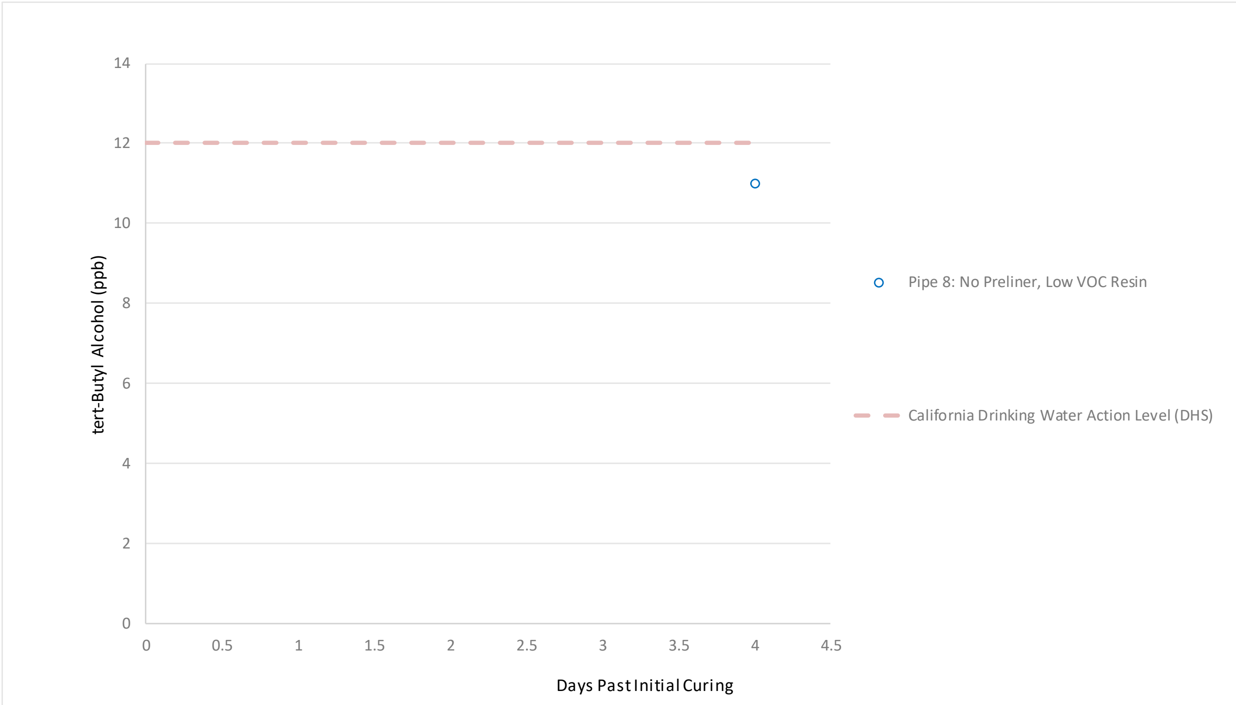

Figure 14. Simulated Field Experiment Tert-butyl Alcohol Results

Table 14. tert-Butyl Benzene

Analyte	ND Value	Units	Environmental Threshold
tert-Butyl Benzene	0.5	µg/L	260 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	ND			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.5	ND
2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

Table 15. Toluene Results

Analyte	ND Value	Units	Environmental Threshold
Toluene	0.50	µg/L	150 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	ND			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.89	ND
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.7	0.60
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	ND	0.69	0.81	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

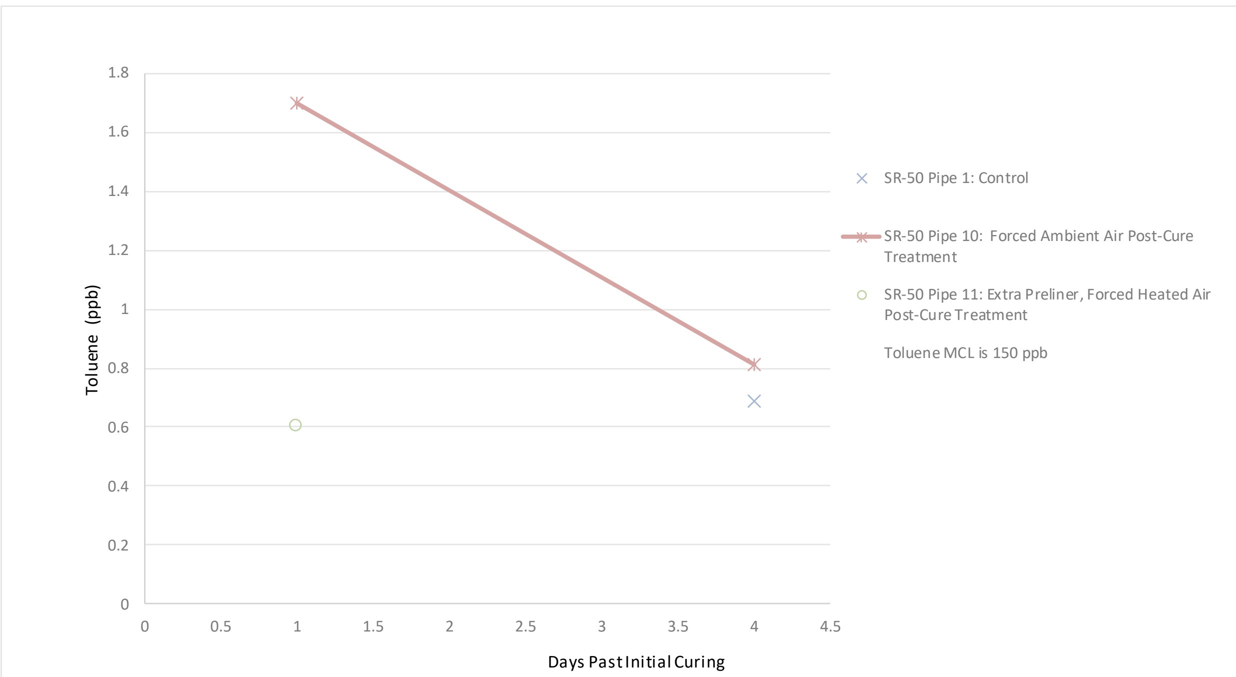

Figure 15. Field Experiment Toluene Results

Table 16. Total Trihalomethanes Results

Analyte	ND Value	Units	Environmental Threshold
Total Trihalomethanes	0.50	µg/L	80 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	4.8	ND	ND			
1	0.25	52.3	7.4	7.35	7	5.2	4.2	49.3	7.9	26.1	23.7	23.6
2	0.5	43.8	7.3	8.55	7.2	7.5	4.5	52.3	6.5	25.5	27.6	7.6
3	1	51.4	6.1	6.9	7.9	6.4	4.3	69.3	8	9.4	8.7	9.9
4	2	38.4	6.1	8.1	5.7	5.3	4.3	44.8	7.8	7.74	7.62	6.47
5	4	50	4.5	7.3	6	6.25	4.5	44.7	5.85	2	2	1.8
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

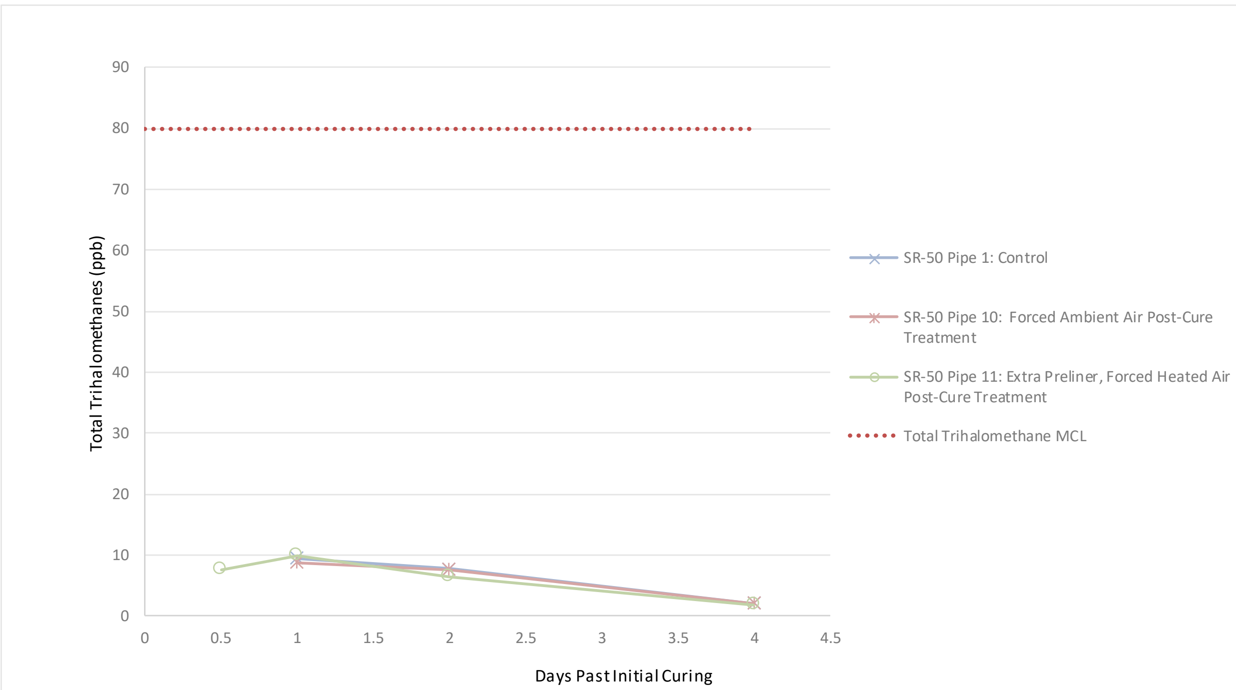

Figure 16. Field Experiment Total Trihalomethane Results

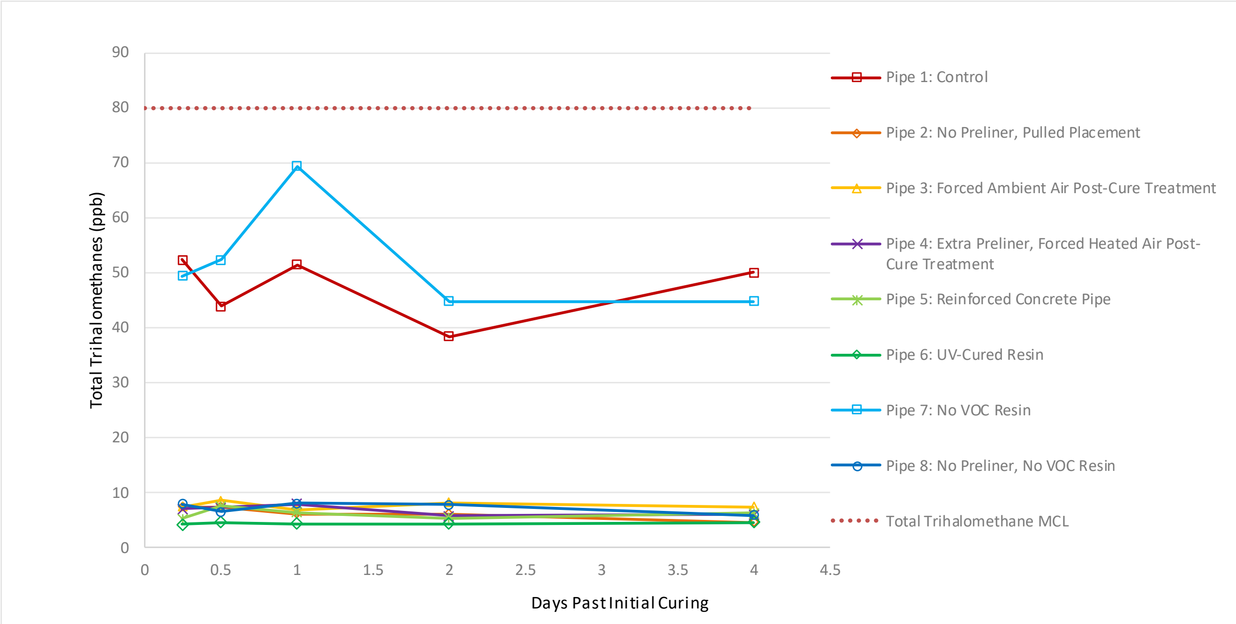

Figure 17. Simulated Field Experiment Total Trihalomethane Results

Table 17. Total Xylenes Results

Analyte	ND Value	Units	Environmental Threshold
Xylenes (total)	1.0	µg/L	1750 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	3.7	ND	ND	ND	ND	ND	2.5	ND			
1	0.25	ND	ND	ND	ND	ND	ND	2.1	ND	1.8	ND	ND
2	0.5	2.2	ND	ND	ND	ND	ND	2.1	ND	ND	2.2	ND
3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.0	ND
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	2.1	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

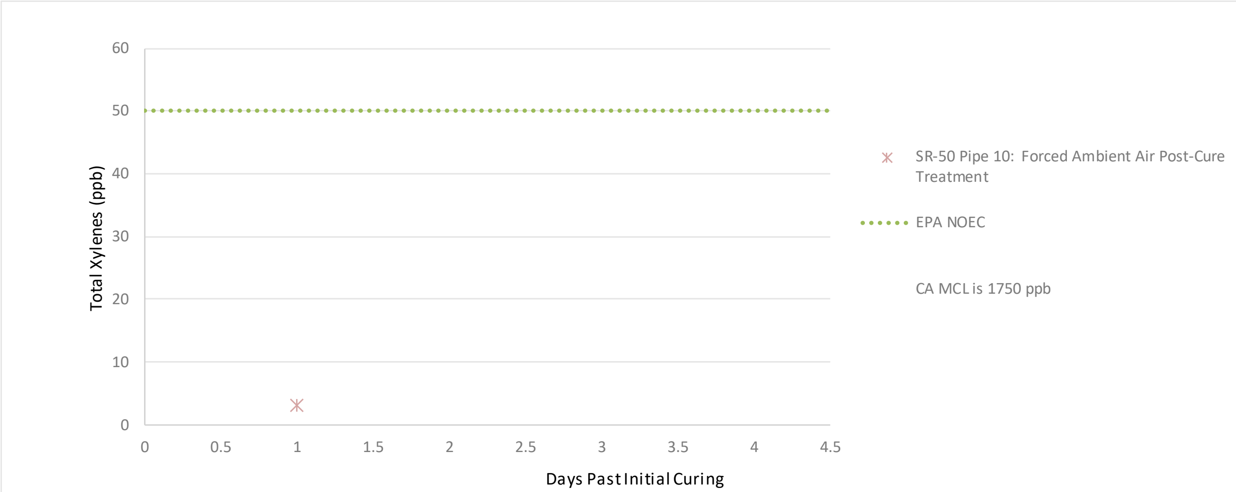

Figure 18. Field Experiment Total Xylene Results

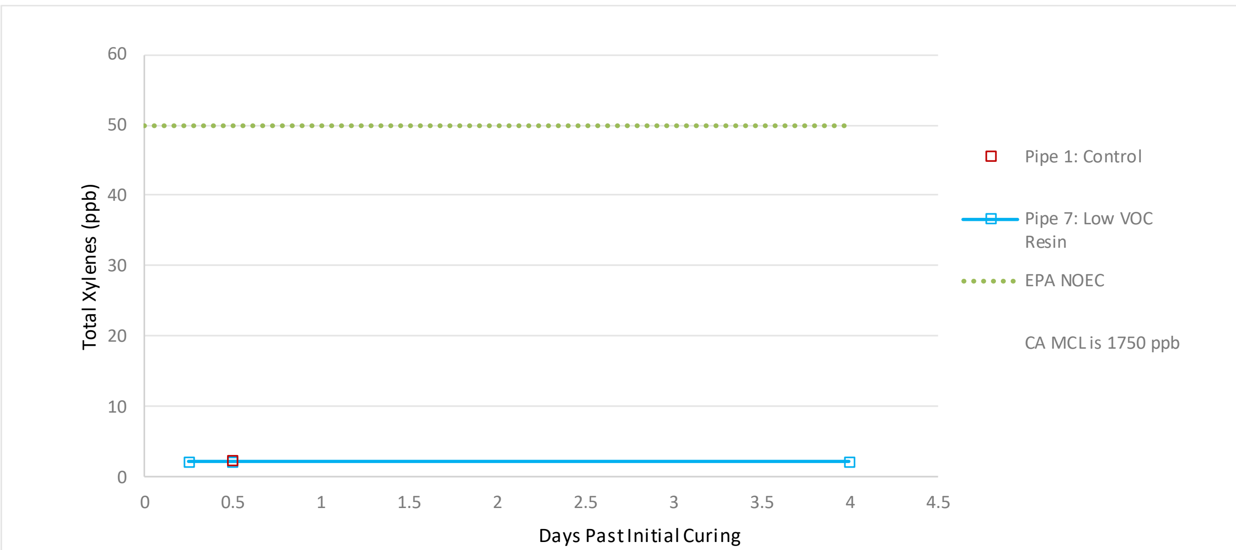

Figure 19. Simulated Field Experiment Total Xylene Results

Table 18. 1,2,4-Trimethylbenzene Results

Analyte	ND Value	Units	Environmental Threshold
1,2,4-Trimethylbenzene	0.50	µg/L	330 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	ND			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.2
2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.4	1.5
3	1	ND	ND	ND	ND	ND	ND	ND	ND	1.3	1.5	1.5
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

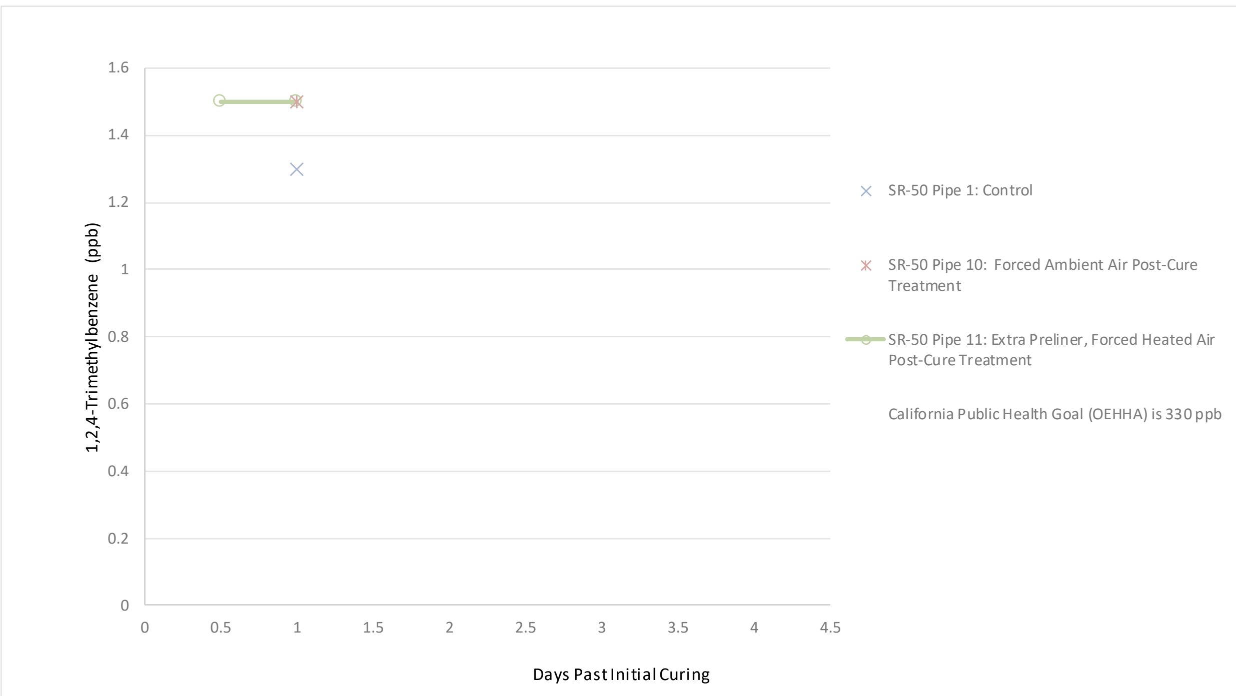

Figure 20. Field Experiment 1,2,4-Trimethylbenzene Results

Table 19. 1,3,5-Trimethylbenzene Results

Analyte	ND Value	Units	Environmental Threshold
1,3,5-Trimethylbenzene	0.50	µg/L	330 µg/L

Run	Days	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: Low VOC Resin	Pipe 8: No Preliner, Low VOC Resin	SR-50 Pipe 1: Control	SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment	SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment
Condensate	0	ND	ND	ND	ND	ND	ND	ND	ND			
1	0.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.5
2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.3
3	1	ND	ND	ND	ND	ND	ND	ND	ND	1.2	1.3	1.3
4	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	13									ND	ND	ND
7	15									ND	ND	ND
8	17									ND	ND	ND

Red flagged results are from samples collected from the containment systems.

In absence of condensate, a sample collection run was performed 2 hours after final cool down.

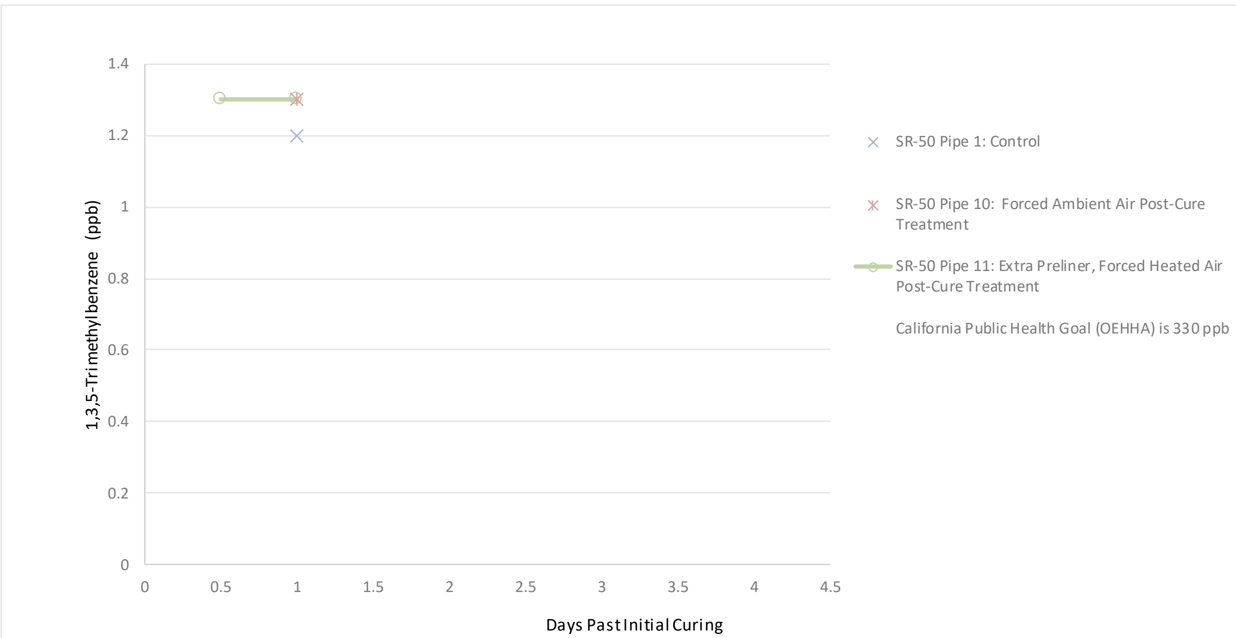

Figure 21. Field Experiment 1,3,5-Trimethylbenzene Results

Background Concentrations

Table 20. Water Source and Influent Bromodichloromethane Results

Analyte	ND Value	Units
Bromodichloromethane	0.50	µg/L

	3-5-2016 Samples	4-26-2016 Samples	8-9-2016 Samples	8-10-2016 Samples	8-11-2016 Samples	8-12-2016 Samples	8-13-2016 Samples	8-14-2016 Samples	8-15-2016 Samples	SR-50 9-9-2014 Sample	SR-50 9-24-2014 Sample
Tap Water Source		ND	ND	ND	0.57	ND	ND	ND	ND		
Influent	2.7	ND	ND	ND	ND	ND	ND	ND	ND	4.8	ND
Tap Water Duplicate				ND							

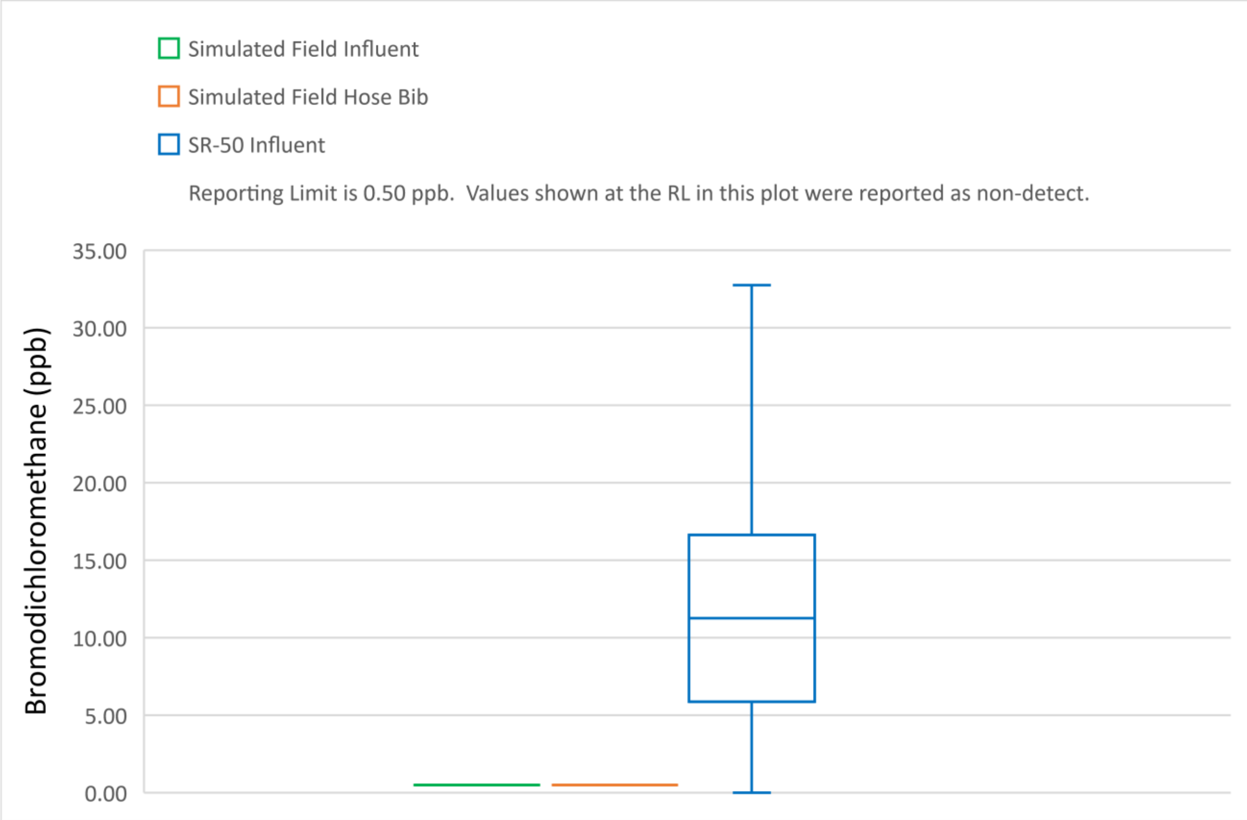

Figure 22. Box Plot Comparing Bromodichloromethane Concentrations for the Simulated Field Dosing System Influent Samples, Simulated Field Samples at the Source (Hose Bib), and Field Dosing System Influent Samples

Table 21. Water Source and Influent Chloroform Results

Analyte		ND Value	Units								
Chloroform		0.50	µg/L								
	3-5-2016 Samples	4-26-2016 Samples	8-9-2016 Samples	8-10-2016 Samples	8-11-2016 Samples	8-12-2016 Samples	8-13-2016 Samples	8-14-2016 Samples	8-15-2016 Samples	SR-50 9-9-2014 Sample	SR-50 9-24-2014 Sample
Tap Water Source		6.7	7.0	7.8	9.0	6.8	6.4	7.4	1.3		
Influent	38	4.5	7.5	6.7	7.9	6.0	6.4	6.9	2.0	22	ND
Tap Water Duplicate				7.6							

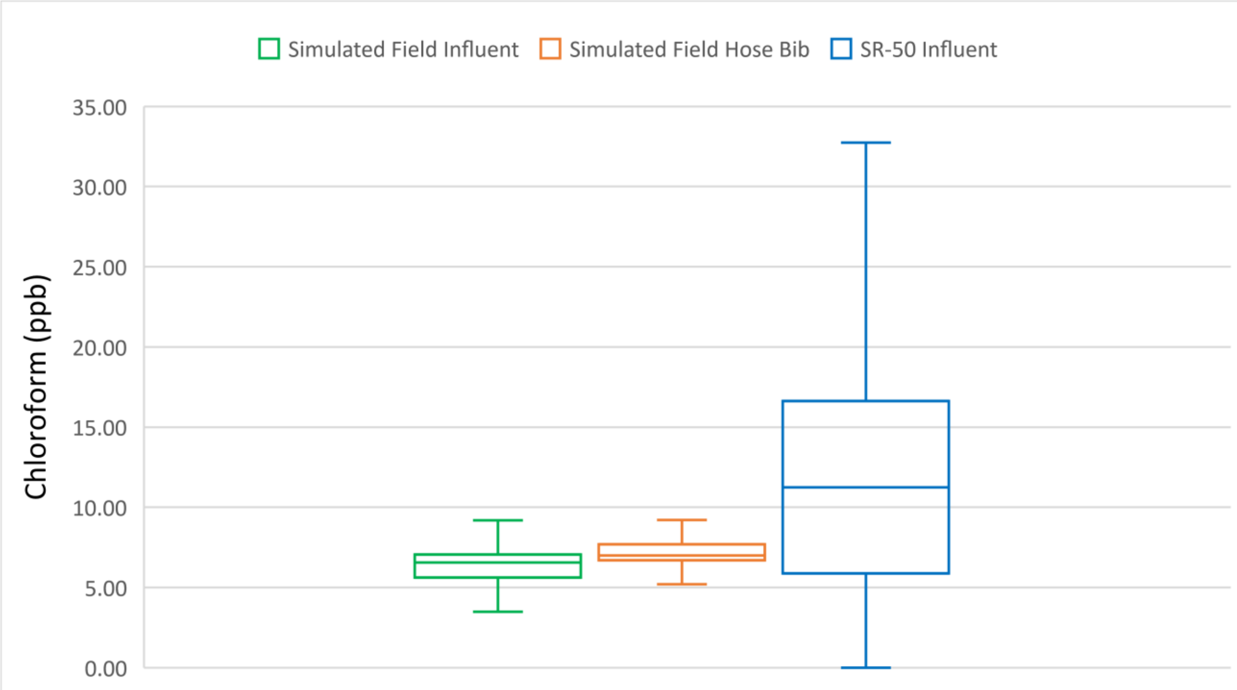

Figure 23. Box Plot Comparing Chloroform Concentrations for the Simulated Field Dosing System Influent Samples, Simulated Field Samples at the Source (Hose Bib), and Field Dosing System Influent Samples

Table 22. Water Source and Influent Dibromochloromethane Results

Analyte	ND Value	Units
Dibromochloromethane	0.50	µg/L

	3-5-2016 Samples	4-26-2016 Samples	8-9-2016 Samples	8-10-2016 Samples	8-11-2016 Samples	8-12-2016 Samples	8-13-2016 Samples	8-14-2016 Samples	8-15-2016 Samples	SR-50 9-9-2014 Sample	SR-50 9-24-2014 Sample
Tap Water Source		ND	ND	ND	ND	ND	ND	ND	ND		
Influent	ND	ND	ND	ND	ND	ND	ND	ND	ND	3	ND
Tap Water Duplicate				ND							

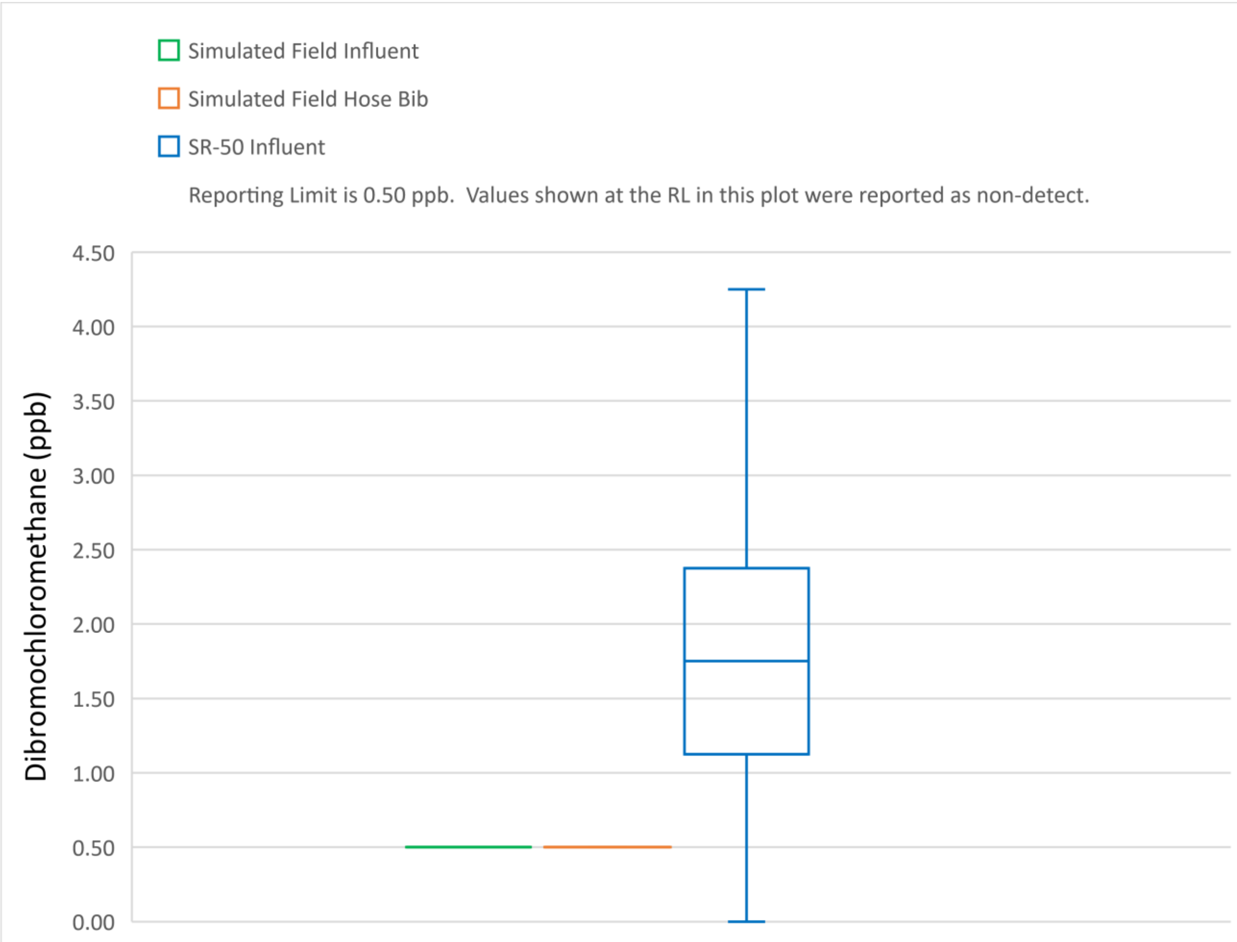

Figure 24. Box Plot Comparing Dibromochloromethane Concentrations for the Simulated Field Dosing System Influent Samples, Simulated Field Samples at the Source (Hose Bib), and Field Dosing System Influent Samples

Table 23. Water Source and Influent Styrene Results

Analyte	ND Value	Units
Styrene	0.50	µg/L

	3-5-2016 Samples	4-26-2016 Samples	8-9-2016 Samples	8-10-2016 Samples	8-11-2016 Samples	8-12-2016 Samples	8-13-2016 Samples	8-14-2016 Samples	8-15-2016 Samples	SR-50 9-9-2014 Sample	SR-50 9-24-2014 Sample
Tap Water Source		ND	ND	ND	ND	ND	ND	ND	ND		
Influent	3.9	ND	ND	1.5	ND	ND	ND	ND	ND	1.6	ND
Tap Water Duplicate				ND							

Refer to Figure 18 in the main report for a graph displaying background Styrene data.

Table 24. Water Source and Influent Total Trihalomethane Results

Analyte	ND Value	Units
Total Trihalomethanes	0.50	µg/L

	3-5-2016 Samples	4-26-2016 Samples	8-9-2016 Samples	8-10-2016 Samples	8-11-2016 Samples	8-12-2016 Samples	8-13-2016 Samples	8-14-2016 Samples	8-15-2016 Samples	SR-50 9-9-2014 Sample	SR-50 9-24-2014 Sample
Tap Water Source		8.2	8.5	9.2	10.6	9.4	7.5	7.9	8.4		
Influent	41.7	6	9	8.2	10.5	8.3	7.9	8.9	2.8	30.8	ND
Tap Water Duplicate											

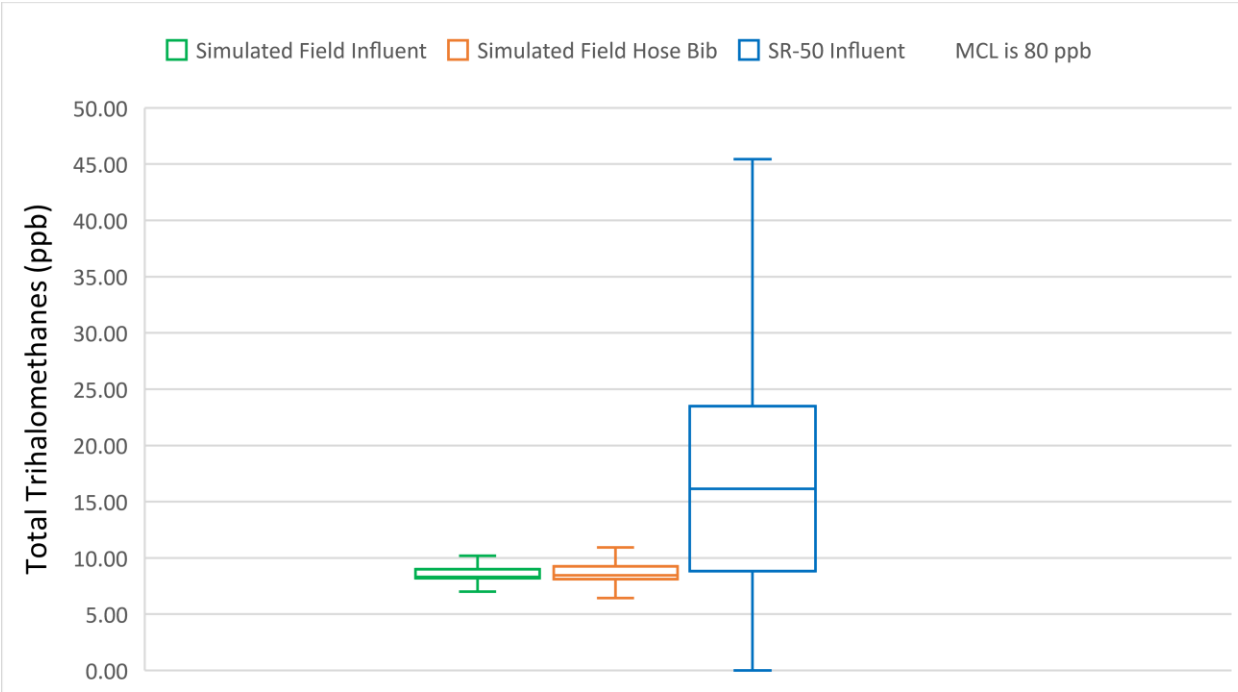

Figure 25. Box Plot Comparing Total Trihalomethane Concentrations for the Simulated Field Dosing System Influent Samples, Simulated Field Samples at the Source (Hose Bib), and Field Dosing System Influent Samples

Meteorological Data

Table 25. Simulated Field Study Meteorological Data

Run		Condenstae	1	2	3	4	5
Days		0	0.25	0.5	1	2	4
Pipe 1: Control	Date	3/5/2016	3/5/2016	3/6/2016	3/6/2016	3/7/2016	3/9/2016
	Max Temp (°F)	65	65	61	61	55	66
	Min Temp (°F)	58	58	49	49	42	46
	Mean Temp (°F)	62	62	55	55	49	56
Pipe 2: No Preliner, Pulled Placement	Date	8/11/2016	8/11/2016	8/11/2016	8/12/2016	8/13/2016	8/15/2016
	Max Temp (°F)	93	93	93	97	100	92
	Min Temp (°F)	57	57	57	59	59	55
	Mean Temp (°F)	75	75	75	78	80	74
Pipe 3: Forced Ambient Air Post-Cure Treatment	Date	8/9/2016	8/9/2016	8/10/2016	8/10/2016	8/11/2016	8/13/2016
	Max Temp (°F)	94	94	91	91	93	100
	Min Temp (°F)	57	57	59	59	57	59
	Mean Temp (°F)	76	76	75	75	75	80
Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Date	8/10/2016	8/10/2016	8/10/2016	8/11/2016	8/12/2016	8/14/2016
	Max Temp (°F)	91	91	91	93	97	101
	Min Temp (°F)	59	59	59	57	59	66
	Mean Temp (°F)	75	75	75	75	78	84
Pipe 5: Reinforced Concrete Pipe	Date	8/10/2016	8/10/2016	8/11/2016	8/11/2016	8/12/2016	8/14/2016
	Max Temp (°F)	91	91	93	93	97	101
	Min Temp (°F)	59	59	57	57	59	66
	Mean Temp (°F)	75	75	75	75	78	84
Pipe 6: UV-Cured Resin	Date	1/12/2016	1/12/2016	1/12/2016	1/13/2016	1/14/2016	1/16/2016
	Max Temp (°F)	58	58	58	60	53	60
	Min Temp (°F)	50	50	50	42	37	48
	Mean Temp (°F)	54	54	54	51	45	54
Pipe 7: No VOC Resin	Date	3/5/2016	3/5/2016	3/5/2016	3/6/2016	3/7/2016	3/9/2016
	Max Temp (°F)	65	65	65	61	55	66
	Min Temp (°F)	58	58	58	49	42	46
	Mean Temp (°F)	62	62	62	55	49	56
Pipe 8: No Preliner, No VOC Resin	Date	8/9/2016	8/9/2016	8/10/2016	8/10/2016	8/11/2016	8/13/2016
	Max Temp (°F)	94	94	91	91	93	100
	Min Temp (°F)	57	57	59	59	57	59
	Mean Temp (°F)	76	76	75	75	75	80

Table 26. Field Study Meteorological Data

Run		Condensate	1	2	3	4	5	6	7	8
Days		0	0.25	0.5	1	2	4	13	15	17
SR-50 Pipe 1: Control	Date				9/10/2014	9/11/2014	9/13/2014	9/22/2014	9/24/2014	9/26/2014
	Max Temp (°F)				70.21	75.21	79.21	81.21	70.21	64
	Min Temp (°F)				48.21	52.21	56.21	61.21	52.21	48
	Mean Temp (°F)				59.21	63.71	67.71	71.21	61.21	56
SR-50 Pipe 10: Post-cure Forced Ambient Air	Date				9/10/2014	9/11/2014	9/13/2014	9/22/2014	9/24/2014	9/26/2014
	Max Temp (°F)				70.21	75.21	79.21	81.21	70.21	64
	Min Temp (°F)				48.21	52.21	56.21	61.21	52.21	48
	Mean Temp (°F)				59.21	63.71	67.71	71.21	61.21	56
SR-50 Pipe 11: Extra Preliner with Post-cure Forced Heated Air	Date			9/10/2014	9/10/2014	9/11/2014	9/13/2014	9/22/2014	9/24/2014	9/26/2014
	Max Temp (°F)			70.21	70.21	75.21	79.21	81.21	70.21	64
	Min Temp (°F)			2/17/1900	48.21	52.21	56.21	61.21	52.21	48
	Mean Temp (°F)			59.21	59.21	63.71	67.71	71.21	61.21	56

Refer to Figure 19 in the main report for a graph displaying mean daily air temperature data.

Table 27. Simulated Field Study Precipitation and Humidity Data

Pipes 1 & 7 Precipitation and Humidity Data						
Station Name	**Elevation (ft.)**	**Latitude**	**Longitude**	**Date**	**Cumulative Precipitation (in.)**	**Average Daily RH (%, Bryte Park)**
CSU (Bryte)	25 (30)	38.555 (Bryte Park: 38.600065)	-121.416 (Bryte Park: -121.533798)	3/4/2016	0.49	89
				3/5/2016	1.63	90
				3/6/2016	1.95	74
				3/7/2016	2.34	88
				3/8/2016	2.34	71
				3/9/2016	2.35	78
Pipe 6 Precipitation and Humidity Data						
CSU (Bryte)	25 (30)	38.555 (Bryte Park: 38.600065)	-121.416 (Bryte Park: -121.533798)	1/3/2016	0.01	62
				1/4/2016	0.12	80
				1/5/2016	1.31	91
				1/6/2016	1.96	88
				1/7/2016	2	91
				1/8/2016	2.03	90
				1/9/2016	2.08	83
				1/10/2016	2.17	88
				1/11/2016	2.18	82
				1/12/2016	2.18	81
				1/13/2016	2.41	78
				1/14/2016	2.47	86
				1/15/2016	2.62	91
				1/16/2016	2.77	87
Pipes 2, 3, 4, 5, & 8 Precipitation and Humidity Data						
Station Name	**Elevation (ft.)**	**Latitude**	**Longitude**	**Date**	**Cumulative Precipitation (in.)**	**Average Daily RH (%, Bryte Park)**
CSU (Bryte)	25 (30)	38.555 (Bryte Park: 38.600065)	-121.416 (Bryte Park: -121.533798)	8/9/2016	0	48
				8/10/2016	0	48
				8/11/2016	0	50
				8/12/2016	0	46
				8/13/2016	0	38
				8/14/2016	0	34
				8/15/2016	0	47

Refer to Figures 20 to 22 in the main report for graphs displaying simulated field cumulative precipitation and humidity data.

Table 28. Field Study Precipitation and Humidity Data

SR-50 Pipes 1, 10, & 11 Precipitation and Humidity Data						
Station Name	Elevation (ft.)	Latitude	Longitude	Date	Precipitation (in.)	Average Daily RH (%, Camino)
Forni Ridge (Camino)	7600 (Camino: 2780)	38.555 (Camino: 38.753136)	-121.416 (Camino: -120.7336)	9/10/2014	0	22
				9/11/2014	0	19
				9/12/2014	0	18
				9/13/2014	0	19
				9/14/2014	0	23
				9/15/2014	0	26
				9/16/2014	0	28
				9/17/2014	0	28
				9/18/2014	0	69
				9/19/2014	0	62
				9/20/2014	0	46
				9/21/2014	0.07	54
				9/22/2014	0.02	42
				9/23/2014	0	42
				9/24/2014	0	49
				9/25/2014	0.19	83
				9/26/2014	0.15	69

Refer to Figure 23 in the main report for a graph displaying field cumulative precipitation and humidity data.

Soil Moisture

Table 29. Simulated Field Study Soil Moisture Data, 3-5-2017 (Pipes 1 & 7)

	Temperature (deg. F)	Soil wt (grams) Initial (wet)	Final (dry)	% Water Content
Sample 1	62.6	35.1392	30.2917	0.160027
Sample 2	62.5	23.4399	20.1315	0.164339
Sample 3	63	35.6269	31.8508	0.118556
Average	62.7	31.402	27.424667	0.147641

Temperature Cure Logs

Table 30. Simulated Field Study Pipe 1 Cure Log Data

Pipe 1: Control Cure Log				
Time	Elapsed Time (min.)	PSI	Steam Temp	Thermal Interface Temp (˚F)
1:20	0:00	5	65	65
1:25	0:05	5	80	75
1:30	0:10	5	170	101
1:35	0:15	5	180	135
1:40	0:20	5	190	140
1:45	0:25	5	186	150
1:50	0:30	5	190	153
1:55	0:35		195	200
2:00	0:40		187	185
2:05	0:45		190	180
2:10	0:50		190	181
2:15	0:55		189	180
2:20	1:00		190	180
2:25	1:05		185	172
2:30	1:10		185	175
2:35	1:15		174	168
2:40	1:20		165	164
2:45	1:25		165	162
2:50	1:30		165	163
			165	162
Cool Down				
2:55	1:35		147	156
3:00	1:40		129	138
3:05	1:45		118	122
3:10	1:50		110	108

Table 31. Simulated Field Study Pipe 2 Cure Log Data

Pipe 2: No Preliner, Pulled Placement Cure Log				
Time	Elapsed Time (min.)	PSI	Steam Temp	Thermal Interface Temp (˚F)
8:15	0:00	5	250	60
8:20	0:05	5	248	92
8:25	0:10	5	248	126
8:30	0:15	5	248	235
8:35	0:20	5	248	280
8:40	0:25	5	249	256
8:45	0:30	5	248	241
8:50	0:35	5	248	220
8:55	0:40	5	248	210
9:00	0:45	5	248	204
9:05	0:50	5	248	202
9:10	0:55	5	248	202
9:15	1:00	5	248	201
9:20	1:05	5	250	200
9:25	1:10	5	250	200
9:30	1:15	5	248	199
9:35	1:20	5	250	195
9:40	1:25	5	250	200
9:45	1:30	5	250	200
9:50	1:35	5	250	199
9:55	1:40	5	250	198
10:00	1:45	5	248	197
10:05	1:50	5		181
10:10	1:55	5		169
10:15	2:00	5		153
10:20	2:05	5		140
10:25	2:10	5		123
10:30	2:15	5		121
10:35	2:20	5		116
10:40	2:25	5		112
10:45	2:30	5		108
10:50	2:35	5		101

Table 32. Simulated Field Study Pipe 3 Cure Log Data

Pipe 3: Forced Ambient Air Post-Cure Treatment Cure Log				
Time	Elapsed Time (min.)	PSI	Steam Temp	Thermal Interface Temp (˚F)
10:50	0:00	5	240	58
10:55	0:05	5	240	145
11:00	0:10	5	240	170
11:05	0:15	5	240	200
11:10	0:20	5	240	182
11:15	0:25	5	240	181
11:20	0:30	5	240	178
11:25	0:35	5	240	177
11:30	0:40	5	240	177
11:35	0:45	5	240	176
11:40	0:50	5	250	177
11:45	0:55	5	250	176
11:50	1:00	5	250	176
11:55	1:05	5	250	175
12:00	1:10	5	250	173
12:05	1:15	5	250	168
12:10	1:20	5	250	167
12:15	1:25	5	250	167
12:20	1:30	5	250	163
12:25	1:35	5	250	159
12:30	1:40	5	250	152
12:35	1:45	5		141
12:40	1:50	5		125
12:45	1:55	5		110
12:50	2:00	5		105
12:55	2:05	5		100
13:00	2:10	5		95

Table 33. Simulated Field Study Pipe 4 Cure Log Data

Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment Cure Log				
Time	Elapsed Time (min.)	PSI	Steam Temp	Thermal Interface Temp (˚F)
8:35	0:00	5	248	65
8:40	0:05	5	250	149
8:45	0:10	5	250	153
8:50	0:15	5	250	244
8:55	0:20	5	250	239
9:00	0:25	5	248	215
9:05	0:30	5	248	207
9:10	0:35	5	248	201
9:15	0:40	5	248	197
9:20	0:45	5	248	194
9:25	0:50	5	248	193
9:30	0:55	5	248	193
9:35	1:00	5	248	193
9:40	1:05	5	248	193
9:45	1:10	5	248	193
9:50	1:15	5	248	193
9:55	1:20	5	248	194
10:00	1:25	5	248	194
10:05	1:30	5	248	194
10:10	1:35	5	248	194
10:15	1:40	5	248	194
10:20	1:45	5	248	194
10:25	1:50	5	239	174
10:30	1:55	5	233	162
10:35	2:00	5	230	151
10:40	2:05	5		142
10:45	2:10	5		137
10:50	2:15	5		129
10:55	2:20	5		121
11:00	2:25	5		119
11:05	2:30	5		114
11:10	2:35	5		108
11:15	2:40	5		99
11:20	2:45	5		85

Table 34. Simulated Field Study Pipe 5 Cure Log Data

Pipe 5: Reinforced Concrete Pipe Cure Log				
Time	Elapsed Time (min.)	PSI	Steam Temp	Thermal Interface Temp (˚F)
12:50	0:00	5	230	60
12:55	0:05	5	250	101
13:00	0:10	5	248	113
13:05	0:15	5	248	150
13:10	0:20	5	248	155
13:15	0:25	5	248	160
13:20	0:30	5	248	162
13:25	0:35	5	248	165
13:30	0:40	5	248	169
13:35	0:45	5	248	169
13:40	0:50	5	248	169
13:45	0:55	5	249	170
13:50	1:00	5	249	170
13:55	1:05	5	248	170
14:00	1:10	5	248	169
14:05	1:15	5	248	169
14:10	1:20	5	248	169
14:15	1:25	5	248	169
14:20	1:30	5	248	170
14:25	1:35	5	248	170
14:30	1:40	5	248	170
14:35	1:45	5	246	165
14:40	1:50	5		159
14:45	1:55	5		143
14:50	2:00	5		133
14:55	2:05	5		129
15:00	2:10	5		126
15:05	2:15	5		123
15:10	2:20	5		121
15:15	2:25	5		118
15:20	2:30	5		117
15:25	2:35	5		115
15:30	2:40	5		114
15:35	2:45	5		110
15:40	2:50	5		105
15:45	2:55	5		100

Table 35. Simulated Field Study Pipe 6 Cure Log Data

Pipe 6: UV-Cured Resin Cure Log														
Time	Elapsed Time	PSI	Temp 1 (light train segment 1, ˚F)	Temp 2 (light train segment 2, ˚F)	Time	Elapsed Time	PSI	Temp 1 (light train segment 1, ˚F)	Temp 2 (light train segment 2, ˚F)	Time	Elapsed Time	PSI	Temp 1 (light train segment 1, ˚F)	Temp 2 (light train segment 2, ˚F)
6:40	0:00	1.2	43	32	7:13	0:33	1.4	47	44	7:47	1:06	6.1	61	52
6:41	0:00	1.3	43	32	7:14	0:33	1.8	47	44	7:47	1:06	6.6	61	53
6:41	0:01	1.3	43	32	7:14	0:34	1.8	47	44	7:48	1:07	6.6	61	53
6:42	0:01	1.4	42	32	7:15	0:34	2.3	47	45	7:48	1:07	6.6	61	53
6:42	0:02	1.4	42	32	7:16	0:35	2.6	47	45	7:49	1:08	6.6	61	53
6:43	0:02	1.5	42	33	7:16	0:35	3.1	48	45	7:49	1:08	6.6	61	53
6:43	0:03	2.8	42	32	7:17	0:36	3.1	48	45	7:50	1:09	6.6	62	53
6:44	0:03	0.1	42	32	7:17	0:36	3.1	48	45	7:50	1:09	6.6	62	53
6:45	0:04	0	42	32	7:18	0:37	3.9	48	46	7:51	1:10	6.6	62	53
6:45	0:04	1.3	42	32	7:18	0:37	4	48	45	7:51	1:10	6.6	62	54
6:46	0:05	2.6	42	32	7:19	0:38	4.1	48	45	7:52	1:11	6.6	62	54
6:46	0:05	0.2	42	32	7:19	0:38	4.1	4.9	45	7:52	1:11	6.6	62	54
6:47	0:06	0.1	42	32	7:20	0:39	4.1	49	46	7:53	1:12	6.6	62	54
6:47	0:06	1.3	42	32	7:20	0:39	4.4	49	46	7:53	1:12	6.6	63	54
6:48	0:07	1.8	42	32	7:21	0:40	4.9	49	46	7:54	1:13	6.6	63	54
6:48	0:07	2.3	42	33	7:21	0:40	4.9	49	46	7:54	1:13	6.4	63	55
6:49	0:08	2.3	42	32	7:22	0:41	5	50	46	7:55	1:14	6	63	55
6:49	0:08	2.3	42	32	7:22	0:41	5	50	46	7:55	1:14	6	63	56
6:50	0:09	2.3	42	31	7:23	0:42	5.3	50	46	7:56	1:15	6	64	57
6:50	0:09	2.3	42	31	7:23	0:42	5.4	51	46	7:56	1:15	6	65	57
6:51	0:10	2.3	42	31	7:24	0:43	5.5	51	47	7:57	1:16	6.1	67	58
6:51	0:10	2.3	42	31	7:24	0:43	5.5	51	47	7:57	1:16	6	69	68
6:52	0:11	2.3	42	31	7:25	0:44	5.5	51	47	7:58	1:17	6	72	77
6:52	0:11	2.3	42	31	7:25	0:44	5.5	52	47	7:58	1:18	6	75	87
6:53	0:12	2.7	43	32	7:26	0:45	5.5	52	47	7:59	1:18	6	79	97
6:53	0:12	2.7	43	32	7:26	0:45	5.5	52	47	7:59	1:19	6.1	82	105
6:54	0:13	2.9	43	32	7:27	0:46	5.5	53	47	8:00	1:19	6.2	85	114
6:54	0:13	2.9	43	32	7:27	0:47	5.6	53	47	8:00	1:20	6.4	88	121
6:55	0:14	2.9	43	32	7:28	0:47	5.6	53	47	8:01	1:20	6.3	92	129
6:55	0:14	2.9	43	32	7:28	0:48	5.6	53	48	8:02	1:21	6.3	96	132
6:56	0:15	2.9	43	32	7:29	0:48	5.6	54	48	8:02	1:21	6.6	100	124
6:56	0:16	2.9	43	32	7:29	0:49	5.6	54	48	8:03	1:22	6.6	103	112
6:57	0:16	2.9	43	32	7:30	0:49	5.6	54	48	8:03	1:22	6.6	107	121
6:57	0:17	3	43	32	7:31	0:50	5.6	54	48	8:04	1:23	6.7	111	120
6:58	0:17	3	43	32	7:31	0:50	5.6	55	48	8:04	1:23	6.8	115	135
6:58	0:18	3.4	43	32	7:32	0:51	5.6	55	48	8:05	1:24	5.8	119	142
6:59	0:18	3.1	43	32	7:32	0:51	5.6	55	48	8:05	1:24	6.2	123	145
7:00	0:19	3	43	32	7:33	0:52	5.7	55	48	8:06	1:25	6.2	126	144
7:00	0:19	-0.1	43	32	7:33	0:52	5.7	56	49	8:06	1:25	6.3	130	144
7:01	0:20	-0.1	43	32	7:34	0:53	5.7	56	49	8:07	1:26	6.3	133	143
7:01	0:20	-0.1	43	32	7:34	0:53	5.7	56	49	8:07	1:26	6.3	137	145
7:02	0:21	-0.1	43	32	7:35	0:54	5.7	56	49	8:08	1:27	6.4	140	146
7:02	0:21	-0.1	43	32	7:35	0:54	5.7	56	49	8:08	1:27	6.3	144	149
7:03	0:22	-0.1	43	40	7:36	0:55	5.8	57	49	8:09	1:28	6.2	147	153
7:03	0:22	-0.1	0	0	7:36	0:55	5.8	57	49	8:09	1:28	6.3	151	155
7:04	0:23	-0.1	44	42	7:37	0:56	5.8	57	50	8:10	1:29	6.3	154	155
7:04	0:23	-0.1	44	42	7:37	0:56	5.8	57	50	8:10	1:29	6.3	158	161
7:05	0:24	-0.1	44	41	7:38	0:57	5.8	57	50	8:11	1:30	6.6	161	168
7:05	0:24	-0.1	45	42	7:38	0:57	5.8	58	50	8:11	1:30	6.5	165	182
7:06	0:25	-0.1	45	42	7:39	0:58	5.8	58	50	8:12	1:31	6.5	168	193
7:06	0:25	0.5	45	43	7:39	0:58	5.8	58	50	8:12	1:31	6.4	172	202
7:07	0:26	0.5	45	43	7:40	0:59	5.8	58	50	8:13	1:32	6.6	175	208
7:07	0:26	0.5	45	43	7:40	0:59	5.8	58	51	8:13	1:33	6.7	177	214
7:08	0:27	0.5	45	43	7:41	1:00	5.9	59	51	8:14	1:33	6.7	180	218
7:08	0:27	0.5	46	43	7:41	1:00	60	59	51	8:14	1:34	1.3	181	217
7:09	0:28	0.5	46	43	7:42	1:01	6	59	51	8:15	1:34	0	183	221
7:09	0:28	0.5	46	43	7:42	1:02	6	59	51	8:15	1:35	0	184	220
7:10	0:29	0.5	46	43	7:43	1:02	6	59	51	8:16	1:35	0	184	219
7:10	0:29	0.5	46	44	7:43	1:03	6	60	52	8:16	1:36	0	185	218
7:11	0:30	0.5	46	44	7:44	1:03	6.1	60	52	8:17	1:36	0	185	217
7:11	0:31	0.5	46	44	7:44	1:04	6.1	60	52	8:18	1:37	0	185	216
7:12	0:31	0.5	47	44	7:45	1:04	6.1	60	52	8:18	1:37	0	184	214
7:12	0:32	0.7	47	44	7:45	1:05	6.1	60	52	8:19	1:38	0	184	213
7:13	0:32	1.1	47	44	7:46	1:05	6.1	61	52					

Table 36. Simulated Field Study Pipe 7 Cure Log Data

Pipe 7: Low VOC Resin Cure Log				
Time	Elapsed Time (min.)	PSI	Steam Temp	Thermal Interface Temp (˚F)
10:05	0:00	0		64
10:15	0:10	5	120	64
10:30	0:25	5	172	180
10:35	0:30	5	175	181
10:40	0:35	5	160	175
10:45	0:40	5	160	161
10:50	0:45	5	160	150
10:55	0:50	5	160	152
11:00	0:55	5	160	155
11:05	1:00	5	160	148
11:10	1:05	5	160	147
11:15	1:10	5	160	145
11:20	1:15	5	160	143
11:25	1:20	5	160	143
11:30	1:25	5	160	143
11:35	1:30	5	135	130
11:40	1:35	5	123	122
11:45	1:40	0	110	109

Table 37. Simulated Field Study Pipe 8 Cure Log Data

Pipe 8: No Preliner, Low VOC Resin Cure Log				
Time	Elapsed Time (min.)	PSI	Steam Temp	Thermal Interface Temp (˚F)
15:20	0:00	5	240	58
15:25	0:05	5	240	85
15:30	0:10	5	240	135
15:35	0:15	5	240	140
15:40	0:20	5	240	145
15:45	0:25	5	240	150
15:50	0:30	5	240	158
15:55	0:35	5	240	158
16:00	0:40	5	240	158
16:05	0:45	5	240	161
16:10	0:50	5	240	164
16:15	0:55	5	240	166
16:20	1:00	5	240	167
16:25	1:05	5	240	168
16:30	1:10	5	240	169
16:35	1:15	5	240	170
16:40	1:20	5	240	171
16:45	1:25	5	240	173
16:50	1:30	5	240	174
16:55	1:35	5	240	174
17:00	1:40	5	240	175
17:05	1:45	5	240	176
17:10	1:50	5	240	177
17:15	1:55	5	240	170
17:20	2:00	5		160
17:25	2:05	5		140
17:30	2:10	5		130
17:35	2:15	5		122
17:40	2:20	5		115
17:45	2:25	5		109
17:50	2:30	5		95

Table 38. Field Study Pipe 1 Cure Log Data

SR-50 Pipe 1: Control Cure Log					
Time	Elapsed Time (min.)	PSI	Boiler in	Boiler out	Thermal Interface Temp (˚F)
8:00	0:00	4.5			57
8:05	0:05	4.5			57
8:10	0:10	4.5			58
8:15	0:15	4.5	306	250	59
8:20	0:20	4.5	307	265	124
8:25	0:25	4.5	307	265	198
8:30	0:30	4.5	307	265	241
8:35	0:35	4.5	308	270	213
8:40	0:40	4.5	308	270	192
8:45	0:45	4.5	308	270	189
8:50	0:50	4.5	308	270	185
8:55	0:55	4.5	308	270	184
9:00	1:00	4.5	309	270	184
9:05	1:05	4.5	309	270	184
9:10	1:10	4.5	309	270	185
9:15	1:15	4.5	309	270	185
9:20	1:20	4.5	308	270	185
9:25	1:25	4.5	309	270	186
9:30	1:30	4.5	308	270	186
9:35	1:35	4.5	309	270	186
9:40	1:40	4.5	308	270	186
9:45	1:45	4.5	309	270	187
9:50	1:50	4.5	309	270	187
9:55	1:55	4.5	309	270	187
10:00	2:00	4.5	310	270	187
10:05	2:05	4.5	309	270	187
10:10	2:10	4.5	310	270	188
10:15	2:15	4.5	310	270	188
10:20	2:20	4.5	310	270	188
10:25	2:25	4.5	212	145	169
10:30	2:30		203	145	143
10:35	2:35		198	145	127
10:40	2:40		151	145	113
10:45	2:45		121	145	105
10:50	2:50		102	145	99
10:55	2:55				

Table 39. Field Study Pipe 10 Cure Log Data

SR-50 Pipe 10: Forced Ambient Air Post-Cure Treatment Cure Log					
Time	Elapsed Time (min.)	PSI	Boiler in	Boiler out	Thermal Interface Temp (˚F)
11:15	0:00	4.5			49
11:20	0:05	4.5			51
11:25	0:10	4.5	308	240	63
11:30	0:15	4.5	309	245	122
11:35	0:20	4.5	309	250	151
11:40	0:25	4.5	308	270	158
11:45	0:30	4.5	309	265	156
11:50	0:35	4.5	309	265	154
11:55	0:40	4.5	308	265	154
12:00	0:45	4.5	308	265	154
12:05	0:50	4.5	309	265	155
12:10	0:55	4.5	309	265	155
12:15	1:00	4.5	309	265	156
12:20	1:05	4.5	308	265	156
12:25	1:10	4.5	309	265	157
12:30	1:15	4.5	309	265	158
12:35	1:20	4.5	308	265	158
12:40	1:25	4.5	309	265	159
12:45	1:30	4.5	309	265	159
12:50	1:35	4.5	308	265	160
12:55	1:40	4.5	308	265	160
13:00	1:45	4.5	308	265	161
13:05	1:50	4.5	308	265	161
13:10	1:55	4.5	309	265	161
13:15	2:00	4.5	309	265	161
13:20	2:05	4.5	309	265	160
13:25	2:10	4.5	308	265	160
13:30	2:15	4.5	309	265	159
13:35	2:20	4.5	209	150	151
13:40	2:25		188	150	126
13:45	2:30		107	150	115
13:50	2:35		103	150	103

Table 40. Field Study Pipe 11 Cure Log Data

SR-50 Pipe 11: Extra Preliner, Forced Heated Air Post-Cure Treatment					
Time	Elapsed Time (min.)	PSI	Boiler in	Boiler out	Thermal Interface Temp (˚F)
16:30	0:00	4.5			
16:35	0:05	4.5			
16:40	0:10	4.5	310	250	64
16:45	0:15	4.5	311	260	65
16:50	0:20	4.5	311	260	68
16:55	0:25	4.5	311	265	147
17:00	0:30	4.5	311	265	233
17:05	0:35	4.5	311	265	218
17:10	0:40	4.5	311	265	207
17:15	0:45	4.5	311	265	192
17:20	0:50	4.5	311	265	182
17:25	0:55	4.5	312	265	173
17:30	1:00	4.5	311	265	166
17:35	1:05	4.5	312	265	166
17:40	1:10	4.5	312	265	166
17:45	1:15	4.5	312	265	166
17:50	1:20	4.5	312	265	166
17:55	1:25	4.5	312	265	166
18:00	1:30	4.5	312	265	167
18:05	1:35	4.5	312	265	167
18:10	1:40	4.5	312	265	168
18:15	1:45	4.5	312	265	168
18:20	1:50	4.5	312	265	168
18:25	1:55	4.5	312	265	168
18:30	2:00	4.5	312	265	168
18:35	2:05	4.5	312	265	168
18:40	2:10	4.5	312	265	168
18:45	2:15	4.5	312	265	168
18:50	2:20	4.5	271	150	157
18:55	2:25	4.5	209	150	149
19:00	2:30	4.5	189	150	135
19:05	2:35	4.5	127	150	118
19:10	2:40	4.5	106	150	103

Field Experiment QA/QC

Laboratory Analysis

Table 41. Laboratory QA/QC Field Study Pipes 1, 10 & 11

Units = µg/L	Percent Recovery							
QCTYPE	SR-50: Pipe 1: Control, Pipe 10: Forced Ambient Air, Pipe 11: Heated Forced Air with Extra PreLiner							
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	Chlorobenzene	1,1-Dichloroethene	Benzene	Toluene	Trichloroethene
Blank	108	89	120					
Blank								
Blank	114	90	103					
Blank	93	100	106					
Blank	105	89	102					
LCS	102	98	96	103	95	100	100	95
LCS				88	114	95	93	104
LCS	108	101	96	81	108	113	107	118
LCS	99	99	101	96	95	97	95	98
LCS	95	102	98	89	89	98	98	113
LCS Dup	78	98	100	104	101	105	104	99
LCS Dup				95	119	100	98	108
LCS Dup	95	98	97	106	107	109	103	115
LCS Dup	97	100	102	102	108	110	104	110
LCS Dup	102	102	94	96	99	103	104	100

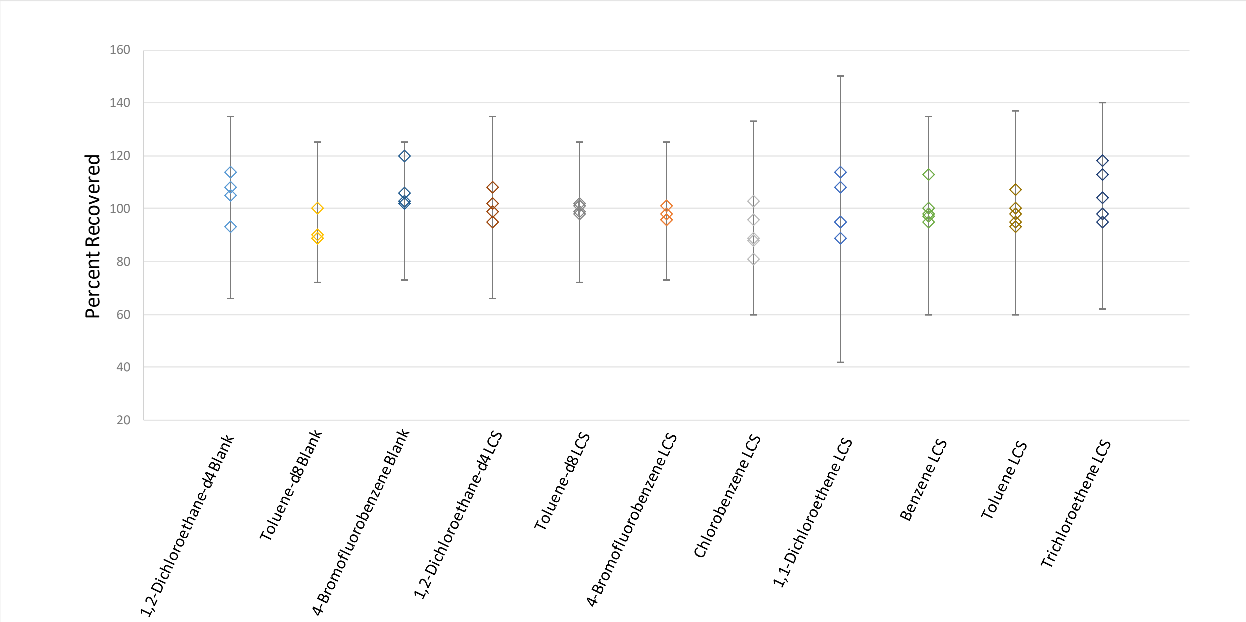

Figure 26. Field Experiment Percent Recovery Data

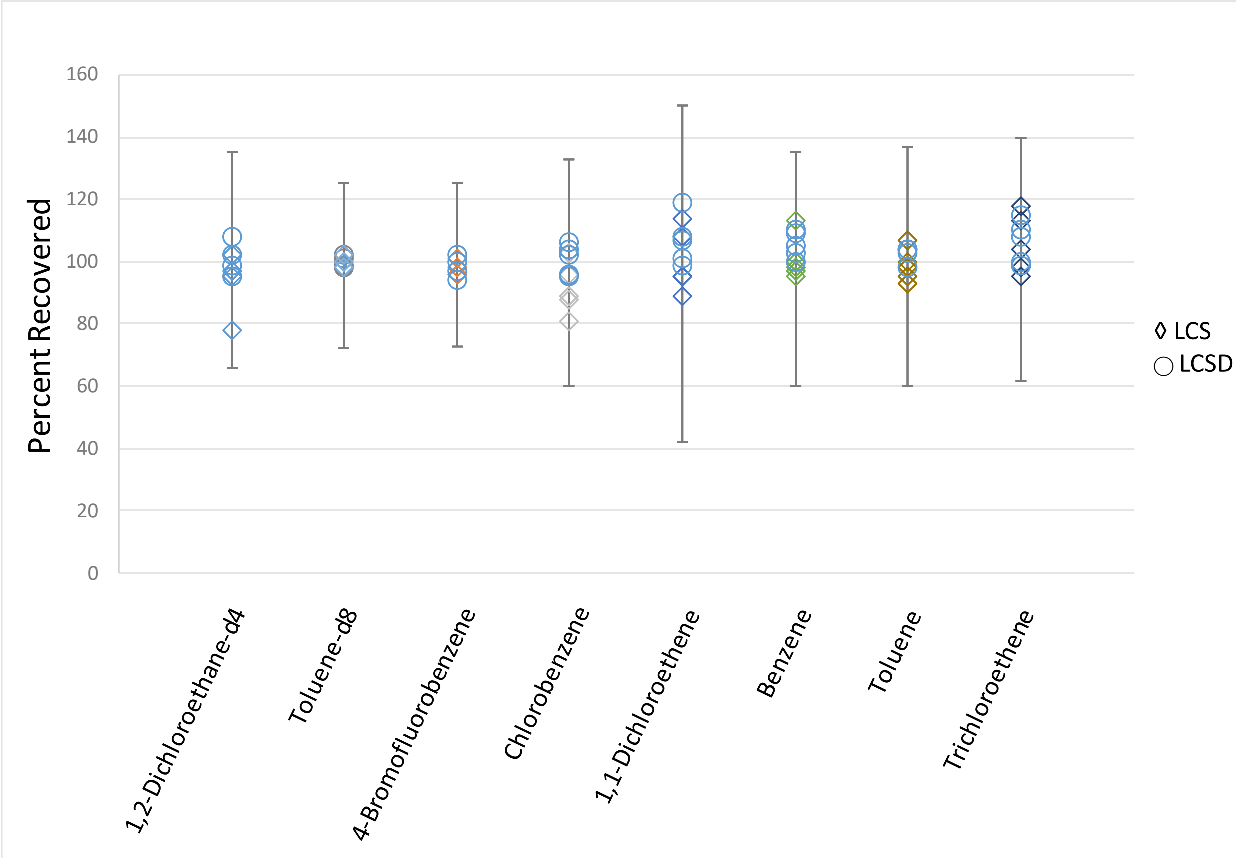

Figure 27. Field Experiment LCS/LCSD Comparison Data

Simulated Field Experiment QA/QC

Laboratory Analysis

Internal laboratory quality control analysis was performed for all sample analysis. Percent recoveries are presented in Figure 28,Figure 29, and Figure 30. The error bars in these figures represent confidence limits, which are determined by the laboratory. Figure 29 shows comparisons between lab control samples (LCS) and LCS duplicates (LCSD). Figure 32 shows comparisons between matrix spike samples (MS) and MS duplicates (MSD). All QC results were within acceptable ranges of percent recovery.

Table 42. Laboratory QC/QA Simulated Field Study Pipes 1 and 7

Units = µg/L	Percent Recovery							
QCTYPE	Pipe 1: Control, Pipe 7: Low VOC Resin							
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	Chlorobenzene	1,1-Dichloroethene	Benzene	Toluene	Trichloroethene
Blank	117	91	99					
Blank	115	90	101					
LCS	92	100	102	109	107	112	113	106
LCS	89	104	101	90	109	92	94	88
LCS Dup	96	102	121	99	98	103	103	99
LCS Dup	96	101	105	94	75	82	93	96

Table 43. Laboratory QA/QC Simulated Field Study Pipes 2, 3, 4, 5, & 8

Units = µg/L	Percent Recovery							
QCTYPE	Pipe 2: No Preliner, Pulled Placement, Pipe 3: Forced Ambient Air Post-Cure Treatment, Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment, Pipe 5: Reinforced Concrete Pipe, Pipe 8: No Preliner, Low VOC Resin							
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	Chlorobenzene	1,1-Dichloroethene	Benzene	Toluene	Trichloroethene
Blank	115	86	113					
Blank	114	93	117					
Blank	123	84	115					
Blank	112	91	113					
Blank	117	85	114					
Blank	121	90	119					
Blank	109	93	110					
Blank	118	93	119					
LCS	103	108	116	92	105	103	99	93
LCS	108	110	103	96	114	110	108	99
LCS	94	104	109	96	97	105	101	98
LCS	100	94	96	98	99	110	95	95
LCS	99	109	108	106	117	119	116	106
LCS	116	120	101	96	116	117	116	102
LCS	101	102	96	99	109	118	106	102
LCS	113	117	108	94	97	111	110	98
LCS Dup	105	108	107	100	118	114	110	105
LCS Dup	105	113	96	97	117	113	112	103
LCS Dup	94	105	115	105	111	119	114	109
LCS Dup	103	100	99	94	103	109	96	95
LCS Dup	100	111	108	108	122	123	120	114
LCS Dup	109	116	101	103	126	121	118	108
LCS Dup	112	118	102	91	117	109	109	98
LCS Dup	102	115	110	95	85	109	109	96

Table 44. Laboratory QA/QC Simulated Field Study Pipe 6

Units = µg/L	Percent Recovery							
QCTYPE	Pipe 6: UV-Cured Resin							
	1,2-Dichloroethane-d4	Toluene-d8	4-Bromofluorobenzene	Chlorobenzene	1,1-Dichloroethene	Benzene	Toluene	Trichloroethene
Blank	113	93	108					
LCS	93	99	94	94	111	110	110	108
LCS Dup	90	98	93	106	106	109	107	108
Matrix Spike	102	102	83	111	120	115	114	110
Matrix Spike Dup	95	98	79	112	121	116	114	112

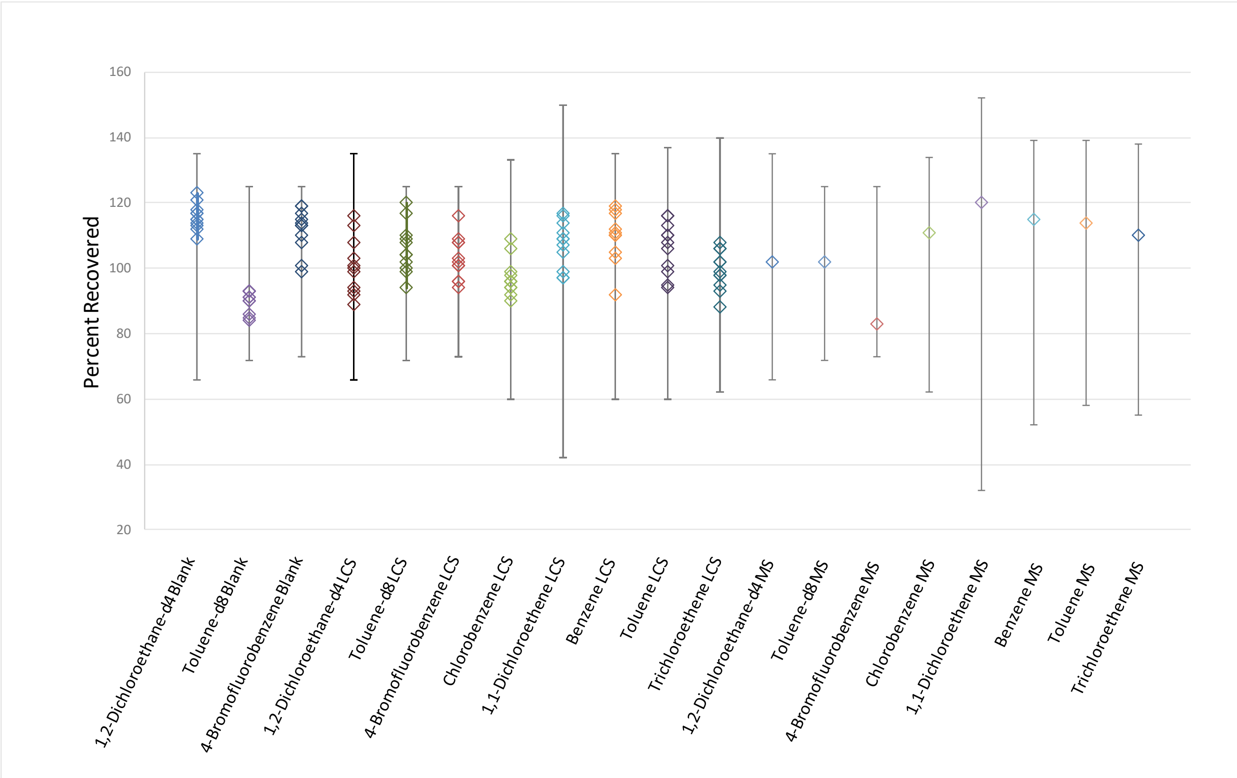

Figure 28. Simulated Field Experiment Percent Recovery Data

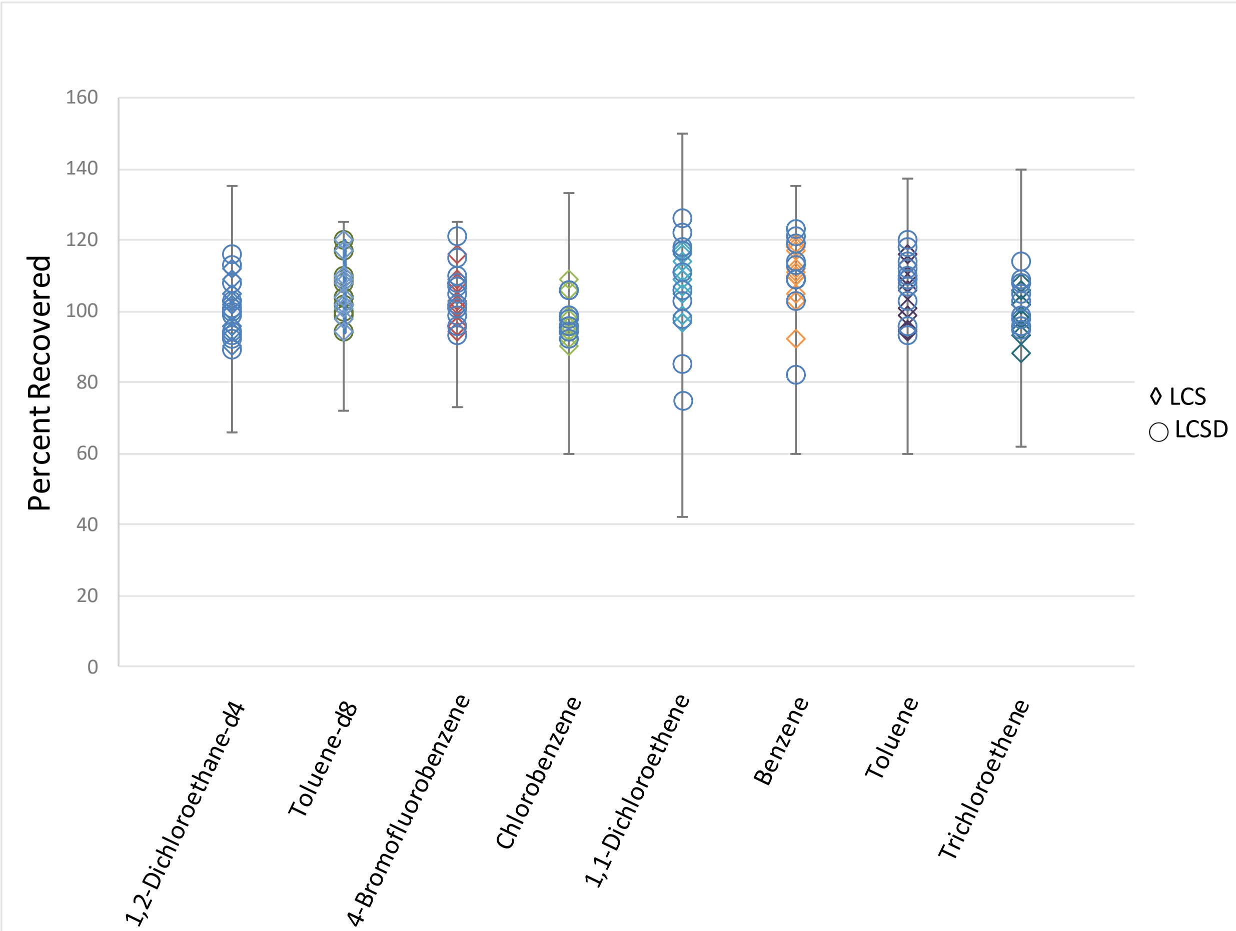

Figure 29. Simulated Field Experiment LCS/LCSD Comparison Data

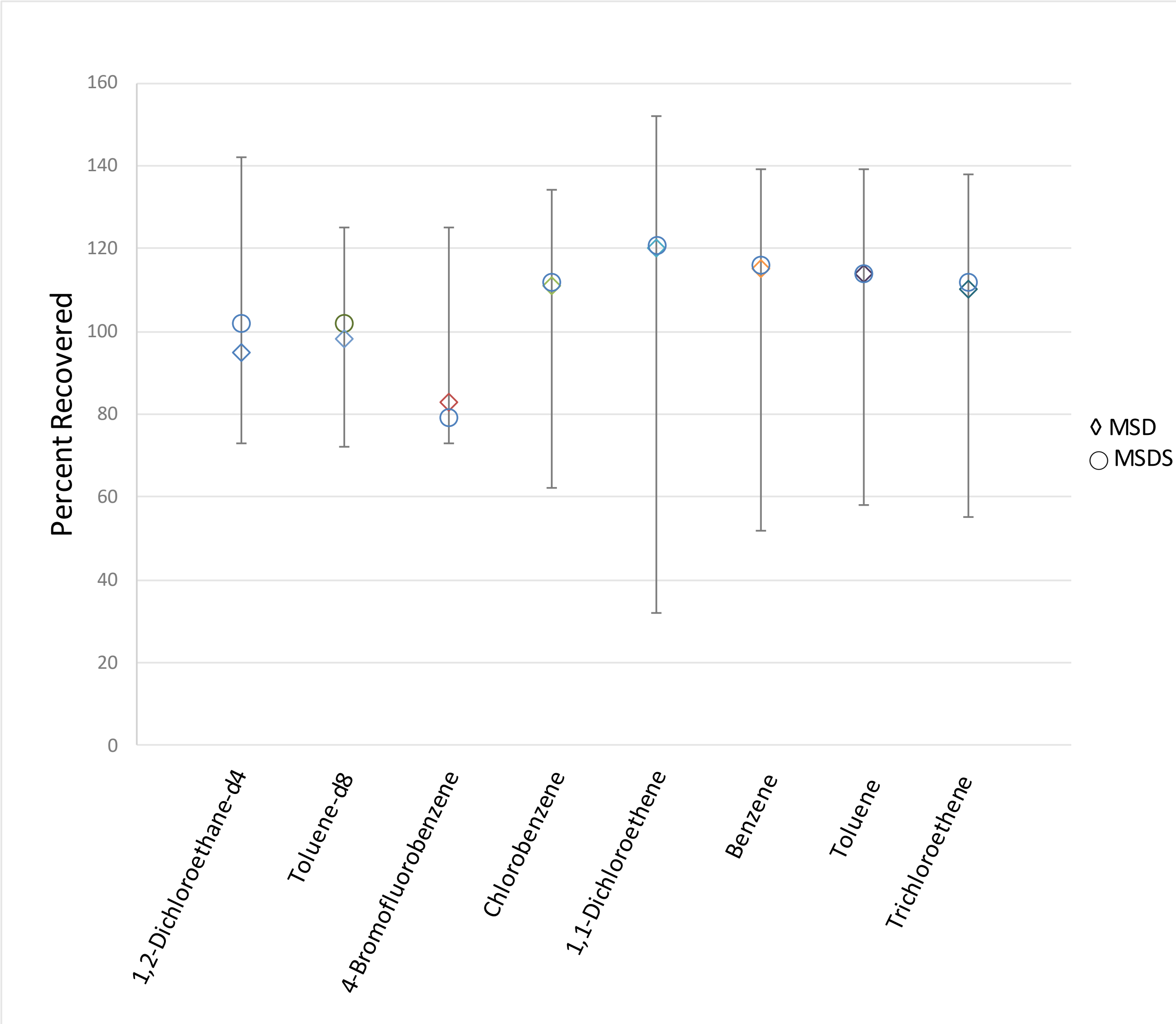

Figure 30. Simulated Field MS/MSD Comparison Data

Physical Properties

Quality control samples were tested to verify strength performance and thickness values met contract specifications and ASTM D 790 requirements. Flexural strength, flexural modulus, and thickness results for simulated field experiment samples are shown in Figure 32,Figure 31, and Figure 33, respectively. All simulated field experiment for flexural strength, flexural modulus, and thickness samples met contract and ASTM specification requirements.

Table 45. Simulated Field Study Flexural Modulus Data

Minimum Flexural Modulus		
Minimum Flexural Modulus for Heat Cured Polyester and Vinylester	250000	psi
Modulus for UV Cured Sample	725000	psi

Specimen Number	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: No VOC Resin	Pipe 8: No Preliner, No VOC Resin	Units
Sample 1									
1	495000	489000	710000	735000	572000	1057452	400000	238000	psi
2	542000	474000	637000	672000	595000	1090496	385000	260000	psi
3	616000	479000	695000	645000	619000	1102401	373000	248000	psi
4	331000	441000	697000	702000	595000	1225185	422000	259000	psi
5	289000	467000	639000	705000	551000	1168528	443000	238000	psi
Mean	455000	470000	676000	692000	586000	1129000	405000	249000	psi
SD	140000	18000	35000	34000	26000	67000	28000	11000	psi
Sample 2									
1		432000	682000	622000	610000			281000	psi
2		486000	699000	634000	636000			332000	psi
3		481000	669000	636000	634000			284000	psi
4		485000	709000	634000	621000			276000	psi
5		439000	696000	644000	640000			322000	psi
Mean		465000	691000	634000	628000			299000	psi
SD		27000	16000	8000	12000			26000	psi
Sample 3									
1		490000	692000	635000	571000			295000	psi
2		462000	625000	621000	667000			273000	psi
3		477000	685000	635000	667000			267000	psi
4		507000	684000	647000	662000			299000	psi
5		471000	687000	656000	644000			262000	psi
Mean		481000	675000	639000	642000			279000	psi
SD		18000	28000	13000	41000			17000	psi

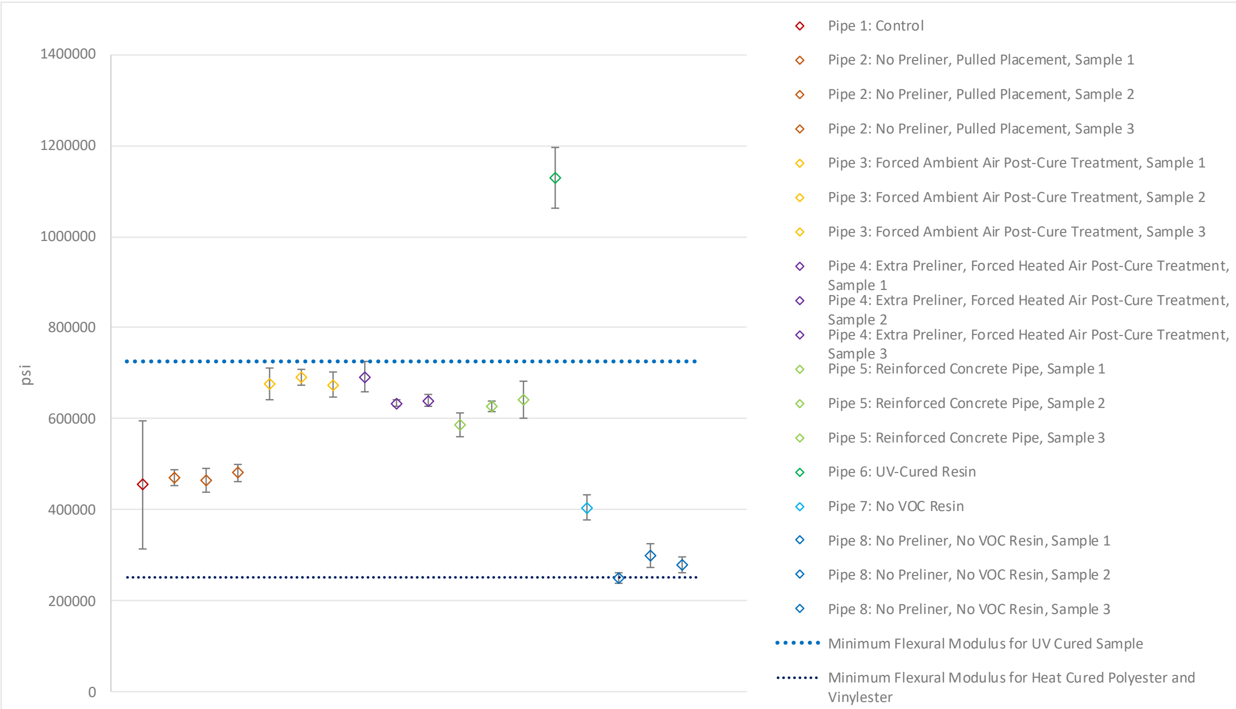

Figure 31. Simulated Field QA/QC Flexural Modulus Data

Table 46. Simulated Field Study Flexural Strength Data

Minimum Flexural Strength			
Minimum Flexural Strength for Heat Cured Polyester and Vinylester	4500 psi	Minimum Flexural Strength for UV Cured Sample	6500 psi

Sample Number	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: No VOC Resin	Pipe 8: No Preliner, No VOC Resin	Units
Sample 1									
1	9630	6640	8550	7890	6640	19220	4770	4730	psi
2	10250	6580	8240	7530	7150	16931	5020	4750	psi
3	10540	6780	8170	7650	6670	20269	5080	4930	psi
4	6900	6050	8000	8180	6540	21982	5070	4900	psi
5	6280	6670	7820	7850	6630	23101	5350	4900	psi
Mean	8720	6540	8160	7820	6730	20300	5060	4840	psi
SD	1980	290	270	250	240	2410	210	90	psi
Sample 2									
1		6610	8210	6910	6660			5020	psi
2		6960	8520	6340	6920			5360	psi
3		6180	8280	6810	6780			5130	psi
4		6580	7890	6490	7060			4510	psi
5		6260	8410	6950	6950			5130	psi
Mean		6520	8260	6700	6870			5030	psi
SD		310	240	270	160			320	psi
Sample 3									
1		7170	8310	6480	6050			4750	psi
2		6650	7870	6630	6900			4790	psi
3		6630	8020	6600	6760			4670	psi
4		6860	8190	5850	6860			4720	psi
5		6690	8330	5440	6830			4540	psi
Mean		6800	8140	6200	6680			4690	psi
SD		230	200	530	360			100	psi

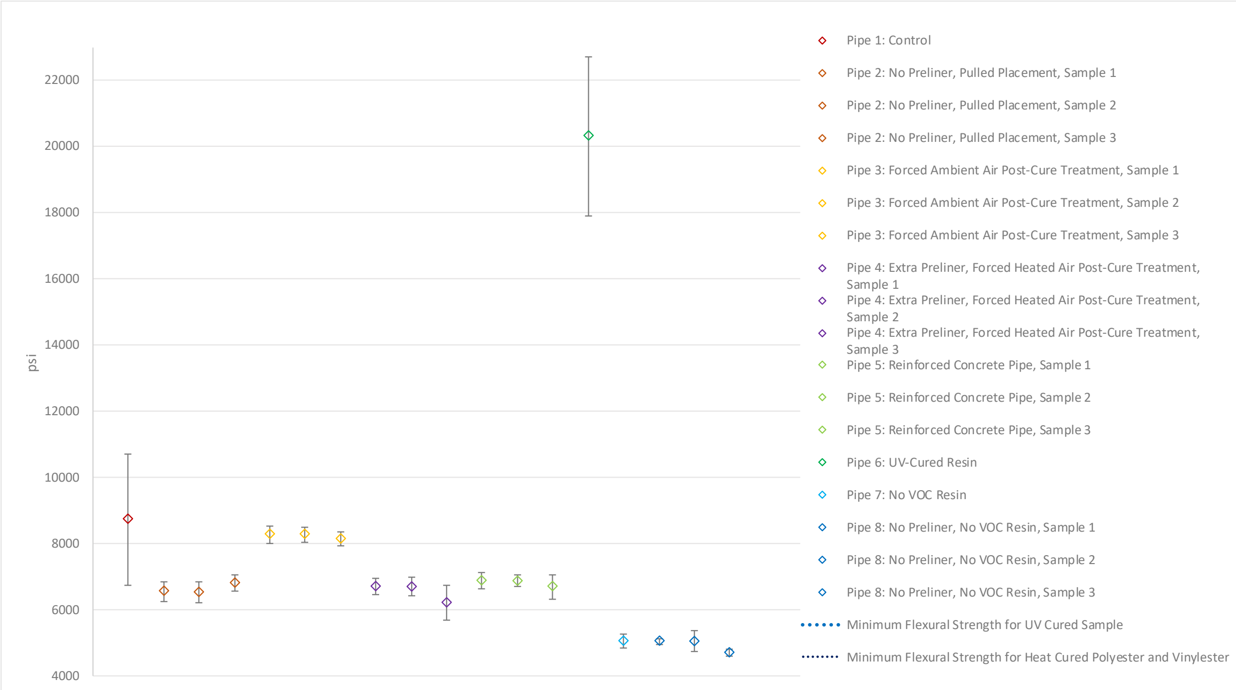

Figure 32. Simulated Field QA/QC Flexural Strength Data

Table 47. Simulated Field Study Nominal Thickness Data

Nominal Thickness									
0.3									
Sample Location	Pipe 1: Control	Pipe 2: No Preliner, Pulled Placement	Pipe 3: Forced Ambient Air Post-Cure Treatment	Pipe 4: Extra Preliner, Forced Heated Air Post-Cure Treatment	Pipe 5: Reinforced Concrete Pipe	Pipe 6: UV-Cured Resin	Pipe 7: No VOC Resin	Pipe 8: No Preliner, No VOC Resin	Units
1	0.274	0.421	0.383	0.386	0.393	0.311	0.301	0.486	in
2	0.332	0.424	0.382	0.378	0.383	0.302	0.464	0.488	in
3	0.251	0.445	0.375	0.389	0.387	0.308	0.296	0.483	in
4	0.423	0.447	0.376	0.386	0.378	0.309	0.440	0.515	in
5	0.239	0.438	0.385	0.373	0.386	0.299	0.260	0.518	in
6	0.347	0.419	0.388	0.380	0.386	0.307	0.391	0.518	in
7	0.235	0.417	0.387	0.379	0.391	0.313	0.253	0.500	in
8	0.364	0.412	0.385	0.385	0.397	0.298	0.330	0.482	in
Mean	0.308	0.428	0.383	0.382	0.388	0.306	0.342	0.499	in
SD	0.069	0.013	0.005	0.005	0.006	0.006	0.081	0.016	in
LL	0.240	0.414	0.378	0.377	0.382	0.300	0.261	0.483	in
UL	0.377	0.441	0.387	0.387	0.394	0.311	0.422	0.515	in

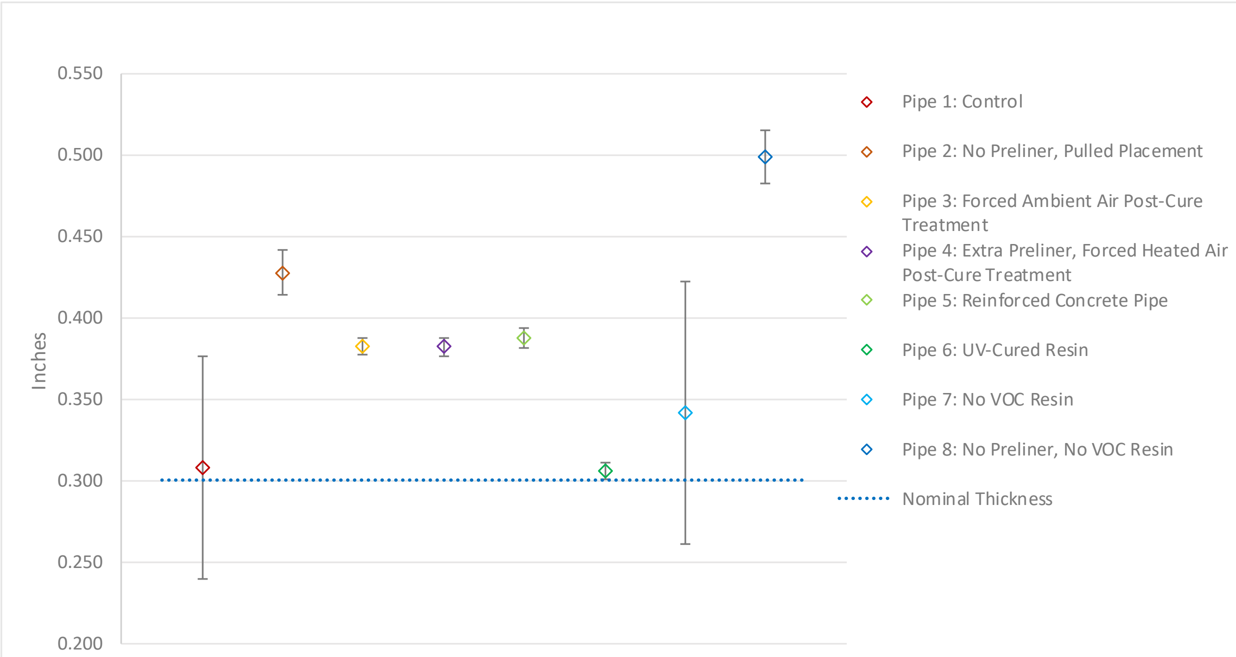

Figure 33. Simulated Field QA/QC Nominal Thickness Data

Appendix C: Photos

Simulated Field Pipes 1 and 7

Figure 1. Styrene Sheen on Effluent

Figure 2. Plastic Lined Catchment for Effluent

Figure 3. View of the CIPP Liner (Simulated Field Pipe 1) After Installation

Figure 4. Wood Barrier to Prevent Backflow

Figure 5. Influent End of Dosing Setup

Figure 6. Effluent End of Simulated Field Pipes 1 & 7 with Plastic Lined Trench

Figure 7. Preparing to Collect Grab Samples

Figure 8. Preparing to Collecting Grab Samples

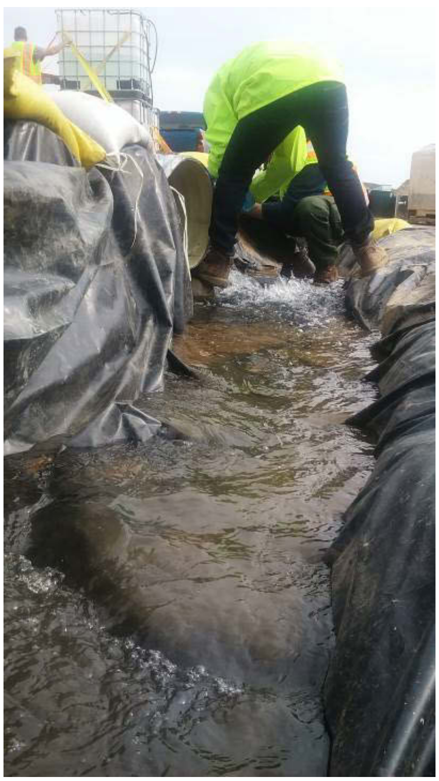

Figure 9. Grab Sample Collection

Figure 10. Grab Sample Collection

Figure 11 Effluent in Containment Trench

Figure 12. Simulated Field Pipe 7 After Collection of Grab Samples

Figure 13. Pumping Effluent into Storage Tanks

Figure 14. Simulated Field Pipe 1 Grab Sample Collection

Figure 15. Simulated Field Pipe 1 Grab Sample Duplicate Collection

Figure 16. Sheen on Surface of Effluent

Figure 17. Pipe 1 After Grab Sample Collection

Figure 18. Close-up of Styrene Sheen in Effluent Catchment

Figure 19 Effluent Catchment Showing Film on Water

Simulated Field Pipe 6

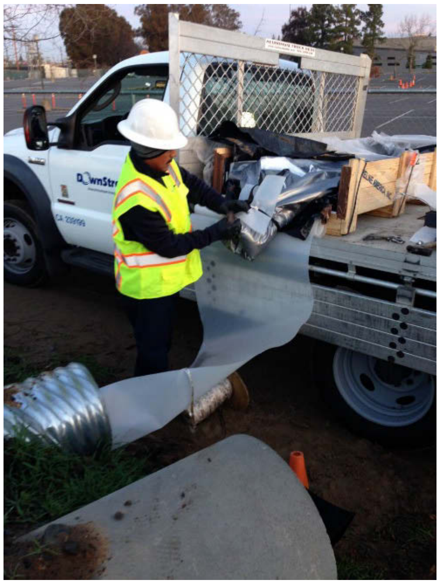

Figure 20. UV Liner Placement

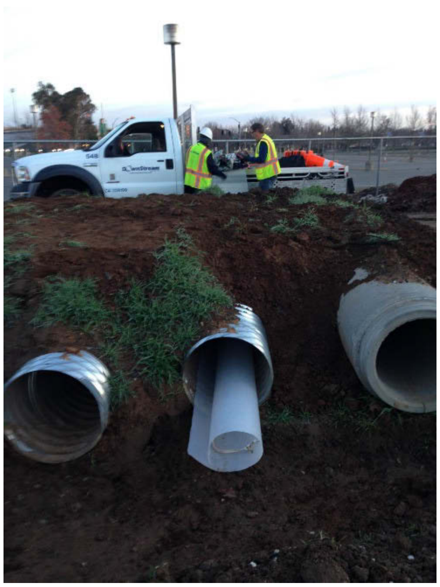

Figure 21. UV Liner Placement

Figure 22. Contractor Air Pump

Figure 23. Contractor Equipment Trailer

Figure 24. Liner Air Bladder Inflation

Figure 25. Light Train Segment

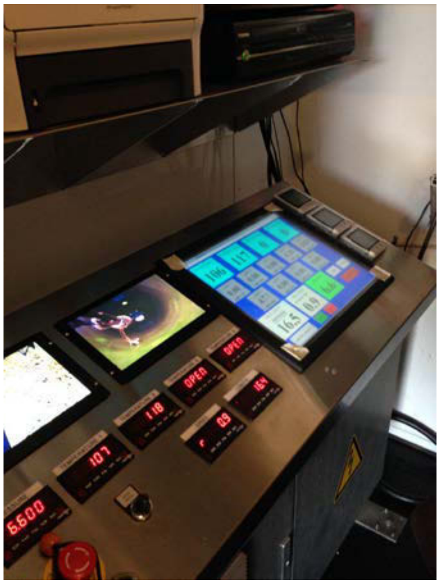

Figure 26. UV Installation Contractor Control Panel

Figure 27. UV Liner After Curing

Figure 28. Finished UV Installation

Figure 29. Simulated Field Pipe 6 Sample Collection

Simulated Field Pipes 2, 3, 4, 5, and 8

Figure 30. Removal of Effluent into Storage Tanks

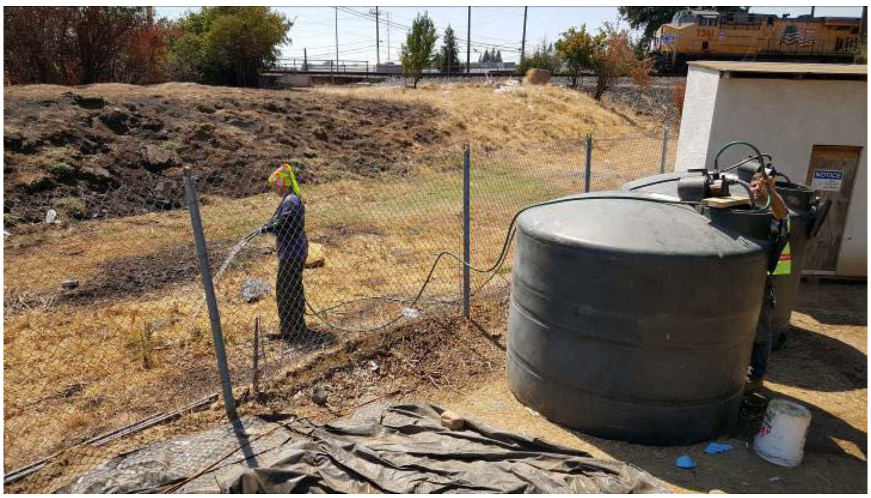

Figure 31. Effluent Disposal

Figure 32. Setup for CIPP Lining Installation

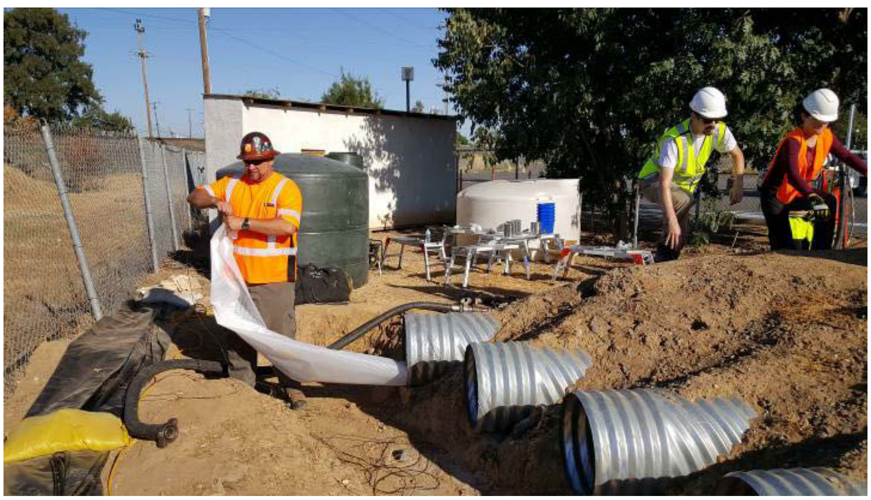

Figure 33. Preliner Pulled Through Corrugated Pipe

Figure 34. Steam Discharge During CIPP Installation

Figure 35. Sampling Team Member Wearing Personal Protection Equipment

Figure 36. Steam Curing of CIPP

Figure 37. Steam Discharge from CIPP Setup

Figure 38. Curing of Separate CIPP Lining Sample for Structural Analysis

Figure 39. Feeding CIPP Lining Through Steam Curing Setup

Figure 40. Steam Discharge Outlet

Figure 41. Steam Valves Between Equipment Truck and CIPP

Figure 42. Curing of CIPP Plate for QC Sampling

Figure 43. Removal of Excess Lining

Figure 44. Collection of Condensate Grab Sample

Figure 45. Condensate Grab Sample Collection

Figure 46. Forced Ambient Air Post-Cure Treatment setup

Figure 47. Resin Debris inside of CIPP lining

Figure 48. Debris from Cutting Tail from Liner

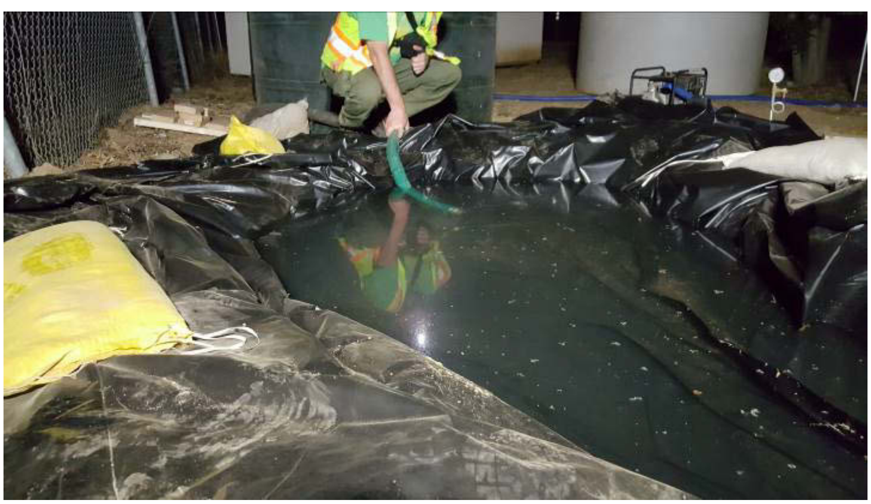

Figure 49. Removal of Contaminated Effluent into Storage Tanks

Figure 50. CIPP Lining Plate Sample for QC

Figure 51. Condensate Immediately after CIPP Installation

Figure 52. Condensate Grab Sample Collection

Figure 53. Preliner for RCP CIPP Installation

Figure 54. Influent Side of Concrete Pipe During CIPP Installation

Figure 55. Effluent Side of Concrete Pipe During CIPP Installation

Figure 56. Grab Sample Collection

Figure 57. Incomplete Liner Resin Wet-out Causing Liner Delamination

Figure 58. Delamination of CIPP Lining from the Inside of the CIPP

Figure 59. Truck and Trailer with Dosing Setup

Figure 60. Styrene Sheen on Effluent

Figure 61. Visible Film and Debris from CIPP Lining in Effluent

Figure 62. Grab Sample Collection at Night

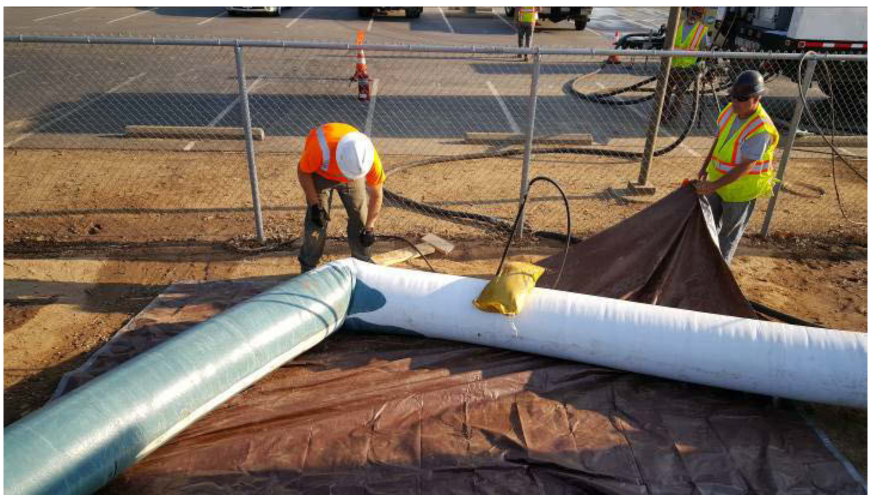

Figure 63. CIPP Liner Installation

Figure 64. Tap Water Grab Sample Collection

Figure 65. Tap Water Grab Sample Collection

Figure 66. Influent Water Grab Sample Collection

Figure 67. Influent Water Grab Sample Collection

Thickness Samples from Simulated Field Experiments

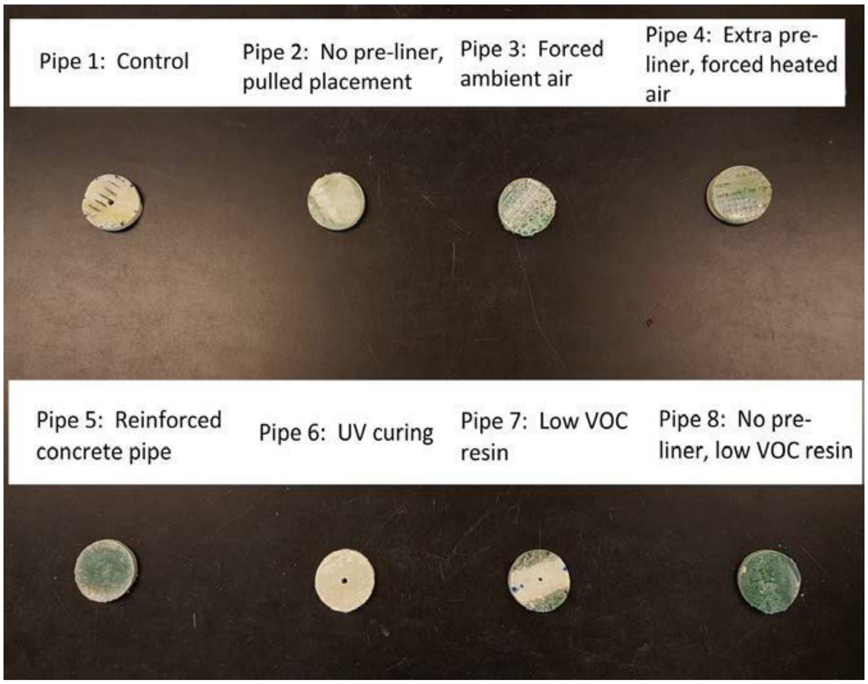

Figure 68. Outside of CIPP Lining Coupons

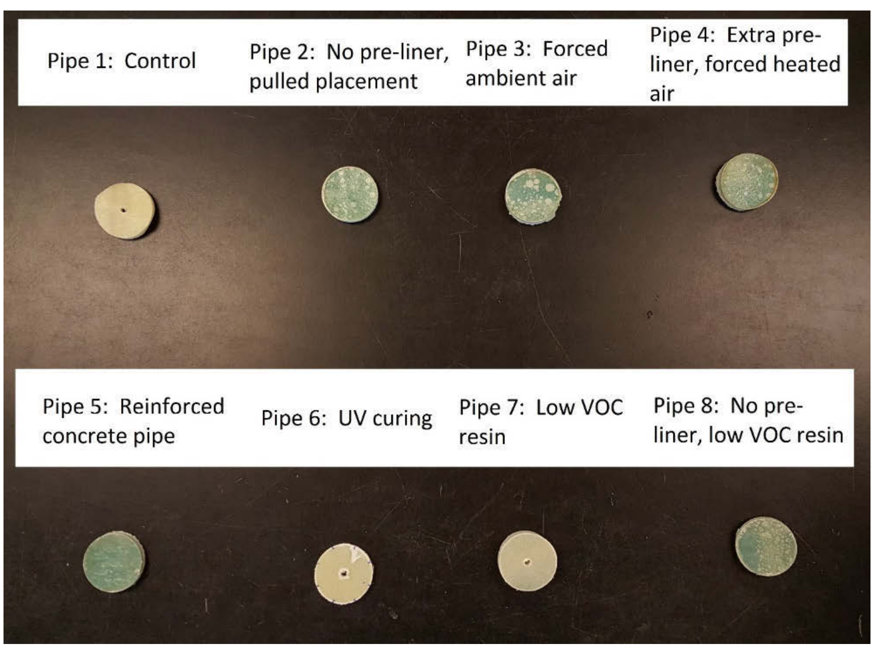

Figure 69. Inside of CIPP Lining Coupons

Figure 70. CIPP Lining Coupons collected for Structural Analysis

Field Experiments

Figure 71. Refrigerated Liner Truck with CIPP Liner

Figure 72. Steam Generation Equipment Truck

Figure 73. Steam Generation Equipment Truck

Figure 74. CIPP Liner Installation Equipment

Figure 75. Field Pipe 11 CIPP Liner Installation

Figure 76. Field Pipe 1 CIPP Installation with Tail

Figure 77. Field Pipe 1 Liner Grouting

Figure 78. Field Pipe 1 CIPP Liner Installation

Figure 79. Field Pipe 11 CIPP Installation at Headwall

Figure 80. Oily Sheen Below Field Pipe 11 Prior to Sampling Activities

Figure 81. Heater Equipment for Pipe 11 Post-Cure Treatment

Figure 82. Field Sampling Team Safety Meeting

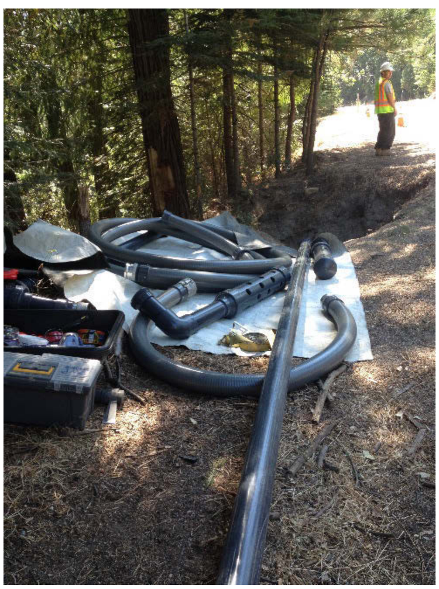

Figure 83. Field Dosing System Pipes and Hoses

Figure 84. Field Pipe 1 Site Preparation for Sample Collection

Figure 85. Field Pipe 10 Dosing Pipe Placement

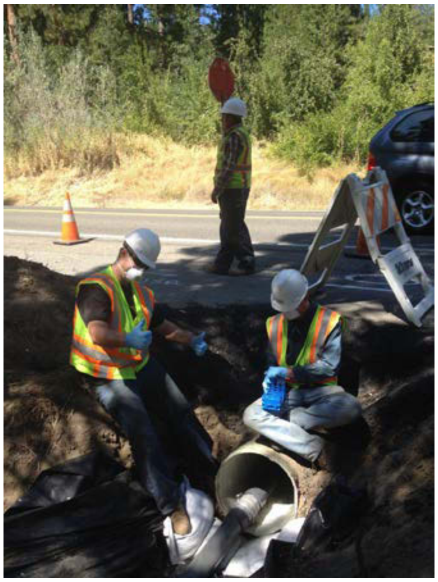

Figure 86. Field Pipe 10 Sample Collection

Appendix D: Contractor Submittals

This appendix includes the documents submitted by the contractors, including the work plan and cure logs as required by the Caltrans specifications.

MICHELS CORPORATION

No: 1

To: Quimu Contracting
PO Box 1177
Dixon, CA 95620

ATTN: Miguel

Date: 5/27/2014	Job No: 03-4M4404
Job Name: CALTRANS	
Job Location: Kybutz, CA	
RE:	
State Hwy 50 in El Dorado County	
at various locations	

Gentlemen:

Michels Corporation is sending you

- [x] Herewith,
- [ ] Under separate cover,

the following items:

TRANSMITTAL

- [ ] Technical Data
- [ ] MSDS
- [ ] TV Report (s)
- [ ] DVD (s)
- [ ] Shop Drawings
- [x] Submittal
- [ ] Attachments fo Subcontract
- [ ] Insurance Certificate
- [ ] Certified Payroll
- [ ] Quotation
- [ ] Contract
- [ ] Subcontract

Copies	Dated	Description
1	5/27/2014	Hard copy of Submittals
1	5/27/2014	USB Drive

These are transmitted as checked below:

- [x] For Approval
- [ ] For Your Use
- [ ] As Required
- [ ] For Review & Comment
- [ ] Approved as Submitted
- [ ] Approved as Noted
- [ ] Returned for Corrections
- [ ]
- [ ]
- [ ]
- [ ]
- [ ]

Remarks: If you have any additional questions, please feel to contact me at 503-364-1199.

Signed: Andy Thompson

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

Department: CALTRANS

Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County

Project Title: Construction on State HWY in El Dorado County

City's Project Number: 03-4M4404

Prepared By: Andy Thompson

Michels Project No: 40435

Date Received:

Engineer: Darlene Wulff

Contractor: Michels Corp

Submittal number: 1

Submittal Date: 5/27/2014

Revision Date: NA

Revision Number: NA

Specification Section: 15-6.11A(3)

Subsection: 1

Item: Resin Sample

Page: 26

Deviation (Y or N): N

Engineer's Stamp

Submittal Description: Resin Sample - METS Lab

Intended Use: Quality Assurance

Plan Sheet: NA

Manufacturer: NA

Supplier: Michels

Applicable Standard:

Referenced Document:

Notes:

CONTRACTOR SUBMITTAL SUMMARY

FILE NO.:

PROJECT NAME: **State HWY in Amador County at Various Locations**

Attention: Transportation Laboratory
METS
(Attention: Chemical Laboratory)
5900 Folsom Blvd.
Sacramento, CA 95819

SUBMITTAL NO.: 1

ORIGINAL ■ 2ND ☐ 3RD ☐ 4TH ☐

DATE RECEIVED: 5-27-14

DATE RETURNED:

Section: Submittals

SUB SEC./PAGE NO.: 15-6.11A(3)

SUPPLIER/SUB: Michels Corp.
1715 16th St. SE
Salem, OR 97302

ITEM: Resin Sample

REVIEW ACTION

	NO. COPIES RECEIVED	NO EXCEPTIONS OBSERVED	MAKE CORRECTIONS NOTED	REVISE AS NOTED AND RESUBMIT	NO. COPIES RETURNED
Description:					
submit unreacted liquid resin sample for fingerprint analysis					
Remarks:					
For Caltrans Projects: **04-4M4404** **03-1C1804** **03-4M2604**					

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department: CALTRANS
Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County
Project Title: Construction on State HWY in El Dorado County
City's Project Number: 03-4M4404

Prepared By: Andy Thompson
Michels Project No: 40435

Date Received:
Engineer: Darlene Wulff
Contractor: Michels Corp

Submittal number: 2
Submittal Date: 5/27/2014
Revision Date: NA
Revision Number: NA

Specification Section: 15-6.11A(3)
Subsection: 2
Item: Summary Sheet
Page: 20
Deviation (Y or N): N

Engineer's Stamp

Submittal Description: Summarize characteristics of culverts per subsection 2 of submittals
Intended Use: Requested Information
Plan Sheet: NA
Manufacturer: NA
Supplier: Michels

Applicable Standard: ASTM F1216
Referenced Document:
Notes:

Michels Corporation
dba Michels Pipeline Constructiom
1715 16th Street SE
Salem, OR 97302
office: 503.364.1199
fax: 503.391.8317

Job Name: Construction On State Highway
City Job No. 03-4M4404
Michels Job No. 40435
Prepared By: Andy Thompson
Page:
Date: 5/27/2014

2. Summary Sheet

Section 15-6.11A(3) Submittals

2			2.1		2.2							2.3	2.4	2.5	2.6	2.7		
					2.2.1	2.2.2	2.2.3	2.2.4			2.2.5							
Culvert No.	Culvert Diameter (in)	PM (Mile)	Calculated Minimum Thicknesses (mm)	Recommended Head (PSI)	Minimum Pressure (PSI)	Maximum Allowable Pressure (PSI)	Postcure Temperature (°C)	Minimum Cold (PSI)	Maximum Heated (PSI)	Maximum Cold (PSI)	Cure Time (hrs)	Cor72-AT-470	Maximum Exothermic Temperature (°C)	Method of Insertion	Cure Method	Proposed Length (ft.)	Access Point	Termination Point
1	18.00	47.74	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-220	air-inv.	steam	37.40	inlet	outlet
2	24.00	47.93	12.80	6.30	4.90	9.70	110	4.90	8.40	9.70	2.00	X	180-220	air-inv.	steam	39.40	inlet	outlet
4(a)	18.00	48.07	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-220	air-inv.	steam	53.30	inlet	outlet
4(b)	18.00	48.07	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-221	air-inv.	steam	18.30	inlet	outlet
5	18.00	48.28	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-221	air-inv.	steam	71.00	inlet	outlet
6	18.00	48.45	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-222	air-inv.	steam	45.20	inlet	outlet
7(a)	18.00	48.52	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-223	air-inv.	steam	52.10	inlet	outlet
7(d)	18.00	48.52	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-224	air-inv.	steam	28.90	inlet	outlet
7e	18.00	48.52	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-225	air-inv.	steam	32.50	inlet	outlet
8	30.00	48.71	10.70	4.50	3.50	6.90	110	3.50	6.00	6.90	2.00	X	180-224	air-inv.	steam	46.50	inlet	outlet
9	18.00	48.79	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-225	air-inv.	steam	58.00	inlet	outlet
10	18.00	48.99	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-226	air-inv.	steam	46.60	inlet	outlet
11	18.00	49.04	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-227	air-inv.	steam	59.40	inlet	outlet
12	18.00	49.56	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-228	air-inv.	steam	77.80	inlet	outlet
13	18.00	49.86	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-229	air-inv.	steam	61.30	inlet	outlet
14	18.00	50.14	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-230	air-inv.	steam	109.40	inlet	outlet
16	24.00	51.47	12.80	6.30	4.90	9.70	110	4.90	8.40	9.70	2.00	X	180-231	air-inv.	steam	150.00	inlet	outlet
17	18.00	51.52	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-232	air-inv.	steam	78.00	inlet	outlet
18	18.00	51.57	8.60	5.60	4.30	8.70	110	4.30	7.50	8.70	2.00	X	180-233	air-inv.	steam	105.50	inlet	outlet

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
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DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department: CALTRANS
Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County
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City's Project Number: 03-4M4404

Prepared By: Andy Thompson
Michels Project No: 40435

Date Received:
Engineer: Darlene Wulff
Contractor: Michels Corp

Submittal number: 3
Submittal Date: 5/27/2014
Revision Date:
Revision Number:

Specification Section: 15-6.11A(3)
Subsection: 3.1
Item: Manufacturer's Information
Page: 20
Deviation (Y or N): N

Engineer's Stamp

Submittal Description: Resin, Resin Enhancer,Bond enhancer and typical properties
Intended Use: Quality Assurance
Plan Sheet: NA
Manufacturer: Interplastics
Supplier: Interplastics

Applicable Standard: NA
Referenced Document: NA
Notes:

TECHNICAL DATA SHEET

COR72-AT-470

COR72-AT-470 is an enhanced, pre-promoted, thixotropic, corrosion resistant, unsaturated polyester resin for use in the manufacture of liner pipe using cured-in-place techniques. It has been designed to exhibit superior flexural and tensile moduli properties. This product will withstand exposure to various chemical solutions, as well as municipal sewage and water. **COR72-AT-470** has been tested and has passed the requirements of ASTM D5813, F1216 and F1743 for corrosion resistance and physical properties. Also, it has been tested according to ASTM D2990 for Flexural Modulus Creep. Data on these tests and any corrosion recommendations will be supplied upon request.

RELATED PRODUCTS

COR72-AT-470M Contains an odor-masking agent	**COR72-AT-472** Viscosity: 2,000-3,000
COR72-AT-470HT Thixotropic Index: 4.0-5.0	**COR72-AT-472S** Viscosity: 2,000-3,000
COR72-AT-470S RTCS: >48 Hours	RTCS: >48 Hours

LIQUID PROPERTIES

Viscosity, Brookfield Model RV #4 Spindle @ 20 rpm, 77°F (25°C), cps	4,000-5,000
Thixotropic Index	3.0-4.0
Gel time @ 140°F (60°C) in water bath, catalyzed with 0.75 phr Perkadox 16 and 0.38 phr Trigonox 42S	
Gel Time, 130 to 150°F (54.4 to 65.6°C), min:sec	8:00-13:00
Gel to Peak Time, 150°F (65.6°C) to Peak Exotherm, min:sec	1:00-6:00
Peak Exotherm	250-340°F 121-171°C
Non-Volatile Content, %	67-72
Room Temperature Catalyzed Stability (RTCS), hours	>20
Specific Gravity	1.25-1.30

TYPICAL PROPERTIES OF A 1/8" (3.2 mm) CASTING

Flexural Strength, ASTM D790	11,900	psi	82.1	MPa
Flexural Modulus, ASTM D790	7.87×10^5	psi	5,430	MPa
Tensile Strength, ASTM D638	7,400	psi	51	MPa
Tensile Modulus, ASTM D638	7.42×10^5	psi	5,120	MPa
Tensile Elongation, ASTM D638	1.3	%	1.3	%
Barcol Hardness, 934-1 gauge, ASTM D2583	50		50	
Heat Distortion Temperature, ASTM D648	230	°F	110	°C

TYPICAL PROPERTIES OF A 1/4" (6 mm) FELT LAMINATE

Flexural Strength, ASTM D790	8,400	psi	58	MPa
Flexural Modulus, ASTM D790	7.33×10^5	psi	5,060	MPa
Tensile Strength, ASTM D638	5,000	psi	34	MPa
Tensile Modulus, ASTM D638	7.50×10^5	psi	5,170	MPa
Tensile Elongation, ASTM D638	0.81	%	0.81	%
Barcol Hardness, 934-1 gauge, ASTM D2583	44		44	

The use of different Free Radical Initiators can change gel time, cure time, peak exotherm and catalyzed stability. If Initiator(s) other than that listed above are used, the customer should carefully evaluate its suitability before implementation into their process.

January 2, 2003

INTERPLASTIC CORPORATION
Thermoset Resins Division

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

Corrosion Test Data
COR72-AT and AZ Type Products
Flexural Strength and Modulus Retention

ASTM F1216 & D543 (CIPP)

Immersion Media	Flexural Strength Retention, % Months 1	3	6	12	Flexural Modulus Retention, % Months 1	3	6	12
100% Tap Water	94	100	97	89	100	96	93	91
5% Nitric Acid	100	92	86	82	86	88	81	80
10% Phosphoric Acid	98	88	90	95	84	89	83	80
10% Sulfuric Acid	93	91	93	93	92	92	94	93
100% Fuel C	85	100	100	100	96	97	99	94
0.1% Detergent	99	92	91	90	100	99	99	93
0.1% Soap Solution	100	87	100	90	97	94	100	92
100% Vegetable Oil	81	100	81	100	100	96	80	97

ASTM D5813, F1743 & D543 (CIPP)

1% Nitric Acid	100	84	86	100	100	93	86	93
5% Sulfuric Acid	94	81	95	87	87	92	81	80
100% Fuel C	85	100	100	100	96	97	99	94
0.1% Detergent	99	92	91	90	100	99	99	93
0.1% Soap Solution	100	87	100	90	97	94	100	92
100% Vegetable Oil	81	100	81	100	100	96	80	97

ASTM C581 & D543 (GRP)

100% Tap Water	100	97	100	100	100	95	100	91
1% Nitric Acid	100	100	100	80	100	93	99	83
5% Nitric Acid	100	100	96	80	97	94	96	81
10% Phosphoric Acid	100	100	100	100	100	100	99	88
5% Sulfuric Acid	100	100	91	82	98	100	88	90
10% Sulfuric Acid	100	100	100	95	94	83	85	80
100% Fuel C	100	100	90	100	95	100	100	100
0.1% Detergent	100	100	100	100	100	95	100	100
0.1% Soap Solution	91	96	82	100	97	100	93	90
100% Vegetable Oil	100	100	100	100	98	100	100	90
pH 0.5 Solution	100	100	91	82	98	100	88	90
pH 10 Solution	100	100	100	100	100	95	100	100

Other Corrosion Testing (CIPP)

1% Sodium Hydroxide	95	95	90	69	100	96	93	91
1% Sodium Hypochlorite	94	84	92	80	96	95	98	85
1% Ammonium Hydroxide	100	100	100	99	99	100	94	92

Note: Non-shaded regions are the applicable test durations as it relates to achievement of the minimum acceptable retentions.
All corrosion media maintained @ 73.4± 3.6°F (23 ± 2°C).

Date: March 10, 2004

INTERPLASTIC CORPORATION
Thermoset Resins Division

1225 Willow Lake Boulevard
Saint Paul, Minnesota 55110-5145
(651) 481-6860 Fax (651) 481-9836

February 18, 2013

Mr. Chris Tavernier, Operations Manager
Michels Pipe Services
1715 16th Street SE
Salem, OR 97302

Dear Mr. Tavernier:

You have requested information on a cured-in-place pipe (CIPP) resin manufactured by Interplastic Corporation, COR72-AT-470HT. This resin has been manufactured by Interplastic Corporation for over twenty five(25) years and over 270 million pounds has been used to successfully renovate deteriorated sewer and storm water lines.

Interplastic Corporation is certified under ISO9001-2000.

This resin meets the requirements found in ASTM F1216, ASTM F1743, and ASTM D-5813 from the standpoint of achievable mechanical properties and corrosion resistance. This resin has also been tested under ASTM D2990 and exhibits a creep retention factor of 50%.

Michels Pipe Services have successfully used this resin to renovate deteriorated lines using the CIPP process.

The formulation for this resin includes a resin enhancer which allows the system to exhibit higher mechanical properties. Resin formulations for Interplastic Corporation are proprietary. The enhancer amount used in the resin is approximately 25%. The enhancer and resin form an acceptable bond resulting in the increased properties. This system is designed to be used in an aqueous environment.

I hope that this information proves to be useful. Please contact me at 281-687-8617 if you have additional questions or comments on this matter.

Sincerely,

Kaleel Rahaim

Kaleel Rahaim
Business Manager Remediation Polymers
Thermoset Resins Division

Cc: Nicole Kleweno, Dave Herzog, Ben Hazen, Jason Schiro

INTERPLASTIC CORPORATION
1225 Willow Lake Boulevard
Saint Paul, Minnesota 55110-5145
(651) 481-6860 Fax (651) 481-9836

May 2, 2014

Mr. Chris Tavernier
Michels Pipe Services
1715 16th Street SE
Salem, OR 97302

Dear Mr. Tavernier:

You have requested information on a cured-in-place pipe (CIPP) resin manufactured by Interplastic Corporation, COR78-AT-559, T or TH. This resin has been manufactured by Interplastic Corporation for over five (5) years and over 50 million pounds has been used to successfully renovate deteriorated sewer and storm water lines.

Interplastic Corporation is certified under ISO9001-2000.

This resin meets the requirements found in ASTM F1216, ASTM F1743, and ASTM D-5813 from the standpoint of achievable mechanical properties and corrosion resistance. This resin has also been tested under ASTM D2990 and exhibits a creep retention factor of 50%.

Michels Pipe Services have successfully used this resin to renovate deteriorated lines using the CIPP process.

The formulation for this resin includes a resin enhancer which allows the system to exhibit higher mechanical properties. Resin formulations for Interplastic Corporation are proprietary. The enhancer amount used in the resin is approximately 27%. The enhancer and resin form an acceptable bond resulting in the increased properties. This system is designed to be used in an aqueous environment.

I hope that this information proves to be useful. Please contact me at 281-687-8617 if you have additional questions or comments on this matter.

Sincerely,

Kaleel Rahaim

Kaleel Rahaim
Business Manager Remediation Polymers
Thermoset Resins Division

INTERPLASTIC CORPORATION
Thermoset Resins Division

INTERPLASTIC CORPORATION

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

May 2, 20069

M9 9a9 Rahaim9
11014 Acanthus Lan9
Houston, TX 770959

D9a9 M9 Rahaim:9

Attach9d a9 th9 fo9owing IR sp9ct9a fo9 th9 CIPP CD 9 vision: 9

- COR72-AA Typ9 R9sins9
- COR72-AT Typ9 R9sins9
- COR78-AA Typ9 R9sins9
- COR78-AT-3XX Typ9 R9sins9
- COR78-AT-4XX Typ9 R9sins9
- CORVE81909

I wi9 s9nd an unp9ot9ct9d copy to Bobbi J9ns9n so sh9 may inco9po9at9 th9 g9aphs to th9 CD as n9 d9d9

If you hav9 any qu9stions 9 ga9ding this info9mation o9 n9 d mo9 info9mation on any of ou9 p9oducts in9 g9n9 a , p9 as9 ca9 us9

Sinc9 y,9

Jason Schi9o, S9nio9 Ch9mist9
Co9 osion and Sp9cia ty R9sins9

JDS:a k9

cc:9 T B9nn9tt, D Dana, D H9 zog,9
B J9ns9n, T McCab9

CIPP IR Sp9ct9a Rahaim, 9 JDS 0502069doc9

INTERPLASTIC CORPORATION
Thermoset Resins Division

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

ASTM D-2990 10,000-Hour Flexural Modulus Creep Data

(400 psi Stress Load)

	COR72-AA or CA Type Products	**CORVE8190 Product**
Test Time, hours	Flexural Modulus, psi	Flexural Modulus, psi
0.01	596,753.00	537,589.00
0.1	596,752.30	537,588.10
0.2	596,751.70	537,587.30
0.5	596,749.70	537,584.70
1	596,746.40	537,580.40
2	596,739.90	537,571.80
5	596,720.20	537,546.00
20	596,621.70	537,417.00
50	596,424.80	537,158.90
100	596,096.60	536,728.90
200	595,440.10	535,868.70
500	593,470.90	533,288.30
700	592,158.00	531,568.00
1000	590,188.70	528,987.50
3600	573,121.50	506,623.60
4000	570,495.80	503,183.00
4400	567,870.10	499,742.40
5000	563,931.50	494,581.50
5500	560,649.40	490,280.80
10000	531,110.00	451,574.00
438000	***558,765***	***487,811***

Note: The results in bold italics were calculated from the equation obtained from the trendline from the graphs.

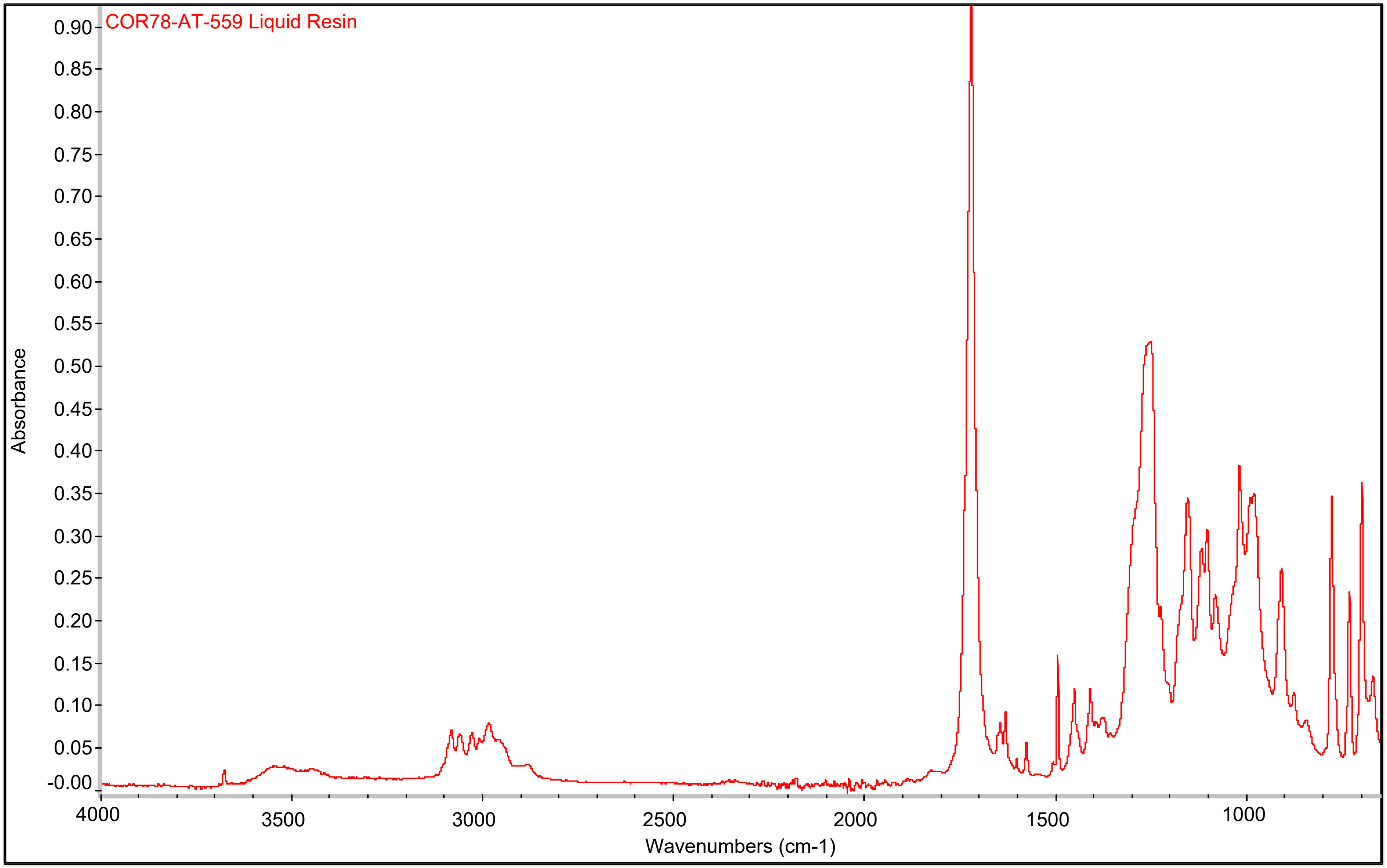
Date: August 21, 2001

INTERPLASTIC CORPORATION
Thermoset Resins Division

INTERPLASTIC CORPORATION

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

COR78-AT-5XX Type Resin



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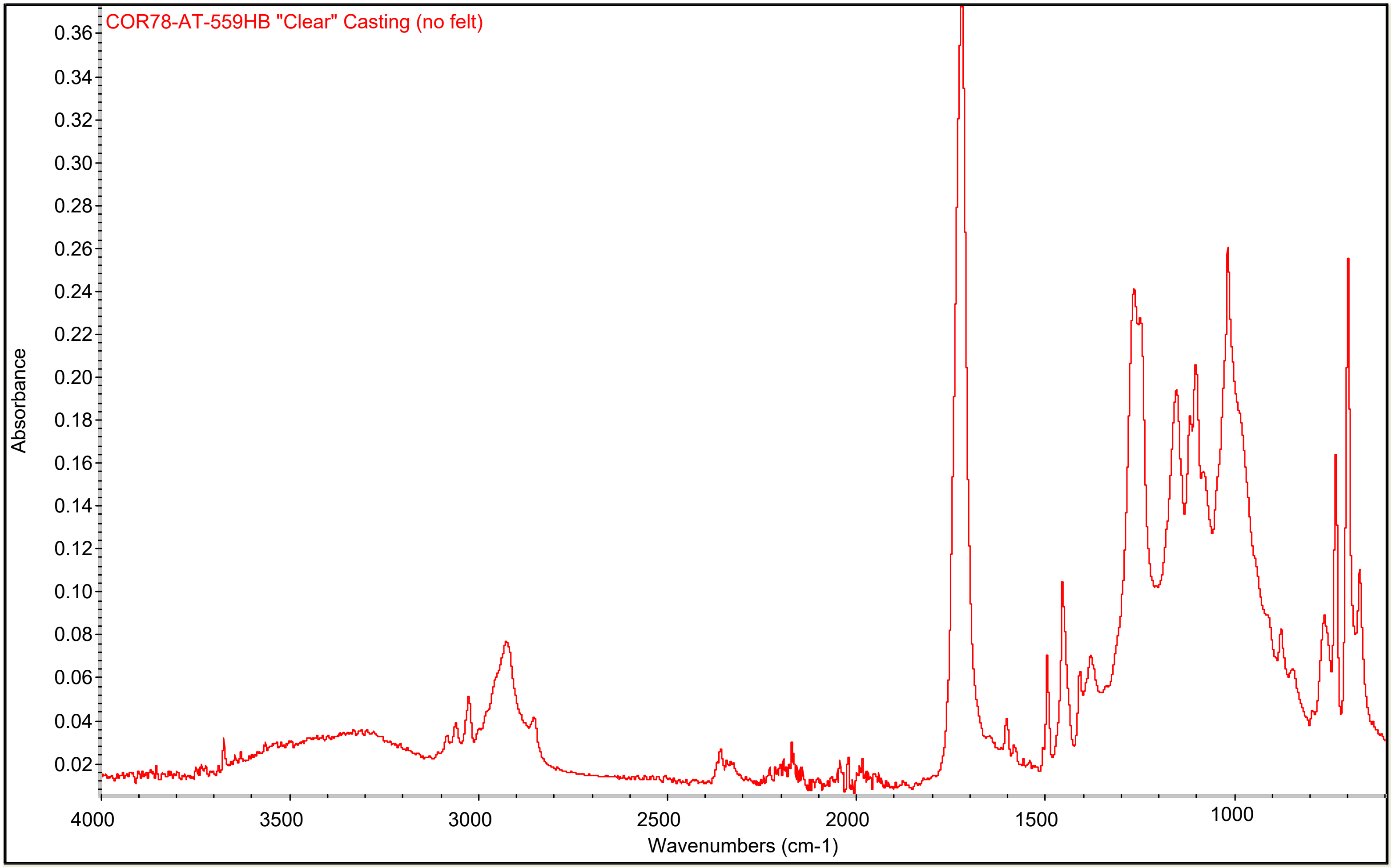
Thermoset Resins Division

INTERPLASTIC CORPORATION

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

COR78-AT-5XX Type Resin-Cured Sample (No Felt)

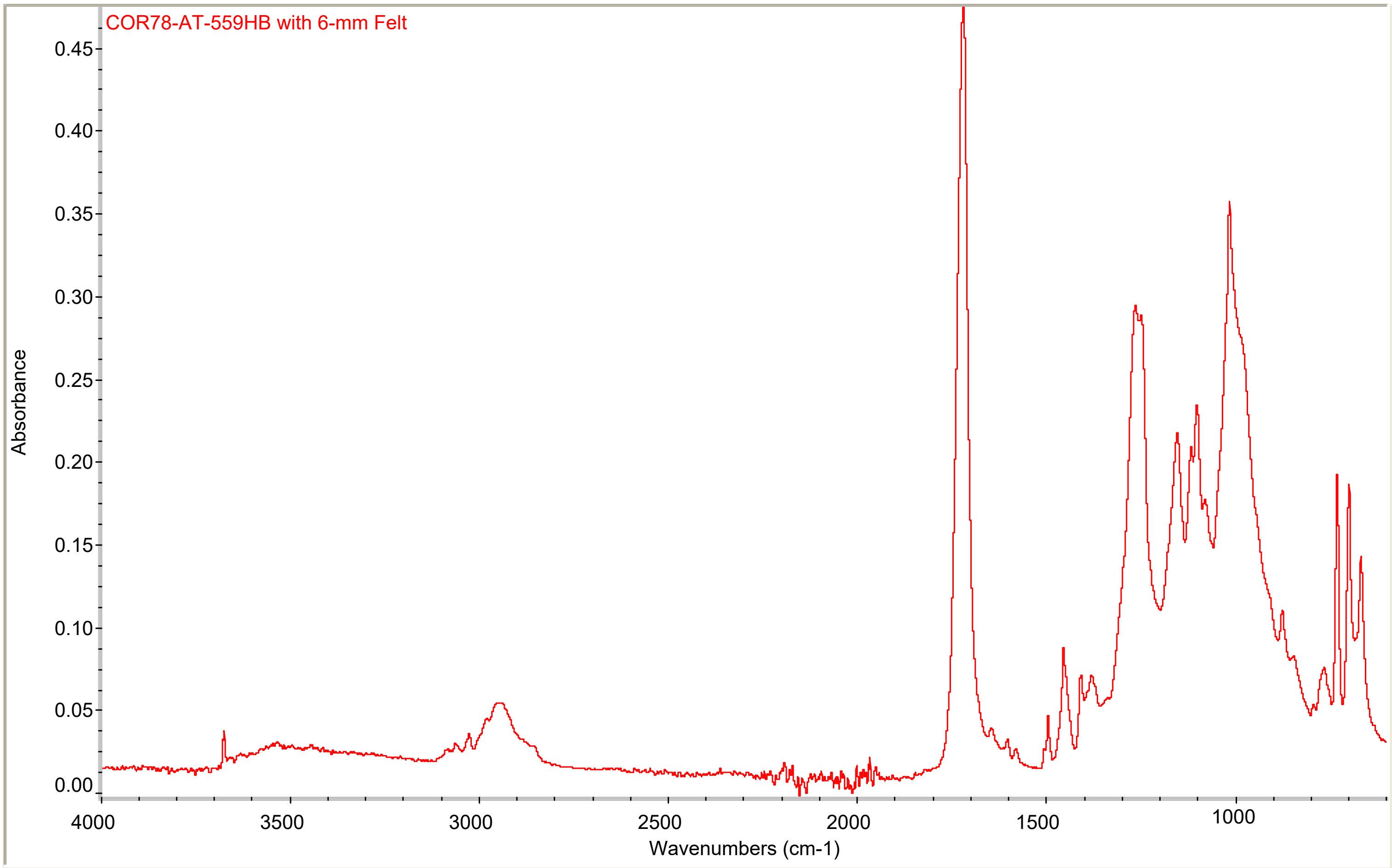


INTERPLASTIC CORPORATION
Thermoset Resins Division

INTERPLASTIC CORPORATION

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

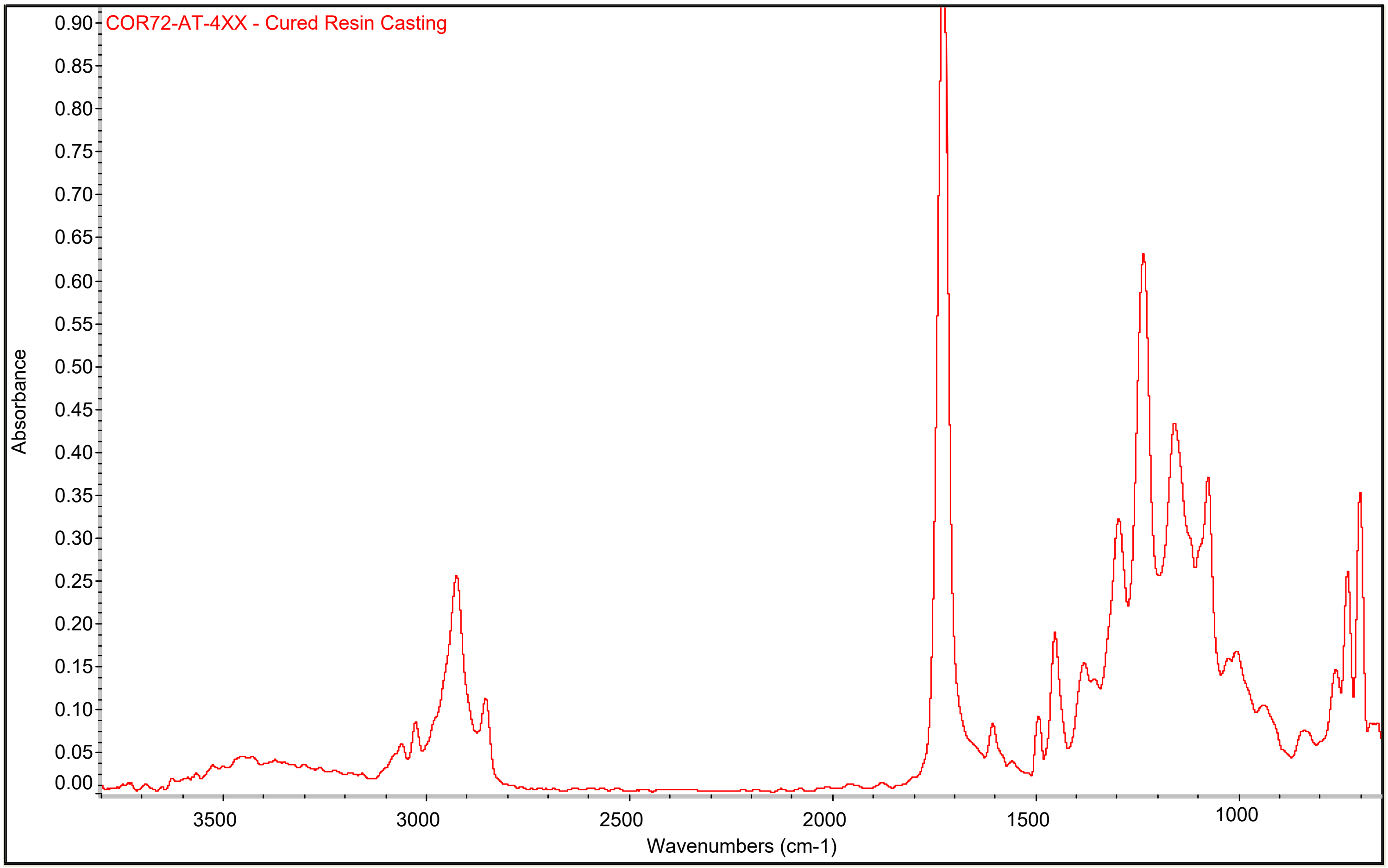
COR78-AT-5XX Type Resin-Cured Sample (With Felt)



INTERPLASTIC CORPORATION

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

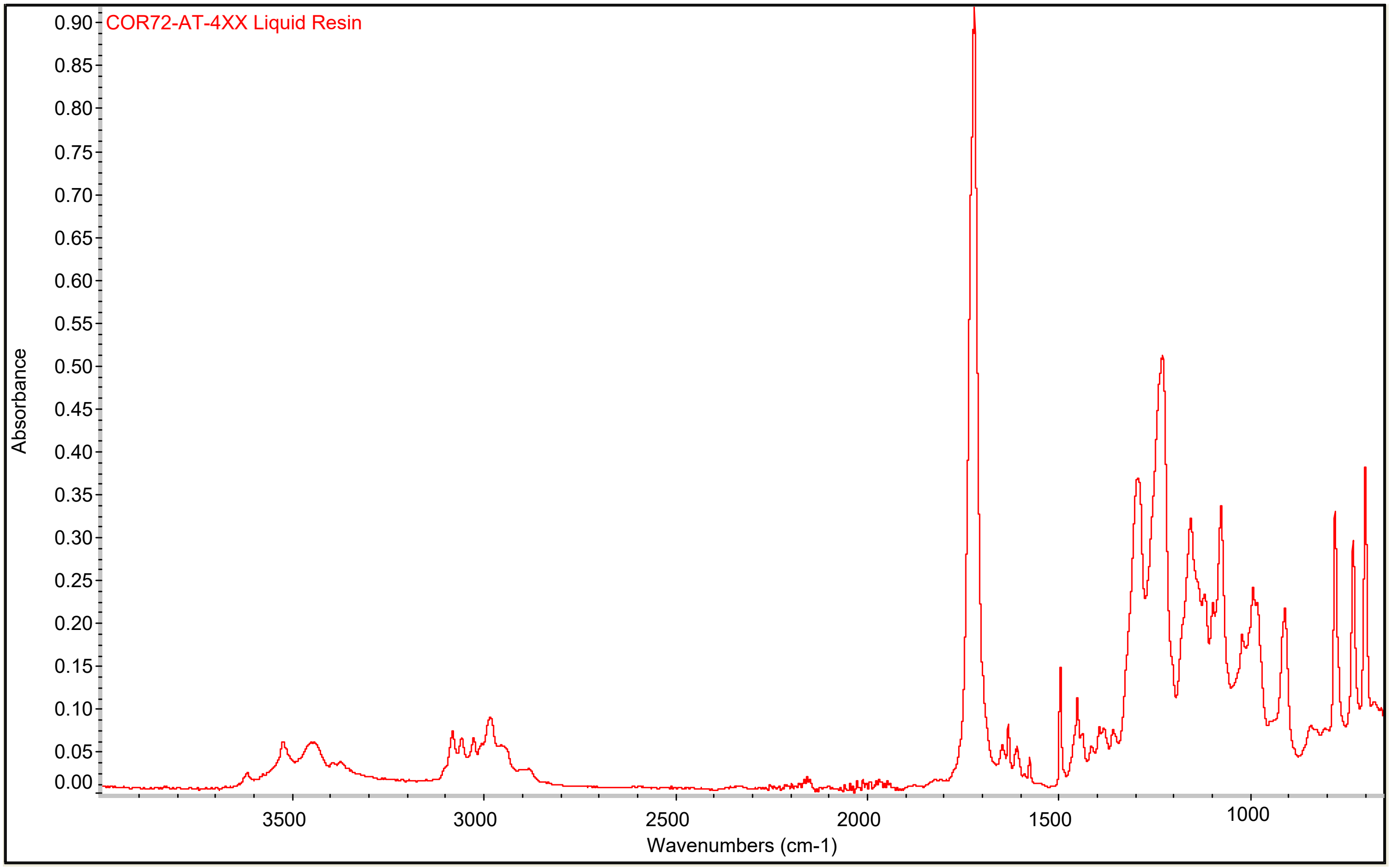
COR72-AT-4XX Type Cured Casting Sample



INTERPLASTIC CORPORATION

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

COR72-AT-4XX Type Liquid Resin Sample



Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department: CALTRANS

Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County

Project Title: Construction on State HWY in El Dorado County

City's Project Number: 03-4M4404

Prepared By: Andy Thompson

Michels Project No: 40435

Date Received:

Engineer: Darlene Wulff

Contractor: Michels Corp

Submittal number: 4

Submittal Date: 5/27/2014

Revision Date: NA

Revision Number: NA

Specification Section: 15-6.11A(3)

Subsection: 3.2

Item: Resin

Page: 20

Deviation (Y or N): N

Engineer's Stamp

Submittal Description: Resin Enhancer Data

Intended Use: Quality Assurance

Plan Sheet: NA

Manufacturer: NA

Supplier: NA

Applicable Standard: NA

Referenced Document: NA

Notes:

INTERPLASTIC CORPORATION
1225 Willow Lake Boulevard
Saint Paul, Minnesota 55110-5145
(651) 481-6860 Fax (651) 481-9836

May 13, 2014

Mr. Andy Thompson, Project Manager
Michels Pipe Services
1715 16th Street SE
Salem, OR 97302

Dear Mr. Thompson:

You have requested information on cured-in-place pipe (CIPP) resins manufactured by Interplastic Corporation, COR72-AT-470HT and COR78-AT-559T. These resins has been manufactured by Interplastic Corporation for over twenty five (25) years and over 270 million pounds has been used to successfully renovate deteriorated sewer and storm water lines.

Interplastic Corporation is certified under ISO9001-2000.

This resin meets the requirements found in ASTM F1216, ASTM F1743, and ASTM D-5813 from the standpoint of achievable mechanical properties and corrosion resistance. This resin has also been tested under ASTM D2990 and exhibits a creep retention factor of 50%.

Michels Pipe Services have successfully used these resins to renovate deteriorated lines using the CIPP process.

The formulations for these resins includes resin enhancers which allows the system to exhibit higher mechanical properties. Resin formulations for Interplastic Corporation are proprietary. The enhancer amount used in the resin is approximately 25%. The enhancer and resin form an acceptable bond resulting in the increased properties. The COR72-AT-470HT has a bonding agent on the enhancing agent. This bonding agent is compatible with the resin system. The COR78-AT-559T enhancing agent does not require a bonding agent. This system is designed to be used in an aqueous environment.

I hope that this information proves to be useful. Please contact me at 281-687-8617 if you have additional questions or comments on this matter.

Sincerely,

Kaleel Rahaim

Kaleel Rahaim
Business Manager Remediation Polymers
Thermoset Resins Division

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department:	CALTRANS
Project Location:	RTE 50 at various locations near Kyburz, CA in El Dorado County
Project Title:	Construction on State HWY in El Dorado County
City's Project Number:	03-4M4404
Prepared By:	Andy Thompson
Michels Project No:	40435

Date Received:

Engineer:	Darlene Wulff
Contractor:	Michels Corp
Submittal number:	5
Submittal Date:	5/27/2014
Revision Date:	NA
Revision Number:	NA
Specification Section:	15-6.11A(3)
Subsection:	3.3
Item:	Fabric Tube
Page:	20
Deviation (Y or N):	N

Engineer's Stamp

Submittal Description:	Fabric Tube Desc.
Intended Use:	CIPP Reference Manual
Plan Sheet:	NA
Manufacturer:	Applied Felts
Supplier:	Applied Felts
Applicable Standard:	NA
Referenced Document:	NA

Notes:

PREMIER-PIPE USA
"Common Sense Solutions"

Phone: (952) 944-8093
Fax: (952) 944-4399
Cell: (612) 385-4101

9855 West 78th Street, Suite 400, Eden Prairie, Minnesota 55344

March 7th, 2012

To Whom It May Concern:

This letter certifies that Michels Pipe Services, a division of Michels Corporation, is a certified licensed and trained installer of the Premier-Pipe process (a CIPP process) as certificated by Premier-Pipe USA. Michels Pipe Services has been a trained and certificated installer since 2002 with documented footage installed in the United States in excess of 1,000,000' linear feet. J.W.M. Environmental, Inc. is the Licensor of Premier-Pipe USA and Premier-Pipe Canada.

J.W.M. Environmental, Inc. certifies that all CIPP liners installed by Michels Pipe Services meets or exceeds the recognized organizational standards of ASTM F1216 latest addition.

If you have any questions, please contact me.

Sincerely,

J.W.M. Environmental, Inc.

James W. Mortell, Jr.
President

APPLIED FELTS

Applied Felts Inc. 450 College Drive Martinsville, Virginia 24112
Telephone (276) 656-1904 Fax (276) 656-1909
E-mail: office@appliedfelts.com

Product Information

Cure-Line Pipe® Inversion Tube

DESCRIPTION

A multiple layer felt liner with impermeable coating conforming to ASTM-1216.

APPLICATION

Installation Method: Inversion
Impregnation Method: Vacuum impregnation and pressure rollers

CURING METHODS:

Resin Type	Coating	Warm Water < 50°C	Hot Water < 90°C	Steam< 110°C
Polyester	Polyurethane	Yes	Yes	Yes
	PVC	Yes	N/A	N/A
Vinyl Ester	Polyurethane	N/A	Yes	Yes
	PVC	N/A	N/A	N/A
Epoxy	Polyurethane	Yes	Yes	Yes
	PVC	Yes	N/R	N/R

N/A= Not applicable
N/R= Not Recommended

DIAMETER RANGE Generally (6" to 80")

THICKNESS RANGE 1.5mm to 100mm

AVAILABLE MANUFACTURED LENGTHS Any length made to order

This Product Information sheet gives general information. Exact coating type and thickness will depend on the specific types of resin being used. Please contact our Technical Team for specific advice.

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2000

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 9001:2000 for the following scope:

Manufacture of textile products used in pipeline rehabilitation.

For and on behalf of BSI:

Gary L Pearson

President, BSI Management Systems (Americas)

Originally registered: **08/15/2000** Latest Issue: **10/04/2006** Expiry Date: **10/03/2009**

Page: 1 of 2

BSI Management Systems

APPLIED FELTS

450 College Drive
Martinsville, VA 24112
(276) 656-1904, Fax (276) 656-1909. E-Mail office@appliedfelts.com

TECHNICAL INFORMATION

Product: Inversion Liner for Hot Water/Steam Cure Installation (PROCESS QUALITY CONTROL)

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

Attachment 1

2. Production of Felt (Nonwoven)

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	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 modulii 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.	Coating mass 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 weighed 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

Property	Control	Test
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 Manufacturing Specification	Inspection regime includes measurement of a sample of liners against Manufacturing Specifications.
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

Table 6.1 con't

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

Product: 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%) (dependant on specific liner and installation details).

The felt is manufactured to a thickness specification of $\pm$ 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.

Head Installation Chart(in feet)

Ideal Head
Min Head
Max Cold Head
Max Hot Head

Thickness in mm

Diam.	4.50	6.00	7.50	9.00	10.50	12.00	13.50	15.00	16.50	18.00	19.50	21.00	22.50	24.00	27.00	28.5	30.00	33.00
6" Ideal	23	31																
6 Min	18	24																
6 Cld	30	39																
6 Hot	26	33																
8" Ideal	17	22	28															
8 Min	13	17	21															
8 MaxCld	22	30	37															
8 MaxHot	20	25	32															
10" Ideal	13	17	22	26														
10 Min	10	13	17	20														
10 MaxCld	18	24	31	36														
10 MaxHot	16	21	26	31														
12"	10	14	18	21														
12 Min	8	11	13	16														
12 MaxCld	15	20	25	30														
12 MaxHot	13	17	22	26														
15" Ideal			14	17	19	22	25	28										
15 Min			10	13	15	17	19	21										
15 MaxCld			20	24	28	32	36	39										
15 MaxHot			17	21	24	28	31	33										
18" Ideal		9	11	14	16	18	21	23										
18 Min		7	9	10	12	14	16	17										
18 MaxCld		13	17	20	23	27	30	33										
18 MaxHot		11	14	17	20	23	26	29										
21" Ideal			10	12	14	15	17	19	21	23	25							
21 Min			8	9	10	12	13	15	16	18	19							
21 MaxCld			14	17	20	23	26	29	31	33	36							
21 MaxHot			12	15	17	20	22	25	27	30	32							
24" Ideal			9	10	12	13	15	17	19	20	22							
24 Min			7	8	9	10	12	13	14	15	17							
24 MaxCld			12	15	17	20	22	25	27	30	32							
24 MaxHot			11	13	15	17	20	22	24	26	28							
27" Ideal				9	10	12	13	15	16	18	19							
27 Min				7	8	9	10	11	12	14	15							
27 MaxCld				13	15	18	20	22	24	27	26							
27 MaxHot				11	13	15	17	19	21	23	25							
30" Ideal				8	10	11	12	13	15	16	17	17	21	21	24			
30 Min				6	7	8	9	10	11	12	13	14	15	16	18			
30 MaxCld				12	14	16	18	20	22	24	26	28	30	32	36			
30 MaxHot				10	12	14	16	17	19	21	23	24	26	28	31			
36" Ideal					8	9	10	11	12	13	14	15	17	18	20			
36 Min					6	7	8	9	8	10	11	12	13	14	15			
36 MaxCld					11	13	15	17	18	20	22	23	25	27	30			
36 MaxHot					10	11	13	14	16	17	19	20	22	23	26			
42" Ideal							9	10	10	11	12	13	14	15	17			
42 Min							7	7	8	9	10	10	11	11	13			
42 MaxCld							13	14	16	17	18	20	21	23	26			
42 MaxHot							11	12	14	15	16	17	19	20	22			
48" Ideal							8	8	9	10	11	11	12	13	15	16	17	18
48 Min							6	6	7	8	8	9	10	10	11	12	13	14
48 MaxCld							11	12	14	15	16	17	19	20	22	24	25	27
48 MaxHot							10	11	12	13	14	15	16	17	18	21	22	24
54" Ideal								7	8	9	10	10	11	12	13	14	15	16
54 Min								6	6	7	7	8	9	9	10	11	11	12
54 MaxCld								11	12	13	14	15	17	18	20	21	22	24
54 MaxHot								10	10	11	12	13	14	15	17	18	19	21
60" Ideal										8	9	9	10	10	12	12	13	14
60 Min										6	7	7	8	8	9	10	10	11
60 MaxCld										12	13	14	15	16	18	19	20	22
60 MaxHot										10	11	12	13	14	16	16	17	19
63" Ideal										8	8	9	10	10	11	12	12	14
63 Min										6	6	7	7	8	9	9	10	10
63 MaxCld										11	12	13	13	15	17	18	19	21
63 MaxHot										10	11	11	12	13	15	16	16	18
72" Ideal										7	7	8	8	9	10	10	11	12
72 Min										5	6	6	6	7	8	8	9	9
72 MaxCld										10	11	11	12	13	15	16	17	18
72 MaxHot										9	10	10	11	11	13	14	14	16

CERTIFICATION

This certifies that Applied Felts manufactured tubes meet the material requirements of ASTM F1216-93. In support of ASTM D5035, specifically as it relates to tensile strengths, our liner tensile properties average 1100 psi. The minimum tensile strength is 750 psi as per ASTM D5813-95 item 6.1 *Fabric Tube Strength* (see Page 10). 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 twelve years, and supplied materials for the CIPP industry for more than twenty years. Over 22 million feet of our liner has been successfully installed world wide, of which 10 million feet has been installed in the United States. Over 97,476 feet of our liner with diameter 36" and above have been installed in the U.S.

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 9002 company.

FABRIC TUBE STRENGTH

BATCH	1809			8/15/07
Roll #	Warp Break	Warp Modulus	Weft Break	Weft Modulus
1809/01	2250	10.42	2980	8.01
1809/02	2250	10.56	3110	7.19
1809/03	2210	9.83	2730	6.43
1809/04	2200	9.23	2940	5.96
1809/05	2210	10.53	3040	6.42
1809/06	2260	10.47	2910	6.20
1809/07	2330	10.61	2830	6.77
1809/08	2480	11.28	2870	7.41
1809/09	2240	10.64	2860	6.96
1809/10	2480	12.21	2920	7.68
1809/11	2230	11.02	2930	7.96
1809/12	2220	10.73	2940	7.83
1809/13	2370	12.32	2890	7.14
1809/14	2370	11.38	2860	6.94
1809/15	2320	11.80	2920	6.50
1809/16	2340	11.31	2900	7.45
1809/17	2380	12.24	2820	7.56
1809/18	2390	12.20	2820	7.28
1809/19	2190	9.82	2800	7.48
1809/20	2250	10.67	2700	6.27
1809/21	2000	9.47	2860	7.17
1809/22	2360	12.32	2750	6.91
1809/23	2260	11.72	2910	7.99
1809/24	2270	11.23	2970	7.66
1809/25	2320	10.39	2940	7.30
1809/26	2180	11.27	2800	6.83
1809/27	2320	10.72	2680	7.18
1809/28	2290	11.82	2930	6.54
1809/29	2280	10.92	3060	7.58
1809/30	2180	9.26	2840	6.94
1809/31	2220	9.59	2870	7.21
1809/32	2290	10.61	2860	7.69
1809/33	2250	10.27	2810	7.02
Average	2278 1101 psi	10.87		7.14

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 (ie. both loops of the sling onto the crane hook).

Storage and Handling con't.

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.

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department: CALTRANS
Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County
Project Title: Construction on State HWY in El Dorado County
City's Project Number: 03-4M4404

Prepared By: Andy Thompson
Michels Project No: 40435

Date Received:
Engineer: Darlene Wulff
Contractor: Michels Corp

Submittal number: 6
Submittal Date: 5/27/2014
Revision Date: NA
Revision Number: NA

Specification Section: 15-6.11A(3)
Subsection: 3.4
Item: Installation Procedure
Page: 20
Deviation (Y or N): N

Engineer's Stamp

Submittal Description: Installation Procedures for CIPP
Intended Use: CIPP Reference Manual
Plan Sheet: NA
Manufacturer: NA
Supplier: NA

Applicable Standard: NA
Referenced Document: NA
Notes:

INSTALLING PREMIER PIPE USING THE AIR/STEAM METHOD

1. The inversion frame should be placed directly over the pipeline to be lined. A suitable access to the pipeline, i.e.; manhole, pothole or hatch, shall be provided to ensure the liner is not hindered in any way.
2. A suitable air source is required for maintaining installation and curing pressures.
3. The liner should be transported in a climate controlled vessel to prevent a premature exotherm during transit.
4. The vessel transporting the liner should be placed in close proximity to the inversion frame.
5. After the liner is secured to the inversion frame, a lubricant, such as mineral oil, needs to be applied to prevent friction and aid in the inverting of the liner.
6. Apply air to liner and maintain a pressure within the recommended range of pressures as determined by the manufacturer while the liner is inverting. If the liner stops or is stopped during the inversion; air pressure can be increased or decreased accordingly to resume inverting the liner.
7. Although not necessary, it is recommended that a rope be attached to the tail end of the liner before it goes through the inversion frame. The rope should be used to control the feed rate of the liner.
8. Once the liner has reached the termination point and is up against a suitable restraint, steam can be introduced to begin the curing of the liner. Curing should be performed by manufacturer’s recommendations.

INTERPLASTIC
CORPORATION

Suggested Cure Schedule - Hot Air or Steam
For Cured-In-Place-Pipe Applications
<u>Using COR72, COR78 and CORVE Series Resins</u>

Felt Thickness, mm	Type of Cure	Temperature, °F	Time, minutes
<10	Ramp	140 Interface	30

Heat liner with hot air mixture until an interface temperature (between the liner and the host pipe) reaches a temperature of 105 degrees F, minimum. Begin increasing the live steam component until the interface temperature reaches a minimum of 140 degrees F. Insure that the interface temperature at the upstream and downstream end of the liner are comparable. After liner achieves maximum peak exotherm, begin cooldown process to a hot air temperature of 120 degrees F. This decrease in temperature should take no less than 30 minutes.

Felt Thickness, mm	Type of Cure	Temperature, °F	Time, minutes
10 - 18	Stage	105 Interface	20
		130 Interface	40

Heat liner with hot air mixture until an interface temperature (between the liner and the host pipe) reaches a temperature of 105 degrees F, minimum. Begin increasing the live steam component until the interface temperature reaches a minimum of 130 degrees F. Insure that the interface temperature at the upstream and downstream end of the liner are comparable. After liner achieves maximum peak exotherm, begin cooldown process to a hot air temperature of 120 degrees F. This decrease in temperature should take no less than 40 minutes.

Note: Ramp/stage upheating should occur in a reasonable amount of time in order to avoid monomer boiling and resin/liner cracking.
Suggested time interval to reach maximum ramp/stage temperature (peak exotherm) of the interface/liner should be approximately 30 minutes.

These suggestions are provided assuming a high temperature catalyst system is employed.
They are not intended for ambient cure resin/catalyst systems.

This is information is provided free of charge and is intended to be used strictly as a reference guideline.
Many variables such as groundwater, pipe/ground conditions and climate may require deviations from the above suggestions.

Apr-08

FIELD CURE RECORD DS#												Cure process
Time 5-Min Int.	Head / PSI	Boiler In	Boiler Out	MH		MH		MH		MH		☐ Steam ☐ Water
				wire 1	wire 2	wire 1	wire 2	wire 1	wire 2	wire 1	wire 2	Notes

Job Name:		**Operator:**		**Weather:**	
Client:		**Diameter**		**City/State:**	
Owner:		**Length:**		**Date:**	
Michels #:		**Wall (mm):**		**DS#**	

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Engineer: Darlene Wulff
Contractor: Michels Corp

Submittal number: 7
Submittal Date: 5/27/2014
Revision Date: NA
Revision Number: NA

Specification Section: 15-6.11A(3)
Subsection: 3.5
Item: End Seal Material
Page: 20
Deviation (Y or N): N

Engineer's Stamp

Submittal Description: End Seal Materials
Intended Use: CIPP Reference Manual
Plan Sheet: NA
Manufacturer: NA
Supplier: NA

Applicable Standard: NA
Referenced Document: NA
Notes:

MASCO FLASH | Cement Based Patching Mortar

DESCRIPTION

MASCO FLASH is a ready-to-use, cement based concrete and masonry patching compound formulated specifically for use around water. It requires only potable water for mixing. MASCO FLASH achieves initial set in approximately 20 minutes, and final set in 35-40 minutes. After initial set, MASCO FLASH may be shaved to conform to the contours of the surrounding surface. MASCO FLASH undergoes a chemical "hyper hydration" and produces a very stable, low permeable, cementitious matrix, when combined with the correct amount of water. When properly mixed and applied, MASCO FLASH develops a very high strength and a tenacious bond.

USES

- Interior or exterior above or below grade
- Vertical, overhead and horizontal repairs
- Outstanding repair material for tunnels, basements, concrete pipe, curbs, catch basins, vaults, formed and precast concrete
- Freeze thaw durable
- Trowelable repair mortar

FEATURES AND BENEFITS

- Initial set in 20 minutes
- Final set within 35-40 minutes
- May be "shaved" to desired shape
- High strength
- Excellent durability

MATERIAL PROPERTIES AT 75° F.

ASTM C109 Compressive Strength, PSI	24 Hour 7 day 28 Day	3,000 5,000 6,000
ASTM C266 Set Time, Gilmore, Min	Initial Final	20 35-40
ASTM C190 Tensile Strength, PSI	7 Day Avg. 28 Day Avg.	325 450
ASTM C78 Flexural Strength, PSI	28 Day Avg.	990
OH DOT 1042 Shear Bond Strength, PSI	24 Hour Avg. 7 Day Avg.	900 1,250
ASTM C666 Freeze Thaw Durability Factor	300 Cycles	98.25%
ASTM C157 Shrinkage Initial Final Expansion Initial Final	7 Day 28 Day 7 Day 28 Day	-0.053% -0.160% 0.049% 0.102%
ASTM C672 Scaling Resistance	25 Cycles	0% loss
ASTM D1411 Chloride		<0.01%

SURFACE PREPARATION

Concrete surfaces must be structurally sound, free of loose or deteriorated concrete and free of dust, dirt, laitance, oil, grease, curing compounds, coatings and other bond inhibiting materials from surface. Be sure repair area is not less than 1/4 inch in depth. Preparation work should be done by high pressure water blast, scabbler, or other appropriate mechanical means to obtain an exposed aggregate surface with a minimum surface profile of ±1/16 inch. Saturate surface with clean water. Substrate should be saturated surface dry (SSD) with no standing water during application.

MIXING INSTRUCTIONS

Mix only enough material that can be applied within 10 – 15 minutes. MASCO FLASH will require approximately 5 to 5-1/2 quarts of potable water per 50 lb bag to achieve the proper mix consistency. In a clean container, add 3/4 of mixing water. Using a ½" slow speed (400-600 rpm) drill and a Jiffy mixer, gradually add the MASCO FLASH powder to produce a mortar with a smooth consistency and without lumps. Add remaining liquid to obtain desired consistency. Do not mix longer than 60 seconds. Mix small quantities of MASCO FLASH in a clean pail with a margin trowel at ratio of approximately 3 parts powder with 1 part mixing water.
To fill horizontal patches or formed repair areas deeper than 1.0 inch depth, MASCO FLASH should be extended with 20 pounds of clean 3/8 inch pea gravel. The pea gravel aggregate should be added after the powder is added to the mixing water.

APPLICATION TECHNIQUES

Minimum ambient and surface temperatures 40°F and rising at time of application. Saturate surface with clean water. Substrate should be saturated surface dry (SSD) with no standing water during application. Apply a scrub coat of the mixed MASCO FLASH by hand or stiff brush working mixture thoroughly into voids and pores of surface to eliminate air pockets. Before scrub coat dries, follow immediately with a layer of MASCO FLASH. If scrub coat dries before mortar is applied, scrub coat must be mechanically removed back to a clean surface.
Alternatively a brush coat of MASCOBOND EVA can be used as a bonding agent for areas not subject to water immersion or applications below 50°F. Consult MASCOBOND EVA data sheet for details. Expansion joints and control joints must be extended through MASCO FLASH. Moving cracks will "telegraph" through MASCO FLASH.
HAND APPLIED VERTICAL SURFACES: Follow application techniques above, then apply MASCO FLASH from a minimum 1/4" to 1" depth by rubber gloves or trowel using sufficient pressure to fill surface holes and voids and to ensure maximum bond to the substrate. Completely fill all voids around steel reinforcement. For repair depths greater than 1.0 inch, apply MASCO FLASH in lifts. Rake or score the fresh MASCO FLASH with edge of trowel to create a keyed surface area for improved adhesion. After Initial set, (SSD) dampen surface and apply

another layer of MASCO FLASH. Slightly overfill the final layer and immediately following initial set, shave the material with edge of margin trowel following the finished surface. Shave MASCO FLASH toward the common bonding edge between repair material and existing surface. Use a wet sponge float for final finishing.

FOR HORIZONAL OR FORMED REPAIRS: **Follow application techniques above,** then apply MASCO FLASH from a minimum 1/4" to 1" depth with trowel or float using sufficient pressure to fill surface holes and voids and to ensure maximum bond to the substrate. A broom, wood or steel trowel finish may be applied to the surface. To fill areas deeper than 1.0 inch, MASCO FLASH should be extended with up to 20 pounds of clean 3/8 inch pea gravel. When extended, MASCO FLASH can be applied in lifts of up to 3 inches. Do not featheredge MASCO FLASH.

CURING

As per ACI 308 Standard Practice for Curing Concrete, curing of MASCO FLASH is required. Moist cure with wet burlap or polyethylene or a water based compatible curing compound such as MASCO CURE & SEAL WB. Moist cure should begin immediately after finishing. Protect newly applied material from direct sunlight, wind, rain, frost and freezing. Pretesting of curing compound other than MASCO CURE & SEAL WB is recommended. Curing compounds adversely affect the adhesion of following layers of mortars, toppings or protective coatings. If repairs will receive a subsequent coating or topping complete removal of curing compound will be necessary. Consult subsequent coating manufacturers' guidelines. In hot weather conditions refer to ACI 305R Hot Weather Concreting for more information. In cold weather conditions refer to ACI 306R Cold Weather Concreting for more information.

YIELD

One 50 bag of MASCO FLASH will yield approximately 0.50 cu. ft. When extended with 20 lbs clean washed 3/8" pea gravel yield will be approximately 0.60 cu. ft.

CAUTIONS

Do not apply MASCO FLASH below 40°F. Do not apply to a frost filled surface. Protect from freezing. Addition of coarse aggregates may result in variations of the physical properties of the mortar. Excessive moisture and high humidity will slow curing time. Always do a sample area first. When used as an underlayment, always follow the directions of floor covering manufacturer concerning maximum moisture content and surface bondability and perform required tests.

PACKAGING

50 lb. bag MASCO FLASH Powder.
Storage: 50°-85°F in protected, dry storage.
Protect from freezing.
Shelf Life: 1 year.
Freight Class: 55.
DOT/UN Shipping Name: Non-regulated
DOT Hazard Class: Non-regulated
Shipping Name: Non-regulated

HAZARDS IDENTIFICATION

MASCO FLASH Powder: Breathing dust may cause nose, throat, or lung irritation and choking. May cause eye irritation, severe burns and damage to the cornea. May cause dry skin, redness, discomfort, irritation or severe burns. May produce allergic reaction. Thickening of the skin (scleroderma) may be associated with exposure to high levels of crystalline silica. Ingestion of large amounts may cause intestinal distress. Prolonged inhalation of respirable silica will result in permanent lung damage, silicosis. Respirable crystalline silica is a suspected cancer agent by NTP and IARC. Read MSDS for more information.

FIRST AID:

Inhalation: Remove victim from exposure to fresh air. Seek medical attention.
Eyes: Rinse carefully with water. Seek medical attention.
Skin: Wash thoroughly with soap and water. Use moisturizing creams for irritated skin. Seek medical attention for burns or if irritation persists.
Ingestion: Do not induce vomiting but drink plenty of water. Seek medical attention for discomfort.

CLEANUP INSTRUCTIONS

Clean tools and equipment with water before MASCO FLASH. Hardened MASCOPATCH will require mechanical abrasion for removal.

TECHNICAL SERVICE: For Technical Service on all Masons Supply products contact:

MASONS SUPPLY
2637 SE 12th Ave
Portland, OR 97202
(503)234-4321, FAX (503)234-5606
masco.net

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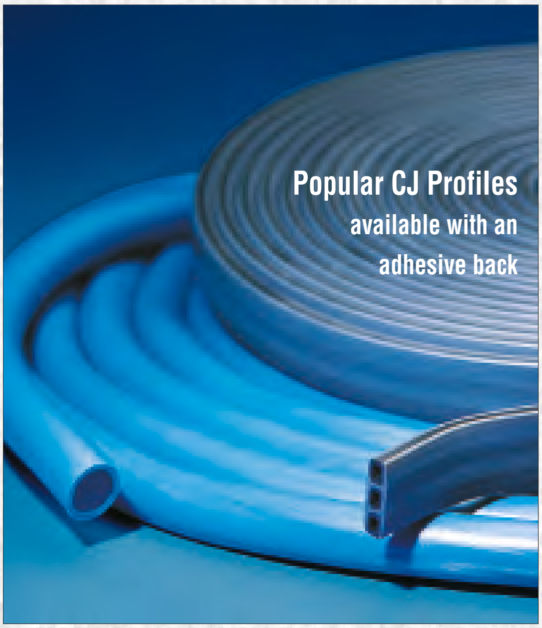
3/07

Hydrotite

hydrophilic water sealing materials

The Benchmark for Expandable Waterstops

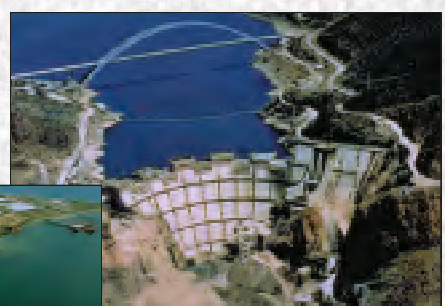


Hydrotite is a state-of-the-art hydrophilic waterstop with unmatched durability and watersealing capacity. Comprised of <u>NON-BENTONITE</u>, modified chloroprene rubber, **Hydrotite** expands up to EIGHT TIMES its original volume when exposed to water. This expansion creates an effective compression seal within joints of limited movement. Recognized worldwide, **Hydrotite** has a proven track record as a high quality and cost effective solution to your water containment needs.

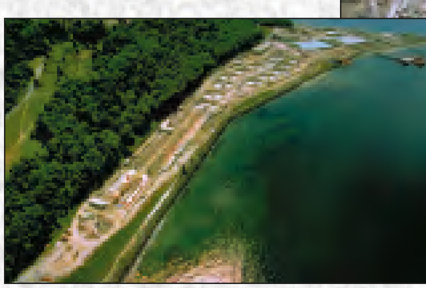
Since 1950, GREENSTREAK has maintained its position of industry leadership by responding to the unique needs of our customers. **Hydrotite** is one more example of our continued dedication to the construction market and to the advancement of joint sealing technologies.

TYPICAL STRUCTURES UTILIZING *HYDROTITE*:

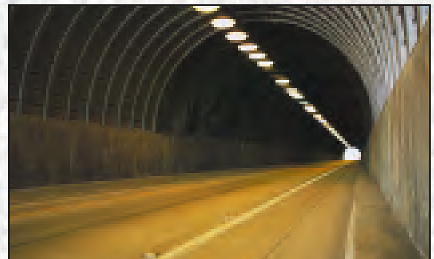
- Water and waste water treatment facilities
- Primary and secondary containment structures
- Tunnels and culverts
- Dams, locks, canals, water reservoirs and aqueducts
- Pipe penetrations
- Swimming pools
- Storage tanks
- Retaining walls
- Foundations
- Slabs on grade



Hydroelectric and Flood Control Projects



Water and Waste Water Treatment Plants



Tunnels

GREENSTREAK®

3400 Tree Court Industrial Blvd., St. Louis, Missouri 63122
Phone: 800. **325-9504** or 636. **225-9400**
Fax: 800. **551-5145** or 636. **225-9854**
www.greenstreak.com

Flexible solutions. Concrete performance.

HYDROTITE: The Benchmark for Expandable Waterstops

Hydrotite® is a state-of-the-art hydrophilic waterstop now available from GREENSTREAK®. Comprised of a modified chloroprene rubber, **Hydrotite** has unmatched durability and water sealing capacity. **Hydrotite** expands up to EIGHT TIMES its volume when exposed to water. This remarkable hydrophilic property enables **Hydrotite** to reliably seal joints.

BEFORE EXPANSION AFTER EXPANSION

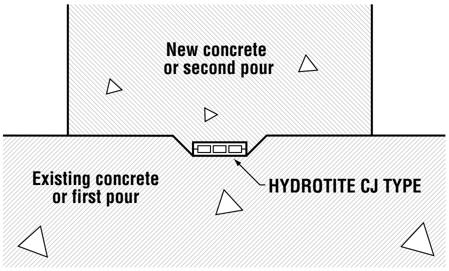
Note: *Hydrotite CJ-Type is not a sealing material for expansion joints and should not be used as such.*

Exceptional Qualities to Ensure Unparalleled Performance

- Swells up to EIGHT times its volume when exposed to water
- Comprised of NON-BENTONITE, modified chloroprene rubber
- Outstanding physical properties
- Available as a co-extruded profile to provide directional expansion (also available as a single extrusion)
- Special expansion delay coating to allow concrete cure prior to expansion
- Reliable and durable (lifespan up to 100 years)
- ISO 9002 certified
- CJ-0725-3K-ADH and CJ-1020-2K-ADH offered with an adhesive back
- Simple, low cost installation
- Available in a multitude of sizes and shapes for numerous applications
- Appropriate for retro-fit as well as new construction
- Can withstand high hydrostatic pressures (150' head minimum for most profiles)
- International acceptance
- 15 years of service

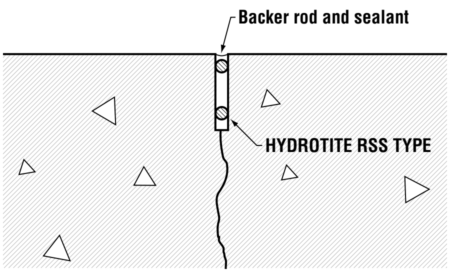
HYDROTITE CJ: A Superior Waterstop for Concrete Joint Gaps

As this innovative product absorbs water and expands, it conforms to gap variations along the joint. This action ensures complete sealing even under extraordinary hydrostatic pressures. Due to its slim profile, it won't project like conventional waterstops and trap air or become displaced by the second pour. The result is optimum concrete placement. **Hydrotite CJ**, is treated with a special expansion-delay coating to prevent it from reacting to the fresh, moist concrete and expanding before curing takes place.



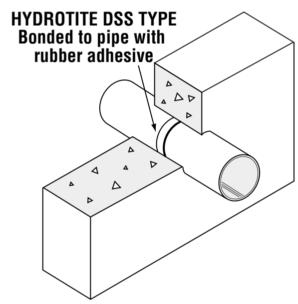
HYDROTITE RSS: Seal for Sawed Control Joints/Joint Repairs

Hydrotite RSS profiles create effective seals in sawed control joints and in the repair of failed joints. **Hydrotite** eliminates hydrostatic pressure below the sealant, thus extending the sealant's life. Select solid profiles with slightly larger diameters than the joint width for joints of consistent widths. Hollow profiles should be selected based on the maximum width of joints with varying widths. Compress both profiles slightly on initial insertion.



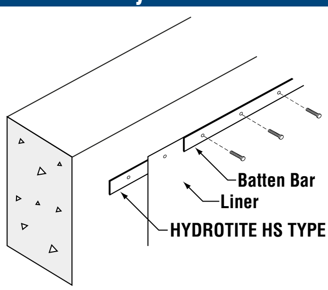
HYDROTITE DSS: Pipe Penetrations/Pipe Thimbles

The DSS profiles can be bonded to various piping materials, including concrete, steel and plastic. Bond **Hydrotite DSS** to the pipe prior to concrete placement. Installation in existing walls requires an oversize cutout be made and **Hydrotite** installed both on the pipe and the outside diameter of the cutout. Fill the annulus with a non-shrink grout. Embedded pipe thimbles can also be sealed with **Hydrotite DSS**.



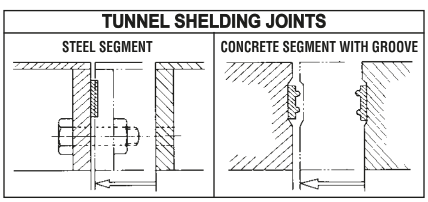
HYDROTITE HS: Termination for Liner Systems

Hydrotite HS-0540-30 is used to complete liner systems. Placed under a batten bar, between the liner and concrete wall, **Hydrotite HS** effectively terminates the liner. Dual composition prevents the profile from expanding out from under the batten bar. The HS profile can be supplied solid or with 3/8 inch diameter prepunched holes on 6 inch centers for ease of installing anchors.



HYDROTITE DS: Ideal In Shield Segment Tunnel Lining Systems

The outstanding hydrophilic performance of **Hydrotite DS** enables it to follow the expansion and contraction of joint gaps, creating an effective seal even under high water pressure. In contrast, conventional compressive seals tend to lose their elasticity and restoring force over time and, therefore, their water-sealing effectiveness. Furthermore, conventional seals must be thicker compared to **Hydrotite DS** to have the same gap-sealing ability.

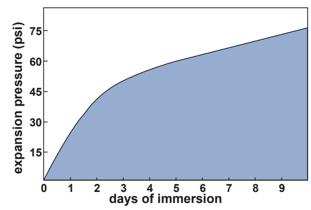


PROPERTIES OF *HYDROTITE*

Property	Test Method	Unit	Hydrophilic Rubber Minimum	Hydrophilic Rubber Typical	Chloroprene Rubber Minimum	Chloroprene Rubber Typical
Tensile Strength	ASTM D412	lb/in2	350	366	1300	1570
Elongation	ASTM D412	%	600	670	400	450
Hardness	ASTM D2240	Shore A	52+/-5	54	50+/-5	50
Tear Resistance	ASTM D624	lb/in	50	60.3	100	123
Specific Gravity	ASTM D792		1.32+/-0.1	1.32	1.38+/-0.1	1.38

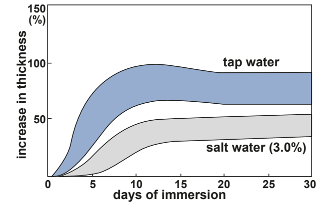
EXPANSION CHARACTERISTICS

Typical expansion pressures of **Hydrotite** are shown below.



SWELLING CHARACTERISTICS

Swelling characteristics of **Hydrotite** depend on the water quality as typical examples shown below.



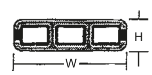
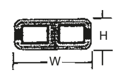
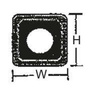
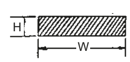
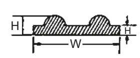
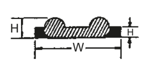
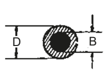
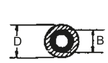
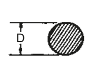
INSTALLATION GUIDELINES

1. For best results, apply **Hydrotite** to smooth, even surfaces to ensure good bonding.
2. Provide 2" minimum concrete cover.
3. **Hydrotite** can be installed to the plain surface of concrete or in a formed keyway.

4. **Hydrotite** should be spliced by cutting ends square (or mitered) with a sharp knife or shears. Bond the prepared ends together with a cyanacrylate (super glue) adhesive. **Leakmaster** can be used to further protect the splice area.

5. Remove all dust, oil, etc. From concrete surface prior to adhering **Hydrotite**.
6. CJ-0725-3K-ADH and CJ-1020-2K-ADH are available with an adhesive back for adhering to the concrete surface. Bonding of other **Hydrotite** profiles can be accomplished using a contact adhesive compatible with chloroprene rubber. On rough concrete surfaces, **GREENSTREAK 7300 Epoxy** or **Leakmaster** should be used to smooth the surface and to adhere **Hydrotite**.
7. Concrete nails, in conjunction with adhesives, are recommended for vertical or overhead applications.

SHAPE AND APPLICATION

	ITEM	NOMINAL SIZE mm (inches)			PACKAGING UNIT METERS/REEL x REELS (FT/BOX)
FOR CONSTRUCTION JOINTS					
		H	W		
	CJ-0725-3K	7 (.28)	25 (.98)		10m x 4 (131)
	CJ-0725-3K-ADH	Same as above with pressure sensitive adhesive backing			
	CJ-1020-2K	10 (.39)	20 (.79)		10m x 5 (164)
	CJ-1020-2K-ADH	Same as above with pressure sensitive adhesive backing			
	CJ-1030-4M	10 (.39)	30 (1.18)		10m x 4 (131)
	CJ-3030-M	30 (1.18)	30 (1.18)		10m x 1 (33)
FOR PIPE PENETRATIONS, CONCRETE CURBS, TUNNEL LINING SEGMENTS					
		H	W		h
	SS-0215	2 (.08)	15 (.59)	–	25m x 4 (328)
	SS-0220	2 (.08)	20 (.79)	–	25m x 4 (328)
	SS-0320	3 (.12)	20 (.79)	–	25m x 4 (328)
	SS-0520	5 (.20)	20 (.79)	–	20m x 4 (262)
	RS-0520-3.5I	5 (.20)	20 (.79)	3.5 (.14)	20m x 5 (328)
	RS-0723-3.5I	7 (.28)	23 (.91)	3.5 (.14)	15m x 4 (196)
	DS-0415-2.5I	4 (.16)	15 (.59)	2.5 (.10)	20m x 5 (328)
	DS-0420-2.5I	4 (.16)	20 (.79)	2.5 (.10)	20m x 5 (328)
	DS-0520-3.5I	5 (.20)	20 (.79)	3.5 (.14)	20m x 5 (328)
	DS-0615-4.5I	6 (.24)	15 (.59)	4.5 (.18)	15m x 5 (245)
	DSS-0320	3 (.12)	20 (.79)	–	25m x 4 (328)
	DSS-0420	4 (.16)	20 (.79)	–	25m x 5 (328)
	HS-0540-30	5 (.20)	40 (1.57)	–	20m x 3 (196)
FOR JOINT REPAIR, CONTROL JOINTS, SPECIAL APPLICATIONS					
			D	B	
	RSS-1006 D		10 (.39)	6 (.24)	20m x 3 (196)
	RSS-1208 D		12 (.47)	8 (.31)	20m x 2 (131)
	RSS-1409 D		14 (.55)	9 (.35)	10m x 2 (65)
	RSS-1610 D		16 (.63)	10 (.39)	10m x 2 (65)
	RSS-2014 D		20 (.79)	14 (.55)	10m x 2 (65)
	RSS-2519 D		25 (.98)	19 (.75)	5m x 2 (32)
	RSS-0806 C		8 (.31)	6 (.24)	20m x 5 (320)
	RSS-1007 C		10 (.39)	7 (.28)	20m x 3 (196)
	RSS-1209 C		12 (.47)	9 (.35)	20m x 2 (131)
	RSS-1410 C		14 (.55)	10 (.39)	15m x 2 (98)
	RSS-040 P		4 (.16)	–	20m x 10 (656)
	RSS-050 P		5 (.20)	–	20m x 10 (656)
	RSS-060 P		6 (.24)	–	20m x 10 (656)
	RSS-080 P		8 (.31)	–	20m x 5 (320)
	RSS-100 P		10 (.39)	–	20m x 3 (196)
	RSS-120 P		12 (.47)	–	20m x 2 (131)
	RSS-140 P		14 (.55)	–	15m x 2 (98)
	RSS-160 P		16 (.63)	–	10m x 2 (65)

LEAKMASTER

SINGLE COMPONENT WATER-SWELLING SEALANT

LEAKMASTER

LEAKMASTER LV-1 is a single component water-swelling sealant with excellent and unique properties.

Its development was based on C.I. Kasei's technology and long experience in water-swelling sealants.

LEAKMASTER may be applied in locations where conventional solid sealants cannot be easily applied. This includes irregular shaped joints, rough surfaces, odd penetrations, etc.

After curing, LEAKMASTER has excellent physical properties. The rubber-like elasticity of the material and expansion characteristics create an effective watertight seal.

ADVANTAGES

EASY APPLICATION – As a moisture-cure single component water-swelling sealant, standard caulking guns can be used.

PHYSICAL PROPERTIES – After curing, LEAKMASTER has better physical properties than those of conventional sealants.

EXPANSION – LEAKMASTER expands approximately two times its original volume when exposed to water. It provides excellent water sealing properties while retaining its rubberlike elasticity.

ADHESION – Before swelling, LEAKMASTER adheres to various materials such as concrete, metal, glass, etc.

MAIN APPLICATION

- Water sealing at joints of in-situ cast concrete
- Water sealing around H-section steel joints and bars
- Caulking for water distribution systems
- Pipe penetrations
- Irregular joint surfaces
- Waterproofing work

CHARACTERISTICS

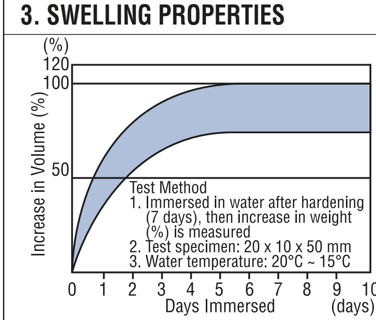
1. GENERAL PROPERTIES

Appearance	Putty-Like
Color	Grey
Specific Gravity	1.30
Extrudability	Within 20 seconds (at 23°C)
Slump	3mm max. (at 23°C)
Tack-Free Time	Within 8 hours (at 23°C, 60% R.H.)
	JIS-A-5758

2. PROPERTIES AFTER HARDENING

Hardness	35 Shore A
Tensile Strength	30 kgf/cm^2 (425 psi)
Elongation	1250%
Tear Strength	10 kgf/cm (56 lb/in)
	JIS-K-6301

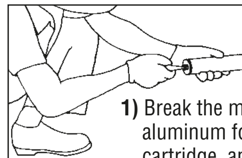
3. SWELLING PROPERTIES



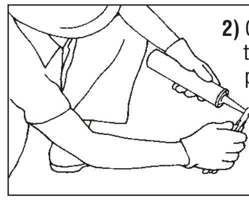
4. ADHESION PROPERTIES

	Steel	Aluminum	Mortar
50% Modulus (kgf/cm^2)	4.5 64 psi	6.5 92 psi	6.5 92 psi
Max. Tensile Strength (kgf/cm^2)	7.0 99 psi	12.2 173 psi	11.1 157 psi
Elongation at Break (%)	330	580	570
			JIS-A-5758

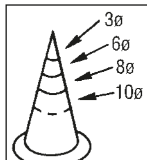
APPLICATION



1) Break the moisture-proofing aluminum foil at the top of the cartridge, and remove the metal back seamer from the bottom.

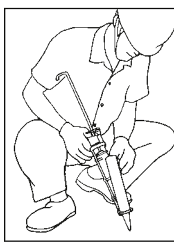


2) Cut the nozzle at the appropriate position diagonally.

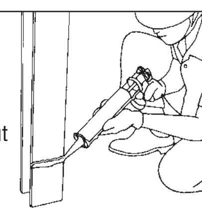


NOZZLE DIAMETER	LENGTH
3mm∅ (1/8 in)	35-40m (125 ft)
6mm∅ (1/4 in)	8-10m (30 ft)
8mm∅ (3/8 in)	4-5m (15 ft)
10mm∅ (1/2 in)	Approx. 3m (8 ft)

3) Average extrudable length vs. nozzle diameter.



4) Put the cartridge into caulking gun.



5) Apply Leakmaster continuously without a break to the place to be sealed.

PACKAGING

Item No.	LEAKMASTER LV-1
Cartridge	320 cc
Carton	24 cartridges

WARRANTY: These specifications are to be used only as a general guideline by engineers in formulating preliminary specifications, and should not be relied upon without site-specific product testing; Greenstreak assumes no responsibility for the improper reliance upon or misuse of such data. In addition, product design and specifications are subject to change without notice.

All statements regarding this product are based upon procedures and tests which the manufacturer believes are reliable, and may be changed for improvement of quality without notice; but it will be the sole responsibility of the customer and/or end user to use this product properly, and therefore assume all risk and liability in connection herewith.

GREENSTREAK GROUP, INC
A Family of Construction Companies

3400 Tree Court Industrial Blvd., St. Louis, Missouri 63122
Phone: 800. **325-9504** or 636. **225-9400**
Fax: 800. **551-5145** or 636. **225-9854**
www.greenstreak.com

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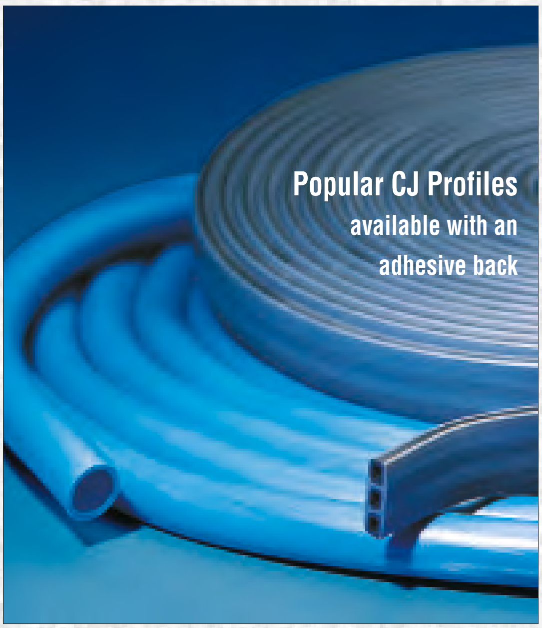
Hydrotite

hydrophilic water sealing materials

The Benchmark for Expandable Waterstops

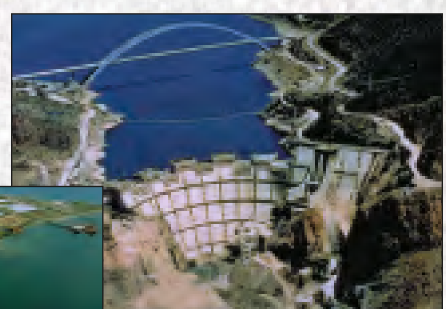


Hydrotite is a state-of-the-art hydrophilic waterstop with unmatched durability and watersealing capacity. Comprised of NON-BENTONITE, modified chloroprene rubber, **Hydrotite** expands up to EIGHT TIMES its original volume when exposed to water. This expansion creates an effective compression seal within joints of limited movement. Recognized worldwide, **Hydrotite** has a proven track record as a high quality and cost effective solution to your water containment needs.

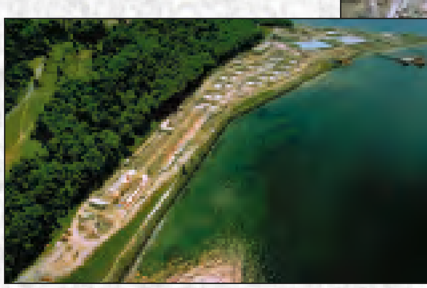
Since 1950, GREENSTREAK has maintained its position of industry leadership by responding to the unique needs of our customers. **Hydrotite** is one more example of our continued dedication to the construction market and to the advancement of joint sealing technologies.

TYPICAL STRUCTURES UTILIZING *HYDROTITE*:

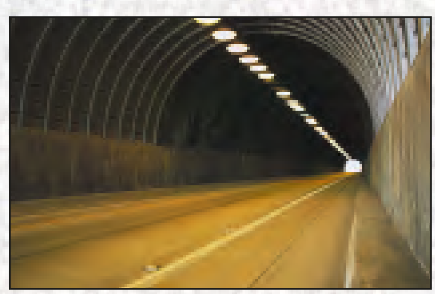
- Water and waste water treatment facilities
- Primary and secondary containment structures
- Tunnels and culverts
- Dams, locks, canals, water reservoirs and aqueducts
- Pipe penetrations
- Swimming pools
- Storage tanks
- Retaining walls
- Foundations
- Slabs on grade



Hydroelectric and Flood Control Projects



Water and Waste Water Treatment Plants



Tunnels

GREENSTREAK®

3400 Tree Court Industrial Blvd., St. Louis, Missouri 63122
Phone: 800. **325-9504** or 636. **225-9400**
Fax: 800. **551-5145** or 636. **225-9854**
www.greenstreak.com

HYDROTITE: The Benchmark for Expandable Waterstops

Hydrotite® is a state-of-the-art hydrophilic waterstop now available from GREENSTREAK®. Comprised of a modified chloroprene rubber, **Hydrotite** has unmatched durability and water sealing capacity. **Hydrotite** expands up to EIGHT TIMES its volume when exposed to water. This remarkable hydrophilic property enables **Hydrotite** to reliably seal joints.

BEFORE EXPANSION AFTER EXPANSION

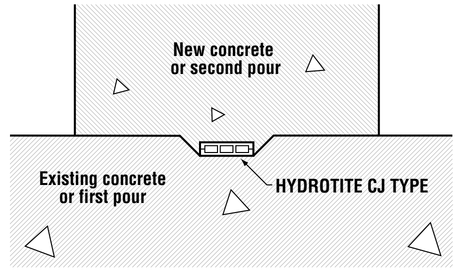
Note: *Hydrotite CJ-Type is not a sealing material for expansion joints and should not be used as such.*

Exceptional Qualities to Ensure Unparalleled Performance

- Swells up to EIGHT times its volume when exposed to water
- Comprised of <u>NON-BENTONITE</u>, modified chloroprene rubber
- Outstanding physical properties
- Available as a co-extruded profile to provide directional expansion (also available as a single extrusion)
- Special expansion delay coating to allow concrete cure prior to expansion
- Reliable and durable (lifespan up to 100 years)
- ISO 9002 certified
- CJ-0725-3K-ADH and CJ-1020-2K-ADH offered with an adhesive back
- Simple, low cost installation
- Available in a multitude of sizes and shapes for numerous applications
- Appropriate for retro-fit as well as new construction
- Can withstand high hydrostatic pressures (150' head minimum for most profiles)
- International acceptance
- 15 years of service

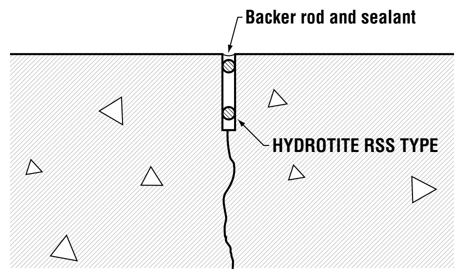
HYDROTITE CJ: A Superior Waterstop for Concrete Joint Gaps

As this innovative product absorbs water and expands, it conforms to gap variations along the joint. This action ensures complete sealing even under extraordinary hydrostatic pressures. Due to its slim profile, it won't project like conventional waterstops and trap air or become displaced by the second pour. The result is optimum concrete placement. **Hydrotite CJ**, is treated with a special expansion-delay coating to prevent it from reacting to the fresh, moist concrete and expanding before curing takes place.



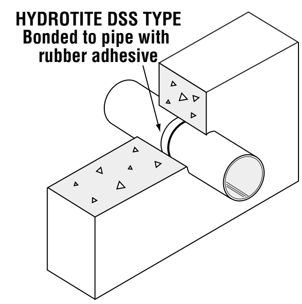
HYDROTITE RSS: Seal for Sawed Control Joints/Joint Repairs

Hydrotite RSS profiles create effective seals in sawed control joints and in the repair of failed joints. **Hydrotite** eliminates hydrostatic pressure below the sealant, thus extending the sealant's life. Select solid profiles with slightly larger diameters than the joint width for joints of consistent widths. Hollow profiles should be selected based on the maximum width of joints with varying widths. Compress both profiles slightly on initial insertion.



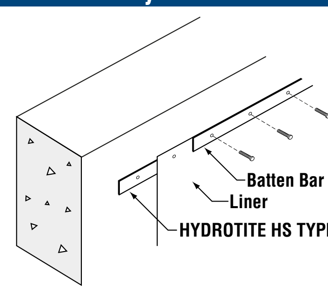
HYDROTITE DSS: Pipe Penetrations/Pipe Thimbles

The DSS profiles can be bonded to various piping materials, including concrete, steel and plastic. Bond **Hydrotite DSS** to the pipe prior to concrete placement. Installation in existing walls requires an oversize cutout be made and **Hydrotite** installed both on the pipe and the outside diameter of the cutout. Fill the annulus with a non-shrink grout. Embedded pipe thimbles can also be sealed with **Hydrotite DSS**.



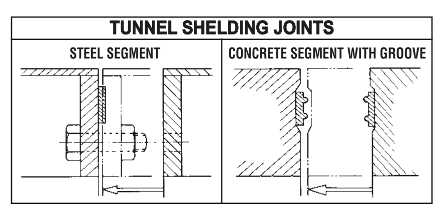
HYDROTITE HS: Termination for Liner Systems

Hydrotite HS-0540-30 is used to complete liner systems. Placed under a batten bar, between the liner and concrete wall, **Hydrotite HS** effectively terminates the liner. Dual composition prevents the profile from expanding out from under the batten bar. The HS profile can be supplied solid or with 3/8 inch diameter prepunched holes on 6 inch centers for ease of installing anchors.



HYDROTITE DS: Ideal In Shield Segment Tunnel Lining Systems

The outstanding hydrophilic performance of **Hydrotite DS** enables it to follow the expansion and contraction of joint gaps, creating an effective seal even under high water pressure. In contrast, conventional compressive seals tend to lose their elasticity and restoring force over time and, therefore, their water-sealing effectiveness. Furthermore, conventional seals must be thicker compared to **Hydrotite DS** to have the same gap-sealing ability.

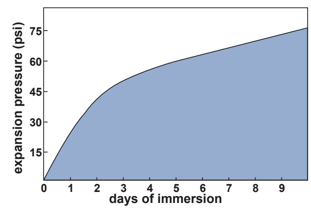


PROPERTIES OF *HYDROTITE*

Property	Test Method	Unit	Hydrophilic Rubber		Chloroprene Rubber	
			Minimum	Typical	Minimum	Typical
Tensile Strength	ASTM D412	lb/in2	350	366	1300	1570
Elongation	ASTM D412	%	600	670	400	450
Hardness	ASTM D2240	Shore A	52+/-5	54	50+/-5	50
Tear Resistance	ASTM D624	lb/in	50	60.3	100	123
Specific Gravity	ASTM D792		1.32+/-0.1	1.32	1.38+/-0.1	1.38

EXPANSION CHARACTERISTICS

Typical expansion pressures of **Hydrotite** are shown below.



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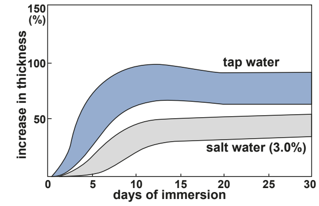


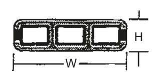
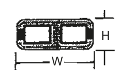
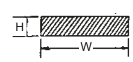
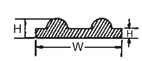
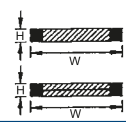
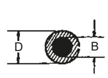
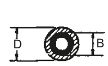
INSTALLATION GUIDELINES

1. For best results, apply **Hydrotite** to smooth, even surfaces to ensure good bonding.
2. Provide 2" minimum concrete cover.
3. **Hydrotite** can be installed to the plain surface of concrete or in a formed keyway.

4. **Hydrotite** should be spliced by cutting ends square (or mitered) with a sharp knife or shears. Bond the prepared ends together with a cyanacrylate (super glue) adhesive. **Leakmaster** can be used to further protect the splice area.

5. Remove all dust, oil, etc. From concrete surface prior to adhering **Hydrotite**.
6. CJ-0725-3K-ADH and CJ-1020-2K-ADH are available with an adhesive back for adhering to the concrete surface. Bonding of other **Hydrotite** profiles can be accomplished using a contact adhesive compatible with chloroprene rubber. On rough concrete surfaces, **GREENSTREAK 7300 Epoxy** or **Leakmaster** should be used to smooth the surface and to adhere **Hydrotite**.
7. Concrete nails, in conjunction with adhesives, are recommended for vertical or overhead applications.

SHAPE AND APPLICATION

	ITEM	NOMINAL SIZE mm (inches)			PACKAGING UNIT METERS/REEL x REELS (FT/BOX)
FOR CONSTRUCTION JOINTS					
		H	W		
	CJ-0725-3K	7 (.28)	25 (.98)		10m x 4 (131)
	CJ-0725-3K-ADH	Same as above with pressure sensitive adhesive backing			
	CJ-1020-2K	10 (.39)	20 (.79)		10m x 5 (164)
	CJ-1020-2K-ADH	Same as above with pressure sensitive adhesive backing			
	CJ-1030-4M	10 (.39)	30 (1.18)		10m x 4 (131)
	CJ-3030-M	30 (1.18)	30 (1.18)		10m x 1 (33)
FOR PIPE PENETRATIONS, CONCRETE CURBS, TUNNEL LINING SEGMENTS					
		H	W		h
	SS-0215	2 (.08)	15 (.59)	–	25m x 4 (328)
	SS-0220	2 (.08)	20 (.79)	–	25m x 4 (328)
	SS-0320	3 (.12)	20 (.79)	–	25m x 4 (328)
	SS-0520	5 (.20)	20 (.79)	–	20m x 4 (262)
	RS-0520-3.5I	5 (.20)	20 (.79)	3.5 (.14)	20m x 5 (328)
	RS-0723-3.5I	7 (.28)	23 (.91)	3.5 (.14)	15m x 4 (196)
	DS-0415-2.5I	4 (.16)	15 (.59)	2.5 (.10)	20m x 5 (328)
	DS-0420-2.5I	4 (.16)	20 (.79)	2.5 (.10)	20m x 5 (328)
	DS-0520-3.5I	5 (.20)	20 (.79)	3.5 (.14)	20m x 5 (328)
	DS-0615-4.5I	6 (.24)	15 (.59)	4.5 (.18)	15m x 5 (245)
	DSS-0320	3 (.12)	20 (.79)	–	25m x 4 (328)
	DSS-0420	4 (.16)	20 (.79)	–	25m x 5 (328)
	HS-0540-30	5 (.20)	40 (1.57)	–	20m x 3 (196)
FOR JOINT REPAIR, CONTROL JOINTS, SPECIAL APPLICATIONS					
			D	B	
	RSS-1006 D		10 (.39)	6 (.24)	20m x 3 (196)
	RSS-1208 D		12 (.47)	8 (.31)	20m x 2 (131)
	RSS-1409 D		14 (.55)	9 (.35)	10m x 2 (65)
	RSS-1610 D		16 (.63)	10 (.39)	10m x 2 (65)
	RSS-2014 D		20 (.79)	14 (.55)	10m x 2 (65)
	RSS-2519 D		25 (.98)	19 (.75)	5m x 2 (32)
	RSS-0806 C		8 (.31)	6 (.24)	20m x 5 (320)
	RSS-1007 C		10 (.39)	7 (.28)	20m x 3 (196)
	RSS-1209 C		12 (.47)	9 (.35)	20m x 2 (131)
	RSS-1410 C		14 (.55)	10 (.39)	15m x 2 (98)
	RSS-040 P		4 (.16)	–	20m x 10 (656)
	RSS-050 P		5 (.20)	–	20m x 10 (656)
	RSS-060 P		6 (.24)	–	20m x 10 (656)
	RSS-080 P		8 (.31)	–	20m x 5 (320)
	RSS-100 P		10 (.39)	–	20m x 3 (196)
	RSS-120 P		12 (.47)	–	20m x 2 (131)
	RSS-140 P		14 (.55)	–	15m x 2 (98)
	RSS-160 P		16 (.63)	–	10m x 2 (65)

LEAKMASTER

SINGLE COMPONENT WATER-SWELLING SEALANT

LEAKMASTER

LEAKMASTER LV-1 is a single component water-swelling sealant with excellent and unique properties.

Its development was based on C.I. Kasei's technology and long experience in water-swelling sealants.

LEAKMASTER may be applied in locations where conventional solid sealants cannot be easily applied. This includes irregular shaped joints, rough surfaces, odd penetrations, etc.

After curing, LEAKMASTER has excellent physical properties. The rubber-like elasticity of the material and expansion characteristics create an effective watertight seal.

ADVANTAGES

EASY APPLICATION – As a moisture-cure single component water-swelling sealant, standard caulking guns can be used.

PHYSICAL PROPERTIES – After curing, LEAKMASTER has better physical properties than those of conventional sealants.

EXPANSION – LEAKMASTER expands approximately two times its original volume when exposed to water. It provides excellent water sealing properties while retaining its rubberlike elasticity.

ADHESION – Before swelling, LEAKMASTER adheres to various materials such as concrete, metal, glass, etc.

MAIN APPLICATION

- Water sealing at joints of in-situ cast concrete
- Water sealing around H-section steel joints and bars
- Caulking for water distribution systems
- Pipe penetrations
- Irregular joint surfaces
- Waterproofing work

CHARACTERISTICS

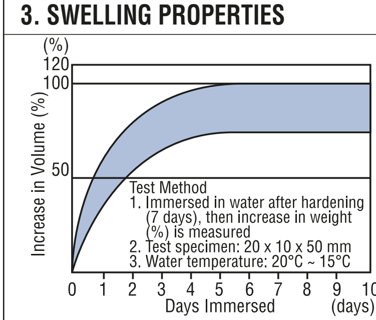
1. GENERAL PROPERTIES

Appearance	Putty-Like
Color	Grey
Specific Gravity	1.30
Extrudability	Within 20 seconds (at 23°C)
Slump	3mm max. (at 23°C)
Tack-Free Time	Within 8 hours (at 23°C, 60% R.H.)
	JIS-A-5758

2. PROPERTIES AFTER HARDENING

Hardness	35 Shore A
Tensile Strength	30 kgf/cm^2 (425 psi)
Elongation	1250%
Tear Strength	10 kgf/cm (56 lb/in)
	JIS-K-6301

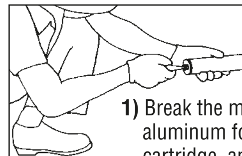
3. SWELLING PROPERTIES



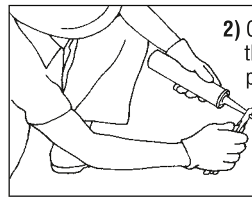
4. ADHESION PROPERTIES

	Steel	Aluminum	Mortar
50% Modulus (kgf/cm^2)	4.5 64 psi	6.5 92 psi	6.5 92 psi
Max. Tensile Strength (kgf/cm^2)	7.0 99 psi	12.2 173 psi	11.1 157 psi
Elongation at Break (%)	330	580	570
			JIS-A-5758

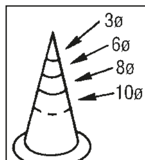
APPLICATION



1) Break the moisture-proofing aluminum foil at the top of the cartridge, and remove the metal back seamer from the bottom.

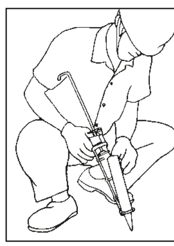


2) Cut the nozzle at the appropriate position diagonally.

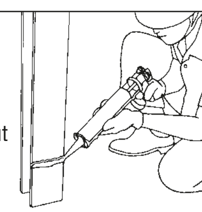


NOZZLE DIAMETER	LENGTH
3mm∅ (1/8 in)	35-40m (125 ft)
6mm∅ (1/4 in)	8-10m (30 ft)
8mm∅ (3/8 in)	4-5m (15 ft)
10mm∅ (1/2 in)	Approx. 3m (8 ft)

3) Average extrudable length vs. nozzle diameter.



4) Put the cartridge into caulking gun.



5) Apply Leakmaster continuously without a break to the place to be sealed.

PACKAGING

Item No.	LEAKMASTER LV-1
Cartridge	320 cc
Carton	24 cartridges

WARRANTY: These specifications are to be used only as a general guideline by engineers in formulating preliminary specifications, and should not be relied upon without site-specific product testing; Greenstreak assumes no responsibility for the improper reliance upon or misuse of such data. In addition, product design and specifications are subject to change without notice.

All statements regarding this product are based upon procedures and tests which the manufacturer believes are reliable, and may be changed for improvement of quality without notice; but it will be the sole responsibility of the customer and/or end user to use this product properly, and therefore assume all risk and liability in connection herewith.

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www.greenstreak.com

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03/08

Construction

Sikadur® 31, Hi-Mod Gel (1:1 Mix Ratio)

High-modulus, high-strength, structural, epoxy paste adhesive

Description

Sikadur 31, Hi-Mod Gel, is a 2-component, 100% solids, solvent-free, moisture-tolerant, high-modulus, high-strength, structural epoxy paste adhesive. It conforms to the current ASTM C-881, Types I and IV, Grade-3, Class-B/C and AASHTO M-235 specifications.

Where to Use

- Structural bonding of concrete, masonry, metals, wood, etc. to a maximum glue line of ⅛ in. (3 mm).
- Grout bolts, dowels, and pins.
- Seals cracks and around injection ports prior to pressure-injection grouting.
- Interior, vertical, and overhead repair of concrete as an epoxy mortar binder.
- As a pick-proof sealant around windows, doors, lock-ups etc. inside correctional facilities.

Advantages

- Meets physical requirements of ASTM C-881 Types I, II & IV, Grade 3, Classes B & C.
- Suitable for potable water contact, meets NSF/ANSI Standard 61.
- Excellent adhesion to concrete, masonry, metals, wood, and most structural materials.
- Paste consistency ideal for vertical and overhead repair of concrete.
- Fast-setting and strength-producing adhesive.
- Convenient easy mix ratio A:B = 1:1 by volume.

Typical Data *(Material and curing conditions @ 73°F (23°C) and 50% R.H.)*

Shelf Life 2 years in original, unopened containers

Storage Conditions Store dry at 40°-95°F (4°-35°C). **Condition material to 65°-85°F (18°-29°C) before using.**

Color Gray

Mixing Ratio Component 'A' : Component 'B' = 1:1 by volume

Consistency Non-sag paste

Pot Life Approximately 60 minutes @ 73°F. (500 gram mass)

Tack-Free Time 1.5 - 2.5 hours at 30 mils. thick

Tensile Properties (ASTM D-638)
7 day Tensile Strength 3,300 psi (22.7 MPa)
Elongation at Break 0.9 %

Flexural Properties (ASTM D-790)
7 day Flexural Strength (Modulus of Rupture) 6,100 psi (42.0 MPa)
Tangent Modulus of Elasticity in Bending 1.67×10^6 psi (11,520 MPa)

Shear Strength (ASTM D-732) **7 day** Shear Strength 4,600 psi (31.7 MPa)

Bond Strength (ASTM C-882)

Hardened Concrete to Hardened Concrete:
2 day (dry cure) 2,200 psi (15.2 MPa)
2 day (moist cure) 2,400 psi (16.5 MPa)
14 day (moist cure) 2,900 psi (20.0 MPa)

Hardened Concrete to Steel:
2 day (dry cure) 2,900 psi (20.0 MPa)

Tensile Bond Strength (Pull-off Method, Dyna, ASTM C-1583-04)
2 day 420 psi (2.9 MPa)

Heat Deflection Temperature (ASTM D-648) **7 day** (Fiber Stress Loading = 264 psi) 135°F (57°C)

Water Absorption (ASTM D-570) **24 hour** 0.07%

Compressive strength (ASTM D-695) psi (MPa)

	40°F (4°C)* **	73°F (23°C)* **	90°F (32°C)* **
2 hour	-	-	450 (3.1)
4 hour	-	800 (5.5)	10,500 (72.4)
8 hour	-	8,500 (58.6)	12,200 (84.1)
16 hour	700 (4.8)	10,500 (72.4)	13,000 (89.6)
1 day	6,000 (41.4)	13,000 (89.6)	15,000 (103.4)
3 day	11,000 (75.8)	14,000 (96.5)	16,000 (110.3)
7 day	12,900 (88.9)	15,000 (103.4)	16,000 (110.3)
14 day	13,500 (93.0)	15,400 (106.1)	16,000 (110.3)
28 day	14,000 (96.5)	16,000 (110.3)	16,000 (110.3)

Compressive Modulus of Elasticity (ASTM D-695) **7 day** 7.95×10^5 psi (5,485 MPa)

* Material cured and tested at temperatures indicated.
** See Limitations section for further information.

Coverage
1 gal. yields 231 cu. in. (3,785 cm^3) of epoxy paste adhesive. 1 gal. (3.8 L) mixed with 1 gal. (3.8 L) by loose volume of oven-dried aggregate yields approximately 346 cu. in. (5,670 cm^3) of epoxy mortar.

Packaging
1 gal. and 3 gal. (11.4 L) units.

How to Use

Surface Preparation
Surface must be clean and sound. It may be dry or damp, but free of standing water. Remove dust, laitance, grease, curing compounds, impregnations, waxes, and any other contaminants.
Preparation Work: Concrete - Should be cleaned and prepared to achieve a laitance and contaminant free, open textured surface by blastcleaning or equivalent mechanical means.
Steel - Should be cleaned and prepared thoroughly by blastcleaning.

Mixing
Pre-mix each component. Proportion 1 part Component 'B' to 1 part Component 'A' by volume into a clean pail. Mix thoroughly for 3 minutes with Sika paddle on low-speed (400- 600 rpm) drill until uniform in color. Mix only that quantity which can be used within its pot life. Prior to mixing, material should be conditioned to 65°-85°F (18°-29°C). To prepare an epoxy mortar, slowly add up to 1 part, by loose volume of an oven-dried aggregate, to 1 part of the mixed Sikadur 31, Hi-Mod Gel, and mix until uniform in consistency.

Application
As a structural adhesive - Apply the neat mixed Sikadur 31, Hi-Mod Gel to the prepared substrates. Work into the substrate for positive adhesion. Secure the bonded unit firmly into place until the adhesive has cured. Glue line should not exceed 1/8-in. (3 mm).
To seal cracks for injection grouting - Place the neat mixed material over the cracks to be pressure injected and around each injection port. Allow sufficient time to set before pressure injecting.
For interior vertical and overhead patching - Place the prepared mortar in void, working the material into the prepared substrate, filling the cavity. Strike off level. Lifts should not exceed 1-in (25 mm).
As a pick-proof sealant - Use automated or manual method. Apply an appropriate size bead of material around the area being sealed. Seal with neat Sikadur 31, Hi-Mod Gel.

Limitations
- **THE NTSB HAS STATED THAT THIS PRODUCT IS APPROVED FOR SHORT TERM LOADS ONLY AND SHOULD NOT BE USED IN SUSTAINED TENSILE LOAD ADHESIVE ANCHORING APPLICATIONS WHERE ADHESIVE FAILURE COULD RESULT IN A PUBLIC SAFETY RISK. CONSULT A DESIGN PROFESSIONAL PRIOR TO USE.**
- Components of original 2:1 mix ratio formulation of Sikadur 31, Hi-Mod Gel cannot be cross-mixed with components of Sikadur 31, Hi-Mod Gel (NEW 1:1 Mix Ratio) formulation.
- Minimum substrate and ambient temperature 40°F (4°C).
- Do not thin. Solvents will prevent proper cure.
- When preparing an epoxy mortar, use oven-dried aggregate only.
- Maximum epoxy mortar thickness is 1 in. (25 mm) per lift.
- Epoxy mortar is for interior use only. Material is a vapor barrier after cure.
- Minimum age of concrete must be 21-28 days, depending upon curing and drying conditions, for mortar applications.
- Porous substrates must be tested for moisture-vapor transmission prior to mortar applications.
- Not for sealing cracks under hydrostatic pressure.
- Not an aesthetic product. Color may alter due to variations in lighting and/or UV exposure.

WARNING
Component 'A' - IRRITANT, SENSITIZER. Contains epoxy resin, silica, and calcium carbonate. Causes eye irritation. May cause skin/respiratory irritations. Prolonged and/or repeated contact with skin may cause allergic reaction/sensitization. Harmful if swallowed. **Deliberate concentrations of vapors for purposes of inhalation is harmful and can be fatal.**
Component 'B' - CORROSIVE, SENSITIZER, IRRITANT. Contains Amines, silica quartz (sand), and calcium carbonate. Contact with skin and eyes causes severe burns. Causes eye/skin/respiratory irritation. Prolonged and/or repeated contact may cause allergic reaction/sensitization. Harmful if swallowed. **Deliberate concentrations of vapors for purposes of inhalation is harmful and can be fatal.**
Cured material, if sanded, may result in exposure to a chemical known to the State of California to cause cancer.

First Aid
Eyes - Hold eyelids apart and flush thoroughly with water for 15 minutes. **Skin** - Remove contaminated clothing. Wash skin thoroughly for 15 minutes with soap and water. **Inhalation** - Remove person to fresh air. **Ingestion** - Do not induce vomiting. Contact a physician. **In all cases, contact a physician immediately if symptoms persist.**

Handling & Storage
Avoid direct contact with eyes and skin. Wear chemical resistant gloves/goggles/clothing. Avoid breathing vapors. Use with adequate general and local exhaust ventilation. Use a properly fitted NIOSH approved respirator. Wash thoroughly after handling product. Remove contaminated clothing and launder before reuse. Store product in a closed container in a cool, dry place.

Construction

Clean Up	Avoid contact. Wear chemical resistant clothing/gloves/goggles. In absence of adequate ventilation, use a properly fitted NIOSH respirator. Uncured material can be removed with solvent. Follow solvent manufacturer's instructions for use and warnings. Cured material (when Component 'A' combined with Component 'B') can only be removed mechanically. In case of spill, ventilate area and contain spill. Collect with absorbent material. Dispose of in accordance with current, applicable local, state and federal regulations.

Visit our website at www.sikaconstruction.com **1-800-933-SIKA NATIONWIDE**

Regional Information and Sales Centers. For the location of your nearest Sika sales office, contact your regional center.

Sika Corporation
201 Polito Avenue
Lyndhurst, NJ 07071
Phone: 800-933-7452
Fax: 201-933-6225

Sika Canada Inc.
601 Delmar Avenue
Pointe Claire
Quebec H9R 4A9
Phone: 514-697-2610
Fax: 514-694-2792

Sika Mexicana S.A. de C.V.
Carretera Libre Celaya Km. 8.5
Fracc. Industrial Balvanera
Corregidora, Queretaro
C.P. 76920
Phone: 52 442 2385800
Fax: 52 442 2250537

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

Department: CALTRANS

Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County

Project Title: Construction on State HWY in El Dorado County

City's Project Number: 03-4M4404

Prepared By: Andy Thompson

Michels Project No: 40435

Date Received:

Engineer: Darlene Wulff

Contractor: Michels Corp

Submittal number: 8

Submittal Date: 5/27/2014

Revision Date: NA

Revision Number: NA

Specification Section: 15-6.11A(3)

Subsection: 3.6

Item: Pre-Liner

Page: 20

Deviation (Y or N): N

Engineer's Stamp

Submittal Description: Preliner Description

Intended Use: CIPP Reference Manual

Plan Sheet: NA

Manufacturer: NA

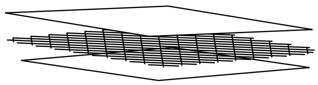
Supplier: NA

Applicable Standard: NA

Referenced Document: NA

Notes:

GRIFFOLYN® TX 1200



Griffolyn® TX-1200 is a 3-ply laminate combining two layers of linear low density polyethylene and a high-strength cord grid. It is specifically engineered to provide high strength and durability in a lightweight material.

PHYSICAL PROPERTIES AND TYPICAL VALUES

PROPERTY	ASTM TEST METHOD	U.S. VALUE	METRIC VALUE
Weight	D-751	38 LB/1000 FT²	18.5 KG/100 M²
3" Load @ Yield	D-882	90 LBF	400 N
3" Load @ Break	D-882	54 LBF	240 N
		2500 PSI	17 MPA
3" Elongation @ Break	D-882	400 %	400 %
Tongue Tear	D-2261	22 LBF	98 N
Trapezoidal Tear	D-4533	29 LBF	129 N
PPT Resistance	D-2582	29 LBF	129 N
Dart Impact Strength	D-1709	1.6 LBS	0.73 KG
Cold Impact Strength	D-1790	-40°F	-40°C
Permeance	E-96	0.040 Grain/Hr•Ft²•in.Hg	2.30 NG/(PA•S•M²)

FEATURES

- Multiple layers and cord reinforcement resist punctures and tears.
- UV stabilization protects the material from degradation during extended exposure to sunlight.
- Cold-crack resistance eliminates failures in extremely cold temperatures.
- Low permeability greatly inhibits moisture transmission.
- Flexibility and light weight allow for easy handling and quick installation.
- Custom fabrication is available to meet your exact specifications.
- Long life expectancy allows for significant cost savings through reuse and fewer replacements.
- Class C, ASTM E-1745-97 Standard Specification for water vapor retarders used in contact with soil or granular fill under concrete slabs.

TOLLFREE 1.800.231.6074
9209 Almeda Genoa Rd. • Houston, Texas 77075
P: 713.507.4251 • F: 713.507.4295
Email: ri@reefindustries.com

SUGGESTED APPLICATIONS

- Pallet, cable reel and drum covers for outside storage.
- Custom bags and tubing.
- Temporary walls, plant dividers, building enclosures and containment tents.
- Shipping container covers and liners.
- Floor covers, dust partitions and cleanroom enclosures.
- Soil covers to control leachate for stockpiles and landfills.
- Agricultural storage systems, hay covers and windbreaks.
- Athletic field and equipment covers.
- Interim landfill covers
- Architectural vapor retarder for underslab, walls, ceilings and in roofing systems.

ORDERING INFORMATION

AVAILABLE COLORS:
Black, White, and Clear

SIZES:
Standard rolls from 4' x 100' to 40' x 100' in increments of 4' widths are available for immediate shipment. Standard length and width tolerances are ± 1% (minimum 2")

Custom sizes up to 200' x 300' and custom fabrication are avaiable to meet your exact specifications.

USABLE TEMPERATURE RANGE:
Minimum: -45˚F -42˚C
Maximum: 170˚F 77˚C

OUTDOOR EXPOSURE

Under normal continuous exposure the average life expectancy ranges from 30 to 48 months.

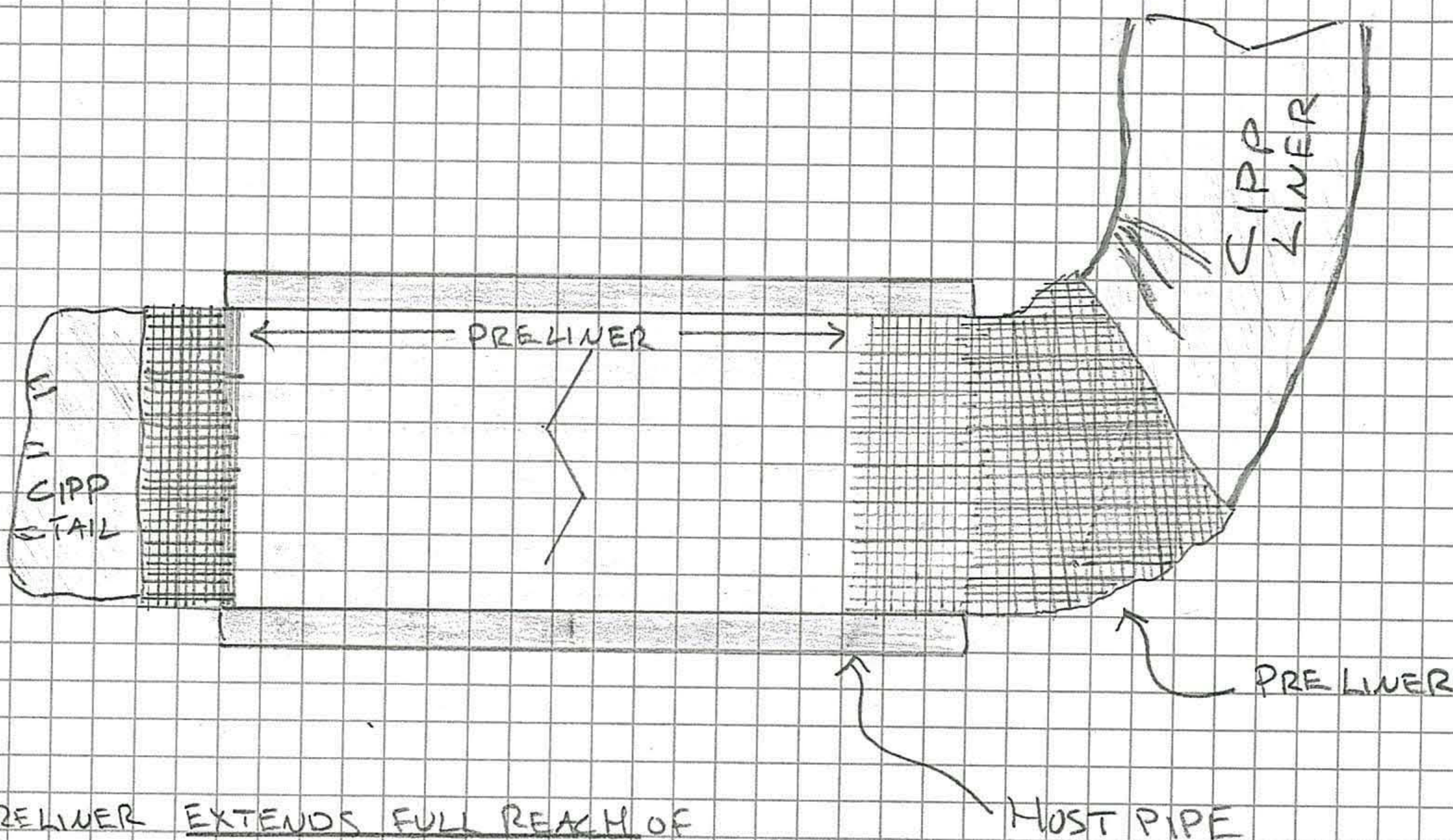
TOLLFREE 1.800.231.6074
9209 Almeda Genoa Rd. • Houston, Texas 77075
P: 713.507.4251 • F: 713.507.4295
Email: ri@reefindustries.com

Pre-liner installation procedure

The procedure for installing a Preliner, for use with CIPP is as follows:

1. Upon completion of the final pre-video inspection of the pipe, attach Preliner, with a rope, to the camera/tractor equipment
2. The pre-liner material should be either; rolled out above ground or suspended on a stand to allow unspooling as it enters through the manhole.
3. Pre-liner often comes in 600’ lengths but the manufacturer recommends using duct tape to join required lengths together.
4. Once the Preliner has been strung through the pipe, make sure there is at least 1 foot of excess at each end.
5. On the end of the pipe, opposite from the CIPP installation manhole, attach the Preliner, using duct tape, to a manhole blower in order to pre inflate the pre-liner.
6. With pre-liner inflated, help feed CIPP liner into the end of the pre-liner. Keeping the pre-liner inflated during the CIPP installation helps to ensure that the pre-liner is not torn or ran over during the install.

PRELINER DIAGRAM



PRELINER EXTENDS FULL REACH OF SEGMENT + 2-3' AT EACH END.

PRELINER IS INSTALLED UPON COMPLETION OF PRE CCTV PRIOR TO INSTALLATION OF CIPP LINER

PRELINER SHOULD BE KEPT INFLATED DURING INVERSION PROCESS.

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

MICHELS CORPORATION

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department: CALTRANS

Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County

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City's Project Number: 03-4M4404

Prepared By: Andy Thompson

Michels Project No: 40435

Date Received:

Engineer: Darlene Wulff

Contractor: Michels Corp

Submittal number: 9

Submittal Date: 5/27/2014

Revision Date: NA

Revision Number: NA

Specification Section: 15-611A(3)

Subsection: 3.7

Item: CIPP Lubricant

Page: 20

Deviation (Y or N): N

Engineer's Stamp

Submittal Description: Mineral Oil or Vegetable Oil

Intended Use: CIPP Reference Mnaual

Plan Sheet: NA

Manufacturer: NA

Supplier: NA

Applicable Standard: NA

Referenced Document: NA

Notes:

penreco.

Penreco® Drakeol® LT Mineral Oil N.F.

Material Safety Data Sheet

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name:	Penreco® Drakeol® LT Mineral Oil N.F.
MSDS Code:	776510
Synonyms:	Penreco® Drakeol® 100G, 100 Penreco® Drakeol® 5, 5A., 6, 6LP, 6VR, 7, 7A, 7PG, 8, 9, 10, 10B, 10C, 13, 15, GD-LP, GD-Med., 70HP, 75HP, 90HP, 100HP Peneteck® and Drakesol® 260-AT Draketex 50
Intended Use:	General White Oil
Responsible Party:	Penreco 8701 New Trails Dr. Suite 175 The Woodlands, TX 77381
Customer Service:	800-245-3952 www.penreco.com
Technical Information:	800-245-3952
MSDS Information:	Internet: http://w3.conocophillips.com/NetMSDS/
Emergency Telephone Numbers:	Chemtrec: 800-424-9300 (24 Hours) California Poison Control System: 800-356-3219

2. HAZARDS IDENTIFICATION

Emergency Overview

WARNING!

Aspiration Hazard

NFPA

Appearance: Transparent / water white
Physical Form: Liquid
Odor: Odorless

Potential Health Effects
Eye: Not known to be an eye irritant.

Skin: Not known to be a skin irritant. No harmful effects from skin absorption have been reported.

Inhalation (Breathing): Expected to have a low degree of toxicity by inhalation.

Ingestion (Swallowing): No harmful effects reported from ingestion. ASPIRATION HAZARD - This material can enter lungs during swallowing or vomiting and cause lung inflammation and damage.

Signs and Symptoms: Effects of overexposure may include irritation of the respiratory tract, irritation of the digestive tract, diarrhea.

See Section 11 for additional Toxicity Information.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Component	CAS	Concentration (wt %)
White Mineral Oil	8042-47-5	100

4. FIRST AID MEASURES

Eye: If irritation or redness develops from exposure, flush eyes with clean water. If symptoms persist, seek medical attention.

Skin: First aid is not normally required. However, it is good practice to wash any chemical from the skin.

Inhalation (Breathing): First aid is not normally required. If breathing difficulties develop, move victim away from source of exposure and into fresh air. Seek immediate medical attention.

Ingestion (Swallowing): Aspiration hazard: Do not induce vomiting or give anything by mouth because this material can enter the lungs and cause severe lung damage. If victim is drowsy or unconscious and vomiting, place on the left side with the head down. If possible, do not leave victim unattended and observe closely for adequacy of breathing. Seek medical attention.

Notes to Physician: Acute aspirations of large amounts of oil-laden material may produce a serious aspiration pneumonia. Patients who aspirate these oils should be followed for the development of long-term sequelae. Inhalation exposure to oil mists below current workplace exposure limits is unlikely to cause pulmonary abnormalities.

5. FIRE-FIGHTING MEASURES

NFPA 704 Hazard Class

Health: 0 **Flammability:** 1 **Instability:** 0 (0-Minimal, 1-Slight, 2-Moderate, 3-Serious, 4-Severe)

Unusual Fire & Explosion Hazards: This material may burn, but will not ignite readily. If container is not properly cooled, it can rupture in the heat of a fire. Vapors are heavier than air and can accumulate in low areas.

Extinguishing Media: Dry chemical, carbon dioxide, foam, or water spray is recommended. Water or foam may cause frothing of materials heated above 212°F. Carbon dioxide can displace oxygen. Use caution when applying carbon dioxide in confined spaces.

Fire Fighting Instructions: For fires beyond the incipient stage, emergency responders in the immediate hazard area should wear bunker gear. When the potential chemical hazard is unknown, in enclosed or confined spaces, or when explicitly required by DOT, a self contained breathing apparatus should be worn. In addition, wear other appropriate protective equipment as conditions warrant (see Section 8).

Isolate immediate hazard area and keep unauthorized personnel out. Stop spill/release if it can be done with minimal risk. Move undamaged containers from immediate hazard area if it can be done with minimal risk.

Water spray may be useful in minimizing or dispersing vapors and to protect personnel. Cool equipment exposed to fire with water, if it can be done with minimal risk. Avoid spreading burning liquid with water used for cooling purposes.

See Section 9 for Flammable Properties including Flash Point and Flammable (Explosive) Limits

6. ACCIDENTAL RELEASE MEASURES

Personal precautions: This material may burn, but will not ignite readily. Keep all sources of ignition away from spill/release.

Spill precautions: Stay upwind and away from spill/release. Notify persons down wind of the spill/release, isolate immediate hazard area and keep unauthorized personnel out. Stop spill/release if it can be done with minimal risk. Wear appropriate protective equipment, including respiratory protection, as conditions warrant (see Section 8).

Environmental precautions: Prevent spilled material from entering sewers, storm drains, other unauthorized drainage systems, and natural waterways. Dike far ahead of spill for later recovery or disposal. Spilled material may be absorbed into an appropriate absorbent material.

Methods for cleaning up: Immediate cleanup of any spill is recommended. Notify fire authorities and appropriate federal, state, and local agencies. If spill of any amount is made into or upon navigable waters, the contiguous zone, or adjoining shorelines, notify the National Response Center (phone number 800-424-8802).

7. HANDLING AND STORAGE

Handling: Do not enter confined spaces such as tanks or pits without following proper entry procedures such as ASTM D-4276 and 29CFR 1910.146. Do not wear contaminated clothing or shoes. Use good personal hygiene practices.

"Empty" containers retain residue and may be dangerous. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose such containers to heat, flame, sparks, or other sources of ignition. They may explode and cause injury or death. "Empty" drums should be completely drained, properly bunged, and promptly shipped to the supplier or a drum reconditioner. All containers should be disposed of in an environmentally safe manner and in accordance with governmental regulations. Before working on or in tanks which contain or have contained this material, refer to OSHA regulations, ANSI Z49.1, and other references pertaining to cleaning, repairing, welding, or other contemplated operations.

Storage: Keep container(s) tightly closed. Use and store this material in cool, dry, well-ventilated areas away from heat and all sources of ignition. Store only in approved containers. Keep away from any incompatible material (see Section 10). Protect container(s) against physical damage.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Component	ACGIH	OSHA	Other:
White Mineral Oil	TWA: 5 mg/m^3 STEL: 10 mg/m^3 As Oil Mist, If Generated	TWA: 5 mg/m^3 As Oil Mist, If Generated	---

Note: State, local or other agencies or advisory groups may have established more stringent limits. Consult an industrial hygienist or similar professional, or your local agencies, for further information.

Engineering controls: If current ventilation practices are not adequate to maintain airborne concentrations below the established exposure limits additional engineering controls may be required.

Personal Protective Equipment (PPE):

Eye/Face: While contact with this material is not expected to cause irritation, the use of approved eye protection to safeguard against potential eye contact is considered good practice.

Skin: Not required based on the hazards of the material. However, it is considered good practice to wear gloves when handling chemicals.

Respiratory: A NIOSH certified air purifying respirator with an organic vapor cartridge in combination with a Type 95 (R or P) particulate filter may be used under conditions where airborne concentrations are expected to exceed exposure limits.

Protection provided by air purifying respirators is limited (see manufacturer`s respirator selection guide). Use a positive pressure air supplied respirator if there is potential for an uncontrolled release, exposure levels are not known, or any other circumstances where air purifying respirators may not provide adequate protection.

A respiratory protection program that meets OSHA`s 29 CFR 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator`s use.

Other Protective Equipment: A source of clean water should be available in the work area for flushing eyes and skin. Impervious clothing should be worn as needed.

Suggestions for the use of specific protective materials are based on readily available published data. Users should check with specific manufacturers to confirm the performance of their products.

9. PHYSICAL AND CHEMICAL PROPERTIES

Note: Unless otherwise stated, values are determined at 20°C (68°F) and 760 mm Hg (1 atm).
Data represent typical values and are not intended to be specifications.

Appearance:	Transparent / water white
Physical Form:	Liquid
Odor:	Odorless
Odor Threshold:	No data
pH:	Not applicable
Vapor Pressure:	<0.1mm Hg
Vapor Density (air=1):	>1
Boiling Point/Range:	>520°F / >271°C
Melting/Freezing Point:	No data
Solubility in Water:	Negligible
Partition Coefficient (n-octanol/water) (Kow):	No data
Specific Gravity:	0.81-0.87 @ 60°F (15.6°C)
Evaporation Rate (nBuAc=1):	<1
Flash Point:	>280°F / >138°C
Test Method:	Cleveland Open Cup (COC), ASTM D92
LEL (vol % in air):	No data
UEL (vol % in air):	No data
Autoignition Temperature:	No data

10. STABILITY AND REACTIVITY

Stability: Stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.

Conditions to Avoid: Avoid high temperatures and all sources of ignition (see Sections 5 and 7).

Materials to Avoid (Incompatible Materials): Avoid contact with strong oxidizing agents.

Hazardous Decomposition Products: Combustion can yield carbon dioxide, carbon monoxide and other oxides.

Hazardous Polymerization: Will not occur.

11. TOXICOLOGICAL INFORMATION

Acute Data:

Component	Oral LD50	Dermal LD50	Inhalation LC50
White Mineral Oil	>5 g/kg (rat)	>2 g/kg	>5 mg/l (rat)

12. ECOLOGICAL INFORMATION

Not evaluated.

13. DISPOSAL CONSIDERATIONS

The generator of a waste is always responsible for making proper hazardous waste determinations and needs to consider state and local requirements in addition to federal regulations.

This material, if discarded as produced, would not be a federally regulated RCRA "listed" hazardous waste and is not believed to exhibit characteristics of hazardous waste. See Sections 7 and 8 for information on handling, storage and personal protection and Section 9 for physical/chemical properties. It is possible that the material as produced contains constituents which are not required to be listed in the MSDS but could affect the hazardous waste determination. Additionally, use which results in chemical or physical change of this material could subject it to regulation as a hazardous waste.

Container contents should be completely used and containers should be emptied prior to discard.

14. TRANSPORTATION INFORMATION

U.S. Department of Transportation (DOT)

14. TRANSPORTATION INFORMATION

Shipping Description: Not regulated
Note: If shipped by land in a packaging having a capacity of 3,500 gallons or more, the provisions of 49 CFR, Part 130 apply. (Contains oil)

International Maritime Dangerous Goods (IMDG)
Shipping Description: Not regulated

International Civil Aviation Org. / International Air Transport Assoc. (ICAO/IATA)
UN/ID #: Not regulated

	LTD. QTY	Passenger Aircraft	Cargo Aircraft Only
Packaging Instruction #:	---	---	---
Max. Net Qty. Per Package:	---	---	---

15. REGULATORY INFORMATION

CERCLA/SARA - Section 302 Extremely Hazardous Substances and TPQs (in pounds):
This material does not contain any chemicals subject to the reporting requirements of SARA 302 and 40 CFR 372.

CERCLA/SARA - Section 311/312 (Title III Hazard Categories)

Acute Health: No
Chronic Health: No
Fire Hazard: No
Pressure Hazard: No
Reactive Hazard: No

CERCLA/SARA - Section 313 and 40 CFR 372:
This material does not contain any chemicals subject to the reporting requirements of SARA 313 and 40 CFR 372.

EPA (CERCLA) Reportable Quantity (in pounds):
This material does not contain any chemicals with CERCLA Reportable Quantities.

California Proposition 65:
This material does not contain any chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm at concentrations that trigger the warning requirements of California Proposition 65.

Canadian Regulations:
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS Hazard Class
None

National Chemical Inventories:

Component	AICS	DSL	NDSL	CHINA	ELINCS	EINECS	ENCS	KOREA	PICCS	TSCA
White Mineral Oil 8042-47-5	X	X		X		X	X	X	X	X

Legend: AICS - Australia Inventory of Chemical Substances, DSL - Domestic Substances List (Canada), NDSL - Non-Domestic Substances List (Canada), CHINA - Inventory List, ELINCS - EU List of Notified Chemical Substances, EINECS - European Inventory of Existing Commercial Chemical Substances, ENCS - Japan Existing and New Chemical Substances, KOREA - Existing and Evaluated Chemical Substances, PICCS - Philippines Inventory of Chemicals and Chemical Substances, TSCA - United States Section 8(b) Inventory

U.S. Export Control Classification Number: EAR99

16. OTHER INFORMATION

16. OTHER INFORMATION

Issue Date:	12-Jul-2007
Status:	Final
Previous Issue Date:	01-Nov-2006
Product Code:	5040304
Revised Sections or Basis for Revision:	Format change
MSDS Code:	776510

MSDS Legend:
ACGIH = American Conference of Governmental Industrial Hygienists; CAS = Chemical Abstracts Service Registry; CEILING = Ceiling Limit (15 minutes); CERCLA = The Comprehensive Environmental Response, Compensation, and Liability Act; EPA = Environmental Protection Agency; IARC = International Agency for Research on Cancer; LEL = Lower Explosive Limit; NE = Not Established; NFPA = National Fire Protection Association; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration; PEL = Permissible Exposure Limit (OSHA); SARA = Superfund Amendments and Reauthorization Act; STEL = Short Term Exposure Limit (15 minutes); TLV = Threshold Limit Value (ACGIH); TWA = Time Weighted Average (8 hours); UEL = Upper Explosive Limit; WHMIS = Worker Hazardous Materials Information System (Canada)

Disclaimer of Expressed and implied Warranties:
The information presented in this Material Safety Data Sheet is based on data believed to be accurate as of the date this Material Safety Data Sheet was prepared. HOWEVER, NO WARRANTY OF MERCHANTABILITY, FITNESS FOR ANY PARTICULAR PURPOSE, OR ANY OTHER WARRANTY IS EXPRESSED OR IS TO BE IMPLIED REGARDING THE ACCURACY OR COMPLETENESS OF THE INFORMATION PROVIDED ABOVE, THE RESULTS TO BE OBTAINED FROM THE USE OF THIS INFORMATION OR THE PRODUCT, THE SAFETY OF THIS PRODUCT, OR THE HAZARDS RELATED TO ITS USE. No responsibility is assumed for any damage or injury resulting from abnormal use or from any failure to adhere to recommended practices. The information provided above, and the product, are furnished on the condition that the person receiving them shall make their own determination as to the suitability of the product for their particular purpose and on the condition that they assume the risk of their use. In addition, no authorization is given nor implied to practice any patented invention without a license.

Vegetable Oil

MSDS # 786.00

ScholAR Chemistry

Section 1: Product and Company Identification

Vegetable Oil

Synonyms/General Names: Soybean Oil
Product Use: For educational use only
Manufacturer: Columbus Chemical Industries, Inc., Columbus, WI 53925.

24 Hour Emergency Information Telephone Numbers

CHEMTREC (USA): 800-424-9300 **CANUTEC (Canada): 613-424-6666**

ScholAR Chemistry; 5100 W. Henrietta Rd, Rochester, NY 14586; (866) 260-0501; www.Scholarchemistry.com

Section 2: Hazards Identification

Clear, light yellow, oily liquid; faint odor.

HMIS (0 to 4)

CAUTION! Combustible liquid.
Target organs: None known.

This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

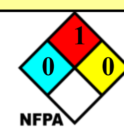
Section 3: Composition / Information on Ingredients

Vegetable Oil (8001-22-7), 100%

Always seek professional medical attention after first aid measures are provided.

Eyes: Immediately flush eyes with excess water for 15 minutes, lifting lower and upper eyelids occasionally.
Skin: Immediately flush skin with excess water for 15 minutes while removing contaminated clothing.
Ingestion: Call Poison Control immediately. Rinse mouth with cold water. Give victim 1-2 cups of water or milk to drink. Induce vomiting immediately.
Inhalation: Remove to fresh air. If not breathing, give artificial respiration.

When heated to decomposition, emits acrid fumes.
Protective equipment and precautions for firefighters: Use foam or dry chemical to extinguish fire. Firefighters should wear full fire fighting turn-out gear and respiratory protection (SCBA). Cool container with water spray. Material is not sensitive to mechanical impact or static discharge.



Section 6: Accidental Release Measures

Use personal protection recommended in Section 8. Isolate the hazard area and deny entry to unnecessary and unprotected personnel. Contain spill with sand or absorbent material and place in sealed bag or container for disposal. Ventilate and wash spill area after pickup is complete. See Section 13 for disposal information.

Section 7: Handling and Storage — Green

Handling: Use with adequate ventilation and do not breathe dust or vapor. Avoid contact with skin, eyes, or clothing. Wash hands thoroughly after handling.
Storage: Store in General Storage Area [Green Storage] with other items with no specific storage hazards. Store in a cool, dry, well-ventilated, locked store room away from incompatible materials.

Section 8: Exposure Controls / Personal Protection

Use ventilation to keep airborne concentrations below exposure limits. Have approved eyewash facility, safety shower, and fire extinguishers readily available. Wear chemical splash goggles and chemical resistant clothing such as gloves and aprons. Wash hands thoroughly after handling material and before eating or drinking. Exposure guidelines: Vegetable Oil : OSHA PEL: N/A, ACGIH: TLV: N/A, STEL: N/A.

Section 9: Physical and Chemical Properties

Molecular formula	Natural Product.	**Appearance**	Clear, light yellow, oily liquid.
Molecular weight	N/A.	**Odor**	Faint odor.
Specific Gravity	~0.9 g/mL @ 60°C.	**Odor Threshold**	N/A.
Vapor Density (air=1)	N/A.	**Solubility**	Insoluble.
Melting Point	22-31°C.	**Evaporation rate**	N/A. *(Butyl acetate = 1).*
Boiling Point/Range	N/A.	**Partition Coefficient**	N/A. *(log P_{OW}).*
Vapor Pressure (20°C)	N/A.	**pH**	N/A.
Flash Point:	255°C (491°F).	**LEL**	N/A.
Autoignition Temp.:	N/A.	**UEL**	N/A.

N/A = Not available or applicable

Section 10: Stability and Reactivity

Avoid heat and moisture.
Stability: Stable under normal conditions of use and storage.
Incompatibility: Oxidizing materials.
Shelf life: Indefinite if stored properly.

Section 11: Toxicology Information

Acute Symptoms/Signs of exposure: ***Eyes***: Redness, tearing, itching, burning, conjunctivitis. ***Skin***: Redness, itching. ***Ingestion***: Irritation and burning sensations of mouth and throat, nausea, vomiting and abdominal pain. ***Inhalation***: Irritation of mucous membranes, coughing, wheezing, shortness of breath,
Chronic Effects: No information found.
Sensitization: none expected
Vegetable Oil: LD50 [oral, rat]; N/A; LC50 [rat]; N/A; LD50 Dermal [rabbit]; N/A
Material has not been found to be a carcinogen nor produce genetic, reproductive, or developmental effects.

Section 12: Ecological Information

Ecotoxicity (aquatic and terrestrial): Not considered an environmental hazard.

Section 13: Disposal Considerations

Check with all applicable local, regional, and national laws and regulations. Local regulations may be more stringent than regional or national regulations. Small amounts of this material may be suitable for sanitary sewer or trash disposal.

Section 14: Transport Information

DOT Shipping Name:	Not regulated by DOT.	**Canada TDG:**	Not regulated by TDG.
DOT Hazard Class:		**Hazard Class:**	
Identification Number:		**UN Number:**	

Section 15: Regulatory Information

EINECS: Listed (232-274-4).
TSCA: All components are listed or are exempt.
WHMIS Canada: Not WHMIS Controlled.
California Proposition 65: Not listed.

The product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

Section 16: Other Information

Current Issue Date: December 19, 2011
Disclaimer: Scholar Chemistry and Columbus Chemical Industries, Inc., ("S&C") believes that the information herein is factual but is not intended to be all inclusive. The information relates only to the specific material designated and does not relate to its use in combination with other materials or its use as to any particular process. Because safety standards and regulations are subject to change and because S&C has no continuing control over the material, those handling, storing or using the material should satisfy themselves that they have current information regarding the particular way the material is handled, stored or used and that the same is done in accordance with federal, state and local law. ***S&C makes no warranty, expressed or implied, including (without limitation) warranties with respect to the completeness or continuing accuracy of the information contained herein or with respect to fitness for any particular use.***

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department: CALTRANS
Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County
Project Title: Construction on State HWY in El Dorado County
City's Project Number: 03-4M4404

Prepared By: Andy Thompson
Michels Project No: 40435

Date Received:
Engineer: Darlene Wulff
Contractor: Michels Corp

Submittal number: 10
Submittal Date: 5/27/2014
Revision Date: NA
Revision Number: NA

Specification Section: 15-6.11A(3)
Subsection: 4
Item: Calibration for Temp. and Pressure
Page: 20
Deviation (Y or N): N

Engineer's Stamp

Submittal Description: Temperature Reader, Pressure Guages and Sample Cure Log.
Intended Use: CIPP Reference Manual
Plan Sheet: NA
Manufacturer: NA
Supplier: NA

Applicable Standard: NA
Referenced Document: NA
Notes:

Bourdon Tube Pressure Gauge
Stainless Steel Construction
Model 21X.53

WIKA Datasheet 21X.53

Applications

- Intended for adverse service conditions where pulsating or vibration exists (with liquid filling)
- Hydraulics & compressors
- Suitable for gaseous or liquid media that will not obstruct the pressure system

Special Features

- Vibration and shock resistant (with liquid filling)
- Stainless steel case
- Pressure ranges up to 15,000 psi

Bourdon Tube Pressure Gauge Model 21X.53

Standard Features

Design
ASME B40.100 & EN 837-1

Sizes
2", 2½" & 4" (50, 63 & 100 mm)

Accuracy class
2" & 2½": ± 2/1/2% of span (ASME B40.100 Grade A)
4": ± 1% of span (ASME B40.100 Grade 1A)

Ranges
Vacuum / Compound to 200 psi
Pressure from 15 psi to 15,000 psi
Pressure from 15 psi to 10,000 psi - 2" size
or other equivalent units of pressure or vacuum

Working pressure

2 & 2½":	Steady:	¾ full-scale value
	Fluctuating:	⅔ full-scale value
	Short time:	full-scale value
4":	Steady:	full-scale value
	Fluctuating:	0.9 x full-scale value
	Short time:	1.3 x full-scale value

Operating temperature
Ambient: -40°F to +140°F (-40°C to +60°C) - dry
-4°F to +140°F (-20°C to +60°C) - glycerine filled
-40°F to +140°F (-40°C to +60°C) - silicone filled
Medium: +140°F (+60°C) maximum

Temperature error
Additional error when temperature changes from reference temperature of 68°F (20°C) ±0.4% for every 18°F (10°C) rising or falling. Percentage of span.

Weather protection
Weather tight (NEMA 4X / IP 65)

Pressure connection
Material: copper alloy
Lower mount (LM) or center back mount (CBM) - 2" & 2½"
Lower mount (LM) or lower back mount (LBM) - 4"
⅛" NPT, ¼" NPT or ½" NPT limited to wrench flat areaABS (2" & 2½") and white aluminum (4")

Bourdon tube
2½" Size- Material: Copper alloy
30" Hg (VAC) to 800 psi - C-type (soldered)
1000 psi to 15,000 psi - helical type (soldered)
Changes to stainless steel at 7,500 psi brazed
4" Size- Material: Copper alloy ≤ 1,000 psi
316 stainless steel ≥ 1,500 psi
30" Hg (Vac) to 1,000 psi- C-type (soldered)
1,500 psi to 15,000 psi- helical type (brazed)
Changes to stainless steel at 1,500 psi

Movement
Copper alloy

Dial
White ABS (2" & 2½") and white aluminum (4")

Pointer
Black aluminum

Case
304 stainless steel with vent plug and stainless steel crimp ring. Suitable for liquid filling.

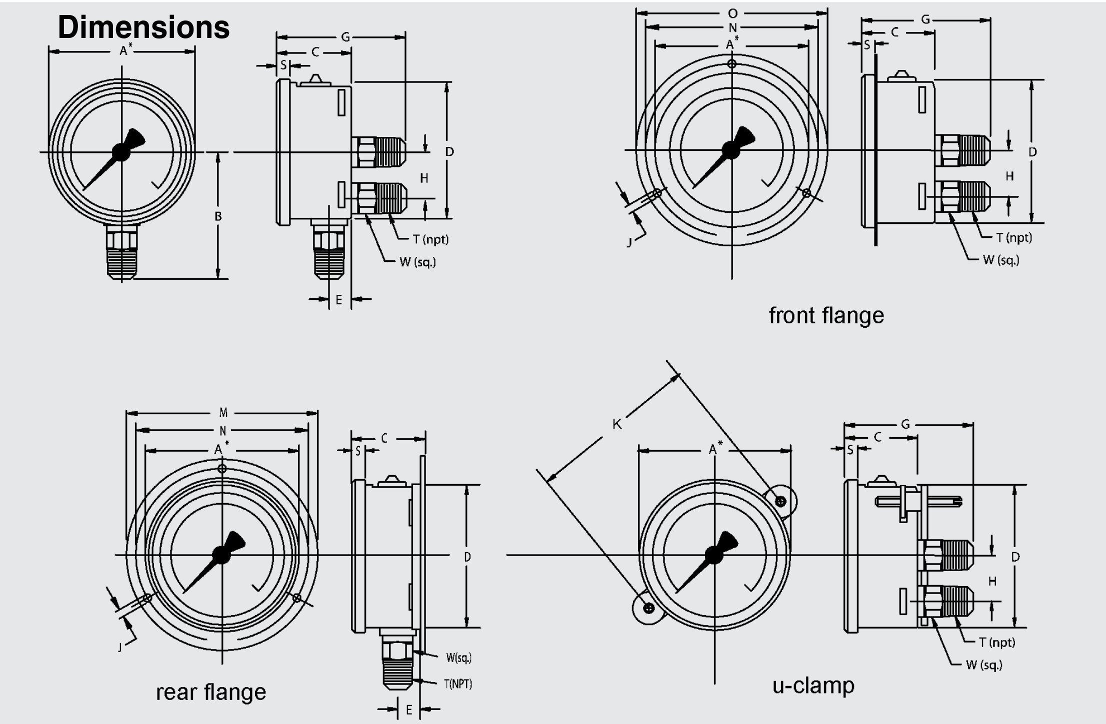
Case connection sealed with O-ring, (O-ring material dependent on the case fill):
- 2½": EPDM O-ring for Glycerine case fill; Viton O-ring for Silicone fill
- 4": EPDM O-ring for Glycerine or Silicone case fill; Viton O-ring for Halocarbon or Fluorolube fill

Window
Polycarbonate with Buna-N gasket

Case fill
Glycerine 99.7% - Type 213.53

Optional extras
- Brass restrictor
- Stainless steel front or rear flange - 2½" & 4"
- Zinc-plated steel or SS U-clamp bracket (field installable)
- External zero adjustment (2½" only)
- Red drag pointer or mark pointer
- Silicone or Fluorolube case filling
- Special connections limited to wrench flat area
- Custom dial layout
- Other pressure scales available
  bar, kPa, MPa, kg/cm^2 and dual scales

Dimensions



Size		A	B	C	D	E	G	H	J	K	M	N	O	S	T	W	Weight	
2”	mm	55	48	30	50	12	53	-	3.6	72	71	60	17	5.5		14	0.27 lb.	dry
	in	2.17	1.89	1.18	1.97	0.47	2.09	-	0.14	2.83	2.80	2.36	2.80	0.22	¼”	0.55	0.33 lb.	filled
2½”	mm	69	54	32	62	13	54	-	3.6	72	88.1	75	85	6.5		14	0.36 lb.	dry
	in	2.69	2.13	1.26	2.45	0.51	2.13	-	0.14	2.83	3.47	2.95	3.35	0.26	¼”	0.55	0.44 lb.	filled
4”	mm	107	87	48	100	15.5	79.5	30	4.8	109	132	116	132	8		22	1.10 lb.	dry
	in	4.21	3.43	1.89	3.91	0.61	3.13	1.18	0.19	4.29	5.20	4.57	5.20	0.31	½”	0.87	1.76 lb.	filled

Note: For ¼” NPT connections on 4” gauges, reduce B dimension by 5mm/0.2”

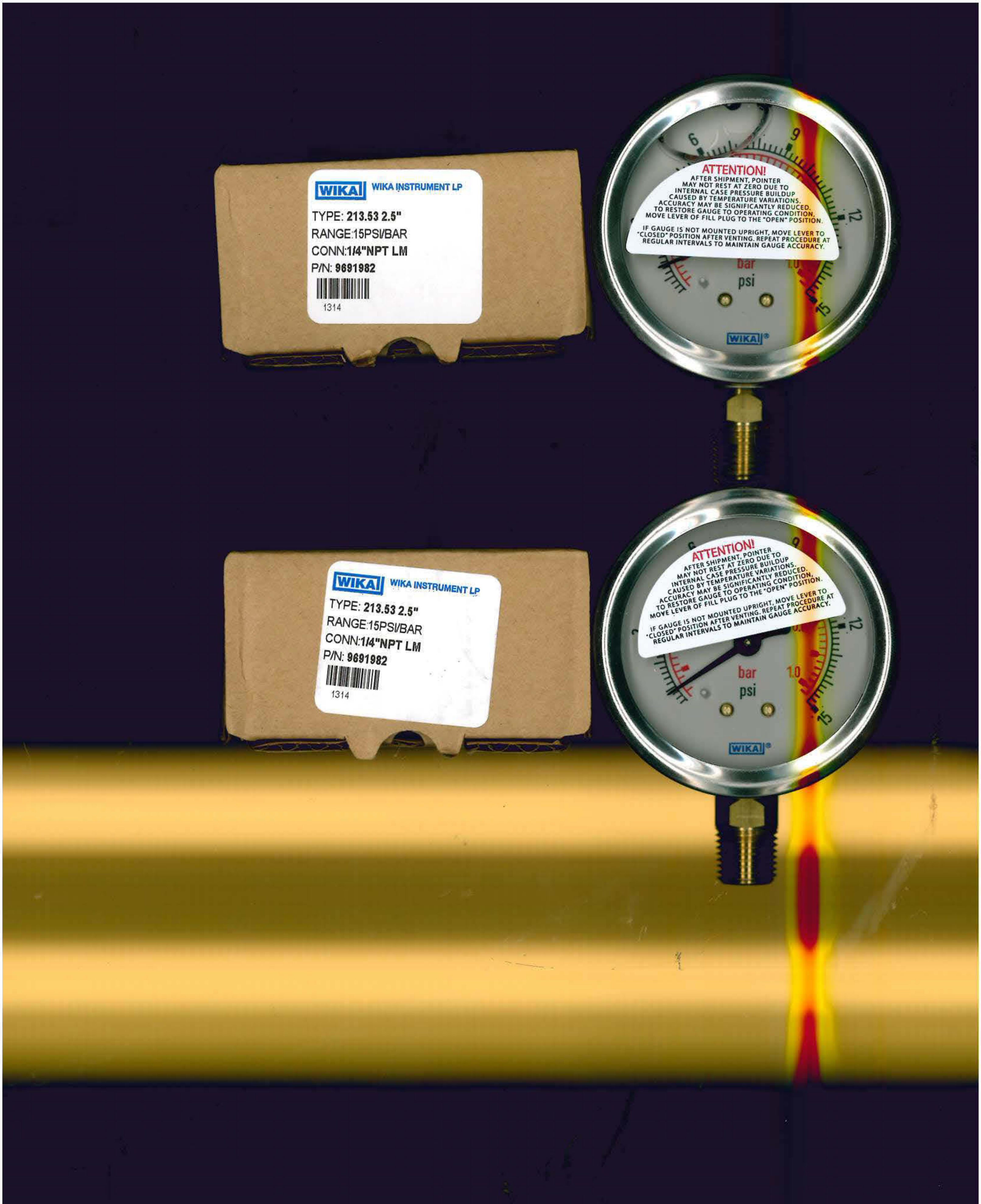
Recommended panel cut-out:
2”- U-clamp: 51mm
front flange: n/a

2½”- U-clamp: 63mm
front flange: 65mm

4”- U-clamp: 101mm
front flange: 104mm

4½”- panel mount adapter 104mm minimum
(not shown)

WIKA Instrument Corporation
1000 Wiegand Boulevard
Lawrenceville, GA 30043-5868
Tel: 888-WIKA-USA • 770-513-8200
Fax: 770-338-5118
E-Mail: info@wika.com
www.wika.com


WIKA
WIKA INSTRUMENT LP
TYPE: 213.53 2.5"
RANGE:15PSI/BAR
CONN:1/4"NPT LM
P/N: 9691982
1314
ATTENTION!
AFTER SHIPMENT, POINTER MAY NOT REST AT ZERO DUE TO INTERNAL CASE PRESSURE BUILDUP CAUSED BY TEMPERATURE VARIATIONS. ACCURACY MAY BE SIGNIFICANTLY REDUCED. TO RESTORE GAUGE TO OPERATING CONDITION, MOVE LEVER OF FILL PLUG TO THE "OPEN" POSITION.
IF GAUGE IS NOT MOUNTED UPRIGHT, MOVE LEVER TO "CLOSED" POSITION AFTER VENTING. REPEAT PROCEDURE AT REGULAR INTERVALS TO MAINTAIN GAUGE ACCURACY.
bar
psi
WIKA
WIKA
WIKA INSTRUMENT LP
TYPE: 213.53 2.5"
RANGE:15PSI/BAR
CONN:1/4"NPT LM
P/N: 9691982
1314
ATTENTION!
AFTER SHIPMENT, POINTER MAY NOT REST AT ZERO DUE TO INTERNAL CASE PRESSURE BUILDUP CAUSED BY TEMPERATURE VARIATIONS. ACCURACY MAY BE SIGNIFICANTLY REDUCED. TO RESTORE GAUGE TO OPERATING CONDITION, MOVE LEVER OF FILL PLUG TO THE "OPEN" POSITION.
IF GAUGE IS NOT MOUNTED UPRIGHT, MOVE LEVER TO "CLOSED" POSITION AFTER VENTING. REPEAT PROCEDURE AT REGULAR INTERVALS TO MAINTAIN GAUGE ACCURACY.
bar
1.0
psi
WIKA

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UEi certifies that the instrument listed below was calibrated to UEi standards and

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The recommended calibration interval for maintaining instrument accuracy is one year.

CUSTOMER: MICHELS CORP.

INSTRUMENT: DT301

SERIAL NUMBER: 131105494

DATE: 04/08/14

TESTED BY: P.B.#060

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The recommended calibration interval for maintaining instrument accuracy is one year.

CUSTOMER: MICHELS CORP.

INSTRUMENT: DT301

SERIAL NUMBER: 131105476

DATE: 04/08/14

TESTED BY: P.B.#060

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UEi certifies that the instrument listed below was calibrated to UEi standards and met or exceeded all published specifications at the time of shipment.

The recommended calibration interval for maintaining instrument accuracy is one year.

CUSTOMER: MICHELS CORP.

INSTRUMENT: DT302

SERIAL NUMBER: 130402119

DATE: 04/08/14

TESTED BY: P.B.#060

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DT301 Digital Temperature Logger
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HOLD
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LOGGING
CLEAR
EXIT
ENTER
DT302 Digital Temperature Logger
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T1/T2
T1-T2
MAX/MIN
HOLD
°C/°F/K
RECALL
SETUP
LOGGING
CLEAR
EXIT
ENTER
DT301 Digital Temperature Logger
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POWER
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LOGGING
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EXIT
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131105476
130402119
131105494

will record temperature in 5 minute intervals.

UEI DT301 Apollo 1 Digital Temperature Logger

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Description of UEI DT301 Apollo 1 Digital Temperature Logger:

UEI DT301 Apollo 1 Digital Temperature Logger offers logging capabilities with 9,999 memory positions, monitoring and uploading data to a computer via USB can be routine, helping to analyze system performance trends with the included software. This digital temperature logger features an amber backlit display that offers large easy-to-read digits.

Characteristics of UEI DT301 Apollo 1 Digital Temperature Logger:

	Single Thermocouple input
	Temp range -346 to +2192 F (J)
	Temp range -328 to +2498 F (K)
	Data logging
	9,999 Memory positions
	USB interface (software included)
	Thermocouple temperature offset
	MIN, MAX, AVG & Hold

	Probe Storage
	Accepts J, K, T and E type probes
	5 year limited warranty
Includes:	1 J type probe with clip, 2 AAA batteries, Quick Start Guide and Owners Manual
Specifications of UEI DT301 Apollo 1 Digital Temperature Logger:	
Measurement Range	J-Type: -346 to +2192 F (-210 to +1200 C); K-Type: -328 to +2498 F (-200 to +1370 C); T-Type: -418 to +752 F (-250 to +400 C); E-Type: -238 to +1832 F (-150 to +1000 C)
Display Resolution	0.1 F/ C < 1000 1.0 F/ C 1000
Accuracy	J, K, T, and E-Type; [0.1% +1.0 F (0.5 C)] [Below -148 F (-100 C): add 0.2% of reading for J, K, and E-Type; and 0.1% of reading for T-Type
Temperature Coefficient	0.01% of reading 0.1 F per F(+0.05 C per C) for <+64 F (+18 C) or +82 F (+28 C) [Below -148 F (-100 C): add 0.05% of reading for J, K, and E-type; and 0.1% of reading for T-type
Real Time Clock Tolerance	About 1 second per day
Maximum Differential Common Mode Voltage	1V (maximum voltage difference between any pair of inputs)
Temperature Scale	ITS-90 (International Temperature Scale of 1990)
Applicable Standards	N.I.S.T. Monograph 175 revised to ITS-90
Battery	2 x LR03 (AAA) type 1.5V
Dimension	7.20 (H) x 3.70 (W) x 1.70 (D)
Weight	Approx. 16.2 oz
Certification	CE
Safety	IEC 1010-1 (2001), UL 3111-1 (6, 1994), EN 61010-1 (2001), CSA C22.2; No. 1010.1 (1992)
CAT I	Over Voltage (Installation) CATEGORY I, Pollution Degree 2 per IEC 1010-1
Compliance	IEC 60529: IP67 (Ingress Protection rating) Water Immersion (3 up to 30 min) No ingress of dust (20mBar up to 8 hrs.)
Datasheet:	

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Department: CALTRANS

Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County

Project Title: Construction on State HWY in El Dorado County

City's Project Number: 03-4M4404

Prepared By: Andy Thompson

Michels Project No: 40435

Date Received:

Engineer: Darlene Wulff

Contractor: Michels Corp

Submittal number: 11

Submittal Date: 5/27/2014

Revision Date: NA

Revision Number: NA

Specification Section: 15-6.11A(3)

Subsection: 5

Item: 3rd Party Testing

Page: 20

Deviation (Y or N): N

Engineer's Stamp

Submittal Description: 3rd Party Testing Info

Intended Use: CIPP Refernece Manual

Plan Sheet: NA

Manufacturer: NA

Supplier: NA

Applicable Standard: ASTM F 1216

Referenced Document: ASTM F 1216

Notes:

INTERPLASTIC CORPORATION
Thermoset Resins Division

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

Corrosion Test Data
COR72-AT and AZ Type Products
Flexural Strength and Modulus Retention

ASTM F1216 & D543 (CIPP)

Immersion	Flexural Strength Retention, %				Flexural Modulus Retention, %			
	Months				Months			
Media	1	3	6	12	1	3	6	12
100% Tap Water	94	100	97	89	100	96	93	91
5% Nitric Acid	100	92	86	82	86	88	81	80
10% Phosphoric Acid	98	88	90	95	84	89	83	80
10% Sulfuric Acid	93	91	93	93	92	92	94	93
100% Fuel C	85	100	100	100	96	97	99	94
0.1% Detergent	99	92	91	90	100	99	99	93
0.1% Soap Solution	100	87	100	90	97	94	100	92
100% Vegetable Oil	81	100	81	100	100	96	80	97

ASTM D5813, F1743 & D543 (CIPP)

1% Nitric Acid	100	84	86	100	100	93	86	93
5% Sulfuric Acid	94	81	95	87	87	92	81	80
100% Fuel C	85	100	100	100	96	97	99	94
0.1% Detergent	99	92	91	90	100	99	99	93
0.1% Soap Solution	100	87	100	90	97	94	100	92
100% Vegetable Oil	81	100	81	100	100	96	80	97

ASTM C581 & D543 (GRP)

100% Tap Water	100	97	100	100	100	95	100	91
1% Nitric Acid	100	100	100	80	100	93	99	83
5% Nitric Acid	100	100	96	80	97	94	96	81
10% Phosphoric Acid	100	100	100	100	100	100	99	88
5% Sulfuric Acid	100	100	91	82	98	100	88	90
10% Sulfuric Acid	100	100	100	95	94	83	85	80
100% Fuel C	100	100	90	100	95	100	100	100
0.1% Detergent	100	100	100	100	100	95	100	100
0.1% Soap Solution	91	96	82	100	97	100	93	90
100% Vegetable Oil	100	100	100	100	98	100	100	90
pH 0.5 Solution	100	100	91	82	98	100	88	90
pH 10 Solution	100	100	100	100	100	95	100	100

Other Corrosion Testing (CIPP)

1% Sodium Hydroxide	95	95	90	69	100	96	93	91
1% Sodium Hypochlorite	94	84	92	80	96	95	98	85
1% Ammonium Hydroxide	100	100	100	99	99	100	94	92

Note: Non-shaded regions are the applicable test durations as it relates to achievement of the minimum acceptable retentions.
All corrosion media maintained @ 73.4$\pm$ 3.6°F (23 $\pm$ 2°C).

INTERPLASTIC CORPORATION
Thermoset Resins Division

INTERPLASTIC CORPORATION

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

COR78-AT-5XX Type Resins

ASTM F1216 & D543 (CIPP) Corrosion Data @ 73.4 +/- 3.6°F (23 +/- 2°C)

Immersion Media	Flexural Strength Retention, % Months 1	12	Flexural Modulus Retention, % Months 1	12
100% Tap Water (pH 6 - 9)	97		97	
5% Nitric Acid	96		96	
10% Phosphoric Acid	94		100	
10% Sulfuric Acid	95		100	
100% Gasoline	100		99	
0.1% Detergent	94		96	
0.1% Soap Solution	95		97	
100% Vegetable Oil	98		100	

ASTM D5813, F1743 & D543 (CIPP) Corrosion Data @ 73.4 +/- 3.6°F (23 +/- 2°C)

Immersion Media	Flexural Strength Retention, % Months 1	12	Flexural Modulus Retention, % Months 1	12
1% Nitric Acid	97		98	
5% Sulfuric Acid	98		100	
100% Gasoline	100		99	
0.1% Detergent	94		96	
0.1% Soap Solution	95		97	
100% Vegetable Oil	98		100	

Note: Non-shaded regions are the applicable test durations as it relates to achievement of the minimum acceptable retentions.

**All testing was conducted by HTS Pipe Consultants, Inc.

HTS Pipe Consultants, Inc.
420 Pickering Street, Houston, TX 77091
www.htspipeconsultants.com

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Toll Free 1-800-692-TEST

August 16, 2011

Interplastic Corporation
Thermoset Resins Division
2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-4235

Attn: Mr. Jason Schiro, Senior Chemist
Corrosion and Specialty Resins

Re: One Month Test Results
Chemical Resistance Testing of
Cured in-Place Pipe (CIPP) Samples
No. LB-00048515

Dear Mr. Schiro:

Please find enclosed one month chemical resistance test results for samples of Cured-in-Place Pipe received in our laboratory on July 7, 2011. Per your instructions the sample has been identified as #LB-00048515. The samples were constructed with COR78-AT-5XX type resin.

All of the test coupons were prepared and post-cured by the Research and Development Laboratory of Interplastic Corporation's Thermoset Resins Division. The resin was initiated with 0.70% and 0.35% by weight of Akzo Nobel's Perkadox 16 and Trigonox 42S, respectively. The initiated resin was impregnated into the felt and clamped between metal plates with precision spacers. The panels were gelled at 150° F (66°C) and held at that temperature for four hours. The panels were then post-cured at 180°F (82°C) for sixteen additional hours. The test coupons were cut and labeled from the cured panels. Each coupon was edge-coated with the same resin used to construct the coupon, and post-cured an additional 4 hours at 150°F (66°C).

The testing program was conducted in accordance with the following:

- ASTM F1216, "Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin –Impregnated Tube".
- ASTM F1743, "Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)".
- ASTM D5813, "Standard Specification for Cured-in-Place Thermosetting Resin Sewer Pipe".

- ASTM D2122, "Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings".
- ASTM D790, "Test Method for Flexural Properties of Unreinforced and Reinforced Plastics".

The initial weight, hardness (ASTM D2583) and thickness (ASTM D2122) of each coupon sample was recorded prior to immersion. One (1) coupon sample was utilized as a control base sample.

The coupon samples were immersed in 10 different chemical reagents. Eight of the reagents are as specified in ASTM F1216, section X2, Table X2.1. The other two reagents (Nitric Acid 5% and Sulfuric Acid 10%) are as specified in ASTM F1743, section 8, table 2. The coupon samples were exposed to the reagents for a period of 1 month. At the end of 1 month the coupon samples were removed from the reagent containers, rinsed, dried, weighed and tested for thickness and hardness.

The coupon samples were then tested for flexural strength and flexural modulus of elasticity. A summary of all test data and percent change in each property is included in the attached summary of test data. ASTM F1216, Section X2.2.1 states that the test specimens should lose no more than 20% of their initial flexural strength and flexural modulus during the exposure time. As indicated by these test results, all of these samples comply with that specification requirement.

Should you have any questions or comments regarding these tests or this report, please do not hesitate to call us. Thank you very much.

Sincerely,

Larry L. McMichael
Principal
S:/ClientInformation/InterplasticCorp.-CIPPChemicalResistance
30DayResults/LB-00048515

SUMMARY OF TEST DATA
RESISTANCE OF CIPP TO CHEMICAL REAGENTS

SAMPLE ID: COR78-AT-5XX Duration: 30 Days Date Tested: 8/12/2011

Chemical Reagent (Concentration)	Mechanical Property	Test Method ASTM D	Unit	Control Sample	30 Days Value	30 Days % Change
Tap water (100%)	Observation	543		N/A	No Change	pH 7.5
	Weight	543	g	144.84	145.47	0.43
	Hardness	2583		89.2	89.2	0.00
	Thickness	2122	in.	0.265	0.265	0.00
			mm.	6.7	6.7	0.00
	Max. Flexural	790	psi	8180	7896	-3.47
	Modulus	790	psi	665887	648714	-2.58
Nitric Acid (5%)	Observation	543		N/A	No Change	pH 0.2
	Weight	543	g	147.19	147.87	0.46
	Hardness	2583		88.0	88.0	0.00
	Thickness	2122	in.	0.269	0.269	0.00
			mm.	6.8	6.8	0.00
	Max. Flexural	790	psi	8180	7858	-3.94
	Modulus	790	psi	665887	640045	-3.88
Phosphoric Acid (10%)	Observation	543		N/A	No Change	pH 0.7
	Weight	543	g	146.16	146.72	0.38
	Hardness	2583		88.2	88.2	0.00
	Thickness	2122	in.	0.276	0.276	0.00
			mm.	7.0	7.0	0.00
	Max. Flexural	790	psi	8180	7709	-5.76
	Modulus	790	psi	665887	663334	-0.38
Sulfuric Acid (10%)	Observation	543		N/A	No Change	pH 0.1
	Weight	543	g	143.33	143.80	0.33
	Hardness	2583		89.0	89.0	0.00
	Thickness	2122	in.	0.265	0.265	0.00
			mm.	6.7	6.7	0.00
	Max. Flexural	790	psi	8180	7774	-4.96
	Modulus	790	psi	665887	667650	0.26

HTS Pipe Consultants

SUMMARY OF TEST DATA
RESISTANCE OF CIPP TO CHEMICAL REAGENTS

SAMPLE ID: COR78-AT-5XX Duration: 30 Days Date Tested: 8/12/2011

Chemical Reagent (Concentration)	Mechanical Property	Test Method ASTM D	Unit	Control Sample	30 Days	
					Value	% Change
Gasoline (100%)	Observation	543		N/A	No Change	pH-NA
	Weight	543	g	142.18	142.37	0.13
	Hardness	2583		88.8	88.8	0.00
	Thickness	2122	in.	0.270	0.270	0.00
			mm.	6.9	6.9	0.00
	Max. Flexural	790	psi	8180	8527	4.24
	Modulus	790	psi	665887	656421	-1.42
Vegetable Oil (100%)	Observation	543		N/A	No Change	pH-NA
	Weight	543	g	150.03	150.11	0.05
	Hardness	2583		88.8	88.8	0.00
	Thickness	2122	in.	0.283	0.283	0.00
			mm.	7.2	7.2	0.00
	Max. Flexural	790	psi	8180	8039	-1.72
	Modulus	790	psi	665887	675249	1.41
Detergent (0.1%)	Observation	543		N/A	No Change	pH 5.6
	Weight	543	g	154.08	154.72	0.42
	Hardness	2583		89.4	89.4	0.00
	Thickness	2122	in.	0.283	0.283	0.00
			mm.	7.2	7.2	0.00
	Max. Flexural	790	psi	8180	7697	-5.90
	Modulus	790	psi	665887	638719	-4.08
Soap (0.1%)	Observation	543		N/A	No Change	pH 5.8
	Weight	543	g	147.44	148.08	0.43
	Hardness	2583		88.6	88.6	0.00
	Thickness	2122	in.	0.274	0.274	0.00
			mm.	7.0	7.0	0.00
	Max. Flexural	790	psi	8180	7778	-4.91
	Modulus	790	psi	665887	644970	-3.14

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SUMMARY OF TEST DATA
RESISTANCE OF CIPP TO CHEMICAL REAGENTS

SAMPLE ID: COR78-AT-5XX Duration: 30 Days Date Tested: 8/12/2011

Chemical Reagent (Concentration)	Mechanical Property	Test Method ASTM D	Unit	Control Sample	30 Days Value	30 Days % Change
Nitric Acid (1%)	Observation	543		N/A	No Change	pH 0.5
	Weight	543	g	132.37	132.96	0.45
	Hardness	2583		89.0	89.0	0.00
	Thickness	2122	in.	0.254	0.254	0.00
			mm.	6.5	6.5	0.00
	Max. Flexural	790	psi	8180	7967	-2.60
	Modulus	790	psi	665887	652904	-1.95
Sulfuric Acid (5%)	Observation	543		N/A	No Change	pH 0.3
	Weight	543	g	136.69	137.23	0.40
	Hardness	2583		88.4	88.4	0.00
	Thickness	2122	in.	0.258	0.258	0.00
			mm.	6.6	6.6	0.00
	Max. Flexural	790	psi	8180	8015	-2.02
	Modulus	790	psi	665887	664824	-0.16

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Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26.

OPERATOR NAME:
E. CARRILLO

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, CONTROL

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.532	0.242	4.0
2	0.534	0.250	4.0
3	0.535	0.258	4.0
4	0.533	0.263	4.0
5	0.537	0.269	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0449	41.6	8020	653474
2	0.0505	44.4	7991	679712
3	0.0453	49.2	8282	672851
4	0.0500	50.5	8226	663459
5	0.0505	54.3	8382	659940
Mean	0.0482	48.0	8180	665887
Standard Deviation	0.0029	5.0	170	10428
Minimum	0.0449	41.6	7991	653474
Maximum	0.0505	54.3	8382	679712

F128-2-C.is_flex

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Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26.

OPERATOR NAME:
E. CARRILLO

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN TAP WATER (100%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.531	0.242	4.0
2	0.533	0.253	4.0
3	0.538	0.264	4.0
4	0.536	0.274	4.0
5	0.535	0.280	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0467	39.8	7674	636433
2	0.0485	45.1	7939	652616
3	0.0451	50.8	8132	648610
4	0.0498	53.5	7973	643495
5	0.0499	54.3	7761	662414
Mean	0.0480	48.7	7896	648714
Standard Deviation	0.0021	6.1	181	9759
Minimum	0.0451	39.8	7674	636433
Maximum	0.0499	54.3	8132	662414

F128-2-1.is_flex

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Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26.

OPERATOR NAME:
E. CARRILLO

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN NITRIC ACID (5%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.535	0.258	4.0
2	0.535	0.265	4.0
3	0.537	0.271	4.0
4	0.532	0.277	4.0
5	0.536	0.280	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0432	48.3	8130	631059
2	0.0500	48.3	7715	632280
3	0.0446	49.9	7589	630538
4	0.0500	53.1	7811	663120
5	0.0500	56.3	8044	643226
Mean	0.0476	51.2	7858	640045
Standard Deviation	0.0034	3.5	226	13910
Minimum	0.0432	48.3	7589	630538
Maximum	0.0500	56.3	8130	663120

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Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26.

OPERATOR NAME:
E. CARRILLO

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN PHOPHORIC ACID (10%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.534	0.265	4.0
2	0.537	0.272	4.0
3	0.533	0.279	4.0
4	0.531	0.285	4.0
5	0.531	0.287	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0488	49.8	7972	676749
2	0.0462	51.4	7761	670671
3	0.0442	53.7	7768	651951
4	0.0311	51.0	7099	661853
5	0.0423	57.9	7948	655446
Mean	0.0425	52.8	7709	663334
Standard Deviation	0.0068	3.2	355	10341
Minimum	0.0311	49.8	7099	651951
Maximum	0.0488	57.9	7972	676749

F128-2-3.is_flex

HTS Pipe Consultants, Inc.
420 Pickering Street, Houston, TX 77091
www.htspipeconsultants.com

Phone 713-692-8373
Fax 713-692-8502
Toll Free 1-800-692-TEST

HTS Pipe Consultants

Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26.

OPERATOR NAME:
E. CARRILLO

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN SULFURIC ACID (10%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.532	0.252	4.0
2	0.537	0.262	4.0
3	0.537	0.269	4.0
4	0.538	0.275	4.0
5	0.533	0.279	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0440	44.5	7905	645290
2	0.0499	49.1	7991	653064
3	0.0501	50.7	7833	682337
4	0.0496	52.2	7694	694689
5	0.0383	51.5	7449	662871
Mean	0.0464	49.6	7774	667650
Standard Deviation	0.0052	3.1	212	20508
Minimum	0.0383	44.5	7449	645290
Maximum	0.0501	52.2	7991	694689

F128-2-4.is_flex

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Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26

OPERATOR NAME:
E. Carrillo

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN GASOLINE (100%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.535	0.257	4.0
2	0.534	0.265	4.0
3	0.538	0.274	4.0
4	0.541	0.281	4.0
5	0.540	0.285	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0512	47.5	8065	633658
2	0.0462	54.0	8647	664297
3	0.0438	58.0	8611	662401
4	0.0502	60.0	8426	657865
5	0.0503	64.9	8883	663883
Mean	0.0483	56.9	8527	656421
Standard Deviation	0.0032	6.6	305	12978
Minimum	0.0438	47.5	8065	633658
Maximum	0.0512	64.9	8883	664297

F128-2-5.is_flex

HTS Pipe Consultants, Inc.
420 Pickering Street, Houston, TX 77091
www.htspipeconsultants.com

Phone 713-692-8373
Fax 713-692-8502
Toll Free 1-800-692-TEST

Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26

OPERATOR NAME:
E. Carrillo

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN VEGETABLE OIL (100%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.536	0.268	4.0
2	0.534	0.278	4.0
3	0.536	0.285	4.0
4	0.533	0.291	4.0
5	0.533	0.295	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0500	53.7	8371	650918
2	0.0485	54.8	7967	680738
3	0.0411	55.4	7631	678077
4	0.0490	62.4	8296	685359
5	0.0433	61.3	7928	681152
Mean	0.0464	57.5	8039	675249
Standard Deviation	0.0039	4.0	300	13849
Minimum	0.0411	53.7	7631	650918
Maximum	0.0500	62.4	8371	685359

F128-2-6.is_flex

HTS Pipe Consultants, Inc.
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www.htspipeconsultants.com

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Toll Free 1-800-692-TEST

HTS Pipe Consultants

Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26

OPERATOR NAME:
E. Carrillo

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN DETERGENT(0.1%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.529	0.268	4.0
2	0.534	0.278	4.0
3	0.537	0.285	4.0
4	0.536	0.290	4.0
5	0.536	0.293	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0459	50.5	7972	626162
2	0.0447	55.7	8103	625880
3	0.0382	51.5	7082	652229
4	0.0484	59.0	7857	624722
5	0.0407	57.3	7472	664601
Mean	0.0436	54.8	7697	638719
Standard Deviation	0.0041	3.7	417	18512
Minimum	0.0382	50.5	7082	624722
Maximum	0.0484	59.0	8103	664601

F128-2-7.is_flex

HTS Pipe Consultants, Inc.
420 Pickering Street, Houston, TX 77091
www.htspipeconsultants.com

Phone 713-692-8373
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Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26

OPERATOR NAME:
E. Carrillo

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN SOAP (0.1%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.529	0.253	4.0
2	0.534	0.265	4.0
3	0.532	0.276	4.0
4	0.535	0.285	4.0
5	0.536	0.290	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0485	46.3	8202	626116
2	0.0406	51.1	8169	667818
3	0.0439	52.3	7747	648301
4	0.0397	54.4	7516	639037
5	0.0459	54.5	7254	643577
Mean	0.0437	51.7	7778	644970
Standard Deviation	0.0037	3.4	412	15213
Minimum	0.0397	46.3	7254	626116
Maximum	0.0485	54.5	8202	667818

F128-2-8.is_flex

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HTS Pipe Consultants

Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26

OPERATOR NAME:
E. Carrillo

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN NITRIC ACID (1%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.532	0.241	4.0
2	0.534	0.249	4.0
3	0.535	0.255	4.0
4	0.536	0.261	4.0
5	0.530	0.265	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0421	40.9	7946	630824
2	0.0411	43.8	7940	639510
3	0.0481	46.8	8067	658640
4	0.0487	48.5	7974	658865
5	0.0477	49.1	7910	676680
Mean	0.0455	45.8	7967	652904
Standard Deviation	0.0036	3.4	60	18032
Minimum	0.0411	40.9	7910	630824
Maximum	0.0487	49.1	8067	676680

F128-2-9.is_flex

HTS Pipe Consultants, Inc.
420 Pickering Street, Houston, TX 77091
www.htspipeconsultants.com

Phone 713-692-8373
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Friday, August 12, 2011

FLEXURAL PROPERTIES OF PLASTICS
ASTM D790
3 POINT BEND

INSTRON CORPORATION
BLUEHILL V. 2.26

OPERATOR NAME:
E. Carrillo

TEMPERATURE (F) / HUMIDITY (%)
71 / 50

RATE (in/min)
.110

SAMPLE ID:

78-AT-5XX, SAMPLE SOAKED IN SULFURIC ACID (5%) FOR 30 DAYS

	WIDTH (in)	THICKNESS (in)	SUPPORT SPAN (in)
1	0.536	0.248	4.0
2	0.536	0.255	4.0
3	0.535	0.262	4.0
4	0.535	0.265	4.0
5	0.531	0.267	4.0

	STRAIN @ MAX (in/in)	MAXIMUM LOAD (lbf)	FLEXURAL STRENGTH (psi)	FLEXURAL MODULUS (psi)
1	0.0476	42.3	7695	618620
2	0.0495	48.0	8270	673286
3	0.0500	48.8	7967	695363
4	0.0465	49.9	7971	651761
5	0.0501	51.5	8169	685090
Mean	0.0487	48.1	8015	664824
Standard Deviation	0.0016	3.5	221	30498
Minimum	0.0465	42.3	7695	618620
Maximum	0.0501	51.5	8270	695363

F128-2-10.is_flex

DGK Technologies *Common Sense and Uncommon Technology*

3754 NW Sierra Drive
Camas, WA 98607

Phone (360) 833-8725
Fax (360) 833-8728

October 25, 2012

Pat Anderson
Michel's Pipeline Services
1715 16th Street SW
Salem, OR 97302

Mr. Anderson,

DGK Technologies is an independent full service third party testing laboratory that specializes in destructive testing for composite materials. Our laboratory also provides services that include expert witness consulting, failure analysis, and new material development. Owner, Doug Kleweno has over 25 years of materials development experience that includes polymer materials R&D at Dow Chemical, Development Manager at Inllner USA, and authoring several ASTM testing specifications. All testing equipment is new and state of the art and fully certified by Instron Corporation for the accuracy and precision of the testing results.

I am writing to specifically summarize the procedure(s) followed for third party testing associated with cured-in-place pipe (CIPP) quality control verification for each installation.

First, I want to emphasize that the procedures followed by DGK Technologies are not unique to our company. The procedures are well defined in American Standard Test Method (ASTM) documents that are widely accepted in North America for a wide range of technologies and materials evaluations (i.e. ASTM F1216 & ASTM D790).

Please see the attached write up on the following document and the attached ASTM standards for the procedure. I also have provided a copy of a test report from a recent project that is representative of the information provided to the contractor and project owner. If you have additional questions, please let me know so I can follow up with you.

Best Regards,

Doug Kleweno

Doug Kleweno
President
DGK Technologies
Cell 360-713-7707

DGK Technologies *Common Sense and Uncommon Technology*

3754 NW Sierra Drive
Camas, WA 98607

Phone (360) 833-8725
Fax (360) 833-8728

November 20, 2012

DGK Report Number:	MPS111512-20415-2

Mr. Pat Anderson
Michels Pipeline Services
1715 16th Street SE
Salem, OR 97302

Customer Project Name: Marysville

Customer Project Number: 20415
Date Sample Received: 11/15/12
Date Sample Tested: 11/19/12

A plate sample was delivered to DGK Technologies, LLC for testing. The sample was tested for flexural modulus and strength in accordance with ASTM D790, Method I, Procedure A for three point bend flexural properties. A span to depth ratio of 16:1 was used as specified in the test standard. Five (5) specimens were cut from the sample provided for each test method and the summarized results below are the average of the five (5) specimens.

SAMPLE ID	MANHOLE TO MANHOLE	MAXIMUM FLEXURAL STRENGTH (PSI) ASTM D790	FLEXURAL MODULUS OF ELASTICITY (PSI) ASTM D790
Sample 2 42" x 18mm	Route 20 @ 11th & 20th St Location ID 174R_A	7,114	645,602

Note: Per ASTM F1216 & F1743 for cured-in-place pipe, the minimum requirements are 4500psi for Flexural Strength and 250,000psi for Flexural Modulus, as measured in accordance with ASTM D790.

The following table contains the thickness measurements from the sample plate submitted.

MEASUREMENT OF THICKNESS FOR CURED IN PLACE PIPE SAMPLES ASTM D2122

Sample ID	Manhole To Manhole	No. 1	No. 2	No. 3	No. 4	No. 5	Ave. Inches	Ave. mm
Sample 2 42" x 18mm	Route 20 @ 11th & 20th St Location ID 174R_A	0.775 19.69	0.784 19.91	0.757 19.23	0.797 20.24	0.808 20.52	0.784	19.92

Sincerely,

Doug Kleweno

Doug Kleweno
President

This test report relates only to the samples tested and shall not be reproduced except in full without approval from DGK Technologies, LLC.

DGK Technologies Common Sense and Uncommon Technology

3754 NW Sierra Drive
Camas, WA 98607

Phone (360) 833-8725
Fax (360) 833-8728

November 20, 2012

DGK Report Number:	MPS111512-20415-3

Mr. Pat Anderson
Michels Pipeline Services
1715 16th Street SE
Salem, OR 97302

Customer Project Name: Marysville

Customer Project Number: 20415
Date Sample Received: 11/15/12
Date Sample Tested: 11/19/12

A plate sample was delivered to DGK Technologies, LLC for testing. The sample was tested for flexural modulus and strength in accordance with ASTM D790, Method I, Procedure A for three point bend flexural properties. A span to depth ratio of 16:1 was used as specified in the test standard. Five (5) specimens were cut from the sample provided for each test method and the summarized results below are the average of the five (5) specimens.

SAMPLE ID	MANHOLE TO MANHOLE	MAXIMUM FLEXURAL STRENGTH (PSI) ASTM D790	FLEXURAL MODULUS OF ELASTICITY (PSI) ASTM D790
Sample 3 24" x 10.5mm	Route 20 @ 10th Street Location ID 172A	7,635	634,367

Note: Per ASTM F1216 & F1743 for cured-in-place pipe, the minimum requirements are 4500psi for Flexural Strength and 250,000psi for Flexural Modulus, as measured in accordance with ASTM D790.

The following table contains the thickness measurements from the sample plate submitted.

MEASUREMENT OF THICKNESS FOR CURED IN PLACE PIPE SAMPLES ASTM D2122

Sample ID	Manhole To Manhole	No. 1	No. 2	No. 3	No. 4	No. 5	Ave. Inches	Ave. mm
Sample 3 24" x 10.5mm	Route 20 @ 10th Street Location ID 172A	0.490 12.45	0.494 12.55	0.495 12.57	0.490 12.45	0.484 12.29	0.491	12.46

Sincerely,

Doug Kleweno
Doug Kleweno
President

This test report relates only to the samples tested and shall not be reproduced except in full without approval from DGK Technologies, LLC.

DGK Technologies Common Sense and Uncommon Technology

3754 NW Sierra Drive
Camas, WA 98607

Phone (360) 833-8725
Fax (360) 833-8728

November 20, 2012

DGK Report Number:	MPS111512-20415-4

Mr. Pat Anderson
Michels Pipeline Services
1715 16th Street SE
Salem, OR 97302

Customer Project Name: Marysville

Customer Project Number: 20415
Date Sample Received: 11/15/12
Date Sample Tested: 11/19/12

A plate sample was delivered to DGK Technologies, LLC for testing. The sample was tested for flexural modulus and strength in accordance with ASTM D790, Method I, Procedure A for three point bend flexural properties. A span to depth ratio of 16:1 was used as specified in the test standard. Five (5) specimens were cut from the sample provided for each test method and the summarized results below are the average of the five (5) specimens.

SAMPLE ID	MANHOLE TO MANHOLE	MAXIMUM FLEXURAL STRENGTH (PSI) ASTM D790	FLEXURAL MODULUS OF ELASTICITY (PSI) ASTM D790
Sample 4 24" x 10.5mm	Route 20 @ 10th Street Location ID 172A	6,485	614,850

Note: Per ASTM F1216 & F1743 for cured-in-place pipe, the minimum requirements are 4500psi for Flexural Strength and 250,000psi for Flexural Modulus, as measured in accordance with ASTM D790.

The following table contains the thickness measurements from the sample plate submitted.

MEASUREMENT OF THICKNESS FOR CURED IN PLACE PIPE SAMPLES ASTM D2122

Sample ID	Manhole To Manhole	No. 1	No. 2	No. 3	No. 4	No. 5	Ave. Inches	Ave. mm
Sample 4 24" x 10.5mm	Route 20 @ 10th Street Location ID 172A	0.427 10.85	0.441 11.20	0.433 11.00	0.429 10.90	0.435 11.05	0.433	11.00

Sincerely,

Doug Kleweno

Doug Kleweno
President

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DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Michels Pipeline Construction
1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

Department:	CALTRANS
Project Location:	RTE 50 at various locations near Kyburz, CA in El Dorado County
Project Title:	Construction on State HWY in El Dorado County
City's Project Number:	03-4M4404
Prepared By:	Andy Thompson
Michels Project No:	40435

Date Received:

Engineer:	Darlene Wulff
Contractor:	Michels Corp
Submittal number:	12
Submittal Date:	5/27/2014
Revision Date:	NA
Revision Number:	NA
Specification Section:	15-6.11A(3)
Subsection:	6
Item:	Manufactures Certifications
Page:	21
Deviation (Y or N):	N
Submittal Description:	Crew Certifications
Intended Use:	Crew Certifications
Plan Sheet:	NA
Manufacturer:	NA
Supplier:	NA
Applicable Standard:	NA
Referenced Document:	NA

Engineer's Stamp

Notes:

INTERPLASTIC CORPORATION
1225 Willow Lake Boulevard
Saint Paul, Minnesota 55110-5145
(651) 481-6860 Fax (651) 481-9836

May 2, 2014

Mr. Chris Tavernier
Michels Pipe Services
1715 16th Street SE
Salem, OR 97302

Dear Mr. Tavernier:

You have requested information on a cured-in-place pipe (CIPP) resin manufactured by Interplastic Corporation, COR78-AT-559, T or TH. This resin has been manufactured by Interplastic Corporation for over five (5) years and over 50 million pounds has been used to successfully renovate deteriorated sewer and storm water lines.

Interplastic Corporation is certified under ISO9001-2000.

This resin meets the requirements found in ASTM F1216, ASTM F1743, and ASTM D-5813 from the standpoint of achievable mechanical properties and corrosion resistance. This resin has also been tested under ASTM D2990 and exhibits a creep retention factor of 50%.

Michels Pipe Services have successfully used this resin to renovate deteriorated lines using the CIPP process.

The formulation for this resin includes a resin enhancer which allows the system to exhibit higher mechanical properties. Resin formulations for Interplastic Corporation are proprietary. The enhancer amount used in the resin is approximately 27%. The enhancer and resin form an acceptable bond resulting in the increased properties. This system is designed to be used in an aqueous environment.

I hope that this information proves to be useful. Please contact me at 281-687-8617 if you have additional questions or comments on this matter.

Sincerely,

Kaleel Rahaim

Kaleel Rahaim
Business Manager Remediation Polymers
Thermoset Resins Division

INTERPLASTIC CORPORATION
Thermoset Resins Division

1225 Willow Lake Boulevard
Saint Paul, Minnesota 55110-5145
(651) 481-6860 Fax (651) 481-9836

February 18, 2013

Mr. Chris Tavernier, Operations Manager
Michels Pipe Services
1715 16th Street SE
Salem, OR 97302

Dear Mr. Tavernier:

You have requested information on a cured-in-place pipe (CIPP) resin manufactured by Interplastic Corporation, COR72-AT-470HT. This resin has been manufactured by Interplastic Corporation for over twenty five(25) years and over 270 million pounds has been used to successfully renovate deteriorated sewer and storm water lines.

Interplastic Corporation is certified under ISO9001-2000.

This resin meets the requirements found in ASTM F1216, ASTM F1743, and ASTM D-5813 from the standpoint of achievable mechanical properties and corrosion resistance. This resin has also been tested under ASTM D2990 and exhibits a creep retention factor of 50%.

Michels Pipe Services have successfully used this resin to renovate deteriorated lines using the CIPP process.

The formulation for this resin includes a resin enhancer which allows the system to exhibit higher mechanical properties. Resin formulations for Interplastic Corporation are proprietary. The enhancer amount used in the resin is approximately 25%. The enhancer and resin form an acceptable bond resulting in the increased properties. This system is designed to be used in an aqueous environment.

I hope that this information proves to be useful. Please contact me at 281-687-8617 if you have additional questions or comments on this matter.

Sincerely,

Kaleel Rahaim

Kaleel Rahaim
Business Manager Remediation Polymers
Thermoset Resins Division

Cc: Nicole Kleweno, Dave Herzog, Ben Hazen, Jason Schiro

Premier-Pipe USA

Ron Smisek

of

Michels Pipe Services

Is recognized as a trained and certified CIPP wetout technician of Premier-Pipe USA

James W. Mortell

President

Premier-Pipe USA

Premier-Pipe USA

Josh Smisek

of

Michels Pipe Services

Is recognized as a trained and certified CIPP installer of Premier-Pipe USA

James W. Mortell

President

Premier-Pipe USA

Premier-Pipe USA

Victor Garlock

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James W. Mortell

President

Premier-Pipe USA

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Buck Haupt
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James W. Mortell

President

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Jerrick Rodriguez

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James W. Mortell

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James W. Mortell

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__*James W. Mortell*__

President

Premier-Pipe USA

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Mike Schmeisser
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James W. Mortell

President
Premier-Pipe USA

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1715 16th St. SE
Salem, OR 97302
(503)364-1199 main
(503)391-8317 fax

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department:	CALTRANS
Project Location:	RTE 50 at various locations near Kyburz, CA in El Dorado County
Project Title:	Construction on State HWY in El Dorado County
City's Project Number:	03-4M4404
Prepared By:	Andy Thompson
Michels Project No:	40435

Date Received:

Engineer:	Darlene Wulff
Contractor:	Michels Corp
Submittal number:	13
Submittal Date:	5/27/2014
Revision Date:	NA
Revision Number:	NA
Specification Section:	15-6.11A(3)
Subsection:	7
Item:	MSDS Sheets
Page:	21
Deviation (Y or N):	N
Submittal Description:	MSDS Sheets for Chemicals on Site
Intended Use:	Hazmat Awareness
Plan Sheet:	NA
Manufacturer:	NA
Supplier:	NA
Applicable Standard:	NA
Referenced Document:	NA

Engineer's Stamp

Notes:

Michels Corporation

May 27, 2014

RE: Subsection 7: MSDS Use and Location

To: Engineer

1. Mineral Oil – Not used. Replace with Vegetable Oil
2. Diesel – Used in trucks and Air Compressor
3. Sikadur 31 – Used on pipe ends and end seals
4. Triginox-C – Blended into the resin in Michels CIPP liners as a catalyst.
5. Perkadox -16 - Blended into the resin in Michels CIPP liners as a catalyst.

The items referenced above are used at the Drainage Sytems below.

DS 1-18, excluding DS 3 and 15

Sincerely,

Andy Thompson
Michels Corporation
503-428-2009
athompso@michels.us

MINERAL OIL

penreco.

MATERIAL SAFETY DATA SHEET

Penreco® Drakeol® LT Mineral Oil N.F.

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name: Penreco® Drakeol® LT Mineral Oil N.F.

Synonyms: Penreco® Drakeol® 100G, Penreco® Drakeol® 100
Penreco® Drakeol® 5, 5A., 6, 6LP, 6VR, 7, 7A, 7PG, 8, 9, 10, 13, 15, GD
Penetack® and Drakesol® 260-AT
White Mineral Oil

Intended Use: General White Oil

Responsible Party: Penreco
8701 New Trails Dr. Suite 175
The Woodlands, TX 77381

Customer Service: 800-245-3952
www.penreco.com

Technical Information: 800-245-3952

Emergency Overview

24 Hour Emergency Telephone Numbers:
Spill, Leak, Fire or Accident Call CHEMTREC:
North America: (800) 424-9300
Others: (703) 527-3887 (collect)

California Poison Control System: (800) 356-3219

Health Hazards/Precautionary Measures: None anticipated.

Physical Hazards/Precautionary Measures: Keep away from all sources of ignition.

Appearance: Transparent Water-white
Physical Form: Liquid
Odor: None

NFPA 704 Hazard Class:
Health: 0 (Least)
Flammability: 1 (Slight)
Instability: 0 (Least)

2. COMPOSITION / INFORMATION ON INGREDIENTS

NON-HAZARDOUS COMPONENTS					
Component / CAS No:	Concentration (wt %)	ACGIH:	OSHA:	NIOSH:	Other:
White Mineral Oil 8042-47-5	100	5 mg/m³ TWA 10 mg/m³ STEL	5 mg/m³ TWA	2500 mg/m³ IDLH	As Oil Mist, if Generated 5 mg/m³ NOHSC TWA

Fire Fighting Instructions: For fires beyond the incipient stage, emergency responders in the immediate hazard area should wear bunker gear. When the potential chemical hazard is unknown, in enclosed or confined spaces, or when explicitly required by DOT, a self contained breathing apparatus should be worn. In addition, wear other appropriate protective equipment as conditions warrant (see Section 8).

Isolate immediate hazard area, keep unauthorized personnel out. Stop spill/release if it can be done with minimal risk. Move undamaged containers from immediate hazard area if it can be done with minimal risk.

Water spray may be useful in minimizing or dispersing vapors and to protect personnel. Cool equipment exposed to fire with water, if it can be done with minimal risk. Avoid spreading burning liquid with water used for cooling purposes.

6. ACCIDENTAL RELEASE MEASURES

This material may burn, but will not ignite readily. Keep all sources of ignition away from spill/release.

Stay upwind and away from spill/release. Notify persons down wind of the spill/release, isolate immediate hazard area and keep unauthorized personnel out. Stop spill/release if it can be done with minimal risk. Wear appropriate protective equipment including respiratory protection as conditions warrant (see Section 8).

Prevent spilled material from entering sewers, storm drains, other unauthorized drainage systems, and natural waterways. Dike far ahead of spill for later recovery or disposal. Spilled material may be absorbed into an appropriate absorbent material.

Notify fire authorities and appropriate federal, state, and local agencies. Immediate cleanup of any spill is recommended.

7. HANDLING AND STORAGE

Handling: Do not enter confined spaces such as tanks or pits without following proper entry procedures such as ASTM D-4276 and 29CFR 1910.146. The use of appropriate respiratory protection is advised when concentrations exceed any established exposure limits (see Sections 2 and 8).

Do not wear contaminated clothing or shoes. Use good personal hygiene practices.

"Empty" containers retain residue and may be dangerous. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose such containers to heat, flame, sparks, or other sources of ignition. They may explode and cause injury or death. "Empty" drums should be completely drained, properly bunged, and promptly shipped to the supplier or a drum reconditioner. All containers should be disposed of in an environmentally safe manner and in accordance with governmental regulations.

Before working on or in tanks which contain or have contained this material, refer to OSHA regulations, ANSI Z49.1, and other references pertaining to cleaning, repairing, welding, or other contemplated operations.

Storage: Keep container(s) tightly closed. Use and store this material in cool, dry, well-ventilated areas away from heat and all sources of ignition. Store only in approved containers. Keep away from any incompatible material (see Section 10). Protect container(s) against physical damage.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering controls: If current ventilation practices are not adequate to maintain airborne concentrations below the established exposure limits (see Section 2), additional engineering controls may be required.

Personal Protective Equipment (PPE):

Respiratory: A NIOSH certified air purifying respirator with a Type 95 (R or P) particulate filter may be used under conditions where airborne concentrations are expected to exceed exposure limits (see Section 2).

Protection provided by air purifying respirators is limited (see manufacturer's respirator selection guide). Use a NIOSH approved self-contained breathing apparatus (SCBA) or equivalent operated in a pressure demand or other positive pressure mode if there is potential for an uncontrolled release, exposure levels are not known, or any other circumstances where air purifying respirators may not provide adequate protection.

A respiratory protection program that meets OSHA's 29 CFR 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator's use.

12. ECOLOGICAL INFORMATION

Not evaluated at this time.

13. DISPOSAL CONSIDERATIONS

This material, if discarded as produced, is not a RCRA "listed" hazardous waste. However, it should be fully evaluated for hazardous waste characteristics prior to disposal (40 CFR 261). Use which results in chemical or physical change or contamination may subject it to regulation as a hazardous waste. Along with properly characterizing all waste materials, consult state and local regulations regarding the proper disposal of this material.

Container contents should be completely used and containers should be emptied prior to discard. Container rinsate could be considered a RCRA hazardous waste and must be disposed of with care and in full compliance with federal, state and local regulations. Larger empty containers, such as drums, should be returned to the distributor or to a drum reconditioner. To assure proper disposal of smaller empty containers, consult with state and local regulations and disposal authorities.

14. TRANSPORTATION INFORMATION

DOT

Shipping Description: Not Regulated
Proper Shipping Name: Not classified as hazardous
Note: Material is unregulated unless shipped by land in a packaging having a capacity of 3500 gallons or more. Then the provisions of 49 CFR, Part 130 apply.

IMDG

Shipping Description: Not regulated

ICAO/IATA

Shipping Description: Not regulated

15. REGULATORY INFORMATION

U.S. Regulations:

EPA SARA 311/312 (Title III Hazard Categories)

Acute Health:	No
Chronic Health:	No
Fire Hazard:	No
Pressure Hazard:	No
Reactive Hazard:	No

SARA - Section 313 and 40 CFR 372:
This material contains the following chemicals subject to the reporting requirements of SARA 313 and 40 CFR 372:
--None Known--

EPA (CERCLA) Reportable Quantity (in pounds):
--None Known--

CERCLA/SARA - Section 302 Extremely Hazardous Substances and TPQs (in pounds):
This material contains the following chemicals subject to the reporting requirements of SARA 302 and 40 CFR 372:
-- None Known --

California Proposition 65:
Warning: This material contains the following chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm, and are subject to the requirements of California Proposition 65 (CA Health & Safety Code Section 25249.5):
-- None Known --

Carcinogen Identification:
This material has not been identified as a carcinogen by NTP, IARC, or OSHA.

Diesel

CITGO Gasolines, All Grades Unleaded

Material Safety Data Sheet

CITGO Petroleum Corporation
P.O. Box 4689
Houston, TX 77210

MSDS No. UNLEAD
Revision Date 10/14/2008

IMPORTANT: This MSDS is prepared in accordance with 29 CFR 1910.1200. Read this MSDS before transporting, handling, storing or disposing of this product and forward this information to employees, customers and users of this product.

Hazard Rankings

	HMIS	NFPA
Health Hazard	* 2	1
Fire Hazard	3	3
Reactivity	0	0

* = Chronic Health Hazard

Protective Equipment

Minimum Recommended
See Section 8 for Details

Emergency Overview

Physical State Liquid.

Color Transparent, clear to amber or red.

Odor Pungent, characteristic gasoline.

DANGER:
Extremely flammable liquid; vapor may cause flash fire or explosion.
Vapor may travel considerable distance to source of ignition and flash back.
Use Only as a Motor Fuel. Do Not Siphon by Mouth.
Harmful or fatal if swallowed - Can enter lungs and cause damage.
High concentrations of vapor reduce oxygen available for breathing and may cause suffocation.
May be harmful if inhaled or absorbed through the skin.
Mist or vapor may irritate the eyes, mucous membranes, and respiratory tract.
Liquid contact may cause eye and skin irritation.
Overexposures may cause central nervous system (CNS) depression and target organ effects (See Section 3).
Harmful or fatal if swallowed - Can enter lung and cause damage.
Inhalation overexposure can increase the heart's susceptibility to arrhythmias (irregular beats).
Contains Benzene - Cancer Hazard.
Long term exposure to gasoline vapor has caused cancer in laboratory animals.
Avoid Spills. Spills may present both a physical and an environmental hazard.

SECTION 1. PRODUCT IDENTIFICATION

Trade Name	CITGO Gasolines, All Grades Unleaded	Technical Contact	(832) 486-5940
Product Number	Various	Medical Emergency	(832) 486-4700
CAS Number	Mixture.	CHEMTREC Emergency (United States Only)	(800) 424-9300
Product Family	Motor fuels.		

Synonyms Unleaded Gasolines; Conventional Unleaded Gasoline with Ethanol; Unleaded Gasoline with Ethanol; Reformulated Unleaded Gasoline with Ethanol; Motor Gasolines; Petrol; Automobile Motor Fuels; Finished Gasolines; Gasoline, Regular Unleaded; Gasoline, Mid-grade Unleaded; Gasoline, Premium Unleaded; Reformulated Gasolines (RFG); Reformulated Motor Fuels; Oxygenated Motor Spirits; Gasoline, Regular Reformulated; Gasoline, Mid-grade Reformulated; Gasoline, Premium Reformulated; CBOB; RBOB; GTAB; Clean Burning Gasoline (CBG); CARB Gasoline with Ethanol.

SECTION 2. COMPOSITION

Gasoline is a complex and variable mixture that originates from finished refinery streams. These streams can contain the components listed below that are regulated or are associated with certain potential health effects. The typical concentration of ethanol in gasoline does not exceed 10% (v/v).

Component Name(s)	CAS Registry No.	Concentration (%)
Toluene	108-88-3	<25
Pentanes, all isomers	Mixture	<20
Octanes, all isomers	Mixture	<20
Xylene, all isomers	1330-20-7	<18
Hexane, other isomers	Mixture	<15
Heptane, all isomers	142-82-5	<15
Ethanol	64-17-5	<10
n-Hexane	110-54-3	<8
Benzene	71-43-2	<5
Trimethylbenzenes, all isomers	25551-13-7	<5
2,2,4-Trimethylpentane	540-84-1	<5
Cumene	98-82-8	<4
Ethylbenzene	100-41-4	<4
1, 2, 4 Trimethylbenzene	95-63-6	<3
Cyclohexane	110-82-7	<3
lopentane	287-92-3	<2
hthalene	91-20-3	<2
Styrene	100-42-5	<1

SECTION 3. HAZARDS IDENTIFICATION

Also see Emergency Overview and Hazard Ratings on the top of Page 1 of this MSDS.

Major Route(s) of Entry Skin contact. Eye contact. Inhalation. Ingestion.

Signs and Symptoms of Acute Exposure

Inhalation Breathing high concentrations may be harmful. Mist or vapor can irritate the throat and lungs. Breathing this material may cause central nervous system depression with symptoms including nausea, headache, dizziness, fatigue, drowsiness, or unconsciousness. Breathing high concentrations of this material, for example, in an enclosed space or by intentional abuse, can cause irregular heartbeats which can cause death.

Eye Contact This product can cause eye irritation with short-term contact with liquid, mists or vapor. Symptoms include stinging, watering, redness, and swelling. In severe cases, permanent eye damage can result.

Skin Contact This material can cause skin irritation. The severity of irritation will depend on the amount of material that is applied to the skin and the speed and thoroughness that it is removed. It is likely that some components of this material are able to pass into the body through the skin and may cause similar effects as from breathing or swallowing it. If the skin is damaged or abraded, absorption increases.

Ingestion

 Continued on Next Page

If swallowed, this material may irritate the mucous membranes of the mouth, throat, and esophagus. It can be readily absorbed by the stomach and intestinal tract. Symptoms include a burning sensation of the mouth and esophagus, nausea, vomiting, dizziness, staggered gait, drowsiness, loss of consciousness and delirium, as well as additional central nervous system (CNS) effects.

Due to its light viscosity, there is a danger of aspiration into the lungs during swallowing and subsequent vomiting. Aspiration can result in severe lung damage or death. Cardiovascular effects include shallow rapid pulse with pallor (loss of color in the face) followed by flushing (redness of the face). Also, progressive CNS depression, respiratory insufficiency and ventricular fibrillation leads to death.

Chronic Health Effects Summary

Intentional misuse by deliberately concentrating and inhaling gasoline can be harmful or fatal. Altered mental state, drowsiness, peripheral motor neuropathy, irreversible brain damage ("Petrol Sniffers Encephalopathy"), delirium, seizures and sudden death are associated with repeated abuse of gasoline or naphtha.

Chronic effects of ingestion and subsequent aspiration into the lungs may include pneumatocele (lung cavity) formation and chronic lung dysfunction.

Benzene, a component of this product, is associated with blood disorders and may damage bone marrow, causing certain types of anemia. The International Agency for Research on Cancer (IARC) (1987, 2004, 2007) and the U.S. EPA (IRIS 2007) have determined that benzene is a human carcinogen. It is also capable of causing changes in living cells' genetic material (chromosomes) and is considered to be a mutagen.

Repeated and prolonged overexposure to n-hexane has been associated with peripheral nerve tissue damage. Adverse effects include numbness, tingling, pain, and loss of muscle control in the extremities, disorientation, impaired vision and reflexes, decline in motor function and paralysis.

Prolonged or repeated overexposure to toluene, a component of this product, has been associated with reproductive effects in experimental animals and in long-term chemical abuse situations. Long-term overexposure to toluene has been associated with impaired color vision. Also, long-term overexposure to toluene in occupational environments have been associated with hearing damage.

Prolonged or repeated overexposure to xylene, a component of this product, has been associated with hearing damage in laboratory animals. Repeated overexposure may cause injury to bone marrow, blood cells, kidney, and liver.

Refer to Section 11 of this MSDS for additional health-related information.

Conditions Aggravated by Exposure

Disorders of the following organs or organ systems that may be aggravated by significant exposure to this material or its components include: Skin, Respiratory System, Liver, Kidneys, Central Nervous System (CNS), Cardiovascular System, Blood-forming system.

Target Organs

May cause damage to the following organs: blood, kidneys, lungs, the reproductive system, liver, mucous membranes, heart, peripheral nervous system, cardiovascular system, upper respiratory tract, skin, auditory system, bone marrow, central nervous system (CNS), eye, lens or cornea

Carcinogenic Potential

This material may contain benzene, ethylbenzene, naphthalene or styrene at concentrations above 0.1%. Benzene is considered to be a known human carcinogen by OSHA, IARC and NTP. IARC has identified ethylbenzene, styrene, naphthalene, gasoline and gasoline engine exhaust as possibly carcinogenic to humans (Group 2B) based on laboratory animal studies.

 Continued on Next Page

OSHA Hazard Classification is indicated by an "X" in the box adjacent to the hazard title. If no "X" is present, the product does not exhibit the hazard as defined in the OSHA Hazard Communication Standard (29 CFR ~~10.1200).

OSHA Health Hazard Classification				OSHA Physical Hazard Classification					
Irritant	X	Sensitizer		Combustible		Explosive		Pyrophoric	
Toxic		Highly Toxic		Flammable	X	Oxidizer		Water-reactive	
Corrosive		Carcinogenic	X	Compressed Gas		Organic Peroxide		Unstable	

SECTION 4. FIRST AID MEASURES

Take proper precautions to ensure your own health and safety before attempting rescue or providing first aid. For more specific information, refer to Exposure Controls and Personal Protection in Section 8 of this MSDS.

Inhalation Immediately move victim to fresh air. If victim is not breathing, immediately begin rescue breathing. If heart has stopped, immediately begin cardiopulmonary resuscitation (CPR). If breathing is difficult, 100 percent humidified oxygen should be administered by a qualified individual. Seek medical attention immediately. If exposed to benzene in an emergency situation, a medical evaluation should be completed at the end of the work-shift in accordance with OSHA requirements.

Eye Contact Flush eyes with cool, clean, low-pressure water for at least 15 minutes. Hold eyelids apart to ensure complete irrigation of the eye and eyelid tissue. If easily accomplished, check for and remove contact lenses. If contact lenses cannot be removed, seek immediate medical attention. Do not use eye ointment. Seek medical attention.

~in Contact Remove contaminated shoes and clothing. Flush affected area with large amounts of water. If skin surface is damaged, apply a clean dressing and seek medical attention. Do not use ointments. If skin surface is not damaged, clean affected area thoroughly with mild soap and water. Seek medical attention if tissue appears damaged or if pain or irritation persists.

Ingestion Do not induce vomiting. If spontaneous vomiting is about to occur, place victim's head below knees. If victim is drowsy or unconscious, place on the left side with head down. Never give anything by mouth to a person who is not fully conscious. Do not leave victim unattended. Seek medical attention immediately.

Notes to Physician INHALATION: Inhalation overexposure can produce toxic effects. Monitor for respiratory distress. If cough or difficulty in breathing develops, evaluate for upper respiratory tract inflammation, bronchitis, and pneumonitis. Administer supplemental oxygen with assisted ventilation, as required.

This material (or a component) sensitizes the heart to the effects of sympathomimetic amines. Epinephrine and other sympathomimetic drugs may initiate cardiac arrhythmias in individuals exposed to this material. Administration of sympathomimetic drugs should be avoided.

INGESTION: If ingested, this material presents a significant aspiration and chemical pneumonitis hazard. Induction of emesis is not recommended. Consider activated charcoal and/or gastric lavage. If patient is obtunded, protect the airway by cuffed endotracheal intubation or by placement of the body in a Trendelenburg and left lateral decubitus position.

SECTION 5. FIRE FIGHTING MEASURES

NFPA Flammability ~~ssification NFPA Class-IB flammable liquid.

~~sh Point Closed cup: -43°C (-45°F). (Tagliabue [ASTM D-56])

Lower Flammable Limit AP 1.4 % **Upper Flammable Limit** AP 7.6 %

Autoignition Temperature	AP 280°C (536°F)
zardous Combustion oducts	Carbon dioxide, carbon monoxide, smoke, fumes, unburned hydrocarbons, aldehydes and other products of incomplete combustion.
Special Properties	Flammable Liquid! This material releases vapors at or below ambient temperatures. When mixed with air in certain proportions and exposed to an ignition source, its vapor can cause a flash fire. Use only with adequate ventilation. Vapors are heavier than air and may travel long distances along the ground to an ignition source and flash back. A vapor and air mixture can create an explosion hazard in confined spaces such as sewers. If container is not properly cooled, it can rupture in the heat of a fire.
Extinguishing Media	SMALL FIRE: Use dry chemicals, carbon dioxide, foam, or inert gas (nitrogen). Carbon dioxide and inert gas can displace oxygen. Use caution when applying carbon dioxide or inert gas in confined spaces. LARGE FIRE: Use foam, water fog, or water spray. Water may be ineffective. Water may not extinguish the fire. Water fog and spray are effective in cooling containers and adjacent structures. However, water can be used to cool the external walls of vessels to prevent excessive pressure, autoignition or explosion. DO NOT use a solid stream of water directly on the fire as the water may spread the fire to a larger area.
Protection of Fire Fighters	Firefighters must use full bunker gear including NIOSH-approved positive pressure self-contained breathing apparatus to protect against potential hazardous combustion or decomposition products and oxygen deficiencies. Evacuate area and fight the fire from a maximum distance or use unmanned hose holders or monitor nozzles. Cover pooling liquid with foam. Containers can build pressure if exposed to radiant heat; cool adjacent containers with flooding quantities of water until well after the fire is out. Withdraw immediately from the area if there is a rising sound from a venting safety device or discoloration of vessels, tanks, or pipelines. Be aware that burning liquid will float on water. Notify appropriate authorities of potential fire and explosion hazard if liquid enter sewers or waterways.

ECTION 6. ACCIDENTAL RELEASE MEASURES

Take proper precautions to ensure your own health and safety before attempting spill control or clean-up. For more specific information, refer to the Emergency Overview on Page 1, Exposure Controls and Personal Protection in Section 8 and Disposal Considerations in Section 13 of this MSDS.

Flammable Liquid! Release causes an immediate fire or explosion hazard. Evacuate all non-essential personnel from immediate area and establish a "regulated zone" with site control and security. A vapor-suppressing foam may be used to reduce vapors. Eliminate all ignition sources. All equipment used when handling this material must be grounded. Stop the leak if it can done without risk. Do not touch or walk through spilled material. Remove spillage immediately from hard, smooth walking areas. Prevent spilled material from entering waterways, sewers, basements, or confined areas. Absorb or cover with dry earth, sand, or other non-combustible material and transfer to appropriate waste containers. Use clean, non-sparking tools to collect absorbed material.

For large spills, secure the area and control access. Prevent spilled material from entering sewers, storm drains, other drainage systems, and natural waterways. Dike far ahead of a liquid spill to ensure complete collection. Water mist or spray may be used to reduce or disperse vapors; but, it may not prevent ignition in closed spaces. This material will float on water and its run-off may create an explosion or fire hazard. Verify that responders are properly HAZWOPER-trained and wearing appropriate respiratory equipment and fire-resistant protective clothing during cleanup operations. In an urban area, cleanup spill as soon as possible; in natural environments, cleanup on advice from specialists. Pick up free liquid for recycle and/or disposal if it can be accomplished safely with explosion-proof equipment. Collect any excess material with absorbent pads, sand, or other inert non-combustible absorbent materials. Place into appropriate waste containers for later disposal. Comply with all applicable local, state and federal laws and regulations.

SECTION 7. HANDLING AND STORAGE

Handling

FLAMMABLE LIQUID AND VAPOR. **USE ONLY as a motor fuel.** DO NOT siphon by mouth. DO NOT use as a lighter fluid, solvent or cleaning fluid. Prior to handling or refueling, stop all engines and auxillary equipment. Turn off all electronic equipment including cellular telephones. DO NOT leave nozzle unattended during filling or refueling a vehicle. DO NOT re-enter vehicle while refueling. Keep nozzle spout in contact with the container during the entire filling operations.

A static electrical charge can accumulate when this material is flowing through pipes, nozzles or filters and when it is agitated. A static spark discharge can ignite accumulated vapors particularly during dry weather conditions. Always bond receiving containers to the fill pipe before and during loading, following NFPA-704 and /or API RP 2003 requirements. Always keep nozzle in contact with the container throughout the loading process. Do not fill any portable container in or on a vehicle. Special precautions, such as reduced loading rates and increased monitoring, must be observed during "switch loading" operations (i.e., loading this material in tanks or shipping compartments that previously contained middle distillates or similar products).

A spill or leak can cause an immediate fire or explosion hazard. Keep containers closed and do not handle or store near heat, sparks, or any other potential ignition sources. Avoid contact with oxidizing agents. Do NOT breathe vapor. Use only with adequate ventilation and personal protection. Never siphon by mouth. Avoid contact with eyes, skin, and clothing. Prevent contact with food and tobacco products. Do NOT take internally.

When performing repairs and maintenance on contaminated equipment, keep unnecessary persons away from the area. Eliminate all potential ignition sources. Drain and purge equipment, as necessary, to remove material residues. Follow proper entry procedures, including compliance with 29 CFR 1910.146 prior to entering confined spaces such as tanks or pits. Use gloves constructed of impervious materials and protective clothing if direct contact is anticipated. Use appropriate respiratory protection when concentrations exceed any established occupational exposure level (See Section 8) Promptly remove contaminated clothing. Wash exposed skin thoroughly with soap and water after handling.

Non-equilibrium conditions may increase the fire hazard associated with this product. A static electrical charge can accumulate when this material is flowing through pipes, nozzles or filters and when it is agitated. A static spark discharge can ignite accumulated vapors particularly during dry weather conditions. Always bond receiving containers to the fill pipe before and during loading. Always confirm that receiving container is properly grounded. Bonding and grounding alone may be inadequate to eliminate fire and explosion hazards associated with electrostatic charges. Carefully review operations that may increase the risks associated with static electricity such as tank and container filling, tank cleaning, sampling, gauging, loading, filtering, mixing, agitation, etc. In addition to bonding and grounding, efforts to mitigate the hazards of an electrostatic discharge may include, but are not limited to, ventilation, inerting and/or reduction of transfer velocities. Dissipation of electrostatic charges may be improved with the use of conductivity additives when used with other mitigation efforts, including bonding and grounding. Always keep nozzle in contact with the container throughout the loading process.

Do NOT fill any portable container in or on a vehicle. Do NOT use compressed air for filling, discharging or other handling operations. Product container is NOT designed for elevated pressure. Do NOT pressurize, cut, weld, braze solder, drill, or grind on containers. Do NOT expose product containers to flames, sparks, heat or other potential ignition sources. Empty containers may contain material residues which can ignite with explosive force. Observe label precautions.

Protect the environment from releases of this material. Prevent discharges to surface waters and groundwater. Maintain handling, transfer and storage equipment in proper working order.

Misuse of empty containers can be dangerous. Empty containers may contain material residues which can ignite with explosive force. **Cutting or welding of empty containers**

 Continued on Next Page

can cause fire, explosion, or release of toxic fumes from residues. Do not pressurize or expose empty containers to open flame, sparks, or heat. Keep container closed and drum bungs in place. All label warnings and precautions must be observed. Return empty drums to a qualified reconditioner. Consult appropriate federal, state and local authorities before reusing, reconditioning, reclaiming, recycling, or disposing of empty containers and/or waste residues of this material.

Storage

Keep container tightly closed. Store in a cool, dry, well-ventilated area. Store only in approved containers. Do not store with oxidizing agents. Do not store at elevated temperatures or in direct sunlight. Protect containers against physical damage. Head spaces in tanks and other containers may contain a mixture of air and vapor in the flammable range. Vapor may be ignited by static discharge. Storage area must meet OSHA requirements and applicable fire codes. Additional information regarding the design and control of hazards associated with the handling and storage of flammable and combustible liquids may be found in professional and industrial documents including, but not limited to, the National Fire Protection Association (NFPA) publications NFPA 30 ("Flammable and Combustible Liquid Code"), NFPA 77 ("Recommended Practice on Static Electricity") and the American Petroleum Institute (API) Recommended Practice 2003, ("Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents").

Consult appropriate federal, state and local authorities before reusing, reconditioning, reclaiming, recycling or disposing of empty containers or waste residues of this product.

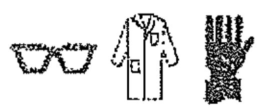
SECTION 8. EXPOSURE CONTROLS AND PERSONAL PROTECTION

Engineering Controls

Provide ventilation or other engineering controls to keep the airborne concentrations of vapor or mists below the applicable workplace exposure limits indicated below. All electrical equipment should comply with the National Electrical Code. An emergency eye wash station and safety shower should be located near the work-station.

rsonal Protective uipment

Personal protective equipment should be selected based upon the conditions under which this material is used. A hazard assessment of the work area for PPE requirements should be conducted by a qualified professional pursuant to OSHA regulations. The following pictograms represent the minimum requirements for personal protective equipment. For certain operations, additional PPE may be required.



Eye Protection

Safety glasses equipped with side shields are recommended as minimum protection in industrial settings. Chemical goggles should be worn during transfer operations or when there is a likelihood of misting, splashing, or spraying of this material. A suitable emergency eye wash water and safety shower should be located near the work station.

Hand Protection

Avoid skin contact. Use gloves (e.g., disposable PVC, neoprene, nitrile, vinyl, or PVC/NBR). Wash hands with plenty of mild soap and water before eating, drinking, smoking, use of toilet facilities or leaving work. DO NOT use this material as a skin cleaner.

Body Protection

Avoid skin contact. Wear long-sleeved fire-retardant garments (e.g., Nomex®) while working with flammable and combustible liquids. Additional chemical-resistant protective gear may be required if splashing or spraying conditions exist. This may include an apron, boots and additional facial protection. If product comes in contact with clothing, immediately remove soaked clothing and shower. Promptly remove and discard contaminated leather goods.

Respiratory Protection For known vapor concentrations above the occupational exposure guidelines (see below), use a NIOSH-approved organic vapor respirator if adequate protection is provided. Protection factors vary depending upon the type of respirator used. Respirators should be used in accordance with OSHA requirements (29 CFR 1910.134). For airborne vapor concentrations that exceed the recommended protection factors for organic vapor respirators, use a full-face, positive-pressure, supplied air respirator. Due to fire and explosion hazards, do not enter atmospheres containing concentrations greater than 10% of the lower flammable limit of this product.

General Comments Warning! Use of this material in spaces without adequate ventilation may result in generation of hazardous levels of combustion products and/or inadequate oxygen levels for breathing. Odor is an inadequate warning for hazardous conditions.

Occupational Exposure Guidelines

Substance	Applicable Workplace Exposure Levels
Gasoline	**ACGIH (United States).** TWA: 300 ppm 8 hour(s). STEL: 500 ppm 15 minute(s).
Pentanes, all isomers	**ACGIH (United States).** TWA: 600 ppm 8 hour(s). **OSHA (United States).** TWA: 1000 ppm 8 hour(s).
Octanes, all isomers	**ACGIH (United States).** TWA: 300 ppm 8 hour(s). **OSHA (United States).** TWA: 500 ppm 8 hour(s).
Toluene	**ACGIH (United States). Skin** TWA: 20 ppm 8 hour(s). **OSHA (United States).** TWA: 200 ppm 8 hour(s). CEIL: 300 ppm PEAK: 500 ppm 1 times per shift, 10 minute(s).
Hexane, other isomers	**ACGIH (United States).** TWA: 500 ppm 8 hour(s). STEL: 1000 ppm 15 minute(s).
Heptane, all isomers	**ACGIH (United States).** TWA: 400 ppm 8 hour(s). STEL: 500 ppm 15 minute(s). **OSHA (United States).** TWA: 500 ppm 8 hour(s).
Xylene, all isomers	**ACGIH (United States).** TWA: 100 ppm 8 hour(s). STEL: 150 ppm 15 minute(s). **OSHA (United States).** TWA: 100 ppm 8 hour(s).
Ethanol	**ACGIH (United States).** TWA: 1000 ppm 8 hour(s). **OSHA (United States).** TWA: 1000 ppm 8 hour(s).
Benzene	**ACGIH (United States). Skin** TWA: 0.5 ppm 8 hour(s). STEL: 2.5 ppm 15 minute(s). **OSHA (United States). Skin Notes: See Table Z-2 for exclusions in 20 CFR 1910.1028 to the PEL.** TWA: 1 ppm 8 hour(s). STEL: 5 ppm 15 minute(s).
n-Hexane	**ACGIH (United States). Skin** TWA: 50 ppm 8 hour(s). **OSHA (United States).** TWA: 500 ppm 8 hour(s).
Cumene	**ACGIH (United States).** TWA: 50 ppm 8 hour(s). **OSHA (United States). Skin**

	TWA: 50 ppm 8 hour(s).
Trimethylbenzenes, all isomers	**ACGIH (United States).** TWA: 25 ppm 8 hour(s).
ylbenzene	**ACGIH (United States).** TWA: 100 ppm 8 hour(s). STEL: 125 ppm 15 minute(s). **OSHA (United States).** TWA: 100 ppm 8 hour(s).
Cyclohexane	**ACGIH (United States).** TWA: 100 ppm 8 hour(s). **OSHA (United States).** TWA: 300 ppm 8 hour(s).
Cyclopentane	**ACGIH (United States).** TWA: 600 ppm 8 hour(s).
Naphthalene	**ACGIH (United States). Skin** TWA: 10 ppm 8 hour(s). STEL: 15 ppm 15 minute(s). **OSHA (United States).** TWA: 10 ppm 8 hour(s).
Styrene	**ACGIH (United States).** TWA: 20 ppm 8 hour(s). STEL: 40 ppm 15 minute(s). **OSHA (United States).** TWA: 100 ppm 8 hour(s). STEL: 200 ppm 15 minute(s). PEAK: 600 ppm

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES (TYPICAL)

Physical State	Liquid.	**Color**	Transparent, clear to amber or red.	**Odor**	Pungent, characteristic gasoline.
Specific Gravity	0.72 - 0.77 (Water = 1)	**pH**	Not applicable	**Vapor Density**	3 to 4 (Air = 1)
Boiling Range	38 to 204°C (100 to 400°F)			**Melting/Freezing Point**	Not available.
Vapor Pressure	220 to 450 mm Hg at 20°C (68°F) or 6 to 15 Reid-psia at 37.8°C (100°F).			**Volatility**	720 to 770 g/l VOC (w/v)
Solubility in Water	Very slightly soluble in cold water. (<0.1 % w/w)			**Viscosity (cSt @ 40°C)**	<1
Flash Point	Closed cup: -43°C (-45°F). (Tagliabue [ASTM D-56])				
Additional Properties	Average Density at 60°F = 6.0 to 6.4 lbs./gal. (ASTM D-2161)				

SECTION 10. STABILITY AND REACTIVITY

Chemical Stability	Stable.	**Hazardous Polymerization**	Not expected to occur.
Conditions to Avoid	Keep away from heat, flame and other potential ignition sources. Keep away from strong oxidizing conditions and agents.		
Materials Incompatibility	Strong acids, alkalies and oxidizers such as liquid chlorine, other halogens, hydrogen peroxide and oxygen.		
.ardous Decomposition Products	No additional hazardous decomposition products were identified other than the combustion products identified in Section 5 of this MSDS.		

SECTION 11. TOXICOLOGICAL INFORMATION

. ./ other health-related information, refer to the Emergency Overview on Page 1 and the Hazards Identification in Section 3 of this MSDS.

Toxicity Data

Gasoline

VAPOR (TELo) Acute: 140 ppm (Human) (8 hours) - Mild eye irritant.
VAPOR (TELo) Acute: 500 ppm (Human) (1 hour) - Moderate eye irritant.
INHALATION (TCLo) Acute: 900 ppm (Human) (1 hour) - CNS and pulmonary effects.
DERMAL (TDLo) Acute: 53 mg/kg (Human) - Skin allergy effects.
INHALATION (LC50) Acute: 101,200 ppm (Rat, Mouse, & Guinea Pig) (5 minutes).

A major epidemiological study concluded that there was no increased risk of kidney cancer associated with gasoline exposures for petroleum refinery employees or neighboring residents. Another study identified a slight trend in kidney cancers among service station employees following a 30-year latency period. Two-year inhalation toxicity studies with fully vaporized unleaded gasoline (at concentrations of 67, 292 and 2,056 ppm in air) produced kidney damage and kidney tumors in male rats, but not in female rats or mice of either sex. Results from subsequent scientific studies suggest that the kidney damage, and probably the kidney tumor response, is limited to the male rat. The kidney tumors apparently were the result of the formation of alpha-2u-globulin, a protein unique to male rats. This finding is not considered relevant to human exposure. Under conditions of the study, there was no evidence that exposure to unleaded gasoline vapor is associated with developmental toxicity. Experimental studies with laboratory animals did suggest that overexposure to gasoline may adversely effect male reproductive performance. Also, in laboratory studies with rats, the maternal and developmental "no observable adverse effect level" (NOAEL) was determined to be 9,000 ppm (75% of the LEL value). Female mice developed a slightly higher incidence of liver tumors compared to controls at the highest concentration. In a four week inhalation study of Sprague Dawley® rats, gasoline vapor condensate was determined to induce sister chromatid exchanges in peripheral lymphocytes. IARC has listed gasoline as possibly carcinogenic to humans (Group 2B).

Pentanes, all isomers

Studies of pentane isomers in laboratory animals indicate exposure to extremely high levels (roughly 10 vol.%) may induce cardiac arrhythmias (irregular heartbeats) which may be serious or fatal.

Toluene

Effects from Acute Exposure:

Deliberate inhalation of toluene at high concentrations (e.g., glue sniffing and solvent abuse) has been associated with adverse effects on the liver, kidney and nervous system and can cause CNS depression, cardiac arrhythmias and death. Case studies of persons abusing toluene suggest isolated incidences of adverse effects on the fetus including birth defects.

Effects from Repeated or Prolonged Exposure:

Studies of workers indicate long-term exposure may be related to impaired color vision and hearing. Some studies of workers suggest long-term exposure may be related to neurobehavioral and cognitive changes. Some of these effects have been observed in laboratory animals following repeated exposure to high levels of toluene. Several studies of workers suggest long-term exposure may be related to small increases in spontaneous abortions and changes in some gonadotropic hormones. However, the weight of evidence does not indicate toluene is a reproductive hazard to humans. Studies in laboratory animals indicate some changes in reproductive organs following high levels of exposure, but no significant effects on mating performance or reproduction were observed. Case studies of persons abusing toluene suggest isolated incidences of adverse effects on the fetus including birth defects. Findings in laboratory animals were largely negative. Positive findings include small increases in minor skeletal and visceral malformations and developmental delays following very high levels of maternal exposure. Studies of workers indicate long-term exposure may be related to effects on the liver, kidney and blood, but these appear to be limited to changes in serum enzymes and decreased leukocyte counts. Studies in laboratory animals indicate some evidence of adverse effects on the liver, kidney, thyroid, and pituitary gland following very high levels of exposure. The relevance of these findings to humans is not clear at this time.

Heptane, all isomers
n-Heptane was not mutagenic in the Salmonella/microsome (Ames) assay and is not considered to be carcinogenic.

Xylene, all isomers
Effects from Acute Exposure:
ORAL (LD_{50}), Acute: 4,300 mg/kg [Rat].
INHALATION (LC_{50}), Acute: 4,550 ppm for four hours [Rat].
DERMAL (LD_{50}), Acute: 14,100 uL/kg [Rabbit].
Overexposure to xylene may cause upper respiratory tract irritation, headache, cyanosis, blood serum changes, CNS damage and narcosis. Effects may be increased by the use of alcoholic beverages. Evidence of liver and kidney impairment were reported in workers recovering from a gross over-exposure.

Effects from Prolonged or Repeated Exposure:
Impaired neurological function was reported in workers exposed to solvents including xylene. Studies in laboratory animals have shown evidence of impaired hearing following high levels of exposure. Studies in laboratory animals suggest some changes in reproductive organs following high levels of exposure but no significant effects on reproduction were observed. Studies in laboratory animals indicate skeletal and visceral malformations, developmental delays, and increased fetal resorptions following extremely high levels of maternal exposure. Adverse effects on the liver, kidney, bone marrow (changes in blood cell parameters) were observed in laboratory animals following high levels of exposure. The relevance of these observations to humans is not clear at this time.

Ethanol
Inhalation exposure to ethanol vapor at concentrations above applicable workplace exposure levels is expected to produce eye and mucus membrane irritation. Human exposure at concentrations from 1000 to 5000 ppm produced symptoms of narcosis, stupor and unconsciousness. Subjects exposed to ethanol vapor in concentrations between 500 and 10,000 ppm experienced coughing and smarting of the eyes and nose. At 15,000 ppm there was continuous lacrimation and coughing. While extensive acute and chronic effects can be expected with ethanol consumption, ingestion is not expected to be a significant route of exposure to this product.

Benzene

ORAL (LD50):	Acute: 930 mg/kg [Rat]. 4700 mg/kg [Mouse].
INHALATION (LC50):	
(VAPOR):	Acute: 10000 ppm 7 hour(s) [Rat]. 9980 ppm 8 hour(s) [Mouse].

Studies of Workers Over-Exposed to Benzene:
Studies of workers exposed to benzene show clear evidence that over-exposure can cause cancer of the blood forming organs (acute myelogenous leukemia) and aplastic anemia, an often fatal disease. Studies also suggest over-exposure to benzene may be associated with other types of leukemia and other blood disorders. Some studies of workers exposed to benzene have shown an association with increased rates of chromosome aberrations in circulating lymphocytes. One study of women workers exposed to benzene suggested a weak association with irregular menstruation. However, other studies of workers exposed to benzene have not demonstrated clear evidence of an effect on fertility or reproductive outcome in humans. Benzene can cross the placenta and affect the developing fetus. Cases of aplastic anemia have been reported in the offspring of persons severely over-exposed to benzene.

Studies in Laboratory Animals:
Studies in laboratory animals indicate that prolonged, repeated exposure to high levels of benzene vapor can cause bone marrow suppression and cancer in multiple organ systems. Studies in laboratory animals show evidence of adverse effects on male reproductive organs following high levels of exposure but no significant effects on reproduction have been observed. Embryotoxicity has been reported in studies of laboratory animals but effects were

limited to reduced fetal weight and skeletal variations.

n-Hexane
This material contains n-hexane. Long-term or repeated exposure to n-hexane can cause permanent peripheral nerve damage. Initial symptoms are numbness of the fingers and toes. Also, motor weakness can occur in the digits, but may also involve muscles of the arms, thighs and forearms. The onset of these symptoms may be delayed for several months to a year after the beginning of exposure. Co-exposure to methylethyl ketone or methyl isobutyl ketone increases the neurotoxic properties of n-hexane. In laboratory studies, prolonged exposure to elevated concentrations of n-hexane was associated with decreased sperm count and degenerative changes in the testicles of rats.

Cumene
Effects from Acute Exposure:
Overexposure to cumene may cause upper respiratory tract irritation and severe CNS depression.

Effects from Prolonged or Repeated Exposure:
Studies in laboratory animals indicate evidence of adverse effects on the kidney and adrenal glands following high level exposure. The relevance of these findings to humans is not clear at this time.

Trimethylbenzenes, all isomers
Studies of Workers:
Levels of total hydrocarbon vapors present in the breathing atmosphere of these workers ranged from 10 to 60 ppm. The TCLo for humans is 10 ppm, with somnolence and respiratory tract irritation noted.

Studies in Laboratory Animals:
In inhalation studies with rats, four of ten animals died after exposures of 2400 ppm for 24 hours. An oral dose of 5 mL/kg resulted in death in one of ten rats. Minimum lethal intraperitoneal doses were 1.5 to 2.0 mL/kg in rats and 1.13 to 12 mL/kg in guinea pigs. Mesitylene (1, 3, 5 Trimethylbenzene) inhalation at concentrations of 1.5, 3.0, and 6.0 mg/L for six hours was associated with dose-related changes in white blood cell counts in rats. No significant effects on the complete blood count were noted with six hours per day exposure for five weeks, but elevations of alkaline phosphatase and SGOT were observed. Central nervous system depression and ataxia were noted in rats exposed to 5,100 to 9,180 ppm for two hours.

Ethylbenzene
Effects from Acute Exposure:
ORAL (LD50), Acute: 3,500 mg/kg [Rat].
DERMAL (LD50), Acute: 17,800 uL/kg [Rabbit].
INTRAPERITONEAL (LD50), Acute: 2,624 mg/kg [Rat].

Effects from Prolonged or Repeated Exposure:
Findings from a 2-year inhalation study in rodents conducted by NTP were as follows: Effects were observed only at the highest exposure level (750 ppm). At this level the incidence of renal tumors was elevated in male rats (tubular carcinomas) and female rats (tubular adenomas). Also, the incidence of tumors was elevated in male mice (alveolar and bronchiolar carcinomas) and female mice (hepatocellular carcinomas). IARC has classified ethyl benzene as "possibly carcinogenic to humans" (Group 2B). Studies in laboratory animals indicate some evidence of post-implantation deaths following high levels of maternal exposure. The relevance of these findings to humans is not clear at this time. Studies in laboratory animals indicate limited evidence of renal malformations, resorptions, and developmental delays following high levels of maternal exposure. The relevance of these findings to humans is not clear at this time. Studies in laboratory animals indicate some evidence of adverse effects on the liver, kidney, thyroid, and pituitary gland.

Cyclohexane
ORAL (LD50): Acute: 12705 mg/kg [Rat]. 813 mg/kg [Mouse].

Cyclohexane can cause eye, skin and mucous membrane irritation, CNS depressant and narcosis at elevated concentrations. In experimental animals exposed to lethal concentrations by inhalation or oral route, generalized vascular damage and degenerative changes in the heart, lungs, liver, kidneys and brain were identified.

Cyclohexane has been the focus of substantial testing in laboratory animals. Cyclohexane was not found to be genotoxic in several tests including unscheduled DNA synthesis, bacterial and mammalian cell mutation assays, and in vivo chromosomal aberration. An increase in chromosomal aberrations in bone marrow cells of rats exposed to cyclohexane was reported in the 1980's. However, a careful re-evaluation of slides from this study by the laboratory which conducted the study indicates these findings were in error, and that no significant chromosomal effects were observed in animals exposed to cyclohexane. Findings indicate long-term exposure to cyclohexane does not promote dermal tumorigenesis.

Naphthalene
Studies in Humans Overexposed to Naphthalene:
Severe jaundice, neurotoxicity (kernicterus) and fatalities have been reported in young children and infants as a result of hemolytic anemia from over-exposure to naphthalene. Persons with Glucose 6-phosphate dehydrogenase (G6PD) deficiency are more prone to the hemolytic effects of naphthalene. Adverse effects on the kidney have also been reported from over-exposure to naphthalene but these effects are believed to be a consequence of hemolytic anemia, and not a direct effect.

Studies in Laboratory Animals:
Hemolytic anemia has been observed in laboratory animals exposed to naphthalene. Laboratory rodents exposed to naphthalene vapor for 2 years (lifetime studies) developed non-neoplastic and neoplastic tumors and inflammatory lesions of the nasal and respiratory tract. Cataracts and other adverse effects on the eye have been observed in laboratory animals exposed to high levels of naphthalene. Findings from a large number of bacterial and mammalian cell mutation assays have been negative. A few studies have shown chromosomal effects (elevated levels of Sister Chromatid Exchange or chromosomal aberrations) *in vitro*.

Styrene
Neurological injury associated with chronic styrene exposure include distal hypesthesia, decreased nerve conduction velocity, and altered psychomotor performance. These effects did not occur with exposures to airborne concentrations that were less than 100 ppm. Increased deaths from degenerative neurological disorders were found in a comprehensive epidemiological study of Danish reinforced plastics workers. These workers were reported to have a 2.5-fold increased risk for myeloid leukemia with clonal chromosome aberrations. Also, there are several studies that suggest potential reproductive effects in humans and experimental animals from overexposure to styrene. Styrene was not mutagenic in the standard (liquid phase) Ames Salmonella/microsome assay, but was weakly positive when tested in the vapor phase. IARC has listed styrene as possibly carcinogenic to humans (Group 2B).

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

Unleaded gasoline is potentially toxic to freshwater and saltwater ecosystems. Various grades of gasoline exhibited range of lethal toxicity (LC_{50}) from 40 PPM to 100 PPM in ambient stream water with Rainbow Trout (*Salmo irideus*). A 24-hour TLm (Median Toxic Limit) was calculated to be 90 PPM with juvenile American Shad (*Squalius cephalus*). In Bluegill Sunfish (*Lepomis macrochirus*), Grey Mullet (*Chelon labrosus*) and Gulf Menhaden (*Brevoortia patronus*), gasoline exhibited a 96-hour LC_{50} of 8 PPM, 2 PPM, and 2 PPM, respectively.

Environmental Fate

Biodegradability: Readily biodegradable in aerobic conditions. Residual components most recalcitrant to biodegration are branched alkanes.

Partition Coefficient (log Kow): 2.13 to 4.85.

Photodegration: Gasoline will partition to air, with the atmospheric half-life for constituents ranging from 0.8 days to 16 days.

Stability in water: Gasoline is not readily susceptible to hydrolysis under aquatic conditions. and the constituents readily partition to air.

SECTION 13. DISPOSAL CONSIDERATIONS

Hazard characteristic and regulatory waste stream classification can change with product use. Accordingly, it is the responsibility of the user to determine the proper storage, transportation, treatment and/or disposal methodologies for spent materials and residues at the time of disposition.

Maximize material recovery for reuse or recycling. Recovered non-usable material may be regulated by US EPA as a hazardous waste due to its ignitibility (D001) and/or its toxic (D018) characteristics. Conditions of use may cause this material to become a "hazardous waste", as defined by federal or state regulations. It is the responsibility of the user to determine if the material is a RCRA "hazardous waste" at the time of disposal. Transportation, treatment, storage and disposal of waste material must be conducted in accordance with RCRA regulations (see 40 CFR 260 through 40 CFR 271). State and/or local regulations may be more restrictive. Contact your regional US EPA office for guidance concerning case specific disposal issues.

SECTION 14. TRANSPORT INFORMATION

The shipping description below may not represent requirements for all modes of transportation, shipping methods or locations outside of the United States.

US DOT Status A U.S. Department of Transportation regulated material.

Proper Shipping Name Gasoline, 3, UN 1203, PG II
Gasohol, 3, NA 1203, PGII (Use only for gasoline blended with less than 20% ethanol)

.ard Class 3 DOT Class: Flammable liquid.

Packing Group II

UN/NA Number UN1203 or NA1203

Reportable Quantity A Reportable Quantity (RQ) has not been established for this material.

Placard(s)

Emergency Response Guide No. 128

MARPOL III Status Not a DOT "Marine Pollutant" per 49 CFR 171.8.

SECTION 15. REGULATORY INFORMATION

TSCA Inventory This product and/or its components are listed on the Toxic Substances Control Act (TSCA) inventory.

SARA 302/304 Emergency Planning and Notification The Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III requires facilities subject to Subparts 302 and 304 to submit emergency planning and notification information based on Threshold Planning Quantities (TPQs) and Reportable Quantities (RQs) for "Extremely Hazardous Substances" listed in 40 CFR 302.4 and 40 CFR 355. No components were identified.

SARA 311/312 Hazard ...tification The Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III requires facilities subject to this subpart to submit aggregate information on chemicals by "Hazard Category" as defined in 40 CFR 370.2. This material would be classified under the following hazard categories:

Fire, Acute (Immediate) Health Hazard, Chronic (Delayed) Health Hazard

SARA 313 Toxic ‹mical Notification ‹..d Release Reporting

This product contains the following components in concentrations above *de minimis* levels that are listed as toxic chemicals in 40 CFR Part 372 pursuant to the requirements of Section 313 of SARA:
Toluene [CAS No.: 108-88-3] Concentration: <25%
Xylene, all isomers [CAS No.: 1330-20-7] Concentration: <18%
n-Hexane [CAS No.: 110-54-3] Concentration: <8%
Benzene [CAS No.: 71-43-2] Concentration: <5%
Cumene [CAS No.: 98-82-8] Concentration: <4%
Ethylbenzene [CAS No.: 100-41-4] Concentration: <4%
1,2,4--Trimethylbenzene [CAS No.: 95-63-6] Concentration: <3%
Cyclohexane [CAS No.: 110-82-7] Concentration: <3%
Naphthalene [CAS No.: 91-20-3] Concentration: <2%
Styrene [CAS No.: 100-42-5] Concentration: <1%

CERCLA

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requires notification of the National Response Center concerning release of quantities of "hazardous substances" equal to or greater than the reportable quantities (RQ's) listed in 40 CFR 302.4. As defined by CERCLA, the term "hazardous substance" does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically designated in 40 CFR 302.4. Chemical substances present in this product or refinery stream that may be subject to this statute are:
Toluene [CAS No.: 108-88-3] RQ = 1000 lbs. (453.6 kg) Concentration: <25%
Xylene, all isomers [CAS No.: 1330-20-7] RQ = 100 lbs. (45.36 kg) Concentration: <18%
n-Hexane [CAS No.: 110-54-3] RQ = 5000 lbs. (2268 kg) Concentration: <8%
Benzene [CAS No.: 71-43-2] RQ = 10 lbs. (4.536 kg) Concentration: <5%
2,2,4-Trimethylpentane [CAS No.: 540-84-1] RQ = 1000 lbs. (453.6 kg) Concentration: <5%
Cumene [CAS No.: 98-82-8] RQ = 5000 lbs. (2268 kg) Concentration: <4%
Ethylbenzene [CAS No.: 100-41-4] RQ = 1000 lbs. (453.6 kg) Concentration: <4%
Cyclohexane [CAS No.: 110-82-7] RQ = 1000 lbs. (453.6 kg) Concentration: <3%
Naphthalene [CAS No.: 91-20-3] RQ = 100 lbs. (45.36 kg) Concentration: <2%
Styrene [CAS No.: 100-42-5] RQ = 1000 lbs. (453.6 kg) Concentration: <1%

Clean Water Act (CWA)

This material is classified as an oil under Section 311 of the Clean Water Act (CWA) and the Oil Pollution Act of 1990 (OPA). Discharges or spills which produce a visible sheen on waters of the United States, their adjoining shorelines, or into conduits leading to surface waters must be reported to the EPA's National Response Center at (800) 424-8802.

California Proposition 65

This material may contain the following components which are known to the State of California to cause cancer, birth defects or other reproductive harm, and may be subject to the requirements of California Proposition 65 (CA Health & Safety Code Section 25249.5): Gasoline (Wholly Vaporized and Engine Exhaust), Benzene [CAS No. 71-43-3], Toluene [CAS No. 108-88-3], Ethylbenzene [CAS No.100-41-4] and Naphthalene [CAS No.91-20-3]

New Jersey Right-to-Know Label

Gasoline [NJDEP CAS No. 8006-61-9]

Additional Remarks

As minimum requirements, CITGO recommends that the following advisory information be displayed on equipment used to dispense gasoline in motor vehicles. Additional warnings specified by various regulatory authorities may be required: "DANGER: Extremely Flammable. Use as a Motor Fuel Only. No Smoking. Stop Engine. Turn Off All Electronic Equipment Including Cellular Telephones. Do Not Overfill Tank. Keep Away from Heat and Flames. Do Not leave nozzle unattended during refueling. **Static Sparks Can Cause a Fire, especially when filling portable containers.** Containers must be metal or other material approved for storing gasoline. PLACE CONTAINER ON GROUND. DO NOT FILL ANY PORTABLE CONTAINER IN OR ON A VEHICLE. Keep nozzle spout in contact with the container during the entire filling operation. **Harmful or Fatal If Swallowed. Long Term-Exposure Has Caused Cancer In Laboratory Animals.** Avoid prolonged breathing of vapors. Keep face away from nozzle and gas tank. Never siphon by mouth."
WHMIS Class B-2: Flammable liquid with a flash point lower than 37.8°C (100°F).
WHMIS Class D-2B: Material causing other toxic effects (TOXIC).

SECTION 16. OTHER INFORMATION

..fer to the top of Page 1 for the HMIS and NFPA Hazard Ratings for this product.

REVISION INFORMATION

Version Number	9.1
Revision Date	10/14/2008

ABBREVIATIONS

AP: Approximately	EQ: Equal	>: Greater Than	<: Less Than
NA: Not Applicable	ND: No Data	NE: Not Established	

ACGIH: American Conference of Governmental Industrial Hygienists

AIHA: American Industrial Hygiene Association

IARC: International Agency for Research on Cancer

NIOSH: National Institute of Occupational Safety and Health

NPCA: National Paint and Coating Manufacturers Association

EPA: US Environmental Protection Agency

HMIS: Hazardous Materials Information System

OSHA: Occupational Safety and Health Administration

NTP: National Toxicology Program

NFPA: National Fire Protection Association

DISCLAIMER OF LIABILITY

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***** END OF MSDS *****

MATERIAL SAFETY DATA SHEET

Diesel Fuel (All Types) **MSDS No. 9909**

EMERGENCY OVERVIEW
CAUTION!
OSHA/NFPA COMBUSTIBLE LIQUID - SLIGHT TO MODERATE IRRITANT
EFFECTS CENTRAL NERVOUS SYSTEM
HARMFUL OR FATAL IF SWALLOWED

Moderate fire hazard. Avoid breathing vapors or mists. May cause dizziness and drowsiness. May cause moderate eye irritation and skin irritation (rash). Long-term, repeated exposure may cause skin cancer.
If ingested, do NOT induce vomiting, as this may cause chemical pneumonia (fluid in the lungs).

NFPA 704 (Section 16)

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Hess Corporation
1 Hess Plaza
Woodbridge, NJ 07095-0961

EMERGENCY TELEPHONE NUMBER (24 hrs):	CHEMTREC (800) 424-9300
COMPANY CONTACT (business hours):	Corporate Safety (732) 750-6000
MSDS INTERNET WEBSITE:	www.hess.com (See Environment, Health, Safety & Social Responsibility)

SYNONYMS: Ultra Low Sulfur Diesel (ULSD); Low Sulfur Diesel; Motor Vehicle Diesel Fuel; Diesel Fuel #2; Dyed Diesel Fuel; Non-Road, Locomotive and Marine Diesel Fuel; Tax-exempt Diesel Fuel

See Section 16 for abbreviations and acronyms.

2. COMPOSITION and CHEMICAL INFORMATION ON INGREDIENTS

INGREDIENT NAME (CAS No.)	CONCENTRATION PERCENT BY WEIGHT
Diesel Fuel (68476-34-6)	100
Naphthalene (91-20-3)	Typically < 0.01

A complex mixture of hydrocarbons with carbon numbers in the range C9 and higher. Diesel fuel may be dyed (red) for tax purposes. May contain a multifunctional additive.

3. HAZARDS IDENTIFICATION

EYES
Contact with liquid or vapor may cause mild irritation.

SKIN
May cause skin irritation with prolonged or repeated contact. Practically non-toxic if absorbed following acute (single) exposure. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are repeatedly exposed.

INGESTION
The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death.

Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

INHALATION
Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

WARNING: the burning of any hydrocarbon as a fuel in an area without adequate ventilation may result in hazardous levels of combustion products, including carbon monoxide, and inadequate oxygen levels, which may cause unconsciousness, suffocation, and death.

CHRONIC EFFECTS and CARCINOGENICITY
Similar products produced skin cancer and systemic toxicity in laboratory animals following repeated applications. The significance of these results to human exposures has not been determined - see Section 11 Toxicological Information.

IARC classifies whole diesel fuel exhaust particulates as probably carcinogenic to humans (Group 2A). NIOSH regards whole diesel fuel exhaust particulates as a potential cause of occupational lung cancer based on animal studies and limited evidence in humans.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
Irritation from skin exposure may aggravate existing open wounds, skin disorders, and dermatitis (rash).

4. FIRST AID MEASURES

EYES
In case of contact with eyes, immediately flush with clean, low-pressure water for at least 15 min. Hold eyelids open to ensure adequate flushing. Seek medical attention.

SKIN
Remove contaminated clothing. Wash contaminated areas thoroughly with soap and water or waterless hand cleanser. Obtain medical attention if irritation or redness develops.

INGESTION
DO NOT INDUCE VOMITING. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Monitor for breathing difficulties. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

INHALATION
Remove person to fresh air. If person is not breathing provide artificial respiration. If necessary, provide additional oxygen once breathing is restored if trained to do so. Seek medical attention immediately.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES:

FLASH POINT:	> 125 °F (> 52 °C) minimum PMCC
AUTOIGNITION POINT:	494 °F (257 °C)
OSHA/NFPA FLAMMABILITY CLASS:	2 (COMBUSTIBLE)
LOWER EXPLOSIVE LIMIT (%):	0.6
UPPER EXPLOSIVE LIMIT (%):	7.5

FIRE AND EXPLOSION HAZARDS
Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

EXTINGUISHING MEDIA
SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO2, water spray, fire fighting foam, or Halon.

LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.

FIRE FIGHTING INSTRUCTIONS
Small fires in the incipient (beginning) stage may typically be extinguished using handheld portable fire extinguishers and other fire fighting equipment.

Firefighting activities that may result in potential exposure to high heat, smoke or toxic by-products of combustion should require NIOSH/MSHA- approved pressure-demand self-contained breathing apparatus with full facepiece and full protective clothing.

Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

See Section 16 for the NFPA 704 Hazard Rating.

6. ACCIDENTAL RELEASE MEASURES

ACTIVATE FACILITY'S SPILL CONTINGENCY OR EMERGENCY RESPONSE PLAN.

Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to confirm spill areas. Spills may infiltrate subsurface soil and groundwater; professional assistance may be necessary to determine the extent of subsurface impact.

Carefully contain and stop the source of the spill, if safe to do so. Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection.

Take up with sand or other oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal - caution, flammable vapors may accumulate in closed containers. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

7. HANDLING and STORAGE

HANDLING PRECAUTIONS
Handle as a combustible liquid. Keep away from heat, sparks, and open flame! Electrical equipment should be approved for classified area. Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.

Diesel fuel, and in particular low and ultra low sulfur diesel fuel, has the capability of accumulating a static electrical charge of sufficient energy to cause a fire/explosion in the presence of lower flashpoint products such as gasoline. The accumulation of such a static charge occurs as the diesel flows through pipelines, filters, nozzles and various work tasks such as tank/container filling, splash loading, tank cleaning; product sampling; tank gauging; cleaning, mixing, vacuum truck operations, switch loading, and product agitation. There is a greater potential for static charge accumulation in cold temperature, low humidity conditions.

Documents such as 29 CFR OSHA 1910.106 "Flammable and Combustible Liquids, NFPA 77 Recommended Practice on Static Electricity, API 2003 "Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents and ASTM D4865 "Standard Guide for Generation and Dissipation of Static

Electricity in Petroleum Fuel Systems" address special precautions and design requirements involving loading rates, grounding, bonding, filter installation, conductivity additives and especially the hazards associated with "switch loading." ["Switch Loading" is when a higher flash point product (such as diesel) is loaded into tanks previously containing a low flash point product (such as gasoline) and the electrical charge generated during loading of the diesel results in a static ignition of the vapor from the previous cargo (gasoline).]

Note: When conductivity additives are used or are necessary the product should achieve 25 picosiemens/meter or greater at the handling temperature.

STORAGE PRECAUTIONS

Keep away from flame, sparks, excessive temperatures and open flame. Use approved vented containers. Keep containers closed and clearly labeled. Empty product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose such containers to sources of ignition.

Store in a well-ventilated area. This storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". Avoid storage near incompatible materials. The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

WORK/HYGIENIC PRACTICES

Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

8. EXPOSURE CONTROLS and PERSONAL PROTECTION

EXPOSURE LIMITS

Components (CAS No.)	Source	Exposure Limits TWA/STEL	Note
Diesel Fuel: (68476-34-6)	OSHA	5 mg/m, as mineral oil mist	
	ACGIH	100 mg/m^3 (as totally hydrocarbon vapor) TWA	A3, skin
Naphthalene (91-20-3)	OSHA	10 ppm TWA	
	ACGIH	10 ppm TWA / 15 ppm STEL	A4, Skin

ENGINEERING CONTROLS

Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.

EYE/FACE PROTECTION

Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

SKIN PROTECTION

Gloves constructed of nitrile, neoprene, or PVC are recommended. Chemical protective clothing such as of E.I. DuPont TyChem®, Saranex® or equivalent recommended based on degree of exposure. Note: The resistance of specific material may vary from product to product as well as with degree of exposure. Consult manufacturer specifications for further information.

RESPIRATORY PROTECTION
A NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection.

Use a positive pressure, air-supplied respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

9. PHYSICAL and CHEMICAL PROPERTIES

APPEARANCE
Clear, straw-yellow liquid. Dyed fuel oil will be red or reddish-colored.

ODOR
Mild, petroleum distillate odor

BASIC PHYSICAL PROPERTIES

BOILING RANGE:	320 to 690 oF (160 to 366 °C)
VAPOR PRESSURE:	0.009 psia @ 70 °F (21 °C)
VAPOR DENSITY (air = 1):	> 1.0
SPECIFIC GRAVITY (H_2O = 1):	0.83 to 0.88 @ 60 °F (16 °C)
PERCENT VOLATILES:	100 %
EVAPORATION RATE:	Slow; varies with conditions
SOLUBILITY (H_2O):	Negligible

10. STABILITY and REACTIVITY

STABILITY: Stable. Hazardous polymerization will not occur.

CONDITIONS TO AVOID and INCOMPATIBLE MATERIALS
Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources. Keep away from strong oxidizers; Viton ®; Fluorel ®

HAZARDOUS DECOMPOSITION PRODUCTS
Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke).

11. TOXICOLOGICAL PROPERTIES

ACUTE TOXICITY
Acute dermal LD50 (rabbits): > 5 ml/kg
Primary dermal irritation: extremely irritating (rabbits)
Guinea pig sensitization: negative
Acute oral LD50 (rats): 9 ml/kg
Draize eye irritation: non-irritating (rabbits)

CHRONIC EFFECTS AND CARCINOGENICITY
Carcinogenic: OSHA: NO IARC: NO NTP: NO ACGIH: A3

Studies have shown that similar products produce skin tumors in laboratory animals following repeated applications without washing or removal. The significance of this finding to human exposure has not been determined. Other studies with active skin carcinogens have shown that washing the animal's skin with soap and water between applications reduced tumor formation.

MUTAGENICITY (genetic effects)
This material has been positive in a mutagenicity study.

12. ECOLOGICAL INFORMATION

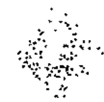
Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

13. DISPOSAL CONSIDERATIONS

Consult federal, state and local waste regulations to determine appropriate disposal options.

14. TRANSPORTATION INFORMATION

PROPER SHIPPING NAME:	Diesel Fuel	Placard (International Only):
HAZARD CLASS and PACKING GROUP:	3, PG III	
DOT IDENTIFICATION NUMBER:	NA 1993 (Domestic) UN 1202 (International)	
DOT SHIPPING LABEL:	None	



Use Combustible Placard if shipping in bulk domestically

15. REGULATORY INFORMATION

U.S. FEDERAL, STATE, and LOCAL REGULATORY INFORMATION

This product and its constituents listed herein are on the EPA TSCA Inventory. Any spill or uncontrolled release of this product, including any substantial threat of release, may be subject to federal, state and/or local reporting requirements. This product and/or its constituents may also be subject to other regulations at the state and/or local level. Consult those regulations applicable to your facility/operation.

CLEAN WATER ACT (OIL SPILLS)

Any spill or release of this product to "navigable waters" (essentially any surface water, including certain wetlands) or adjoining shorelines sufficient to cause a visible sheen or deposit of a sludge or emulsion must be reported immediately to the National Response Center (1-800-424-8802) as required by U.S. Federal Law. Also contact appropriate state and local regulatory agencies as required.

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIRONMENT)

The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil, refined, and unrefined petroleum products and any indigenous components of such. However, other federal reporting requirements (e.g., SARA Section 304 as well as the Clean Water Act if the spill occurs on navigable waters) may still apply.

SARA SECTION 311/312 - HAZARD CLASSES

ACUTE HEALTH	CHRONIC HEALTH	FIRE	SUDDEN RELEASE OF PRESSURE	REACTIVE
X	X	X	--	--

SARA SECTION 313 - SUPPLIER NOTIFICATION

This product may contain listed chemicals below the *de minimis* levels which therefore are not subject to the supplier notification requirements of Section 313 of the Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 and of 40 CFR 372. If you may be required to report releases of chemicals listed in 40 CFR 372.28, you may contact Hess Corporate Safety if you require additional information regarding this product.

CALIFORNIA PROPOSITON 65 LIST OF CHEMICALS

This product contains the following chemicals that are included on the Proposition 65 "List of Chemicals" required by the California Safe Drinking Water and Toxic Enforcement Act of 1986:

INGREDIENT NAME (CAS NUMBER)	Date Listed
Diesel Engine Exhaust (no CAS Number listed)	10/01/1990

CANADIAN REGULATORY INFORMATION (WHMIS)

Class B, Division 3 (Combustible Liquid) and Class D, Division 2, Subdivision B (Toxic by other means)

16. OTHER INFORMATION

NFPA® HAZARD RATING

HEALTH:	0
FIRE:	2
REACTIVITY:	0

Refer to NFPA 704 "Identification of the Fire Hazards of Materials" for further information

HMIS® HAZARD RATING

HEALTH:	1 *	* Chronic
FIRE:	2	
PHYSICAL:	0	

SUPERSEDES MSDS DATED: 02/28/2001

ABBREVIATIONS:

AP = Approximately   < = Less than   > = Greater than
N/A = Not Applicable   N/D = Not Determined   ppm = parts per million

ACRONYMS:

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute (212) 642-4900
API	American Petroleum Institute (202) 682-8000
CERCLA	Comprehensive Emergency Response, Compensation, and Liability Act
DOT	U.S. Department of Transportation [General Info: (800) 467-4922]
EPA	U.S. Environmental Protection Agency
HMIS	Hazardous Materials Information System
IARC	International Agency For Research On Cancer
MSHA	Mine Safety and Health Administration
NFPA	National Fire Protection Association (617)770-3000
NIOSH	National Institute of Occupational Safety and Health
NOIC	Notice of Intended Change (proposed change to ACGIH TLV)
NTP	National Toxicology Program
OPA	Oil Pollution Act of 1990
OSHA	U.S. Occupational Safety & Health Administration
PEL	Permissible Exposure Limit (OSHA)
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit (NIOSH)
SARA	Superfund Amendments and Reauthorization Act of 1986 Title III
SCBA	Self-Contained Breathing Apparatus
SPCC	Spill Prevention, Control, and Countermeasures
STEL	Short-Term Exposure Limit (generally 15 minutes)
TLV	Threshold Limit Value (ACGIH)
TSCA	Toxic Substances Control Act
TWA	Time Weighted Average (8 hr.)
WEEL	Workplace Environmental Exposure Level (AIHA)
WHMIS	Canadian Workplace Hazardous Materials Information System

Sikadur 31, Hi-Mod Gel

Product Data Sheet
Edition 7.1.2008
Identification no. 039603N
Sikadur 31, Hi-Mod Gel

Sikadur® 31, Hi-Mod Gel (1:1 Mix Ratio)

High-modulus, high-strength, structural, epoxy paste adhesive

Description	Sikadur 31, Hi-Mod Gel, is a 2-component, 100% solids, solvent-free, moisture-tolerant, high-modulus, high-strength, structural epoxy paste adhesive. It conforms to the current ASTM C-881 and AASHTO M-235 specifications.
Where to Use	▪ Structural bonding of concrete, masonry, metals, wood, etc. to a maximum glue line of ⅛ in. (3 mm). ▪ Grout bolts, dowels, and pins. ▪ Seals cracks and around injection ports prior to pressure-injection grouting. ▪ Interior, vertical, and overhead repair of concrete as an epoxy mortar binder. ▪ As a pick-proof sealant around windows, doors, lock-ups etc. inside correctional facilities.
Advantages	▪ Meets physical requirements of ASTM C-881 Types I, II & IV, Grade 3, Classes B & C. ▪ Suitable for potable water contact, meets NSF/ANSI Standard 61 ▪ Excellent adhesion to concrete, masonry, metals, wood, and most structural materials. ▪ Paste consistency ideal for vertical and overhead repair of concrete ▪ Fast-setting and strength-producing adhesive. ▪ Convenient easy mix ratio A:B = 1:1 by volume.

Typical Data *(Material and curing conditions @ 73°F (23°C) and 50% R.H.)*

Shelf Life	2 years in original, unopened containers
Storage Conditions	Store dry at 40°-95°F (4°-35°C). Condition material to 65°-85°F (18°-29°C) before using.
Color	Gray
Mixing Ratio	Component 'A' : Component 'B' = 1:1 by volume
Consistency	Non-sag paste
Pot Life	Approximately 60 minutes @ 73°F. (600 gram mass)
Tack-Free Time	1.5 - 2.5 hours at 30 mils. thick

Tensile Properties (ASTM D-638)
7 day — Tensile Strength: 3,300 psi (22.7 MPa)
Elongation at Break: 0.5 %

Flexural Properties (ASTM D-790)
7 day — Flexural Strength (Modulus of Rupture): 6,100 psi (42.0 MPa)
Tangent Modulus of Elasticity in Bending: 1.67 X 10^6 psi (11,520 MPa)

Shear Strength (ASTM D-732) 7 day Shear Strength 4,600 psi (31.7 MPa)

Bond Strength (ASTM C-882)
Hardened Concrete to Hardened Concrete:
2 day (dry cure) 2,200 psi (15.2 MPa)
2 day (moist cure) 2,400 psi (16.5 MPa)
14 day (moist cure) 2,900 psi (20.0 MPa)
Hardened Concrete to Steel:
2 day (dry cure) 2,900 psi (20.0 MPa)

Tensile Bond Strength (Pull-off Method, Dyna, ASTM C-1583-04)
2 day 420 psi (2.9 MPa)

Heat Deflection Temperature (ASTM D-648) 7 day (Fiber Stress Loading = 264 psi) 135°F (57°C)
Water Absorption (ASTM D-570) 24 hour 0.07%
Compressive strength (ASTM D-695) psi (MPa)

	40°F (4°C)* **	73°F (23°C)* **	90°F (32°C)* **
2 hour	-	-	450 (3.1)
4 hour	-	800 (5.5)	10,500 (72.4)
8 hour		8,000 (55.2)	12,200 (84.1)
16 hour	700 (4.8)	10,500 (72.4)	13,000 (89.6)
1 day	6,000 (41.4)	13,000 (89.6)	15,000 (103.4)
3 day	11,000 (75.8)	14,000 (96.5)	16,000 (110.3)
7 day	12,900 (88.9)	15,000 (103.4)	16,000 (110.3)
14 day	13,500 (93.0)	15,400 (106.1)	16,000 (110.3)
28 day	14,000 (96.5)	16,000 (110.3)	16,000 (110.3)

Compressive Modulus of Elasticity (ASTM D-695) 7 day 7.85 X 10^5 psi (5,405 MPa)

* Material cured and tested at temperatures indicated.
** See Limitations section for further information

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Coverage	1 gal. yields 231 cu. in. (3,785 cm³) of epoxy paste adhesive. 1 gal. (3.8 L) mixed with 1 gal. (3.8 L) by loose volume of oven-dried aggregate yields approximately 346 cu. in. (5,670 cm³) of epoxy mortar.
Packaging	3 gal. (11.4 L) units

How to Use

Surface Preparation	Surface must be clean and sound. It may be dry or damp, but free of standing water. Remove dust, laitance, grease, curing compounds, impregnations, waxes, and any other contaminants. **Preparation Work: Concrete** - Should be cleaned and prepared to achieve a laitance and contaminant free, open textured surface by blastcleaning or equivalent mechanical means. **Steel** - Should be cleaned and prepared thoroughly by blastcleaning.
Mixing	**Pre-mix each component.** Proportion 1 part Component 'B' to 1 part Component 'A' by volume into a clean pail. Mix thoroughly for 3 minutes with Sika paddle on low-speed (400- 600 rpm) drill until uniform in color. Mix only that quantity which can be used within its pot life. Prior to mixing, material should be conditioned to 65°-85°F (18°-29°C). To prepare an epoxy mortar, slowly add up to 1 part, by loose volume of an oven-dried aggregate, to 1 part of the mixed Sikadur 31, Hi-Mod Gel and mix until uniform in consistency.
Application	**As a structural adhesive** - Apply the neat mixed Sikadur 31, Hi-Mod Gel to the prepared substrates. Work into the substrate for positive adhesion. Secure the bonded unit firmly into place until the adhesive has cured. Glue line should not exceed 1/8-in. (3 mm). **To seal cracks for injection grouting** - Place the neat mixed material over the cracks to be pressure injected and around each injection port. Allow sufficient time to set before pressure injecting. **For interior vertical and overhead patching** - Place the prepared mortar in void, working the material into the prepared substrate, filling the cavity. Strike off level. Lifts should not exceed 1-in (25 mm). **As a pick-proof sealant** - Use automated or manual method. Apply an appropriate size bead of material around the area being sealed. Seal with neat Sikadur 31, Hi-Mod Gel
Limitations	■ **THE NTSB HAS STATED THAT THIS PRODUCT IS APPROVED FOR SHORT TERM LOADS ONLY AND SHOULD NOT BE USED IN SUSTAINED TENSILE LOAD ADHESIVE ANCHORING APPLICATIONS WHERE ADHESIVE FAILURE COULD RESULT IN A PUBLIC SAFETY RISK. CONSULT A DESIGN PROFESSIONAL PRIOR TO USE.** ■ Components of original 2:1 mix ratio formulation of Sikadur 31, Hi-Mod Gel cannot be cross-mixed with components of Sikadur 31, Hi-Mod Gel (NEW 1:1 Mix Ratio) formulation. ■ Minimum substrate and ambient temperature 40°F (4°C). ■ Do not thin. Solvents will prevent proper cure. ■ When preparing an epoxy mortar, use oven-dried aggregate only. ■ Maximum epoxy mortar thickness is 1 in. (25 mm) per lift. ■ Epoxy mortar is for interior use only. Material is a vapor barrier after cure. ■ Minimum age of concrete must be 21-28 days, depending upon curing and drying conditions for mortar applications. ■ Porous substrates must be tested for moisture vapor transmission prior to mortar applications ■ Not for sealing cracks under hydrostatic pressure. ■ Not an aesthetic product. Color may alter due to variations in lighting and/or UV exposure.
WARNING	**Component 'A' - IRRITANT, SENSITIZER.** Contains epoxy resin, silica, and calcium carbonate. Causes eye irritation. May cause skin/respiratory irritations. Prolonged and/or repeated contact with skin may cause allergic reaction/sensitization. Harmful if swallowed. **Deliberate concentrations of vapors for purposes of inhalation is harmful and can be fatal.** **Component 'B' - CORROSIVE, SENSITIZER, IRRITANT.** Contains Amines, silica quartz (sand), and calcium carbonate. Contact with skin and eyes causes severe burns. Causes eye/skin/respiratory irritation. Prolonged and/or repeated contact may cause allergic reaction/sensitization. Harmful if swallowed. **Deliberate concentrations of vapors for purposes of inhalation is harmful and can be fatal.** Cured material, if sanded, may result in exposure to a chemical known to the State of California to cause cancer.
First Aid	**Eyes** - Hold eyelids apart and flush thoroughly with water for 15 minutes. **Skin** - Remove contaminated clothing. Wash skin thoroughly for 15 minutes with soap and water. **Inhalation** - Remove person to fresh air. **Ingestion** - Do not induce vomiting. Contact a physician. **In all cases, contact a physician immediately if symptoms persist.**
Handling & Storage	Avoid direct contact with eyes and skin. Wear chemical resistant gloves/goggles/clothing. Avoid breathing vapors. Use with adequate general and local exhaust ventilation. Use a properly fitted NIOSH approved respirator. Wash thoroughly after handling product. Remove contaminated clothing and launder before reuse. Store product in a closed container in a cool, dry place.

MATERIAL SAFETY DATA SHEET

INTERPLASTIC CORPORATION
1225 Willow Lake Boulevard
St. Paul, MN 55110-5145
(651) 481-6860

CHEMTREC 24-Hour Emergency Telephone (800) 424-9300

ATTN: PLANT MGR/SAFETY DIR

Date Printed:	12/15/10
Revision Date:	12/15/10
MSDS File ID:	MSDSLETO
Customer No:	
Warehouse No:	0001

This MSDS complies with 29 CFR 1910.1200 (Hazard Communication).

SECTION I - PRODUCT IDENTIFICATION

Product Name:	COR72-AT-470 CIPP ISO RESIN
General or Generic ID:	Unsaturated Polyester Resin
Hazard Classification:	Flammable Liquid

SECTION II - HAZARDOUS COMPONENTS

INGREDIENT	CAS NO.	PERCENT	OSHA-PEL	ACGIH-TL NOTE
Unsaturated Polyester Base Resin	See Index	69.0	None-Estb.	None-Est
Styrene	100-42-5	31.4	50 ppm TWA	50 ppm (1&2)

(1) OSHA has formally endorsed a styrene industry proposal for a voluntary 50 ppm PEL for workplace exposure to styrene. This proposal was agreed upon by representatives of the UPR industry. The OSHA STEL is 100 ppm. The ACGIH recently changed the TLV for styrene from 50 ppm to 20 ppm, and the STEL from 100 ppm to 40 ppm.
(2) HMIS Rating for Styrene: Health=2; Fire=3; Physical Hazard=2

SECTION III - PHYSICAL DATA

PROPERTY		MEASUREMENT
Initial Boiling Point	For Styrene	293.40 Deg F (145.22 Deg C) @ 760.00 mm Hg
Vapor Pressure	For Styrene	4.3 mm Hg 68 Deg F (20 Deg C)
Specific Gravity		1.01-1.30 @ 77 Deg F (25 Deg C)
Vapor Density	Air = 1	3.6
Evaporation Rate		Slower than Ether

SECTION IV - FIRE AND EXPLOSION DATA

Flash Point: 88 Deg F (31.1 Deg C) for Volatile Component

Flammable: (Lowest Value of Styrene) Lower - 1.1%
(Upper Value of Styrene) Upper - 6.1%

Extinguishing Media: Foam, carbon dioxide, dry chemical, or water fog.

Hazardous Decomposition Products: May form toxic materials such as carbon dioxide, carbon monoxide, and various hydrocarbons.

Special Firefighting Procedures: Wear self-contained breathing apparatus with a full facepiece operated in pressure demand or other positive pressure mode when fighting fires.

Vapors are heavier than air and may travel along the ground or may be moved by ventilation and ignited by ignition sources at locations distant from material handling point.

Never use welding or cutting torch on or near drum (even empty) because product vapor can ignite explosively.

SECTION V - HEALTH DATA

Permissible Exposure Level: Not established for product. See Section II.

POTENTIAL HEALTH EFFECTS

Eyes - Can cause severe irritation, redness, tearing, blurred vision.

Skin - Prolonged or repeated contact can cause moderate irritation, defatting, dermatitis.

Inhalation - Excessive inhalation of vapors can cause nasal irritation, dizziness, weakness, fatigue, nausea, headache, possible unconsciousness, and even asphyxiation.

Swallowing - Can cause gastrointestinal irritation, nausea, vomiting, diarrhea. Aspiration of material into the lungs can cause chemical pneumonitis.

SECTION V - HEALTH DATA (continued)

TARGET ORGAN EFFECTS

Overexposure to this material (or its components) has been suggested as a cause of the following effects in laboratory animals, and may aggravate pre-existing disorders of these organs in humans: mild, reversible kidney effects, effects on hearing, respiratory tract (nose, throat, and airways), testis, liver. Overexposure to this material (or its components) has been suggested as a cause of the following effects in humans, and may aggravate pre-existing disorders of these organs: central nervous system effects, mild effects on color vision, effects on hearing, and respiratory tract damage (nose, throat, and airways).

FIRST AID

If on Skin: Thoroughly wash exposed area with soap and water. Remove contaminated clothing. Launder contaminated clothing before re-use.

If in Eyes: Flush with large amount of water, lifting upper and lower lids occasionally. Get medical attention.

If Swallowed: Do not induce vomiting. Keep person warm, quiet, and get medical attention. Aspiration of material into the lungs due to vomiting can cause chemical pneumonitis which can be fatal.

If Inhaled: If affected, remove individual to fresh air. If breathing is difficult, administer oxygen. If breathing has stopped, give artificial respiration. Keep person warm, quiet, and get medical attention.

PRIMARY ROUTE(S) OF ENTRY

Inhalation, skin absorption, skin contact, eye contact.

SECTION VI - REACTIVITY DATA

Hazardous Polymerization:	Possible
Stability:	Stable
Incompatibility:	Avoid contact with strong alkalies, strong mineral acids, and oxidizing agents.
Conditions to Avoid:	Exposure to excessive heat or open flame, storage in open containers, prolonged storage (6 months), storage above 100 Deg F (38 Deg C), and contamination with oxidizing agents.
Hazardous Decomposition Products:	Carbon monoxide, carbon dioxide, low molecular weight hydrocarbons, and organic acids.

SECTION VII - SPILL OR LEAK PROCEDURES

Eliminate all ignition sources (flares, flames (including pilot lights), and electrical sparks). Persons not wearing protective equipment should be excluded from area of spill until clean-up has been completed. Stop spill at source, dike area of spill to prevent spreading, shovel or pump to tank or drums. Remaining liquid may be absorbed in sand, clay, earth, or other absorbent material and shoveled into containers.

SECTION VIII - PROTECTIVE EQUIPMENT TO BE USED

Respiratory Protection:	If PEL of the product or any component is exceeded, an NIOSH/MSHA approved respirator is advised in absence of proper engineering control (see your safety equipment supplier). Engineering or administrative controls should be implemented to reduce exposure.
Ventilation:	Provide sufficient mechanical (general and/or local exhaust) ventilation to maintain exposure below TLV(s).
Protective Gloves:	Wear chemical resistant gloves that afford proper protection to the hands, such barrier creams maybe used in some environments as long as proper skin protection is afforded.
Eye Protection:	Chemical splash goggles in compliance with OSHA regulations are advised; however, OSHA regulations also permit other type safety glasses. (Consult your safety equipment supplier.)
Other Protective Equipment:	Work clothing that covers arms and legs.

SECTION IX - SPECIAL PRECAUTIONS

Containers of this material may be hazardous when empty. Since empty containers retain product residues (vapors, liquid, and/or solids), all hazard precautions given in this MSDS must be observed.

The information accumulated herein is believed to be accurate, but is not warranted to be, whether originating with Interplastic or not. Recipients are advised to confirm in advance of need that the information is current, applicable, and suitable to their circumstances.

SECTION X - SUPPLEMENT

Styrene has been identified as a possible human carcinogen by the International Agency for Research on Cancer (IARC). The IARC determination is based on "limited evidence" in animals and other "relevant data." IARC concedes there is "inadequate evidence" on humans for its findings.

The Styrene Information and Research Center (SIRC) recently sponsored studies to evaluate potential health effects in laboratory rats and mice exposed by inhalation to styrene for six hours per day for five days per week of their lifetime. The rat study, completed in 1996, showed no increased incidence of tumors related to styrene exposure at levels up to 1000 parts per million (ppm). The results of the mouse study are in the process of being analyzed, and so far only the lungs have been evaluated. The number of lung tumors observed at exposure levels of 20 to 160 ppm was increased as compared to the number of tumors seen in unexposed mice. These lung tumor results from the mouse study have been added to the MSDS for styrene.

The lung effects in the new mouse study are in contrast to findings in other studies in both rodents and humans, including the recent SIRC-sponsored study in rats. No link between styrene exposure and an increased incidence of cancer has been found collectively in eight studies of workers in the reinforced plastics and composites industries prior to 1992, or in two subsequent studies of composites/reinforced plastics workers. All together, over 90,000 people have been studied. Exposure levels in these industries are above the levels routinely measured in styrene and polystyrene production.

Also in the recent animal studies, irritation and degenerative effects on the olfactory cells in the nose (responsible for the sense of smell) were observed in mice exposed repeatedly by inhalation to 20 ppm and above, and in rats exposed to 50 ppm and above. Atrophy (degeneration) of the olfactory nerve was observed at levels at or above 40 ppm in mice and at or above 500 ppm in rats. SIRC is conducting follow-up research to further understand these findings and their possible importance to humans. Liver damage has been reported in mice at exposure levels of 100 ppm or above; comparable liver damage has not been reported in rats or humans exposed to styrene. It appears that mice are more sensitive to styrene than are other species. Information about potential damage to olfactory cells, irritation in the respiratory tract, and potential liver damage has been added to the MSDS for styrene.

We recommend that the precautions in this MSDS be followed.

SECTION XI - SUPPLIER NOTIFICATION

This product contains toxic chemicals subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 and of 40 CFR 372. Please refer to "Section II - Hazardous Components" for the specific product and concentration.

SECTION XII - TRANSPORTATION INFORMATION

Regulatory Information	UN Number	Proper Shipping Name	Class	Packaging Group	Label	Additional Information
US DOT	UN-1866	Resin Solution	3	III	Flammable Liquid	RQ for Styrene=1000 pounds*

* For shipments in a single container exceeding the RQ for styrene the letters RQ must appear in the proper shipping name.

BASE RESIN CAS INDEX

The base resins indicated under Section II are identified by one or more of the following CAS numbers:

113060-15-4	28572-30-7	58182-50-6	67859-89-6
135108-89-3	28679-80-3	61224-63-3	49624-93-3
141224-31-9	29011-83-4	62569-28-2	79-41-1
14807-96-6	29350-58-1	64386-66-9	
149717-53-3	29403-69-8	67380-21-6	
155122-62-6	29403-69-8	64386-67-0	
21645-51-2	30110-00-0	67599-39-7	
25037-66-5	30946-90-8	67712-08-7	
25101-03-5	31260-98-7	67845-68-5	
25215-72-9	31472-46-5	67939-08-6	
25464-21-5	32505-78-5	67939-40-6	
25609-89-6	32677-47-7	68002-44-8	
25749-46-6	32762-75-7	68140-84-1	
25749-49-9	36346-15-3	68140-88-5	
25987-82-0	36425-15-7	68171-28-8	
26098-37-3	36425-16-8	68238-98-2	
26123-45-5	37339-47-2	68299-40-1	
26265-08-7	37347-86-7	68492-68-2	
26301-26-8	37999-57-8	68511-26-2	
26588-55-6	42133-45-9	68585-94-4	
26795-76-6	464920-01-2	68647-07-4	
27342-37-6	52453-94-8	72259-64-4	
27837-75-8	54228-09-0	81192-92-9	
27863-48-6	56083-98-8	9003-20-7	
28472-89-1	56083-99-9	9065-68-3	
28516-30-5	57863-48-6	37625-93-7	

Triginox – C

Catalyst for resin

AKZO NOBEL

TRIGONOX C

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Product name Trigonox C	**Chemical description** tert-Butyl peroxybenzoate
	Chemical formula C11 H14 O3
CAS-number 614-45-9	**Chemical family** Organic Peroxides/peroxyesters
Supplier Akzo Nobel Polymer Chemicals LLC 525 West Van Buren Street Chicago, IL 60607-3823 USA www.akzonobel-polymerchemicals.com	
Emergency telephone + 1-914-693-6946 Dobbs Ferry, NY USA	**transportation Emergency** CHEMTREC - USA: 1-800-424-9300 CANUTEC - CANADA: 1-613-996-6666
Product use Polymerization initiator	**product/technical Information** 1-800-828-7929
Date of first issue 1994-03-31	**Date of last issue / Revision** 2005-02-28 / 9.00

2. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredients	Percentage(s)	CAS number
tert-Butyl peroxybenzoate	98.00	000614-45-9

3. HAZARDS IDENTIFICATION

Emergency overview

Clear, white-to-pale yellow liquid with an aromatic odor.
DANGER!
ORGANIC PEROXIDE.
HEAT OR CONTAMINATION MAY CAUSE HAZARDOUS DECOMPOSITION.
COMBUSTIBLE LIQUID AND VAPOR.
MAY CAUSE EYE, SKIN AND RESPIRATORY TRACT IRRITATION.
This product is a combustible liquid. Peroxides and decomposition products are flammable and can ignite with explosive force if confined.

Health effects

Skin or eye contact and inhalation of vapor or mists are the principal routes of exposure to this product.
Inhalation of vapors and/or mists may cause irritation of the nose, throat and lungs.
Skin contact may cause irritation and redness.
Eye contact may cause slight irritation.
Irritation to the mouth, throat, esophagus and stomach may be caused by ingestion of this material. Ingestion may result in nausea and/or vomiting.

AKZO NOBEL

TRIGONOX C

4. FIRST AID MEASURES

Inhalation
Remove to fresh air. If not breathing, clear victim's airway and start artificial respiration. If victim is breathing, supplemental oxygen may be given from a demand-type or continuous-flow inhaler, preferably with a physician's advice. Get medical attention immediately.

Skin
Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Seek medical attention if indicated. Wash clothing before reuse.

Eye
Immediately flush eyes with large quantities of running water for a minimum of 15 minutes. If the victim is wearing contact lenses, remove them. Take care not to contaminate the victim's healthy skin and eyes. Hold the eyelids apart during the flushing to ensure rinsing of the entire surface of the eye and lids. DO NOT let victim rub eye(s). Do not attempt to neutralize with chemical agents. Get medical attention immediately. Oils or ointments should not be used at this time. Continue flushing for an additional 15 minutes if a physician is not immediately available.

Ingestion
Do NOT induce vomiting. Call a physician or a poison control center immediately. Give victim plenty of water to drink. Never give anything by mouth to an unconscious or convulsing person. Get medical attention immediately.

Note to physician
There are no data available that address medical conditions that are generally recognized as being aggravated by exposure to this product.

No specific antidote is known. Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical conditions.

5. FIRE-FIGHTING MEASURES

Flash point Above the SADT value	**Autoignition temperature** not determined
Flash Method Setaflash Closed Cup	**Explosion limits** lower: N/D upper: N/D

Extinguishing media
Use water fog or spray, dry chemical, foam or carbon dioxide extinguishing agents.

Fire fighting procedures
As in any fire, prevent human exposure to fire, smoke, fumes or products of combustion. Evacuate non-essential personnel from the fire area. Firefighters should wear full-face, self-contained breathing apparatus and impervious protective clothing. If possible, move containers from the fire area. If not leaking, keep fire exposed containers cool with a water fog or spray to prevent rupture due to excessive heat. High pressure water may spread product from broken containers increasing contamination or fire hazard. Contaminated buildings, areas and equipment must not be used until they are properly decontaminated. Dike fire water for later disposal. Do not allow contaminated water to enter waterways.

Fire and explosion hazard
This product is a combustible liquid. Peroxides and decomposition products are flammable and can ignite with explosive force if confined.
This product can produce flammable vapors which may travel to a source of ignition and flash back.

Hazardous products of combustion
Thermal decomposition produces oxides of carbon and/or hazardous fumes, vapors and/or gasses.

TRIGONOX C

NFPA ratings	
Hazard	**Rating**
Health	1
Flammability	3
Reactivity	3

6. ACCIDENTAL RELEASE MEASURES

Methods for cleaning up

Remove all sources of ignition from the spill area. Stop source of spill. If tools are needed, they should be non-sparking. Dike area to prevent spill from spreading. If permitted to enter sewers, this material may create a fire or explosion hazard. Ventilate enclosed areas to prevent formation of flammable or oxygen deficient atmosphere. A water fog, fine spray or blanket of fire-fighting foam can be used to reduce vapors.
Evacuate all non-essential personnel upwind. Any person entering an area of a significant spill or of an unknown concentration of a gas or a vapor should use a NIOSH-approved, positive-pressure/pressuredemand, self-contained breathing apparatus. Protective equipment to prevent skin and eye contact should be worn.
Soak up liquid with a suitable absorbent such as clay, vermiculite, sand or earth. Sweep up absorbed material and place in a chemical waste container for disposal.
Contaminated areas, buildings and equipment must not be used until they are properly decontaminated. Generously cover contaminated area with a slurry of common household, powdered laundry detergent and water. Using a stiff brush, work the slurry into cracks and crevices. Allow to stand for 2-3 minutes. Then flush with water. Repeat if necessary. Dike water for later disposal. Do not allow contaminated water to enter waterways.

7. HANDLING AND STORAGE

Handling

Containers should be located in an area where they can be rotated regularly (first in, first out) and visually inspected for damage or bulging on a regular basis.
Use approved equipment for transport of containers to avoid puncturing or rupturing containers. Do not use air pressure to empty containers.
Protective equipment should be worn when handling this product to avoid eye and skin contact.
Emptied container may retain product residues. Follow all warnings and precautions even after container is emptied.

Storage

To insure product quality, storage temperatures should not exceed 77 F (25 C). To insure against possible exothermic self-accelerating decomposition, storage temperatures must not exceed 131 F (55 C). This storage temperature is derived from the SADT (see Section 10). Keep containers tightly closed. Store away from reducing agents, strong oxidizers, acids, alkalis and accelerators.

Maximum storage temperature

77.00 °F 25.00 °C

General comments

Containers should not be opened until ready for use. Use clean non-sparking equipment and tools when handling.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Respiratory protection

Use a NIOSH-approved organic vapor respirator with dust, mist and fume filters to reduce potential for inhalation exposure if use conditions generate vapor, mist or aerosol and adequate ventilation (e.g., outdoor or well-ventilated area) is not available. Where exposure potential necessitates a higher level of protection, use a NIOSH-approved, positive-pressure/pressure-demand, air-supplied respirator.
When using respirator cartridges or canisters, they must be changed frequently (following each use or at the end of the workshift) to assure breakthrough exposure does not occur.

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TRIGONOX C

Skin protection Skin contact with this product should be prevented through the use of suitable protective clothing, gloves, and footwear selected with regard for use condition exposure potential.
Eye protection Eye contact with liquid or aerosol must be prevented through the use of chemical safety goggles or a face shield selected with regard for use condition exposure potential. Eye wash fountains or other means of washing the eyes with a gentle flow of water should be readily available in all areas where this product is handled or stored. Water should be supplied through insulated and/or heat-traced pipes to prevent freeze-up in winter.
ventilation protection Sufficient good general ventilation should be provided to keep concentration below the exposure limit. All work with laboratory samples should be conducted in a hood.
Other information Safety showers, with quick opening valves which stay open, and eye wash fountains, or other means of washing the eyes with a gentle flow of cool to tepid tap water, should be readily available in all areas where this material is handled or stored. Water should be supplied through insulated and heat-traced lines to prevent freezeups in cold weather.
Applicable exposure limits There are no available exposure limits for this product.

Agency	Value/Unit of measurement
PEL = Permissible Exposure Limit TLV = Threshold Limit Value TWA = Time Weighted Average STEL = Short Term Exposure Limit CEIL = Ceiling Exposure Limit REL = Recommended Exposure Limit WEEL = Workplace Environmental Exposure Limit IDLH = Immediate Dangerous to Life and Health	

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odour Clear, white-to-pale yellow liquid with an aromatic odor.	**pH value** not determined
Odor threshold (ppm) not determined	**Relative vapour density (air=1)** > 6
Volatile % not determined	**Vapour pressure (mm Hg)** 0.33 @ 50 deg C
Boiling point/range not determined	**Evaporation rate** not determined
Melting point/range 46.40 °F 8.00 °C	
Cloud point not determined	**Pour point** not determined
Flash point Above the SADT value	**Solubility in water** Insoluble
Flash method Setaflash Closed Cup	**Solubility in other solvents** not determined

	headache and throat irritation. The peroxide has been found to be genetically active in the Mouse Lymphoma Forward Mutation Assay. Inconclusive results have been obtained in the Ames Test. It did not induce the formation of micronuclia when tested in mice. The reproductive toxicity of this product is not known. The neurotoxic effects of this product are not known. Overexposure to this product may affect the skin, eyes and respiratory system.
Other toxicological information	Prolonged contact with clothing saturated with tert-butyl peroxy benzoate may cause skin irritation and blistering.

12. ECOLOGICAL INFORMATION

Ecotoxicological information	The ecological toxicity of this product is not known.
Bioaccumulation	Chemical fate information on this product is not known.
Other information	Other ecological information on this product is not known.

13. DISPOSAL CONSIDERATIONS

Waste disposal in accordance with regulations
The characteristics of Ignitability (D001) and Reactivity (D003) as per RCRA, would be exhibited by unused product if it becomes a waste material. It is the responsibility of the waste generator to evaluate whether his wastes are hazardous by characteristic or listing. All waste should be disposed of in accord with federal, state and local regulations. Note: State and/or local regulations may be more stringent than federal regulations.

Container disposal
Containers should be cleaned of residual product before disposal. Empty containers should be disposed of in accordance with all applicable laws and regulations.

14. TRANSPORT INFORMATION

Shipping description	ORGANIC PEROXIDE TYPE C, LIQUID (TERT-BUTYL PEROXYBENZOATE, 98%) 5.2, UN3103, PG II NORTH AMERICAN ERG NO:146
Required labels	ORGANIC PEROXIDE.
Environmentally hazardous substance	This product does not contain an environmentally hazardous substance per 49 CFR 172.101, Appendix A.

15. REGULATORY INFORMATION

Products and/or components listed below are subject to the following:	
tert-Butyl peroxybenzoate	
Massachusetts Substance List	yes
New Jersey R-T-K Hazard. Sub.	yes
Toxic Subst. Cont. Act -listed	yes

TRIGONOX C

Domestic Substance List-Canada	yes

Hazard classes	
Description	**Applicable**
HMIS Hazard Rating Source	HMIS
HMIS Health	1
HMIS Flammability	2
HMIS Reactivity	3
WHMIS Hazard classes	B-3, C, D-2B, F

Other regulatory information
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by the Controlled Products Regulations.

16. OTHER INFORMATION

Other information
TRIGONOX is a registered trademark of Akzo Nobel Chemicals Inc.

Created by
B. McHenry, Regulatory Affairs - Americas

MATERIAL SAFETY DATA SHEET
North American Composites
300 Apollo Drive
Lino Lakes, MN 55014
24-Hour Emergency Telephone (800) 424-9300

3701126200
GELCO SERVICES, INC.
P.O. BOX 17370
SALEM, OR 97305-7370

Issue Date: 12/08/2004

The Material Safety Data Sheet accompanying this cover page is for a compound supplied, not manufactured, By North American Composites. It complies with 29 CFR 1910.100.

Product Number	Product Description	
0801	STYRENE - 15PPM	0801.pdf

Interplastic Corporation
1225 Willow Lake Blvd
Vadnais Heights, MN 55110-5145

24-Hour Emergency Telephone (800) 424-9300

ATTN: PLANT MGR/SAFETY DIR

Revision Date: 04/20/92
Issue Date: 12/09/03
MSDS File id: MSDSLT14
Customer No:
Whse No: 0001

This MSDS complies with 29 CFR 1910.1200 (The Hazard Communication Standard)

I. IDENTIFICATION

Product Name: Styrene
Formula: C6H5CHCH2

II. INGREDIENTS AND RECOMMENDED OCCUPATIONAL EXPOSURE LIMITS

Component: Styrene
% Weight: Approximately 100
CAS No.: 100-42-5
Exposure Limits: OSHA-PEL: TWA-50 ppm; STEL-100 ppm
ACGIH-TLV: TWA-50 ppm; STEL-100 ppm

AZARD DATA - DANGER!
Extremely flammable liquid and vapor. May cause eye, skin, and upper respiratory tract irritation.

INGREDIENT HAZARD INFORMATION
Identified as a SARA Section 313 chemical.

III. PHYSICAL DATA

Boiling Point (oF): 295
Melting Point (oF): -138
Vapor Pressure (mm Hg.) @ 20oC: 180
Vapor Density (AIR=1): 4.5
Appearance and Odor: Colorless liquid; aromatic, sweet odor
Specific Gravity (H2O=1) @ 25o/25: 0.90
Evaporation Rate (n-BuAc=1.0): 5.6 Fast
pH: Not Applicable
Solubility in Water: Negligible

VI. SPILL OR LEAK PROCEDURES

TRANSPORTATION EMERGENCIES
Call CHEMTREC (800) 424-9300

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Release can cause fire/explosion. May polymerize/release heat/gases. Liquids/vapors may ignite. Evacuate/limit access. Equip responders with proper protection. Extinguish all ignition sources. Stop release, prevent flow to sewers/public waters. Notify fire/environmental authorities. Blanket with firefighting foam. Restrict water use for clean-up. Impound/recover large land spill. Soak up small spill with inert solids. Use vented disposal containers. On water, material insoluble/floats. Contain/minimize dispersion/collect. Disperse residue to reduce aquatic harm. If spill hardens, contain/collect as any solid. Report per regulatory requirements.

WASTE DISPOSAL METHODS
Contaminated product/soil/water may be RCRA/OSHA hazardous waste due to potential for internal heat generation. (See 40 CFR 261 and 29 CFR 1910.) Landfill solids at permitted sites. Use registered transporters. Burn concentrated liquids in systems that use compatible fuel. Dilute with clean, low viscosity fuel. Avoid flameouts. Assure emissions comply with applicable regulations. Dilute aqueous waste may biodegrade. Avoid over-loading/poisoning plant biomass. Assure effluent complies with applicable regulations.

VII. HEALTH HAZARD DATA

MAJOR EXPOSURE HAZARDS
Inhalation: Yes
Skin Contact: Yes
Eye Contact: Yes
Ingestion: Yes

EFFECTS OF OVEREXPOSURE

INHALATION: Overexposure may cause irritation to the respiratory tract and to other mucous membranes.

EYE CONTACT: May cause moderate irritation, including burning sensation, tearing, redness, or swelling.

SKIN ABSORPTION: No significant signs or symptoms indicative of any health hazard are expected to occur as a result of skin absorption exposure.

SKIN IRRITATION: May cause delayed skin irritation and blistering.

INGESTION: This material may be a slight health hazard if ingested in large quantities.

SKIN: When skin contact is possible, protective clothing, including gloves, apron, sleeves, boots, head, and face rotection should be worn. This equipment must be cleaned horoughly after each use.

ENGINEERING CONTROLS: Local exhaust ventilation may be required to meet exposure standard(s) in addition to general room ventilation.

OTHER HYGIENIC AND WORK PRACTICES: Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.

Use good personal hygiene practices. Wash hands before eating, drinking, smoking, or using toilet facilities. Promptly remove soiled clothing/wash thoroughly before re-use. Shower after work using plenty of soap and water.

X. REGULATORY STATUS

TSCA STATUS: This product (or its ingredients if it is a mixture) appears on the Toxic Substances Control Act Inventory (TSCA).

SARA HAZARD CATEGORIES (Section 311 and Section 312):
Reactivity: Yes
Immediate Health: Yes
Delayed Health: Yes
Fire: Yes

SARA Section 313: See Section II, Ingredient Hazard Statement

DOT SHIPPING NAME: Styrene Monomer

DOT HAZARD CLASS: Flammable Liquid

IDENTIFICATION NUMBER: UN2055

HMIS RATINGS (Hazardous Materials Identification System, Scale 0-4):
Health: 2
Flammability: 3
Reactivity: 2

NFPA RATINGS (National Fire Protection Association, Scale 0-4):
Health: 2
Flammability: 3
Reactivity: 2

Perkadox - 16

Catalyst for resin

PERKADOX 16

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Product label name
Di(4-tert-butylcyclohexyl) peroxydicarbonate, powder

Supplier
Akzo Nobel Polymer Chemicals LLC
525 West Van Buren Street
Chicago, IL 60607-3823

www.akzonobel-polymerchemicals.com

Emergency telephone	**transportation emergency**
+ 1-914-693-6946 Dobbs Ferry, NY USA	CHEMTREC - USA: 1-800-424-9300 CANUTEC - CANADA: 1-613-996-6666

Intended use
polymerization initiator

Date of first issue	**Date of last issue / Revision**
2005-12-08	2005-12-08 / 2.88

Chemical family
peroxides

2. COMPOSITION/INFORMATION ON INGREDIENTS

Information on hazardous ingredients

Chemical description
Di(4-tert-butylcyclohexyl) peroxydicarbonate, powder

Composition / information on ingredients

Number	% w/w	CAS-number	Chemical name
1	> 94.0	015520-11-3	Di(4-tert-butylcyclohexyl) peroxydicarbonate

3. HAZARDS IDENTIFICATION

Emergency overview
white powder with faint odour .
DANGER!
ORGANIC PEROXIDE.
REFRIGERATED ORGANIC PEROXIDE- MAINTAIN COOLING.
HEAT OR CONTAMINATION MAY CAUSE HAZARDOUS DECOMPOSITION.
MAY CAUSE RESPIRATORY TRACT IRRITATION.
Peroxides and peroxide decomposition products are flammable and can ignite with explosive force if confined.

Health effects
Skin and eye contact are the primary routes of exposure to this product.
Inhalation of dust may cause irritation to nose, throat and upper respiratory system.
Skin contact is not expected to cause irritation.
Eye contact may cause slight irritation.
Irritation to the mouth, throat, esophagus and stomach may be caused by ingestion of this material.

Carcinogenicity

Description	Applicable
IARC	no
NTP	no

OSHA	no
ACGIH	no

4. FIRST AID MEASURES

Symptoms and effects
Dust may be irritating to the respiratory tract and cause symptoms of bronchitis .

First aid

General
In all cases of doubt, or when symptoms persist, seek medical attention .

Inhalation
Remove to fresh air . If not breathing, give artificial respiration . Oxygen may additionally be given, by trained personnel, if it is available . Get medical attention if symptoms occur .

Skin
Flush skin with plenty of water . Remove contaminated clothing and shoes . Get medical attention if irritation develops and persists . Wash clothing before reuse . Thoroughly clean or destroy contaminated shoes .

Eye
Immediately flush eyes with plenty of water . If easy to do, contact lenses should be removed during the flushing, by trained personnel . Occasionally hold the eyelids apart during the flushing to ensure rinsing the entire surface of the eye and lids with water . Get medical attention if irritation develops and persists .

Ingestion
Call a physician or a poison control center immediately . Induce vomiting only if directed by medical personnel . The patient should lie on their left side while vomiting to reduce the risk of aspiration . Never give anything by mouth to an unconscious or convulsing person .

Advice to physician
There are no data available that address medical conditions that are generally recognized as being aggravated by exposure to this material .
Attending physician should treat exposed patients symptomatically .

5. FIRE-FIGHTING MEASURES

Extinguishing media
waterspray , foam , sand , dry chemical powder , CO_2 .

Unsuitable extinguishing media
halones .

Hazardous decomposition/ combustion products
CO_2 , Carbon monoxide .4-tert-Butylcyclohexanol .

Protective equipment
Firefighters must wear fire resistant protective equipment . Wear approved respirator and protective gloves .

Other information
Evacuate all non-essential personnel . Extinguish a small fire with powder or carbon dioxide then apply water to prevent re-ignition . Cool closed containers with water . Water used to extinguish a fire should not be allowed to enter the drainage system or water courses . After a fire, ventilate thoroughly the area and soak with water, clean the walls and metallic surfaces .

Fire and explosion hazard
CAUTION: reignition may occur . Decomposition under effect of heating (See also Section Hazardous decomposition products). If involved in a fire, it will support combustion . dust explosion hazard . Vapours may form explosive mixtures with air . In case of fire and/or explosion do not breathe fumes .

NFPA ratings	
Hazard	**Rating**
Health	1
Flammability	3
Reactivity	2

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Do not breathe dust . For personal protection see Section 8 .

Environmental precautions
Do not allow to enter drains or water courses .

Methods for cleaning up
Stop leakage if possible . Eliminate all sources of ignition, and do not generate flames or sparks . Sweep up and put it into a container for disposal . Avoid dust generation . Keep contents moist . The waste should NOT be confined . Flush surroundings with large amounts of water and soap .

Other information
CAUTION: reignition may occur . Evacuate personnel to safe area .

7. HANDLING AND STORAGE

Handling
Never weigh out in the storage room . When using do not eat, drink or smoke . Do not breathe dust . Handle in well ventilated areas . Eliminate all sources of ignition, and do not generate flames or sparks . Keep away from reducing agents (e.g. amines), acids, alkalies and heavy metal compounds (e.g. accelerators, driers, metal soaps) . Keep product and emptied container away from heat and sources of ignition . Confinement must be avoided . Avoid Incompatible materials (See Section 10).

Storage requirements
Store in accordance with local/national regulations . Keep away from food, drink and animal feedingstuffs . Store in a dry well ventilated place away from sources of heat and direct sunlight . Store separate from other chemicals . Keep only in the original container .

Storage

For safety, store below 30 °C .

For maximum quality store below: 20 °C .

Other information
It is recommended to use electrical equipment of temperature group T3. However, autoignition can never be excluded . Wash hands thoroughly after handling or contact . Keep working clothing separately and do not take them home .

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering controls
Ensure good ventilation and local exhaustion of the working area . Explosion proof ventilation recommended .

Personal protection

Respiratory
In case of dust formation use dust mask .

Hand
Wear suitable protective gloves of neoprene or synthetic rubber .

Eye
Wear eye/face protection .

Skin and body Wear suitable protective clothing .
Other information Emergency-shower and facilities for rinsing eyes must be accessible . Launder clothes before re-use .

In this country no exposure limit has been established

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odour white powder with faint odour .
Boiling point/range not applicable (Decomposes)
Melting point/range Decomposes prior to melting .
Flash point not applicable
Flammability Decomposition products may be flammable .
Explosive properties no
Oxidizing properties not applicable
Vapour pressure not applicable
Density 1130 kg/m³ (20°C / 68°F)Specific gravity = 1.13 (20°C / 68°F)
Bulk density 450-480 kg/m³ (20°C / 68°F)Specific gravity = 0.45-0.48 (20°C / 68°F)
Solubility in water Insoluble at 20°C / 68°F
Solubility in other solvents Soluble with aliphatic solvents .
pH value slightly acidic
Partition coefficient n-octanol/water not determined
Relative vapour density (air=1) not applicable
Viscosity not applicable
Active oxygen content 3.8 %
Peroxide content 95 %

Autoignition temperature Test method not applicable (See Section 7)
SADT 40 °C . See also Section 10.
Explosion limits not determined
Volatile % not determined

10. STABILITY AND REACTIVITY

Stability	
	SADT - (Self accelerating decomposition temperature) is the lowest temperature at which self accelerating decomposition may occur with a substance in the packaging as used in transport . A dangerous self-accelerating decomposition reaction and, under certain circumstances, explosion or fire can be caused by thermal decomposition at and above the following temperature: 40 °C . Contact with incompatible substances can cause decomposition at or below the SADT 40 °C .
	To insure against possible exothermic self-accelerating decomposition, storage temperatures must not exceed emergency temperature of 35 °C .
Conditions to avoid	
	Under no circumstances should this product be exposed to temperatures above the emergency temperature of 35 °C . If the product temperature exceeds 35 °C all available means shall be used to bring the temperature under control and the emergency procedures shall be started . Emergency procedures will vary depending on conditions . Contact Akzo Nobel for assistance with developing an emergency response plan .
	To maintain quality store in original closed container below: 20 °C .
	Confinement must be avoided .
Incompatibilities Avoid contact with rust , iron and Copper . Contact with incompatible materials such as acids, alkalies, heavy metals and reducing agents will result in hazardous decomposition . Do not mix with peroxide accelerators . Use only Stainless steel 316, PVC, polyethylene or glass-lined equipment .	
Polymerization Polymerization does not occur .	
Decomposition Hazardous decomposition products ; 4-tert-Butylcyclohexanol .	
Other information Emergency procedures will vary depending on conditions . The customer must have an emergency response plan in place . Contact Akzo Nobel for assistance with developing an emergency response plan .	

11. TOXICOLOGICAL INFORMATION

Di(4-tert-butylcyclohexyl) peroxydicarbonate	
Acute toxicity	
	Oral LD50 rat :> 2000 mg/kg
Irritation	
	Skin Non-irritating (24 hours exposure time)
	Eye Mildly irritating

Genotoxicity
Ames test : Not mutagenic

12. ECOLOGICAL INFORMATION

Di(4-tert-butylcyclohexyl) peroxydicarbonate

Ecotoxicity

fish
Acute toxicity , (Oncorhynchus mykiss .) 96h-LC50 = 704 mg/l . No Observed Effect Concentration (NOEC) =>320 mg/l

bacteria
Activated sludge respiration inhibition test EC50 = >1000 mg/l .

Fate

Degradation Biotic
Not readily biodegradable (Closed bottle test).

13. DISPOSAL CONSIDERATIONS

Product
Due to the high risk of contamination recycling/recovery is not recommended . Waste disposal in accordance with regulations (most probably controlled incineration).

Contaminated packaging
According to local regulations . Emptied container might retain product residues . Follow all warnings even after the container is emptied .

Other information
For further advice contact manufacturer .

14. TRANSPORT INFORMATION

Land transport (ADR/ RID) and / or DOT

Class
5.2

TREM-Card or ERG Number
NORTH AMERICAN ERG NO: 148

UN number
3114

Proper Shipping Name
Organic peroxide type c, solid, temperature controlled (Di(4-tert-butylcyclohexyl) peroxydicarbonate)

Required labels
ORGANIC PEROXIDE.

EMERGENCY TEMPERATURE : 35 °C .

CONTROL TEMPERATURE : 30 °C .

The control temperature is the maximum temperature at which the formulation can be transported safely during a prolonged period of time .

Sea transport (IMDG-code/ IMO)

Class
5.2

PERKADOX 16

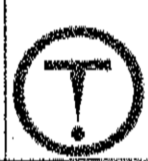
UN number 3114
EMS F-F, S-R
Marine pollutant no
Proper Shipping Name Organic peroxide type c, solid, temperature controlled (Di(4-tert-butylcyclohexyl) peroxydicarbonate)
Other information Label(s) : 5.2
EMERGENCY TEMPERATURE : 35 °C .
CONTROL TEMPERATURE : 30 °C .
The control temperature is the maximum temperature at which the formulation can be transported safely during a prolonged period of time .

Air transport (ICAO-TI/ IATA-DGR)
UN number Forbidden

15. REGULATORY INFORMATION

Products and/or components listed below are subject to the following:	
Di(4-tert-butylcyclohexyl) peroxydicarbonate	
New Jersey R-T-K Hazard. Sub.	yes
Toxic Subst. Cont. Act -listed	yes
Domestic Substance List-Canada	yes

Hazard classes	
Description	**Applicable**
HMIS Hazard Rating Source	HMIS
HMIS Health	1
HMIS Flammability	3
HMIS Reactivity	2
WHMIS Hazard classes	C,D-2B,F

Other regulatory information No other regulatory information is available on this product.

16. OTHER INFORMATION

History	
Other information	PERKADOX: This is a registered trademark of Akzo Nobel Chemicals BV or any of its affiliated companies in one or more territories in the world .
Date of printing/ pdf file generated	2005-12-20
Revision	2.88
Composed by	N. Shoshenskiy, Regulatory Affairs - North America . J.W. Wessels - Regulatory Affairs - Europe .
Changes were made in section	globalized

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(503)391-8317 fax

DRIVING INNOVATION.
TRANSFORMING CONSTRUCTION.

Department: CALTRANS
Project Location: RTE 50 at various locations near Kyburz, CA in El Dorado County
Project Title: Construction on State HWY in El Dorado County
City's Project Number: 03-4M4404

Prepared By: Andy Thompson
Michels Project No: 40435

Date Received:
Engineer: Darlene Wulff
Contractor: Michels Corp

Submittal number: 14
Submittal Date: 5/27/2014
Revision Date: NA
Revision Number: NA

Specification Section: 15-6.11A(3)
Subsection: 8
Item: CIPP Liner Designs
Page: 21
Deviation (Y or N): N

Engineer's Stamp

Submittal Description: CIPP Liner Design for Each Culvert Location
Intended Use: Design Guide
Plan Sheet: NA
Manufacturer: NA
Supplier: NA

Applicable Standard: ASTM F1216
Referenced Document: ASTM F1216
Notes:

PROJECT INFORMATION

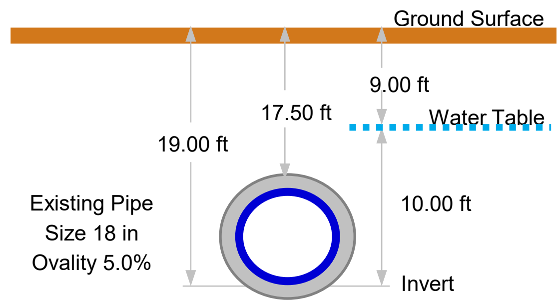
27-May-14

CALTRANS 03-4M4404 - In El Dorado County

DS 1,4,5,6,7,9,10,11,12,13,14,17,18

Required minimum thickness is 8.6mm

Michels recommends a nominal liner thickness of 9mm for all 18" depths



Partially Deteriorated Design
Required Liner Thickness: 8.6 mm

BY ASTM F1216 VERSION		F1216-09	CIPP liner design by Appendix X1 method of ASTM F1216-09		
EXISTING PIPE PARAMETERS		ENTERED	**FACTOR SUMMARY - PARTIALLY DETERIORATED**		
Design Condition		Partially Det.	Flexural Modulus Design	125,000 psi	50% of Short-term
Inside Dia. of Existing Pipe		18 in	Flexural Strength Design	2,250 psi	50% of Short-term
Depth to Invert		19 ft	Minimum Dia for host pipe	17.10 in	For 5% ovality
Water Table Below Surface		9 ft	Maximum Dia for host pipe	18.90 in	For 5% ovality
Ovality, Δ		5%	Ovality Reduction Factor, C	0.640	
Soil Density	Note 1	120 lb/ft3	Water Pressure - Invert	4.33 psi	10.00 ft
Soil Modulus	Note 1	1,000 psi	Vacuum Pressure	0.00 psi	
Live Load	Note 1	2. HS-20	Total Design Pressure, Invert	4.33 psi	For X1.1 & X1.2
Other Load	Note 1	0 psi			
Vacuum Condition		0 psi			
CIPP LINER PARAMETERS		ENTERED			
Flexural Modulus short-term		250,000 psi			
Flexural Strength short-term		4,500 psi			
Long-term Retention		50%			
Enhancement Factor		7			
Poisson's Ratio		0.3	Note 1: Entries ignored for Partially Deteriorated design.		
Safety Factor		2			

PARTIALLY DETERIORATED DESIGN REQUIRES SATISFYING F1216-X1 EQUATIONS X1.1 & X1.2

Equations X1.1 & X1.2 solved for liner thickness t		**t mm**	**t in**	**DR**
X1.1: $P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$ For load due to groundwater at invert	Governs	8.6 mm	0.34 in	53.2
X1.2: $(1.5\Delta/100)(1+\Delta/100)DR^2-0.5(1+\Delta/100)DR=\sigma_L/(PN)$ For minimum thickness for ovality		7.6 mm	0.30 in	60.2
-		-	-	-
-		-	-	-
Required Liner Thickness - Partially Deteriorated		**8.6 mm**	**0.34 in**	**53.2**

t mm is rounded-up to 1 decimal place; t in = t mm/25.4; DR = (Inside Diameter in)/(t mm/25.4) NA - Not Available/Applicable

FLOW COMPARISON PARAMETERS		**FLOW COMPARISON FOR: ENTERED LINER THICKNESS**		
Liner Thickness - Entered	9.0 mm	Inside Diameter before Lining	18.00 in	
Before Lining Manning n	0.0150	Inside Diameter after Lining	17.29 in	9.0 mm liner
After Lining Manning n	0.0100	Flow Capacity after Lining	135%	Of before Lining

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: PARTIALLY DETERIORATED DESIGN **F1216-09**

Partially deteriorated design requires satisfying 2 equations: X1.1 and X1.2

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner, with safety factor, from groundwater and any vacuum

Determine P for liner thickness of …………………… t = 8.6 mm t is from summary page

K = Enhancement factor = 7

E_L = Flexural Modulus Long-term = (Flexural Modulus Short-term) x (Long-term Retention)

= 250000 x 50% = 125000 psi

v = Poisson's ratio = 0.3

DR = D/t = 18/(8.6/25.4) = 53.16 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is ovality of host pipe as entered. Δ = 5

C = ([1- 5/100]/[1+5/100]^2)^3 = 0.64

N = Safety Factor = 2 As entered.

P = [(2 x 7 x 125000)/(1-0.3^2)] x [1/(53.16-1)^3] x [0.64/2] = 4.34 psi

Determine actual external pressure on liner, Pa

Pa = Ground water pressure, Pgw, + Vacuum pressure, Pv, (if any vacuum)

Pgw = 0.433 x H = 0.433 x 10 ft = 4.33 psi. Where H is height of water over invert.

Pv = 0 psi As entered.

Pa = Pgw + Pv = 4.33 + 0 = 4.33 psi

Compare Pa to P

Actual external pressure on liner, Pa = 4.33 psi

Allowed external pressure for 8.6 mm liner, P = 4.34 psi

Is P ≥ Pa? Yes. Equation X1.1 is satisfied by 8.6 mm liner rhickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 53.16 as calculated above

Is DR ≤ 100? Yes. Note X1.2 is satisfied by liner DR of 53.2

Check Equation X1.2

X1.2: $[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Δ = 5 As shown above in determination of C, Ovality Reduction Factor, above.

DR, calculated above = 53.16

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) =4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 4.33 psi See above

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

t = [3 x (Δ/100) x Do)]/[0.5 + {0.25 + (6 x (Δ/100) x (σ_L/(P x N x (1+(Δ/100))}^.5]

t = [3 x (5/100) x 18)]/[0.5 + {0.25 + (6 x (5/100) x (2250/(4.33 x 2 x (1+(5/100))}^0.5] = 7.6 mm

Compare liner t to t required by Equation X1.2

Liner t: 8.6 mm t is from summary page

Required t: 7.6 mm

Is Liner t ≥ Required t? Yes. Equation X1.2 is satisfied by 8.6 mm liner thicknes.

Summary for Partially Deteriorated Design

Partially Deteriorated design requires satisfying Eqs X1.1 & X1.2

Eq X1.1 Satisfied by selected liner thickness of 8.6 mm

Eq X1.2 Satisfied by selected liner thickness of 8.6 mm

Required liner thickness for Partially Deteriorated design is…………. 8.6 mm

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING - For Entered t

Flow = Q = Area x Velocity =$[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, imperial units t = 9 mm

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft) D1 = 18 in = 1.5 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 17.29 in = 1.441 ft

= {[(3.142 x (1.441^2)/4] x [(1.486/0.01)] x (1.441/4)^(2/3)} / {[(3.142 x (1.5)^2)/4] x [(1.486/0.015)] x (1.5/4)^(2/3) = 1.35

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 135% of existing capacity.

IGNORE THIS PAGE - NOT REQUIRED FOR PARTIALLY DETERIORATED DESIGN

Check Equation X1.3 *X1.3 not required for Partially Deteriorated Design*

If F1216-07a, Equation X1.3 is: q_t=[C/N] x $[32R_wB'E'_s(E_LI/D^3)]^{1/2}$ Not using this equation

If F1216-09, Equation X1.3 is: q_t=[1/N] x $[32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ Using this equation

Where qt is the maximum allowed external pressure on the liner from cover, live loads and other loads
Determine qt for liner thickness of …………………… t = 8.6 mm t is from summary page
C = Ovality Reduction Factor, calculated on page 1, = 0.64
N = Safety Factor = 2
Rw = Water Bouyancy Factor (0.67 min, 1.0 max) = 1-0.33(Hw/H) = 1-0.33(8.5/17.5) = 0.84
Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2
B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.4381 Where H = 17.5 and e = 2.718
E's = Modulus of soil reaction = 1000 psi. As entered.
EL = Long-term modulus for CIPP, calculated on page 1, = 125000 psi
I = Moment of inertia for liner = (t^3)/12 = (8.6/25.4)^3)/12 = 0.003235
D = Inside diameter of existing pipe (as entered) = mean OD of liner = 18 in
qt=[1/N]x[32xRwxB'xE'sxCx(ELxI/D^3)]^(1/2)
qt = (1/2 x [32 x 0.84 x 0.4381 x 1000 x 0.64 x ((125000 x 0.003235)/18^3)]^(1/2) = 11.43 psi

Determine actual external pressure on liner, qta

qta = Pw + Ps + Pl + Po
Pw = Water load = 0.433 x Hw = 0.433 x 8.5 = 3.68 psi Hw is water over top of pipe.
Ps = Soil Load = (w x H x Rw)/144 = (120 x 17.5 x 0.84)/144) = 12.25 psi H is soil height over top of pipe
Pl = Live load = 0.05 psi Note 1: Entries ignored for Partially Deteriorated design.
Po = Other load = 0 psi As entered
qta = 3.68 + 12.25 + 0.05 + 0 = 15.98 psi

Compare qta to qt

qta =	15.98 psi	Actual external pressure on liner
qt =	11.43 psi	Allowed external pressure for 8.6 mm liner
Is qt ≥ qta?		NA

Check Equation X1.4 *X1.4 not required for Partially Deteriorated Design*

(E x I)/D^3 = E/(12 x (DR^3)) ≥ 0.093

Determine for liner thickness …………………… t = 8.6 mm t is from summary page
E = initial (short-term) modulus = 250000 psi
DR = liner dimension ratio = D/t = 18 / (8.6 / 25.4) = 53.16
E/(12 x (DR^3)) = 250000/(12 x 53.16^3) = 0.13868
Is E/(12 x (DR^3)) ≥ 0.093? NA

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

Eq X1.1	Ignore this page
Eq X1.2	Ignore this page
Eq X1.3	Ignore this page
Eq X1.4	Ignore this page

IGNORE THIS PAGE - FOR FULLY DETERIORATED ONLY.

PROJECT INFORMATION

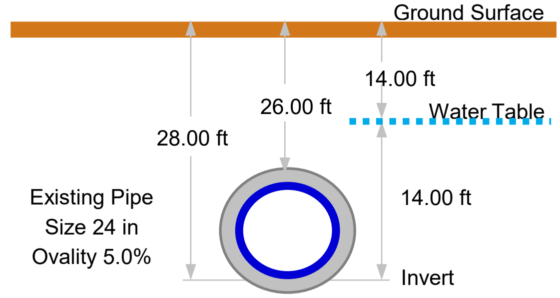
27-May-14

CALTRANS 03-4M4404 - In El Dorado County

DS 2,16

Required minimum thickness is 12.8mm

Michels recommends a nominal liner thickness of 13.5mm for all 24" depths



Partially Deteriorated Design
Required Liner Thickness: 12.8 mm

BY ASTM F1216 VERSION		F1216-09	CIPP liner design by Appendix X1 method of ASTM F1216-09		
EXISTING PIPE PARAMETERS		ENTERED	**FACTOR SUMMARY - PARTIALLY DETERIORATED**		
Design Condition		Partially Det.	Flexural Modulus Design	125,000 psi	50% of Short-term
Inside Dia. of Existing Pipe		24 in	Flexural Strength Design	2,250 psi	50% of Short-term
Depth to Invert		28 ft	Minimum Dia for host pipe	22.80 in	For 5% ovality
Water Table Below Surface		14 ft	Maximum Dia for host pipe	25.20 in	For 5% ovality
Ovality, Δ		5%	Ovality Reduction Factor, C	0.640	
Soil Density	Note 1	120 lb/ft3	Water Pressure - Invert	6.06 psi	14.00 ft
Soil Modulus	Note 1	1,000 psi	Vacuum Pressure	0.00 psi	
Live Load	Note 1	2. HS-20	Total Design Pressure, Invert	6.06 psi	For X1.1 & X1.2
Other Load	Note 1	0 psi			
Vacuum Condition		0 psi			
CIPP LINER PARAMETERS		ENTERED			
Flexural Modulus short-term		250,000 psi			
Flexural Strength short-term		4,500 psi			
Long-term Retention		50%			
Enhancement Factor		7			
Poisson's Ratio		0.3	Note 1: Entries ignored for Partially Deteriorated design.		
Safety Factor		2			

PARTIALLY DETERIORATED DESIGN REQUIRES SATISFYING F1216-X1 EQUATIONS X1.1 & X1.2

Equations X1.1 & X1.2 solved for liner thickness t		**t mm**	**t in**	**DR**
X1.1: $P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$ For load due to groundwater at invert	Governs	12.8 mm	0.50 in	47.6
X1.2: $(1.5\Delta/100)(1+\Delta/100)DR^2-0.5(1+\Delta/100)DR=\sigma_L/(PN)$ For minimum thickness for ovality		11.8 mm	0.46 in	51.7
-		-	-	-
-		-	-	-
Required Liner Thickness - Partially Deteriorated		**12.8 mm**	**0.50 in**	**47.6**

t mm is rounded-up to 1 decimal place; t in = t mm/25.4; DR = (Inside Diameter in)/(t mm/25.4) NA - Not Available/Applicable

FLOW COMPARISON PARAMETERS		**FLOW COMPARISON FOR: ENTERED LINER THICKNESS**		
Liner Thickness - Entered	13.5 mm	Inside Diameter before Lining	24.00 in	
Before Lining Manning n	0.0150	Inside Diameter after Lining	22.94 in	13.5 mm liner
After Lining Manning n	0.0100	Flow Capacity after Lining	133%	Of before Lining

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: PARTIALLY DETERIORATED DESIGN **F1216-09**

Partially deteriorated design requires satisfying 2 equations: X1.1 and X1.2

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner, with safety factor, from groundwater and any vacuum

Determine P for liner thickness of .... t = 12.8 mm   t is from summary page

K = Enhancement factor = 7

E_L = Flexural Modulus Long-term = (Flexural Modulus Short-term) x (Long-term Retention)

= 250000 x 50% = 125000 psi

v = Poisson's ratio = 0.3

DR = D/t = 24/(12.8/25.4) = 47.63   where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is ovality of host pipe as entered. $\Delta = 5$

C = ([1- 5/100]/[1+5/100]^2)^3 = 0.64

N = Safety Factor = 2   As entered.

P = [(2 x 7 x 125000)/(1-0.3^2)] x [1/(47.63-1)^3] x [0.64/2] = 6.07 psi

Determine actual external pressure on liner, Pa

Pa = Ground water pressure, Pgw, + Vacuum pressure, Pv, (if any vacuum)

Pgw = 0.433 x H = 0.433 x 14 ft = 6.06 psi.   Where H is height of water over invert.

Pv = 0 psi   As entered.

Pa = Pgw + Pv = 6.06 + 0 = 6.06 psi

Compare Pa to P

Actual external pressure on liner, Pa = 6.06 psi

Allowed external pressure for 12.8 mm liner, P = 6.07 psi

Is P ≥ Pa?   Yes. Equation X1.1 is satisfied by 12.8 mm liner rhickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 47.63 as calculated above

Is DR ≤ 100?   Yes. Note X1.2 is satisfied by liner DR of 47.6

Check Equation X1.2

X1.2: $[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

$\Delta = 5$ As shown above in determination of C, Ovality Reduction Factor, above.

DR, calculated above = 47.63

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) =4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 6.06 psi See above

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

$t = [3 \times (\Delta/100) \times Do)]/[0.5 + \{0.25 + (6 \times (\Delta/100) \times (\sigma_L/(P \times N \times (1+(\Delta/100))\}^{.5}]$

t = [3 x (5/100) x 24)]/[0.5 + {0.25 + (6 x (5/100) x (2250/(6.06 x 2 x (1+(5/100))}^0.5] = 11.8 mm

Compare liner t to t required by Equation X1.2

Liner t:	12.8 mm	t is from summary page
Required t:	11.8 mm	
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 12.8 mm liner thicknes.

Summary for Partially Deteriorated Design

Partially Deteriorated design requires satisfying Eqs X1.1 & X1.2

Eq X1.1   Satisfied by selected liner thickness of 12.8 mm

Eq X1.2   Satisfied by selected liner thickness of 12.8 mm

Required liner thickness for Partially Deteriorated design is.............. 12.8 mm

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING - For Entered t

Flow = Q = Area x Velocity $=[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, imperial units   t = 13.5 mm

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft)   D1 = 24 in = 2 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 22.94 in = 1.911 ft

= {[(3.142 x (1.911^2)/4] x [(1.486/0.01)] x (1.911/4)^(2/3)} / {[(3.142 x (2)^2)/4] x [(1.486/0.015)] x (2/4)^(2/3) = 1.33

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 133% of existing capacity.

IGNORE THIS PAGE - NOT REQUIRED FOR PARTIALLY DETERIORATED DESIGN

Check Equation X1.3 *X1.3 not required for Partially Deteriorated Design*

If F1216-07a, Equation X1.3 is: q_t=[C/N] x $[32R_wB'E'_s(E_LI/D^3)]^{1/2}$ Not using this equation

If F1216-09, Equation X1.3 is: q_t=[1/N] x $[32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ Using this equation

Where qt is the maximum allowed external pressure on the liner from cover, live loads and other loads
Determine qt for liner thickness of .... t = 12.8 mm t is from summary page
C = Ovality Reduction Factor, calculated on page 1, = 0.64
N = Safety Factor = 2
Rw = Water Bouyancy Factor (0.67 min, 1.0 max) = 1-0.33(Hw/H) = 1-0.33(12/26) = 0.848
Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2
B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.5753 Where H = 26 and e = 2.718
E's = Modulus of soil reaction = 1000 psi. As entered.
EL = Long-term modulus for CIPP, calculated on page 1, = 125000 psi
I = Moment of inertia for liner = (t^3)/12 = (12.8/25.4)^3)/12 = 0.010665
D = Inside diameter of existing pipe (as entered) = mean OD of liner = 24 in
qt=[1/N]x[32xRwxB'xE'sxCx(ELxI/D^3)]^(1/2)
qt = (1/2 x [32 x 0.848 x 0.5753 x 1000 x 0.64 x ((125000 x 0.010665)/24^3)]^(1/2) = 15.52 psi
Determine actual external pressure on liner, qta
qta = Pw + Ps + Pl + Po
Pw = Water load = 0.433 x Hw = 0.433 x 12 = 5.2 psi Hw is water over top of pipe.
Ps = Soil Load = (w x H x Rw)/144 = (120 x 26 x 0.848)/144) = 18.37 psi H is soil height over top of pipe
Pl = Live load = 0 psi Note 1: Entries ignored for Partially Deteriorated design.
Po = Other load = 0 psi As entered
qta = 5.2 + 18.37 + 0 + 0 = 23.57 psi
Compare qta to qt

qta =	23.57 psi	Actual external pressure on liner
qt =	15.52 psi	Allowed external pressure for 12.8 mm liner
Is qt ≥ qta?		NA

Check Equation X1.4 *X1.4 not required for Partially Deteriorated Design*

(E x I)/D^3 = E/(12 x (DR^3)) ≥ 0.093
Determine for liner thickness .... t = 12.8 mm t is from summary page
E = initial (short-term) modulus = 250000 psi
DR = liner dimension ratio = D/t = 24 / (12.8 / 25.4) = 47.63
E/(12 x (DR^3)) = 250000/(12 x 47.63^3) = 0.1928
Is E/(12 x (DR^3)) ≥ 0.093? NA

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

Eq X1.1	Ignore this page
Eq X1.2	Ignore this page
Eq X1.3	Ignore this page
Eq X1.4	Ignore this page

IGNORE THIS PAGE - FOR FULLY DETERIORATED ONLY.

PROJECT INFORMATION

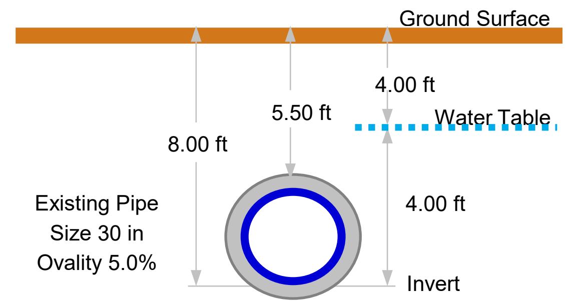
27-May-14

CALTRANS 03-4M4404 - In El Dorado County

DS 2,16

Required minimum thickness is 10.7mm

Michels recommends a nominal liner thickness of 12mm



Partially Deteriorated Design
Required Liner Thickness: 10.7 mm

BY ASTM F1216 VERSION		F1216-09	CIPP liner design by Appendix X1 method of ASTM F1216-09		
EXISTING PIPE PARAMETERS		ENTERED	**FACTOR SUMMARY - PARTIALLY DETERIORATED**		
Design Condition		Partially Det.	Flexural Modulus Design	125,000 psi	50% of Short-term
Inside Dia. of Existing Pipe		30 in	Flexural Strength Design	2,250 psi	50% of Short-term
Depth to Invert		8 ft	Minimum Dia for host pipe	28.50 in	For 5% ovality
Water Table Below Surface		4 ft	Maximum Dia for host pipe	31.50 in	For 5% ovality
Ovality, Δ		5%	Ovality Reduction Factor, C	0.640	
Soil Density	Note 1	120 lb/ft3	Water Pressure - Invert	1.73 psi	4.00 ft
Soil Modulus	Note 1	1,000 psi	Vacuum Pressure	0.00 psi	
Live Load	Note 1	2. HS-20	Total Design Pressure, Invert	1.73 psi	For X1.1 & X1.2
Other Load	Note 1	0 psi			
Vacuum Condition		0 psi			
CIPP LINER PARAMETERS		ENTERED			
Flexural Modulus short-term		250,000 psi			
Flexural Strength short-term		4,500 psi			
Long-term Retention		50%			
Enhancement Factor		7			
Poisson's Ratio		0.3	Note 1: Entries ignored for Partially Deteriorated design.		
Safety Factor		2			

PARTIALLY DETERIORATED DESIGN REQUIRES SATISFYING F1216-X1 EQUATIONS X1.1 & X1.2

Equations X1.1 & X1.2 solved for liner thickness t		**t mm**	**t in**	**DR**
X1.1: $P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$ For load due to groundwater at invert	Governs	10.7 mm	0.42 in	71.2
X1.2: $(1.5\Delta/100)(1+\Delta/100)DR^2-0.5(1+\Delta/100)DR=\sigma_L/(PN)$ For minimum thickness for ovality		8.1 mm	0.32 in	94.1
-		-	-	-
-		-	-	-
Required Liner Thickness - Partially Deteriorated		**10.7 mm**	**0.42 in**	**71.2**

t mm is rounded-up to 1 decimal place; t in = t mm/25.4; DR = (Inside Diameter in)/(t mm/25.4) NA - Not Available/Applicable

FLOW COMPARISON PARAMETERS		**FLOW COMPARISON FOR: ENTERED LINER THICKNESS**		
Liner Thickness - Entered	12.0 mm	Inside Diameter before Lining	30.00 in	
Before Lining Manning n	0.0150	Inside Diameter after Lining	29.06 in	12.0 mm liner
After Lining Manning n	0.0100	Flow Capacity after Lining	138%	Of before Lining

COMMENTS

ASTM F1216 APPENDIX X1 CALCULATION DETAILS: PARTIALLY DETERIORATED DESIGN **F1216-09**

Partially deteriorated design requires satisfying 2 equations: X1.1 and X1.2

Check Equation X1.1

$P = [2KE_L/(1-v^2)] \times [1/(DR-1)^3] \times [C/N]$

P is the maximum allowed external pressure on the liner, with safety factor, from groundwater and any vacuum

Determine P for liner thickness of .... t = 10.7 mm   t is from summary page

K = Enhancement factor = 7

E_L = Flexural Modulus Long-term = (Flexural Modulus Short-term) x (Long-term Retention)

= 250000 x 50% = 125000 psi

v = Poisson's ratio = 0.3

DR = D/t = 30/(10.7/25.4) = 71.21 where D = inside diameter of existing pipe as entered

C = Ovality Reduction Factor = $([1-\Delta/100]/[1+\Delta/100]^2)^3$, where Δ is ovality of host pipe as entered.   Δ = 5

C = ([1- 5/100]/[1+5/100]^2)^3 = 0.64

N = Safety Factor = 2 As entered.

P = [(2 x 7 x 125000)/(1-0.3^2)] x [1/(71.21-1)^3] x [0.64/2] = 1.78 psi

Determine actual external pressure on liner, Pa

Pa = Ground water pressure, Pgw, + Vacuum pressure, Pv, (if any vacuum)

Pgw = 0.433 x H = 0.433 x 4 ft = 1.73 psi.   Where H is height of water over invert.

Pv = 0 psi As entered.

Pa = Pgw + Pv = 1.73 + 0 = 1.73 psi

Compare Pa to P

Actual external pressure on liner, Pa = 1.73 psi

Allowed external pressure for 10.7 mm liner, P = 1.78 psi

Is P ≥ Pa?   Yes. Equation X1.1 is satisfied by 10.7 mm liner rhickness

Check for DR ≤ 100 as per F1216 Appendix X1 Note X1.2

DR = 71.21 as calculated above

Is DR ≤ 100?   Yes. Note X1.2 is satisfied by liner DR of 71.2

Check Equation X1.2

X1.2: $[(1.5 \times \Delta/100) \times (1+\Delta/100) \times DR^2] - [0.5 \times (1+\Delta/100) \times DR] = (\sigma_L)/(P \times N)$

Δ = 5 As shown above in determination of C, Ovality Reduction Factor, above.

DR, calculated above = 71.21

σL = Flex Strength Long-term = (Flex Strength Short-term) x (Long-term Retention) =4500 x 50% = 2250 psi

P = External pressure on liner = Pa = 1.73 psi See above

N = safety factor = 2

Solve Eq. X1.2 for liner thickness, t. Where DR = (Liner OD)/(t)

$t = [3 \times (\Delta/100) \times Do)]/[0.5 + \{0.25 + (6 \times (\Delta/100) \times (\sigma_L/(P \times N \times (1+(\Delta/100))\}^{.5}]$

t = [3 x (5/100) x 30)]/[0.5 + {0.25 + (6 x (5/100) x (2250/(1.73 x 2 x (1+(5/100))}^0.5] = 8.1 mm

Compare liner t to t required by Equation X1.2

Liner t:	10.7 mm	t is from summary page
Required t:	8.1 mm	
Is Liner t ≥ Required t?		Yes. Equation X1.2 is satisfied by 10.7 mm liner thicknes.

Summary for Partially Deteriorated Design

Partially Deteriorated design requires satisfying Eqs X1.1 & X1.2

Eq X1.1   Satisfied by selected liner thickness of 10.7 mm

Eq X1.2   Satisfied by selected liner thickness of 10.7 mm

Required liner thickness for Partially Deteriorated design is.............. 10.7 mm

FULL FLOW CAPACITY COMPARISON BEFORE & AFTER LINING - For Entered t

Flow = Q = Area x Velocity =$[(Pi \times D^2)/4] \times [(1.486/n) \times R^{2/3} \times S^{1/2}]$ Manning formula, imperial units   t = 12 mm

S = Slope = same before & after lining; R = Hydraulic Radius = D/4 for full flow (D in ft)   D1 = 30 in = 2.5 ft

$Q2/Q1 = \{[(Pi \times (D_2^2)/4] \times [(1.486/n_2)] \times (D_2/4)^{2/3}\} / \{[(Pi \times (D_1^2)/4] \times [(1.486/n_1)] \times (D_1/4)^{2/3}\}$ D2 = 29.06 in = 2.421 ft

= {[(3.142 x (2.421^2)/4] x [(1.486/0.01)] x (2.421/4)^(2/3)} / {[(3.142 x (2.5)^2)/4] x [(1.486/0.015)] x (2.5/4)^(2/3) = 1.38

Q1 is existing (before lining). Q2 is after lining. Lined capacity is 138% of existing capacity.

IGNORE THIS PAGE - NOT REQUIRED FOR PARTIALLY DETERIORATED DESIGN

Check Equation X1.3 *X1.3 not required for Partially Deteriorated Design*

If F1216-07a, Equation X1.3 is: q_t=[C/N] x [$32R_wB'E'_s(E_LI/D^3)]^{1/2}$ Not using this equation

If F1216-09, Equation X1.3 is: q_t=[1/N] x [$32R_wB'E'_sC(E_LI/D^3)]^{1/2}$ Using this equation

Where qt is the maximum allowed external pressure on the liner from cover, live loads and other loads
Determine qt for liner thickness of …………………… <u>t = 10.7 mm</u> t is from summary page
C = Ovality Reduction Factor, calculated on page 1, = 0.64
N = Safety Factor = 2
Rw = Water Bouyancy Factor (0.67 min, 1.0 max) = 1-0.33(Hw/H) = 1-0.33(1.5/5.5) = 0.91
Where Hw and H are height of water and height of soil over top of pipe. See F1216 X1.2.2
B' = Coefficent of elastic support = 1/(1+4e^[-0.065H]) = 0.2633 Where H = 5.5 and e = 2.718
E's = Modulus of soil reaction = 1000 psi. As entered.
EL = Long-term modulus for CIPP, calculated on page 1, = 125000 psi
I = Moment of inertia for liner = (t^3)/12 = (10.7/25.4)^3)/12 = 0.00623
D = Inside diameter of existing pipe (as entered) = mean OD of liner = 30 in
qt=[1/N]x[32xRwxB'xE'sxCx(ELxI/D^3)]^(1/2)
qt = (1/2 x [32 x 0.91 x 0.2633 x 1000 x 0.64 x ((125000 x 0.00623)/30^3)]^(1/2) = 5.95 psi

<u>Determine actual external pressure on liner, qta</u>

qta = Pw + Ps + Pl + Po
Pw = Water load = 0.433 x Hw = 0.433 x 1.5 = 0.65 psi Hw is water over top of pipe.
Ps = Soil Load = (w x H x Rw)/144 = (120 x 5.5 x 0.91)/144) = 4.17 psi H is soil height over top of pipe
Pl = Live load = 1.63 psi Note 1: Entries ignored for Partially Deteriorated design.
Po = Other load = 0 psi As entered
qta = 0.65 + 4.17 + 1.63 + 0 = 6.45 psi

<u>Compare qta to qt</u>

qta =	6.45 psi	Actual external pressure on liner
qt =	5.95 psi	Allowed external pressure for 10.7 mm liner
Is qt ≥ qta?		NA

Check Equation X1.4 *X1.4 not required for Partially Deteriorated Design*

(E x I)/D^3 = E/(12 x (DR^3)) ≥ 0.093

Determine for liner thickness …………………… <u>t = 10.7 mm</u> t is from summary page
E = initial (short-term) modulus = 250000 psi
DR = liner dimension ratio = D/t = 30 / (10.7 / 25.4) = 71.21
E/(12 x (DR^3)) = 250000/(12 x 71.21^3) = 0.05769
Is E/(12 x (DR^3)) ≥ 0.093? NA

Summary for Fully Deteriorated Design

Fully Deteriorated design requires satisfying Eqs X1.1, X1.2, X1.3, X1.4

Eq X1.1	Ignore this page
Eq X1.2	Ignore this page
Eq X1.3	Ignore this page
Eq X1.4	Ignore this page

IGNORE THIS PAGE - FOR FULLY DETERIORATED ONLY.

Quality Assurance Testing Results – Manufacturer	Alphaliner 500	Alphaliner 1500
Circumferential Flexural Modulus (psi) (DIN EN 1228)[1]	1,378,000	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) [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.

[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.

INSTALLATION REPORT

CLIENT	sacramento	PROJECT	university
STREET	collagetowne	MANUFACTURE	RELINE AMERICA
PROJECT NUMBER	stateuniversity	PRODUCTION ID	1
MANHOLE TO MANHOLE	updown	PRODUCTION DATE	112415
PIPE DIAMETER	18.00	WALL THICKNESS	7.7
LENGTH	20.00	STORAGE TEMPERATURE	65
SOURCE OF LIGHT	600	OUTSIDE TEMPERATURE	65
		WEATHER	nice

Date_Time	Length	Speed_SP	Speed	Pressure	Temp_1	Temp_2	Temp_3	Temp_4	L1	L2	L3	L4	L5	L6	L7	L8	L9
1/12/2016 6:40:53 AM	5.1	1.7	-	1.2	43	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:41:24 AM	5.1	1.7	-	1.3	43	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:41:55 AM	5.1	1.7	-	1.3	43	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:42:26 AM	5.1	1.7	-	1.4	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:42:57 AM	5.1	1.7	-	1.4	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:43:28 AM	5.1	1.7	-	1.5	42	33	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:43:59 AM	5.1	1.7	-	2.8	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:44:30 AM	5.1	1.7	-	0.1	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:45:01 AM	5.1	1.7	-	0.0	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:45:32 AM	5.1	1.7	-	1.3	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:46:03 AM	5.1	1.7	-	2.6	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:46:34 AM	5.1	1.7	-	0.2	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:47:05 AM	5.1	1.7	-	0.1	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:47:36 AM	5.1	1.7	-	1.3	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:48:07 AM	5.1	1.7	-	1.8	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:48:38 AM	5.1	1.7	-	2.3	42	33	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:49:09 AM	5.1	1.7	-	2.3	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:49:40 AM	5.1	1.7	0	2.3	42	32	0	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:50:11 AM	5.1	1.7	-	2.3	42.00	31.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:50:42 AM	5.1	1.7	-	2.3	42.00	31.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:51:13 AM	5.1	1.7	-	2.3	42.00	31.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:51:44 AM	5.1	1.7	-	2.3	42.00	31.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:52:15 AM	5.1	1.7	-	2.3	42.00	31.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:52:46 AM	5.1	1.7	-	2.3	42.00	31.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:53:17 AM	5.1	1.7	-	2.7	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:53:48 AM	5.1	1.7	-	2.7	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:54:19 AM	5.1	1.7	-	2.9	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:54:50 AM	5.1	1.7	-	2.9	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:55:21 AM	5.1	1.7	-	2.9	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:55:52 AM	5.1	1.7	-	2.9	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:56:23 AM	5.1	1.7	-	2.9	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:56:54 AM	5.1	1.7	-	2.9	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:57:25 AM	5.1	1.7	-	2.9	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:57:56 AM	5.1	1.7	-	3.0	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:58:27 AM	5.1	1.7	-	3.0	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:58:58 AM	5.1	1.7	-	3.4	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 6:59:29 AM	5.1	1.7	-	3.1	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:00:00 AM	5.1	1.7	-	3.0	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:00:31 AM	5.1	1.7	-	-0.1	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:01:02 AM	5.1	1.7	-	-0.1	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:01:33 AM	5.1	1.7	-	-0.1	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:02:04 AM	9.6	1.7	-	-0.1	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:02:35 AM	9.6	1.7	-	-0.1	43.00	32.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:03:06 AM	9.6	1.7	-	-0.1	43.00	40.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:03:37 AM	9.6	1.7	-	-0.1	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:04:08 AM	9.6	1.7	-	-0.1	44.00	42.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:04:39 AM	9.6	1.7	0.10	-0.1	44.00	42.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:05:10 AM	9.6	1.7	-	-0.1	44.00	41.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:05:41 AM	9.6	1.7	-	-0.1	45.00	42.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:06:12 AM	9.6	1.7	-	-0.1	45.00	42.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:06:43 AM	9.6	1.7	-	0.5	45.00	43.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:07:14 AM	9.6	1.7	-	0.5	45.00	43.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:07:45 AM	9.6	1.7	-	0.5	45.00	43.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:08:16 AM	9.6	1.7	-	0.5	45.00	43.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:08:47 AM	12.6	1.7	77.50	0.5	46.00	43.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:09:18 AM	27.1	1.7	-	0.5	46.00	43.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:09:49 AM	27.1	1.7	-	0.5	46.00	43.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:10:20 AM	27.1	1.7	0.10	0.5	46.00	43.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:10:51 AM	27.1	1.7	-	0.5	46.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:11:22 AM	27.1	1.7	0.10	0.5	46.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:11:53 AM	27.1	1.7	-	0.5	46.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:12:24 AM	27.2	1.7	-	0.5	47.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:12:55 AM	27.2	1.7	-	0.7	47.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:13:26 AM	27.2	1.7	-	1.1	47.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:13:57 AM	27.2	1.7	-	1.4	47.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:14:28 AM	27.2	1.7	-	1.8	47.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:14:59 AM	27.2	1.7	-	1.8	47.00	44.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:15:30 AM	27.2	1.7	-	2.3	47.00	45.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:16:01 AM	27.2	1.7	-	2.6	47.00	45.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:16:32 AM	27.2	1.7	-	3.1	48.00	45.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:17:03 AM	27.2	1.7	-	3.1	48.00	45.00	0.00	0	0	0	0	0	0	0	0	0	0

INSTALLATION REPORT

CLIENT	sacramento	PROJECT	university
STREET	collagetowne	MANUFACTURE	RELINE AMERICA
PROJECT NUMBER	stateuniversity	PRODUCTION ID	1
MANHOLE TO MANHOLE	updown	PRODUCTION DATE	112415
PIPE DIAMETER	18.00	WALL THICKNESS	7.7
LENGTH	20.00	STORAGE TEMPERATURE	65
SOURCE OF LIGHT	600	OUTSIDE TEMPERATURE	65
		WEATHER	nice

Date_Time	Length	Speed_SP	Speed	Pressure	Temp_1	Temp_2	Temp_3	Temp_4	L1	L2	L3	L4	L5	L6	L7	L8	L9
1/12/2016 7:17:34 AM	27.2	1.7	-	3.1	48.00	45.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:18:05 AM	27.2	1.7	-	3.9	48.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:18:36 AM	27.2	1.7	-	4.0	48.00	45.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:19:07 AM	27.2	1.7	-	4.1	48.00	45.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:19:38 AM	27.2	1.7	-	4.1	49.00	45.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:20:09 AM	27.2	1.7	-	4.1	49.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:20:40 AM	27.2	1.7	-	4.4	49.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:21:11 AM	27.2	1.7	-	4.9	49.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:21:42 AM	27.2	1.7	-	4.9	49.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:22:13 AM	27.2	1.7	-	5.0	50.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:22:44 AM	27.2	1.7	-	5.0	50.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:23:15 AM	27.2	1.7	-	5.3	50.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:23:46 AM	27.2	1.7	-	5.4	51.00	46.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:24:17 AM	27.2	1.7	-	5.5	51.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:24:48 AM	27.2	1.7	-	5.5	51.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:25:19 AM	27.2	1.7	-	5.5	51.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:25:50 AM	27.2	1.7	-	5.5	52.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:26:21 AM	27.2	1.7	-	5.5	52.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:26:52 AM	27.2	1.7	-	5.5	52.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:27:23 AM	27.2	1.7	-	5.5	53.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:27:54 AM	27.2	1.7	-	5.6	53.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:28:25 AM	27.2	1.7	-	5.6	53.00	47.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:28:56 AM	27.2	1.7	-	5.6	53.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:29:27 AM	27.2	1.7	-	5.6	54.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:29:58 AM	27.2	1.7	-	5.6	54.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:30:29 AM	27.2	1.7	-	5.6	54.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:31:00 AM	27.2	1.7	-	5.6	54.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:31:31 AM	27.2	1.7	-	5.6	55.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:32:02 AM	27.1	1.7	-	5.6	55.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:32:33 AM	27.1	1.7	-	5.6	55.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:33:04 AM	27.1	1.7	-	5.7	55.00	48.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:33:35 AM	27.1	1.7	-	5.7	56.00	49.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:34:06 AM	27.1	1.7	-	5.7	56.00	49.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:34:37 AM	27.1	1.7	-	5.7	56.00	49.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:35:08 AM	27.1	1.7	-	5.7	56.00	49.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:35:39 AM	27.1	1.7	-	5.7	56.00	49.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:36:10 AM	27.1	1.7	-	5.8	57.00	49.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:36:41 AM	27.1	1.7	-	5.8	57.00	49.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:37:12 AM	27.1	1.7	-	5.8	57.00	50.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:37:43 AM	27.1	1.7	-	5.8	57.00	50.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:38:14 AM	27.1	1.7	-	5.8	57.00	50.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:38:45 AM	27.1	1.7	-	5.8	58.00	50.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:39:16 AM	27.1	1.7	-	5.8	58.00	50.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:39:47 AM	27.1	1.7	-	5.8	58.00	50.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:40:18 AM	27.1	1.7	-	5.8	58.00	50.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:40:49 AM	27.1	1.7	-	5.8	58.00	51.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:41:20 AM	27.1	1.7	-	5.9	59.00	51.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:41:51 AM	27.1	1.7	-	6.0	59.00	51.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:42:22 AM	27.2	1.7	0.10	6.0	59.00	51.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:42:53 AM	27.2	1.7	-	6.0	59.00	51.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:43:24 AM	27.2	1.7	-	6.0	59.00	51.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:43:55 AM	27.2	1.7	-	6.0	60.00	52.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:44:26 AM	27.2	1.7	-	6.1	60.00	52.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:44:57 AM	27.2	1.7	-	6.1	60.00	52.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:45:28 AM	27.2	1.7	-	6.1	60.00	52.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:45:59 AM	27.2	1.7	-	6.1	60.00	52.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:46:30 AM	27.2	1.7	-	6.1	61.00	52.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:47:01 AM	27.2	1.7	-	6.1	61.00	52.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:47:32 AM	27.2	1.7	-	6.6	61.00	53.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:48:03 AM	27.2	1.7	-	6.6	61.00	53.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:48:34 AM	27.2	1.7	-	6.6	61.00	53.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:49:05 AM	27.2	1.7	-	6.6	61.00	53.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:49:36 AM	27.2	1.7	-	6.6	61.00	53.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:50:07 AM	27.2	1.7	-	6.6	62.00	53.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:50:38 AM	27.2	1.7	-	6.6	62.00	53.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:51:09 AM	27.2	1.7	-	6.6	62.00	53.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:51:40 AM	27.2	1.7	-	6.6	62.00	54.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:52:11 AM	27.2	1.7	-	6.6	62.00	54.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:52:42 AM	27.2	1.7	-	6.6	62.00	54.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:53:13 AM	27.2	1.7	-	6.6	62.00	54.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:53:44 AM	27.2	1.7	-	6.6	63.00	54.00	0.00	0	0	0	0	0	0	0	0	0	0

INSTALLATION REPORT

CLIENT	sacramento	PROJECT	university
STREET	collagetowne	MANUFACTURE	RELINE AMERICA
PROJECT NUMBER	stateuniversity	PRODUCTION ID	1
MANHOLE TO MANHOLE	updown	PRODUCTION DATE	112415
PIPE DIAMETER	18.00	WALL THICKNESS	7.7
LENGTH	20.00	STORAGE TEMPERATURE	65
SOURCE OF LIGHT	600	OUTSIDE TEMPERATURE	65
		WEATHER	nice

Date_Time	Length	Speed_SP	Speed	Pressure	Temp_1	Temp_2	Temp_3	Temp_4	L1	L2	L3	L4	L5	L6	L7	L8	L9
1/12/2016 7:54:15 AM	27.2	1.7	-	6.6	63.00	54.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:54:46 AM	27.2	1.7	-	6.4	63.00	55.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:55:17 AM	27.2	1.7	-	6.0	63.00	55.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:55:48 AM	27.2	1.7	-	6.0	63.00	56.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:56:19 AM	27.2	1.7	-	6.0	64.00	57.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 7:56:50 AM	27.2	1.7	-	6.0	65.00	57.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 7:57:21 AM	22.0	1.7	41.30	6.1	67.00	58.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 7:57:52 AM	18.6	1.7	-	6.0	69.00	68.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 7:58:23 AM	18.6	1.7	-	6.0	72.00	77.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 7:58:54 AM	18.6	1.0	-	6.0	75.00	87.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 7:59:25 AM	18.6	1.0	-	6.0	79.00	97.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 7:59:56 AM	18.6	1.0	-	6.1	82.00	105.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:00:27 AM	18.6	1.0	-	6.2	85.00	114.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:00:58 AM	18.6	1.0	-	6.4	88.00	121.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:01:29 AM	18.4	1.0	0.80	6.3	92.00	129.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:02:00 AM	18.0	1.0	1.30	6.3	96.00	132.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:02:31 AM	17.5	1.5	1.10	6.6	100.00	124.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:03:02 AM	16.9	1.0	0.90	6.6	103.00	112.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:03:33 AM	16.3	1.0	0.90	6.6	107.00	121.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:04:04 AM	15.8	1.0	0.90	6.7	111.00	126.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:04:35 AM	15.4	1.0	0.90	6.8	115.00	135.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:05:06 AM	14.8	1.5	1.40	5.8	119.00	142.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:05:37 AM	14.1	1.5	1.30	6.2	123.00	145.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:06:08 AM	13.4	1.5	1.30	6.2	126.00	144.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:06:39 AM	12.6	1.5	1.40	6.3	130.00	144.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:07:10 AM	11.9	1.5	1.50	6.3	133.00	143.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:07:41 AM	11.1	1.5	1.60	6.3	137.00	145.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:08:12 AM	10.3	1.5	1.60	6.4	140.00	146.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:08:43 AM	9.5	1.5	1.40	6.3	144.00	149.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:09:14 AM	8.7	1.5	1.60	6.2	147.00	153.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:09:45 AM	8.0	1.5	1.40	6.3	151.00	155.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:10:16 AM	7.3	1.5	1.50	6.3	154.00	155.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:10:47 AM	6.4	1.5	1.50	6.3	158.00	161.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:11:18 AM	5.7	1.5	1.50	6.6	161.00	168.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:11:49 AM	4.8	1.5	1.50	6.5	165.00	182.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:12:20 AM	5.9	1.5	-	6.5	168.00	193.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:12:51 AM	5.9	1.5	-	6.4	172.00	202.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:13:22 AM	5.9	1.5	-	6.6	175.00	208.00	0.00	0	2	2	2	2	2	2	2	2	2
1/12/2016 8:13:53 AM	5.9	1.5	-	6.7	177.00	214.00	0.00	0	0	0	2	2	2	2	2	2	2
1/12/2016 8:14:24 AM	5.9	1.5	-	6.7	180.00	218.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:14:55 AM	5.9	1.5	-	1.3	181.00	217.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:15:26 AM	5.9	1.5	-	0.0	183.00	221.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:15:57 AM	5.9	1.5	-	0.0	184.00	220.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:16:28 AM	5.9	1.5	-	0.0	184.00	219.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:16:59 AM	5.9	1.5	-	0.0	185.00	218.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:17:30 AM	5.9	1.5	-	0.0	185.00	217.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:18:01 AM	5.9	1.5	-	0.0	185.00	216.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:18:32 AM	5.9	1.5	-	0.0	184.00	214.00	0.00	0	0	0	0	0	0	0	0	0	0
1/12/2016 8:19:03 AM	5.9	1.5	-	0.0	184.00	213.00	0.00	0	0	0	0	0	0	0	0	0	0

DEUTSCHES INSTITUT FÜR BAUTECHNIK

German Institute for Construction Technology - a public corporation

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Ref.no.: III 59-1.42.3-3/07

National Technical Approval

Approval number Z-42.3-330

Applicant: Brandenburger Liner GmbH & Co. KG
Taubensuhlstrasse 6
76829 Landau (Palatinate), Germany

Object of approval: Pipe lining procedure called “Brandenburger liner” for rehabilitation of underground, damaged sewage pipes with circular profile and inverted egg-shaped profiles in the diameter range of DN 150 to DN 1000 and 200/300 mm to 800/1200 mm

Valid till: 30 April, 2011

The object of approval named above is nationally technically approved.*
This national technical approval encompasses 22 pages and 25 appendices.

Official seal Nr. 23 of the German Institute for Construction Technology

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* This national technical approval replaces the national technical approval no Z-42.3-330 from 27 September extended by notification from 12 February 2007.

1 Regulations for the measurements

The stability of the intended pipe liners needs to be verified by a stress analysis for each rehabilitation according to the ATV-DVWK Advisory Leaflet M 127-2[7] from the “Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA)” (German Association of Water, Sewage and Waste Management).

For the stress analysis for the pipe liner rigidity of SN ≥ 5,000 M/m^2, a deformation module of the base needs to be applied that matches the lateral line zone of the old pipe. For the stress calculation, a safety coefficient of γ = 2.0 needs to be taken into account.

The reduction factor A for determining the long-time valued according to 10,000-hour test (in accordance with DIN EN 761[21]) is A = 1.78 for the pipe liner “**ADV 75**”, A = 1.60 for the pipe liner “**ADV 95**” and A = 1.33 for the pipe liner “**ADV 120**”.

This results the following Young modulus and bending stress values for the stress analysis according to the ATV-DVWK Advisory Leaflet M 127-2[7]:

1. Pipe liner “**ADV 75**”:

Tensile bending stress$_{\text{short-term, 5\% quantile}}$	= 180 N/mm^2	(26,105psi)	In accordance with DIN EN ISO 178[12]
Tensile bending stress$_{\text{long-term, 5\% quantile}}$	= 100 N/mm^2	(14,503psi)	
Circumference $E_{\text{short-term, 5\% quantile}}$	= 8,500 N/mm^2	(1,232,755psi)	In accordance with DIN EN ISO 1228[11]
Circumference $E_{\text{long-term, 5\% quantile}}$	= 4,700 N/mm^2	(681,641psi)	
Young modulus $E_{\text{short-term, 5\% quantile}}$	= 7,500 N/mm^2	(1,087,725psi)	In accordance with DIN EN ISO 178[12]
Long-term $E_{\text{long-time, 5\% quantile}}$	= 4,200 N/mm^2	(609,126psi)	

2. Pipe liner “**ADV 95**”:

Tensile bending stress$_{\text{short-term, 5\% quantile}}$	= 200 N/mm^2	In accordance with DIN EN ISO 178[12]
Tensile bending stress$_{\text{long-term, 5\% quantile}}$	= 125 N/mm^2	
Circumference $E_{\text{short-term, 5\% quantile}}$	= 9,500 N/mm^2	In accordance with DIN EN ISO 1228[11]
Circumference $E_{\text{long-term, 5\% quantile}}$	= 5,900 N/mm^2	
Young modulus $E_{\text{short-term, 5\% quantile}}$	= 9,500 N/mm^2	In accordance with DIN EN ISO 178[12]
Long-term $E_{\text{long-time, 5\% quantile}}$	= 5,900 N/mm^2	

3. Pipe liner “**ADV 120**”:

Tensile bending stress$_{\text{short-term, 5\% quantile}}$	= 230 N/mm^2	(33,356psi)	In accordance with DIN EN ISO 178[12]
Tensile bending stress$_{\text{long-term, 5\% quantile}}$	= 170 N/mm^2	(24,655psi)	
Circumference $E_{\text{short-term, 5\% quantile}}$	= 12,000 N/mm^2	(1,740,360psi)	In accordance with DIN EN ISO 1228[11]
Circumference $E_{\text{long-term, 5\% quantile}}$	= 9,000 N/mm^2	(1,305,270psi)	
Young modulus $E_{\text{short-term, 5\% quantile}}$	= 10,800 N/mm^2	(1,566,324psi)	In accordance with DIN EN ISO 178[12]
Long-term $E_{\text{long-time, 5\% quantile}}$	= 8,100 N/mm^2	(1,174,743psi)	

2 Regulations for the maintenance

Each of the six sewage pipes rehabilitated during the validity period of this approval as well as at least six residential connections re-established by cap profile technology have to be visually inspected by the applicant. These results along with the accompanying descriptions of the rehabilitated damages have to be submitted without request to the German Institute for Construction Technology during the validity period of this approval.

Three of these completed rehabilitations have to be inspected for leaks at the cost of the applicant under auspices of an expert in addition to the leakage test conducted immediately following the rehabilitation, before the termination of the validity date of this approval.

Kersten | Certified

INTERNATIONAL STANDARD

ISO 7685

First edition
1998-07-15

Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial specific ring stiffness

Systèmes de canalisation en matières plastiques — Tubes en plastiques thermodurcissables renforcés de verre (PRV) — Détermination de la rigidité annulaire spécifique initiale

Reference number
ISO 7685:1998(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 7685 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 6, *Reinforced plastics pipes and fittings for all applications*, in collaboration with CEN/TC 155, *Plastics piping systems and ducting systems.*

This International Standard is one of a series of standards on test methods for plastics piping systems and ducting systems.

International Organization for Standardization
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Internet iso@iso.ch

Printed in Switzerland

Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial specific ring stiffness

1 Scope

This International Standard specifies methods for determining the initial specific ring stiffness of glass-reinforced thermosetting plastics (GRP) pipes. Two methods are given, and within the specified deflection limits each is equally valid and may be used for any diameter.

2 Definitions

For the purposes of this International Standard, the following definitions apply:

2.1
compressive load (F)
load applied to a pipe to cause a diametric deflection

It is expressed in newtons.

2.2
vertical deflection (y)
vertical change in diameter of a pipe in a horizontal position in response to a vertical compressive load (see 2.1)

It is expressed in metres.

2.3
relative vertical deflection (y/d_m)
ratio of the vertical deflection y (see 2.2) to the mean diameter of the pipe d_m (see 2.4)

2.4
mean diameter (d_m)
diameter of the circle corresponding with the middle of the pipe wall cross-section

It is given, in metres, by either of the following equations:

$$d_m = d_i + e$$

$$d_m = d_e - e$$

where

d_i is the average of the measured internal diameters (see 5.3.3), in metres;

d_e is the average of the measured external diameters (see 5.3.3), in metres;

e is the average of the measured wall thicknesses of the pipe (see 5.3.2), in metres.

2.5
specific ring stiffness (S)
a physical characteristic of the pipe, which is a measure of the resistance to ring deflection under external load

This characteristic is determined by testing and is defined, in newtons per square metre, by the equation

$$S = \frac{E \times I}{d_m^3}$$

where

E is the apparent modulus of elasticity as determined in the ring stiffness test, in newtons per square metre;

I is the second moment of area in the longitudinal direction per metre length, expressed in metres to the fourth power per metre, i.e.

$$I = \frac{e^3}{12}$$

where

e is the wall thickness of the test piece, in metres;

d_m is the mean diameter (see 2.4) of the test piece, in metres.

2.6
initial specific ring stiffness (S_0)
initial value of S obtained by testing in accordance with this International Standard

It is expressed in newtons per square metre.

3 Principle

A length of pipe is loaded throughout its length to compress it diametrically. Two ways are given for doing this, method A (constant load) and method B (constant deflection), either of which can be used:

Method A: After applying the load necessary to give a relative deflection of (3 ± 0,5) %, the load is kept constant for a specified period of time and the final deflection is determined at the end of this period.

Method B: After applying the load necessary to give the initial relative deflection specified in the referring standard, the deflection is kept constant for a specified period of time and at the end of this period the final load being applied is determined.

NOTE — It is assumed that the following test parameters are set by the standard making reference to this International Standard:

a) the method to be used (A or B);

b) the length of the test pieces (see 5.1);

c) the number of test pieces (see 5.2);

d) if applicable, the details of conditioning of the test pieces (see clause 6);

e) for method B, the relative deflection to be applied (see 7.3.3).

4 Apparatus

4.1 Compressive-loading machine, comprising a system capable of applying, without shock, a compressive force (suitable for method A or B) at a controlled rate through two parallel load application surfaces conforming to 4.2 so that a horizontally orientated pipe test piece conforming to clause 5 can be compressed vertically. The accuracy of loading shall be ± 1 % of the maximum indicated load.

4.2 Load application surfaces

4.2.1 General arrangement

The surfaces shall be provided by a pair of plates (see 4.2.2), or a pair of beam bars (see 4.2.3), or a combination of one such plate and one such bar, with their major axes perpendicular to and centred on the direction of application of the load F by the compressive-loading machine, as shown in figure 1. The surfaces in contact with the test piece shall be flat, smooth, clean and parallel.

Plates and beam bars shall have a length at least equal to that of the test piece (see clause 5) and a thickness such that visible deformation does not occur during the test.

4.2.2 Plates

The plate(s) shall have a width of at least 100 mm.

4.2.3 Beam bars

Each beam bar shall have rounded edges, a flat face (see figure 1) without sharp edges and a width dependent upon the pipe as follows:

a) for pipes with a nominal size not greater than DN 300, the width shall be 20 mm ± 2 mm;

b) for pipes of nominal sizes greater than DN 300, the width shall be 50 mm ± 5 mm.

The beam bars shall be designed and supported such that no other surface of the beam bar structure comes into contact with the test piece during the test.

4.3 Dimension-measuring instruments, capable of determining

— the necessary dimensions (length, diameter, wall thickness) to an accuracy of within ± 0,1 mm;

— the deflection of the test piece in the vertical direction to an accuracy of within ± 1,0 % of the maximum value.

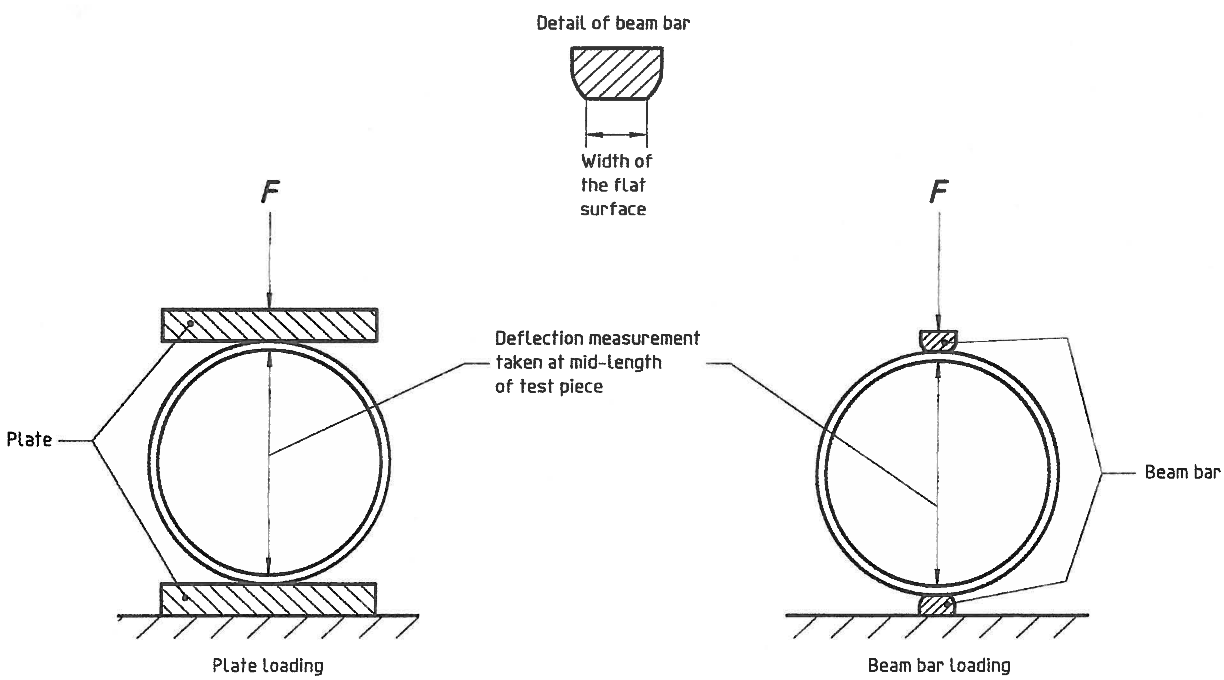


Figure 1 — Schematic diagram of the test arrangement

5 Test pieces

5.1 Preparation

mod. in 1226

Each test piece shall be a complete ring cut from the pipe to be tested. The length of the test piece shall be as specified in the referring standard, with permissible deviations of ± 5 %. Where a referring standard does not exist or does not specify the length of the test piece, the said length shall be 300 mm ± 15 mm.

The cut ends shall be smooth and perpendicular to the axis of the pipe.

Straight lines, to serve as reference lines, shall be drawn on the inside or the outside along the length of the test piece at 60° intervals around its circumference.

5.2 Number

mod. in 1226

The number of test pieces shall be as specified in the referring standard. Where a referring standard does not exist or does not specify the number of test pieces the said number shall be one per pipe size.

5.3 Determination of dimensions

5.3.1 Length

Measure the length of the test piece along each reference line to an accuracy of 0,2 mm.

Calculate the average length L, in metres, of the test piece from the six measured values.

5.3.2 Wall thickness

Measure to within ± 0,2 mm the wall thickness of the test piece at each end of each reference line.

Calculate the average wall thickness e, in metres, of the 12 measured values.

5.3.3 Mean diameter

Measure to an accuracy of within ± 0,5 mm either of the following:

a) the internal diameter d_i of the test piece between each pair of diametrically opposed reference lines at their mid-length, e.g. by means of a pair of calipers;

b) the external diameter d_e of the test piece at the mid-points of the reference lines, e.g. by means of circumferential-wrap steel tape.

Calculate the mean diameter d_m of the test piece using the values obtained for wall thickness and either the internal or the external diameter (see 2.4).

6 Conditioning

Unless otherwise specified by the referring standard, store the test pieces for at least 0,5 h at the test temperature (see 7.1) prior to testing.

mod. in 1226

In cases of dispute, condition the test pieces for 24 h at 23 °C ± 3 °C before testing, or subject them to a mutually agreed conditioning schedule.

7 Procedure

7.1 Test temperature

Conduct the following procedure at the temperature specified in the referring standard.

7.2 Positioning of the test piece

Place a test piece in the apparatus with a pair of diametrically opposed reference lines in contact with the plate(s) and/or beam bar(s).

Ensure that the contact between the test piece and each plate or beam bar is as uniform as possible and that the plate(s) and/or beam bar(s) are not tilted laterally.

7.3 Application of load and measurement of deflection

7.3.1 General

Carry out a test in accordance with 7.3.2 or 7.3.3 at each pair of reference lines (see 5.1). Allow the test piece to recover between each test. In cases of dispute, allow 15 min between each test.

7.3.2 Method A: Using constant load

See figure 2.

Apply the compressive load at an approximately constant rate so that a relative deflection between 2,5 % and 3,5 % is reached in 60 s ± 10 s;

Keep this load constant for 2 min, and at the end of this period determine and record the load and the deflection.

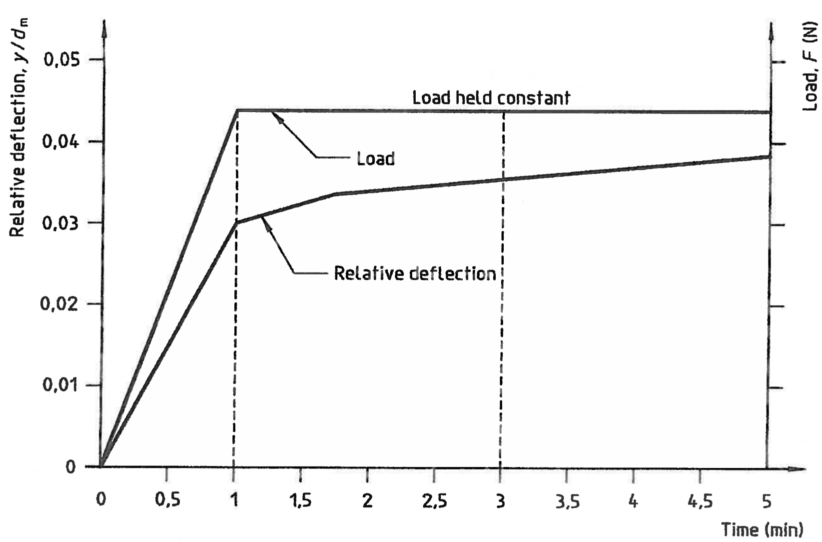


Figure 2 — Method A: Load and corresponding deflection versus time

7.3.3 Method B: Using constant deflection

See figure 3.

Apply the compressive load at an aproximately constant rate so that a relative deflection between 2,5 % and 3,5 % is reached in 60 s ± 10 s.

Keep this deflection constant for 2 min, and at the end of this period determine and record the deflection and the load.

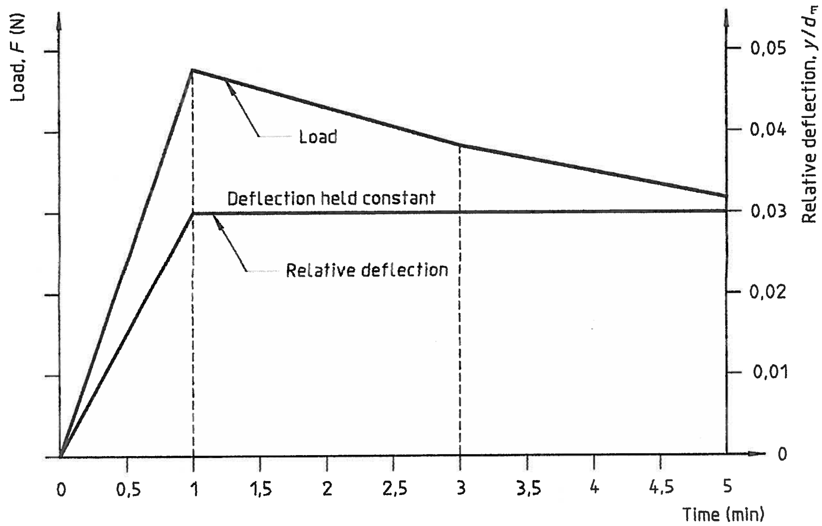


Figure 3 — Method B: Deflection and corresponding load versus time

8 Calculation

Calculate the initial specific ring stiffness S_0 for each of the three positions using the following equation:

$$S_0 = \frac{f \times F}{L \times y}$$

where

f is the deflection coefficient, given by the equation

$$f = \left\{1\,860 + (2\,500 \times y / d_m)\right\} \times 10^{-5};$$

L is the average length of the test piece, expressed in metres;

F is the applied load, expressed in newtons;

y is the deflection, expressed in metres;

d_m is the mean diameter, expressed in metres.

Calculate the average of the three values and record this value as the initial specific ring stiffness of the test piece.

9 Test report

The test report shall include the following information:

a) a reference to this International Standard and the referring standard;

b) all details necessary for complete identification of the pipe tested;

c) the dimensions of each test piece;

d) the number of test pieces;

e) the positions in the pipe from which the test pieces were obtained;

f) the equipment details, including whether beam bars and/or plates were used;

g) the test temperature;

h) the test method used, i.e. method A or B;

i) for each test piece, the loads and corresponding deflections used to calculate the initial specific ring stiffness;

j) the initial specific ring stiffness of each test piece;

k) any factors which may have affected the results, such as any incidents which may have occurred or any operating details not specified in this International Standard;

l) the date of the test.

ICS 23.040.20

Descriptors: piping, pipes (tubes), thermosetting resins, glass reinforced plastics, plastic tubes, tests, mechanical tests, stiffness tests, rules of calculation.

Price based on 7 pages

RELINEAMERICA

SAFETY DATA SHEET (SDS)

Section 1: Identification

Product Name(s): **ALPHALINER**
Ultraviolet (UV) Light Cured
Cured-In-Place Pipe (CIPP)
Fiberglass Reinforced Liner
(Non-Cured Condition)

Manufacturer: Reline America, Inc.
116 Battleground Avenue
Saltville VA 24370-3387
276-496-4000 or 866-998-0808
(8:00 am – 4:30 pm Eastern Time weekdays)

Emergency Contacts: Manufacturing (8:00 am – 4:30 pm ET weekdays): 276-496-4000
CHEMTREC (24 hours everyday): 800-424-9300

Health & Technical Contacts: Health issues: 276-496-4000 (8:00 am – 4:30 pm ET)
Technical product information: 276-496-4000 or fax 276-494-4870

Recommended Use of Product: Impermeable liner for existing piping.

Section 2: Hazard(s) Identification

Hazard Classification: Category 9 other regulated substance, solid, n.o.s (contains styrene)
Packing Group III NA3077

Caution:  Flash point ≥23 °C (73 °F) but ≤60 °C (140 °F) in liquid (gel) form. Can be ignited readily and will burn vigorously and persistently when in solid form.

Emergency Overview: No unusual emergency situations are expected from this product.

Primary Route(s) of Exposure: Inhalation, skin, eye.

Potential Health Effects

Acute (short term):
<u>Eyes</u> – Severe eye irritant which may result in redness, burning, tearing and blurred vision.

<u>Skin</u> – Skin irritant which may result in burning sensation. Repeated or prolonged skin contact may cause dermatitis.

<u>Ingestion</u> – Ingestion may result in mouth, throat, and gastrointestinal irritation, nausea, vomiting, and diarrhea.

<u>Inhalation</u> – Inhalation of gaseous vapors may cause upper respiratory irritation and possible central nervous system effects including headaches, nausea, vomiting, dizziness, loss of coordination, impaired judgment, and general weakness.

Chronic (long term):

Styrene – Classified by ACGIH (the American Conference of Governmental Industrial Hygienists) as category A4 (not classifiable as a human carcinogen).

– Classified by IARC (the International Agency for Research on Cancer) as category 2B (possibly carcinogenic to humans).

– Classified by NTP (the National Toxicology Program) in Group 2 (reasonably anticipated to be a human carcinogen).

– 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 to humans.

Section 3: Composition/Information on Ingredients

Name	C.A.S. Number	% by Weight
Polyester resin	N/A	20 – 40
Styrene	100-42-5	13 – 25
Glass fiber	N/A	35 – 65
Proprietary filler (chemical identity withheld as a trade secret)	N/A	0 – 6
Barrier film	N/A	0 – 2

Section 4: First Aid Measures

Inhalation: Move to a safe area as soon as possible, Rest in a well-ventilated area. Provide oxygen if breathing is difficult. Perform mouth-to-mouth resuscitation if not breathing. Seek immediate medical attention.

Eye Contact: Flush eyes 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 with contaminated skin with running water and non-abrasive soap. Seek medical attention if irritation persists.

Ingestion: Do not induce vomiting. Seek immediate medical attention.

Section 5: Fire Fighting Measures

Flash Point & Method: 83 °F (28 °C) – Styrene, Pensky-Martens closed-cup method

Flammability Limits (%): LFL: 0.9% (Styrene)
UFL: 6.8% (Styrene)

Auto Ignition Temperature: 914 °F (490 °C) – Styrene

Extinguishing Media: Water spray, foam, CO_2 or dry chemical

Unusual Fire & Explosion Hazards: Keep cool with water spray

Fire Fighting Instructions: In a sustained fire wear self-contained breathing apparatus and full protective bunker turnout gear.

Hazardous Combustion Products: Primary combustion products are carbon monoxide, carbon dioxide and low molecular weight hydrocarbons. Other undetermined compounds could be released in small quantities.

Section 6: Accidental Release Measures

Rupture of pipe liner packaging to land, water, and air may require reporting to local, state, and/or federal agencies.

Small Spill: Absorb any spilled resin with an inert material and place in sunlight to cure prior to placing in an appropriate waste disposal container.

Large Spill: Eliminate all ignition sources. Keep unauthorized personnel away from spill and prevent entry into confined areas. Contain with an inert material. Recover as much as possible and cure the remainder in sunlight before placing in an appropriate waste disposal container.

Section 7: Handling & Storage

Storage Temperature: Store below 95 °F (35 °C), avoid prolonged exposure to higher temperatures

Storage Pressure: Not applicable

General: Store below 95 °F (35 °C)

Section 8: Exposure Controls/Personal Protection

Ingredients	ACGIH TLV (US, 3/2012)	OSHA PEL Z2 (US, 11/2006)	NIOSH REL (US, 6/2009)
Polyester Resin	None Established	None Established	None Established
Styrene	8-hour TWA: 20 ppm (85 mg/m^3) 15-minute STEL: 40 ppm (170 mg/m^3)	8-hour TWA: 100 ppm 5-minute AMP: 600 ppm Ceiling: 200 ppm	10-hour TWA: 50 ppm (215 mg/m^3) 15-minute STEL: 100 ppm (425 mg/m^3)

Engineering Controls: Provide exhaust ventilation or other engineering controls to keep airborne vapor concentrations below their respective occupational exposure limits. Provide adequate safety showers and eyewash stations in areas of use.

Personal Protection:

Respiratory Protection: For uncured product: If irritation occurs, or if the TLVs or PELs are exceeded, used a NIOSH/MSHA approved air purifying respirator with organic vapor cartridges or canisters, or supplied air respirators.

During fabrication operations: If irritation occurs, or if the TLVs or PELs are exceeded, wear a NIOSH approved disposable dust respirator such as 3M 8710. Use respiratory protection in accordance with your company's respiratory protection program, local regulations or OSHA regulations under 29 CFR 1910.134.

Skin Protection: Avoid skin contact. Wear impervious gloves. Other protective items include long sleeves, lab coats, or impervious jackets.

Eye Protection: Wear eye protection such as safety glasses with side shields.

Work/Hygienic Practices: Handle in accordance with good industrial hygiene and safety practices. These include avoiding unnecessary exposure and removal of the product from skin, eyes and clothing. Launder contaminated clothing before reuse. Eye wash stations should be available.

Section 9: Physical and Chemical Properties

Appearance	Non-flowable, semisolid/liquid gel impregnated into a glass fiber matrix and encapsulated within a plastic (polyamide) sleeve
Flammability Limits (%)	Styrene LFL = 0.9%, UFL = 6.8%
Odor Type	Aromatic
Vapor Pressure (mm Hg @ 20 °C)	Styrene = 4.5
Odor Threshold	Styrene = 0.14 ppm (0.60 mg/m^3)
Vapor Density (air = 1)	Styrene = 3.59
pH	Not Applicable
Relative Density (water = 1)	1.2 – 2.0
Freezing Point	Not Available
Water Solubility	Insoluble
Boiling Point	Styrene: 293 °F (145 °C)
Flash Point & Method	Styrene: 83 °F (28 °C), Pensky-Martens closed-cup method

Evaporation Rate (*n*-butyl acetate = 1)	Not available
Flammability	Category 3 as liquid: flash point ≥23 °C (73 °F) but ≤60 °C (140 °F) Category 2 as solid: can be ignited readily, will burn vigorously/persistently
Octanol/Water Partition Coefficient	Styrene: Log (K_{OW}) = 2.95
Auto Ignition Temperature:	Styrene: 914 °F (490 °C)
Decomposition Temperature	Styrene: >660 °F (>350 °C)
Viscosity	Not available

Section 10: Stability and Reactivity

General: Stable below 95°F (35°C)

Incompatible Materials & Conditions to Avoid: Peroxides, oxidizers, catalysts for vinyl polymers, strong acids or bases, aluminum chloride.

Hazardous Decomposition Products: Oxides of carbon and low molecular weight hydrocarbons. See Section 5 of this SDS for combustion products statement.

Hazardous Polymerization: Normally stable compound, hazardous polymerization unlikely to occur.

Section 11: Toxicological Information

Toxicity to Animals:	Polyester Resin	Styrene
LD_{50} Oral	Not Available	2650 mg/Kg (rat) 5,000 mg/Kg
LD_{50} Intraperitoneal	Not Available	898 mg/Kg (rat)
LC_{50} Inhalation (gas)	Not Available	2,770 ppm for 4 hours (rat)
LC_{50} Inhalation (vapor)	Not Available	11,800 mg/m³ for 4 hours (rat)
TDL_O Dermal	Not Available	26.4 mg/Kg (rat)

Special remarks on toxicity to animals: Lung effects have been observed in mouse studies, which have been shown to be the result of mouse-specific enzymes (not in humans) that enable cancer production in mice.

Special remarks on chronic effects in humans: No additional remarks.

Special remarks on other toxic effects in humans: No additional remarks.

Carcinogenicity:

Ingredients	ACGIH	IARC	NTP	OSHA
Polyester	No	No	No	No
Styrene	No	Yes (Group 2B)*	Yes (Group 2)†	No

ACGIH = American Conference of Industrial Hygienists; IARC = International Agency for Research on Cancer; NTP = National Toxicology Program; OSHA = Occupational Health and Safety Administration;

*Group 2B = possibly carcinogenic to humans – prior to March 1987 the IARC classified styrene monomer as a Group 3 compound (meaning not classified as to human carcinogenicity);

†Group 2 = reasonably anticipated to be a human carcinogen – prior to June 2011 the NTP did not classify styrene as to carcinogenicity.

Section 12: Ecological Information

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

Section 13: Disposal Considerations

RCRA Hazard Class: Cured product is non-hazardous. Recycle uncured product to process if possible. Consult state and local disposal authorities for disposal options prior to disposing any uncured resin product.

Section 14: Transport Information

DOT Shipping Name: Other regulated substance, solid, n.o.s. (contains styrene)

Hazard Class or Division: 9 **Secondary**: None

Identification No.: NA3077 **Packing Group**: III

Label(s) required (if not excepted): 9

Bulk Packaging: Non-DOT specification, shift-proof, closed motor vehicle

EPA Hazardous Substances: Styrene **RQ**: 1,000 pounds

Marine Pollutants: Styrene Monomer, inhibited

Freight Description: CIPP Liner

Saturated tubes containing less than 2,500 pounds of neat resin (3,000 of a filled resin) are below the threshold that requires labeling as an environmentally hazardous material. However, Reline America, Inc. recommends placing an information label on the end of the tube with the following information:

> *This tube contains a glass fiber matrix saturated with a polyester or vinyl ester resin system. The amount of styrene monomer contained in the resin system present in this tube is less than the amount required to classify it as a regulated quantity of an environmentally hazardous material. Please be advised that DOT has deemed the coating and glass fiber matrix of this tube a sufficient container for domestic transport of this material to the project worksite. This product is not subject to hazardous materials communication requirements when each of the tubes in transit is below the regulated quantity of styrene (1,000 pounds) per tube.*

Saturated tubes containing 2,500 or more pounds of neat resin (3,000 or more pounds of a filled resin) must be labeled for transport, on each end of the tube and each side, as follows:

> ***NA3077, other regulated substance, solid, n.o.s. ("Styrene") 9 III RQ***
>
> This tube contains a regulated quantity of an environmentally hazardous material. The material is styrene monomer, which in its current state of a polyester or vinyl ester resin solution is designated as a Class 9, NA 3077, Packing Group III substance. Please be advised that DOT has deemed the coating and glass fiber matrix of this tube a sufficient container for transporting this resin material to the project work site. Each tube should have this label on each end and each side of the tube.

The transport vehicle shipping a tube containing 2,500 pounds or more of a neat resin (3,000 pounds or more of a filled resin system) may also display the number "3077" on an "orange" panel or "white square-on-point" configuration, on each side and each end, if any tube in the vehicle contains this regulated quantity.

Pursuant to 49 CFR § 172.504(f)(9), the driver of a commercial motor vehicle transporting Alphaliner UV light cured CIPP does <u>not</u> need to have a 'Hazardous Materials' endorsement on their Commercial Driver's License (whether or not the vehicle is placarded).

Section 15: Regulatory Information

TSCA Status: Each ingredient is on the Inventory.

SARA Title III Section 302 Components: None

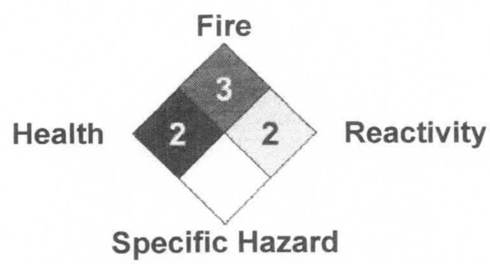
SARA Title III Section 313 Components: Styrene.

California Proposition 65: The State of California lists styrene oxide (a metabolite of styrene monomer) as a known carcinogen on their list of "Chemicals Known to the State to Cause Cancer or Reproductive Toxicity."

Clean Air Act: The federal Clean Air Act, as amended, lists styrene monomer as a hazardous air pollutant.

Section 16: Other Information

NFPA Hazard Rating: (Styrene)



CERTIFICATE OF CONFORMITY

THIS CONFIRMS THAT

Alphaliner 1500 and AOC Vipel Resin meets the standards set out for a

50 Year Design Life

per the National Standards

ASTM F1216 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

ASTM F 2019 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic, (GRP) cured in Place Thermosetting Resin Pipe (CIPP)

ASTM D5813 Standard Specification for Cured in Place Thermosetting Resin Sewer Piping Systems

ASTM F1743 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled in Place Installation of Cured in Place Thermosetting Resin Pipe (CIPP)

1: The Product was installed by an Installer trained by Reline America personnel or official appointed agents, on the specific product listed above

2. The Installer has abided with the rules stated on Reline America Quality Statement

3. The Goods were sold in accordance with Reline America Standard Terms of Sale.

Dated 08 January 2016

Reline America Liner Wall Thickness Design Analysis Report - ASTM

Date:	Thursday, November 3, 2016
Calculations made by:	Jamie Lienberger
Calculations reviewed by:	Gary Lienberger
Project Name:	CSUS
Project Location:	Sacramento

SEGMENT DESIGNATION

1

DESIGN INFORMATION SUMMARY

Condition of Host Pipe		PD
Inside Diameter of Host Pipe (in)	D	18
Ovality of Host Pipe (%)	q	5.0
Flexural Modulus of Elasticity of CIPP, initial (psi)	E	1,653,000
Flexural Strength of CIPP, Initial (psi)	s_i	30,460
Tensile Strength of CIPP, Initial (psi)	s_T	30,000
Design Safety Factor	N	2
Unit Weight of Soil (pcf)	d_s	120
Depth of Cover (ft)	H	1.0
Estimated Constrained Soil Modulus	Ms	2000.00
Height of Groundwater (ft)	H_w	0.0
Surface Live Loading Condition		- none -
Pavement Type		Flexible

WALL THICKNESS CALCULATIONS SUMMARY

Partially Deteriorated Gravity Pipe Condition:

Minimum Thickness Required, Hydrostatic Buckling (in)	Eq. X1.1	0.09
Minimum Thickness Required, Ovality Check (in)	Eq. X1.2	0.03

Fully Deteriorated Gravity Pipe Condition:

Minimum Thickness Required, Luscher's Buckling Equation (in)	Eq. X1.3	0.04
Minimum Thickness Required, Pipe Stiffness (in)	Eq. X1.4	0.16

CIPP WALL THICKNESS DESIGN SUMMARY

Minimum CIPP Thickness Required (in)	t_{min}	0.18
Minimum CIPP Thickness Required (mm)	(mm)	4.57
Minimum CIPP Thickness Required (DR_{CIPP})	DR_{CIPP}	100

Submittals

1. Resin sample submitted and accepted
2. Work Plan
    - 2.1. Calculated thickness of liner – 9 mill. (see calculations)
    - 2.2 Manufactures recommendations:
        - 2.2.1 Minumum pressure – 5 lbs. PSI
        - 2.2.2 Maxum pressure – 15 lbs. PSI
        - 2.2.3 Postcure temperature – 110 degrees F.
        - 2.2.4 Cure pressures – Min cold – 5 lbs, Maxuim heated and cold – 15 lbs PSI
        - 2.2.5 Curing time for steam – 1.5 hrs.
    - 2.3 Resin Trade Name – AOC
    - 2.4 Expected maximum exothermic temperature – 160 degees F.
    - 2.5 Insertion type – Inversion
    - 2.6 Method of cure – Steam
    - 2.7 Termination of segment – extend 3 feet at each end of host pipe
3. Manufacures information:
    - 3.1.1 Supplier – AOC
    - 3.1.2 Infared scans p. 59
    - 3.1.3 N/A (host pipe contains no bituminous coating)
    - 3.1.4 Certificates – p 43 – 58
    - 3.2.1 – 5. N/A (no enhancer used in resin)
    - 3.3.1 Fabric tubesupplier – Applied Felts
    - 3.3.2 Membrane type – Polyeurethane
    - 3.3.3 N/A – Inversion of the liner
    - 3.4 Resin inserted at factory
    - 3.5 Sealing Material – Soka Flex 1A
    - 3.6 N/A – no splicing
    - 3.7 Lubricant – vegetable oil

4 Annual pressure calabration – N/A (temperature and pressure range does not require)

5. Flexual testing – P. 44-47
6. Manufactures certification letterhead – see attached.
7. MSDS - P.19
8. Design Calc – See attached
9. Testing Lab - **HAUSER LABORATORIES** www.hauserlabs.com A Division of Microbac Laboratories, Inc.
4750 Nautilus Court South, Unit A, Boulder, CO 80301-3240 Phone: 720 406 4800 Fax: 303 581 0195

8/13/13

Installation Procedure

1. Clean line from top manhole.
2. CCTV line from top manhole.
3. Place refrigerated liner transport truck and boiler truck at top manhole.
4. Insert liner from top manhole.
5. Introduce air and steam to the liner from top manhole
6. Moniter air pressure and temperature from bottom manhole
7. After liner is fully cured and cooled, remove excess liner from manhole.
8. Post CCTV line.

Tom Byrd
President
Christian Brothers Lining Co.

SPINIELLO CIPP INSTALLATION PROCEDURES

The following are guidelines for installing the Spiniello Liner CIPP system for the Annual Sewer Inspection & Rehabilitation Services (Cured-in-Place Pipe). *The field conditions can vary, especially in these areas of standing water with varying depths, therefore, more specific procedures will be determined after verifying the field conditions.*

PREPARATORY WORK

A. Clean each length of pipe to be lined and dispose of any resulting material in accordance with the cleaning and disposal procedures.

B. Control active leaks to the extent required to install the liner.

C. Provide bypass pumping of sewage flows.

D. Perform a pre-lining television inspection to document that the sewer is clean of all dirt and debris. The CONTRACTOR shall confirm that the conditions are suitable for lining.

E. Prior to inversion, the CONTRACTOR shall take necessary precautions and install temporary dams at the downstream end of the lining work to prevent material from leaving the work area. All temporary devices and construction debris shall be removed prior to reinstating flow through the sewer.

STORAGE AND HANDLING

A. Resin products will be stored in a refrigerated truck at the recommended storage temperature listed for each product. A resin impregnated liner shall be stored in the same manner as the resin products. A liner that has not been impregnated with resin shall be kept out of direct sunlight by covering with a tarp or similar type of covering.

B. Precautions for safe handling of all material shall be performed by adhering to the handling guidelines stated in the manufacturer's MSDS.

RESIN IMPREGNATION

A. The liner tube shall be vacuum-impregnated with resin under controlled conditions to thoroughly saturate the tube prior to being sent for installation. The volume of resin used shall be sufficient to fill all voids in the tube material at nominal thickness and diameter, and to allow for any migration of resin into the cracks and joints of the pipe being rehabilitated.

B. In this case, which is factory resin impregnation; the liner shall be transported and kept in a refrigerated truck until the time of installation. The refrigerated truck shall be equipped with a sealed temperature recording device that continuously monitors the temperature of the liner at all times after leaving the wet-out site. Transportation and storage of the resin impregnated liner shall be done so that the liner is not damaged, exposed to direct sunlight or creates a safety hazard.

C. For more details on the resin impregnation process refer to Wet-Out Procedures below.

INVERSION

A. No CIPP installations shall be undertaken in weather conditions that could jeopardize the installation of the CIPP, or be detrimental to the long term performance of the CIPP.

B. The first step before setting equipment up for inversion is to establish site specific safety measures and the correct traffic control. Once traffic control has been set-up the inversion tower is then erected over the access pit (inversion point). The height of the inversion platform is adjusted to meet the required inversion head depending on the depth of the pipe to be rehabilitated.

C. With the water inversion platform, the liner is then pulled into position and the open end of the down tube is turned inside out and attached to the horizontal frame on the inversion tower. The liner was resin impregnated at the factory, therefore; it will be pulled out of a refrigerated trailer. The inversion down-tube which is suspended from the platform is then formed by inverting the liner through itself. Water is poured into the downtube to carry the inversion along, a lubricant is also added to reduce friction on the liner coating and allow a smooth inversion. The lubricant is in the form of a non-toxic oil-based product such as vegetable oil. The liner then enters through the access pit (inversion point) until it reaches the invert, at which point the inversion end is angled so that its direction of progression is straight into the direction of the host pipe to be lined. This is achieved by pulling up on the turn ropes attached to the mouth of the pipe at the invert of the liner causing the inversion tube to bend approximately 90 degrees (this will of course vary depending on the angular arrangement of the inversion point and the host pipe).

D. As the liner enters the host pipe an electrical thermocouple is placed in the invert between the tube and the pipe wall. This thermocouple placement serves to monitor temperatures during the curing and cool-down process.

E. Water is introduced into the down tube maintaining the required inversion pressure and the water level is constantly regulated during the inversion process. The water pressure is maintained to ensure a tight fit of the liner along the host pipe wall.

F. For the water inversion process, the procedure above continues until the end of the liner is within approximately ten feet of the top of the downtube, this is approximately the halfway point of the inversion. The inversion is then temporarily stopped and a hold back rope and lay flat hose is then tied to the end of the liner. The other end of the hold back rope is then wrapped around the capstan at the top of the inversion tower. The inversion process then continues and the rate of progression is controlled by the force applied to the holdback rope.

G. Using water, the inversion continues until the liner enters approximately 6 to 12 inches into the receiving access pit at the end of the inversion and a backstop is installed at the termination point as a precaution to prevent the liner from progressing past that point (the majority of the force however will be held by the holdback rope).

H. Once the liner is in its satisfactory position and is up to size, the curing process can then begin.

CURING (Resin Manufacturer's cure recommendations govern over general procedures noted below)

A. Curing shall begin immediately following inversion. Curing shall be done by the use of circulating heated water. The CONTRACTOR shall provide adequate equipment and monitoring devices in order to maintain the specified curing temperature until the CIPP has attained its ultimate exotherm.

B. For water installation the water in the liner is heated up to approximately 170 – 200 degrees F to initiate the exothermic reaction of the resin/catalyst mixture. The temperature of the liner and the resulting temperature "spike" during the exothermic reaction is monitored and recorded at the thermocouples. This information along with the size and length of the installation, equipment performance and surrounding site conditions, dictate the length of time used to hold a curing temperature in the liner. The actual time required to cure a liner is left to the Contractor's discretion because of the numerous factors involved. Please refer to the cure schedule for more information (Appendix C).

C. After the liner has cured it is then allowed to cool down before cutting the ends. For water installation, cool water is slowly introduced into the CIPP to cool down the water temperature to approximately 100 degrees F before completely draining. Once again the actual time required for cool down is left to the Contractor's discretion because of the numerous factors involved. Please refer to the cure schedule for more information (Appendix C).

POST CURING

A. Cool down and draining of the pipe shall be undertaken in such a manner to avoid creating a vacuum in the pipe.

B. For each segment of liner installed, samples will be prepared and will be submitted for testing purposes per the project specifications, in accordance with ASTM F1216 and ASTM D790. Restrained samples are preferred as noted.

C. All cutting and sealing of the liner at the ends shall provide a watertight pipe

D. Any gap between an installed liner and the host pipe shall be reviewed on a case by case basis.

E. The liner shall be cleaned and the debris removed. The CONTRACTOR shall then conduct a post-lining television inspection of the completed work. The post-lining television inspection shall verify the quality of the lining work. The CONTRACTOR shall correct non-conforming lining work as noted from the post-lining inspections or otherwise noted by the ENGINEER. The CONTRACTOR shall re-televise or have still digital photographs taken to verify and document the quality of the corrective work.

F. The CONTRACTOR shall prepare and submit internal inspection records according to the CONTRACT DOCUMENTS.

SPINIELLO CIPP INSTALLATION PROCEDURES (AIR)

The following are guidelines for installing the Spiniello Liner CIPP system for the Annual Sewer Inspection & Rehabilitation Services (Cured-in-Place Pipe). Actual field conditions can vary and thus may require adjustments or deviations from these procedures as needed.

PREPARATORY WORK

F. Clean each length of pipe to be lined and dispose of any resulting material in accordance with the cleaning and disposal procedures.

G. Control active leaks to the extent required to install the liner.

H. Provide bypass pumping of sewage flows only when necessary in conditions of flow.

I. Perform a pre-lining television inspection to document that the sewer is clean of all dirt and debris and any protruding laterals have been cut prior to lining. Spiniello shall confirm that the conditions are suitable for lining.

STORAGE AND HANDLING

C. Resin products will be stored in a refrigerated truck at the recommended storage temperature listed for each product. The resin impregnated liner shall be stored in the same manner as the resin products.

D. Precautions for safe handling of all material shall be performed by adhering to the handling guidelines stated in the manufacturer's MSDS.

RESIN IMPREGNATION

D. The liner tube shall be vacuum-impregnated with resin under controlled conditions to thoroughly saturate the tube prior to being sent for installation. The volume of resin used shall be sufficient to fill all voids in the tube material at nominal thickness and diameter, and to allow for any migration of resin into the cracks and joints of the pipe being rehabilitated.

E. In this case, factory or off site resin impregnation, the liner shall be transported and kept in a refrigerated truck until the time of installation. The refrigerated truck shall be equipped with a sealed temperature recording device that continuously monitors the temperature of the liner at all times after leaving the wet-out site. Transportation and storage of the resin impregnated liner shall be done so that the liner is not damaged, exposed to direct sunlight or creates a safety hazard.

F. For more details on the resin impregnation process refer to the section titled Spiniello CIPP Wet-Out Procedures.

INVERSION

I. No CIPP installations shall be undertaken in weather conditions that could jeopardize the installation of the CIPP, or be detrimental to the long term performance of the CIPP.

J. The first step before setting equipment up for inversion is to establish site specific safety measures and the correct traffic control. Once traffic control has been set-up the inversion tower is then erected over the manhole or point of inversion. The height of the inversion tower is adjusted to meet the required inversion head depending on the depth of the pipe to be rehabilitated. In this case, the installation is scheduled to be an air inversion, so the same depth measurement is converted into PSI. (Please note: if the inversion vessel is planned for use, the impregnated liner is already loaded into the vessel before the unit arrives on site).

K. With the portable shooter in place, the liner is then pulled into position and the open end of the down tube is turned inside out and attached to the vertical portable shooter. The liner was resin Impregnated at the factory; therefore, it will be pulled out of a refrigerated trailer. The inversion down-tube which is suspended from the portable shooter is then preformed by inverting the liner through itself. For air inversion the portable shooter is then attached to the truck using steam hose. A lubricant is then added to the inside and outside to reduce friction for a smooth inversion. The lubricant is in the form of a non-toxic oil-based product such as vegetable oil. We may also use Dawn dish-washing liquid for the inversion process. The liner then enters through the manhole or other inversion point until it reaches the invert, at which point the inversion end is angled so that its direction of progression is straight into the direction of the host pipe to be lined. This is achieved by angling the liner in the direction of the host pipe. The angle of the liner is based on the invert in the manhole. After installed in the mouth of the invert, the procedure is to apply air in order to invert the liner. After the half way point, a can is then put on for the rest of the full inversion.

L. As the liner enters the host pipe an electrical thermocouple is placed in the invert between the tube and the pipe wall. This thermocouple placement is repeated at intermediate manholes to monitor temperatures during the curing and cool-down process.

M. Air is introduced into the down tube maintaining the required inversion pressure and air pressure is constantly regulated during the inversion process. When using air, only regulating the air supply allows the operator to slow down or speed up the inversion process. The air pressure is maintained to ensure a tight fit of the liner along the host pipe wall. The inversion process continues until the liner is completely installed to the termination point.

N. Using the air method and since the liner has reached its destination point, the pressure can be reduced and an air hose connection is then attached to the liner allowing pressure to be regulated through a device (B station) that can allow the operator to regulate both the air pressure and record the heat as the curing process takes place

O. Once the liner is in its satisfactory position and is up to size the curing process can then begin.

CURING (Resin Manufacturer's cure recommendations govern over general procedures noted below)

D. Curing shall begin immediately following inversion. Curing shall be accomplished by adding heat to the air source with the use of steam. The CONTRACTOR shall provide adequate equipment and monitoring devices in order to maintain the specified curing temperature until the CIPP has attained its ultimate exotherm.

E. For steam installation, air in the liner is heated by the introduction of steam at approximately 125 - 240 degrees F to initiate the exothermic reaction of the resin/catalyst mixture. The temperature of the liner and the resulting temperature "spike" during the exothermic reaction is monitored and recorded at the thermocouples. This information along with the size and length of the installation, equipment performance and surrounding site conditions, dictate the length of time used to hold a curing temperature in the liner. Please refer to the cure schedule for more information (Appendix C).

F. The actual time required to cure a liner is left to the Contractor's discretion because of the numerous factors involved. Some of the factors that can affect the curing process are the catalyst used, the liner thickness, the material of the host pipe, the heating capacities (Boiler used), the ambient temperature and water content of the surrounding soil. Please refer to the cure schedule for more information (Appendix C).

G. After the liner has cured, it is then allowed to cool down before cutting the ends. For steam installation, the steam introduction is first stopped and compressed air continues to be circulated through the air/water until the temperature measures approximately 115 degrees F at the outgoing end (B station) or is close to sending temperature at A station. Once again the actual time required for cool down is left to the Contractor's discretion because of the numerous factors involved.

POST CURING

G. Cool down and draining of the pipe shall be undertaken in such a manner to avoid creating a vacuum in the pipe.

H. For each segment of liner installed, samples will be prepared and will be submitted for testing purposes per the project specifications, in accordance with ASTM F1216 and ASTM D790. Restrained samples are preferred as noted.

I. All cutting and sealing of the liner at manhole connections shall provide watertight pipe and manhole trough seals.

J. Any gap between installed liner and host pipe shall be filled using Aquatapoxy A6.

K. Following installation of the liner, the liner shall be cleaned and the debris removed. The CONTRACTOR shall then conduct a post-lining television inspection of the completed work. The post-lining television inspection shall verify the quality of the lining work, including the opening and sealing of manholes and service connections. The CONTRACTOR shall correct non-conforming lining work as noted from the post-lining inspections or otherwise noted by the ENGINEER. The CONTRACTOR shall re-televise or have still digital photographs taken to verify and document the quality of the corrective work.

L. The CONTRACTOR shall prepare and submit internal inspection records according to the CONTRACT DOCUMENTS.

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 300,000 psi and tensile strength is not applicable with gravity pipe.

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 Production QA/QC

This section details the QA/QC procedures involved in production of the FerraTex Liner CIPP.

- Liner requirements are collected by way of the job order from the superintendent, and are confirmed by the plant manager.
- Once all requirements are known, a liner is designed which will fulfill all the requirements.
- The design is detailed to the production department and then entered into the production schedule.
- The control and test of the liner properties are detailed in Table 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 criteria.

Table 1-Control & Testing During Production

Property	Control	Test
Circumference of Liner	Monitored at each production stage against manufacturing criteria.	Destructive test of sample. All layers are measured.
Length of Liner	Monitored at each production stage against manufacturing criteria.	Inspection procedure includes measurement of a sample of liners against manufacturing criteria.
Felt Weld Strength	All welding equipment operates at set parameters.	Each weld is visually inspected during production.
Sealing Tape Weld Strengths	All welding equipment operates at set parameters.	Each weld is visually inspected for air inclusion

1 Liner Components

The history of FerraTex's operation dates back to 1989. Our Cured-In-Place Pipe Liners are made of flat stock polyester felt material and Isophthalic polyester resin and are manufactured to comply with requirements of ASTM F1216. The FerraTex Liner CIPP is manufactured at our facility in McKenney, VA. The dry or wet-out tube (depending on the installation) 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)	Raw Felt (Flat stock)	Polyethylene Terephthalate	Polyester Needled Felt	Non Woven
	Polyurethane Membrane	Polypropylene or Thermoplastic Polyurethane Polymer	Polypropylene or Polyurethane Coated Liner	Haartz
	Resin	Polyester Vinyl Ester Styrene Free-Vinyl Ester	COR series L7 Series	Interplastics Corp. AOC
	Catalyst (Initiator)	Peroxide	TRIGNOX® C	Akzo Nobel
		Peroxide	TRIGNOX® K-90	Akzo Nobel
		Peroxide	TRIGNOX® 121 BB75	Akzo Nobel
		Peroxide	PERKADOX® 16	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 (Typically ≥ 6,000)	ASTM D-790
Initial Flexural Modulus (psi)	> 300,000 (Typically ≥ 400,000)	ASTM D-790
Tensile elongation (%)	< 2	ASTM D-638
Compressive Strength (psi)	15,000	ASTM D-695
Hardness (Barcol)	50 – 55	ASTM D-785
Color	Blue/Green	visual

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 jointed 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.

MANUFACTURERS OF ENGINEERED COATED FABRICS

Technical Data Sheet

TPU COATED NONWOVEN PIPELINER MATERIAL

STYLE: LHI

PHYSICAL PROPERTIES	TEST METHOD	SPECIFICATION	TYPICAL DATA
WEIGHT:	ASTM D751	934 - 1094 g/m²	1014 g/m²
THICKNESS:	DM9000 (W4.10.1.84)	3.2 - 4.0 mm	3.6 mm
STYRENE :	DM9000 (W4.10.1.59)	PASS/FAIL	PASS
TENSILE: Warp x Fill	ASTM D751	950 x1030 (N) MIN.	1739 x 1735 (N)
TRAPEZOID TEAR: Warp x Fill	ASTM D1117	195 x 270 (N) MIN.	949 x 841 (N)

HAARTZ
MANUFACTURERS OF ENGINEERED COATED FABRICS

Technical Data Sheet

TPU COATED NONWOVEN PIPELINER MATERIAL

STYLE: FRE

PHYSICAL PROPERTIES	TEST METHOD	SPECIFICATION	TYPICAL DATA
WEIGHT:	ASTM D751	746 - 906 g/m²	826 g/m²
THICKNESS:	DM9000 (W4.10.1.84)	2.3 – 2.9 mm	2.6 mm
STYRENE:	DM9000 (W4.10.1.59)	PASS/FAIL	PASS
TENSILE: Warp x Fill	ASTM D751	950 X 1030 (N) MIN.	1512 x 1608 (N)
TRAPEZOID TEAR: Warp x Fill	ASTM D1117	195 x 270 (N) MIN.	614 X 603 (N)

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard
29 CFR 1910.1200. Standard must be
consulted for specific requirements.

U.S. Department of Labor
Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

Forms Published by WindowChem (707)864-0846

IDENTITY (As Used on Label and List)
HAARTZ I-TPU COATED FELT

Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I

Manufacturer's Name **HAARTZ CORPORATION**	Emergency Telephone Number **(978) 264 2600**
Address (Number, Street, City, State, and ZIP Code) **87 HAYWARD ROAD**	Telephone Number for Information **(978) 264 2600**
ACTON, MA 01720-3000	Date Prepared 3/6/2013
	Signature of Preparer (optional)

Section IIA - Ingredients/Identity Information

	% (optional)
THERMOPLASTIC POLYURETHANE (TPU) COMPOUND	
POLYESTER FIBER WEB	
Rest of the Information considered Proprietary By Haartz Corp.	
List of Suppliers, addresses and telephone numbers can be obtained from	
Haartz Corporation	
Stabilizers (Trade Secret)	< 5.0%

Section IIB - Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)

Section III - Physical/Chemical Characteristics

Boiling Point N/A	N/A	Specific Gravity (H2O = 1)	N/A
Vapor Pressure (mm Hg) N/A	N/A	Melting Point	N/A
Vapor Density (AIR = 1) N/A	N/A	Evaporation rate (Butyl Acetate = 1)	N/A

Solubility in Water
INSOLUBLE

Appearance and Odor
MILD OLOFINIC ODOR

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
N/A (ASTM D-1929)	N/A	N/A	N/A

Extinguishing Media
SMALL FIRE: USE DRY CHEMICAL POWDER, LARGE FIRE: USE WATER SPRAY, FOR OR FOAM.
DO NOT USE WATER JET.

Special Firefighting Procedures
FIRE FIGHTERS AND OTHER PERSONS SUBJECT TO PRODUCTS OF COMBUSTION SHOULD WEAR SELF-CONTAINED BREATHING APPARATUS.

Unusual Fire and Explosion Hazards
DURING A FIRE, IRRITATING AND HIGHLY TOXIC GASES MAY BE GENERATED DURING COMBUSTION OR DECOMPOSITION.

Section V - Reactivity Data

Stability	Unstable		Conditions to Avoid
	Stable	X	

Incompatibility (Materials to Avoid)

N/A

Hazardous Decomposition or Byproducts

CO, CO_2 , AND SMALL AMOUNTS OF ALIPHATIC AND AROMATIC HYDROCARBONS

Hazardous Polymerization	May Occur		Conditions to Avoid
	Will Not Occur	X	

Section VI - Health Hazard Data

Route(s) of Entry:	Inhalation?	Skin?	Ingestion?
	No	No unless in molten state	Unlikely

Health Hazards (Acute and Chronic)

NO KNOWN SIGNIFICANT EFFECTS OR CRITICAL HAZARDS.

Carcinogenicity:	NTP?	IARC Monographs?	OSHA Regulated?
None Known	No	No	No

Signs and Symptoms of Exposure

PRODUCT FINES, DUST MAY CAUSE MECHANICAL IRRITATION

Medical Conditions

PRE-EXISTING EYE AND RESPIRATORY DISORDERS MAY BE AGGRIVATED BY PRODUCT DUST.

Emergency and First Aid Procedure

FLUSH EYES WITH WATER FOR AT LEAST 10 MINUTES. CONTACT WITH MOLTEN MATERIAL SHOULD BE TREATED AS A THERMAL BURN. SEEK MEDICAL ATTENTION FOR ALL BURNS, PARTICULARLY IN THE FACIAL AREA.

Section VII - Precautions for Safe Handling and Use

Steps to be Taken in Case Material is Released or Spilled

AVOID COLLECT PRODUCT FOR DISPOSAL. FOLLOW STANDARD DISPOSAL PROCEDURES.
GENERATING DUST CLOUDS.

Waste Disposal Method

PLACE IN APPROPRIATE CONTAINER AND DISPOSE OF IN COMPLIANCE WITH ALL FEDERAL, STATE AND LOCAL ORDINANCES.

Precautions to be Taken in Handling and Storage

TREAT AS A SOLID THAT CAN BURN. AVOID MOISTURE CONTAMINATION.

Other Precautions

Not Determined

Section VIII - Control Measures

Respiratory Protection (Specify Type)

No special protection for normal use.

Ventilation	Local Exhaust Local exhaust around processing is recommended	Special N/A
	Mechanical (General) N/A	Other N/A

Protective Gloves

As required for hot materials

Other Protective Clothing or Equipment

N/A

Work/Hygienic Practices

USE GOOD INDUSTRIAL HYGIENE PRACTICES AND PROCEDURES.

Provisional Technical Data Sheet

Product Identification: 07016222 6MM

Product Description: 100% Polyester Needle Felt

Property	Target	Tolerance	Method
Weight:	32.7 OZ/SY	+/- 10%	ASTM D461
Thickness:	0.295”	+/- 10%	ASTM D5729
Tensile MD/CD:	250/230 LBS	Target	ASTM D4632
Elongation MD/CD:	100/120%	+/- 25	ASTM D4632
Total PSI:	(TBD) LBS/IN²	Minimum	NWS Internal
Fiber Composition:	100% 15Dx3” Polyester Fiber Auriga Polymer		
Width:	As Specified		NWS Internal

NWS043014 (Temporary) NWS Item# 1320295-xxx.00

NWS

NON WOVEN SOLUTIONS

Provisional Technical Data Sheet

Product Identification: 07016222 4.5MM

Product Description: 100% Polyester Needle Felt

Property	Target	Tolerance	Method
Weight:	24.8 OZ/SY	+/- 10%	ASTM D461
Thickness:	0.235”	+/- 10%	ASTM D5729
Tensile MD/CD:	177/177 LBS	Target	ASTM D4632
Elongation MD/CD:	95/110%	+/- 25	ASTM D4632
Total PSI:	(TBD) LBS/IN²	Minimum	NWS Internal
Fiber Composition:	100% 15Dx3” Polyester Fiber Auriga Polymer		
Width:	As Specified		NWS Internal

NWS043014 (Temporary) NWS Item# 1248320-xxx.00

Provisional Technical Data Sheet

Product Identification: 07016222 3MM

Product Description: 100% Polyester Needle Felt

Property	**Target**	**Tolerance**	**Method**
Weight:	16.6 OZ/SY	+/- 10%	ASTM D461
Thickness:	0.175”	+/- 10%	ASTM D5729
Tensile MD/CD:	130/140 LBS	Target	ASTM D4632
Elongation MD/CD:	85 / 95%	+/- 25	ASTM D4632
Total PSI:	(TBD) LBS/IN²	Minimum	NWS Internal
Fiber Composition:	100% 6Dx3” Polyester Fiber Polymer DAK 54W		
Width:	As Specified		NWS Internal

NWS043014 (Temporary) NWS Item# 1164170-xxx.00

Material Safety Data Sheet

NWS
NON WOVEN SOLUTIONS

May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200
Standard must be consulted for specific requirements.

Identity (as used on Label and List **1164170-xxx.00 (07016222 3mm)** **1248320-xxx.00 (07016222 4.5mm)** **1327295-xxx.00 (07016222 6mm)**	Note: Blank spaces are not permitted. If any item is not applicable or no information is available, spaces must be marked to indicate that.

Section 1 - Manufacturer's Information

Manufacturer's Name **NONWOVEN SOLUTIONS LLC**	Emergency Telephone Number **1-866-697-0277**	
Address (Number, Street, State and Zip Code) **27981 CONCRETE DRIVE**	Telephone Number for Information **1-866-697-0277**	
INGLESIDE, IL, 60041	Date Prepared **4/29/2014**	Date Updated **4/29/2014**
	Signature of Preparer Jsovran	

Section II - Hazardous Ingredients/Identity Information

Hazardous Components (Specify Chemical Identity)	OSHA PEL	ACGIH TLV	Other Limits Recommended	%
Polyester Fiber Web	**N/A**	**N/A**	**N/A**	
CAS # 25038-59-9				
Minor Pigments and Additives	**N/A**	**N/A**	**N/A**	
CAS # N/A				

This material is an "Article" and is considered non-hazardous per OSHA Hazard Communication Standard - 29 CFR 1910.1200

Section III - Physical/Chemical Characteristics

Boiling Point	**Not Applicable**	Specific Gravity (H_2O=1)	**1.38**
Vapour Pressure (mm Hg)	**Not Applicable**	Melting Point	**258° C**
Vapour Density (AIR = 1)	**Not Applicable**	Evaporation Rate (Butyl Acetate = 1)	**Not Applicable**

Solubility in Water
Insoluble

Appearance and Odor
Nonwoven fiber web, no distinct odor

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used)	**Not Applicable**	Flammable Limits	LEL **N/A**	UEL **N/A**

Extinguishing Media
Water fog, foam dry (ABC)

Special Fire Fighting Procedure
Use full bunker gear including NIOSH approved breathing apparatus

Unusual Fire and/or Explosion Hazards

Treat as a solid that burns generally with a low smoke density

Section V - Reactivity Data

Stability	Unstable		Conditions to Avoid
	Stable	xxx	**None Known**

Incombatibility (Materials to Avoid)

Strong Oxidizing Agents

Hazardous Decomposition of Byproducts

CO, CO_2, and small amounts of aliphatic and aromatic hydrocarbons

Hazardous Polymerization	Unstable		Conditions to Avoid
	Stable	xxx	**None Known**

Section VI - Health Hazard Data

Route(s) of Entry:	Inhalation?	Skin?	Ingestion?
	N/A	**N/A**	**N/A**

Health Hazards (Acute and Chronic

None Known

Carcinogenicity:	NTP?	IARC Monographs?	OSHA Regulated?
	N/A	**N/A**	**N/A**

Signs and Symptoms of Exposure

Product fines, dust may cause mechanical irritation

Medical Conditions Genrally Aggravated by Exposure

Pre-existing eye and respiratory disorders may be aggavated by product dust

Emergency and First Aid Procedures

Flush eyes with water for at least 10 minutes. Contact with molten material should be treated as a thermal burn. Seek medical attention for all burns, particularly if in the facial area.

Section VII - Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled

Shovel, sweep or vacuum. Avoid generating dust clouds.

Waste Disposal Method

Place in appropriate container and dispose of in compliance with all federal, state and local ordinances.

Precautions to Be Taken in Handling and Storing

Treat as a solid that can burn

Other Precautions

Store away from oxidizing agents.

Section VIII - Control Measures

Respiratory Protection (Specify Type)

Not required, but appropriate dust mask can be used if product dust is present

Ventilation	Local Exhaust		Special	**N/A**
	Mechanical (General)	**Recommended**	Other	**N/A**

Protective Gloves	Eye Protection
Not Required	**ANSI Z87 Safety glasses recommended**

Other Protective Clothing or Equipment

Not Required

Work/Hygiene Practices

Use good industrial hygiene practices and procedures

Inversion Head Pressures

Pipe Diameter		CIPP pressure thickness	Recommended Inversion pressure	Minimum Inversion pressure	Maximum Inversion pressure
IN	MM	MM	PSI	PSI	PSI
6	152	4.5	10	8	13
6	152	6	14	10	17
8	203	4.5	7	6	10
8	203	6	10	7	13
8	203	7.5	12	9	16
10	254	6	7	5	10
10	254	7.5	9	7	13
10	254	9	10	8	16

As installation conditions, Installers experience and equipment may vary these values stated above are recommendations only.

World Leader in Resin Technology

Vipel® L704-NET-11 Series Polyester Resin

Product Information

Vipel® Isophthalic Based Resin for Underground Sewer Pipe Liners

TYPICAL LIQUID RESIN PROPERTIES*(1) Vipel® L704-NET-11 see back page

	Nominal
Viscosity @ 77°F/25°C, RVF Brookfield Spindle #4 @ 20 RPM, cps.	5,600
Thix Index 2/20	4.3
Color	Opaque
Specific Gravity @ 77°F/25°C	1.11
Non-Volatiles, %	62
Gel Time @ 140°F with (1.0% Di-(4-tert-butyl-cyclohexyl) peroxydicarbonate and 0.5% Trigonox® KSM), minutes	11
Pot Life @ 77°F/25°C (1% Di-(4-tert-butyl-cyclohexyl) peroxydicarbonate and + 0.5% Trigonox® KSM), hours	40

Trigonox is a trademark of Akzo Nobel Chemicals

TYPICAL CAST MECHANICAL PROPERTIES* (2) see back page

		Test Method
Tensile Strength, psi/MPa	13,500/93.1	ASTM D 638
Tensile Modulus, psi/GPa	600,000/4.1	ASTM D 638
Tensile Elongation, %	3.0	ASTM D 638
Flexural Strength, psi/MPa	23,300/161	ASTM D 790
Flexural Modulus, psi/GPa	630,000/4.3	ASTM D 790
Heat Distortion Temperature, °F/°C @ 264 psi	212/100	ASTM D 648
Barcol Hardness	40	ASTM D 2583

*Typical properties are not to be construed as specifications.

DESCRIPTION

The Vipel® L704-NET-11 is a high molecular weight isophthalic/unsaturated polyester resin. Vipel® L704-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.

FEATURES

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

BENEFITS

Adaptability

AOC's Vipel® L704-NET-11 molecular architecture provides an excellent balance of corrosion and physical properties.

Vipel® L704-NET-11 Polyester Resin

PERFORMANCE GUIDELINES

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

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

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 77°F/25°C. After extended storage, some drift may occur in gel time.

During the hot summer months, no more than two months stability at 86°F/30°C should be anticipated.

SAFETY

See appropriate Material Safety Data Sheet for guidelines.

ISO 9001:2000 CERTIFIED

The Quality Management Systems at every AOC manufacturing facility have been certified as meeting ISO 9001:2000 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™ L704-NET-11 pipe at 77°F/25° and 50% relative humidity. Ccastings were prepared using 1.0% Perkadox 16 and 0.5 Trigonox C.

AOC®
World Leader in Resin Technology

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Fax: (44) 1473 216080
europe@aoc-resins.com

World Leader in Resin Technology

December 6, 2013

To Whom It May Concern:

The following cure procedures are recommended when using the L704 polyester resin in Cured In Place Pipe applications. L704 polyester resin can be cured using either hot water or steam. The recommended post cure temperatures are a minimum of 180°F ± 10°F Water Temperature for water and 220°F ± 20°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 the interface temperatures are low, increase the cure time by a minimum of 1 hour for every 10°F. If the pipe to be lined contains a bituminous coating, the use of a pre-liner is recommended.

The liner shall be cooled to an interface temperature of 110°F ± 10°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.

HAUSER®

August 10, 2000
Test Report No. M00248B/40141

CLIENT: AOC
950 Hwy 57 East
Collierville, TN 38017
Attn: Bruce Curry

Re: PO 5061

MATERIAL: One set of fifty rectangular coupons made with 6mm felt impregnated with Vipel™L704 resin were submitted and identified by the client.

TESTING: Chemical Resistance testing per ASTM D5813-95, paragraphs 6.4.1 and 8.2.1 was conducted. Coupons were exposed in accordance with ASTM D543-95 in the solutions shown in the table below at room temperature for a one-year immersion period. Flexural properties testing as described below will be conducted at the conclusion of the immersion period.

Chemical Solution	Concentration, %
Nitric acid	1
Sulfuric acid	5
ASTM Fuel C	100
Vegetable oil	100
Detergent	0.1
Soap	0.1

One set of Control coupons was tested for initial flexural properties as reported in Hauser Laboratories Test Report No. M00248A on August 31, 1999. A second set of Control coupons was exposed for one year at 50% Relative Humidity, and 23°C. These coupons were tested on August 9, 2000 along with the exposed coupons. All testing was conducted in accordance with ASTM D790-98, Procedure A using a span-to-depth ratio of 16:1.

RESULTS: The results are summarized in Table 1 and presented in detail in Table 2. All values exceeded the ASTM D5813 requirements of at least 80% retention of flexural modulus after one-year immersion in all solutions.

TESTING SUPERVISED BY:

Julie Krause-Singh
Department Manager

TESTING CONDUCTED BY:

Dale J. Beasley
Technician III

Hauser Laboratories • 4750 Nautilus Ct. So. • Boulder, CO 80301-3240 • www.hauser.com
• Ph: (800) 241-2322 • Ph: (303) 581-0079 • FAX: (303) 581-0195

TABLE 1
SUMMARY OF CHEMICAL RESISTANCE TEST RESULTS

Solution	Average Retention of Flexural Strength*	Average Retention of Flexural Modulus*
	%	%
Nitric Acid	89	96
Sulfuric Acid	103	95
ASTM Fuel C	145	97
Mineral Oil	112	98
Detergent	118	95
Soap	90	94
ASTM D5813 Requirement		80 minimum

*These calculations were based on the data from the Control sample tested 8/9/00.

TABLE 2
CHEMICAL RESISTANCE TEST RESULTS

Specimen No.	Flexural Strength	Flexural Modulus
	psi	psi
Vipel™L704		
Control 8/31/99		
1	4570	736000
2	5300	709000
3	5410	686000
4	4680	682000
5	7600	665000
6	8670	726000
7	8560	681000
Average	6400	698000
Std. Dev.	1820	26300
Control 8/9/00		
1	8530	528000
2	5180	548000
3	7750	548000
4	4520	590000
5	5340	586000
6	4530	556000
Average	5980	559000
Std. Dev.	1730	24200
1% Nitric Acid		
1	5580	528000
2	5650	531000
3	5800	543000
4	4400	527000
5	5080	521000
6	5300	555000
Average	5300	534000
Std. Dev.	510	12700

TABLE 2 CONTINUED
CHEMICAL RESISTANCE TEST RESULTS

Specimen No.	Flexural Strength	Flexural Modulus
	psi	psi
5% Sulfuric Acid		
1	5820	530000
2	5220	519000
3	5430	520000
4	5750	545000
5	7550	538000
6	6980	537000
Average	6130	531000
Std. Dev.	930	10300
ASTM Fuel C		
1	10300	521000
2	7640	535000
3	4990	536000
4	8490	574000
5	9080	542000
6	11600	560000
Average	8670	545000
Std. Dev.	2280	19200
Mineral Oil		
1	6680	523000
2	5930	509000
3	7790	582000
4	8610	571000
5	5030	566000
6	6290	548000
Average	6720	550000
Std. Dev.	1290	29000

TABLE 2 CONTINUED
CHEMICAL RESISTANCE TEST RESULTS

Specimen No.	Flexural Strength	Flexural Modulus
	psi	psi
Detergent		
1	7320	529000
2	7690	564000
3	4890	514000
4	7480	536000
5	7000	549000
6	7920	507000
Average	7050	533000
Std. Dev.	1100	21600
Soap		
1	5170	508000
2	5410	517000
3	4600	535000
4	5630	526000
5	4330	520000
6	6980	537000
Average	5350	524000
Std. Dev.	940	11100

HAUSER®

May 24, 2000
Test Report No. E90868/40067

CLIENT: AOC
950 Highway 57 East
Collierville, TN 38017
Attn: Dave Treadwell

MATERIAL: Six each rectangular specimens from two plastic materials identified as felt composites L471 and L704 were submitted by the client. The specimens were each approximately 6 inches x ½ inch x 0.3 inches.

TESTING: Flexural creep testing per ASTM D2990-95 using a three-point static-load configuration with a span to depth ratio of approximately 16:1 and a stress level of 400 psi at 23°C and 50% Relative Humidity.

RESULTS: The results for 10000 hours are presented as both graphical and tabular data of flexural modulus versus time for each group of five specimens tested. Tabular results for sample L471 are presented in Table 1 and tabular results for sample L704 are presented in Table 2

TESTING SUPERVISED BY:

Julie Krause-Singh
Department Manager

TESTING CONDUCTED BY:

John C. McCoy
Technician II

Hauser Laboratories • 4750 Nautilus Ct. So. • Boulder, CO 80301-3240 • www.hauser.com
• Ph: (800) 241-2322 • Ph: (303) 581-0079 • FAX: (303) 581-0195

TABLE 2
FLEXURAL CREEP DATA
SAMPLE L704

TEMPERATURE: 23° C/ 50% RH
STRESS: 400 psi

Elapsed Time	FLEXURAL MODULUS, psi					
Hours	1	2	3	4	5	Average
0.00						
0.02	810900	879100	649100	664400	739500	748600
0.10	810900	879100	649100	655900	729500	744900
0.20	798400	879100	641200	631600	710300	732100
0.50	774600	865200	633400	631600	710300	723000
1.00	774600	851700	618500	601900	666400	702600
2.00	741400	838600	604300	588000	666400	687800
3.43	720800	825900	597500	574800	658300	675500
22.08	632900	707900	547700	522000	580400	598200
68.58	625300	681300	505500	491900	550800	571000
114.2	570300	656700	469400	465100	509200	534200
257.4	503900	524100	381000	409300	461400	455900
456.0	439800	514200	378200	362800	412100	421400
792.8	393200	454200	339200	332200	374900	378700
1414.3	368100	436000	326600	321800	350500	360600
1651.6	360400	425800	320600	315800	339500	352400
1802.0	341400	400800	303900	292300	325200	332700
2011.3	339200	400800	303900	292300	323200	331900
2109.6	337000	400800	302200	290700	321300	330400
2154.9	337000	397900	302200	290700	321300	329800
2322.8	332700	397900	302200	289000	317500	327900
2660.8	332700	397900	300400	289000	315700	327100
2808.1	330600	395000	300400	287400	313800	325400
3002.1	330600	395000	300400	287400	313800	325400
3193.5	328500	386600	292100	285800	312000	321000
3312.6	314500	378500	288900	278000	305000	313000
3547.9	310800	373300	282700	272100	301600	308100
3618.8	309800	372100	282700	272100	301600	307700
3834.1	308900	370800	282700	272100	299900	306900
4003.4	307100	370800	282700	272100	299900	306500
4171.3	305300	370800	282700	270700	298200	305500
4513.7	300000	365800	281200	267900	295000	302000

TABLE 2 CONTINUED
FLEXURAL CREEP DATA
SAMPLE L704

Elapsed Time	FLEXURAL MODULUS, psi					
Hours	1	2	3	4	5	Average
4676.1	298300	365800	279700	266500	295000	301000
5012.2	298300	363400	278200	265100	295000	300000
5186.1	298300	363400	278200	265100	295000	300000
5392.3	296600	361000	278200	262400	293400	298300
5689.7	296600	361000	276700	262400	293400	298000
5901.7	294900	361000	275300	262400	293400	297400
6021.8	294900	361000	273800	262400	291800	296800
6167.8	291600	361000	273800	259700	290200	295300
6331.0	291600	361000	275300	259700	290200	295500
6719.3	291600	358600	273800	259700	290200	294800
7338.3	283600	349400	268200	254500	281100	287400
7507.1	283600	349400	271000	253300	281100	287700
7866.4	285200	349400	266900	254500	282600	287700
8251.8	285200	347200	266900	253300	281100	286700
8376.1	282100	347200	266900	253300	281100	286100
8512.6	282100	347200	266200	253300	281100	286000
9016.1	279800	345000	266900	252000	278200	284400
9261.1	279000	342800	265500	250800	278200	283300
9324.3	278300	342800	265500	250800	276800	282800
9571.7	278300	342800	265500	249600	276800	282600
9911.3	274600	338600	264200	248400	275400	280200
10025.4	274600	338600	264200	248400	275400	280200

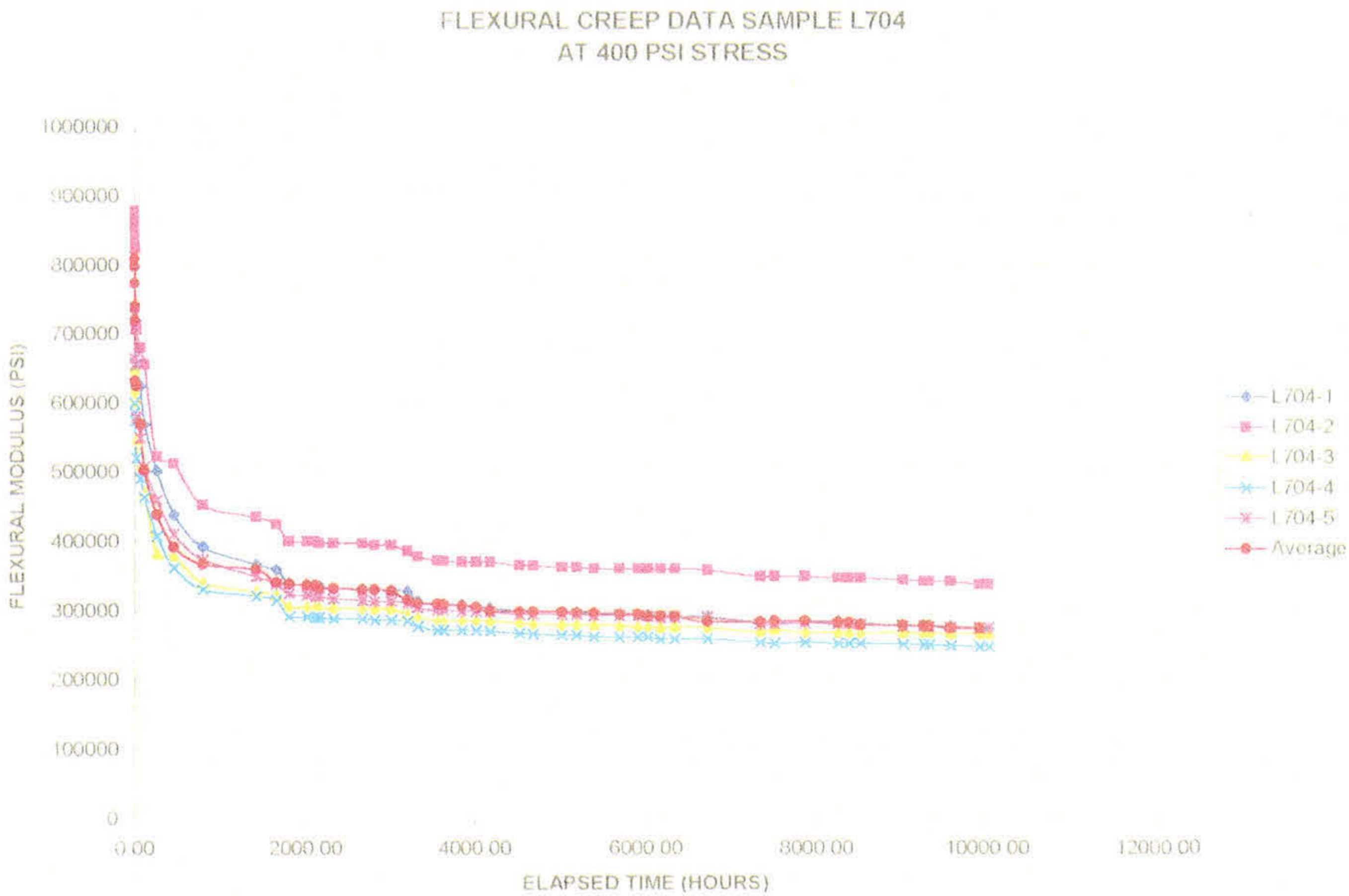

FLEXURAL CREEP DATA SAMPLE L704
AT 400 PSI STRESS
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
FLEXURAL MODULUS (PSI)
0.00
2000.00
4000.00
6000.00
8000.00
10000.00
12000.00
ELAPSED TIME (HOURS)
L704-1
L704-2
L704-3
L704-4
L704-5
Average

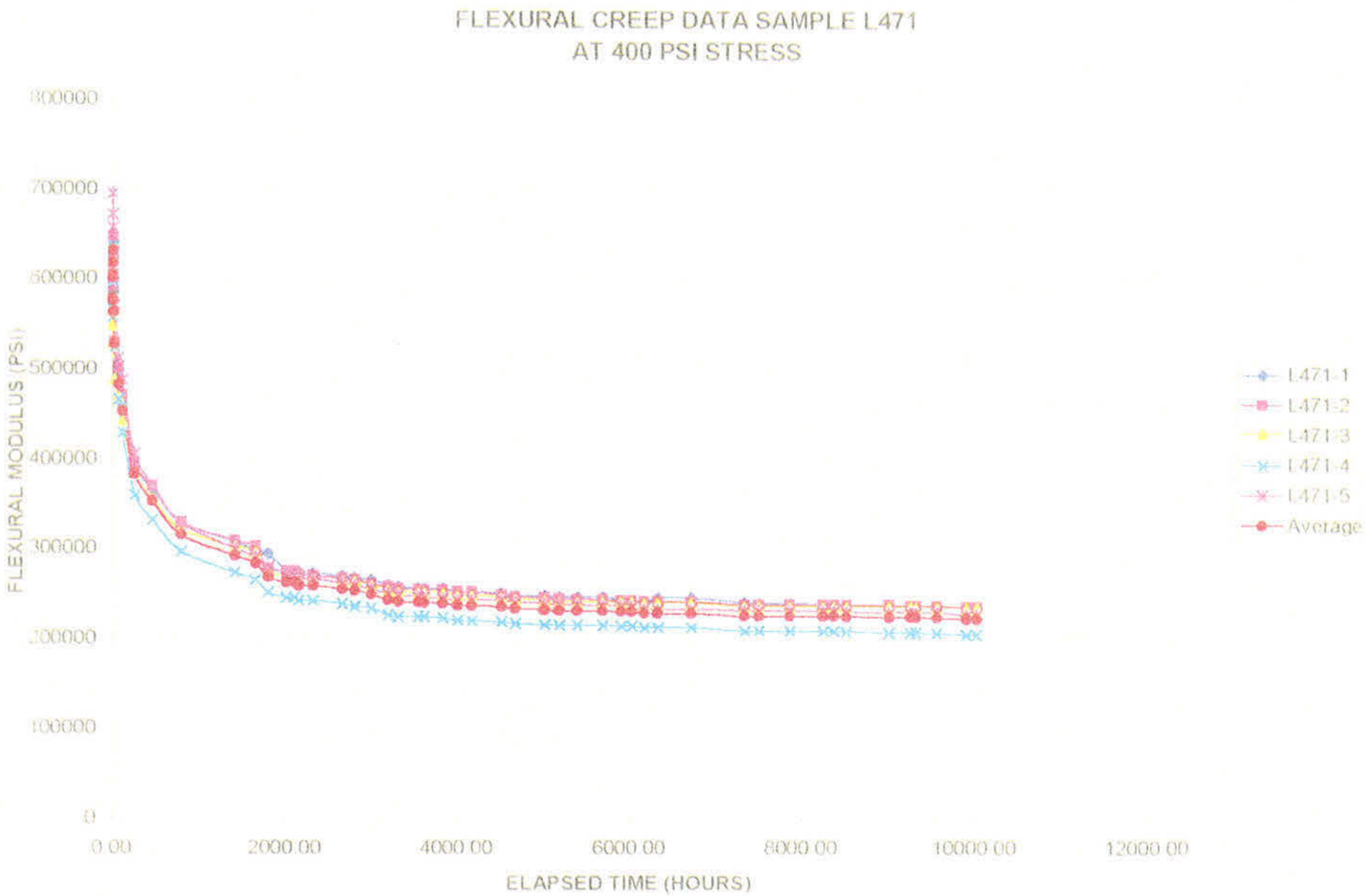
TABLE 1
FLEXURAL CREEP DATA
SAMPLE L471

TEMPERATURE: 23° C/ 50% RH
STRESS: 400 psi

Elapsed Time	FLEXURAL MODULUS, psi					
Hours	1	2	3	4	5	Average
0.00						
0.02	643500	648300	562900	635700	696200	631600
0.10	643500	648300	562900	616100	672900	617300
0.20	629900	626200	547800	603600	658300	603300
0.50	623400	626200	547800	597600	658300	601300
1.00	604500	605600	528900	574600	630900	578200
2.00	598400	605600	528900	569100	630900	576300
3.67	586700	592500	524400	558500	605700	562900
22.4	529600	529900	487000	524200	571400	527500
68.8	498700	501000	468400	466900	513300	482800
114.4	460300	471000	441400	429900	488400	453300
257.6	393700	393600	383500	360000	406500	383300
456.3	367100	369800	354700	332000	371600	352700
793.1	328800	330000	319600	297300	329200	315300
1414.6	308500	309600	302300	274100	299800	292100
1651.9	297700	302800	295000	265600	291200	283900
1802.3	294800	278300	272700	252200	280400	268400
2011.5	275800	275500	269100	245900	272800	262600
2109.8	275800	275500	269100	245900	271600	262200
2155.2	274500	271500	266800	242900	266800	258800
2323.0	273300	270100	266773	242900	266800	258800
2661.0	270800	267500	263300	239000	262200	254900
2808.4	268400	266200	263300	236200	259900	253200
3002.4	266000	261200	258900	234400	255500	249600
3193.7	260200	258700	2535500	227200	250300	243700
3312.9	257900	256300	251466	224700	248200	241400
3548.2	256800	255100	250400	224700	247200	240800
3619.0	255700	255100	250400	224700	246200	240400
3834.4	255700	255100	250400	223800	245200	239800
4003.7	252500	252800	247400	221300	243200	237300
4171.6	252500	252800	247400	220500	243200	237100
4513.9	251400	249300	245400	219700	243233	236124

TABLE 1 CONTINUED
FLEXURAL CREEP DATA
SAMPLE L471

Elapsed Time	FLEXURAL MODULUS, psi					
Hours	1	2	3	4	5	Average
4676.4	248300	247100	243500	218100	241300	234300
5012.4	248300	246000	241600	216500	239400	232500
5186.3	247300	244900	240600	215700	238400	231600
5392.6	247300	244400	240600	215700	238400	231600
5689.9	247300	243800	240600	215700	237500	231300
5901.9	243300	242800	240600	215000	237500	231000
6022.0	242300	242800	240600	215000	236600	230700
6168.1	241300	241700	239700	213400	233800	229000
6331.3	246300	241700	239700	213400	233800	229000
6719.6	246300	241700	239700	213400	233800	229000
7338.6	241300	238600	236000	209700	232100	225900
7507.4	240300	238600	236000	209700	232100	225900
7866.7	240300	238600	236000	209700	232100	225900
8252.1	239400	238600	236000	209700	232100	225900
8376.3	239400	238600	235991	209700	232100	225909
8512.8	238400	238600	236000	209000	231200	225400
9016.3	237500	238600	236000	208200	230300	224800
9261.4	236500	237500	236000	208200	230300	224800
9324.6	236500	237500	236000	208200	230300	224800
9572.0	236500	237500	235100	207500	230300	224800
9911.6	235600	236500	234600	206100	227700	222800
10025.7	235600	236500	234600	206100	227700	222800


FLEXURAL CREEP DATA SAMPLE L471
AT 400 PSI STRESS
FLEXURAL MODULUS (PSI)
800000
700000
600000
500000
400000
300000
200000
100000
0
0.00
2000.00
4000.00
6000.00
8000.00
10000.00
12000.00
ELAPSED TIME (HOURS)
L471-1
L471-2
L471-3
L471-4
L471-5
Average

AOC
World Leader in Resin Technology

ASTM F1216 TEST RESULTS ON L704 SERIES
ONE MONTH RESULTS AT 77°F

	L704 (Isophthalic)	REQUIREMENTS %	PASS OR FAIL
CONTROL SAMPLE			
FLEXURAL STRENGTH, psi	9,544		
STANDARD DEVIATION	252		
FLEXURAL MODULUS, psi	564,989		
STANDARD DEVIATION	15,329		
TAP WATER			
FLEXURAL STRENGH, psi	10,915		
STANDARD DEVIATION	432		
% FLEXURAL STRENGTH, psi RETENTION	100	>80	PASS
FLEXURAL MODULUS, psi	563,496		
STANDARD DEVIATION	10,993		
% FLEXUARAL MODULUS RETENTION	100	>80	PASS
5% NITRIC ACID			
FLEXURAL STRENGH, psi	10,672		
STANDARD DEVIATION	894		
% FLEXURAL STRENGTH, psi RETENTION	100	>80	PASS
FLEXURAL MODULUS, psi	528,173		
STANDARD DEVIATION	13,842		
% FLEXUARAL MODULUS RETENTION	100	>80	PASS
10% PHOSPHORIC ACID			
FLEXURAL STRENGH, psi	10,301		
STANDARD DEVIATION	1,439		
% FLEXURAL STRENGTH, psi RETENTION	100	>80	PASS
FLEXURAL MODULUS, psi	552,544		
STANDARD DEVIATION	9,333		
% FLEXUARAL MODULUS RETENTION	98	>80	PASS
10% SULFURIC ACID			
FLEXURAL STRENGH, psi	12,438		
STANDARD DEVIATION	620		
% FLEXURAL STRENGTH, psi RETENTION	100	>80	PASS
FLEXURAL MODULUS, psi	545,889		
STANDARD DEVIATION	6,319		
% FLEXUARAL MODULUS RETENTION	97	>80	PASS
AMOCO GASOLINE			
FLEXURAL STRENGH, psi	9,209		
STANDARD DEVIATION	1278		
% FLEXURAL STRENGTH, psi RETENTION	97	>80	PASS
FLEXURAL MODULUS, psi	567,531		
STANDARD DEVIATION	4,611		
% FLEXURAL MODULUS RETENTION	100	>80	PASS

VEGETABLE OIL			
FLEXURAL STRENGH, psi	11,809		
STANDARD DEVIATION	2,484		
% FLEXURAL STRENGTH, psi RETENTION	100	>80	**PASS**
FLEXURAL MODULUS, psi	549,755		
STANDARD DEVIATION	27,235		
% FLEXUARAL MODULUS RETENTION	97	>80	**PASS**
0.1% DETERGENT			
FLEXURAL STRENGH, psi	8,073		
STANDARD DEVIATION	1,732		
% FLEXURAL STRENGTH, psi RETENTION	85	>80	**PASS**
FLEXURAL MODULUS, psi	511,284		
STANDARD DEVIATION	15,837		
% FLEXUARAL MODULUS RETENTION	91	>80	**PASS**
0.1% SOAP			
FLEXURAL STRENGH, psi	11,756		
STANDARD DEVIATION	325		
% FLEXURAL STRENGTH, psi RETENTION	100	>80	**PASS**
FLEXURAL MODULUS, psi	549,192		
STANDARD DEVIATION	11,869		
% FLEXURAL MODULUS RETENTION	97	>80	**PASS**

August 1, 1999

Cure Schedule

Prior to curing the CIPP Liner, the interface temperatures (thermocouples) will be placed at all middle manholes in addition to both ends in the invert between the tube and the pipe wall. Please see the recommended curing procedures for the polyester resins as it will clear up many of the reviewer comments from the 1st submittal.

To summarize, Spiniello's steam hold time is normally .5 hr to .45 hr in small pipe applications. This means that the required minimum interface temperature for that particular range of time would be approximately 180-190 degrees Fahrenheit as shown on the table (steam/water temperature would be approximately 180-245 degrees Fahrenheit). A longer range of time would require a less interface temperature as shown on the table. The operator will move to the next cure/cool level once all the interface temperatures have reached or closely arrived at the required temperature. Keep in mind that there could be anomalies from time to time due to thermocouple failures such as malfunction or buried in silt/debris (providing a temperature misread).

Lastly, the manufacturer recommends the liner shall be cooled to a minimum of 110±10 degrees Fahrenheit (interface temperature) using the minimum cool down period listed in the table. Please be aware that at times, especially in hot summer days, you may never get to that required minimum temperature because of the hot ambient temperature feeding into the compressor, which originates even hotter air inside the pipeline. Even though the interface and steam/water temperature will go down, the required temperature by the manufacturer may not be achieved.

Resin Manufacturer's cure temperature recommendations govern over the general procedures noted above.

FERRATEX

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

1 Year Warranty

FERRATEX, as the liner system Manufacturer, hereby warrants the liner system, including all repair material, defect fillers, primers, and liner composite, against any and all defects and liner failures when installed and utilized in accordance with and for the purposes described in its specifications. Manufacturer shall not be liable or responsible under this warranty for any failure caused by fire, war, earthquake or other earth movement, acts of God, negligence, abuse, alteration, or the presence of sewer gasses or chemicals not typically found in domestic sewer collection systems or from any defect in the design of the pump station or lift station or from the failure to properly inspect, service, and maintain the structure. Manufacturer's obligation under this warranty shall further be limited to the repair or replacement of the materials, which an examination shall disclose to Manufacturer's satisfaction to be defective. Warranty on the liner system, as stated herein, shall be one (1) year from the date of Substantial Completion.

◆◆◆

Christian Brothers Lining. — AUTHORIZED LINER INSTALLER

MANUFACTURER SHALL NOT BE LIABLE FOR CONSEQUENTIAL OR SPECIAL DAMAGES UNDER ANY CIRCUMSTANCES. THIS WARRANTY SHALL NOT BE AMENDED, EXTENDED, ALTERED, OR VARIED EXCEPT BY A WRITTEN INSTRUMENT SIGNED BY MANUFACTURER AND AUTHORIZED INSTALLER.

Gerhardt Rodenberger— General Manager

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

20520 Unico Road
McKenney, VA 23872
804.451.3667
www.FerraTex.com

April 25, 2013

To: Whom It May Concern

RE: Christian Brothers Lining Co. – CERTIFIED CIPP INSTALLER

Dear Sir or Madam,

I am writing this letter on behalf of FerraTex, a subsidiary of Spiniello Companies Inc., and supplier of the product Spiniello Liner, a cured-in-place pipe (CIPP) liner used in the rehabilitation of sewer systems worldwide.

As a material supplier for the CIPP industry, we trust our product to certified installers such as Christian Brothers Lining Co. and are proud to call them a customer.

If you should have any additional questions, please do not hesitate to contact me at your convenience. I am available at (804) 451.3667 or via email at grodenberger@ferratex.com .

Best regards,

Gerhardt Rodenberger
General Manager, FerraTex

DISCLAIMER OF WARRANTY: AS INSTALLATION CONDITIONS (INCLUDING, AMONG OTHERS, PIPE TYPE & CONDITION, GROUNDWATER DEPTH & TEMPERATURE, DEPTH OF COVER & SOIL TYPE, LIVE LOADS, SITE ACCESS AND WEATHER) AND INSTALLER EXPERIENCE, TECHNIQUES AND TYPE OF EQUIPMENT VARY GREATLY, FERRATEX EXCLUDES ANY WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH RESPECT TO THE GOODS SOLD HEREUNDER AS TO MERCHANTABILITY, FITNESS FOR PARTICULAR USE OR ANY OTHER MATTER WITH RESPECT TO THE GOODS WHETHER USED ALONE OR IN COMBINATION WITH OTHER PRODUCTS. FERRATEX HAS NOT PROVIDED ANY DESIGN SPECIFICATIONS OR COMPUTATIONS, AND ACCORDINGLY, FERRATEX DOES NOT WARRANT THE DESIGN.

CoREZYN®
INTERPLASTIC CORPORATION
Thermoset Resins Division

CORVE8295

Thixotropic Vinyl Ester Resin

Technical Data Sheet

CORVE8295 is a property enhanced, promoted, thixotropic, corrosion resistant, epoxy vinyl ester resin for use in the manufacture of liner pipe using cured-in-place techniques. This resin contains no Hazardous Air Pollutants (HAP's).

FEATURES	BENEFITS
• Contains No HAP's	• Useful in applications requiring no styrene
• Handling Characteristics of Standard Vinyl Ester	• No special initiators or procedures needed
• Good Fiberglass Wet-Out	• High composites physical properties
• Contains Low-Volatility Materials	• Minimal odor

LIQUID PROPERTIES	RESULTS
Viscosity, Brookfield Model RV #4 Spindle @ 20 rpm, 77°F (25°C), cps	3,700-4,400
Thixotropic Index	3.15-4.00
Gel Time run in a 140°F (60°C) water bath, catalyzed with 0.75% of Perkadox 16 and 0.38% of Trigonox C by weight*	
Gel Time, 130°F to 150°F (54-66°C), min:sec	12:00-17:00
Gel to Peak, 150°F (66°C) to Peak Exotherm Time, min:sec	1:30-5:00
Peak Exotherm	200-260°F (93-127°C)
Room Temperature Catalyzed Stability, hours	>20
Specific Gravity	1.29-1.35

TYPICAL PROPERTIES								
Thickness	1/8 inch (3.2 mm) Casting				1/4 inch (6.4 mm) Laminate			
Construction	Prepared on Base Polymer Only				CIPP Felt Laminate			
Flexural Strength, ASTM D790	11,889	psi	82	MPa	8,769	psi	60	MPa
Flexural Modulus, ASTM D790	706,500	psi	4,872	MPa	671,200	psi	4,629	MPa
Tensile Strength, ASTM D638	8,005	psi	55	MPa	3,751	psi	26	MPa
Tensile Modulus, ASTM D638	843,180	psi	5,815	MPa	724,230	psi	4,995	MPa
Tensile Elongation, ASTM D638	1.33	%	1.33	%	2.16	%	2.16	%
Barcol Hardness, 934-1 gauge, ASTM D2583	45		45		40		40	
Heat Distortion Temperature, ASTM D648	288	°F	142	°C	--		--	
Glass Transition Temperature, CRSTP #92	345	°F	174	°C	--		--	
Specific Gravity @ 73°F (23°C), ASTM D792-00	1.4215		1.4215		--		--	
Water Absorption	0.1101	%	0.1101	%	--		--	

* The gel time and reactivity will vary due to the type and concentration of Free Radical Initiator (catalyst), resin and ambient temperature, and curing conditions. In order to meet your individual needs consult our technical sales representative for assistance.

INTERPLASTIC CORPORATION
2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
651.481.6860 Fax 612.331.4235
www.interplastic.com

Revised: 03/11

MATERIAL SAFETY DATA SHEET

Interplastic Corporation
1225 Willow Lake Blvd
Vadnais Heights, MN 55110-5145

24-Hour Emergency Telephone (800) 424-9300

ATTN: PLANT MGR/SAFETY DIR

Date Printed: 05/19/11
Revision Date: 03/08/11
MSDS File id: MSDSLTY1
Customer No:
Whse No: 005

This MSDS complies with 29 CFR 1910.1200 (The Hazard Communication Standard)

SECTION I - Product Identification

Product Name:	CORVE8295 VINYL ESTER
UN/NA Number:	Not Regulated
General or Generic ID:	Unsaturated Polyester Resin
Hazard Classification:	Slightly Combustible

SECTION II - Hazardous Components

Ingredient	Cas No.	Percent	OSHA-PEL	ACGIH-TLV	NOTE
Unsaturated Polyester Base Resin	See Index	50-65	None-Estb.	None-Est.	
Proprietary Ingredient A	XXXXXXXXXX	05-40	None-Estb.	None-Est	
Proprietary Ingredient B	XXXXXXXXXX	05-40	None-Estb.	None-Est	

SECTION III - Physical Data

Property		Measurement
Initial Boiling Point	For Proprietary Ingredient A	314.00 DEG F @ 4.0 MMHG
	For Proprietary Ingredient B	>250 DEG C
Vapor Pressure	For Proprietary Ingredient A	2.4 MMHG (300 DEG F)
	For Proprietary Ingredient B	not available
Vapor Density	Air = 1	N/DA
	For Proprietary Ingredient B	>1 at 68 DEG F 20 DEG C
Specific Gravity		1.10-1.13 @ 77.00 DEG F (25.00 DEG C)
Evaporation Rate		Slower than Ether
Odor		Ester-like

SECTION IV - Fire and Explosion Data

Flash Point 330 DEG F for Proprietary Ingredient A
Flash Point 261 DEG F for Proprietary Ingredient B

Flammable	(Lowest Value of Proprietary Ingredient A)	Lower - N/DA
	(Upper Value of Proprietary Ingredient A)	Upper - N/DA
	(Lowest Value of Proprietary Ingredient B)	Lower - N/DA
	(Upper Value of Proprietary Ingredient B)	Upper - N/DA

Extinguishing Media: Regular foam or carbon dioxide or dry chemical. Use waterspray/water fog for cooling.

Hazardous Decomposition Products: May form toxic materials:, carbon dioxide and carbon monoxide, various hydrocarbons.

Special Firefighting Procedures: Do not enter fire area without proper protection. See "Decomposition products possible." Fight fire from safe distance/protected location. Heat may build pressure/rupture closed containers, spreading fire, increasing risk of burns/injuries. Do not use solid water stream/may spread fire. Use water spray/fog for cooling. Avoid frothing/steam explosion. Notify authorities if liquid enters sewers/public waters.

Unusual Fire & Explosion Hazards: Heat from fire can generate flammable vapor. When mixed with air and exposed to ignition source, vapors can burn in open or explode if confined. Vapors may be heavier than air. May travel long distances along ground before igniting/flashing back to vapor source. Fine sprays/mists may be combustible at temperatures below normal flash point. Never use welding or cutting torch on or near drum (even empty) because product (even just residue) can ignite explosively.

SECTION V - Health Data

Permissible Exposure Level: Not established for product. See Section II.

Effects of Overexposure: For Proprietary Ingredient A

Eyes - May cause moderate irritation, redness, tearing, blurred vision including swelling and/or a burning sensation.

Skin - May cause delayed skin irritation and blistering.

Breathing - Excessive inhalation of vapors can cause nasal irritation, dizziness, weakness, fatigue, nausea, headache, possible unconsciousness, and even asphyxiation.

Swallowing - Can cause gastrointestinal irritation, nausea, vomiting, diarrhea. Aspiration of material into the lungs can cause chemical pneumonitis.

~ PRODUCT: CORVE8295

First Aid:

If on Skin: Thoroughly wash exposed area with soap and water. Remove contaminated clothing. Flush with lukewarm water for 15 minutes. Seek medical attention if ill effect or irritation develops. Launder contaminated clothing before re-use.

If in Eyes: Flush with large amount of water, lifting upper and lower lids occasionally. Get medical attention.

If Swallowed: Do not induce vomiting. Give 1 part of lukewarm water if victim is completely conscious and alert. Keep person warm, quiet and get medical attention. Aspiration of material into the lungs due to vomiting can cause chemical pneumonitis which can be fatal.

If Breathed: If affected, remove individual to fresh air. If breathing is difficult, administer oxygen. If breathing has stopped, give artificial respiration. Keep person warm, quiet, and get medical attention.

SECTION VI - Reactivity Data

Hazardous Polymerization: Can occur.

Stability: Stable.

Incompatibility: Avoid contact with: strong alkalies, strong mineral acids and oxidizing agents.

Conditions to Avoid: Exposure to excessive heat or open flame; storage in open containers ; prolonged storage (6 months), storage above 38 DEG C (100 DEG F).Contamination with oxidizing agents.

Hazardous Decomposition Products:Carbon Monoxide, Carbon Dioxide, Low Molecular Weight Hydrocarbons, Organic Acids or Acrid fumes of Allylic compounds.

SECTION VII - Spill or Leak Procedures

Steps to be Taken in Case Material is Released or Spilled:

Spill: Evacuate/limit access. Equip responders with proper protection. Stop release. Prevent flow to sewers/public waters. Notify fire/ environmental authorities. Restrict water use for cleanup. Impound/ recover large land spill. Soak up small spill with inert solids. Use suitable disposal containers. On water, material insoluble/may float or sink. Contain.minimize dispersion/collect. Disperse residue to reduce aquatic harm. Report per regulatory requirements.

Waste Disposal Method:

Comply with federal/state/local regulations for solid waste disposal. Recover waste liquids for beneficial recycle/reuse. Incinerate spent dry solids used as spill control absorbents and liquid residues. Avoid Flameouts. Assure emissions comply with applicable regulations.

SECTION VIII - Protective Equipment to be Used

Respiratory Protection: No occupational exposure standards have been developed for this material. Where exposure through inhalation may occur from use, NIOSH/MSHA approved respiratory protection equipment is recommended.
Protective Gloves: Wear resistant gloves such as:, neoprene, nitrile rubber.
Eye Protection: Chemical splash goggles in compliance with OSHA regulations are advised; however, OSHA regulations also permit other type safety glasses (consult your safety equipment supplier). Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.
Hygienic and Work Practices: Use good personal hygiene practices. Wash hands before eating, drinking, smoking, or using toilet facilities. Promptly remove soiled clothing/wash thoroughly before reuse. Shower after work using plenty of soap and water.

SECTION IX - Special Precautions or Other Comments

Containers of this material may be hazardous when emptied. Since emptied containers retain product residues (vapors, liquid, and/or solid), all hazard precautions given in this data sheet must be observed.

Prolonged exposure to Proprietary Ingredient A may damage the lungs and liver.

The information accumulated herein is believed to be accurate but is not warranted to be whether originating with Interplastic or not. Recipients are advised to confirm in advance of need that the information is current, applicable, and suitable to their circumstances.

SECTION X - Supplement

Health Hazards - Sections II and IV

Chronic Health Effects:

Report from a two year gavage study (chronic) conducted with rats showed a significantly increased incidence of mononuclear cell leukemia in female rats, and chronic liver disease in both sexes. The association between the increase is considered to be equivocal (uncertain). In the final report on a similar study with mice, it was concluded that Proprietary Ingredient A is not carcinogenic. However,
hronic
hyperplasia of the stomach was common (toxicology and carcinogenis studies of Proprietary Ingredient A in F344/N rats gavage studies, NTP technical report series no. 284 and carcinogenis bioassay of Proprietary Ingredient A in B6C3F1 mice (gavage study) NTP no. 242.)

SECTION XI - Supplier Notification

This product contains toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 and of 40 CFR 372. Please refer to Section II - Hazardous Components for the specific product and concentration.

BASE RESIN CAS INDEX

The base resins indicated under Section II are identified by one or more of the following CAS numbers:

113060-15-4	28572-30-7	58182-50-6	67859-89-6
135108-89-3	28679-80-3	61224-63-3	49624-93-3
141224-31-9	29011-83-4	62569-28-2	68511-26-2
14807-96-6	29350-58-1	64386-66-9	79-4-1
149717-53-3	29403-69-8	67380-21-6	
155122-62-6	29403-69-8	67386-67-0	
21645-51-2	30110-00-0	67599-39-7	
25037-66-5	30946-90-8	67712-08-7	
25101-03-5	31260-98-7	67845-68-5	
25215-72-9	31472-46-5	67939-08-6	
25464-21-5	32505-78-5	67939-40-6	
25609-89-6	32677-47-7	68002-44-8	
25749-46-6	32762-75-7	68140-84-1	
25749-49-9	36346-15-3	68140-88-5	
25987-82-0	36425-15-7	68171-28-8	
26098-37-3	36425-16-8	68238-98-2	
26123-45-5	37339-47-2	68299-40-1	
26265-08-7	37347-86-7	68492-68-2	
26301-26-8	37999-57-8	68511-26-2	
26588-55-6	42133-45-9	68585-94-4	
26795-76-6	464920-01-2	68647-07-4	
27342-37-6	52453-94-8	72259-64-4	
27837-75-8	54228-09-0	81192-92-9	
27863-48-6	56083-98-8	9003-20-7	
28472-89-1	56083-99-9	9065-68-3	
28516-30-5	57863-48-6	37625-93-7	

INTERPLASTIC CORPORATION
Thermoset Resins Division

1225 Willow Lake Boulevard
Saint Paul, Minnesota 55110-5145
(651) 481-6860 Fax (651) 481-9836

July 29, 2011

To Whom It May Concern:

Interplastic Corporation has assigned commercial resin numbers to the following resins as listed:

DEVELOPMENT NUMBER	COMMERCIAL NUMBER
COR VEX221-464	COR VE8290
COR VEX221-607	COR VE8295

This is a number change only. The formulation has not changed from the development number formulation.

Please call me at 281-687-8617 if you have additional questions or comments on this matter.

Sincerely,

Kaleel Rahaim

Kaleel Rahaim
Business Manager Thermoset Resins Division

CONFIDENTIAL

INTERPLASTIC CORPORATION

VEX221-464 CASTING WITHOUT A THERMOPLASTIC LINER
NSF/ANSI 61-2009 EXTRACTION REDUCTION

DESCRIPTION: INFLUENT **VOLUME: 17 DAY**

COMPOUND	RESULTS	UNITS	REPORTING LIMIT	METHOD	
Bisphenol A	<1.00	µg/L	1.00	EPA 625	
Reactive Diluent #1	<2.00	µg/L	2.00	EPA 625	
Reactive Diluent #2	<2.00	µg/L	2.00	EPA 625	
Styrene	<1.00	µg/L	1.00	EPA 524.2	
pH	8.18	(None)	NA	EPA 150.1	
Temperature	24.1	°C	NA	EPA 150.1	
	pH and Temperature were analyzed on 2/5/10 prior to collection of samples				
	The surface area to volume ratio tested was 42in²/liter, and the ambient				

DESCRIPTION: EFFLUENT 1 **VOLUME: 1 DAY**

COMPOUND	RESULTS	UNITS	REPORTING LIMIT	METHOD	
Bisphenol A	<1.00	µg/L	1.00	EPA 625	
Reactive Diluent #1	15.7	µg/L	4.00	EPA 625	
Reactive Diluent #2	<2.00	µg/L	2.00	EPA 625	
	The testing of the water sample from Day One is not part of the NSF/ANSI 61-2009 test protocol for approval				

Pace Analytical Services, Inc.
723 Kasota Ave. SE
Minneapolis, MN 55414

Phone: 612.656.1100
Fax: 612.656.1181

www.pacelabs.com

LABORATORY ANALYSIS REPORT

DATE:	3/4/2010
CLIENT:	Interplastic Corporation 2015 Northeast Broadway Street Minneapolis, MN 55413
CONTACT:	Jason Schiro

PROJECT:	534
COLLECTED BY:	NDA
PROJECT REC'D:	1/15/2010
PROJECT DESC:	Sample Analysis

Pace Analyticals Product Testing Division received 1 product (s) for the analysis presented in the following report.

All data reported is associated with quality control that met method, EPA, NSF/ANSI or internal laboratory specification. Any exceptions are noted in a footnote or narrative format.

Pace Analytical Services, Inc. appreciates the opportunity to provide you with this product testing service. If you have any questions or comments regarding this report, please feel free to contact us.

Sincerely,

Enclosure

Pace Analytical®

Pace Analytical Services, Inc.
723 Kasota Ave. SE
Minneapolis, MN 55414

Phone: 612.656.1100
Fax: 612.656.1181

www.pacelabs.com

LABORATORY ANALYSIS REPORT PROJECT: 534

NSF/ANSI 61-2009 Reduction

Sample: 005920 **Description: Effluent 1** **Volume: 1 Day**

Compound	Results	Units	Reporting Limit	Method	Date Collected	Date Analyzed
Bisphenol A	<1.00	ug/L	1.00	EPA 625	1/21/2010	3/3/2010
PROPRIETARY INGREDIENT B	15.70	ug/L	4.00	EPA 625	1/21/2010	3/3/2010
PROPRIETARY INGREDIENT A	<2.00	ug/L	2.00	EPA 625	1/21/2010	3/3/2010

Samples were analyzed outside of EPA recomended holding time

Pace Analytical Services, Inc.
723 Kasota Ave. SE
Minneapolis, MN 55414

Phone: 612.656.1100
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www.pacelabs.com

LABORATORY ANALYSIS REPORT PROJECT: 534

SUBCONTRACTED ANALYSIS SUMMARY

Analysis	Method	Laboratory	Location
Bisphenol A	EPA 625	Suburban	Hillside, IL
PROPRIETARY INGREDIENT B	EPA 625	Suburban	Hillside, IL
PROPRIETARY INGREDIENT A	EPA 625	Suburban	Hillside, IL

This report has been reviewed for technical accuracy and completeness. The analyses were performed using EPA or other approved methodologies and the results were reported on an "as received" basis unless otherwise noted. These results relate only to the items tested.

EPA 625 is outside of Pace Analytical's A2LA Accreditation, analysis was subcontracted to Suburban Laboratories in Hillside, IL.

NA = Not Applicable
su - Standard Units
UV - Unit Volume
mg/L = milligrams per Liter
ug/L = micrograms per Liter
GPM = Gallons Per Minute
NTU = Nephelometric Turbidity Unit
(wc) = Water Characteristics

END OF DOCUMENT

Pace Analytical®

Pace Analytical Services, Inc.
723 Kasota Ave. SE
Minneapolis, MN 55414

Phone: 612.656.1100
Fax: 612.656.1181

www.pacelabs.com

LABORATORY ANALYSIS REPORT

DATE: 2/22/2010
CLIENT: Interplastic Corporation
2015 Northeast Broadway Street
Minneapolis,MN 55413

PROJECT: 429
COLLECTED BY: NDA
PROJECT REC'D: 1/15/2010
PROJECT DESC: Pipe Coating

CONTACT: Jason Schiro

Pace Analytical received pre-cut plates of VEX221-464 for extraction outlined in NSF/ANSI 61-2009. The plates were rinsed with cold tap water to remove debris followed by a reagent water rinse.

The plates were conditioned using pH 8 conditioning water for organic compounds for a period of 14 days. The water was changed 10 times during the 14-day conditioning period with a minimum exposure period of 24 hours ± 1 hour. Following the conditioning period, the plates were exposed using pH 8 exposure water. The exposure water was discarded after each of the first two 24 hour exposures and collected after a final 16-hour exposure period.

Pace Analyticals Product Testing Division received 1 product (s) for the analysis presented in the following report.

All data reported is associated with quality control that met method, EPA, NSF/ANSI or internal laboratory specification. Any exceptions are noted in a footnote or narrative format.

Pace Analytical Services, Inc. appreciates the opportunity to provide you with this product testing service. If you have any questions or comments regarding this report, please feel free to contact us.

Sincerely,

Enclosure

Pace Analytical Services, Inc.
723 Kasota Ave. SE
Minneapolis, MN 55414

Phone: 612.656.1100
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LABORATORY ANALYSIS REPORT   PROJECT: 429

NSF/ANSI 61-2009 Extraction Reduction

Sample: 005057   **Description: Influent**   **Volume: 17 Day**

Compound	Results	Units	Reporting Limit	Method	Date Collected	Date Analyzed
Bisphenol A	<1.00	ug/L	1.00	EPA 625	2/6/2010	2/12/2010
PROPIETARY INGREDIENT B	<2.00	ug/L	2.00	EPA 625	2/6/2010	2/12/2010
PROPRIETARY INGREDIENT A	<2.00	ug/L	2.00	EPA 625	2/6/2010	2/12/2010
pH (wc)	8.18	(None)	NA	EPA 150.1	2/6/2010	2/5/2010
Styrene	<1.00	ug/L	1.00	EPA 524.2	2/6/2010	2/8/2010
Temperature (wc)	24.1	°C	NA	EPA 150.1	2/6/2010	2/5/2010

pH and Temperature were analyzed on 2/5/2010 prior to collection of samples.

NSF/ANSI 61-2009 Extraction Reduction

Sample: 005063   **Description: VEX221-464**   **Volume: 17 Day**

Compound	Results	Units	Reporting Limit	Method	Date Collected	Date Analyzed
Bisphenol A	<1.00	ug/L	1.00	EPA 625	2/6/2010	2/12/2010
PROPRIETARY INGREDIENT B	<2.00	ug/L	2.00	EPA 625	2/6/2010	2/12/2010
PROPRIETARY INGREDIENT A	<2.00	ug/L	2.00	EPA 625	2/6/2010	2/12/2010
pH (wc)	8.18	(None)	NA	EPA 150.1	2/6/2010	2/5/2010
Styrene	<1.00	ug/L	1.00	EPA 524.2	2/6/2010	2/8/2010
Temperature (wc)	24.1	°C	NA	EPA 150.1	2/6/2010	2/5/2010

The surface area to volume ratio tested was 42in2/ Liter, and the ambient temperature was 22.5º C.

Pace Analytical Services, Inc.
723 Kasota Ave. SE
Minneapolis, MN 55414

Phone: 612.656.1100
Fax: 612.656.1181

www.pacelabs.com

LABORATORY ANALYSIS REPORT PROJECT: 429

SUBCONTRACTED ANALYSIS SUMMARY

Analysis	Method	Laboratory	Location
Bisphenol A	EPA 625	Suburban	Hillside,IL
PROPRIETARY INGREDIENT B	EPA 625	Suburban	Hillside,IL
PROPRIETARY INGREDIENT A	EPA 625	Suburban	Hillside,IL

This report has been reviewed for technical accuracy and completeness. The analyses were performed using EPA or other approved methodologies and the results were reported on an "as received" basis unless otherwise noted. These results relate only to the items tested.

EPA 625 is outside of Pace Analytical's A2LA accreditation, analysis was subcontracted to Suburban Laboratories in Hillside, IL.

NA = Not Applicable
su - Standard Units
UV - Unit Volume
mg/L = milligrams per Liter
ug/L = micrograms per Liter
GPM = Gallons Per Minute
NTU = Nephelometric Turbidity Unit
(wc) = Water Characteristics

END OF DOCUMENT

ARKEMA

MATERIAL SAFETY DATA SHEET

Printed: 6/30/09

PROPRIETARY INGREDIENT A

PRODUCT IDENTIFICATION AND USE

MANUFACTURER:	ARKEMA CANADA INC. 700 THIRD LINE OAKVILLE, ONTARIO L6J 5A3
EMERGENCY PHONE NUMBER:	(905) 827-9841 (ARKEMA) (613) 996-6666 (CANUTEC)
PRODUCT IDENTIFIER:	
PRODUCT CODE:	AC54125
PRODUCT USE:	ACRYLIC MONOMER
WHMIS CLASSIFICATION:	D2B – TOXIC MATERIAL CAUSING OTHER EFFECTS F - DANGEROUSLY REACTIVE MATERIAL.

HAZARDOUS INGREDIENTS

	% W/W	CAS #	TLV
	99		NE

LD50: 3100 - 6700 MG/KG (ORAL-RAT)
LD50: >3000 MG/KG (DERMAL-RABBIT)

ADDITIONAL INGREDIENT INFORMATION (WHMIS NOT CONTROLLED):
NA

PHYSICAL DATA

PHYSICAL STATE:	LIQUID
ODOUR AND APPEARANCE:	COLOURLESS LIQUID, CAMPHOR ODOUR.
ODOUR THRESHOLD:	NE
SPECIFIC GRAVITY/DENSITY (G/ML):	0.984
VAPOUR PRESSURE:	0.1 MBAR @ 20°C
VAPOUR DENSITY (AIR=1):	NE
VOLATILITY/VOL(%):	NE
SOLUBILITY IN H20:	< 10 PPM @ 20°C
EVAPORATION RATE:	NE
BOILING POINT:	> 250°C
FREEZING POINT:	-60°C
PH:	NA
LOG KOW:	4

SHIPPING INFORMATION

THIS PRODUCT IS NOT TDG REGULATED.

FIRE AND EXPLOSION HAZARD

FLAMMABILITY:	NOT FLAMMABLE.
CONDITIONS:	WILL BURN AT ELEVATED TEMPERATURES.
MEANS OF EXTINCTION:	WATER SPRAY, CARBON DIOXIDE, FOAM OR DRY CHEMICAL. DO NOT USE SOLID STREAM OF WATER.
FLASHPOINT:	119°C (CLOSED CUP)
UPPER EXPLOSION LIMIT (% V):	NE
LOWER EXPLOSION LIMIT (%V):	NE
AUTO-IGNITION TEMPERATURE:	406°C
HAZARDOUS COMBUSTION PRODUCTS:	OXIDES OF CARBON.

NA - NOT APPLICABLE NE - NOT ESTABLISHED

ARKEMA

MATERIAL SAFETY DATA SHEET

Printed: 6/30/09

PRORIETARY INGEDIENT A

EXPLOSION DATA:	LARGE AMOUNTS OF HEAT CAN BE GENERATED WHEN THE MONOMER IS EXPOSED TO A FIRE. COOL CONTAINERS / TANKS WITH WATER SPRAY.
SENSITIVITY TO IMPACT:	NO
SENSITIVITY TO STATIC DISCHARGE:	NO

REACTIVITY

CHEMICAL STABILITY:	UNSTABLE
INCOMPATIBLE MATERIALS:	EXOTHERMIC POLYMERIZATION MAY BE INITIATED BY FREE RADICALS, PEROXIDES.
CONDITIONS OF REACTIVITY:	THE UNCONTROLLED POLYMERIZATION OF THE PRODUCT MAY PRODUCE AN EXPLOSION IN UNVENTED CLOSED CONTAINERS. AVOID HEAT, CONTAMINATION, OXYGEN-FREE ATMOSPHERE, INHIBITOR DEPLETION OR ULTRAVIOLET LIGHT TO PREVENT HAZARDOUS POLYMERIZATION.
HAZARDOUS DECOMPOSITION PRODUCTS:	NE

HEALTH HAZARD INFORMATION

ROUTE OF ENTRY	
SKIN CONTACT:	MAY CAUSE IRRITATION.
SKIN ABSORPTION:	NE
EYE:	MAY CAUSE IRRITATION.
INGESTION:	NE
INHALATION:	MAY CAUSE IRRITATION.
ACUTE OVER EXPOSURE EFFECTS:	NE
CHRONIC OVER EXPOSURE EFFECTS:	NE
SENSITIZATION:	DOES NOT MEET WHMIS CRITERIA.
CARCINOGENICITY:	DOES NOT MEET WHMIS CRITERIA.
TERATOGENICITY:	DOES NOT MEET WHMIS CRITERIA.
MUTAGENICITY:	DOES NOT MEET WHMIS CRITERIA.
REPRODUCTIVE TOXICITY:	DOES NOT MEET WHMIS CRITERIA.

PREVENTIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT:	WEAR SAFETY GLASSES AND USE IMPERVIOUS GLOVES. WHERE AIRBORNE EXPOSURE IS LIKELY, WEAR A NIOSH APPROVED RESPIRATOR EQUIPPED WITH AN ORGANIC VAPOUR CARTRIDGE.
SPECIFIC ENGINEERING CONTROLS:	LOCAL EXHAUST IS RECOMMENDED.
LEAK AND SPILL PROCEDURES:	SOAK UP WITH AN ABSORBENT MATERIAL AND PLACE IN A CLOSED CONTAINER. ADD INHIBITOR AND DISPOSE OF IMMEDIATELY.
WASTE DISPOSAL:	HAZARDOUS WASTE. DO NOT ALLOW PRODUCT TO ENTER THE ENVIRONMENT. CONSULT FEDERAL OR LOCAL AUTHORITIES FOR APPROVED DISPOSAL METHODS.
HANDLING PROCEDURES AND EQUIPMENT:	WASH BEFORE EATING, DRINKING, USING TOBACCO PRODUCTS OR REST ROOMS.
STORAGE REQUIREMENTS:	KEEP IN A CLOSED, LABELED CONTAINER IN A VENTILATED AREA. STORAGE TEMPERATURE SHOULD BE BELOW 30°C (85°F) THE TYPICAL SHELF-LIFE OF THIS PRODUCT IS 12 MONTHS. AVOID STORAGE UNDER AN

ARKEMA

MATERIAL SAFETY DATA SHEET

Printed: 6/30/09

PROPRIETARY INGREDIENT A

OXYGEN-FREE ATMOSPHERE. AN AIR SPACE IS REQUIRED ABOVE THE LIQUID IN ALL CONTAINERS. THE STABILITY OF THE PRODUCT SHOULD BE CHECKED PERIODICALLY (TYPICALLY EVERY 90 DAYS FOR BULK CONTAINERS).

FIRST AID MEASURES

EYE	FLUSH EYES WITH LARGE AMOUNT OF WATER FOR 15 MINUTES WHILE HOLDING EYELIDS OPEN. SEEK MEDICAL ATTENTION IF IRRITATION OCCURS OR PERSISTS.
SKIN	WASH SKIN WITH WATER AND SOAP. SEEK MEDICAL ATTENTION IF IRRITATION OCCURS OR PERSISTS.
INGESTION	DO NOT GIVE LIQUIDS IF PERSON IS UNCONSCIOUS OR VERY DROWSY. DO NOT INDUCE VOMITING. SEEK IMMEDIATE MEDICAL ATTENTION.
INHALATION	REMOVE PERSON TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, APPLY ARTIFICIAL RESPIRATION AND ADMINISTER OXYGEN IF NECESSARY. SEEK MEDICAL ATTENTION.

PREPARATION DATE

PREPARED BY:	TECHNICAL DEPARTMENT.
PHONE NUMBER OF PREPARER:	905-827-9841
DATE PREPARED (MM/DD/YY):	10/26/98
DATE REVISED (MM/DD/YY):	06/30/09

MINIMUM CONTACT WITH THIS AND ALL CHEMICALS IS RECOMMENDED AS A GOOD GENERAL POLICY TO FOLLOW.

THE INFORMATION PRESENTED HEREIN HAS BEEN COMPILED FROM SOURCES CONSIDERED TO BE DEPENDABLE AND IS ACCURATE TO THE BEST OF OUR KNOWLEDGE. HOWEVER, SINCE DATA, SAFETY STANDARDS, AND GOVERNMENT REGULATIONS ARE SUBJECT TO CHANGE AND THE CONDITIONS OF HANDLING AND USE, OR MISUSE ARE BEYOND OUR CONTROL, ARKEMA CANADA MAKES NO WARRANTY EXPRESSED OR IMPLIED, WITH RESPECT TO COMPLETENESS OR CONTINUING ACCURACY OF THE INFORMATION CONTAINED HEREIN AND DISCLAIMS ALL LIABILITY FOR RELIANCE THEREON. USER SHOULD SATISFY HIMSELF THAT HE HAS ALL CURRENT DATA RELEVANT TO HIS PARTICULAR USE.

ScienceLab.com
Chemicals & Laboratory Equipment

Health	2
Fire	1
Reactivity	0
Personal Protection	G

Material Safety Data Sheet

PROPRIETARY INGREDIENT B

Section 1: Chemical Product and Company Identification

Product Name: Diallyl Phthalate

Catalog Codes: SLD2632

CAS#:

RTECS: Not available.

TSCA: TSCA 8(b) inventory:

CI#: Not available.

Synonym:

Chemical Name:

Chemical Formula:

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
		100

Toxicological Data on Ingredients: ORAL (LD50): Acute: 656 mg/kg [Rat]. 1700 mg/kg [Rabbit]. DERMAL (LD50): Acute: 3300 mg/kg [Rabbit]. VAPOR (LC50): Acute: 5200 mg/m 1 hours [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of skin contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator), of eye contact (irritant).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available.
MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast.
TERATOGENIC EFFECTS: Not available.
DEVELOPMENTAL TOXICITY: Not available.
Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. WARM water MUST be used. Get medical attention if irritation occurs.

Skin Contact:
In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: CLOSED CUP: 166°C (330.8°F).

Flammable Limits: Not available.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances:
Slightly flammable to flammable in presence of open flames and sparks, of heat.
Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available.
Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder.
LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill: Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill:
Absorb with an inert material and put the spilled material in an appropriate waste disposal. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Avoid contact with skin. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Safety glasses. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid. (Oily liquid.)

Odor: mild

Taste: Not available.

Molecular Weight: 246.26 g/mole

Color: almost colorless

pH (1% soln/water): Not available.

Boiling Point: 158°C (316.4°F)

Melting Point: -70°C (-94°F)

Critical Temperature: Not available.

Specific Gravity: 1.12 (Water = 1)

Vapor Pressure: Not available.

Vapor Density: 8.3(Air = 1)

Acute Potential Health Effects:
Skin: Causes skin irritation. Irritation may be moderate.
Eyes: Causes eye irritation. Irritation may be mild. Lachrymator.
Inhalation: May cause respiratory tract and mucous membrane irritation. It may affect respiration (dyspnea), and gastrointestinal tract.
Ingestion: May cause digestive tract disturbances. May be harmful if swallowed. It may affect behavior, respiration, and liver.
Chronic Potential Health Effects:
Ingestion: Prolonged or repeated ingestion may affect the liver, respiration and gastrointestinal tract.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: Not available.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations:
Pennsylvania RTK:
Massachusetts RTK:
TSCA 8(b) inventory:
TSCA 8(d) H and S data reporting:

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).
EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R20/22- Harmful by inhalation and if swallowed.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: The product is more soluble in oil; log(oil/water) = 3.2

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility:
Very slightly soluble in cold water.
Soluble in most organic liquids.
Soluble in gasoline, mineral oil, glycerin, certain amines.
Solubility in water: 182 mg/liter water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, incompatible materials. It will polymerize with heat and catalyst.

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Not available.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Yes.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Eye contact.

Toxicity to Animals:
WARNING: THE LC50 VALUES HEREUNDER ARE ESTIMATED ON THE BASIS OF A 4-HOUR EXPOSURE.
Acute oral toxicity (LD50): 656 mg/kg [Rat].
Acute dermal toxicity (LD50): 3300 mg/kg [Rabbit].
Acute toxicity of the vapor (LC50): 5200 mg/m
1 hours [Rat].
3

Chronic Effects on Humans: MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast.

Other Toxic Effects on Humans:
Hazardous in case of skin contact (irritant), of ingestion, of inhalation.
Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May affect genetic material.
May cause cancer based on animal data.

Special Remarks on other Toxic Effects on Humans:

R38- Irritating to skin.
R40- Possible risks of irreversible effects.
R50/53- Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
S2- Keep out of the reach of children.
S24/25- Avoid contact with skin and eyes.
S36/37- Wear suitable protective clothing and gloves.
S46- If swallowed, seek medical advice immediately and show this container or label.
S60- This material and its container must be disposed of as hazardous waste.
S61- Avoid release to the environment. Refer to special instructions/Safety data sheets.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: g

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves.
Lab coat.
Vapor respirator. Be sure to use an approved/certified respirator or equivalent.
Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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Last Updated: 11/06/2008 12:00 PM

third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if ScienceLab.com has been advised of the possibility of such damages.

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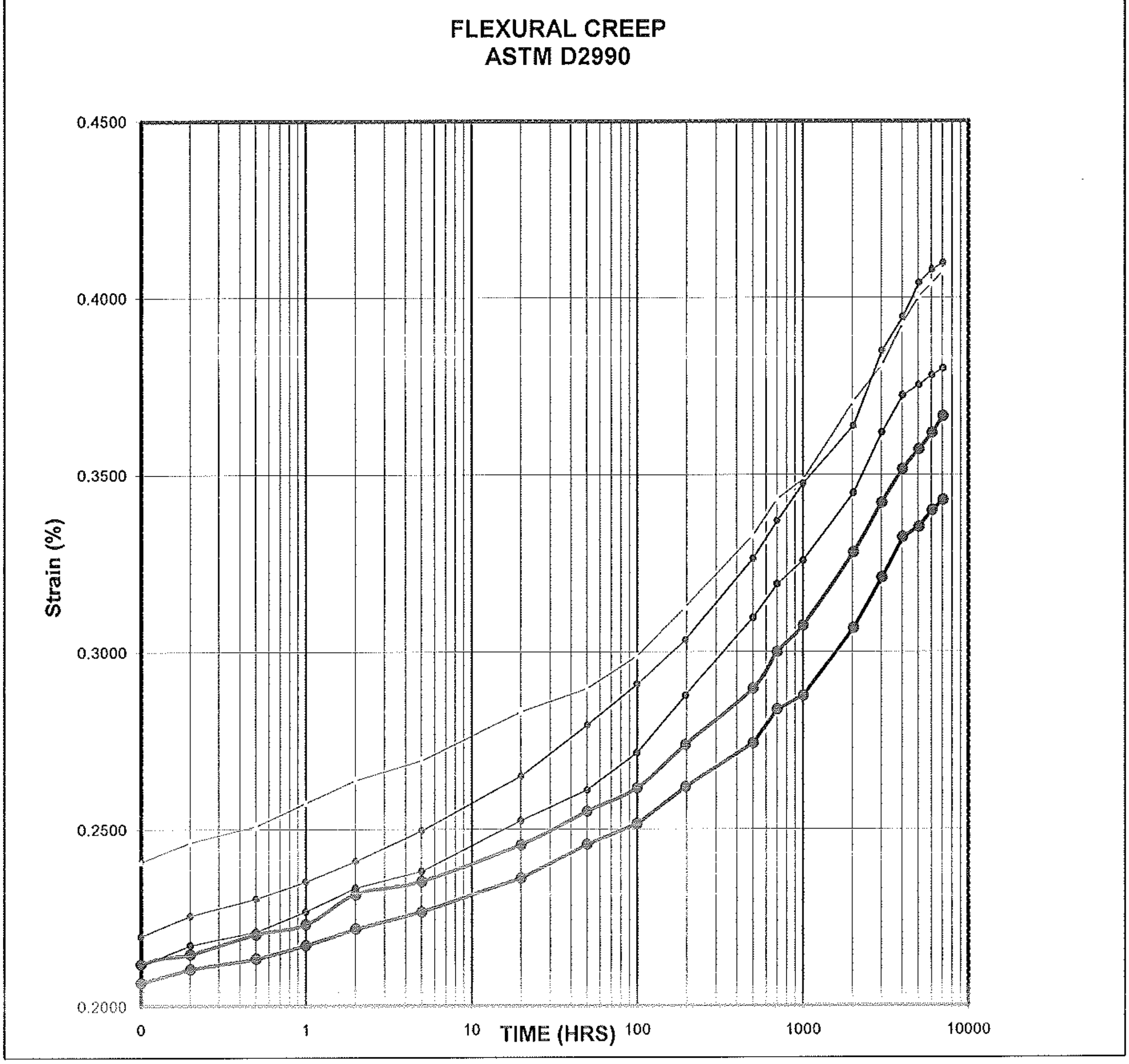

Project Name:

Project No.:

Sample ID No.: *CORVE 8295*

Tested Temperature: 71°*F*

Lab Humidity: *50%*

Specimen Gage Length: 4.0"

Stress: 1300 PSI

HTS Report#: *ICF128.001A*

HTS Report# ICF128.001A

Sample ID: CORVE 8295

Spec# 1		Spec# 2		Spec# 3	
Thickness: 0.254"	Width: 0.519"	Thickness: 0.250"	Width: 0.518"	Thickness: 0.246"	Width: 0.518"
TIME (HRS)	**Strain (%)**	**TIME (HRS)**	**Strain (%)**	**TIME (HRS)**	**Strain (%)**
0.02	0.1981	0.02	0.1969	0.02	0.2306
0.10	0.2067	0.10	0.2119	0.10	0.2408
0.20	0.2105	0.20	0.2147	0.20	0.2463
0.50	0.2134	0.50	0.2203	0.50	0.2509
1	0.2172	1	0.2231	1	0.2574
2	0.2219	2	0.2316	2	0.2638
5	0.2267	5	0.2353	5	0.2694
20	0.2362	20	0.2456	20	0.2832
50	0.2457	50	0.2550	50	0.2897
100	0.2515	100	0.2616	100	0.2989
196	0.2619	196	0.2738	196	0.3127
500	0.2743	500	0.2897	500	0.333
700	0.2838	700	0.3000	700	0.3432
1004	0.2877	1004	0.3075	1004	0.3487
2024	0.3067	2024	0.3281	2024	0.3708
3019	0.3210	3019	0.3422	3019	0.3810
4028	0.3324	4028	0.3516	4028	0.3930
5037	0.3353	5037	0.3572	5037	0.4004
6044	0.3400	6044	0.3619	6044	0.4041
7052	0.3429	7052	0.3666	7052	0.4077

HTS Report ICF128.001A

Sample ID: CORVE 8295

Spec# 4		Spec# 5	
Thickness: 0.256"	Width: 0.517"	Thickness: 0.254"	Width: 0.505"
TIME (HRS)	**Strain (%)**	**TIME (HRS)**	**Strain (%)**
0.02	0.2122	0.02	0.2048
0.10	0.2198	0.10	0.2115
0.20	0.2256	0.20	0.2172
0.50	0.2304	0.50	0.2210
1	0.2352	1	0.2267
2	0.2410	2	0.2334
5	0.2496	5	0.2381
20	0.2650	20	0.2524
50	0.2794	50	0.2610
100	0.2909	100	0.2715
196	0.3034	196	0.2877
500	0.3264	500	0.3096
700	0.3370	700	0.3191
1004	0.3475	1004	0.3258
2024	0.3638	2024	0.3448
3019	0.3850	3019	0.3619
4028	0.3946	4028	0.3724
5037	0.4042	5037	0.3753
6044	0.4080	6044	0.3781
7052	0.4099	7052	0.3800

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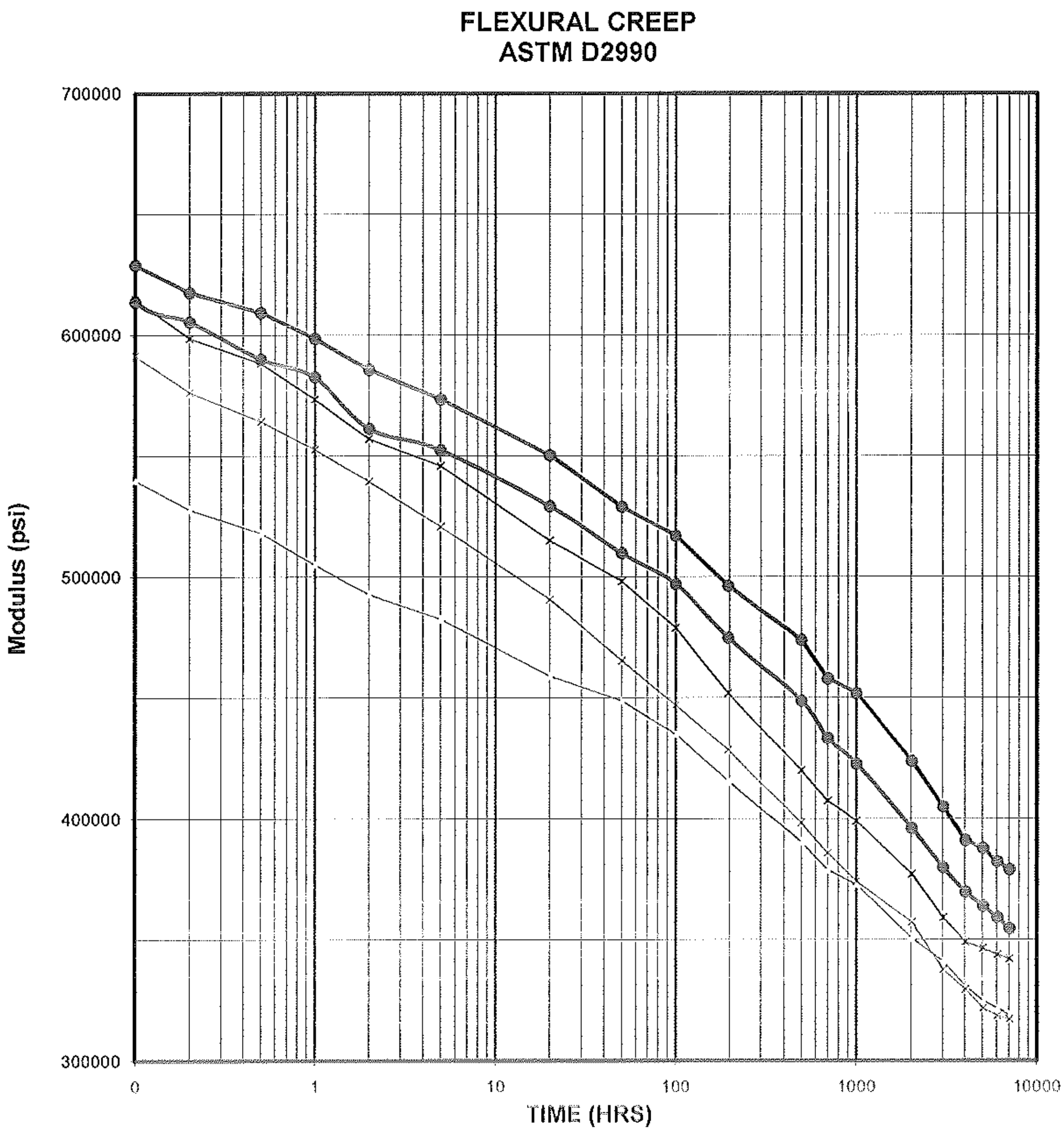


Project Name:

Project No.:

Sample ID No.: *CORVE 8295*

Tested Temperature: 71°*F*

Lab Humidity: *50%*

Specimen Gage Length: 4.0"

Stress: 1300 PSI

HTS Report#: *ICF128.001A*

HTS Report# ICF128.001A

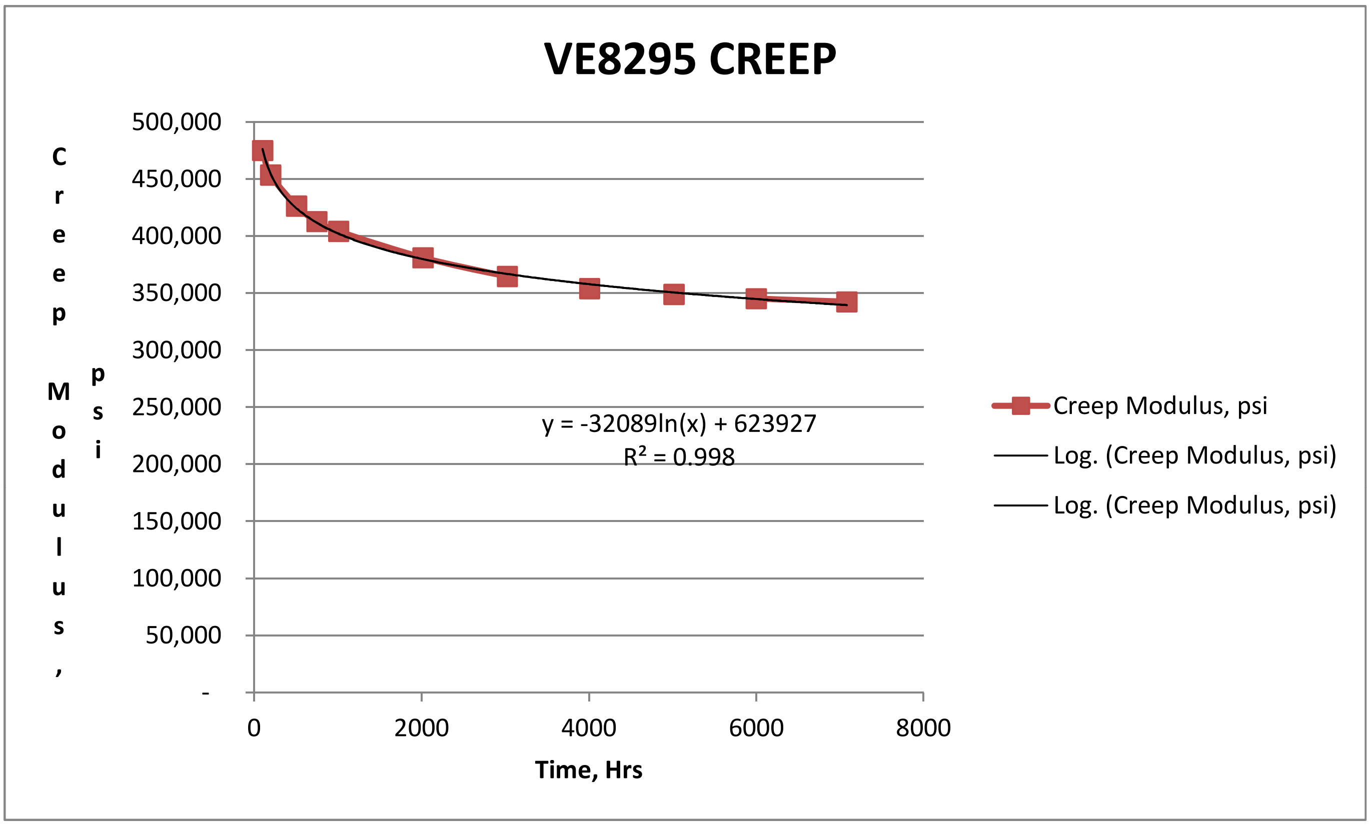
Sample ID: CORVE 8295

Spec# 1		Spec# 2		Spec# 3	
Thickness: 0.254"	Width: 0.519"	Thickness: 0.250"	Width: 0.518"	Thickness: 0.246"	Width: 0.518"
TIME (HRS)	**Modulus (psi)**	**TIME (HRS)**	**Modulus (psi)**	**TIME (HRS)**	**Modulus (psi**
0.02	656168	0.02	660317	0.02	563686
0.10	628954	0.10	613569	0.10	539929
0.20	617570	0.20	605531	0.20	527796
0.50	609299	0.50	590071	0.50	518093
1	598609	1	582633	1	505095
2	585764	2	561404	2	492732
5	573458	5	552457	5	482608
20	550334	20	529262	20	459027
50	529004	50	509804	50	448794
100	516981	100	497013	100	434943
196	496302	196	474886	196	415697
500	473899	500	448759	500	390364
700	457996	700	433333	700	378821
1004	451930	1004	422764	1004	372808
2024	423860	2024	396190	2024	350551
3019	404994	3019	379909	3019	341214
4028	391069	4028	369778	4028	330801
5037	387736	5037	363955	5037	324704
6044	382305	6044	359240	6044	321738
7052	379119	7052	354646	7052	318827

HTS Report ICF128.001A

Sample ID: CORVE 8295

Spec# 4		Spec# 5	
Thickness: 0.256"	Width: 0.517"	Thickness: 0.254"	Width: 0.505"
TIME (HRS)	**Modulus (psi)**	**TIME (HRS)**	**Modulus (psi)**
0.02	612745	0.02	634804
0.10	591339	0.10	614788
0.20	576241	0.20	598609
0.50	564236	0.50	588289
1	552721	1	573458
2	539509	2	557073
5	520833	5	545932
20	490640	20	515030
50	465349	50	498113
100	446920	100	478888
196	428534	196	451930
500	398284	500	419948
700	385802	700	407412
1004	374079	1004	399073
2024	357300	2024	377025
3019	337697	3019	359166
4028	329481	4028	349061
5037	321655	5037	346403
6044	318627	6044	343786
7052	317135	7052	342063



VE8295 CREEP
C r e e p M o d u l u s , p s i
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
-
0
2000
4000
6000
8000
Time, Hrs
y = -32089ln(x) + 623927
R² = 0.998
Creep Modulus, psi
Log. (Creep Modulus, psi)
Log. (Creep Modulus, psi)

Creep at 50 Years	207,100	
Initial Creep	474,949	
Creep Retention Factor:		44%

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HTS Pipe Consultants

November 18, 2010

Interplastic Corporation
Thermoset Resins Division
2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-4235

Attn: Mr. Jason Schiro, Senior Chemist
Corrosion and Specialty Resins

Re: Chemical Resistance Testing of Cured in-Place Pipe (CIPP) Samples VEX221-607-One Year Test Results

Dear Mr. Schiro:

Please find enclosed one year chemical resistance test results for samples of Cured-in-Place Pipe received in our laboratory on October 15, 2009. Per your instructions the samples were constructed with VEX221-607 and all test results/reports are identified as such.

All of the test coupons were prepared and post-cured by the Research and Development Laboratory of Interplastic Corporation's Thermoset Resins Division. Specimens were prepared using VEX221-607, batch number 221-654. The resin was initiated with 0.75% and 0.38% by weight of Akzo Nobel's Perkadox 16 and Trigonox C, respectively. The initiated resin was impregnated into the felt and clamped between metal plates with precision spacers. The panels were gelled at 150° F (66°C) and held at that temperature for four hours. The panels were then post-cured at 180°F (82°C) for sixteen additional hours. The test coupons to be tested for corrosion and flexural creep testing were cut and labeled from the cured panels. Each coupon was edge-coated with the same resin used to construct the coupon, and post-cured an additional 4 hours at 150°F (66°C).

Corrosion Testing

The corrosion testing program was conducted in accordance with the following:

- ASTM F1216, "Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin –Impregnated Tube".

- ASTM F1743, "Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)".
- ASTM D5813, "Standard Specification for Cured-in-Place Thermosetting Resin Sewer Pipe".
- ASTM D2122, "Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings".
- ASTM D790, "Test Method for Flexural Properties of Unreinforced and Reinforced Plastics".

The initial weight, hardness (ASTM D2583) and thickness (ASTM D2122) of each coupon sample was recorded prior to immersion. One (1) coupon sample was utilized as a control base sample.

The coupon samples were immersed in 10 different chemical reagents. Eight of the reagents are as specified in ASTM F1216, section X2, Table X2.1. The other two reagents (Nitric Acid 1% and Sulfuric Acid 5%) are as specified in ASTM F1743, section 8, table 2. The coupon samples were exposed to the reagents for a period of 1 year. At the end of 1 year the coupon samples were removed from the reagent containers, rinsed, dried, weighed and tested for thickness and hardness.

The coupon samples were then tested for flexural strength and flexural modulus of elasticity. A summary of all test data and percent change in each property is included in the attached summary of test data. ASTM F1216, Section X2.2.1 states that the test specimens should lose no more than 20% of their initial flexural strength and flexural modulus during the exposure time. As indicated by these test results, all of these samples comply with that specification requirement.

Should you have any questions or comments regarding the corrosion testing or this report, please do not hesitate to call us. Thank you very much.

Sincerely,
HTS, Inc. Consultants

Khamla Phouangsavanh
Chief Chemist

Larry L. McMichael
CEO/Principal
F/letters/2010/InterplasticCorporation/VEX221-607

SUMMARY OF TEST DATA
RESISTANCE OF CIPP TO CHEMICAL REAGENTS

SAMPLE ID: VEX221-607 Duration: 1 year Date Tested: 11/4/2010

Chemical Reagent (Concentration)	Mechanical Property	Test Method ASTM D	Unit	Control Sample	30 Days	
					Value	% Change
Tap water (100%)	Observation	543		N/A	No Change	pH 7.6
	Weight	543	g	150.72	152.15	0.95
	Hardness	2583		89.0	89.0	0.00
	Thickness	2122	in.	0.290	0.290	0.00
			mm.	7.4	7.4	0.00
	Max. Flexural	790	psi	9033.2	7790.2	-13.76
	Modulus	790	psi	672616	632122	-6.02
Nitric Acid (5%)	Observation	543		N/A	Light Yellow	pH 0.1
	Weight	543	g	140.39	141.80	1.00
	Hardness	2583		90.0	90.0	0.00
	Thickness	2122	in.	0.271	0.271	0.00
			mm.	6.9	6.9	0.00
	Max. Flexural	790	psi	9033.2	8652.0	-4.22
	Modulus	790	psi	672616	609827	-9.34
Phosphoric Acid (10%)	Observation	543		N/A	No Change	pH 0.6
	Weight	543	g	139.89	141.10	0.86
	Hardness	2583		89.0	89.0	0.00
	Thickness	2122	in.	0.270	0.270	0.00
			mm.	6.9	6.9	0.00
	Max. Flexural	790	psi	9033.2	8584.1	-4.97
	Modulus	790	psi	672616	634145	-5.72
Sulfuric Acid (10%)	Observation	543		N/A	No Change	pH 0.1
	Weight	543	g	130.15	131.18	0.79
	Hardness	2583		89.0	89.0	0.00
	Thickness	2122	in.	0.252	0.252	0.00
			mm.	6.4	6.4	0.00
	Max. Flexural	790	psi	9033.2	8577.5	-5.04
	Modulus	790	psi	672616	628500	-6.56

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SUMMARY OF TEST DATA
RESISTANCE OF CIPP TO CHEMICAL REAGENTS

SAMPLE ID: VEX221-607 Duration: 1 year Date Tested: 11/4/2010

Chemical Reagent (Concentration)	Mechanical Property	Test Method ASTM D	Unit	Control Sample	30 Days	
					Value	% Change
Gasoline (100%)	Observation	543		N/A	Light Brown	pH-NA
	Weight	543	g	128.83	129.38	0.43
	Hardness	2583		90.2	90.2	0.00
	Thickness	2122	in.	0.255	0.255	0.00
			mm.	6.5	6.5	0.00
	Max. Flexural	790	psi	9033.2	8973.5	-0.66
	Modulus	790	psi	672616	643067	-4.39
Vegetable Oil (100%)	Observation	543		N/A	No Change	pH-NA
	Weight	543	g	136.50	136.82	0.23
	Hardness	2583		90.0	90.0	0.00
	Thickness	2122	in.	0.269	0.269	0.00
			mm.	6.8	6.8	0.00
	Max. Flexural	790	psi	9033.2	8595.7	-4.84
	Modulus	790	psi	672616	713086	6.02
Detergent (0.1%)	Observation	543		N/A	No Change	pH 6.7
	Weight	543	g	136.06	137.40	0.98
	Hardness	2583		89.2	89.2	0.00
	Thickness	2122	in.	0.266	0.266	0.00
			mm.	6.8	6.8	0.00
	Max. Flexural	790	psi	9033.2	8528.7	-5.58
	Modulus	790	psi	672616	671181	-0.21
Soap (0.1%)	Observation	543		N/A	No Change	pH 7.0
	Weight	543	g	134.57	135.91	1.00
	Hardness	2583		90.4	90.4	0.00
	Thickness	2122	in.	0.259	0.259	0.00
			mm.	6.6	6.6	0.00
	Max. Flexural	790	psi	9033.2	8408.8	-6.91
	Modulus	790	psi	672616	671299	-0.20

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SUMMARY OF TEST DATA
RESISTANCE OF CIPP TO CHEMICAL REAGENTS

SAMPLE ID: VEX221-607 Duration: 1 Year Date Tested: 11/4/2010

Chemical Reagent (Concentration)	Mechanical Property	Test Method ASTM D	Unit	Control Sample	30 Days	
					Value	% Change
Nitric Acid (1%)	Observation	543		N/A	No Change	pH 0.7
	Weight	543	g	134.17	135.47	0.97
	Hardness	2583		89.4	89.4	0.00
	Thickness	2122	In.	0.261	0.261	0.00
			mm.	6.6	6.6	0.00
	Max. Flexural	790	psi	9033.2	8780.6	-2.80
	Modulus	790	psi	672616	663744	-1.32
Sulfuric Acid (5%)	Observation	543		N/A	No Change	pH 0.1
	Weight	543	g	132.60	133.81	0.91
	Hardness	2583		88.8	88.8	0.00
	Thickness	2122	in.	0.256	0.256	0.00
			mm.	6.5	6.5	0.00
	Max. Flexural	790	psi	9033.2	8672.8	-3.99
	Modulus	790	psi	672616	649360	-3.46

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FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN = 4".

Flexural 3 point bend

Instron Corporation
Series IX Automated Materials Testing System 6.05
Test Date: 04 Nov 2010

Operator name: K. PHOUANGSAVANH

Sample Identification: 9F53-3Y1
Interface Type: 42/43/4400 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1100

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.55300	.57000	.56700	.55400	.51300
Depth (in)	.26900	.28300	.29700	.30400	.30800
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN TAP WATER (100%) FOR 1 YEAR

Specimen Number	Displcment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.4845	.0489	56.2	8420.7	637660
2	.4709	.0500	64.4	8461.6	638230
3	.3289	.0366	62.5	7494.2	615172
4	.2574	.0293	62.8	7361.9	637157
5	.2232	.0258	58.5	7212.5	632392
Mean:	.3530	.0381	60.9	7790.2	632122.
Standard Deviation:	.1201	.0110	3.4	602.7	9756.
Minimum:	.2232	.0258	56.2	7212.5	615172.
Maximum:	.4845	.0500	64.4	8461.6	638230.

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Fax 713-692-8502
Toll Free 1-800-692-TEST

FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN - 4"

Flexural 3 point bend

Instron Corporation
Series IX Automated Materials Testing System 6.0

Operator name: E. CARRILLO

Test Date: 04 Nov 2010

Sample Identification: 9F53Y310
Interface Type: 42/43/4400 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1100

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.57700	.57700	.57200	.57200	.57800
Depth (in)	.24300	.25400	.26000	.26700	.27000
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN SULFURIC ACID (5%) FOR 1 YEAR

Specimen Number	Displacment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.5270	.0480	48.1	8472.2	633876
2	.4452	.0424	51.4	8278.1	633180
3	.4859	.0474	57.4	8902.1	662762
4	.5016	.0502	59.8	8800.5	656920
5	.4714	.0477	62.6	8911.1	660061
Mean:	.4862	.0472	55.8	8672.8	649360.
Standard Deviation:	.0308	.0029	6.0	283.6	14602.
Minimum:	.4452	.0424	48.1	8278.1	633180.
Maximum:	.5270	.0502	62.6	8911.1	662762.

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HTS Pipe Consultants

FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN = 4"

Flexural 3 point bend

Instron Corporation
Series IX Automated Materials Testing System 6.05

Operator name: K. PHOUANGSAVANH

Test Date: 04 Nov 2010

Sample Identification: 9F53-3Y9

Sample Type: ASTM

Interface Type: 42/43/4400 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000

Crosshead Speed (in/min): .1100

Humidity (%): 50

Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.56800	.57800	.57300	.57600	.57700
Depth (in)	.24300	.25500	.26500	.27200	.27300
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN NITRIC ACID(1%) FOR 1 YEAR

Specimen Number	Displcment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.4868	.0444	50.5	9034.0	625971
2	.5300	.0507	54.8	8746.7	671646
3	.4590	.0456	60.2	8970.4	681096
4	.4609	.0470	62.8	8836.4	664867
5	.3754	.0384	59.6	8315.7	675140
Mean:	.4624	.0452	57.6	8780.6	663744.
Standard Deviation:	.0564	.0045	4.9	283.1	21917.
Minimum:	.3754	.0384	50.5	8315.7	625971.
Maximum:	.5300	.0507	62.8	9034.0	681096.

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FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN = 4"

Flexural 3 point bend

Operator name: E. CARRILLO

Instron Corporation
Series IX Automated Materials Testing System 6.05
Test Date: 04 Nov 2010

Sample Identification: 9P53-3Y8
Interface Type: 42/43/4400 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1100

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.57700	.57800	.57500	.57800	.57700
Depth (in)	.24500	.25600	.26500	.27200	.27500
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN SOAP (0.1%) FOR 1 YEAR

Specimen Number	Displcment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.4939	.0454	50.7	8776.2	658366
2	.4071	.0391	54.1	8567.6	676112
3	.4002	.0398	55.2	8197.8	681153
4	.3563	.0363	58.5	8208.1	678725
5	.3503	.0361	60.3	8294.1	662137
Mean:	.4016	.0393	55.7	8408.8	671299.
Standard Deviation:	.0575	.0037	3.8	254.1	10327.
Minimum:	.3503	.0361	50.7	8197.8	658366.
Maximum:	.4939	.0454	60.3	8776.2	681153.

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FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN = 4"

Flexural 3 point bend

Operator name: E. CARRILLO

Instron Corporation
Series IX Automated Materials Testing System 6.05
Test Date: 04 Nov 2010

Sample Identification: 9F53-3Y7
Interface Type: 42/43/4400 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1100

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.58000	.57500	.58100	.58000	.58000
Depth (in)	.24000	.25400	.26700	.27700	.28500
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN DETERGENT (0.1%) FOR 1 YEAR

Specimen Number	Displcment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.4695	.0423	49.3	8847.0	637965
2	.5212	.0496	53.7	8678.9	671193
3	.4942	.0495	58.1	8419.3	675694
4	.3280	.0341	60.4	8143.3	693683
5	.3905	.0417	67.2	8554.8	677371
Mean:	.4407	.0434	57.7	8528.7	671181.
Standard Deviation:	.0797	.0065	6.8	266.9	20422.
Minimum:	.3280	.0341	49.3	8143.3	637965.
Maximum:	.5212	.0496	67.2	8847.0	693683.

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FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN = 4"

Flexural 3 point bend

Instron Corporation
Series IX Automated Materials Testing System 6.05
Test Date: 04 Nov 2010

Operator name: K. PHOUANGSAVANH

Sample Identification: 9F53-3Y6
Interface Type: 42/43/4400 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1100

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.58800	.58000	.56800	.57800	.56800
Depth (in)	.24000	.25500	.26700	.27700	.28400
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN VEGETABLE OIL (100%) FOR 1 YEAR

Specimen Number	Displcment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.4231	.0381	51.0	9040.2	680773
2	.3580	.0342	54.0	8597.2	703775
3	.2745	.0275	55.7	8250.5	715322
4	.3553	.0369	65.0	8789.9	738480
5	.3065	.0326	63.4	8300.8	727079
Mean:	.3435	.0339	57.8	8595.7	713086.
Standard Deviation:	.0566	.0042	6.1	332.2	22229.
Minimum:	.2745	.0275	51.0	8250.5	680773.
Maximum:	.4231	.0381	65.0	9040.2	738480.

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FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN = 4".

Flexural 3 point bend

Instron Corporation
Series IX Automated Materials Testing System 6.05

Operator name: K. PHOUANGSAVANH

Test Date: 04 Nov 2010

Sample Identification: 9F53-3Y5
Interface Type: 42/43/4400 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1100

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.57300	.58000	.57500	.57500	.57900
Depth (in)	.24800	.25700	.26300	.26700	.27000
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN GASOLINE (100%) FOR 1 YEAR

Specimen Number	Displacement at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.5498	.0511	52.9	8999.5	635402
2	.5252	.0506	57.7	9043.4	639290
3	.3737	.0369	59.6	8986.7	652060
4	.4354	.0436	60.8	8903.9	637105
5	.4665	.0472	62.8	8934.1	651477
Mean:	**.4701**	**.0459**	**58.8**	**8973.5**	643067.
Standard Deviation:	.0705	.0059	3.8	55.1	8065.
Minimum:	.3737	.0369	52.9	8903.9	635402.
Maximum:	.5498	.0511	62.8	9043.4	652060.

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FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN - 4".

Flexural 3 point bend

Instron Corporation
Series IX Automated Materials Testing System 6.05

Operator name: E.CARRILLO

Test Date: 04 Nov 2010

Sample Identification: 9F53-3Y4

Sample Type: ASTM

Interface Type: 42/43/4400 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000

Crosshead Speed (in/min): .1100

Humidity (%): 50

Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.57700	.57500	.57200	.57000	.56600
Depth (in)	.23500	.24600	.25500	.26200	.26700
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN SULFURIC ACID (10%) FOR 1 YEAR

Specimen Number	Displcment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.5761	.0508	45.8	8618.3	599200
2	.5023	.0463	51.3	8845.7	615442
3	.4722	.0452	55.5	8946.5	655291
4	.3480	.0342	54.7	8381.9	647628
5	.3956	.0396	54.4	8095.3	624938
Mean:	.4588	.0432	52.3	8577.5	628500.
Standard Deviation:	.0896	.0064	4.0	346.6	23051.
Minimum:	.3480	.0342	45.8	8095.3	599200.
Maximum:	.5761	.0508	55.5	8946.5	655291.

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HTS Pipe Consultants

FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN = 4".

Flexural 3 point bend

Operator name: E.CARRILLO

Sample Identification: 9F53-3Y3
Interface Type: 42/43/4400 Series
Machine Parameters of test:
Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1100

Instron Corporation
Series IX Automated Materials Testing System 6.05
Test Date: 04 Nov 2010

Sample Type: ASTM

Humidity (%): 50
Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.56400	.56800	.57000	.57300	.57500
Depth (in)	.25200	.26400	.27700	.28600	.29100
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.
Sample comments: VEX221-607, SAMPLE SOAKED IN PHOSPHORIC ACID (10%) FOR 1 YEAR

Specimen Number	Displcment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.5362	.0507	49.3	8262.2	598373
2	.4711	.0466	59.6	9028.6	675186
3	.3540	.0368	62.3	8552.3	609408
4	.3606	.0387	66.6	8523.3	651443
5	.3663	.0400	69.4	8554.3	636316
Mean:	.4177	.0425	61.4	8584.1	634145.
Standard Deviation:	.0820	.0059	7.8	277.0	31144.
Minimum:	.3540	.0368	49.3	8262.2	598373.
Maximum:	.5362	.0507	69.4	9028.6	675186.

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FLEXURAL PROPERTIES OF PLASTICS (ASTM D790)

SUPPORT SPAN = 4".

Flexural 3 point bend

Instron Corporation
Series IX Automated Materials Testing System 6.(

Operator name: E.CARRILLO

Test Date: 04 Nov 2010

Sample Identification: 9F53-3Y2

Sample Type: ASTM

Interface Type: 42/43/4400 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000

Crosshead Speed (in/min): .1100

Humidity (%): 50

Temperature (deg. F): 71

Dimensions:

	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5
Width (in)	.57600	.57700	.57200	.57900	.57100
Depth (in)	.24500	.25800	.27200	.28200	.28900
Span (in)	4.0000	4.0000	4.0000	4.0000	4.0000

Out of 5 specimens, 0 excluded.

Sample comments: VEX221-607, SAMPLE SOAKED IN NITRIC ACID (5%) FOR 1 YEAR

Specimen Number	Displcment at Yield (in)	Strain at Yield (in/in)	Load at Yield (lbs)	Stress at Yield (psi)	Modulus Of Elasticity (psi)
1	.4769	.0438	51.6	8954.6	572466
2	.4874	.0472	57.0	8907.7	630139
3	.4355	.0444	63.4	8994.6	633892
4	.3358	.0355	62.9	8203.0	597546
5	.3888	.0421	65.2	8200.4	615094
Mean:	**.4249**	**.0426**	**60.0**	**8652.0**	**609827.**
Standard Deviation:	**.0632**	**.0044**	**5.6**	**412.3**	**25328.**
Minimum:	**.3358**	**.0355**	**51.6**	**8200.4**	**572466.**
Maximum:	**.4874**	**.0472**	**65.2**	**8994.6**	**633892.**

INTERPLASTIC CORPORATION
Thermoset Resins Division

INTERPLASTIC CORPORATION

2015 Northeast Broadway Street
Minneapolis, Minnesota 55413-1775
(651) 481-6860 Fax (612) 331-4235

CONFIDENTIAL
VEX221-607

ASTM F1216 & D543 (CIPP) Corrosion Data @ 73.4 +/- 3.6°F (23 +/- 2°C)

Immersion Media	Flexural Strength Retention, % — Months 1	Flexural Strength Retention, % — Months 12	Flexural Modulus Retention, % — Months 1	Flexural Modulus Retention, % — Months 12
100% Tap Water (pH 6 - 9)	100	86	99	94
5% Nitric Acid	97	96	100	91
10% Phosphoric Acid	99	95	100	94
10% Sulfuric Acid	97	95	100	93
100% Gasoline	99	99	100	96
0.1% Detergent	99	94	96	100
0.1% Soap Solution	100	93	95	100
100% Vegetable Oil	100	95	100	100

ASTM D5813, F1743 & D543 (CIPP) Corrosion Data @ 73.4 +/- 3.6°F (23 +/- 2°C)

Immersion Media	Flexural Strength Retention, % — Months 1	Flexural Strength Retention, % — Months 12	Flexural Modulus Retention, % — Months 1	Flexural Modulus Retention, % — Months 12
1% Nitric Acid	98	97	98	99
5% Sulfuric Acid	97	96	98	97
100% Gasoline	99	99	100	96
0.1% Detergent	99	94	96	100
0.1% Soap Solution	100	93	95	100
100% Vegetable Oil	100	95	100	100

Note: Non-shaded regions are the applicable test durations as it relates to achievement of the minimum acceptable retentions.

**All testing was conducted by HTS, Inc.

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Thermoset Resins Division

INTERPLASTIC CORPORATION

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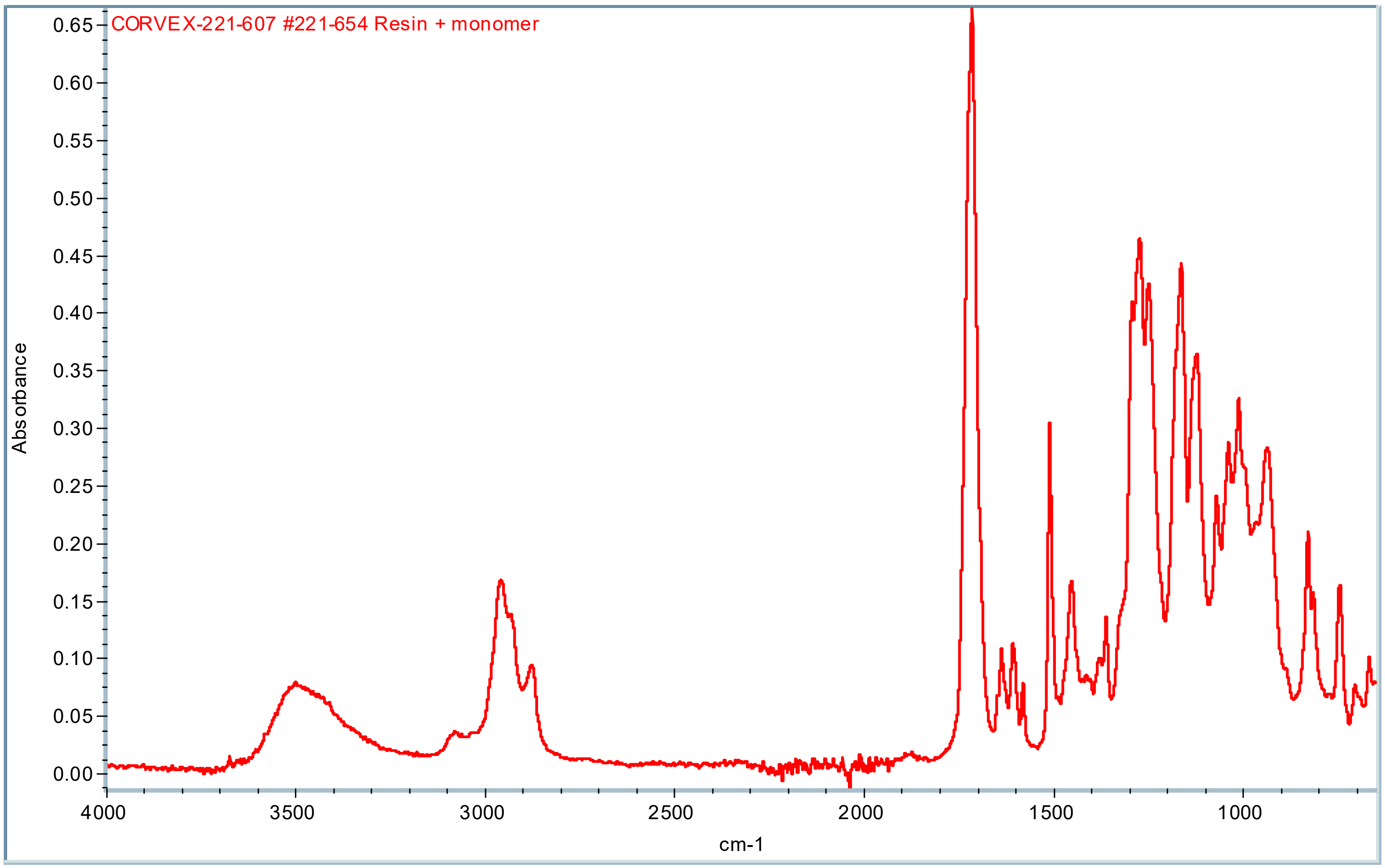

<><><><><><><> CIPP DESIGN <><><><><><><>
(as per ASTM F1216)

Client: Sac State **6/2/2016**
Project: Exp
Location: Sac State

Conduit \ Condition: Gravity Sewer, Partially Deteriorated

400,000	psi	Flexural Modulus
50	%	Flexural Modulus Reduction to Account for Long-term Effects
4,500	psi	Flexural Strength
2		Safety Factor for External Loads
18.0	inches	Mean Diameter
17.6	inches	Minimum Diameter
2	%	Ovality
5.0	feet	Maximum External Water Pressure to flowline
11.0	feet	Depth at Top of Conduit , soil only

Thickness Limitations (in inches)

0.100 : Maximum compressive hoop stress
0.212 : External pressure buckling

Minimum Design Thickness = **0.21** **inches**
= ***5.4*** ***mm***
DR = 85.0

Mode of Failure : External pressure buckling

The input data for this project should be verified in the field prior to construction. Should other conditions exist now or are expected in the field over the design life of this CIPP differing from the information contained herein, then appropriate adjustments must be made to the design calculations.

This Design Spreadsheet uses the equations from ASTM F1216 Appendix X1.2.1. User is responsible for All input values.

tb
Designed by

TB
Checked by

FERRATEX™
www.FerraTex.com

Head Calculator

Diameter	18	in	
Thickness	9	mm	
Change in Elevation		0	ft

(use negative if rise), in feet

	Water Head	Steam PSI	
Minimum Head	12.4	5.5	
Ideal Head*	16.2	7.1	
Max Cold Head	19.9	8.8	Total Head at Tail End based on min head
Max Hot Head**	17.4	7.6	12.4 Max Head OK

* Ideal head is the theoretical head required to properly inflate the liner while maintaining the design thickness
Anything above this will reduce thickness
Anything below this may not fully inflate the liner

** This is the theoretical bursting point of the liner. If your tower and Grade exceed this USE CAUTION

CONTRACTOR SUBMITTAL SUMMARY

Project #: 65A0588

PROJECT NAME: **Pipeline Rehabilitation Services**

CONTRACTOR: SAK Construction
4253 Duluth Ave
Rocklin, CA 95765

ATTN: Todd Chalk

THIS SECTION TO BE COMPLETED BY CLIENT ONLY

SUBMITTAL NO.: 1

1ST ☑ 2ND ☐ 3RD ☐ 4TH ☐

DATE RECEIVED:

DATE RETURNED:

CONTR. SUBMITTAL NO.: 1

ITEM: Summary Sheet

SPEC. SEC./PAGE NO.: SEC. 15.6.11 A(3) 2

SUPPLIER/SUBCONTR.: SAK Construction

DETAILED DESCRIPTION	NO. COPIES RECEIVED	REVIEW ACTION: NO EXCEPTIONS OBSERVED	REVIEW ACTION: MAKE CORRECTIONS NOTED	REVIEW ACTION: REVISE AS NOTED AND RESUBMIT	REVIEW ACTION: REJECT - RESUBMIT	NO. COPIES RETURNED
Summary Sheet						
Cure Schedule						

REMARKS:

OWNER: California Department of Transportation (Caltrans)

PROJECT: Contract No. 65A0588, Pipeline Rehabilitation Services

SAK™

Pipeline Infrastructure. Solved.™

SUMMARY SHEET BY DRAINAGE SYSTEM NUMBER

DRAINAGE SYSTEM NO.	HOST PIPE DIAMETER (in)	CULVERT LENGTH (LF)	HOST PIPE MATERIAL	CALCULATED MINIMUM THICKNESS	INSTALLED THICKNESS	RECOMMENDED POST-CURE TEMPERATURE (°F)	RECOMMENDED PRESSURE (psi)	MINIMUM COLD PRESSURE (psi)	MAXIMUM COLD PRESSURE (psi)	MAXIMUM HOT PRESSURE (psi)	RECOMMENDED CURE TIME (hours)	TRADE NAME OF RESIN TO BE USED	EXPECTED MAX EXOTHERM TEMPERATURE (°F)	METHOD OF LINER INSERTION	PROPOSED CURE METHOD
A2	18	20	CSP	7.6mm	9mm	220	5.8	3.0	19.7	9.8	1.0	AOC L713-LTA	450	Pull in	Steam
A3	18	20	CSP	7.6mm	9mm	220	5.8	3.0	19.7	9.8	1.0	AOC L713-LTA	450	Air Inv	Steam
A4	18	20	CSP	7.6mm	9mm	220	5.8	3.0	19.7	9.8	1.0	AOC L713-LTA	450	Air Inv	Steam
A5	18	20	RCP	7.6mm	9mm	220	5.8	3.0	19.7	9.8	1.0	AOC L713-LTA	450	Air Inv	Steam
A8	19	20	CSP	7.6mm	9mm	220	5.8	3.0	19.7	9.8	1.0	EcoTek L040-TNVG-33	450	Air Inv	Steam

CIPP lengths, access, and termination points for each run will be determined based on a pre-installation survey of the site.

At that time, the pipe diameter and length will be measured so that the CIPP may be ordered to fit the existing host pipe.

Typically, CIPP is installed from the upstream end and terminated at the downstream end of the pipeline, however, site-specific conditions can often impact this decision.

Access limitations, traffic control, and wastewater management considerations may cause the downstream end to be selected for the installation point and/or the upstream end to be selected for the termination point.

World Leader in Resin Technology

May 11, 2010

To Whom It May Concern:

The following cure procedures are recommended when using the L040-TNVG-33 vinyl ester resin in Cured In Place Pipe applications. L040-TNVG-33 vinyl ester resin can be cured using either hot water or steam. The recommended post cure temperatures are a minimum of 180ºF Water Temperature for water and 220ºF 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	5 hr	2.5 hr	130ºF	1 hr
< 10.5 mm	4 hr	2 hr	150ºF	1 hr
10.5 to18 mm	6 hr	4 hr	130ºF	2 hr
10.5 to18 mm	5 hr	3 hr	150ºF	2 hr
19.5 to 30 mm	8 hr	6 hr	120ºF	6 hr
> 30 mm	10 hr	8 hr	110ºF	6 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 100ºF 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.

World Leader in Resin Technology

August 24, 2009

To Whom It May Concern:

The following cure procedures are recommended when using the L713-LTA polyester resin in Cured In Place Pipe applications.

L713-LTA polyester resin can be cured using either hot water or steam. The recommended post cure temperatures are a minimum of 180°F for water cures and 220°F 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.

CONTRACTOR SUBMITTAL SUMMARY

Project #: 65A0588

PROJECT NAME: Pipeline Rehabilitation Services

CONTRACTOR: SAK Construction
4253 Duluth Ave
Rocklin, CA 95765

ATTN: Todd Chalk

THIS SECTION TO BE COMPLETED BY CLIENT ONLY

SUBMITTAL NO.: 2

1ST ☑ 2ND ☐ 3RD ☐ 4TH ☐

DATE RECEIVED:

DATE RETURNED:

CONTR. SUBMITTAL NO.: 2

ITEM: Manufacturer's Information

SPEC. SEC./PAGE NO.: SEC. 15.6.11 A(3) 3

SUPPLIER/SUBCONTR.: SAK Construction

DETAILED DESCRIPTION	NO. COPIES RECEIVED	REVIEW ACTION: NO EXCEPTIONS OBSERVED	REVIEW ACTION: MAKE CORRECTIONS NOTED	REVIEW ACTION: REVISE AS NOTED AND RESUBMIT	REVIEW ACTION: REJECT - RESUBMIT	NO. COPIES RETURNED
Resin Data Sheet						
Resin Enhancer						
Certificate of Compliance Resin						
Fabric Tube Detail Sheet						
Installation Procedures						
Sealing Method						
Preliner Description						
Description of Lubricant						

REMARKS:

EcoTek™
L040-TNVG-33
Vinyl Ester Resin

Product Information

EcoTek Ultra Low VOC Resin for Underground Sewer Pipe Liners

TYPICAL LIQUID RESIN PROPERTIES* (1) see back page

	Nominal
Viscosity @ 77°F/25°C, RVF Brookfield Spindle #4 @ 20 RPM, cps.	6,500
Thix Index 2/20	>2
Color	Light brown
Specific Gravity @ 77°F/25°C	1.28
Gel Time @ 140°F, minutes	33
Pot Life @ 77°F/25°C	48

TYPICAL 6mm PET FELT MECHANICAL PROPERTIES* (2) see back page

		Test Method
Tensile Strength,psi/MPa	3,800/26	ASTM D 638
Tensile Modulus,psi/GPa	570,000/3.9	ASTM D 638
Tensile Elongation, %	0.84	ASTM D 638
Flexural Strength,psi/MPa	7,400/51	ASTM D 790
Flexural Modulus,psi/GPa	550,000/3.8	ASTM D 790
Barcol Hardness	>40	ASTM D 2583

*Typical properties are not to be construed as specifications.

DESCRIPTION

The EcoTek L040-TNVG-33 is an enhanced, Ultra Low VOC resin designed for CIPP applications. L040-TNVG-33 does not contain any styrene monomers or hazardous air pollutants.

FEATURES

- Excellent catalyzed pot life
- Superior mechanical properties
- Contains no styrene

BENEFITS

Adaptability

The EcoTek L040-TNVG-33 molecular architecture provides an excellent balance of corrosion and physical properties.

www.green-resins.com
green-resins@aoc-resins.com

World Leader in Resin Technology
North America
northamerica@aoc-resins.com
Toll Free: +1 (866) 319-8827
www.aoc-resins.com

EcoTek™
L040-TNVG-33
Vinyl Ester Resin

EcoTek GREEN TECHNOLOGIES

PERFORMANCE GUIDELINES

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

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

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 77°F/25°C. After extended storage, some drift may occur in gel time.

During the hot summer months, no more than two months stability at 86°F/30°C should be anticipated.

SAFETY

See appropriate Material Safety Data Sheet for guidelines.

ISO 9001:2000 CERTIFIED

The Quality Management Systems at every AOC manufacturing facility have been certified as meeting ISO 9001:2000 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 gel times shown are typical but may be affected by catalyst, promoter and inhibitor concentrations and resin, mold and shop 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 of EcoTek F010-TNVG-33 at 73°F/23°C and 50% relative humidity. All thixotropic resins should be mixed well prior to use. Testing conducted on 2 ply 3mm PET felt laminates.

www.green-resins.com
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AOC®
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North America
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Toll Free: +1 (866) 319-8827
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World Leader in Resin Technology

Physical Testing Report

Date: 02-05-10 From: Brad Simpson

Sample ID: L040-NVTG-33 field sample from SAK / PIPEnology.

Test	Units	ASTM	**L040-NVTG-33**
Flexural Strength	Psi/Mpa	D-790	6800/47
Flexural Modulus	Mpsi/Gpa	D-790	620/4.3

Comment: **Tested with coated side down. Subtracted 0.015 inches from thickness for calculations.**

Request No. 3859CO

Report No. P10CA31

AOC®
World Leader in Resin Technology

Vipel® L713-LTA Series
Polyester Resin

Product Information

Vipel® Isophthalic Based Resin for Underground Sewer Pipe Liners

TYPICAL FILLED LIQUID RESIN PROPERTIES* (1) see back page

	Nominal
Viscosity @ 77°F/25°C, RVF Brookfield Spindle #4 @ 20 RPM, cps.	6,200
Thix Index 2/20	2.7+
Color	Opaque
Specific Gravity @ 77°F/25°C	1.26
Styrene, %	41
Gel Time @ 140°F with (1.0% Di-(4-tert-butyl-cyclohexyl) peroxydicarbonate and 0.5% Trigonox® KSM), minutes	11
Pot Life @ 77°F/25°C (1% Di-(4-tert-butyl-cyclohexyl) peroxydicarbonate and + 0.5% Trigonox® KSM), hours	40

Trigonox is a trademark of Akzo Nobel Chemicals

TYPICAL FILLED CAST MECHANICAL PROPERTIES* (2) See back page

		Test Method
Tensile Strength, psi/MPa	7570/52	ASTM D 638
Tensile Modulus, psi/GPa	690,000/4.8	ASTM D 638
Tensile Elongation, %	1.5	ASTM D 638
Flexural Strength, psi/MPa	11,550/80	ASTM D 790
Flexural Modulus, psi/GPa	700,000/4.8	ASTM D 790
Heat Distortion Temperature, °F/°C @ 264 psi	132/270	ASTM D 648
Barcol Hardness	43	ASTM D 2583

*Typical properties are not to be construed as specifications.

DESCRIPTION

The Vipel® L713-LTA Series is a high molecular weight isophthalic/unsaturated polyester resin. The Vipel® L713-LTA Series provides the corrosion resistance, durability and toughness that is required for cured in place pipe applications.

BENEFITS

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

Vipel® L713-LTA Series Polyester Resin

PERFORMANCE GUIDELINES

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

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

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 77°F/25°C. After extended storage, some drift may occur in gel time.

During the hot summer months, no more than two months stability at 86°F/30°C should be anticipated.

SAFETY

See appropriate Material Safety Data Sheet for guidelines.

ISO 9001:2000 CERTIFIED

The Quality Management Systems at every AOC manufacturing facility have been certified as meeting ISO 9001:2000 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-LTA pipe at 77°F/25° and 50% relative humidity. Ccastings were prepared using 1.0% Perkadox 16 and 0.5 Trigonox C.

AOC®
World Leader in Resin Technology

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EUROPE
Tel: (44) 1473 288997
Fax: (44) 1473 216080
europe@aoc-resins.com

Pub. No. F-AOC-Vipel® L713-LTA Series Effective Date: May 2008

World Leader in Resin Technology

August 24, 2009

To Whom It May Concern:

AOC L713-LTA resin contains a resin enhancer to increase the flexural modulus of the resin when used in Cured-In-Place-Pipe applications. The resin enhancer used in L713-LTA does not exceed 30 parts resin enhancer per one hundred parts of resin. The resin enhancer used in L713-LTA is made in a batch process and does not require the use of a bond enhancer and is suitable for use in aqueous environments. The type and particle size of the resin enhancer used in L713-LTA is proprietary to AOC, LLC. The resin enhancer used in L713-LTA is compatible for use with felt liners in Cured-In-Place-Pipe applications.

Bill Moore

Bill Moore
AOC, LLC
Product Leader - CIPP

AOC

World Leader in Resin Technology

CERTIFICATION OF COMPLIANCE

August 19, 2013

RE: L040-TNVG vinyl ester CIPP Resin

This letter certifies that the L040-TNVG vinyl ester Cured-In-Place-Pipe ("CIPP") resin manufactured by AOC, LLC for use by SAK Construction is specifically designed for use in CIPP applications. AOC's L040-TNVG vinyl ester resin meets all of the requirements for CIPP applications.

Bill Moore
Product Leader CIPP

State of Tennessee
Shelby County

On this 19th day of August 2013, before me Rene' Taillon, the undersigned Notary Public, personally appeared William A. Moore, personally known to me to be the person whose name is subscribed to the within instrument, and acknowledged that he executed it.

WITNESS my hand and official seal,

Notary Public

RENE' TAILLON
STATE OF TENNESSEE NOTARY PUBLIC
SHELBY COUNTY
My Commission Expires 07-18-2015

AOC
World Leader in Resin Technology

CERTIFICATION OF COMPLIANCE

April 11, 2012

RE: L713-LTA Compatibility

This letter certifies that L713-LTA polyester resin manufactured by AOC, LLC ("AOC") for use by SAK Construction, is manufactured in accordance with good manufacturing practices. The L713-LTA polyester resin meets the requirements of ASTM F1216 and ASTM D5813. The L713-LTA resin is compatible with PET felt CIPP liners produced by Applied Felts, Mississippi Textile Corporation, and SAK Construction.

Bill Moore

Bill Moore
Product Leader CIPP

State of Tennessee
Shelby County

On this 11th day of April 2012, before me Rene' Taillon, the undersigned Notary Public, personally appeared William A. Moore, personally known to me to be the person whose name is subscribed to the within instrument, and acknowledged that he executed it.

WITNESS my hand and official seal,

Rene' Taillon

Notary Public

RENE' TAILLON
STATE OF TENNESSEE NOTARY PUBLIC
SHELBY COUNTY
My Commission Expires 07-18-2015

TECHNICAL INFORMATION

CIPP Liner for Hot Water/Steam Cure Installation
(PROCESS QUALITY CONTROL)

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 Suppliers 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
Polymer granules (Several Specifications)	Hardness/Softness Melting Point Pellet Geometry Supplier Certification
Polymer sealing tape/extrusion	Gauge Density Strength of weld – Heat Opacity

2. Production of Felt (Nonwoven)

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 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	Even fiber distribution
Tacker needling	Operator inspection, set parameters, computer feedback, orientation of fibers	Permits controlled
Reorientation of fibers	Operator inspections, set parameters, computer feedback	Controls relative elongation moduli in length and cross directions
Needling	Operator inspections, set parameters, computer feedback	Density, strength, ability to weld

3. Polymer Coating of Felt

The sole consumable is granular polymer. The polymer 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	Characteristics
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	Coating mass 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 shown in 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. Elongation %

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. Elongation %
Coating Weight and Distribution	Samples weighed to determine distribution of coating in cross direction of roll.
Coating adhesion and ability to weld	Peel strength of sealing tape/extrusion (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 Acknowledgement form.

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

The design is detailed to the Production Department as a Manufacturing Specification. This is then entered into 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

Property	Control	Test
Circumference of liner	Monitored at each production stage against the 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 Manufacturing Specifications	Inspection regime includes measurement or a sample of liners against Manufacturing Specifications.
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 Strengths	All welding equipment operates to set parameters. Overlapped thermal welded.	Each weld is sampled and destructively tested. Results are compared to the Manufacturing Specification.
Polymer Sewn Seam Strength	All sewing equipment operates to set parameters.	Each sewn seam is sampled and destructively tested. Results are compared to the Manufacturing Specification.
Polymer Sealing Tape/Extrusion Weld Strengths	All welding equipment operates to set parameters, chemically bonded seal.	Each weld is sampled, specially conditioned, and destructively tested under conditions that simulate the “worst case” for that liner.

TECHNICAL INFORMATION

CIPP Liner for Hot Water/Steam Cure Installation

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. of water head). Standard thicknesses of 1.5mm, 3mm, 4mm, 4.5mm, and 6mm exist.

Coating:

The coating is a thermoplastic polymer. The nominal weight may be 338 to 430 grams per square meter, with 384 grams per square meter typical. This affords an average coating thickness of 17 MILS.

Liner:

The liner is assembled from layers of plain felt and an outer layer of coated felt. Each inner felt layer edge is butted together and sewn.

The outer polymer coated layer is butted together and sewn, and a polymer sealing tape/extrusion is laid on top and welded over the sewn seam, 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 tolerance at -0 + 5% on nominal ordered thickness.

Fabric Tube Strength

5.0 MM		MFG Date	2/27/2014
Roll Number	MD Specific Strength (Longitudinal)	CD Specific Strength (Transverse)	Ratio Average
1738115	988	1007	0.981
1738149	992	1013	0.980
1738191	1030	1108	0.931
1738230	1010	1045	0.966
Average	**1005**	**1043**	**0.965**

6.5 MM		MFG Date	2/28/2014
Roll Number	MD Specific Strength (Longitudinal)	CD Specific Strength (Transverse)	Ratio Average
1738388	1092	1079	1.010
1738388	1107	1107	1.000
1738422	1134	1124	1.000
1738423	1102	1081	1.019
1738459	1105	1114	0.991
1738460	1104	1089	1.014
Average	**1107**	**1099**	**1.006**

ASTM: D5813-04 Standard Specification for Cured-In-Place Thermosetting Resin Sewer Piping
Section 6.1 Fabric Tube Strength & Section 8.4 Fabric Tube Tensile Properties
Minimum Tensile Strength of 750 PSI in both longitudinal and transverse directions.
(ASTM 1682 withdrawn in 1992 and replaced with D5035)

ASTM: D5035-06 Standard Test Method for Breaking Force and Elongation of Textile Fabrics
(Strip Method for Felted Fabrics)

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, 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% rh, 35 Degrees C: 1 year.

3. Avoid prolonged wet storage.

As with high humidity, the coating is 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.

Storage and Handling con't.

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 the liner is not placed directly onto girt 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 are 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 (ie. Both loops on the sling onto the crane hook).

6. Styrene and Chemical Attack.

Avoid prolonged contact with solvents and chemicals.

Recommended shelf life after impregnation will vary dependent 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.

PIPENOLOGY™
Quality & Technology from the Inside Out

January 1st, 2015

This letter certifies that Pipenology, LLC manufactured tubes meet the material requirements of ASTM F1216-09 (paragraph 5.1) and ASTM F1743-08 (section 6) as well as the minimum strength requirements of ASTM D5813-04 (paragraph 6.1).

Pipenology, LLC is a registered ISO 9001:2008 company and all materials are tested to ensure suitability to the various field applications and recommended installation procedures. All of our materials and finished products are tested to ensure they meet the standards listed above and suitability to each type of application.

Over three million feet of our liner has been successfully installed nationwide. Our liners are assembled in O'Fallon, MO, using only components made in the USA.

Nor-Cal Pipeline Services is a certified installer of Pipenology, LLC CIPP products. Nor-Cal crew personnel are trained in proper installation procedures of Pipenology liners, as well as other CIPP products.

Sincerely,

S Casey Smith
Vice President

PIPENOLOGY™
Quality & Technology from the Inside Out

AIR INVERSION / STEAM CURE INSTALLATION PROCEDURES

INSTALLATION PROCEDURES

1 Invert the resin-impregnated tube into the pipeline using air pressure(or a column of water) at a sufficient head to fully install the tube into position (i.e., depending on the length of the inversion a 8inch diameter liner by 6mm in thickness is typically 10psi to 20psi) On longer installation lengths it might be necessary to add a small amount of water to facilitate the inversion process. Thermocouples should be installed during the inversion process at the host pipe-liner pipe interface(top and bottom) at all access points. Let the liner invert freely (without a holdback rope) for the second half of the inversion and to deflate and exhaust the water, if used, in the inversion process once it reaches the downstream access point. Attach the inlet and outlet pressure fittings to the upstream and downstream ends of the tube; and connect these fittings to the boiler truck and outlet control station, respectively. Re-inflate the liner using pressurized air to the recommended minimum expansion/curing pressure given by tube manufacturer.

2 Once in place and properly inflated, continue discharging air at the downstream end while maintaining the recommended expansion pressure (Installation note: If the pipeline is below the water table, 1.5psi mush be added to the recommended expansion pressure for each 3 feet of external hydrostatic head on the host pipe(measured from the flow line of the host pipe)). Start the steam generator and when ready, begin to discharge steam until an air temperature of 190degF is obtained entering the line. Maintain this exotherm is observed at the downstream end (or the liner is hardened at all observable points); typically this will be achieved in 10 -45 minutes depending upon the diameter and length of the reach.

3 While continuing to maintain the recommended expansion pressure, increase the flow of steam allowing the temperature to rise to a maximum valve of 260degF. This will typically necessitate the operator throttling back the air supply to achieve this maximum temperature. This will begin the liner's post-curing phase. Observe the temperatures at the various interfaces and begin timing.

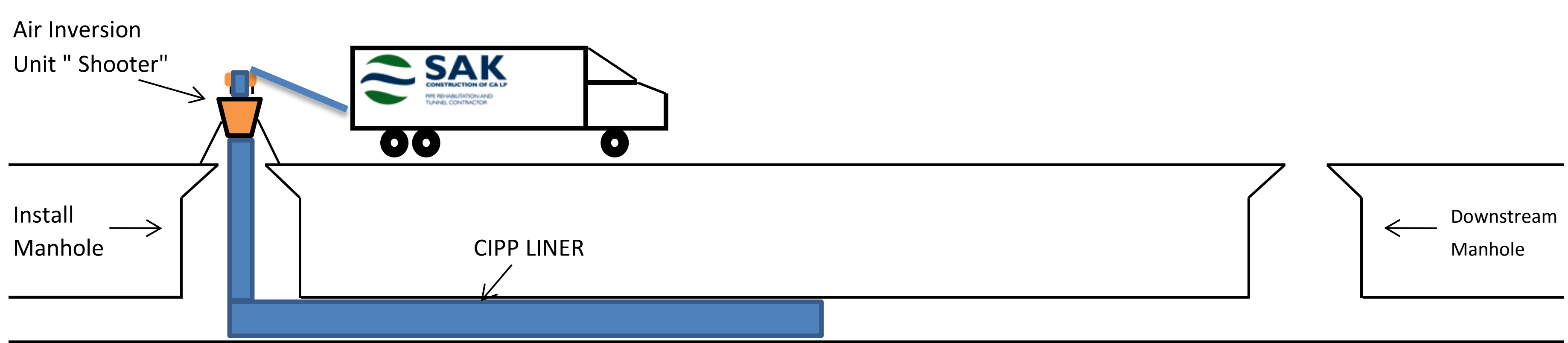
4 PLEASE NOTE. THE COATING HAS A MAXIMUM TEMPERATURE CAPABILITY OF 399degF; DO NOT ALLOW STEAM TO REACH THIS TEMPERATURE OR MELTING OF THE COATING CAN OCCUR.

5 Continue post-curing at the above conditions until the temperature measured at all points along the host pipe-liner interfaces have a reading at or above manufactures recommend temperature and duration

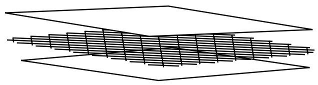
6 Once the post-curing portion of the process is complete, discontinue the addition of steam, continue maintaining the curing pressure and allow maximum ventilation to occur using air flow only. Continue this cool down process until the temperature at the thermocouples placed in the interface(s) report a value below 100deg F. Water may be introduced into the liner during this process to facilitate the cooling process. You may also deploy a chiller on the air. In any event, the cool down rate of the liner (NOT THE AIR) should be no greater than that specified by the resin manufacturer for the thickness being processed. Typical cooling rate are given below:

4.5 - 10.5mm	—	45degF / 10 minutes
10.5 - 18mm	—	35degF / 15 minutes
18 - 22.5mm	—	25degF / 15 minutes

7 Once cool down is complete, the ends of the liner can be opened. Inspect finished line and reinstate the laterals.



GRIFFOLYN® TX 1200



REEF INDUSTRIES, INC.
The Manufacturing Leader of Specialized Industrial Plastic Films Since 1957.

GRIFFOLYN® TX 1200

PRODUCT INFORMATION - SPECIFICATION GUIDE

Griffolyn® TX-1200 is a 3-ply laminate combining two layers of linear low density polyethylene and a high-strength cord grid. It is specifically engineered to provide high strength and durability in a lightweight material.

PHYSICAL PROPERTIES AND TYPICAL VALUES

PROPERTY	ASTM TEST METHOD	U.S. VALUE	METRIC VALUE
Weight	D-751	38 LB/1000 FT^2	18.5 KG/100 M^2
3" Load @ Yield	D-882	90 LBF	400 N
3" Load @ Break	D-882	54 LBF	240 N
		2500 PSI	17 MPA
3" Elongation @ Break	D-882	400 %	400 %
Tongue Tear	D-2261	22 LBF	98 N
Trapezoidal Tear	D-4533	29 LBF	129 N
PPT Resistance	D-2582	29 LBF	129 N
Dart Impact Strength	D-1709	1.6 LBS	0.73 KG
Cold Impact Strength	D-1790	-40°F	-40°C
Permeance	E-96	0.040 Grain/Hr•Ft^2•in.Hg	2.30 NG/(PA•S•M^2)

FEATURES

- Multiple layers and cord reinforcement resist punctures and tears.
- UV stabilization protects the material from degradation during extended exposure to sunlight.
- Cold-crack resistance eliminates failures in extremely cold temperatures.
- Low permeability greatly inhibits moisture transmission.
- Flexibility and light weight allow for easy handling and quick installation.
- Custom fabrication is available to meet your exact specifications.
- Long life expectancy allows for significant cost savings through reuse and fewer replacements.
- Class C, ASTM E-1745-97 Standard Specification for water vapor retarders used in contact with soil or granular fill under concrete slabs.

TOLLFREE 1.800.231.6074
9209 Almeda Genoa Rd. • Houston, Texas 77075
P: 713.507.4251 • F: 713.507.4295
Email: ri@reefindustries.com

SUGGESTED APPLICATIONS

- Pallet, cable reel and drum covers for outside storage.
- Temporary walls, plant dividers, building enclosures and containment tents.
- Shipping container covers and liners.
- Floor covers, dust partitions and cleanroom enclosures.
- Soil covers to control leachate for stockpiles and landfills.
- Agricultural storage systems, hay covers and windbreaks.
- Athletic field and equipment covers.
- Interim landfill covers
- Architectural vapor retarder for underslab, walls, ceilings and in roofing systems.

ORDERING INFORMATION

AVAILABLE COLORS:
Black, White, and Clear

SIZES:
Standard rolls from 4' x 100' to 40' x 100' in increments of 4' widths are available for immediate shipment. Standard length and width tolerances are ± 1% (minimum 2")

Custom sizes up to 200' x 300' and custom fabrication are avaiable to meet your exact specifications.

USABLE TEMPERATURE RANGE:
Minimum: -45˚F -42˚C
Maximum: 170˚F 77˚C

OUTDOOR EXPOSURE

Under normal continuous exposure the average life expectancy ranges from 30 to 48 months.

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9209 Almeda Genoa Rd. • Houston, Texas 77075
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Email: ri@reefindustries.com

Crisco Shortening

MSDS # 235.70

Section 1: Product and Company Identification

Crisco Shortening

Synonyms/General Names: Solid Shortening
Product Use: For educational use only
Manufacturer: Loders Croklaan, Channahan, IL, 60410

24 Hour Emergency Information Telephone Numbers

CHEMTREC (USA): 800-424-9300 **CANUTEC (Canada): 613-424-6666**

ScholAR Chemistry; 5100 W. Henrietta Rd, Rochester, NY 14586; (866) 260-0501; www.Scholarchemistry.com

Section 2: Hazards Identification

White or off-white oily solid, characteristic corn oil odor.

HMIS (0 to 4)

CAUTION! Combustible solid. Not for human consumption
Target organs: None known.

This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

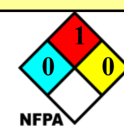
Section 3: Composition / Information on Ingredients

Mixture of fatty acid, triglycerides of vegetable origin, 100%

Always seek professional medical attention after first aid measures are provided.

Eyes: Immediately flush eyes with excess water for 15 minutes, lifting lower and upper eyelids occasionally.
Skin: Immediately flush skin with excess water for 15 minutes while removing contaminated clothing.
Ingestion: Call Poison Control immediately. Rinse mouth with cold water. Give victim 1-2 cups of water or milk to drink. Induce vomiting immediately.
Inhalation: Remove to fresh air. If not breathing, give artificial respiration.

When heated to decomposition, emits acrid fumes.
Protective equipment and precautions for firefighters: Use foam or dry chemical to extinguish fire. Firefighters should wear full fire fighting turn-out gear and respiratory protection (SCBA). Cool container with water spray. Material is not sensitive to mechanical impact or static discharge.



Section 6: Accidental Release Measures

Use personal protection recommended in Section 8. Isolate the hazard area and deny entry to unnecessary and unprotected personnel. Contain spill with sand or absorbent material and place in sealed bag or container for disposal. Ventilate and wash spill area after pickup is complete. See Section 13 for disposal information.

Section 7: Handling and Storage — Green

Handling: Use with adequate ventilation and do not breathe dust or vapor. Avoid contact with skin, eyes, or clothing. Wash hands thoroughly after handling.
Storage: Store in General Storage Area [Green Storage] with other items with no specific storage hazards. Store in a cool, dry, well-ventilated, locked store room away from incompatible materials.

Section 8: Exposure Controls / Personal Protection

Use ventilation to keep airborne concentrations below exposure limits. Have approved eyewash facility, safety shower, and fire extinguishers readily available. Wear chemical splash goggles and chemical resistant clothing such as gloves and aprons. Wash hands thoroughly after handling material and before eating or drinking. Exposure guidelines: Shortening : OSHA PEL: N/A, ACGIH: TLV: N/A, STEL: N/A.

Section 9: Physical and Chemical Properties

Molecular formula	Natural Product.	**Appearance**	White to off-while oil solid
Molecular weight	N/A.	**Odor**	Characteristic corn oil odor.
Specific Gravity	~0.7 – 0.9 g/mL @ 60°C.	**Odor Threshold**	N/A.
Vapor Density (air=1)	N/A.	**Solubility**	Insoluble.
Melting Point	50 °C.	**Evaporation rate**	N/A. *(Butyl acetate = 1).*
Boiling Point/Range	N/A.	**Partition Coefficient**	N/A. *(log P_{OW}).*
Vapor Pressure (20°C)	N/A.	**pH**	N/A.
Flash Point:	N/A	**LEL**	N/A.
Autoignition Temp.:	N/A.	**UEL**	N/A.

N/A = Not available or applicable

Section 10: Stability and Reactivity

Avoid heat and moisture.
Stability: Stable under normal conditions of use and storage.
Incompatibility: Oxidizing materials.
Shelf life: Indefinite if stored properly.

Section 11: Toxicology Information

Acute Symptoms/Signs of exposure: ***Eyes***: Redness, tearing, itching, burning, conjunctivitis. ***Skin***: Redness, itching. ***Ingestion***: Irritation and burning sensations of mouth and throat, nausea, vomiting and abdominal pain. ***Inhalation***: Irritation of mucous membranes, coughing, wheezing, shortness of breath,
Chronic Effects: No information found.
Sensitization: none expected
Shortening: LD50 [oral, rat]; N/A; LC50 [rat]; N/A; LD50 Dermal [rabbit]; N/A
Material has not been found to be a carcinogen nor produce genetic, reproductive, or developmental effects.

Section 12: Ecological Information

Ecotoxicity (aquatic and terrestrial): Not considered an environmental hazard.

Section 13: Disposal Considerations

Check with all applicable local, regional, and national laws and regulations. Local regulations may be more stringent than regional or national regulations. Small amounts of this material may be suitable for sanitary sewer or trash disposal.

Section 14: Transport Information

DOT Shipping Name: Not regulated by DOT.
DOT Hazard Class:
Identification Number:

Canada TDG: Not regulated by TDG.
Hazard Class:
UN Number:

Section 15: Regulatory Information

EINECS: Not Listed
TSCA: All components are listed or are exempt.
WHMIS Canada: Not WHMIS Controlled.
California Proposition 65: Not listed.

The product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

Section 16: Other Information

Current Issue Date: December 16, 2009
Disclaimer: Scholar Chemistry and Columbus Chemical Industries, Inc., ("S&C") believes that the information herein is factual but is not intended to be all inclusive. The information relates only to the specific material designated and does not relate to its use in combination with other materials or its use as to any particular process. Because safety standards and regulations are subject to change and because S&C has no continuing control over the material, those handling, storing or using the material should satisfy themselves that they have current information regarding the particular way the material is handled, stored or used and that the same is done in accordance with federal, state and local law. ***S&C makes no warranty, expressed or implied, including (without limitation) warranties with respect to the completeness or continuing accuracy of the information contained herein or with respect to fitness for any particular use.***

CONTRACTOR SUBMITTAL SUMMARY

Project #: 65A0588

PROJECT NAME: **Pipeline Rehabilitation Services**

CONTRACTOR: SAK Construction 4253 Duluth Ave Rocklin, CA 95765 ATTN: Todd Chalk	**THIS SECTION TO BE COMPLETED BY CLIENT ONLY** SUBMITTAL NO.: 3 1ST ☑ 2ND ☐ 3RD ☐ 4TH ☐ DATE RECEIVED: DATE RETURNED:

CONTR. SUBMITTAL NO.: 3

ITEM: Calibration

SPEC. SEC./PAGE NO.: SEC. 15.6.11 A(3) 4

SUPPLIER/SUBCONTR.: SAK Construction

DETAILED DESCRIPTION	NO. COPIES RECEIVED	REVIEW ACTION: NO EXCEPTIONS OBSERVED	REVIEW ACTION: MAKE CORRECTIONS NOTED	REVIEW ACTION: REVISE AS NOTED AND RESUBMIT	REVIEW ACTION: REJECT - RESUBMIT	NO. COPIES RETURNED
Calibration Record						
Sample Temperature Log						

REMARKS:

PIPEnology inc™
TUNNEL CONTRACTOR

OWNER: Caltrans
CLIENT: Caltrans
CONTRACT #: 06-0J2904
PROJECT NAME: CIPP Lining in Kern County
Hwy 33 Various Locations
PIPENOLOGY JOB #: 1019

HOST PIPE DIAMETER (in): 18
PIPENOLOGY SHOT #: 1
CIPP NOMINAL THICKNESS (mm): 9.0

SHOT LOCATION: Drainage System No 1

TEMPERATURE & PRESSURE LOG DURING CURE

TIME	TOP INTERFACE TEMPERATURE (°F)	BOTTOM INTERFACE TEMPERATURE (°F)	PRESSURE (psi)
10:45 AM	74	72	6.0
10:50 AM	96	85	6.0
10:55 AM	120	99	6.0
11:00 AM	146	108	6.0
11:05 AM	156	119	6.0
11:10 AM	172	125	6.0
11:15 AM	182	137	6.0
11:20 AM	185	145	6.0
11:25 AM	190	156	6.0
11:30 AM	191	166	6.0
11:35 AM	189	169	6.0
11:40 AM	185	170	6.0
11:45 AM	184	171	6.0
11:50 AM	182	172	6.0
11:55 AM	180	173	6.0
12:00 PM	180	174	6.0
12:05 PM	180	174	6.0
12:10 PM	179	175	6.0
12:15 PM	178	175	6.0
12:20 PM	176	175	6.0
12:25 PM	173	175	6.0
12:30 PM	171	175	6.0
12:35 PM	171	178	6.0
12:40 PM	172	180	6.0
12:45 PM	173	182	6.0
12:50 PM	172	180	6.0
12:55 PM	172	178	6.0
1:00 PM	171	175	6.0
1:05 PM	171	174	6.0
1:10 PM	169	172	6.0
1:15 PM	165	169	6.0
1:20 PM	155	162	6.0
1:25 PM	142	157	6.0

OWNER: Caltrans
CLIENT: Caltrans
CONTRACT #: 06-0J2904
PROJECT NAME: CIPP Lining in Kern County
Hwy 33 Various Locations
PIPENOLOGY JOB #: 1019

HOST PIPE DIAMETER (in): 18
PIPENOLOGY SHOT #: 1
CIPP NOMINAL THICKNESS (mm): 9.0

SHOT LOCATION: Drainage System No 1

TEMPERATURE & PRESSURE LOG DURING CURE

TIME	TOP INTERFACE TEMPERATURE (°F)	BOTTOM INTERFACE TEMPERATURE (°F)	PRESSURE (psi)
1:30 PM	130	151	6.0
1:35 PM	127	148	6.0
1:40 PM	119	145	6.0
1:45 PM	110	143	6.0
1:50 PM	109	135	6.0
1:55 PM	107	128	6.0
2:00 PM	105	121	6.0
2:05 PM	100	110	6.0
2:10 PM			
2:15 PM			
2:20 PM			
2:25 PM			
2:30 PM			
2:35 PM			
2:40 PM			
2:45 PM			
2:50 PM			
2:55 PM			
3:00 PM			

CONTRACTOR SUBMITTAL SUMMARY

Project #: 65A0588

PROJECT NAME: Pipeline Rehabilitation Services

CONTRACTOR: SAK Construction
4253 Duluth Ave
Rocklin, CA 95765

ATTN: Todd Chalk

THIS SECTION TO BE COMPLETED BY CLIENT ONLY

SUBMITTAL NO.: 4

1ST ☑ 2ND ☐ 3RD ☐ 4TH ☐

DATE RECEIVED:

DATE RETURNED:

CONTR. SUBMITTAL NO.: 4

ITEM: Third Party Test Reports

SPEC. SEC./PAGE NO.: SEC. 15.6.11 A(3) 5

SUPPLIER/SUBCONTR.: SAK Construction

DETAILED DESCRIPTION	NO. COPIES RECEIVED	REVIEW ACTION: NO EXCEPTIONS OBSERVED	REVIEW ACTION: MAKE CORRECTIONS NOTED	REVIEW ACTION: REVISE AS NOTED AND RESUBMIT	REVIEW ACTION: REJECT - RESUBMIT	NO. COPIES RETURNED
Third Party Test Reports						

REMARKS:

World Leader in Resin Technology

Physical Testing Report

Date: 08/08/11 From: Rick Reeves

Sample ID: L040-TNVG-33 CIPP

Felt Laminate

Test	Units	ASTM	RESULTS
Flexural Strength	Psi	D-790	7300
Flexural Modulus	X10^6Psi	D-790	0.61
Tensile Strength	Psi	D-638	4100
Tensile Modulus	X10^6Psi	D-638	0.64
Elongation	(%)	D-638	0.71
DTUL	Deg.C/F	D-648	117/243

Comment:

Request No.

Report No. P11CC39

World Leader in Resin Technology

ASTM D5813 Test Results on 6 mm Felt Composite
L040-TNVG Ultra Low VOC Resin
One Year Results at 25°C

	L040-TNVG	REQUIREMENTS %	PASS OR FAIL
CONTROL SAMPLE			
FLEXURAL STRENGTH, psi	6,840		
STANDARD DEVIATION	325		
FLEXURAL MODULUS, psi	546,660		
STANDARD DEVIATION	19,767		
1% NITRIC ACID			
FLEXURAL STRENGH, psi	5,770		
STANDARD DEVIATION	327		
% FLEXURAL STRENGTH, psi RETENTION	84.4	>80	PASSED
FLEXURAL MODULUS, psi	525,785		
STANDARD DEVIATION	19,052		
% FLEXUARAL MODULUS RETENTION	96.2	>80	PASSED
5% SULFURIC ACID			
FLEXURAL STRENGH, psi	5,884		
STANDARD DEVIATION	118		
% FLEXURAL STRENGTH, psi RETENTION	86	>80	PASSED
FLEXURAL MODULUS, psi	515,604		
STANDARD DEVIATION	15,306		
% FLEXUARAL MODULUS RETENTION	94.3	>80	PASSED
100% GASOLINE			
FLEXURAL STRENGH, psi	5,651		
STANDARD DEVIATION	34		
% FLEXURAL STRENGTH, psi RETENTION	82.6	>80	PASSED
FLEXURAL MODULUS, psi	445,838		
STANDARD DEVIATION	10,995		
% FLEXUARAL MODULUS RETENTION	81.5	>80	PASSED
100% VEGETABLE OIL			
FLEXURAL STRENGH, psi	6,629		
STANDARD DEVIATION	170		
% FLEXURAL STRENGTH, psi RETENTION	96.9	>80	PASSED
FLEXURAL MODULUS, psi	587,981		
STANDARD DEVIATION	24,438		
% FLEXUARAL MODULUS RETENTION	107	>80	PASSED

0.1% DETERGENT			
FLEXURAL STRENGH, psi	6,189		
STANDARD DEVIATION	198		
% FLEXURAL STRENGTH, psi RETENTION	90.4	>80	PASSED
FLEXURAL MODULUS, psi	529,849		
STANDARD DEVIATION	15,784		
% FLEXUARAL MODULUS RETENTION	96.9	>80	PASSED
0.1% SOAP			
FLEXURAL STRENGH, psi	5,870		
STANDARD DEVIATION	401		
% FLEXURAL STRENGTH, psi RETENTION	85.8	>80	PASSED
FLEXURAL MODULUS, psi	531,649		
STANDARD DEVIATION	19,242		
% FLEXURAL MODULUS RETENTION	97.3	>80	PASSED

June, 2011

STS
Specialty Testing Services

TEST REPORT (CIP PROPERTIES)

CLIENT:	**AOC-Resins**	**Project Name:**	L713-LTA-12
		Project No.	
		Sample ID	
		Diameter:	
	Attention: Bill Moore	**Thickness:**	
		Length:	
		Manhole Location:	
		Installed Date:	
DATE:	7/14/09	**Specimen Prepared By:**	J. Woods
REPORT NO.:	STS-900-0002	**Specimen Tested By:**	J. Woods

REMARKS: **SAMPLES RECEIVED 7/14/09**
SPECIFICATIONS: CUSTOMER SPECIFICATIONS

FLEXURAL PROPERTIES (ASTM D-790)

SAMPLE ID	Depth In.	Width In.	FLEXURAL YIELD STRENGTH PSI	MODULUS OF ELASTICITY PSI
1	.265	.615	7697	684179
2	.267	.611	7806	759894
3	.264	.599	8128	795834
4	.265	.629	7762	772750
5	.274	.600	7781	777591
Mean			**7835**	**758080**
Standard Deviation			168	43260

TENSILE PROPERTIES (ASTM D-638)

SAMPLE ID	Depth In.	Width In.	TENSILE LOAD Lbs.	TENSILE STRENGTH PSI
1	.268	.522	525	3753
2	.266	.495	492	3738
3	.268	.500	514	3840
4	.269	.493	490	3698
5	.269	.503	499	3692
Mean				**3744**
Standard Deviation				59

Remarks:

Respectfully Submitted,
Specialty Testing Services

Johnny Woods
Operations Manager

3171 Green Valley Rd. #451 **Birmingham, Alabama 35243** **Telephone: (205) 281-2349**

Microbac®

TEST REPORT

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

Attention: Bill Moore Re: P.O. #8126

SAMPLES: One sample of cured in place plastic pipe (CIPP) material were submitted and identified by the client as L 713-LT. The sample was received on October 4, 2007.

TESTING: Flexural Properties testing per ASTM D790-07, Procedure A was conducted on five randomly selected specimens. The specimens were tested in full thickness. The specimens were tested using a sixteen to one span to depth ratio. The specimens were conditioned in accordance with ASTM D618-05 (23°C @50% Relative Humidity) for 1 year prior to testing.

Chemical resistance testing in accordance with ASTM D5813-04, Section 8.2.1 was performed on the sample. Sets of five (5) specimens for each exposure were randomly selected for this testing. The specimens were exposed to the chemicals listed in Table 1 for one year. The specimens were then removed from the solutions, rinsed in tap water, wiped dry, and tested for Flexural Properties in accordance with ASTM D790-07. The results of the exposure were then compared to the results of the set of five (5) specimens that had been conditioned at 23°C and 50% RH for the duration of the chemical exposures.

TABLE 1
SOLUTIONS USED FOR CHEMICAL RESISTANCE TESTING

Chemical Solution	Concentration
Nitric acid	1%
Sulfuric acid	5%
ASTM Fuel C	100%
Sodium Hydroxide	0.5%
Vegetable oil	100%
Detergent	0.10%
Soap	0.10%

RESULTS: The results of the chemical exposure testing are presented in Table 1. Details of the flexural properties testing (dimensions, span length, and testing rate) are presented in Tables 2.

DATA REVIEWED AND REPORT WRITTEN BY:

Douglas Bert
Scientist II

REPORT REVIEWED BY:

Steve Ferry
Director, Hauser Laboratories

TABLE 1
L 713-LT FLEXURAL PROPERTIES TEST RESULTS

Specimen Number	Flexural Yield Strength psi	Strain @ Flexural Yield Strength in	Flexural Modulus (Tangent) psi
L 713-LT Unexposed			
1	7400	3.2	669000
2	6440	2.6	678000
3	6210	1.8	656000
4	7010	3.1	644000
5	6920	2.5	650000
Average	6800	2.6	659000
Std. Dev.	470	0.6	14000
L 713-LT Nitric acid			
1	6200	3.0	629000
2	6550	4.3	626000
3	5910	2.8	577000
4	6130	4.4	614000
5	6110	3.5	577000
Average	6180	3.6	605000
Std. Dev.	230	0.7	26000
Retention of Flexural Modulus (%)			91.8

TABLE 1 CONTINUED
L 713-LT FLEXURAL PROPERTIES TEST RESULTS

Specimen Number	Flexural Yield Strength	Strain @ Flexural Yield Strength	Flexural Modulus (Tangent)
	psi	in	psi
L 713-LT Sulfuric acid			
1	5640	1.8	635000
2	6200	3.1	632000
3	6500	3.3	640000
4	6610	3.5	623000
5	6280	3.5	631000
Average	6250	3.0	632000
Std. Dev.	380	0.7	7000
Retention of Flexural Modulus (%)			95.9
L 713-LT ASTM Fuel C			
1	6870	2.4	683000
2	6890	1.9	658000
3	6420	2.5	671000
4	7040	3.1	653000
5	6220	3.6	681000
Average	6690	2.7	669000
Std. Dev.	350	0.7	13000
Retention of Flexural Modulus (%)			101.5
L 713-LT Sodium Hydroxide			
1	5240	3.5	537000
2	5070	2.7	541000
3	5350	3.2	528000
4	5220	3.6	531000
5	5260	3.0	537000
Average	5230	3.2	535000
Std. Dev.	100	0.4	5000
Retention of Flexural Modulus (%)			81.2

TABLE 1 CONTINUED
L 713-LT FLEXURAL PROPERTIES TEST RESULTS

Specimen Number	Flexural Yield Strength	Strain @ Flexural Yield Strength	Flexural Modulus (Tangent)
	psi	in	psi
L 713-LT Vegetable oil			
1	6460	2.5	694000
2	6850	3.1	651000
3	6290	2.5	679000
4	6570	1.8	677000
5	6950	2.5	693000
Average	6620	2.5	679000
Std. Dev.	270	0.5	17000
Retention of Flexural Modulus (%)			103.0
L 713-LT Detergent			
1	6200	4.3	616000
2	6000	3.6	605000
3	6310	3.7	621000
4	6520	4.7	620000
5	6270	3.7	590000
Average	6260	4.0	610000
Std. Dev.	190	0.5	13000
Retention of Flexural Modulus (%)			92.6
L 713-LT Soap			
1	6290	4.0	587000
2	5740	3.1	597000
3	6120	3.0	600000
4	5900	3.2	599000
5	6050	3.5	595000
Average	6020	3.4	596000
Std. Dev.	210	0.4	5000
Retention of Flexural Modulus (%)			90.4

TABLE 2
L713-LT DETAILS OF FLEXURAL PROPERTIES TESTING

Specimen Number	Width	Thickness
	in	in
L 713-LT Un-exposed		
1	0.590	0.250
2	0.590	0.266
3	0.595	0.263
4	0.595	0.258
5	0.591	0.263
Span Length (inches)		4.16
Speed of Testing (inches per minute)		0.11
L 713-LT Nitric acid		
1	0.591	0.263
2	0.598	0.268
3	0.573	0.265
4	0.598	0.270
5	0.596	0.262
Span Length (inches)		4.25
Speed of Testing (inches per minute)		0.11
L 713-LT Sulfuric acid		
1	0.594	0.265
2	0.590	0.270
3	0.593	0.265
4	0.594	0.261
5	0.595	0.268
Span Length (inches)		4.25
Speed of Testing (inches per minute)		0.11
L 713-LT ASTM Fuel C		
1	0.592	0.265
2	0.595	0.256
3	0.594	0.269
4	0.588	0.253
5	0.597	0.268
Span Length (inches)		4.20
Speed of Testing (inches per minute)		0.11

TABLE 3 CONTINUED
L713-LT DETAILS OF FLEXURAL PROPERTIES TESTING

Specimen Number	Width	Thickness
	in	in
L 713-LT Sodium hydroxide		
1	0.591	0.263
2	0.590	0.264
3	0.596	0.256
4	0.595	0.259
5	0.597	0.267
Span Length (inches)		4.19
Speed of Testing (inches per minute)		0.11
L 713-LT Vegetable oil		
1	0.590	0.264
2	0.595	0.265
3	0.596	0.267
4	0.594	0.266
5	0.594	0.270
Span Length (inches)		4.26
Speed of Testing (inches per minute)		0.11
L 713-LT Detergent		
1	0.593	0.265
2	0.594	0.269
3	0.591	0.263
4	0.595	0.266
5	0.594	0.254
Span Length (inches)		4.21
Speed of Testing (inches per minute)		0.11
L 713-LT Soap		
1	0.587	0.259
2	0.598	0.268
3	0.597	0.269
4	0.596	0.265
5	0.593	0.270
Span Length (inches)		4.26
Speed of Testing (inches per minute)		0.11

CONTRACTOR SUBMITTAL SUMMARY

Project #: 65A0588

PROJECT NAME: **Pipeline Rehabilitation Services**

CONTRACTOR: SAK Construction 4253 Duluth Ave Rocklin, CA 95765 ATTN: Todd Chalk	**THIS SECTION TO BE COMPLETED BY CLIENT ONLY** SUBMITTAL NO.: 5 1ST ☑ 2ND ☐ 3RD ☐ 4TH ☐ DATE RECEIVED: DATE RETURNED:

CONTR. SUBMITTAL NO.: 5

ITEM: Certification of Installer

SPEC. SEC./PAGE NO.: SEC. 15.6.11 A(3) 6

SUPPLIER/SUBCONTR.: SAK Construction

DETAILED DESCRIPTION	NO. COPIES RECEIVED	REVIEW ACTION: NO EXCEPTIONS OBSERVED	REVIEW ACTION: MAKE CORRECTIONS NOTED	REVIEW ACTION: REVISE AS NOTED AND RESUBMIT	REVIEW ACTION: REJECT - RESUBMIT	NO. COPIES RETURNED
Certificate of Installer (Resin)						
Certificate of Installer (Liner)						

REMARKS:

AOC®

World Leader in Resin Technology

April 7, 2011

To Whom It May Concern:

SAK Construction is a current AOC customer that has a history of successfully using AOC's Cured In Place Pipe resins.   SAK Construction is an approved installer of AOC resins.

Bill Moore

Bill Moore
AOC, LLC
Product Leader - CIPP

PIPENOLOGY™
Quality & Technology from the Inside Out

January 1st, 2015

To-Whom-it-May-Concern:

This letter certifies that SAK Construction, LLC is an Authorized Installer of Pipenology, LLC CIPP products. SAK crew personnel are trained in the proper installation procedures of Pipenology liners, as well as other CIPP products.

Sincerely,

S Casey Smith
Vice President

CONTRACTOR SUBMITTAL SUMMARY

Project #: 65A0588

PROJECT NAME: **Pipeline Rehabilitation Services**

CONTRACTOR: SAK Construction
4253 Duluth Ave
Rocklin, CA 95765

ATTN: Todd Chalk

THIS SECTION TO BE COMPLETED BY CLIENT ONLY

SUBMITTAL NO.: 6

1ST ☑ 2ND ☐ 3RD ☐ 4TH ☐

DATE RECEIVED:

DATE RETURNED:

CONTR. SUBMITTAL NO.: 6

ITEM: MSDS

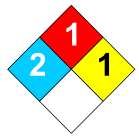
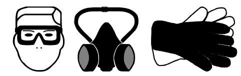
SPEC. SEC./PAGE NO.: SEC. 15.6.11 A(3) 7

SUPPLIER/SUBCONTR.: SAK Construction

DETAILED DESCRIPTION	NO. COPIES RECEIVED	REVIEW ACTION: NO EXCEPTIONS OBSERVED	REVIEW ACTION: MAKE CORRECTIONS NOTED	REVIEW ACTION: REVISE AS NOTED AND RESUBMIT	REVIEW ACTION: REJECT - RESUBMIT	NO. COPIES RETURNED
MSDS						

REMARKS:

World Leader in Resin Technology

WHMIS (Canada)	NFPA (USA)	HMIS (USA)	Protective clothing
 D-2A D-2B	Fire  Health / Reactivity / Specific hazard		

HMIS (USA)		
Health hazards	*	2
Flammability		1
Physical hazards		1
Personal protection		X

Section 1. Chemical product and company identification

Trade name	**L040-TNVG-33**
Product type	Vinyl Ester Resin
Chemical family	Aromatic.
Material uses	Used in the manufacture of thermoset plastic parts.

Manufacturer

AOC, LLC
950 Highway 57 East
Collierville, TN U.S.A. 38017
Website: www.aoc-resins.com
Phone Number: (901) 854-2800
8am-5pm (Central Time) 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 2. Hazards identification

OSHA status	This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).
Routes of entry	Eye contact, Skin contact, Inhalation, Ingestion
Potential acute health effects	**Eyes:** Severe eye irritant which may result in redness, burning, tearing and blurred vision. **Skin:** Skin contact may cause irritation. May cause skin sensitization. **Ingestion:** Ingestion may be harmful. **Inhalation:** May be harmful by inhalation.
Potential chronic health effects	**CARCINOGENIC EFFECTS:** Talc: Classified A2 (suspected for human) by ACGIH. Classified 1 (proven for human) by IARC. Classified 1 (known) by NTP. **MUTAGENIC or TERATOGENIC EFFECTS:** No known effect according to our database.

Section 3. Composition/information on ingredients

Name	CAS #	% by weight
1) Trade Secret Ingredient(s)	Proprietary	30 - 35
2) Talc	14807-96-6	20 - 30

Section 4. 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.

Section 4. First aid measures

Inhalation	Move the victim to a safe area as soon as possible. Allow the victim to rest in a well-ventilated area. 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.

Section 5. Fire fighting measures

The product is:	Non-flammable.
Auto-ignition temperature	375.8°F(191°C)
Flash point	305.6°F (152°C) (Setaflash)
Flammable limits	Not available.
Products of combustion	May produce oxide of carbon; hydrocarbons
Fire hazard	May be combustible at high temperature.
Explosion hazard	Uncontrolled polymerization may cause rapid evolution of heat and increase in pressure that could result in violent rupture of sealed storage vessels or containers.
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 6. 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 7. Handling and storage

Handling	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 III), avoid dust from dried product or grinding of articles made from this material.
Storage	Keep away from heat. Keep away from sources of ignition. Keep container tightly closed. Keep in a cool, well-ventilated place. Containers should be grounded.

Section 8. Exposure controls/personal protection

Exposure limits	Trade Secret Ingredient(s)	Not available.
	Talc	**ACGIH TLV (United States, 1/2008).** TWA: 0.1 f/cc 8 hour(s). **NIOSH REL (United States, 6/2008).** TWA: 2 mg/m³ 10 hour(s). Form: Respirable fraction **OSHA PEL 1989 (United States).** TWA: 2 mg/m³ 8 hour(s). Form: Respirable dust **OSHA PEL Z3 (United States, 9/2005).**

Section 8. Exposure controls/personal protection

	STEL: 1 f/cc 30 minute(s). Form: not containing asbestos TWA: 20 mppcf 8 hour(s). Form: not containing asbestos
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 9. Physical and chemical properties

Physical state	Liquid.
Color	Brown.
Odor	Acrylate
Molecular weight (g/mol)	1000 - 15000
Boiling point	590°F(310°C)
Melting point	Not available.
pH (1% soln/water)	Not applicable.
Vapor pressure	Not available.
Vapor density	Not available.
Specific gravity	1.1 (Water = 1)
Water/oil dist. coeff.	Not available.
Evaporation rate	Not available.
Odor threshold	Not available.
Solubility in water	Slight.
Dispersibility properties	Not dispersed in water.

Section 10. Stability and reactivity

Stability	This product is normally stable, but can become unstable at elevated temperatures.
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	Our database contains no additional remark on the corrosivity of this product

Section 11. Toxicological information

Toxicity to animals

Name	Result	Species	Dose	Exposure
Trade Secret Ingredient(s)	LD50 Dermal	Rabbit	>2 gm/kg	-
	LD50 Intraperitoneal	Rat	345 mg/kg	-
	LD50 Oral	Rat	6200 mg/kg	-

Special remarks on toxicity to animals	No additional remark.
Special remarks on chronic effects on humans	No additional remark.
Special remarks on other toxic effects on humans	**Talc**: Exposure to dusts containing talc can be toxic and can produce acute and chronic effects. Contact with dusts may irritate the eyes. Breathing dust may irritate the nose and throat and cause coughing and chest discomfort. There are reports that relatively mild pneumoconiosis can develop after years of occupational exposure to mixed dusts containing talc. Prolonged inhalation may also produce a fibrotic response.

Section 12. 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.

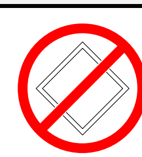
Section 13. Disposal considerations

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

Section 14. Transport information

DOT	Not regulated.
TDG	Not regulated.

Labels



IATA/IMDG	IATA: Not Regulated. IMDG: Not Regulated.
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 15. Regulatory information

Other regulations	**This section does not reference all applicable regulatory compliance lists.**
	TSCA: All ingredients are listed or compliant with TSCA.
	DSL: All ingredients are listed or compliant with the NSNR.
	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): None.
	CERCLA(RQ): None.

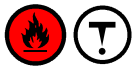
Section 16. Other information

Prepared by	AOC, LLC - Corporate Regulatory Affairs.	TN

LEGAL DISCLAIMER

Material Safety Data Sheet

MSDS no. 13592V1

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

Section I. Chemical Product and Company Identification

Trade name	**L713-LTA-12**	**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	32.0
2) Talc	14807-96-6	20 - 30

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.
Talc: Classified A2 (suspected for human) by ACGIH. Classified 1 (proven for human) by IARC. Classified 1 (known) by NTP.
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) Talc	**OSHA PEL (United States).** TWA: 2 mg/m^3 **ACGIH TLV (United States). Notes: Respirable** TWA: 2 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) Talc	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
Talc:
Exposure to dusts containing talc can be toxic and can produce acute and chronic effects. Contact with dusts may irritate the eyes. Breathing dust may irritate the nose and throat and cause coughing and chest discomfort. There are reports that relatively mild pneumoconiosis can develop after years of occupational exposure to mixed dusts containing talc. Prolonged inhalation may also produce a fibrotic response.

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.

Section XV. Other Regulatory Information

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

LEGAL DISCLAIMER

CONTRACTOR SUBMITTAL SUMMARY

Project #: 65A0588

PROJECT NAME: **Pipeline Rehabilitation Services**

CONTRACTOR: SAK Construction
4253 Duluth Ave
Rocklin, CA 95765

ATTN: Todd Chalk

THIS SECTION TO BE COMPLETED BY CLIENT ONLY

SUBMITTAL NO.: 7

1ST ☑ 2ND ☐ 3RD ☐ 4TH ☐

DATE RECEIVED:

DATE RETURNED:

CONTR. SUBMITTAL NO.: 7

ITEM: CIPP Liner Designs

SPEC. SEC./PAGE NO.: SEC. 15.6.11 A(3) 8

SUPPLIER/SUBCONTR.: SAK Construction

DETAILED DESCRIPTION	NO. COPIES RECEIVED	REVIEW ACTION: NO EXCEPTIONS OBSERVED	REVIEW ACTION: MAKE CORRECTIONS NOTED	REVIEW ACTION: REVISE AS NOTED AND RESUBMIT	REVIEW ACTION: REJECT - RESUBMIT	NO. COPIES RETURNED
CIPP Liner Designs						

REMARKS:

OWNER: Caltrans
PROJECT: Pipeline Rehabilitation

Pipeline Infrastructure. Solved.™

CIPP STRUCTURAL DESIGN CALCULATIONS

DESIGN PARAMETERS COMMON ACROSS ENTIRE PROJECT (for parameters that vary by line segment, see the table below)

CIPP Flexural Properties Utilized for Design with Normal Groundwater Loading - Groundwater where noted - None noted in specifications or drawings

Currently, normal groundwater loading designs assume groundwater encountered at the crown of the pipe - See table below

	Polyester		Low VOC	
Short-term Flexural Modulus:	Polyester	400,000 psi	Low VOC	300,000 psi
Long-term Flexural Modulus (retention 50%):		200,000 psi		150,000 psi
Flexural Strength:		4500 psi		5000 psi
Host Pipe Condition:		Fully Deteriorated		Fully Deteriorated
Factor of Safety:		2.0		2.0
Ovality:		5.0%		5.0%
Unit Weight of Soil:		120 pcf		120 pcf
Modulus of Soil Reaction:		1,000 psi		1,000 psi
Live Loading:		AASHTO H-20		AASHTO H-20

(Railroad AREMA E-80 loading is currently N/A to the work sites on this project)

SHOT NUMBER	VARIATION	U/S MH	D/S MH	U/S DEPTH	D/S DEPTH	CIPP DESIGN THICKNESS	RECOMMENDED INSTALL THICKNESS	DIAM.	STATED LENGTH	LATS
1	A2	Inlet A2-1	Outlet A2-2	2.0	2.0	7.62mm	9mm	18	20	
2	A3	Inlet A3-1	Outlet A3-2	2.0	2.0	7.62mm	9mm	18	20	
3	A4	Inlet A4-1	Outlet A4-2	2.0	2.0	7.62mm	9mm	18	20	
4	A5	Inlet A5-1	Outlet A5-2	2.0	2.0	7.62mm	9mm	18	20	
5	A8	Inlet A8-1	Outlet A8-2	2.0	2.0	7.62mm	9mm	18	20	

CONTRACTOR SUBMITTAL SUMMARY

Project #: 65A0588

PROJECT NAME: **Pipeline Rehabilitation Services**

CONTRACTOR: SAK Construction 4253 Duluth Ave Rocklin, CA 95765 ATTN: Todd Chalk	**THIS SECTION TO BE COMPLETED BY CLIENT ONLY** SUBMITTAL NO.: 8 1ST ☑ 2ND ☐ 3RD ☐ 4TH ☐ DATE RECEIVED: DATE RETURNED:

CONTR. SUBMITTAL NO.: 8

ITEM: CIPP Sampling Method

SPEC. SEC./PAGE NO.: SEC. 15.6.11 A(3) 1.2

SUPPLIER/SUBCONTR.: SAK Construction

DETAILED DESCRIPTION	NO. COPIES RECEIVED	REVIEW ACTION: NO EXCEPTIONS OBSERVED	REVIEW ACTION: MAKE CORRECTIONS NOTED	REVIEW ACTION: REVISE AS NOTED AND RESUBMIT	REVIEW ACTION: REJECT - RESUBMIT	NO. COPIES RETURNED
CIPP Sampling Method						

REMARKS:

Pipeline Infrastructure. Solved.™

4253 Duluth Ave. • Rocklin, CA 95765 • Ph: 916.408.5038 • Fax: 888.857.1215

RE: CIPP Sampling Method – Specification Section (15-6.11 A (4) Quality Control)

Field Quality Control:

CIPP Flat plate samples will not be cured in the pipe when doing a steam cure inversion. Any non-essential foreign object should not be in the pipe during a steam cure. It could inhibit circulation, cause a foreign heat sink and increase the chances of a condensation pocket. All these things could prohibit a successful cure. The flat plate samples are made from the same tube and resin as the rest of the CIPP liner. They are cured using the same steam over the same time period as the CIPP Liner. They are placed in a bag and cured under a steam discharge point at one of the ends. They are representative of the CIPP liner. Our Third Party Testing Laboratory only requires a 6" x 10" specimen for each sample; we will provide one sample plate that is 12" x 24" that will be cut into thirds for the 3 required samples. This sample curing method does not comply with the specification which states "*Place 3 each 6" x 16" aluminum plates clamped molds, each containing a flat plate sample, inside CIPP during resin curing period.*

The sampling method in this specification was written for a water inversion / water cure which has become an obsolete method over the last few years when lining storm drains. The current methods using an air inversion / steam cure prohibit placing the sample(s) inside the CIPP liner during cure.

Sincerely

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