UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 22 1997

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

MEMORANDUM

SUBJECT: Transmittal of Survey of Flexible Piping Systems

FROM: Anna Hopkins Virbick, Director
Office of Underground Storage Tanks

TO: EPA UST/LUST Regional Program Managers
State UST Program Managers

The purpose of this memorandum is to transmit for your information a survey of flexible piping systems (attached), recently completed by an OUST contractor. This version updates the survey on flexible piping sponsored by the Office of Underground Storage Tanks (OUST) in 1995. Included in the updated survey is information on what companies are making which types of flex pipe, the number of installations, piping construction, compatibility, materials warranty, and the status of the various systems in meeting national codes and standards.

If you have any additional information that would be helpful or questions about this work, please contact Paul Miller by phone at (703) 603-7165 or E-mail at miller.paul@epamail.epa.gov.

Attachment

cc: RPM's Managers (w/o attachment)
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Bob Versaw, Advanced Polymer Technology, Inc.
Reid Van Cleave, Ameron Fiberglass Pipe Systems
Glenn Eckart, Buffalo Environmental Products Corp.
Michael Nolan, Containment Technologies
Chris Ursillo, Environ Products, Inc.
Bill Watkins, Titeflex Industrial Americas
Randy Braun, Total Containment, Inc.
Richard Lewis, Western Fiberglass, Inc.

SURVEY OF FLEXIBLE PIPING SYSTEMS

March 1997

ICF Incorporated
Fairfax, VA

BACKGROUND

For the purposes of this survey, a flexible pipeline is defined as a pipeline constructed of flexible material that can be installed in single long runs without the necessity of regular joints either to extend the length of the line or change directions. This material is usually shipped in rolls that are hundreds of feet long, with the installer cutting lengths to fit the requirements of each installation. Most varieties of flexible piping are available with secondary containment either as an option or an integral part of the primary piping. In all cases, the secondary containment piping will not serve as primary piping. The secondary containment piping is designed to channel leakage back to a sump or monitor point, where it can be detected.

Because these pipelines differ significantly from the more traditional steel and fiberglass reinforced plastic (FRP) pipelines, the U.S. Environmental Protection Agency (EPA) has periodically requested a survey of their characteristics and availability. This is the third installment of this survey.[1]

METHODOLOGY

The survey was conducted by contacting flexible piping manufacturers that were identified through a variety of sources of information, including previous surveys, trade journals, and industry contacts.[2] For the purposes of this review, a flexible piping manufacturer is defined as a company that markets a flexible piping system (i.e., piping, fittings, joints, etc.). This includes companies that manufacture one or more components of a flexible piping system but employ third party components (e.g., piping manufactured by Furon Synflex) to complete their systems, as well as companies that manufacture all of the components of their flexible piping system. Manufacturers included in this review have pursued Underwriters Laboratories (UL) and/or Underwriters Laboratories of Canada (ULC) listings for their products; however, it is possible that other manufacturers exist or that new piping materials may enter the market in the future. Manufacturers and personnel contacted are listed in Table 1.

Information provided by manufacturers was not independently verified. A draft of this document was submitted to survey respondents and Marcel Moreau Associates for technical review.

[1] This survey is an update of the 1995 survey conducted by Marcel Moreau Associates and the 1993 survey conducted by Ken Wilcox Associates.

[2] ICF limited its search to up to nine public respondents, so as not to trigger requirements under the Paperwork Reduction Act of 1980 for Office of Management and Budget clearance on surveys of 10 or more public respondents.

Table 1. List of Manufacturers of Flexible Piping Systems Included in the Survey

Manufacturer	Contact	Phone
Advanced Polymer Technology, Inc.	Bob Versaw	616-759-9112
Ameron Fiberglass Pipe Systems	Reid Van Cleave	713-690-7777
Buffalo Environmental Products Corp.	*Glenn Eckart*	*410-553-0170*
Containment Technologies	Michael Nolan	610-993-8140
Environ Products, Inc.	Chris Ursillo	610-594-0297
Titeflex Industrial Americas	Bill Watkins	413-739-5631
Total Containment, Inc.	Randy Braun	610-666-7777
Western Fiberglass, Inc. (a.k.a. Western FG)	Richard Lewis	707-523-2050

Since 1995, one manufacturer of flexible piping systems, Smith Fiberglass Products, has chosen to discontinue domestic sales of its flexible piping product, Smithflex. Another manufacturer, Buffalo Environmental Products Corp., did not respond to requests for updated information. As a result, Buffalo Environmental's product information in this survey (*shown in italics*) has not been updated from the 1995 survey. Two additional manufacturers (Titeflex Industrial Americas and Western Fiberglass) have been included in this survey.[3]

RESULTS

An overview of flexible piping systems is presented in Tables 2 and 3 at the end of this **Results** section. Table 2 describes key parameters of available flexible piping systems, while Table 3 details construction and compatibility information. Other specific information for individual manufacturers is presented below:

Advanced Polymer Technology - (Poly-Tech)

- ⋆ All diameters of pipe are available in models for either pressure or suction pumping systems.
- ⋆ All diameters of pipe are available in either coaxial secondarily contained or direct bury (single walled) models.
- ⋆ Primary and secondary piping are installed as a single unit. The secondary pipe fits snugly around the primary and contains small grooves parallel to the pipe axis to channel leakage to a point where it can be detected.
- ⋆ The nylon 12 used as a liner for the primary pipe has been used by General Motors for the fuel lines

[3] Sources indicate that two additional manufacturers, Centron International, Inc., and S. Bravo Systems, Inc., have also pursued UL 971 listings for their products. Through preliminary discussions with a Centron representative, it became evident that Centron manufactures traditional rigid fiberglass piping rather than flexible piping. S. Bravo Systems manufactures flexible piping systems, but representatives from S. Bravo did not respond to requests for information. As a result, Centron International and S. Bravo Systems product information is not included in this survey.

in its automobiles since 1980.

- ⋆ Fittings used in this system are bolt-on compression fittings.
- ⋆ All piping models incorporate a patented permeation barrier technology to reduce permeation to very low levels.
- ⋆ There is also a 3" diameter primary pipe that differs in construction from the smaller diameter pipe construction listed in Table 3. The 3" diameter primary pipe is constructed of a modified cross-linked polyacrylonitrile elastomer liner, permeation barriers, polyester braid, wire helix, and nitrile cover. The secondary jacket on the 3" pipe is a tight-fitting sleeve comprised of modified cross-linked polyacrylonitrile elastomer, polyester braid, and nitrile cover. There are no flow channels in the secondary jacket of the 3" model.
- ⋆ Also available is a flexible product designed for vent lines and vapor recovery applications. The product is available in 2" and 3" diameters, single wall or coaxial double wall. The 2" vent piping is similar in construction to the 3" pressure piping, with the 3" vent piping being similar in construction to the 3" pressure piping.
- ⋆ A flexible, metallic-ducted (MD series) pipe is available for use in marina and above-ground applications.
- ⋆ UL listings for both primary and secondary pipe have been obtained on 1.5", 1.75", and 2" piping. ULC listings for both primary and secondary pipe have been obtained on 0.5", 0.75", 1", 1.5", 1.75", and 2" piping. ULC listings have also been obtained on system components such as sumps, entry boots, etc.

Ameron Fiberglass Pipe Systems - (Dualoy 3000/FLX II and Dualoy 3000/FLX III)

- ⋆ Dualoy 3000/FLX I has been discontinued since the 1995 survey.
- ⋆ The Dualoy 3000/FLX systems (1.5" and 2") are UL listed for all fuels, including 100% alcohols, for both primary and secondary piping.
- ⋆ The Dualoy 3000/FLX systems (1.5" and 2") utilize a swaged on swivel coupling that allows for 1" of axial movement.
- ⋆ The Dualoy 3000/FLX II (1.5" and 2") systems combine a flexible primary pipe with rigid secondary fiberglass containment that is mechanically jointed.
- ⋆ The Dualoy 3000/FLX III (1.5" and 2") systems combine a primary flexible pipe with a coaxial secondary jacket in one unit for direct burial.
- ⋆ The Dualoy 3000/FLX primary systems (1.5" and 2") are UL listed for a 75 psi operating pressure.

Buffalo Environmental Products Corp. - (Bufflex II)[4]

- ’ *Piping is available both in replaceable (primary piping slides in and out of secondary) and non-replaceable (primary and secondary in intimate contact) varieties, all with smooth bores.*
- ’ *The Nylon 11 liner (refer to Table 3) is used in primary piping that is to handle petroleum-based fuels with 10% or less alcohol content. Kynar (a Teflon based material) is used in primary piping that is to handle fuel blends with greater than 10% alcohol content.*
- ’ *The Bufflex primary piping construction includes a double helix spring steel wire reinforcement to provide flexibility without kinking. The piping construction greatly reduces stretching of the piping when used with pressurized pumps and prevents collapse of the piping when used with*

[4] As noted on page 2, this information has not been updated from the 1995 survey.

suction pumps.

- *The secondary containment is smooth bore PVC reinforced with a PVC spiral member. There are no corrugations to trap product or hinder insertion of the primary pipe.*
- *The replaceable type piping comes with a 30 year warranty and $2 million pollution liability insurance coverage, provided the piping is properly installed and monitored. The non-replaceable piping has a one year warranty and no accompanying insurance.*
- *The UL 971 listing for the primary pipe is pending, with acceptance expected by March 1, 1995.*

Containment Technologies - (Perma-Flexx)

- The manufacturer prefers to call this product a pipe rather than a hose. This product can be used for vent and vapor recovery piping because of its ability to lay flat and maintain its slope underground.
- All diameters of pipe can be used for pressurized or suction pumping systems.
- All diameters of primary piping can be used in secondarily contained or single-wall (direct bury) applications.
- The secondary piping is installed after the primary piping is already in place. The primary pipe cannot be removed or replaced without excavation.
- Although only relatively recently introduced in North America, this piping technology has been in use in Europe since 1981. Millions of feet of this product have been installed worldwide.
- The 10 year materials warranty applies when the piping is used with tank and dispenser sumps manufactured by Containment Technologies.
- Perma-Flexx primary piping is UL listed, and both the primary and secondary piping is listed with ULC, including MTBE blends.

Environ Products - (GeoFlex-S and GeoFlex-D)

- Earlier models of piping from this manufacturer include Flex I (single walled, direct bury), Flex II (double walled), and Geoflex I (doubled-walled, for petroleum fuels only). Environ currently manufactures GeoFlex-S (Single Wall) and GeoFlex-D (Double Wall) piping, as well as GeoVent-S (Single Wall) vent piping.
- Environ offers piping in 0.75", 1.5", and 2" sizes for both pressure and suction systems. All Environ GeoFlex and GeoVent piping is UL listed for petroleum, alcohols, and petroleum-alcohol mixtures. 1.5" and 2" GeoFlex-D have listings for both the primary and secondary pipes. 3" GeoFlex is currently undergoing UL testing.
- 2" GeoVent-S piping has been tested by UL under vacuum conditions without failure.
- Environ also offers GeoDuct flexible ducting. This large diameter corrugated pipe permits removal of either GeoFlex-S or GeoFlex-D without excavation.
- Environ offers the LDS Leak Detection System, which is a full secondary containment leak detection system. The interstitial space of the GeoFlex-D piping and containment sumps can be monitored using this leak detection system. The LDS Leak Detection System is UL 913 and 1238 listed for use in Class I--Division I--Group D hazardous locations. Third-party confirmation that the LDS system meets EPA regulatory guidelines for automatic line leak detectors is expected by April 1, 1997.
- Environ is testing with Underwriters Laboratories for “Coax” double wall fittings for use with GeoFlex-D piping. These fittings provide full secondary containment and monitoring of the fittings and riser pipe. Listing is expected in the Spring of 1997.
- Installation of the GeoFlex piping system and an Environ manufactured or approved leak detection system qualifies the installation for a 30 year warranty.

- ⋆ In addition to the Listings noted above, Environ currently has UL listings on flexible entry boots, dispenser sumps, dispenser mounting frames, tank sumps, and tank sump mounting devices.

Titeflex Industrial Americas - (Primeflex, Primeflex 20)

- ⋆ Primeflex is constructed from 304 stainless steel wire braid with a flexible PTFE convoluted innercore. End fittings are made from zinc plated carbon steel.
- ⋆ Primeflex is designed to be used with both rigid and flexible secondary containment. It can be installed in both new and existing installations with field attachable fittings. Fittings are available in rigid, swivel, male, female, and flanged varieties.
- ⋆ UL listing is pending on the Primeflex 20 piping.

Total Containment - (Enviroflex, Omniflex)

- ⋆ Enviroflex primary piping is installed after the secondary is in place and can be removed and replaced. Omniflex primary and secondary are installed as a single unit; the primary cannot be removed from the secondary.
- ⋆ First generation Enviroflex primary piping (yellow color) has been discontinued except for a 2.5" pipe system for diesel fuel applications. Second generation Enviroflex primary piping (bone color) is compatible with petroleum-based fuel and alcohol/petroleum blends up to 100% ethanol or methanol.
- ⋆ All diameters of pipe can be used for both pressurized and suction pumping systems.
- ⋆ 1.5" and 2.5" primary pipe has a corrugated inner tube to provide flexibility without kinking.
- ⋆ Total Containment also offers a 2.5 inch vent and vapor recovery pipe that is UL and ULC listed and is compatible with petroleum-based fuels and alcohol/petroleum blends up to 100% ethanol or methanol.
- ⋆ HDPE tank and dispenser sumps, with penetration fittings, are available, carry a UL and ULC listing, and are compatible with petroleum-based fuels and alcohol/petroleum blends up to 100% ethanol or methanol.
- ⋆ Total Containment offers a line of fiberglass tank and dispenser sumps. The fiberglass tank and dispenser sumps are being prepared for submittal to UL and ULC for approval.

Western Fiberglass, Inc. - (Co-Flex)

- ⋆ In addition to double-walled Co-Flex piping, Western also manufactures 2", 3", and 4" Stage II Vapor/Vent/Remote Fill single wall pipe and 3", 4", and 6" Conduit/Chase triple containment pipe. UL listed tank top, utility, vapor, transition, and dispenser mounting/containment assemblies (sumps) are also available.
- ⋆ Double-walled Co-Flex piping may be installed within a HDPE conduit/chase to achieve triple containment.
- ⋆ Co-Flex is supplied in 1000 foot reels or 200 foot boxes and is UV protected for outdoor storage. Cut lengths are available.
- ⋆ Western also manufactures clamp-on Direct Connection termination fittings that are placed on the outside of the pipe and tightened with a torque wrench.
- ⋆ Piping products are suitable for suction or pressure systems.

Table 2: Description of Available Flexible Piping Systems

Company	Product	Diameter (Inch)	First Installation	Number of Installations	Installer Training	Minimum Bend Radius (Inches)	Test Pressure: Primary/ Secondary	Listing	Materials Warranty
Advanced Polymer Technology	Poly-Tech	.5, .75, 1, 1.5, 1.75, 2, 3	May 1992	2500 world wide (65-70% US)	on-site training required for first job, video training aids available	24 (1.5" pipe)	60/10 psi (1.5")	UL 971 ULC-ORD-C107.14, 107.19, 107.21 (see text for specific listings)	10 years
Ameron	Dualoy 3000/FLX II 1.5 2.0		April 1995	70	on-site training required for first job. Classroom training and slide program also available	24 30	50/10-15 psi	UL 971	10 years
	Dualoy 3000/FLX III 1.5 2.0		June 1996	50		24 30	50/10-15 psi	UL 971	10 years
Buffalo[1]	*Bufflex II*	*1, 1.5, 2*	*1989-90*	*300 (US) 700 (other)*	*on-site training required for first job*	*15*	*60/5-15 psi*	*ULC-ORD-C107.4, 107.19, 107.21*	*30 years + pollution liability insurance*
Containment Technologies	Perma-Flexx	.75, 1.65, 2	March 1993	1200 (75% North America, 25% South America)	training video; onsite training is optional	36	60/5 psi	UL 971 (primary only) ULC-ORD-C107.14, 107.19, 107.21	10 years
Environ	GeoFlex-S GeoFlex-D	.75, 1.5, 2, (3" -Spr. '97)	June 1992	Thousands worldwide	onsite training required for first job	24	60/10 psi	UL 971 ULC-ORD-C107.14, 107.19, 107.21	10 years 30 year system

NOTE: Only officially completed UL 971 listings are indicated in this table. **UL listings are for primary and secondary piping unless otherwise noted.** ULC-ORD-C107.14 is at present an unpublished draft document.

[1] Information not updated from the 1995 survey.

Table 2, continued

Company	Product	Diameter (Inch)	First Installation	Number of Installations	Installer Training	Minimum Bend Radius (Inches)	Test Pressure: Primary/ Secondary	Listing	Materials Warranty
Titeflex Industrial Americas	Primeflex	1.5, 2.0	1993	10 (total)	onsite training	7.5	60 psi	UL 971 (primary only)	1 year
	Primeflex 20	1.5, 2.0				10	60 psi	UL 971 (pending - primary only)	20 years
Total Containment	Enviroflex	.5, .75, 1, 1.5, 2.5	Nov. 1989	7500 (US) 1600 (other)	onsite training required for first job	6 (1.5 primary) or 12 (2.5 primary) 24 (secondary)	60/5-10 psi	UL 971 ULC-ORD-C107.4, 107.19, 107.21	10 years
	Omniflex	1.5	June 1994	950		15 (primary) 24 (secondary)	60/5-10 psi	UL 971 ULC-ORD-C107.4, 107.7, 107.19	
Western FG	Co-Flex	1.5	March 1995	Thousands	onsite training required for first job, classroom available	24	50/5-15 psi	UL 971 ULC-ORD-C107.14, 107.19	10 years
		2.0				30			

NOTE: Only officially completed UL 971 listings are indicated in this table. **UL listings are for primary and secondary piping unless otherwise noted.** ULC-ORD-C107.14 is at present an unpublished draft document.

Table 3: Construction and Compatibility of Flexible Piping Systems

Company	Product	Primary Pipe Construction (Inside to Outside)	Primary Pipe Compatibility	Secondary Pipe Construction (Inside to Outside)	Secondary Pipe Compatibility
Advanced Polymer Technology	Poly-Tech	- Nylon 12 liner - proprietary permeation barrier - Nylon 6 braid - polyethylene cover	petroleum, alcohols, MTBE	- polyethylene - permeation barrier - polyethylene	petroleum, alcohols, MTBE
Ameron	Dualoy 3000/FLX II Dualoy 3000/FLX III	- fluoroplastic liner - nylon/nylon braid - fluoroplastic liner - nylon/nylon braid	petroleum, alcohols, MTBE petroleum, alcohols, MTBE	FLX II: - resin rich liner - epoxy resin - glass fiber - epoxy resin FLX III: -polyethlene	petroleum, alcohols
Buffalo[1]	*Bufflex II*	*- Nylon 11 or Kynar* *- polyester yarn braiding* *- polyurethane* *- double helix spring steel wire* *- polyurethane*	*petroleum, alcohols*	*- polyvinylchloride (PVC)*	*petroleum, alcohols*
Containment Technologies	Perma-Flexx	- nylon (Dupont Selar) - polyethylene	petroleum, alcohols, MTBE	- polyethylene	petroleum, alcohols, MTBE
Environ	Geoflex-S & -D	- proprietary permeation barrier - flexible structural filler layer - braided fiber reinforcement - thermoplastic	petroleum, alcohols, MTBE	- polyethylene - proprietary tie layer - nylon	petroleum, alcohols, MTBE

[1] Information not updated from the 1995 survey.

Table 3, continued

Company	Product	Primary Pipe Construction (Inside to Outside)	Primary Pipe Compatibility	Secondary Pipe Construction (Inside to Outside)	Secondary Pipe Compatibility
Titeflex Industrial Americas	Primeflex Primeflex 20	- PTFE Teflon impregnated fiberglass - stainless steel braid - PTFE Teflon impregnated fiberglass - PPS	petroleum, alcohols, MTBE	None	N/A
Total Containment	Enviroflex Omniflex	- proprietary inner tube - reinforcing braid - polyethylene	petroleum, alcohols, MTBE	-polyethylene	petroleum, alcohols, MTBE (Enviroflex only)
Western FG	Co-Flex	- PVDF - inner liner-Urethane-Polyester reinforcement braid-jacket	petroleum, alcohols, MTBE	- polyethylene	petroleum, alcohols, MTBE

ADDITIONAL ITEMS OF INTEREST

Underwriters Laboratories, Inc. (UL) Listings

Nonmetallic petroleum piping systems are currently evaluated using UL Standard 971, "Nonmetallic Underground Piping for Flammable Liquids." The focus of the standard is nonmetallic primary and secondary rigid petroleum piping (i.e., fiberglass). However, the standard contains provisions that apply to flexible piping. Some of the major tests for flexible piping include: a sustained pressure test; a leakage test; immersion tests; an air oven aging test; and a permeability test. For a more complete description of the tests applying to flexible piping in UL 971, please refer to Appendix A of this survey. A discussion of the Underwriters Laboratories of Canada (ULC) standards for flexible piping is also included in Appendix A.

UL is currently developing and revising the UL standards for underground piping systems and related categories. UL plans to formally incorporate specific requirements for flexible piping into UL 971 in 1997. In addition, UL has developed a listing program for vapor recovery pipe and vent pipe. If there is sufficient interest, UL will incorporate provisions for vapor recovery and vent pipe into UL 971 or a separate standard.[5]

Underwriters Laboratories of Canada (ULC) Listings

UL has a parallel organization in Canada known as Underwriters' Laboratories of Canada (ULC). In response to the need to evaluate flexible piping systems for use in Canada, ULC has developed what it calls "Other Recognized Documents" or "ORD." These documents describe a specific series of tests that are used to evaluate a product. These documents are developed within ULC and are reviewed by other inspection agencies, but have not undergone the rigorous outside committee review process required for a ULC Standard. ULC has developed the following three ORD's to evaluate flexible piping systems:

ULC/ORD-C107.4-1992	Ducted Flexible Underground Piping Systems for Flammable and Combustible Liquids
ULC/ORD-C107.19-1992	Secondary Containment of Underground Piping for Flammable and Combustible Liquids
ULC/ORD-C107.21-1992	Under Dispenser Sumps

In addition, ULC is developing a draft ORD (C107.14) intended to evaluate flexible piping systems which are to be directly buried. For more information on this draft ORD, refer to Appendix A of this survey.

Methyl Tertiary Butyl Ether (MTBE)

Although MTBE has been used as a blending component of gasoline since 1979, only in recent years has MTBE become widely used to raise the oxygen content of gasoline. This is primarily due to EPA requiring the use of oxygenated gasoline in many cities during the winter and summer months to reduce carbon monoxide pollution.[6] Because of the increase in use of MTBE, at least seven of the flexible piping

[5] *UL 971: An Evaluation of Flexible Piping,* Petroleum Equipment and Technology, July/August 1996.

[6] Information obtained from www.chevron.com/prodserv/gas_q&a/mtbe.html.

manufacturers included in this survey have tested their products for compatibility with MTBE.[7] Currently, MTBE is not designated as an official testing liquid in the UL 971 testing process. However, several manufacturers have requested and received UL and/or ULC testing for MTBE. Realize, however, that UL/ULC testing for MTBE does not imply that a particular product has undergone more rigorous testing and evaluation than a product that has been manufacturer tested. Table 4 summarizes the MTBE testing that each manufacturer has pursued to date.

Table 4. MTBE Testing Performed on Flexible Piping Systems To-Date

Manufacturer and Product	Testing Performed
Advanced Polymer Technology (Poly-Tech)	ULC Testing -- Primary and Secondary Piping
Ameron (Dualoy 3000/FLX II & 3)	Manufacturer Testing -- Primary Piping
Buffalo (Bufflex II)	*Unknown*
Containment Technologies (Perma-Flexx)	UL Testing -- Primary Piping, ULC Testing -- Primary and Secondary Piping
Environ (GeoFlex-S & GeoFlex-D)	UL Testing -- Primary and Secondary Piping
Titeflex Industrial Americas (Primeflex & Primeflex 20)	Manufacturer Testing -- Primary Piping
Total Containment (Enviroflex & Omniflex)	ULC Testing -- Primary and Secondary Piping (both products), UL Testing -- Secondary Piping (Enviroflex only)
Western FG (Co-Flex)	UL Testing -- Primary and Secondary Piping

Compatibility and Permeability

Compatibility and permeability are important characteristics of flexible piping systems, but the terms are often confused. Compatibility is the ability of a material to retain its physical properties when exposed to another substance. Permeability is a measure of the amount of a substance that migrates through a material over a given time period.

For example, polyethylene is compatible with petroleum products. This means that it does not significantly dissolve, degrade, or fall apart when in contact with petroleum products. However, polyethylene is relatively permeable to petroleum products. This means that the liquid level in a tightly sealed polyethylene container filled with gasoline would slowly decrease over time as gasoline molecules migrate through the walls of the container. A study sponsored by a fiberglass piping manufacturer indicated that a sample of corrugated polyethylene secondary containment piping filled with gasoline lost 39% of its weight over a period of 181 days (undated, untitled sales brochure by Ameron Fiberglass Pipe Systems).

Constructing flexible petroleum piping that is compatible with petroleum and alcohol liquids is

[7] It is unclear as to whether Buffalo Environmental has performed product testing for MTBE, because they did not provide an update on their products.

relatively easy. The most challenging aspect of constructing a flexible piping system has proven to be meeting the permeation standard of no more than one percent loss of liquid over a 180 day period that is used by both UL and ULC for primary piping. UL uses this same permeation test for secondary piping. The ULC ORD for secondary piping includes evaluations of compatibility but does not evaluate the permeability of the secondary piping.

CONCLUSIONS

Flexible piping technology has come into widespread use for dispensing motor fuels. Since 1995, the flexible piping industry has seen an approximately 50 percent increase in the number of system installations. With the increasing use of MTBE, several flexible piping manufacturers have performed product testing for MTBE, and some manufacturers have requested and received UL and/or ULC testing for MTBE. To date, problems with flexible piping systems have been limited to fungal decay of first generation polyurethane coated piping. The fungal decay is mostly cosmetic and does not cause product failure, however, one manufacturer (Total Containment) has changed its outer layer construction to polyethylene and is in the process of replacing the polyurethane piping. Most manufacturers are now marketing third and fourth generation products. Problems with these systems have been infrequent, and manufacturers have stood by their products. From an environmental protection standpoint, the performance of this technology to date has been excellent.

APPENDIX A

ADDITIONAL INFORMATION ON UL AND ULC LISTINGS AND UL 971 TEST REQUIREMENTS FOR FLEXIBLE PIPE

UNDERWRITERS LABORATORIES, INC. (UL) LISTINGS

Underwriters Laboratories in the United States has been the primary testing organization for underground petroleum piping systems. When a new product is presented to UL for testing, UL personnel review the product and determine a testing program. If demand warrants, the testing program may become more formally defined as a UL "Subject," which often serves as a preliminary "Standard." A UL "Standard" is created by review and evaluation of a "Subject" by interested parties to create a consensus document which is recognized as an "American National Standard" by the American National Standards Institute (ANSI).

Flexible piping is currently evaluated under UL Standard 971. Table A-1 presents a summary of the major test requirements required to obtain a UL 971 listing.

UNDERWRITERS' LABORATORIES OF CANADA (ULC) LISTINGS

Underwriters Laboratories of Canada is developing a draft ORD (C107.14) intended to evaluate flexible piping systems which are to be directly buried. In ULC terminology, secondarily contained ducted piping is the type where small diameter primary pipe (typically 1.5 or 2 inch) is installed inside a larger diameter (typically 4 inch) outer pipe. C107.4 is the appropriate ORD for ducted flexible piping. The C107.14 test protocol is also intended to test any single walled flexible piping buried directly in the ground. Although several manufacturers have had their products tested according to the proposed C107.14 test protocol, the document is still in draft form and could not be reviewed for this survey. C107.14 differs from C107.4 in that it includes the following additional tests: accelerated light and water test, low temperature drop test (-40°C), low temperature impact resistance test (-40°C), room temperature impact resistance, cyclic operation test (1,000 cycles at 50 psi), crush strength test, flattening test, burst strength test (650 psi) and an identification test.

READING A UL OR ULC LABEL

All products that have achieved a UL 971 or a ULC/ORD-C107.4 listing are not created equal. It is important to recognize that within each evaluation there are variables that a manufacturer can select, such as type of liquid for which the product is intended. For example, both UL and ULC listings may be for "petroleum products only" or for "petroleum products, alcohols, and alcohol-gasoline mixtures." These variables will be reflected only on the actual label that is affixed to the product. In other words, a UL 971 or ULC 107.4 listing does not automatically imply that a product is suitable for use with alcohol fuels. Alcohol compatibility and other qualifying statements can be determined only be reading the UL or ULC label affixed to the product.

Both UL and ULC listings are for "underground" piping. This means that it is assumed that the piping will be buried and not subject to fire exposure. Unless specifically tested for fire exposure, the UL and ULC listings for flexible piping do not apply to portions of flexible pipe that are exposed in underground sumps.

Table A-1. UL 971 Test Requirements

Test	Requirements
Permeability	Samples of primary and secondary pipe filled with representative liquids for 180 days shall not exhibit a rate of permeation greater than 4 g/m^2/day for primary piping and 24 g/m^2/day for secondary piping.
Air Oven Aging	Samples of primary and secondary pipe and fittings shall be subjected to air oven aging at 70°C (158°F) for 30, 90, and 180 days. Samples shall then be subjected to a crush-strength test, an apparent tensile-strength test, and an adhesive shear strength test. Samples exposed to air oven aging shall retain 80 percent of the physical properties of a sample not exposed to air oven aging.
Leakage	Samples of primary and secondary piping shall not leak when they are subjected to a hydrostatic pressure of two times the maximum rated pressure for a period of five minutes.
Hydrostatic Strength	Samples of primary piping shall not leak or be damaged when subjected to a hydrostatic pressure of five times the maximum rated pressure for a period of one minute.
Cyclic Pressure	Samples of primary piping and fittings shall not be damaged or leak when subjected to cyclic pressure conditions in accordance with ASTM D2143-69 (1987).
Immersion	Samples of primary and secondary piping will be immersed in Type A test liquids for 30, 90, 180, and 270 days and Type B test liquids for 30, 90, and 180 days. Samples of primary piping that have been immersed for 270 days in Type A liquids shall retain 50 percent of their properties, and samples of primary piping that have been immersed for 180 days in Type B liquids shall retain 30 percent of their properties. Samples of secondary piping that have been immersed for 270 days in Type A liquids shall retain 50 percent of their properties, and samples of secondary piping that has been immersed for 30 days in internal and 180 days in external Type B liquids shall retain 30 percent of their original properties. Systems of pipe and fittings shall undergo analogous testing.
Additional Tests for Primary and Secondary Piping: Torque Test, Bending-Moment Test, Bending Test, Drop-Test, Low-Temperature Drop Test, Ball-Impact Test, Low-Temperature Ball-Impact Test, and Crush-Strength Test.	