Evaluation of Hose-in-Hose Transfer Line Service Life

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Abstract: This document presents a determination for the amount of expected service life from Hose-in-Hose Transfer Lines based on vendor information and past HIHTL experience.

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EVALUATION OF HOSE-IN-HOSE TRANSFER LINE SERVICE LIFE

April, 2003

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EVALUATION OF HOSE-IN-HOSE TRANSFER LINE SERVICE LIFE

1.0 INTRODUCTION

Hose-in-Hose Transfer Lines (HIHTL) are used to convey waste to and from tanks in support of Interim Stabilization and Retrieval activities. HIHTLs consist of a nominal 2" diameter reinforced rubber primary hose inserted inside a nominal 4" diameter encasement hose. Each hose is fabricated from inner and outer Ethylene Propylene Diene Monomer (EPDM) rubber liners with steel wire and fabric reinforcement. The ends of hose assemblies are fitted with connections to make a joint, fit to a nozzle assembly, or allow for future connections. Prudent engineering dictates that the equipment used to transfer waste have a life in excess of the forecasted operational time period, with some margin to allow for future adjustments to the planned schedule. This document evaluates the effective service life of the Hose-in-Hose Transfer Lines, based on information submitted by the manufacturer, published literature and calculations.

The effective service life of transfer line assemblies is a function of several factors. Foremost among these are the hose material's resistance to the harmful effects of process fluid characteristics, ambient environmental conditions, exposure to ionizing radiation and the manufacturer's stated shelf life. In order to determine the transfer line service life this evaluation examines the certification of shelf life, the certification of chemical compatibility with waste, catalog information of ambient ratings and published literature on the effects of exposure to ionizing radiation on the mechanical properties of elastomeric materials. These certificates for each hose are located in the acceptance test report of vendor testing for the project which procured that hose.

During initial hose procurements, the hose-in-hose transfer line vendor River Bend Hose Specialty (RBHS) submitted a letter, dated 6/8/00, which recommended the service and shelf life of the hose to be seven years. In submittals for later hose procurements, RBHS submitted a letter, dated 11/6/00, which recommended the service life of the hose to be three years. This submittal was followed by documentation, on 2/14/01, which submitted new storage requirements and restated the seven year shelf life. RBHS revised their original hose service life estimate to a more conservative three years due to concerns over the effects of chemicals in transferred waste.

The above mentioned submittals from RBHS are the primary drivers of the three year service life limit established by this document. However, if the service life could be extended there would be substantial cost savings associated with future tank farms transfers to be done during the completion of Interim Stabilization and Retrieval operations. To extend the service life, further evaluation may be performed related to the effects of the tank waste on the hoses. Such an evaluation may serve to verify or extend the limit imposed by the vendor's recommendations. The following sections justify and define the three year service life and seven year shelf life.

2.0 EVALUATION

In conformance with the requirements of RPP-6028, Section 4.3, the manufacturer of transfer line assemblies, for CHG Contract Order 6911, has submitted information to support the evaluation of service life of the supplied material (non-trade name: Versigard). This information, enclosed in Appendix A, was submitted in the form of letters from the vendor, River Bend Hose Specialty (RBHS) of South Bend, IN, along with hose certificates and a catalog sheet. HIHTL specifications other than RPP-6028 are used to procure similar hose assemblies (i.e. RPP-14859), and contain the same requirements for documentation. Submitted documents are retained in an Acceptance Test Report (ATR) for each HIHTL project.

In addition, River Bend Hose Specialty's submittals have been supplemented by a letter from Granford Manufacturing (a subsidiary of the Goodyear Tire and Rubber Co.), the manufacturer of the primary components comprising transfer line assemblies. This letter, discussing chemical compatibility, is enclosed in Appendix B and is discussed in the following sections.

2.1 Ambient Conditions and Shelf Life

Appendix A includes RBHS's letter of 6/8/00 which specifies the shelf life of the EPDM hose used in the transfer line to be seven years from date of manufacture. An attachment to the letter, also included in Appendix A, provides guidelines for storage of the supplied hose, until it is assembled, to ensure it performs its intended function throughout that life.

River Bend Hose Specialty has also submitted a letter for storage and use of the completed hose-in-hose assembly for a seven year shelf life, included in Appendix A. This modifies some of the storage requirements provided by Granford Manufacturing to account for the differences obtained by assembling and shipping. The requirements differ after assembly because insulation is wrapped about the outer hose and the assembly is shipped on a reel with cardboard and plastic wrapped about the entire hose assembly. If all other storage conditions are met, the hose assembly may be stored outside for up to seven years, the shelf life. During use, protection from light is achieved by the transfer system shielding design, which blocks all natural sunlight. Ozone protection is achieved by not storing or installing the hose assembly near any large, ozone emitting, electrical equipment. Also, the waste to be transferred is not a known source of ozone. Finally, hoses should be protected from attack by insects and rodents. This protection is achieved by an on going site-wide pest management program, HNF-11170, *Integrated Biological Control* (Johnson, 2002).

The information in Appendices A and B allows the following conclusions. From the day that a transfer line is manufactured, the assembly must be deployed within seven years and not exceed three years of service. If the transfer line is installed and used within four years of the manufacturing date, it may transfer waste for up to a full three years. If the transfer line is stored for five years and then used it may only transfer waste for up to two years. The total number of years a transfer line is stored and used cannot exceed the seven year shelf life.

2.2 Process Conditions

Appendix A includes a copy of the catalog sheet (page A-10), which lists characteristics of the hose material (modified as tests prove the hoses's capabilities, from page A-7). Limiting values of process pressure and temperature in the documentation are equal to or exceed the values specified in procurement specifications (i.e. RPP-6028 & RPP-14859) see table 1 below. As such, material used in the manufacture of transfer lines referred to in this letter will not be degraded by exposure to process conditions related to temperature and pressure.

Table 1

	2" Inner Hose		4" Outer Hose	
	Required	Per Catalog	Required	Per Catalog
Working Pressure	375 psig	425 psig	170 psig *	250 psig
Working Temperature	-25 to 180°F **	-40 to 180°F	-25 to 180°F **	-40 to 180°F

* Value represents the most current hose design. The prior design had a 60 psig outer hose working pressure.

** Value represents the most current hose design. The prior design had a maximum working temperature of 130°F.

An additional consideration is that solids contained in the tank waste may cause abrasive erosion. However, rubber is commonly used in equipment, such as tires and pumps, that must withstand exposure to abrasive materials. Rubber has the ability to deform elastically under impact, which makes it ideally suitable to resist abrasive erosion. Published data contained in the Parker O-Ring Handbook rates EPDM as highly resistant to abrasive erosion, enclosed as Appendix E.

2.3 Chemical Compatibility

Appendix B includes an evaluation of chemical compatibility, prepared by the hose material manufacturer, Granford Manufacturing, Inc. This evaluation discusses chemical compatibility of the hose material and states that the subject hose material is compatible with waste concentrations defined in attached tables. These tables list worst case chemical concentrations for tank farms 241-S, 241-SX, and 241-U, as identified in CHG Interoffice Memorandums, file numbers 74B20-00-047 and 74B20-00-048, dated 8/11/00, issued by Data Development and Interpretation, and included as Appendix D to this document. This evaluation includes reference to published literature which indicates hose material is suitable for continuous duty under exposure to chemical concentrations and process temperatures which bound the application parameters defined in RPP-6028, Tables 3-1, 3-2 & 3-3.

Appendix D contains information in the form of CHG Interoffice Memorandums, on tank waste that EPDM hoses which have been evaluated and approved to transfer. For new waste analyses as long as the concentrations of compounds are lower than those previously analyzed we can conclude that EPDM hoses are suitable to transfer that waste. All waste concentrations are discussed with the hose manufacturer. Results are captured in the engineering evaluation, documented in the ATRs. An example of this is the effect of oxalic acid on EPDM, a chemical not present in significant quantities in previously analyzed tanks. Appendix G includes information accumulated from the manufacturer and independent parties on the use of EPDM in substantial amounts of oxalic acid. The information contained indicates that the exposure to oxalic acid will not have any detrimental effects on the hose under the current design.

Some waste compositions while not approved for continuous use may be approved by the manufacturer for intermittent use. If the hose is used to transfer this type of waste beyond the manufacturers recommendations the service life may be reduced. Appendix D contains information pertaining to the effects of organics in tank 241-C-103 as an example where intermittent use was recommended.

2.4 Resistance to Ionizing Radiation

The resistance of the specified material to deleterious effects resulting from exposure to ionizing radiation has been identified by researching published literature. Significant research into effects on elastomeric materials has been published by SteriGenics International, Inc., Chicago, IL. This firm is a recognized authority in the field of sterilization of medical instruments and has evaluated many materials for degradation of mechanical properties under the effects of ionizing radiation. Appendix C to this document is a printout of information on this topic downloaded from SteriGenics International's website at http://www.sterigenics.com/med/lit/library1.htm, August 8, 2000.

In Table 2 of Appendix C, EPDM is listed as having a tolerance level of 100 to 200 Kgray. Doses in excess of this amount may cause cross-linking and discoloration of the rubber material.

Cross-linking increases EPDM tensile strength and reduces elongation. Although the transfer line would experience some elongation from higher than normal internal pressures (eg. during potential unplugging), reduction of the extent of this elongation does not pose a hazard. An increase in EPDM tensile strength is a beneficial effect, essentially making the hose stronger. However, this effect is mitigated by a consequent reduction in flexibility. This embrittlement is the primary source of degradation due to radiation exposure of EPDM and results in the threshold values identified above. Material discoloration is a cosmetic effect, and though it may be a notable sign of radiation exposure, it has no impact on the transfer lines' ability to perform intended functions. It should be noted the strength of the transfer line comes from the 2 stainless steel wire helixes in the hose. Stainless steel is commonly used in tank farm equipment that contacts radioactive waste and should not experience degrading effects in this circumstance.

Converting the minimum threshold value of 100 Kgray to a time period requires assumption of an exposure dose rate. If we presume a very conservative (high) dosage resulting from exposure to any tank waste to be 100 Rad/hr (per CHG Radiological Engineering and RPP-6161 (Pierson, 2000)), the computation of exposure time to achieve threshold dose is as follows:

Method: threshold value divided by dose rate equals exposure time to reach threshold
Assumptions: Threshold value = 100 Kgray = $1x10^7$ Rad
Dose rate = 100 Rad/hr
So: ($1x10^7$ Rad) / (100 rad/hr) = 1×10^5 hrs.
Converting to years,
[(1×10^5 hours) / (24 hrs/day)] / (365 days/yr) = 11.41 years

2.5 Copper Tape and Heat Trace

In order to keep the waste from freezing and plugging the transfer line, heat trace has been applied to the outside of the primary or secondary hose. Copper tape is wrapped over the heat trace for improved conductivity and these are both covered with EPDM tape. The heat trace's chemical resistance is described as resistant to aqueous, organic, or inorganic chemicals and corrosives (See Appendix F). Therefore, the heat trace has no compatibility issues in the instance of a leak. The EPDM tape is the same kind of EPDM in the hoses, so there are no compatibility issues. The material safety data sheet (MSDS) for the copper tape is in Appendix F. This MSDS states that there are no potential hazards from using copper tape. Also, copper is a noble metal and hydrogen evolution is not usually part of the corrosion process, so no adverse reactions should occur, see Appendix F.

3.0 OTHER CONSIDERATIONS

The outer hose confines leaks from the inner hose and routes the waste to pits at either end for leak detection. Regulatory requirements specify such a leak must be detected within 24 hours. The chemicals in the waste do not affect the outer hose when there are no leaks since the hose material is not exposed to these constituents. Also, radiation exposure does not significantly harm the hose, primary or secondary, until 11 years has passed, longer than the shelf life. As indicated in Appendix A, the transfer line manufacturer's evaluation of service life of the transfer line is three years, due to continuous exposure of the inner hose to waste. If there are no leaks, the outer hose is essentially being stored, with protection from sunlight, ozone and pests. Since the outer hose is protected from the environment and does not contact waste unless a leak occurs, its service life can be evaluated as greater than the three year limit identified for the inner hose. In fact, should no leakage be detected during transfer operations, the outer hose itself may be considered to have a seven year service life from the time of manufacture.

The HIHTL consists of multiple components, primarily consisting of the inner hose, outer hose, heat trace, insulation and end fittings. The heat trace is wrapped about the inner hose to assist in maintaining the temperature of the waste so as to minimize the risk of plugging. The heat trace is qualified by test to ensure the heat input does not result in temperatures greater than the recommended temperature of the hose material. The insulation also assists in maintaining the process temperature of the waste. Insulation is applied about the outer hose and this contact has no impact on the hose material. End fittings are fabricated from stainless steel, complying with appropriate ASTM Standards and fabricated and tested in accordance with ASME B31.3. Based on extensive site experience, stainless steel components are known to be chemically compatible with the waste. Of the transfer line components, the inner hose is the limiting factor when considering service life. The transfer line is not designed for maintenance of the individual components and, as such, must be treated as an entire assembly.

4.0 CONCLUSIONS

Based on the information presented in the above sections and referenced documentation, we conclude the service life of the inner hose establishes the limits of service life for the finished assemblies. Since the process and environmental conditions to which the transfer line is subjected will not adversely affect the hose, the effective service life is that stated by the vendor - three years from the date of initial transfer. Transfer line assemblies have a shelf life of seven years from the date of hose manufacture, if stored in accordance with Section 2.1.

This evaluation provides documentation showing that a three year service life has been justified. In the event that transfer lines are to be operated after three years from the date of initial transfer and within the shelf life of seven years, they must be reevaluated for their ability to perform intended functions.

5.0 REFERENCES

Eagle, O. H., 2003, RPP-14456 Rev. 0, *Acceptance Test Report for Vendor Testing of Hose-in-Hose Transfer Lines for the 241-C-106 Retrieval Program*

Johnson, A. R., 2002, HNF-11170, Rev. 1, *Integrated Biological Control*

Parker Seal Group, *Parker O-Ring Handbook*, 1992.

Pierson, R. M., 2000, RPP-6161, Rev. 0, Radiological Design Review Screening - 241-SX-105 Hose-in-Hose Transfer System for the Interim Stabilization Program.

Reynolds, D. A., 2002, RPP-13448, Rev. 0, Organic Layer in Tank 241-C-103 in Relationship to Saltwell Pumping.

Torres, T. D. ,2000a, RPP-6153, Rev. 1, *Engineering Task Plan for Hose-in-Hose Transfer System for the Interim Stabilization Program*

Torres, T. D., 2000b, RPP-6028, Rev. 1, *Hose-in-Hose Transfer Lines for Hanford's Interim Stabilization Program.*

Torres, T. D., 2001a, RPP-6567, Rev. 1, *Acceptance Test Report for Vendor Acceptance Testing of Hose-in-Hose Transfer Lines.*

Torres, T. D., 2001b, RPP-6511, Rev. 1, *Acceptance Test Report for Acceptance Test Procedure for Hose-in-Hose Transfer Lines Secondary Encasements.*

Torres, T. D., 2001c, RPP-7642, Rev. 0, *Evaluation of Hose & Hose Assembly Service Life For SY-101 Cross Site Transfer.*

Torres, T. D., 2002, RPP-13554 Rev. 0, *Specification for Hose-in-Hose Transfer Lines for the 241-C-106 Retrieval Project.*

APPENDIX A

River Bend Hose Specialty Submittals

A - 2 to 7
River Bend Hose Specialty letter dated June 8, 2000
With attachments (Certificate for HIHTLs A through F
And specification sheet)

A – 8
River Bend Hose Specialty letter dated November, 6, 2000

A – 9
River Bend Hose Specialty Storage Requirements
From: J. Betz (River Bend Hose Specialty -- President)

A - 10
River Bend Hose, Safe-T Chem-Acid Transfer Hose, Catalog Sheet

June 8, 2000

CH2M-Hill Hanford Group
Richland, WA 99352
VIA FAX

Attention: Alice Hendrickson

Subject: CHG Contract 6911
Submittal information for engineering evaluations

Dear Ms. Hendrickson:

This letter, plus attachments, provides the information required for engineering evaluations, and is submitted pursuant to the requirements of your procurement specification, RPP-6028, Rev. 0A, Section 5.4

Static Dissipative Properties

The static dissipative properties of the hose utilized in manufacture of the specified transfer lines have been identified by the hose manufacturer - Le Manufacturier Granford, Inc., a subsidiary of the Goodyear Tire and Rubber Co. These properties have been identified by performance of a manufacturer's standard test.

The manufacturer's test and results demonstrating acceptable properties has been previously submitted to your organization during the manufacture of material under your contract 4069.

As indicated on the attached certificate of conformance provided by the manufacturer, the lots of hose procured for the subject contract include the requisite static dissipative properties. Should you require additional copies of the previously submitted material, please so advise.

Chemical Compatibility

The attached certificate of conformance provided by the hose manufacturer specifies that the hose material utilized on this project is chemically compatible with the fluid specified in RPP-6028, Rev. 0A, at the dilution levels recorded in Table 3-1 of that document. Other material exposed to the specified fluid has been furnished by CHG.

Design Life

The attached certificate of conformance specifies the shelf life of the hose material utilized on this project to be at least 7 years from the date of manufacture (April 1, 2000). The manufacturer has further certified the hose material is chemically compatible with the waste.

Published literature on the base material (EPDM) indicates it is suitable for use in with process temperatures in excess of 200 degr F. The second attachment to this letter is a copy of catalog information provided by the hose manufacturer. In it, the hose manufacturer has identified 180 degr F as the limit appropriate for EPDM hoses fitted with mechanically joined ends. As temperatures in excess of this limit result in degradation of joint strength and integrity (based on the current state of the art in joint design and the mechanical properties of EPDM hose at this temperature), 180 degr F is the maximum suitable operating temperature for ambient or process conditions. This value is well in excess of the 130 degr F ambient and process requirements, and the 155 degr F heat trace contact temperature, specified in RPP-6028.

The details of the planned installation prevent hose assemblies from being exposed to damaging UV radiation, thus removing this potentially limiting factor from consideration.

As no information has been provided as to the rate of exposure to ionizing radiation, we are unable to identify the serviceable life of the hose with respect to exposure to same.

In the absence of exposure to ionizing radiation, and since no other exposure specified in the procurement documentation is outside the capabilities defined by the hose manufacturer, we conclude the service life of the supplied material to be 7 years from date of manufacture (April 1, 2000). However, we make no warranty as to fitness of this material for any specified duration of operation, as ionizing radiation exposure remains undefined.

Materials Requirements

Evaluation information necessary to demonstrate materials requirements of the specification are complied with consists of the attached Goodyear certificate of compliance, which has been previously submitted for this contract, and the results of tests of physical characteristics related to pressure retention, tensile strength, and static dissipative properties.

Resistance to ambient environmental conditions

CHG's attention is directed to published literature on the environmental limitations of the base material - EPDM, and the information presented above regarding the determination of design life.

Thank you for the opportunity of bringing this information to your attention. Should you have comments or questions regarding the enclosed, please do not hesitate to contact me.

Regards,

James C. Betz

James C. Betz
President - River Bend Hose Specialty

Le Manufacturier Granford Inc.
(SUBSIDIARY OF THE GOODYEAR TIRE & RUBBER CO.)

127, RANG PARENT, ST-ALPHONSE DE GRANBY, QUÉ, J0E 2A0
TÉL.: (450) 375-5050 --- 1-800-363-8345 --- Fax: (450) 375-6254

CERTIFICATE

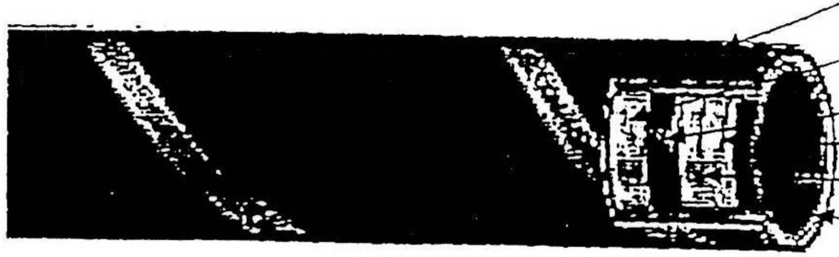
We hereby certify the component stated below were designed to the following characteristics :

TYPE	EPDM Suction and discharge hose
MANUFACTURER	Granford Manufacturing Inc./Goodyear
ADDRESS	127 Rang Parent, St-Alphonse de Granby
	Québec, J0E 2A0
	Canada
MODEL NAME	546-418-064 and 546-418-123

SPECIFICATIONS	
Hose application	Over ground transfer line used to transfer waste
Nominal bore diameter (mm)	51 and 102
Hose type	Static dissipating
Working pressure	375 psi (4:1 safety factor) for 51 mm hose 60 psi (5:1 safety factor) for 102 mm hose

Attachment #1 to RBHS/CHG LTR dated 6/8/00

Hose construction



Electrical properties

Versigard rubber compound used in this hose has an electrical resistance , when tested with an insulation tester at 500 V, of 10^4 to 10^5 ohms per feet.

Chemical compatibility

A literature check of the chemicals listed in table 3-1 (refer to attached fax), CHEMICAL CONSTITUENTS OF UNDILUTED WASTE, was done and revealed no compatibility issues at those dilution levels.

Component conformance

We certify that the tube and cover components of the hose items shipped per purchase order # S67995 (listed below) were built using EPDM (Versigard) rubber material coming from the following lot numbers:

Material Number	Specification Number	Description	EPDM Rubber Lot #	
			Tube	Cover
20077296	54641806400800	Langlois 2x80 S-037 EPDM S&D	78238	78238
20118226	54641806402000	Langlois 2x200 S-037 EPDM S&D	78238	78238
20118227	54641806402250	Langlois 2x225 S-037 EPDM S&D	85564	85564
20118228	54641806402500	Langlois 2x250 S-037 EPDM S&D	85564	85564
20118228	54641806402500	Langlois 2x250 S-037 EPDM S&D	85564	85564
20118229	54641806402750	Langlois 2x275 S-037 EPDM S&D	85564	85564
20077299	54641812300800	Langlois 4x80 S-037 EPDM S&D	78238	85564
20118690	54641812302000	Langlois 4x200 S-037 EPDM S&D	78238	85564
20118691	54641812302250	Langlois 4x225 S-037 EPDM S&D	85564	85566
20118692	54641812302500	Langlois 4x250 S-037 EPDM S&D	85564	85564
20118692	54641812302500	Langlois 4x250 S-037 EPDM S&D	85564	85564
20118693	54641812302750	Langlois 4x275 S-037 EPDM S&D	85566	85566

~~Attachment~~ #1 to RBHS/CHG LTR dated 6/8/00

Shelf Life

The estimated shelf life for Goodyear EPDM Suction and Discharge hose, manufactured under purchase order #S67995, is seven (7) years from the date of manufacture (April 1 2000), unless otherwise specified by Goodyear.

Rubber hose products in storage can be affected adversely by temperature, humidity, ozone, sunlight, oils, solvents, corrosive liquids and fumes, insects, rodents and radioactive materials. In order to prevent such detrimental effects, the following guidelines should be observed:

- Hose should not be piled or stacked to such an extent that the weight of the stack creates distortions on the lengths stored at the bottom.
- Hose which is shipped in coils should be stored so that the coils are in a horizontal plane.
- Whenever feasible, rubber hose products should be stored in their original shipping containers, especially when such containers are wooden crates or cardboard cartons which provide some protection against the deteriorating effects of oil, solvents and corrosive liquids: shipping containers also provide some protection against ozone and sunlight.
- Certain rodents and insects will damage rubber hose products, and adequate protection from them should be provided.
- The ideal temperature for the storage of rubber products ranges from 50 to 70F (10 – 21C) with a maximum limit of 100F (38C). If stored below 32F (0C), some rubber products become stiff and would require warming before being placed in service. Rubber products should not be stored near sources of heat such as radiators, base heaters, etc., nor should they be stored under conditions of high or low humidity.
- To avoid the adverse effects of high ozone concentration, rubber hose products should not be stored near electrical equipment that may generate ozone or be stored for any lengthy period in geographical areas of known high ozone concentration.
- Exposure to direct and reflected sunlight even through windows should be avoided. Uncovered hose should not be stored under fluorescent or mercury lamps which generate light waves harmful to rubber.
- Storage areas should be relatively cool and dark, and free of dampness and mildew.
- Items should be stored on a first-in, first-out basis, since even under the best of conditions, an unusually shelf life long could deteriorate certain rubber products.

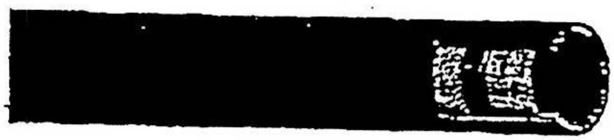
CERTIFICATION	
Signed	*(signature)*
Name	Pascal Langlois
Title	Process / R&D Engineer
Date	Thursday, April 06, 2000

Attachment #2 to RBHS/CHG LTR dated 6/8/00

S-037 EPDM
SUCTION & DISCHARGE

GOODYEAR

CHEMICAL TRANSFER HOSE



APPLICATION: Goodyear's S-037 is designed for use in tank truck or in plant applications for the transfer of industrial chemicals, sludge and sediments. It is not recommended for petroleum products.

CONSTRUCTION:

TUBE: Black Versigard

REINFORCEMENT: 4-spiral plied synthetic fabric with 2-wire helix

COVER: Black Versigard (Wrapped impression)

TEMPERATURE: -40°F to 180° (-40° C to 82°)

PACKAGING: 100' exact length, coiled, polywrapped

COUPLINGS: Contact fitting manufacturer for proper fitting recommendation and coupling procedure.

NON-STOCK/ SAMPLES: 400' minimum order for color change or special branding

ORDER CODES: 546-418

NOM. ID	NOM. OD	MAX. WP	BEND RADIUS	VACUUM HG	WEIGHT
in.	in.	psi	in.	In.	lb./ft.
2	2.75	375	8	29	1.62
3	3.80	300	12	29	2.73
4	4.90	200	16	29	3.79

Note: Refer to the Goodyear Chemical Resistance Chart for Specific Chemical and Temperature Compatibility.

River Bend hose specialty

1111 South Main Street
South Bend, IN 46601
(219) 233-1133
Fax (219) 282-2244

November 6, 2000

Gary Sandall
CH2M-Hill Hanford Group
Richland, WA 99352

Subject: CHG Contract 8971

This letter provides the information required for engineering evaluations, and is submitted pursuant to the requirements of your procurement specification, RPP-6028 Rev.1 Sections 5.4 & 4.3

Static Dissipating Properties Section 3.2.6

The Versigard rubber compound for the tube and cover used in this hose has an electrical resistance, when tested with an insulation tester at 500V, of 10^4 to 10^5 ohms per foot.

Chemical Compatibility Section 3.2.7

A literature check of the chemicals listed in table 3-3 revealed no compatibility issues at those dilution levels.

Design Life Section 3.2.7

It is necessary to look at a number of factors in this application including chemical reaction of mixtures to the rubber compound in determining design life. This needs to be combined with retention at elevated temperature and pressure. Also to be considered is the unknown effect of exposure to ionizing radiation and the normal reduction in physical properties over time. We find it difficult to give a concrete number. Therefore, we think that three years is the maximum time this hose should be in service. As with previous orders we make no warranty relating to this time factor, as we have no long term data concerning this application.

River Bend Transfer Systems, LLC

1840 TERMINAL DRIVE
RICHLAND, WA 99352

PHONE: (509) 943-4673
FAX: (509) 943-8875

UNPACKING AND STORAGE RECOMMENDATIONS HOSE IN HOSE TRANSFER LINES

1. Use care in unwrapping plastic and cardboard to avoid damage to hose.
2. If a spindle is used to unroll hose, some provisions must be made to slow the reel as it unwinds, as the tendency will be for the hose to roll off quickly.
3. Never tug on or pull Transfer Line Assemblies by the ends alone. Use a choker strap at some point along the hose length.

The estimated shelf life for the Hose in Hose Transfer Line Assembly is seven (7) years from the date identified as the date of manufacture unless otherwise specified.

Rubber hose products in storage can be affected by environmental elements. In order to prevent detrimental effects, the following guidelines should be observed:

- Hose should be stored as shipped, on reel, in either a vertical or horizontal position.
- Whenever feasible, the Transfer Line should be stored in its original shipping/packing materials so that plastic wrapping and cardboard covering will provide some protection against possible deteriorating elements.
- Hose ends should be kept covered to avoid infestation by rodents or insects that could conceal themselves on the inside of the hose.
- The ideal temperature for storage of the Transfer Line ranges from 30 to 70 F, although intermittent seasonal ambient temperatures from -30 to 120 F will not be destructive to the hose. If stored below 32 F, the Transfer Line may become stiff and could require warming before being placed in service.
- Exposure to direct and reflected sunlight should be avoided.
- If the Transfer Line is to be stored outside, the packing/shipping material should be intact and the Transfer line should be covered with a tarpaulin or other protective covering.
- If the Transfer Line is exposed to the sun for a prolonged period, a section of hose should be inspected for deterioration every two years.
- Optimum storage area is in a covered area that is cool and dark, and free of dampness and mildew.

River Bend Transfer Systems, LLC

Safe-T Chem-Acid Transfer Hose

APPLICATION: Safe-T Chem-Acid Transfer is a versatile premium high pressure hose developed to handle a wide range of industrial chemicals, acids, sludge and sediments in both suction and discharge service. This strong and durable hose will find many uses in the transfer of a wide range of chemicals at elevated temperatures and higher than normal pressures. Safe-T Chem-Acid Transfer was developed to accomodate the transfer of hazardous chemicals and chemical waste. The hose design will allow it to be used as a hose-in-hose assembly to be used in place of a double wall containment pipe. With state and federal regulatory agencies insisting on safe and dependable handling of chemicals and chemical waste, this hose will exceed the demands of the chemical industry. It is not recommended for refined petroleum products.

CONSTRUCTION:
- **TUBE:** Black Versigard * (EPDM)
- **REINFORCEMENT:** 4-spiral plied synthetic fabric with 2-wire helix
- **COVER:** Black Versigard (Wrapped impression)

TEMPERATURE: -40°F to 180° (-40° C to 82°)

PACKAGING: Custom Lengths Only (400 ft. Minimum)

NOM. ID	NOM. OD	MAX. WP @ 70°	BEND RADIUS	VACUUM HG	WEIGHT
in.	in.	psi	in.	in.	lb./ft.
1 1/2	2.25	450	7	29	1.31
2	2.75	425	8	29	1.62
2 1/2	3.30	375	15	29	2.10
3	3.75	375	18	29	2.45
4	4.90	250	16	29	3.79
5	5.90	200	30	29	5.86
6	6.91	200	36	29	6.08
8	9.00	150	44	29	9.14

*Versigard is a Registered Trademark of Goodyear Tire and Rubber
Note: Refer to the Goodyear Chemical Resistance Chart for Specific Chemical and Temperature Compatability.

APPENDIX B

Granford Mfg., Inc. letter dated August 17, 2000
From: Pascal Langlois (Granford Mfg. Process Engineer)
To: J.R. Buchanan (COGEMA Engr Corp. - Design Agent)

LE MANUFACTURIER GRANFORD INC.
127, rang Parent – St-Alphonse de Granby (Québec) Canada J0E 2A0
tel.: (450) 375-5050 ext. 256 | fax: (450) 375-6[illegible]

FAX

Date :	August 17, 2000
To :	Joseph R. Buchanan / Jeff Barnes
Company :	Cogema Engineering
Fax :	509-376-3383
From :	Pascal Langlois

3 Pages (including front page)

Subject : Chemical resistance

Mr. Buchanan, Mr. Barnes;

Per your request, here is the evaluation of the Versigard S&D hose with the chemicals listed in tables 1 and 2 (attached).

First, here is a summary of the application operation parameters:

Temperature:	Waste =	80-155 F
	Rinse water =	140-160 F
	Maximum =	180 F (authorization basis)
Pressure:	waste =	0-100 psig
	rinse water =	100 psig
	maximum =	375 psig

- The hose (2" ID) will, the majority of the time, be conveying waste at a temperature ranging from 80 to 155 F and at a pressure of 0 to 100 psig. It is estimated that waste pumping will occur 60% of the time. Also, waste will be diluted 1:1 with water prior to being conveyed through the hose; so actual chemical concentrations inside the hose will be half of what is described in tables 1 and 2 attached.

- Intermittently and for short periods of time, the hose will be subjected to higher temperatures (140 up to 160 F) and increased pressure (100 psi); this will happen when enduser may want to use hot rinse water to clean out a tank and the line to minimize the formation of salts and line clogging.

LE MANUFACTURIER GRANFORD INC.
327, rang Parent - St-Alphonse de Granby (Québec) Canada J0E 2A0
tel.: (450) 375-5050 ext. 256 - fax: (450) 375-6254

- In extraordinary situations and for short periods of time, the hose can be subjected to very high temperature (180 F) and working pressure (375 psig); this will happen if the hose is clogged due to salt formation and accumulation in the hose and enduser wants to unclog the hose.

Considering the waste listed in tables 1 and 2, sodium hydroxide is considered as the most detrimental constituent to the hose compounds because of it's superior concentration compared to the other constituents and highly corrosive nature. The other constituents may also degrade the hose compounds but it is anticipated that this degradation would be to a lesser degree because concentrations are significantly lower than that of sodium hydroxide.

Considering sodium hydroxide alone, our chemical resistance data shows that EPDM may be used for continuous service with this chemical at up to 50% concentration and 150 F (ref. Goodyear chemical resistance chart - Catalog #99-130). Goodyear does not have chemical resistance data on mixtures similar to those listed in tables 1 and 2.

Other chemical literature (Chemical resistance guide for Elastomers – 1988 edition) gives an "A" rating to EPDM with sodium hydroxide in solution (under 15% concentration) up to 250 F. An "A" rating in this literature is described as "Excellent, little or no swelling or softening or surface deterioration". Again, no chemical resistance data was found in this literature for mixtures similar to those listed in tables 1 and 2.

So, taking into consideration the actual waste concentration levels conveyed in the hose, the general operating parameters, the intermittent operating parameters, the extraordinary operating parameters and the chemical resistance data, the Versigard S&D hose should meet these application parameters.

It must be mentioned however that the compounds comprised in a rubber hose put in application will normally age over time and show a reduction in physical properties characteristic of most rubber compounds. Also, for lack of experimental data, we cannot predict how long the hose will last in this particular application. Finally, as we discussed, we cannot comment on any coupling retention issues as we have no experimental data on this particular hose assembly and we do not perform the coupling assembly at the plant

Best regards,

Pascal L

Pascal Langlois
Process/R&D Eng.

Attachment to FAX transmission dated 8/14/00 from J.R. Buchanan – COGEMA Engr. to P. Langlois – Granford Manufacturing

Table 1. Chemical Constituents of Undiluted Waste – 241-U Farm

Chemical Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Sodium Hydroxide[2]	83.0	83,000	116,000
Ammonia	1.29	1,290	1,800
Total Organic Carbon	34.6	34,600	48,400
Organic Constituent			
Acetate	1.10	1,100	1,540
Formate	9.57	9,570	13,400
Glycolate	8.71	8,710	12,200
Iminodiacetate	2.20	2,200	3,080
Nitrilotriacetate	0.957	957	1,340
Oxalate	7.36	7,360	10,300

Notes:

[1]Calculated assuming a specific gravity of 1.4

[2]Based on hydroxide analysis

Table 2. Chemical Constituents of Undiluted Waste – 241-S/SX Farm

Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Sodium Hydroxide[2]	156	156,000	211,000
Ammonia	1.33	1,330	1,800
Total Organic Carbon	4.75	4,750	6,410
Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Acetate	2.03	2,030	2,740
Formate	2.17	2,170	2,930
Glycolate	0.739	739	998
Oxalate	7.93	7,930	10,700

Notes:

[1]Calculated assuming a specific gravity of 1.35

[2]Based on hydroxide analysis, with a conversion factor of 2.35

Material trade name: Versigard (EPDM) RBHS P.O. Number: S67995

Mfr Lot nos:	20077296	20118226	20118227	20118228	20118229
	20077299	20118690	20118691	20118692	20118693

APPENDIX C

SteriGenics International Inc.
Irradiation Processing Technology-Materials Consideration

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http://www.sterigenics.com/med/lit/library1.htm

Irradiation Processing Technology
Materials Considerations

Radiation's Effects. Radiation interacts with polymers in two basic ways: *chain scission*, which results in reduced tensile strength and reduced elongation; and *crosslinking*, which results in increased tensile strength and reduced elongation.

Both reactions occur simultaneously. One, however, is usually predominant, depending upon the polymer and additives involved. Chain scission has been shown to affect stressed polymers (containing residual molding stress) more than other polymers. The combined effect of solvent-induced stress, residual molding stress, and applied load act to intensify radiation damage. This may account for the wide differences in radiation tolerance reported.

Generally, polymers which contain aromatic ring structures (e.g. polystyrene) are resistant to radiation effects, whereas the aliphatic polymers exhibit varying degrees of radiation resistance depending upon their levels of unsaturation and substitution.

The manufacturer's attention should focus on the possible effect of radiation on mechanical properties such as tensile strength, elastic modulus, impact strength and elongation. Each may influence the device's performance and, therefore, should be evaluated by functional testing. Some effects of radiation, such as reduced elongation due to chain scission, may detract from the device's performance. In other cases, the effects of radiation can be beneficial. For example, crosslinking of polyethylene and silicones increases their tensile strength.

Radiation Stabilizers and Additives. Color change is another effect of radiation. While not related to changes in other physical properties, coloration may be relevant to market reaction to the product. Most polymer manufacturers have addressed this subject by using color-compensated materials or special additives which minimize radiation-induced color changes.

Additives are usually included in small amounts (less than 1%) in commercial polymer products. Their primary purposes are: to aid in processing; to stabilize the material; and to impart particular properties to the product.

Radiation stabilizers have been developed and are now available for many polymers. For example, tint-based, multi-function stabilizers are now commonly used to counteract PVC's typical color change due to irradiation. Other additives, called antirads which usually act as antioxidants, help prevent radiation damage.

These additives can act either as reactants, which readily combine with radiation-generated free radicals within the polymer, or as primary energy absorbers, preventing the interaction of the radiation energy with the polymer itself.

Material Evaluation. When evaluating the radiation stability of a polymer and the ultimate success of a component or medical device, the following should be taken into consideration:

- *Stabilizers and antioxidants added to a polymer can reduce the effects of irradiation on the device's mechanical properties and/or physical appearance*;

- *Thin part sections, thin films, and fibers present in a component or device can allow for excessive oxygen exposure during the irradiation process, thus causing degradation of the polymer material*;

- *Residual mold stress present after molding and assembly of a component or device can promote molecular scissioning during irradiation*;

- *Highly oriented moldings which are strong in the axis of orientation but are already very weak in the cross-flow axis become weaker after irradiation; and*

- *High molecular weight polymers having low melt flow will survive radiation better by providing longer molecules and stronger parts before and after irradiation.*

Table 2, "Radiation Tolerance Levels of Polymers Used For Medical Applications" provides a general reference of the commonly used polymers for medical devices and their typical characteristics following irradiation. However, it is important to remember that not all brand products share these common characteristics.

For some materials and products that are sensitive to oxidative effects such as low molecular weight polypropylene, polytetrafluorethylene and polyacetals, radiation tolerance levels for electron beam (e-beam) exposure may be slightly higher than for gamma exposure. This is due to the higher dose rates and shorter exposure times of e-beam irradiation compared to those of gamma irradiation, which reduce the degradative effects of oxygen. However, most materials have good oxidative resistance and retain physical properties equally well regardless of the radiation source, as the references by Ishigaki and Hermanson have demonstrated. Comparison of radiation's effects for e-beam with gamma is not easily accomplished unless product-specific characteristics, which include part thickness, volume of product, molecular weight, scission to cross-link ratio, oxygen sensitivity, use of antioxidants and aging effects, are known and entered into the evaluation.

Material Compatibility and Validation. Each polymer reacts differently to ionizing radiation. Thus, it is important to verify that the maximum administered dose will not have a detrimental effect on the device's function or the patient's safety over the products' intended shelf life.

Experimental samples of the product should be irradiated to at least the highest dose to be encountered during routine processing. For example, a product which is to receive a sterilizing dosage of 25 to 40 kiloGrays should be tested by dosing samples to at least 40 kiloGrays. A conservative approach is to irradiate samples at doses up to twice the anticipated maximum dose.

Since various device applications call for certain performance properties or functional characteristics, it is important to test each device in an appropriate manner, using both new and aged product.

Table 1 reviews typical tests of physical properties. Other tests, which more closely approximate the actual mechanical application, may also be employed by the engineering or research staff.

Results of the evaluation should be retained in the device history file, serving as physical confirmation that all product claims and specifics have been met. If product testing indicates a potentially adverse effect from high levels of radiation, a maximum permissible dose should be established by the manufacturer and emphasized in the specific processing instructions to the contract sterilizer.

Table 1. Physical and Functional Test Methods for Plastics Material Evaluation

TEST METHOD	TEST REFERENCES
TEST FOR EMBRITTLEMENT	
1. Tensile properties	
a) Tensile strength	ISO/R 527:1966
b) Ultimate elongation	ISO/R 527:1966
c) Modulus of elasticity	ISO/R 527:1966
d) Work	ISO/R 527:1966
2. Flexural properties	
a) Flange bending test	"Stability of Irradiated Polypropylene 1. Mechanical Properties", Williams, Dunn, Sugg, Stannet, Advances in Chemistry Series, No. 169, Stabilization and Degradation of Polymers, Eds. Allara, Hawkins, pp. 142-150, 1978.
b) Flexbar test	ISO 178:1975
3. Impact resistance	1985 ASTM Standards, Vol. 08.01-Plastics, D-1822-84
4. Hardness	
a) Shore	ISO 868:1985
b) Rockwell	1985 ASTM Standards, Vol. 08.01-Plastics, D-785-65
5. Compressive strength	ISO 604:1973
6. Burst strength	1985 ASTM Standards, Vol. 08.01-Plastics (Tubing), D-1180-57
7. Tear strength	1985 ASTM Standards, Vol. 08.01-Plastics, D-1004-66, and ISO 6383/1-1983
TEST FOR DISCOLORATION	
1. Yellowness index	1985 ASTM Standards, Vol. 08.02-Plastics, D-1925-70
2. Optical spectrometry	1985 ASTM Standards, Vol. 08.02-Plastics, D-1746-70

NOTE - Source: International Atomic Energy Agency. *Guidelines for industrial radiation sterilization of disposable medical products. Co-60 gamma irradiation*. TEC DOC-539. Vienna IAEA, 1990.

Table 2. Radiation Tolerance Levels of Polymers Used for Medical Application

MATERIAL	TOLERANCE LEVEL (kGy)	COMMENTS
Elastomers 1		
Butyl	50	Sheds particulate after irradiation.
Ethylene-Propylene Diene Monomer (EPDM)	100-200	Crosslinks, yellows slightly.
Fluoro Elastomer	50	Avoid multiple sterilization.
Natural Rubber (Isoprene)	100	Very stable with sulfur or resin cure systems. Avoid stressing product by not bending, folding or wrinkling in packaging.
Nitrile	200	Avoid multiple sterilization.
Polyacrylic	50-200	Avoid multiple sterilization.
Polychloroprene (Neoprene)	200	Avoid multiple sterilization.
Silicones (Peroxide & Platinum Catalyst Systems)	50-100	Crosslink density increases more in peroxide systems than in platinum systems. Silicones retain a slight memory of coiling shape in packaging.
Styrene-Butadiene	100	Avoid multiple sterilization.
Urethanes	100-200	Wide variations in urethane chemistry applied to medical devices. Requires testing of part process and geometry to validate.
Thermosets		All thermosets as a class are highly resistant.
Allyl Digylcol Carbonate (Polyester)	5,000-10,000	Retains clarity.
Epoxies	1,000	Many good formulations available. Test the formulation selected for use. Frequently substituted for toxic solvents in assembly. Success depends on joint design and application process.
Phenolics	50,000	
Polyesters	10-1,000	Use of glass and other fillers improves physicals.
Polyurethanes	100-1,000	Wide formulation variations for urethanes. Dose tolerance depends on monomers used in formulation. Minimum 100-1,000 kGy are tolerated for thermosets.
Thermoplastics		
Acrylonitrile/Butadiene/Styrene (ABS)	1,000	Protected by Benzene ring structure. Butadiene impact modifier degrades above 100 kGy. Avoid high dose on high impact grades.
Aromatic Polyesters (PET, PETG)	1,000	Very stable, retains excellent clarity. Drying is essential. Good in luer connectors.
Cellulosics		
Esters and Ethers	50	Thin films and fibers embrittle above 50 kGy.
Paper, Card, Corrugated Fibers	100-200	Papers discolor and embrittle, but are acceptable for single use.

Cellulose Acetate Propionate and Butyrate	50	Plasticized versions slowly embrittle above 50 kGy.
Fluoropolymers		
Tetrafluoroethylene (PTFE)	5	Liberates fluorine gas, disintegrates to powder. Avoid use.
Polychlorotrifluoroethylene (PCTFE)	200	
Polyvinyl Fluoride	1,000	
Polyvinylidene Fluoride (PVDF)	1,000	
Ethylene-Tetrafluoroethylene (ETFE)	1,000	
Fluorinated Ethylene Propylene (FEP)	50	
High Performance Engineering Resins	1,000-10,000	Substitutes for metal, these resins have high strength and good elongation that tolerate radiation well. Resins include nylon, polycarbonate, ABS, polysulfone, polyester, polyether ketone, liquid crystal polymer, polyetherimide, polyimide, and others.
Polyacetals (Delrin, Celcon)	15	Avoid use due to embrittlement.
Polyacrylics		
Polymethylmethacrylate	100	Yellows at 20-40 kGy; clarity recovers partially on aging.
Polyacrylonitrile	100	Yellows at 20-40 kGy.
Polyacrylate	100	Yellows at 20-40 kGy.
Polycyanoacrylate	200	Many good formulations. Adhesives function at 100 kGy with less than 30% degradation.
Polyamides (Nylons)		
Aliphatic & Amorphous Grades	50	Discolors, no resterilization. Avoid thin films and fibers. Nylon 11 and 12 perform better. Dry before molding.
Aromatic Polyamide-imide	10,000	High heat/strength grade. Stabilized by Benzene ring structure.
Polycarbonate	1,000	Discolors, clarity recovers after aging. Dry before molding.
Polyethylene (LDPE, LLDPE, HDPE, UHMWPE)	1,000	Crosslinks to gain strength, loses some elongation. All polyethylenes tolerate radiation well. Low density is most resistant. HDPE packaging film including spin-bonded porous packaging may lose 40-50% elongation at doses of 50 kGy. Implants of UHMWPE have reports of early wear at 50 kGy.
Polyimides	10,000	
Polymethylpentene	20	Subject to oxidation degradation. Avoid use.
Thermoplastics, cont'd		
Polyphenylene Sulfide	1,000	
Polypropylene, Radiation Stabilized		Higher tolerance levels reported using e-beam.

	Homopolymer	20-50	Used with marginal success in syringes. Subject to orientation and oxidation embrittlement. Degrades over time. Validate with real time aging. Avoid use of non-stabilized Polypropylene.
	Copolymers of Propylene-Ethylene	25-60	More stable than Homopolymer. Successful in syringe applications using suitable stabilizer package.
	Polystyrene	10,000	All styrenes are stabilized by Benzene ring structure.
	Polysulfone	10,000	Amber color before irradiation.
	Polyurethane, polyether and polyester	100-200	Excellent physicals and chemical resistance to stress-cracking.
	Rigid and flexible		Drying is essential to success. Good in luer connectors. All types show irreversible yellowing.
	Polyvinylbutyral	100	Yellows.
	Polyvinylchloride (PVC)	100	Yellows, can be tinted for color correction. Success depends on quality of material, formulation and processing. Tubing crosslinks becoming slightly stiffened.
	Polyvinylidene Chloride (PVDC)	100	Yellows, releases HCL.
	Styrene/Acrylonitrile (SAN)	1,000	Yellows at 40 kGy.

NOTE RE ELASTOMERS:

1. Radiation tolerance is affected by the base polymer and the curing system used. Sulfur and resin cures are more durable.
2. All elastomers are subject to crosslinking in the shape packaged during sterilization and can be expected to take on a memory of that shape. Avoid folds, coils, curves.

Where a range of dose is listed the lower number is the threshold of damage where the first change in physical properties can be detected (all radiation is cumulative). Where conflicting data is presented in the literature, the lower, more conservative dose has been selected.

References: This datasheet includes information from Polymer Manufacturers Data Sheets, SPE Encyclopedia of Plastics, Handbook of Polymer Plastics, SPE Monographs and the following articles and literature, in conjunction with expert review from independent plastics consultant James A. Stubstad.

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APPENDIX D

INTEROFFICE MEMO

CH2MHILL
Hanford Group, Inc.

From:	Data Development and Interpretation	74B20-00-047
Phone:	373-1027	
Date:	August 11, 2000	
Subject:	CHEMICAL CHARACTERISTICS FOR LIQUID WASTE IN U TANK FARM	

To:	C. E. Hanson	S7-70
Copies:	G. A. Barnes	S7-70
	J. R. Buchanan	S7-70
	J. G. Field	R2-12
	L. A. Fort	R2-12
	W. F. Zuroff	S7-24
	LMS File/LB	

References:

(1) "Sample Analysis/Tank Results RPP-241," available on the Tank Characterization Database at http://twins.pnnl.gov/data/datamenu.htm, dated, August 9, 2000.

(2) RPP-6028, "Specification for Hose in Hose Transfer Lines for Hanford's Interim Stabilization Project," Rev. 0, dated April 3, 2000.

The purpose of this memo is to document the bounding chemical concentrations of the liquid waste in tanks 241-U-106, 241-U-107, 241-U-108, and 241-U-111 for the Interim Stabilization Project procurement specification of a hose-in-hose transfer line for use on these tanks (Reference 2). The chemical constituents for which these concentrations were requested are: sodium hydroxide, ammonia, organic carbon, and organic compounds.

Table 1 lists the highest observed concentrations of sodium hydroxide and total organic carbon in liquid waste samples from tanks 241-U-106, 241-U-107, 241-U-108, and 241-U-111 (Reference 1 and Attachment). Table 2 lists the highest concentrations of specific organic compounds observed in these samples. Because of limited ammonia data for these tanks, the ammonia value in Table 1 is taken from the highest ammonia concentration observed in liquid waste samples from tanks containing wastes similar to the wastes in tanks 241-U-106, 241-U-107, 241-U-108, and 241-U-111. Other than the organic compounds listed in Table 2, there are no organic analysis data available for tanks 241-U-106, 241-U-107, 241-U-108, 241-U-111 or for tanks containing similar wastes.

Table 1. Chemical Constituents of Undiluted Waste

Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Sodium Hydroxide[2]	83.0	83,000	116,000
Ammonia	1.29	1,290	1,800
Total Organic Carbon	34.6	34,600	48,400

Notes:
[1]Calculated assuming a specific gravity of 1.4
[2]Based on hydroxide analysis

C. E. Hanson
Page 2
August 11, 2000

Table 2. Organic Compounds Identified

Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Acetate	1.10	1,100	1,540
Formate	9.57	9,570	13,400
Glycolate	8.71	8,710	12,200
Iminodiacetate	2.20	2,200	3,080
Nitrilotriacetate	0.957	957	1,340
Oxalate	7.36	7,360	10,300

Note.
[1]Calculated assuming a specific gravity of 1.4

If there are any questions regarding this information, please contact me at 373-1027 or Mr. J. G. Field, on 376-3753.

L. M. Sasaki, Engineer II
Data Development and Interpretation

dmn

Attachment

CH2MHILL
Hanford Group, Inc.

INTEROFFICE MEMO

From:	Data Development and Interpretation	74B20-00-048
Phone:	373-6343	
Date:	August 11, 2000	
Subject:	CHEMICAL CHARACTERISTICS FOR LIQUID WASTE IN S AND SX TANK FARMS	

To:	C. E. Hanson	S7-70
cc:	G. A. Barnes	S7-70
	J. R. Buchanan	S7-70
	J. G. Field	R2-12
	L. A. Fort	R2-12
	W. F. Zuroff	S7-24
	TLL File/LB	

References: (1) "Sample Analysis/Tank Results RPP-241," available on the Tank Characterization Database at http://twins.pnl.gov/data/datamenu.htm, dated August 9, 2000.
(2) RPP-6028, "Specification for Hose in Hose Transfer Lines for Hanford's Interim Stabilization Project," Rev. 0, dated April 3, 2000.

The purpose of this memo is to document the bounding chemical concentrations of the liquid waste in tanks 241-S-101, 241-S-107, 241-S-109, 241-S-111, 241-S-112, 241-SX-101, 241-SX-102, 241-SX-103, and 241-SX-105 for the Interim Stabilization Project procurement specification of a hose-in-hose transfer line for use on these tanks (Reference 2). The chemical constituents for which these concentrations were requested are: sodium hydroxide, ammonia, organic carbon, and organic compounds.

Table 1 lists the highest observed concentrations of ammonia, sodium hydroxide and total organic carbon in liquid waste samples from tanks 241-S-101, 241-S-107, 241-S-109, 241-S-111, 241-SX-101, 241-SX-102, 241-SX-103, and 241-SX-105 (Reference 1). Analytical data from tank 241-S-112 was not available, however the waste in tank 241-S-112 is well represented by the values of the other tanks listed. Table 2 lists the highest concentrations of specific organic compounds observed in these samples. Other than the organic compounds listed in Table 2, there are no organic analysis data available for tanks 241-S-101, 241-S-107, 241-S-109, 241-S-111, 241-SX-101, 241-SX-102, 241-SX-103, and 241-SX-105 or for tanks containing similar wastes. The average specific gravity of 1.35 measured for tanks 241-S-101, 241-S-107, 241-S-109, 241-S-111, 241-SX-101, 241-SX-102, 241-SX-103, and 241-SX-105 was used to convert liquid units to solid units.

Table 1. Chemical Constituents of Undiluted Waste

Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Sodium Hydroxide[2]	156	156,000	211,000
Ammonia	1.33	1,330	1,800
Total Organic Carbon	4.75	4,750	6,410

Notes:
[1]Calculated assuming a specific gravity of 1.35
[2]Based on hydroxide analysis, with a conversion factor of 2.35

Table 2. Organic Compounds Identified

Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Acetate	2.03	2,030	2,740
Formate	2.17	2,170	2,930
Glycolate	0.739	739	998
Oxalate	7.93	7,930	10,700

Note:
[1]Calculated assuming the average specific gravity of 1.35

If there are any questions regarding this information, please contact me at 373-6343 or Mr. J. G. Field, on 376-3753.

for [signature]
T. L. Lauricella, Scientist
Data Development and Interpretation

dmn

CH2MHILL
Hanford Group, Inc.

INTEROFFICE MEMO

From: Process Control — 7M100-00-001.PC
Phone: 373-6343
Date: October 4, 2000
Subject: CHEMICAL CHARACTERISTICS FOR LIQUID WASTE IN TANKS 241-BY-105 AND 241-BY-106

To: C. E. Hanson S7-70

cc:
G. A. Barnes S7-70
V. C. Boyles R2-11
J. R. Buchanan S7-70
J. G. Field R2-12
N. W. Kirch R2-11
W. F. Zuroff S7-24
LAF File/LB

References:
1. "Sample Analysis/Tank Results RPP-241," available on the Tank Characterization Database at http://twins.pnl.gov/data/datamenu.htm, dated October 4, 2000.

2. RPP-6028, "Specification for Hose in Hose Transfer Lines for Hanford's Interim Stabilization Project," Rev. 0, dated April 3, 2000.

The purpose of this memo is to document the bounding chemical concentrations of the liquid waste in tanks 241-BY-105 and 241-BY-106 for the Interim Stabilization Project procurement specification of a hose-in-hose transfer line for use on these tanks (Reference 2). The chemical constituents for which these concentrations were requested are: sodium hydroxide, ammonia, organic carbon, and organic compounds.

Table 1 lists the highest observed concentrations of ammonia, sodium hydroxide and total organic carbon in liquid waste samples from tanks 241-BY-105 and 241-BY-106 (Reference 1). Table 2 lists the highest concentrations of specific organic compounds observed in these samples. The average specific gravity of 1.4 for tanks 241-BY-105 and 241-BY-106 was used to convert liquid units to solid units.

Table 1. Chemical Constituents of Undiluted Waste

Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Sodium Hydroxide[2]	102	102,000	144,000
Ammonia	0.74	740	1,030
Total Organic Carbon	3.0	2,970	4,160

Notes:
[1]Calculated assuming a specific gravity of 1.4
[2]Based on hydroxide analysis, with a conversion factor of 2.35

Table 2. Organic Compounds Identified

Constituent	Concentration, mg/g[1]	Concentration, mg/kg[1]	Concentration, mg/L
Acetate	2.59	2,590	3,625
Formate	1.26	1,260	1,770
Glycolate	0.21	206	288
Oxalate	0.4	400	560

Note:
[1]Calculated assuming the average specific gravity of 1.4

If there are any questions regarding this information, please contact me at 376-0178 or Mr. V. C. Boyles, on 373-1321.

L. A. Fort, P.E. Senior Engineer
Tank Farm Alternate Criticality Safety Representative

laf/mjg

RPP-6711 Rev. 2
RPP-6153 Rev. 3

INTEROFFICE MEMO

From:	Process Control	7G300-02-MAK-015
Phone:	373-3115	
Date:	April 19, 2002	
Subject:	CHEMICAL COMPOSITION IN THE TANK 241-C-103 WASTE THAT WILL BE SEEN BY THE RUBBER HOSE	
To:	R. E. Mendoza	R4-08
Copies:	V. C. Boyles	R2-11
	M. A. Knight	R2-11 Mallinic
	D. M. Nguyen	R2-12
	DAR File/LB	

References:

1. PNL-10412, "Permeation of Tank C-103 Sludge Simulant by Organic Solvent," Revision 1, Pacific Northwest Laboratory, Richland, Washington, dated August 1995.

2. PNL-10128, "Waste Tank Organic Safety Program Analytical Methods Developments: FY 1994 Progress Report," Pacific Northwest Laboratory, Richland, Washington, dated September 1994.

3. Tank Characterization Database at http://twins.pnl.gov:8001/TCD/main.html, Lockheed Martin Hanford Corp., Richland,Washington., dated 1998.

Tank 241-C-103 (C-103) will be Saltwell pumped to a double-shell tank starting later this year. Current plans are to pump the liquid through an above ground line that will be made out of rubber. The purpose of this memo is to identify the chemicals that the rubber may be exposed to during pumping C-103 so that the proper rubber may be specified.

Table 1 shows the chemical composition of the liquid phase in C-103. Grab samples of the liquid that were taken in August 2001 were used as the basis of this table (Reference 3). The liquid phase is rather dilute and the chemical species are sodium salts. The liquid phase is a saturated solution in carbonate/bicarbonate. The carbonate/bicarbonate is acting as a buffer to give a pH of about 10.

Table 1: Chemical Composition of the Liquid Phase of Tank 241-C-103

Species	Median Value, Molar	Range, Molar
Sodium ion	1.66	1.61 to 1.73
Total Inorganic Carbon, Carbonate or Bicarbonate	0.54	0.5 to 0.63
Total Organic Carbon,	0.59	0.52 to 0.60
Nitrite	0.41	0.35 to 0.42
Ammonia	0.075	0.060 to 0.094
Fluoride	0.088	0.082 to 0.091
Phosphate	0.026	0.018 to 0.034
Oxalate	0.038	0.031 to 0.046
Nitrate	0.018	0.014 to 0.018
Sulfate	0.030	0.030 to 0.033
%Water	87%	85.6% to 91%
PH	9.98	9.93 to 10.15
Specific Gravity	1.08	1.01 to 1.09
Cs-137 in uCi/mL	43.7	42.9 to 45.4

Tank C-103 is known to have a floating organic layer. It is anticipated that the solids will act as an absorber of the organics as the organic layer attempts to flow through the solids to the Saltwell. However, some unknown amount of organics may get pumped (Reference 1). Table 2 is the chemicals that comprise the floating organic layer (Reference 2).

Table 2: Chemical Composition of Organic Layer in Tank 241-C-103

Component	Weight %	CAS Number
Dodecane	2.8	124-18-5
Alkane	0.2	
Alkane	1.1	
Tridecane	11.4	629-50-5
Alkane	0.5	
Alkane	1.0	
Tetradecane	6.0	629-59-4
Alkane	0.7	
Pentadecane	0.9	629-62-9
DBBP	1.9	
TBP	47.2	126-73-8

The rows listed as alkanes were unidentified peaks on a mass spectroscopy instrument. DBBP is di-butyl butyl phosphonate, a degradation product of TBP. TBP is tri-butyl phosphate. The other identified components are part of the NPH (normal paraffin hydrocarbon) used as a diluent for the TBP.

This brine is saturated in carbonate and/or bicarbonate. No dilution water is anticipated therefore major changes in temperature may have an effect on the precipitation of solids. A heat trace system to keep the waste warm while pumping will certainly be beneficial.

If you have any questions please call me at 373-3115.

D. A. Reynolds, Principle Engineer
Process Control

River/Bend
hose specialty

1111 South Main Street
South Bend, IN 46601
(219) 233-1133
Fax (219) 282-2244

November 25, 2002

To: Ruben Mendoza
COGEMA Engineering
Richland, WA 99352

From: Jim Betz

Subject: Use of HIHTL after Tank 241-C-103

I have reviewed document RPP-13448 Rev.0 (Organic Layer In Tank 241-C-103 Relationship To Saltwell Pumping). My concern is the contact time of the organic layer with the EPDM. EPDM rubber is only able to handle concentrated organic material for a short time, about 6 to 10 hours, before the tube will start to swell. After this time frame irreversible swelling may begin to occur and the longer the contact the greater the swelling. Swelling is the first reaction you can see as the fluid starts to attack the tube. If this condition would continue for several weeks to months the integrity of the EPDM could be compromised.

Our first recommendation would be to minimize the organics pumped during this transfer, leaving it in the tank to retrieve with the sludge when you can dilute it with water. If this is not possible, at the end of your pumping we recommend that you flush the hose with water equal to or greater than 5 times the total capacity of the primary line, followed by a flush with a mild detergent (dish water) 3 times or more.

If the EPDM has worst case contact with the organic layer as described by RPP-13448, (2100 gallons of higher concentration organics for 9 hours). The hose will need to be examined and a determination made whether to continue using that hose or to replace it.

INTEROFFICE MEMO

CH2MHILL
Hanford Group, Inc.

RPP-6711 Rev. 2
7G300-02-MAK-044

From:	Process Control	
Phone:	372-2493	
Date:	November 13, 2002	
Subject:	CHEMICAL CHARACTERISTICS FOR WASTE IN TANK 241-C-106	
To:	T. D. Torres	R4-01
Copies:	W. B. Barton	R2-11
	J. R. Buchanan	R4-01
	M. A. Knight [signature]	R2-11
	R. E. Mendoza	R4-08
	D. M. Nguyen	R2-12
	J. G. Propson	L4-07
	B. Zuroff	S7-24
	THM File/LB	

References:

1. "Sample Analysis/Tank Results RPP-241," available on the Tank Characterization Database at http://twins.pnnl.gov/data/datamenu.htm, dated November 7, 2002.

2. ECN 673101, S. Sifuentes, "Supplemental Change to RPP-6028 Rev. 3 to Update Information and Add Statement for a Locking Mechanism to Hose Connection and to Add Chemical Composition Table," dated July 2, 2002.

3. RPP-6028, "Specification For Hose in Hose Transfer Lines for Hanford's Interim Stabilization Program," Rev. 3, CH2M HILL Hanford Group, Inc. Richland, Washington, dated April 29, 2002.

4. Internal Memorandum, L. M. Sasaki, to C. E. Hanson, "Chemical Characteristics or Liquid Waste in U Tank Farm," 74B20-00-047, dated August 11, 2000.

The purpose of this memo is to document the bounding chemical concentrations of the liquid and solid waste in tank 241-C-106 for the 241-C-106 Closure Project procurement specification of a hose-in-hose transfer line. The chemical constituents requested are hydroxide, ammonia, organic carbon, and organic compounds. The bounding chemical concentrations for 241-C-106 were also compared to chemical concentrations contained in previous specifications (References 2 through 4).

Tank 241-C-106 contains approximately 36,000 gallons of total material that was left in this tank after sluicing in 1998 and 1999. This volume includes approximately 9,100 gallons of sludge. Retrieval of 241-C-106 will be a multi-step process. First, some of the supernatant will be transferred to 241-AN-106 to expose the solids since sluicing through a layer of liquid is inefficient.

Then solids will be sluiced to the centrally located pump. Supernatant will be recycled within 241-C-106 until solids levels in the slurry increase to reasonable levels. The slurry will then be transferred to 241-AN-106. Raw water will then be added to 241-C-106 as sluicing medium and the process repeated until tank 241-C-106 is empty to the limits of technology.

The initial fluid transferred through the hose-in-hose transfer line will be primarily 241-C-106 supernatant. The composition of 241-C-106 supernatant is the same as the supernatant in 241-AY-102. A very low solids content is anticipated initially. Table 1 lists the average and highest observed concentrations for requested compounds from 241-AY-102 supernatant samples prior to the recent caustic and nitrate additions (Reference 1). These values were multiplied by a factor of 2 to compensate for evaporation in 241-C-106.

Table 1 Chemical Constituents of 241-C-106 Supernatant

Constituent Name	Average Reported Value	Maximum Reported Value	Units
Bromide	352	352	ug/mL
Chloride	264	276	ug/mL
Hydroxide	2844	3800	ug/mL
Nitrate	362	364	ug/mL
Nitrite	13748	14160	ug/mL
Sulfate	4282	4372	ug/mL
ammonia	22	40	ug/mL
carbonate	21500	22000	ug/mL
Acetate	658	670	ug/mL
Oxalate	4746	4826	ug/mL
Total organic carbon	3230	3260	ug/mL

Slurry transferred through the hose-in-hose transfer line will primarily consist of 241-C-106 solids suspended in raw water. Initially, the raw water will contain small amounts of supernatant. However, the amount of supernatant will decrease rapidly with time. The composition of 241-C-106 solids are the same as the composition of solids prior to the 1998-1999 sluicing campaigns. Solids concentration levels will range from 0 to 15% by weight solids with an average of 3 to 5 wt%. Table 2 lists the average and highest observed concentrations for requested compounds from 241-C-106 solids samples (Reference 1).

Table 2 Chemical Constituents of 241-C-106 Solids

Constituent Name	Average Reported Value	Maximum Reported Value	Units
Specific gravity	1.18	1.25	
Chloride	343.26	588.00	ug/mL
Fluoride	224.12	347.00	ug/mL
Nitrate	1157.72	2044.00	ug/mL
Nitrite	27695.00	30500.00	ug/mL
Phosphate	680.82	1213.00	ug/mL
Sulfate	7306.79	7980.00	ug/mL
carbonate	22275.00	24600.00	ug/mL
Total organic carbon	5437.81	34800.00	ug/mL
Dodecane	18.55	27.00	ug/mL
Oxalate	3152.79	3700.00	ug/mL
Pentadecane	4.32	6.27	ug/mL
Tetradecane	52.30	77.00	ug/mL
Tributyl phosphate	40.35	48.80	ug/mL
Tridecane	82.30	119.00	ug/mL
Undecane	2.83	4.07	ug/mL

The inorganic and organic constituents of the 241-C-106 supernatant are bounded by the constituents of undiluted waste from 241-S/SX farms contained in Table 3-1 of Reference 3.

The inorganic, oxalate, and Total Organic Carbon constituents of the 241-C-106 solids are bounded by the constituents of undiluted waste from 241-S/SX farms contained in Table 3-1 of Reference 3.

The organic constituents of the 241-C-106 solids are bounded by the chemical composition of the organic layer in tank 241-C-103 contained in Table 3-5 of Reference 2.

If there are any questions regarding this information, please contact me at 372-2493.

Thomas H May

T. H. May, Engineer
Process Engineering

lbc

APPENDIX E

Data Table from Parker Seal - Parker O-Ring Handbook, 1992

TABLE A3-10
COMPARISON OF PROPERTIES OF COMMONLY USED ELASTOMERS

ELASTOMER TYPE (POLYMER)	PROPERTIES: PARKER COMPOUND PREFIX LETTER	ABRASION RESISTANCE	ACID RESISTANCE	CHEMICAL RESISTANCE	COLD RESISTANCE	DYNAMIC PROPERTIES	ELECTRICAL PROPERTIES	FLAME RESISTANCE	HEAT RESISTANCE	IMPERMEABILITY	OIL RESISTANCE	OZONE RESISTANCE	SET RESISTANCE	TEAR RESISTANCE	TENSILE STRENGTH	WATER/STEAM RESISTANCE	WEATHER RESISTANCE
Butadiene	D	E	FG	FG	G	F	G	P	F	F	P	P	G	GE	E	FG	F
Butyl	B	FG	G	E	G	F	G	P	G	E	P	GE	FG	G	G	G	GE
Chlorinated Polyethylene	K	G	F	FG	FP	G	G	GE	G		FG	E	F	FG	G	F	E
Chlorosulfonated Polyethylene	H	G	G	E	FG	F	F	G	G	G	F	E	F	G	F	F	E
Epichlorohydrin	Y	G	FG	G	GE	G	F	FG	FG	GE	E	E	PF	G	G	F	E
Ethylene Acrylic	A	F	F	FG	G	F	F	P	E	E	F	E	G	F	G	PF	E
Ethylene Propylene	E	GE	G	E	GE	GE	G.	P	E	G	P	E	GE	GE	GE	E	E
Fluorocarbon	V	G	E	E	FP	GE	F	E	E	G	E	E	GE	F	GE	FG	E
Fluorosilicone	L	P	FG	E	GE	P	E	G	E	P	G	E	GE	P	F	F	E
Isoprene	I	E	FG	FG	G	F	G	P	F	F	P	P	G	GE	E	FG	F
Natural Rubber	R	E	FG	FG	G	E	G	P	F	F	P	P	G	GE	E	FG	F
Neoprene	C	G	FG	FG	FG	F	F	G	G	G	FG	GE	F	FG	G	F	E
Nitrile or Buna N	N	G	F	FG	G	GE	F	P	G	G	E	P	GE	FG	GE	FG	F
Phosphonitrilic Fluoroelastomer	F	F	P	G	E	F	FG	G	E	G	E	E	G	FP	F	F	E
Polyacrylate	A	G	P	P	P	F	F	P	E	E	E	E	F	FG	F	P	E
Polysulfide	T	P	P	G	G	F	F	P	P	E	E	E	P	P	F	F	E
Polyurethane	P	E	P	F	G	E	FG	P	F	G	G	E	F	GE	E	P	E
SBR or Buna S	G	G	F	FG	G	G	G	P	FG	F	P	P	G	FG	GE	FG	F
Silicone	S	P	FG	GE	E	P	E	F	E	P	PG	E	GE	P	P	F	E

P — POOR F — FAIR G — GOOD E — EXCELLENT

A3-32

APPENDIX F

Heat Trace and Copper Tape information

Page F-2 to 3
Raychem Heat Trace Information (BTV2-CT)

Page F-4 to 5
Raychem Heat Trace Information (HBTV2-CT)

Pages F-6 to 10
Material Safety Data Sheets for Copper Tape

Pages F-11 to 12
Copper Compatibility
Fontana, Mars G., and Norbert D. Greene, *Corrosion Engineering*, Second Edition, McGraw-Hill Book Company, 1978

Raychem

BTV

D100
OATO
011A

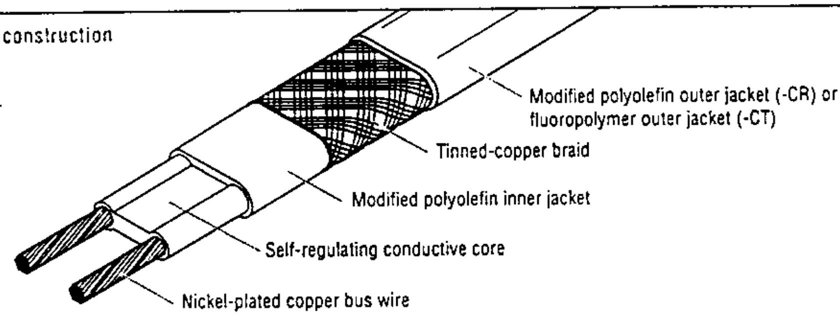
Self-regulating heating cables

Electrical freeze protection for both nonhazardous and hazardous (classified) locations

The BTV family of self-regulating heating cables provides the solution to freeze-protection and process-temperature maintenance applications. BTV heating cables maintain process temperatures up to 150°F (65°C) and can withstand intermittent exposure to temperatures up to 185°F (85°C). The heating cables are configured for use in nonhazardous and hazardous (classified) locations, including areas where corrosives may be present.

Raychem® BTV cables meet the requirements of the U.S. National Electrical Code and the Canadian Electrical Code. For additional information, contact your Tyco Thermal Controls representative or call Tyco Thermal Controls at (800) 545-6258.

Heating cable construction

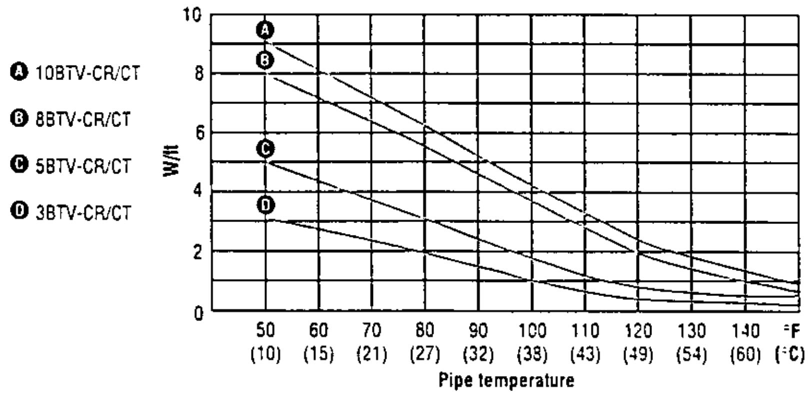


Application	
Area classification	Nonhazardous and hazardous locations
Traced surface type	Metal and plastic
Chemical resistance	Exposure to aqueous inorganic chemicals: Use -CR (modified polyolefin outer jacket) Exposure to organic chemicals or corrosives: Use -CT (fluoropolymer outer jacket) For aggressive organics and corrosives: Consult your Tyco Thermal Controls representative.
Supply voltage	
BTV1	100–130 Vac
BTV2	200–277 Vac
Temperature rating	
Maximum maintain or continuous exposure temperature (power on)	150°F (65°C)
Maximum intermittent exposure temperature, 1000 hours (power on)	185°F (85°C)
Temperature ID number (T-rating)	T6: 185°F (85°C) Temperature ID numbers are consistent with North America national electrical codes.
Approvals	**Hazardous Locations** FM APPROVED, UL LISTED: Class I, Div. 2, Groups A, B, C, D; Class II, Div. 2, Groups F, G; Class III[1] CSA: Class I, Div. 1 & 2[2], Groups A, B, C, D; Class II, Div. 1 & 2[2], Groups E, F, G; Class III **Zone Approvals** FM APPROVED: CLI, ZN1, AEx e II[3] BTV heating cables also have many other approvals including BASEEFA, PTB, DNV, and ABS.
Design and installation	For proper design and installation, use TraceCalc® Pro software or the Design section of the *Industrial Product Selection and Design Guide*. Also, refer to the *Installation & Maintenance Manual—Ordinary and CID2 Locations* (H54484). Literature is available through the Tyco Thermal Controls Fax-on-Demand system and via the Tyco Thermal Controls Web site, www.tycothermal.com.

(1) FM Approved only.
(2) BTV-CR is CSA Certified for Division 2 only.
(3) BTV-CT only.

Nominal power output rating on metal pipes at 120 V, 240 V

	Adjustment factors	
	Power output	Circuit length
208 V		
3BTV2-CR/CT	0.82	0.96
5BTV2-CR/CT	0.85	0.94
8BTV2-CR/CT	0.89	0.92
10BTV2-CR/CT	0.89	0.92
277 V		
3BTV2-CR/CT	1.13	1.08
5BTV2-CR/CT	1.12	1.09
8BTV2-CR/CT	1.08	1.11
10BTV2-CR/CT	1.08	1.11



To choose the correct heating cable for your application, use the Design section of the *Industrial Product Selection and Design Guide.* For more detailed information, use TraceCalc Pro design software.

Maximum circuit lengths based on circuit-breaker sizes

	Ambient temperature at start-up	Maximum continuous circuit length (in feet) per circuit breaker							
		120 V				240 V			
		15 A	20 A	30 A	40 A	15 A	20 A	30 A	40 A
3BTV-CR/CT	50°F	330	330	330	330	660	660	660	660
	0°F	200	265	330	330	395	530	660	660
	–20°F	175	235	330	330	350	465	660	660
	–40°F	155	205	310	330	310	410	620	660
5BTV-CR/CT	50°F	230	270	270	270	460	540	540	540
	0°F	140	190	270	270	285	380	540	540
	–20°F	125	165	250	270	250	330	500	540
	–40°F	110	145	220	270	220	295	440	540
8BTV-CR/CT	50°F	150	200	210	210	300	400	420	420
	0°F	100	130	200	210	200	265	400	420
	–20°F	85	115	175	210	175	235	350	420
	–40°F	80	105	155	210	155	210	315	420
10BTV-CR/CT	50°F	120	160	180	180	240	315	360	360
	0°F	80	110	160	180	160	215	325	360
	–20°F	70	95	140	180	145	190	285	360
	–40°F	65	85	125	170	125	170	255	340

Note: Tyco Thermal Controls and national electrical codes require both ground-fault protection of equipment and a grounded metallic covering on all heating cables. Following are some of the ground-fault breakers that satisfy this equipment protection requirement: Square D Type QOB-EPD or QO-EPD; Raychem/Square D Type GFPD EHB-EPD (277 Vac); Cutler Hammer (Westinghouse) Type QBGFEP.

Product characteristics

	3BTV 5BTV	8BVT 10BTV
Minimum bend radius	@68°F (20°C):1/2 in (12.7 mm)	@68°F (20°C): 1/2 in (12.7 mm)
Weight (lb per 10 ft, nominal)	0.7	1.0
Bus wire size	16 AWG	16 AWG
Outer jacket color	Black	Black
Heating cable dimensions	0.46 x 0.25 in	0.65 x 0.26 in

Components

Tyco Thermal Controls offers a full range of components for power connections, splices, and end seals. These components must be used to ensure proper functioning of the product and compliance with warranty, code, and approvals requirements.

Raychem

HBTV

D100
OATO
011A

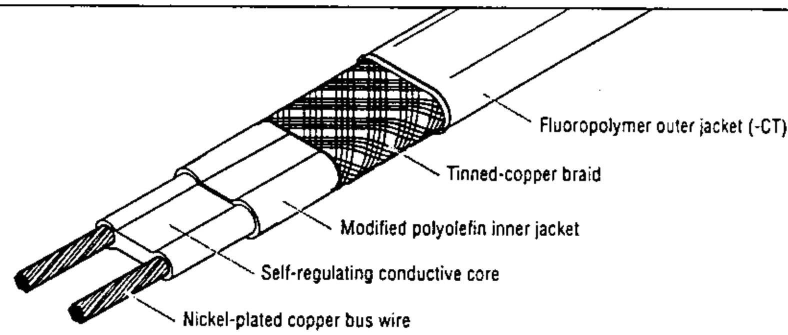
Class I, Division 1, self-regulating heating cables for hazardous locations

Electrical freeze protection for hazardous (CID1) locations

The HBTV family of self-regulating heating cables provides the solution to freeze-protection and process-temperature maintenance applications for CID1 areas. HBTV heating cables maintain process temperatures up to 150°F (65°C) and can withstand intermittent exposure to temperatures up to 185°F (85°C). The cables are configured for use in hazardous (CID1) areas, including areas where corrosives may be present.

Raychem® HBTV cables meet the requirements of the U.S. National Electrical Code. For additional information, contact your Tyco Thermal Controls representative or call Tyco Thermal Controls at (800) 545-6258.

Heating cable construction

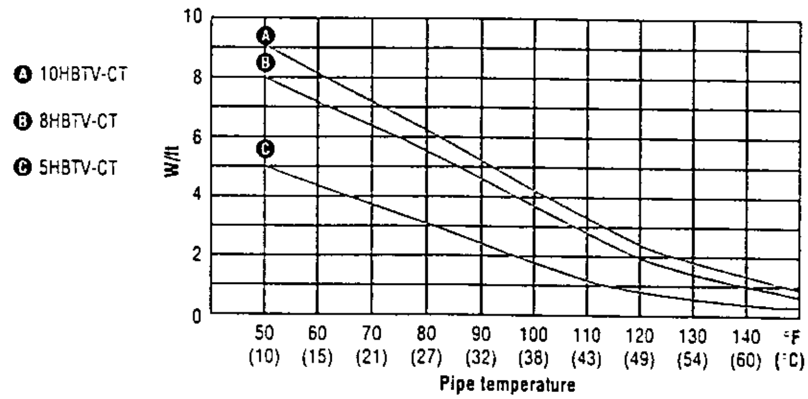


Application	
Area classification	Hazardous (classified) locations
Traced surface type	Metal and plastic
Chemical resistance	Organic and aqueous inorganic chemicals and corrosives
Supply voltage	
HBTV1	100–130 Vac
HBTV2	200–277 Vac
Temperature rating	
Maximum maintain or continuous exposure temperature (power on)	150°F (65°C)
Maximum intermittent exposure temperature, 1000 hours (power on or off)	185°F (85°C)
Temperature ID number (T-rating)	T6: 185°F (85°C) Temperature ID numbers are consistent with North America national electrical codes.
Approvals (1) All Class I, Div. 1 designs must be reviewed by the manufacturer	**Hazardous Locations** FM APPROVED Class I, Div. 1,(1) Groups B, C, D Class II, Div. 1, Groups E, F, G
Design and installation	For proper design and installation, use TraceCalc® Pro software or the Design section of the *Industrial Product Selection and Design Guide.* Also, refer to the *Installation Guide for Hazardous Division 1 Locations* (H56075). Literature is available through the Tyco Thermal Controls Fax-on-Demand system and via the Tyco Thermal Controls Web site, www.tycothermal.com.

Nominal power output rating on metal pipes at 120 V/240 V

	Adjustment factors	
	Power output	Circuit length
208 V		
5HBTV2-CT	0.85	0.94
8HBTV2-CT	0.89	0.92
10HBTV2-CT	0.89	0.92
277 V		
5HBTV2-CT	1.12	0.94
8HBTV2-CT	1.08	1.11
10HBTV2-CT	1.08	1.11

To choose the correct heating cable for your application, use the Design section of the *Industrial Product Selection and Design Guide*. For more detailed information, use TraceCalc Pro design software.



Maximum circuit lengths based on circuit-breaker sizes

	Ambient temperature at start-up	Maximum continuous circuit length (in feet) per circuit breaker							
		120 V				240 V			
		15 A	20 A	30 A	40 A	15 A	20 A	30 A	40 A
5HBTV-CT	50°F	230	270	270	270	460	540	540	540
	0°F	140	190	270	270	285	380	540	540
	–20°F	125	165	250	270	250	330	500	540
	–40°F	110	145	220	270	220	295	440	540
8HBTV-CT	50°F	150	200	210	210	300	400	420	420
	0°F	100	130	200	210	200	265	400	420
	–20°F	85	115	175	210	175	235	350	420
	–40°F	80	105	155	210	155	210	315	420
10HBTV-CT	50°F	120	160	180	180	240	315	360	360
	0°F	80	110	160	180	160	215	325	360
	–20°F	70	95	140	180	145	190	285	360
	–40°F	65	85	125	170	125	170	255	340

Note: Tyco Thermal Controls and national electrical codes require both ground-fault protection of equipment and a grounded metallic covering on all heating cables. Following are some of the ground-fault breakers that satisfy this equipment protection requirement: Square D Type QOB-EPD or QO-EPD; Raychem/Square D Type GFPD EHB-EPD (277 Vac); Cutler Hammer (Westinghouse) Type QBGFEP.

Product characteristics

	5HBTV-CT	8HBTV-CT 10HBTV-CT
Minimum bend radius	@68°F (20°C): 1/2 in (12.7 mm)	@68°F (20°C): 1/2 in (12.7 mm)
Weight (lb per 10 ft, nominal)	0.7	1.0
Bus wire size	16 AWG	16 AWG
Outer jacket color	Black	Black
Heating cable dimensions	0.46 x 0.25 in	0.65 x 0.25 in

Components

Tyco Thermal Controls offers a full range of components for power connections, splices, and end seals. These components must be used to ensure proper functioning of the product and compliance with warranty, code, and approvals requirements.

MATERIAL SAFETY DATA SHEET

3M
3M Center
St. Paul, Minnesota
55144-1000
1-800-364-3577 or (651) 737-6501 (24 hours)

This material safety data sheet (MSDS) is provided as a courtesy in response to a customer request. This product is not regulated under, and a MSDS is not required for this product by the OSHA Hazard Communication Standard (29 CFR 1910.1200) because, when used as recommended or under ordinary conditions, it should not present a health and safety hazard. However, use or processing of the product not in accordance with the product's recommendations or not under ordinary conditions may affect the performance of the product and may present potential health and safety hazards.

DIVISION: ELECTRICAL PRODUCTS DIVISION
TRADE NAME:
3M ELECTRICAL TAPE 1170, 1181, 1182, 1183, 1190, 1194, 1245, 1267, 1345
ISSUED: December 03, 1997
SUPERSEDES: June 20, 1997
DOCUMENT: 07-5271-7

1. INGREDIENT

INGREDIENT	C.A.S. NO.	PERCENT
ACRYLIC POLYMER	9017-68-9	50 - 75
METAL BACKING (Al, Cu, Sn coated Cu, or Cu coated polyester fabric)	Unknown	25 - 50

2. PHYSICAL DATA

BOILING POINT: N/A
VAPOR PRESSURE: N/A
VAPOR DENSITY: N/A
EVAPORATION RATE: N/A
SOLUBILITY IN WATER: N/A
SPECIFIC GRAVITY: N/D
PERCENT VOLATILE: 0 %
pH: N/A
VISCOSITY: N/A
MELTING POINT: N/D

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

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2. PHYSICAL DATA (continued)

APPEARANCE AND ODOR:
Roll of Tape, Metal backing, Clear adhesive

---

3. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:.................... N/A
FLAMMABLE LIMITS - LEL:........ N/A
FLAMMABLE LIMITS - UEL:........ N/A
AUTOIGNITION TEMPERATURE:...... N/D

EXTINGUISHING MEDIA:
Water spray, Carbon dioxide

SPECIAL FIRE FIGHTING PROCEDURES:
Wear full protective clothing, including helmet, self-contained, positive pressure or pressure demand breathing apparatus, bunker coat and pants, bands around arms, waist and legs, face mask, and protective covering for exposed areas of the head.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
None known.

NFPA HAZARD CODES: HEALTH: 0 FIRE: 0 REACTIVITY: 0
UNUSUAL REACTION HAZARD: none

OSHA FIRE HAZARD CLASS: Not applicable

---

4. REACTIVITY DATA

STABILITY: Stable

INCOMPATIBILITY - MATERIALS/CONDITIONS TO AVOID:
None known.

HAZARDOUS POLYMERIZATION: Hazardous polymerization will not occur.

HAZARDOUS DECOMPOSITION PRODUCTS:
Carbon Monoxide and Carbon Dioxide.

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

5. ENVIRONMENTAL INFORMATION

SPILL RESPONSE:
Not applicable.

RECOMMENDED DISPOSAL:
Dispose of waste product in a sanitary landfill.

ENVIRONMENTAL DATA:
Not determined.

REGULATORY INFORMATION:
Volatile Organic Compounds: 0 %.
VOC Less H2O & Exempt Solvents: 0 %.

Since regulations vary, consult applicable regulations or authorities before disposal.

EPCRA HAZARD CLASS:
FIRE HAZARD: No PRESSURE: No REACTIVITY: No ACUTE: No CHRONIC: No

6. SUGGESTED FIRST AID

EYE CONTACT:
No need for first aid is anticipated.

SKIN CONTACT:
No need for first aid is anticipated.

INHALATION:
No need for first aid is anticipated.

IF SWALLOWED:
No need for first aid is anticipated.

7. PRECAUTIONARY INFORMATION

EYE PROTECTION:
Not applicable.

SKIN PROTECTION:
Not applicable.

RECOMMENDED VENTILATION:
Not applicable.

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

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7. PRECAUTIONARY INFORMATION (continued)

RESPIRATORY PROTECTION:
Avoid breathing of thermal decomposition products. Avoid breathing of dust created by cutting, sanding or grinding. Select one of the following NIOSH approved respirators based on airborne concentration of contaminants and in accordance with OSHA regulations: half-mask dust respirator.

PREVENTION OF ACCIDENTAL INGESTION:
Wash hands after handling and before eating.

RECOMMENDED STORAGE:
Store at temperature and conditions as recommended on product literature.

FIRE AND EXPLOSION AVOIDANCE:
Not applicable.

EXPOSURE LIMITS

INGREDIENT	VALUE	UNIT	TYPE	AUTH	SKIN*
ACRYLIC POLYMER......................	NONE	NONE		NONE	NONE
METAL BACKING (Al, Cu, Sn coated Cu, or Cu coated polyester fabric).	NONE	NONE		NONE	NONE

* SKIN NOTATION: Listed substances indicated with 'Y' under SKIN refer to the potential contribution to the overall exposure by the cutaneous route including mucous membrane and eye, either by airborne or, more particularly, by direct contact with the substance. Vehicles can alter skin absorption.

SOURCE OF EXPOSURE LIMIT DATA:
- NONE: None Established

---

8. HEALTH HAZARD DATA

EYE CONTACT:
Eye contact is not expected to occur during normal use of the product.

SKIN CONTACT:
No adverse health effects are expected from skin contact.

INHALATION:
Health effects from inhalation are not expected unless the product is over heated and decomposition occurs.

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

MSDS: 3M ELECTRICAL TAPE 1170, 1181, 1182, 1183, 1190, 1194, 1245, 1267, 1345
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8. HEALTH HAZARD DATA (continued)

Dust from cutting, grinding, sanding or machining may cause irritation of the respiratory system.

IF SWALLOWED:
Ingestion is not a likely route of exposure to this product.

OTHER HEALTH HAZARD INFORMATION:
This product, when used under reasonable conditions or in accordance with the 3M directions for use, should not present a health and safety hazard. However, use or processing of the product in a manner not in accordance with the product's directions for use may affect the performance of the product and may present potential health and safety hazards.

SECTION CHANGE DATES

HEADING	SECTION CHANGED SINCE June 20, 1997	ISSUE

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

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CORROSION ENGINEERING

SECOND EDITION

MARS G. FONTANA

Regents' Professor and Chairman Emeritus
Department of Metallurgical Engineering
Fontana Corrosion Center
The Ohio State University

NORBERT D. GREENE

Department of Metallurgy
and Department of Restorative Dentistry
University of Connecticut

McGRAW-HILL BOOK COMPANY

New York St. Louis San Francisco Auckland Bogotá Düsseldorf
Johannesburg London Madrid Mexico Montreal New Delhi
Panama Paris São Paulo Singapore Sydney Tokyo Toronto

5-11 Lead and Its Alloys Lead is one of our oldest metals. It was used for water piping during the time of the Roman Empire, and some of it is still in operation. Lead ornaments and coins were utilized several thousand years ago. Lead forms protective films consisting of corrosion products such as sulfates, oxides, and phosphates. Most of the lead produced goes into corrosion applications; a large portion involves sulfuric acid. (See isocorrosion chart in Chap. 7.) Lead and its alloys are used as piping, sheet linings, solders (Pb-Sn), type metals, storage batteries, radiation shields, cable sheath, terneplate (steel coated with Pb-Sn alloy), bearings, roofing, and ammunition. Lead is soft, easily formed, and has a low melting point. Lead-lined steel is often made by "burning on" the lead. It is subject to erosion corrosion because of its softness.

When corrosion resistance is required for process equipment, chemical lead containing about 0.06% copper is specified, particularly for sulfuric acid. This lead is resistant to sulfuric, chromic, hydrofluoric, and phosphoric acids; neutral solutions; seawater; and soils. It is rapidly attacked by acetic acid and generally not used in nitric, hydrochloric, and organic acids.

Chemical lead exhibits a tensile strength of about 2300 lb/in.^{2} at room temperature. Hard leads, containing 3 to 18% antimony, double this strength. However, the strength of both materials drops rapidly as temperature is increased, and they show about the same strength around 230°F. Design stress at appreciably higher temperatures drops to zero.

5-12 Copper and Its Alloys Copper is different from most other metals in that it combines corrosion resistance with high electrical and heat conductivity, formability, machinability, and strength when alloyed, except for high temperatures. Copper exhibits good resistance to urban, marine, and industrial atmospheres and waters. Copper is a noble metal, and hydrogen evolution is not usually part of the corrosion process. For this reason it is not corroded by acids unless *oxygen* or other *oxidizing agents* (e.g., HNO_3) are present. For example, reaction between copper and sulfuric acid is not thermodynamically possible; but corrosion proceeds in the presence of oxygen, and the products are copper sulfate and water. Reduction of oxygen to form hydroxide ions is the predominant cathodic reaction for copper and its alloys. Copper-base alloys are resistant to neutral and slightly alkaline solutions with the exception of those containing ammonia, which cause stress corrosion and sometimes rapid general attack. In strongly reducing conditions at high temperatures (300 to 400°C), copper alloys are often superior to stainless steels and stainless alloys. Dezincification and stress corrosion are discussed in Chap. 3.

Table 5-7 lists chemical compositions and mechanical properties of some typical and common copper-base materials. Hundreds of compositions with a wide variety of mechanical properties are commercially available. For example a range of tensile strength from about 30,000 to 200,000 lb/in.^{2} is exhibited by pure copper and copper alloyed with 2% beryllium. The most common alloys

APPENDIX G

Oxalic Acid Information

G – 2, 3
Email from Goodyear Representative
to River Bend Hose Specialty Rep.
March 27, 2003
Regarding Oxalic Acid

G – 4, 5
EPDM/Oxalic Acid Chemical
Compatibility Position Paper

G – 6 to 18
Reference Literature for Oxalic Acid

From: clayton.rundio@goodyear.com>
To: jbetz@riverbendhose.com>
Cc: clayton.rundio@goodyear.com>
Sent: Thursday, March 27, 2003 4:27 PM

Subject: Re: River Bend Hose Specialty-South Bend, IN

Jim, here is the answer you were looking for. Not sure why Pascal originally replied at intermittent usage. This should handle your need.

Clayton

----- Forwarded by Clayton Rundio/NA/GDYR on 03/27/2003 04:21 PM -----
Pascal Langlois

To: Clayton Rundio/NA/GDYR@GOODYEAR
cc: Tom Alfredson/NA/GDYR@GOODYEAR

Subject: Re: River Bend Hose Specialty-South Bend, IN (Document link: Clayton Rundio)

Clayton, I did not get your fax. I was out of the office on the 19 so maybe someone else took it in my place??

Anyhow, I did look at references other than the Goodyear Chemical Recommendation Chart and according to the Chemical Resistance Guide for Elastomers II, EPDM is rated A for Oxalic acid at 100% concentration up to 250 F. Since the actual concentration is only 12 to 15% and that the Chemical Guide for Elastomers II is a well recognized reference in the rubber industry, the HAHA EPDM S&D hose could be used for continuous service.

Regards, Pascal

From: Clayton Rundio on 2003-03-27 11:06

To: Pascal Langlois/NA/GDYR@GOODYEAR
cc: Tom Alfredson/NA/GDYR@GOODYEAR, Clayton Rundio/NA/GDYR@GOODYEAR

Subject: River Bend Hose Specialty-South Bend, IN

RE: HOSE-IN-A-HOSE-----OXALIC ACID-----MY 3/19/03 FAX TO YOU

Jim Betz is being pressured to have an answer to the fax I sent to you on 3/19 with additional information from other sources showing EPDM to be rated as excellent to be used with OXALIC ACID. I just looked in a Dayco catalog and they too list EPDM as excellent.

A couple additional things that Jim Betz has learned is that for OXALIC ACID to become liquid it must be at about 355 F. At 100 F the acid can only reach a 15% solution.

Jim has stripped back a sample of our hose exposing various components at ambient temperatures and has had the hose in a acid bath (about 8% solution) for a week with all elements of the hose exposed and has not seen any visual change to the wire/tube/fabric, etc. nor has there been any durometer change.

It would seem that at the 12-15% solution that will be used in the application that EPDM would be good for continuous service in lieu of the additional information. Jim needs to have this verified by you, or a good description of why we only consider our EPDM with this acid good for intermittent service as you suggested in your 3/12 e-mail.

Jim needs your response today so he can handle his customer before he leaves (Jim will be gone for a week).

Clayton

EPDM/Oxalic Acid Chemical Compatibility Position Paper

Background

Hose-in-hose transfer lines (HIHTLs) are used to support interim stabilization and retrieval of various waste storage tanks in the 200 East and West tank farms, and have been used successfully in transferring tank waste since 1999. The basic design of the HIHTL consists of an inner 2-in. diameter ethylene propylene diene monomer (EPDM) rubber hose, encased inside an open-ended 4-in. diameter EPDM hose.

HIHTLs may be used in retrieval of the C-106 tank. In this application, the hoses would be exposed to up to 1 Molar (approx. 10%) concentrations of oxalic acid added to C-106 to help dissolve solids. As a result, the EPDM hoses need to be evaluated for compatibility with the oxalic acid.

Scope

This paper analyzes data on the chemical resistance of EPDM in contact with oxalic acid, and makes recommendations on the suitability of using HIHTLs to transfer the C-106 retrieval waste.

Discussion

A literature search was made for chemical resistance data for EPDM exposed to oxalic acid. The table below summarizes the results of this search:

Chemical Resistance of EPDM in Oxalic Acid Service

Company or Manufacturer	Comments
1. DuPont	"A" rating - little or no effect
2. George Fischer	Resistant to a 50% solution up to 300 F
3. Cole-Parmer	"A" rating – excellent
4. Gates Industrial Hose	Acceptable for intermittent contact with a 50% solution
5. Harrington Plastics	"A" rating – excellent
6. Warren-Rupp Pumps	"A" rating – excellent
7. River Bend/Goodyear	"B" rating – may be used for intermittent service
8. Nibco	Excellent up to 50% solution and 210 F

(Refer to attached literature)

The above data suggests that EPDM is regarded as "acceptable" to "excellent" in oxalic acid service exceeding potential conditions for C-106 Retrieval.

In order to obtain some empirical data, River Bend Transfer Systems has also performed an informal immersion test. Coupons of the 2-in. inner EPDM hose were placed in a bath of 11%, or 1.2 Molar, solution of oxalic acid for approximately one week. Visual and swelling checks have not indicated any adverse effects on the hose.

Recommendation

Based on the favorable results of both the literature search and the immersion test, it is recommended to continue using the existing HIHTLs for C-106 retrieval operations.

DuPont

Chemical	Kalrez®	NBR	EPDM	VMQ	FVMQ	FKM	T
Nitrodiethylaniline	A						
Nitrodiphenyl Ether	A						
Nitroethane	A	U	B	U	U	U	
Nitrofluorobenzene	A						
Nitrogen	A	A	A	A	A	A	A
Nitrogen Oxides	A						C
Nitrogen Peroxide	A* 2037						C
Nitrogen Tetroxide	B* 1045	U	C	U	U	U	C
Nitrogen Trifluoride	B* 4079						C
Nitroglycerine	A						
Nitroglycerol	A						
Nitroisopropylbenzene	A						
Nitromethane	A	U	B	U	U	U	
Nitrophenol	A						
Nitropropane	A						
Nitrosyl Chloride	A						
Nitrosylsulphuric Acid	A						
Nitrothiophene	A						
Nitrotoluene	A						C
Nitrous Acid	A						
Nitrous Oxide	A*						
Nonane	A						
Octachlorotoluene	A	U	U	U	B	A	
Octadecane	A	A	U	U	A	A	
Octanal	A* 4079						
N-Octane	A	B	U	U	B	A	B
Octyl Acetate	A						
Octyl Alcohol	A	B	C	B	B	A	B
Octyl Chloride	A						
Octyl Phthalate	A						
Olefins	A						
Oleic Acid	A	C	U	U	—	B	
Oleum (Fuming Sulfuric Acid)	A	B	U	U	B	A	
Oleyl Alcohol	A						
Olive Oil	A	A	B	C	A	A	C
Ortho Chloroaniline	A						
Ortho Chlorophenol	A						
Ortho Cresol	A						
Ortho Nitrotoluene	A						C
Orthophos[17] Acid	A						
Oxalic Acid	A	B	A	B	A	A	
Oxygen (Cold)	A* 2037	B	A	A	A	A	C
Oxygen (Hot)	A*	U	C	B	U	B	C
Ozone	A*	U	A	A	B	A	A
Paint Thinner	A	U	U	U	B	B	
Paracymene	A						
Para-Dichlorobenzene	A						U
Paraffins	A						
Para-Formaldehyde	A*						
Paraldehyde	A*						U
Para-Nitroaniline	A						
Para-Nitrobenzoic Acid	A						
Para-Nitrophenol	A						
Parathion	A						
Para-Toluene Sulfonic Acid	A						
Peanut Oil	A	A	C	A	A	A	C
Pectin (Liquor)	A						
Pelagonic Acid	A						
Penicillin (Liquid)	A						
Pentachloroethane	A						

Chemical	Kalrez®	NBR	EPDM	VMQ	FVMQ	FKM	T
Pentachlorophenol	A						
Pentaerythritol	A						
Pentaerythritol Tetranitrate	A						
Pentane	A						A
Pentoxone[13]	A						
Pentyl Pentanoate	A						
Peracetic Acid	A						C
Perchloric Acid	A* 4079	U	B	U	A	A	C
Perchloroethylene	A	B	U	U	B	A	B
Perfluorotriethylamine	B* 1050LF						
Permanganic Acid	A* 2037						
Persulfuric Acid (Caro's Acid)	A						C
Petrolatum	A						
Petrolatum Ether	A						
Petroleum, Crude	A* 1050LF						
Petroleum—Above 121°C (250°F)	A	U	U	U	U	B	
Petroleum—Below 121°C (250°F)	A	A	U	B	B	A	
Phenol (Carbolic Acid)	A	U	B	U	A	A	
Phenolic Sulfonate	A						
Phenolsulfonic Acid	A						
Phenyl Acetate	A						
Phenyl Ethyl Ether (Phenetole)	A	U	U	U	U	U	C
Phenyl Hydrazine	A* 1050LF	U	B	—	—	A	
Phenylacetamide	A						C
Phenylacetic Acid	A						
Phenylbenzene (Biphenyl/Diphenyl)	A	U	U	U	B	A	
Phenylene Diamine	A* 1050LF						
Phenylethyl Alcohol	A						
Phenylethyl Molonic Ester	A						
Phenylglycerine	A						
Phenylhydrazine Hydrochloride	A* 1050LF						U
Phenylmercuric Acetate	A						
Phorone (Diisopropylidene Acetone)	A	U	C	U	U	U	U
Phosgene	A						
Phosphine	A						
Phosphoric Acid, 20%	A	B	A	B	B	A	B
Phosphoric Acid, 45%	A	U	A	C	B	A	C
Phosphorus (Molten)	A						
Phosphorus Oxychloride	A						C
Phosphorus Trichloride	A	U	A	—	A	A	C
Phthalic Acid	A						
Phthalic Anhydride	A						
Pickling Solution	A	U	C	U	U	B	
Picric Acid	A	B	B	U	B	A	
Pine Oil	A	U	U	U	A	A	B
Pine Tar	A						
Pinene	A	B	U	U	B	A	
Piperazine	A* 1050LF						
Piperidine	A	U	U	U	U	U	
Plating Solution—Chrome	A	—	A	U	—	A	
Plating Solution—Others	A	A	A	U	—	A	
Polyethylene Glycol	A						
Polyglycerol	A						
Polyglycol	A						
Polyvinyl Acetate Emulsion	A	—	A	—	—	—	

parts rating may be conservative, as actual field experience and the example above have demonstrated.

In comparing the chemical and fluid resistance of Kalrez perfluoroelastomers to that of Teflon[†] fluoropolymer resins, certain differences should be kept in mind:

- Kalrez is an amorphous low-modulus rubber whereas Teflon is a crystalline high-modulus plastic. In fluid environments where high permeation occurs, Kalrez will probably swell to a greater extent than Teflon, even though the polymer is not chemically attacked.
  Environments in which this is most noticeable are fully halogenated solvents and Freon[†]. Serviceability of Kalrez[†] in these environments will be dependent upon the specifics of the application.
- As with all elastomers, it is necessary to compound Kalrez perfluoroelastomers with fillers and curatives to gain desired mechanical properties for functionality. In a limited number of environments, even though the polymer is stable, the fillers and curative systems may interact with the chemicals. However, because the level of fillers in Kalrez perfluoroelastomers is much lower than in most other elastomers, such filler interactions are generally negligible with Kalrez parts. Where such interactions can occur, such as in highly oxidative environments, service performance is dependent on the conditions of the application and may be affected by compound choice.

Because each application is unique, it is recommended that users of Kalrez perfluoroelastomer parts always conduct their own evaluations to determine the suitability of Kalrez for their application. Because of laboratory constraints and differences in field applications, the results shown in this technical information may be based on conditions that may not necessarily reflect actual operating environments for a specific application. Additionally, many elastomeric materials may show excellent chemical resistance to pure reagents in relatively short-term laboratory tests. However, they may fail in actual service because of chemical attack by additives and/or impurities. Kalrez perfluoroelastomer parts, with their near-universal chemical resistance, provide an extra degree of safety against these unknown corrosive influences.

Case histories are available from your authorized Kalrez distributor detailing proven performance of Kalrez parts in over 100 specific chemical applications. Information on test performance in a limited number of specific chemicals is also available through your authorized Kalrez distributor.

Caution

Kalrez perfluoroelastomer parts, like all fluorinated products, should not be exposed to molten or gaseous alkali metals, such as sodium and potassium, because a

Rating System

A Elastomer shows little or no effect (generally less than 10% swell) after exposure to the chemical; slight swelling or loss of properties may occur under severe conditions but this should not affect performance.

B Elastomer may be affected by the chemical after exposure, as evidenced by slight visible swelling (10%–30%) and/or loss of physical properties; Kalrez parts will often perform satisfactorily long after other elastomers have failed.

C Elastomer is affected by the chemical after exposure, as evidenced by moderate to severe swelling and/or loss of physical properties; limited functionality is possible but must be determined by testing.

U Elastomer is not suitable for service in the chemical.

Where no rating is shown, insufficient information was available to make a judgment.

An asterisk (*) next to a Kalrez perfluoroelastomer rating indicates that differences may exist between Kalrez compounds in certain applications that could affect relative performance. The compound numbers indicated are recommended for that application. If no compound number appears beside the asterisk (*), contact your authorized distributor or DuPont Dow Elastomers for the best compound. For such environments, other elastomers generally have very limited serviceability.

GEORGE FISCHER +GF+

Piping Systems America

Chemical Resistance Guide

To view chart of another material type click: [Metal] [Plastic] *Material Details

Note: Individual temperature ranges can be displayed by placing the mouse pointer over the corresponding blue bar.

Acid of Sugar / Ethane Dioic Acid / Oxalic Acid

Elastomer	Chemical Concentration	Rating
Chemraz®	Saturated	R
Chemraz®	5%	R
Chemraz®	10%	R
Chemraz®	50%	R
CR (Neoprene® GR-M)	Saturated	R
CR (Neoprene® GR-M)	5%	R
CR (Neoprene® GR-M)	10%	R
CR (Neoprene® GR-M)	50%	R
CSM (Hypalon®)	Saturated	R
CSM (Hypalon®)	5%	R
CSM (Hypalon®)	10%	R
CSM (Hypalon®)	50%	R
EPDM	Saturated	R
EPDM	5%	R
EPDM	10%	R
EPDM	50%	R
FPM (Viton®)	Saturated	R
FPM (Viton®)	5%	R
FPM (Viton®)	10%	R
FPM (Viton®)	50%	R
Kalrez®	Saturated	R
Kalrez®	5%	R
Kalrez®	10%	R
Kalrez®	50%	R
NBR (Nitrile Buna-N)	Saturated	no data
NBR (Nitrile Buna-N)	5%	U
NBR (Nitrile Buna-N)	10%	U

°C: 15 26 38 49 60 71 82 93 104 116 127 138 149 160 171 182 193 204 216 227 238

°F: 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460

NBR (Nitrile Buna-N)	50%	U																					
Elastomer	Chemical Concentration	Rating	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	°F
			15	26	38	49	60	71	82	93	104	116	127	138	149	160	171	182	193	204	216	227	238	°C

key

For Metals

E = Less then 2 Mils penetration/year

G = Less then 20 Mils penetration/year

S = Less then 50 Mils penetration/year

X = Greater then 50 Mils penetration/year

no data = Data Not Available

For Plastics & Elastomers

R = Resistant

L = Reduced service life less then 10 years

U = Unsatisfactory

no data = Data Not Available

A CAUTIONARY NOTE REGARDING THE CHEMICAL RESISTANCE LIST

This list is intended to serve as a general guide only, and is not a substitute for actual testing of the chemicals and pipe material under specific working conditions. The results shown are based on data accumulated from experiments, immersion and, when available, data from tests, which include temperature and pressure as, stress factors.

Where mixed chemicals and/or high or low temperature and pressure factors are added to chemical resistance factors in the use of a particular piping material, it is advisable to test the suitability of the material under the proposed temperature and pressure conditions.

The data shown here is based upon information from various sources available at the time the site was created. Information included may vary between company and product line specific guidelines. We reserve the right to revise this data from time to time in the sight of subsequent research and experience.

back

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This page was last updated 10/21/2002 04:15:50

Chemical Compatability Results

The Material Selected --	EPDM
Interacting with the Chemical --	Oxalic Acid (cold)
Has a Compatibility Level of --	**A- Excellent**

Ratings -- Chemical Effect

A = Excellent.

B = Good -- Minor Effect, slight corrosion or discoloration.

C = Fair -- Moderate Effect, not recommended for continuous use. Softening, loss of strength, swelling may occur.

D = Severe Effect, not recommended for **ANY** use.

N/A = Information Not Available.

Explanation of Footnotes

1. Satisfactory to 72°F (22° C)
2. Satisfactory to 120°F (48° C)

DANGER!

Variations in chemical behavior during handling due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.
SERIOUS INJURY MAY RESULT
Use suitable guards and/or personal protection when handling chemicals

WARNING!

The information in this chart has be supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility.
Before permanent installation, test the equipment with the chemic and under the specific conditions of your application.

Ratings of chemical behavior listed in this chart apply to a 48-hr expos Cole-Parmer has no knowledge of p effects beyond this period.
Cole Parmer does not warrant (neither express or implied) that the information in this chart is accurate or complete or that any material is suitable for any pur

Search Again

Industrial Hose

Note: For Explanation of Ratings, Refer to Page 142

Chemical Resistance Table

39496-000
January 1, 2003
Supersedes 39496-000
June 3, 2002

Contact Denver Product Application for recommendations for chemicals not listed.
Phone (303) 744-5070

1 = Preferred - Constant Contact
2 = Acceptable - Intermittent Contact
X = Not Recommended
- = No Data

NOTE: Ratings are for the affect on the *polymer only*!

Chemical	Form (at room temperature unless otherwise stated)	Gates Hose / Polymers															Couplings / Adapters					
		Stallion®	Mustang® 45HW	Renegade	Food & Bev. Mstr.																	
		T	K	L	S	P	C	D	D	A	H	V	M	J	Z	G						
		Teflon®	Gatron	UHMWPE	Sanitron	EPDM	NBR	SBR	NR	Neoprene	Butyl	Fluorocarbon	Hypalon®	CPE	Nylon	PVC	Iron/Carbon Steel	Stainless Steel 304	Stainless Steel 316	Aluminum	Brass	Polypro
Oils, Mineral (Aliphatic or Aromatic)	Liquids	1	2	-	X	X	2	X	X	X	X	1	2	2	1	X	-	-	-	-	-	2
Oils, Vegetable (Soybean, Coconut, Corn)	Liquids	1	1	-	X	X	1	X	X	-	X	1	X	-	1	-	-	-	-	-	-	1
Oleic Acid (fatty acid)	Yellow to Red Oily Liquid	1	2	2	2	2	2	X	X	2	2	2	X	2	-	2	2	2	1	1	2	1
Oleum (Fuming Sulfuric, 30% SO_3 or less)	Clear to Off White Fuming Liquid	1	X	X	X	X	X	X	X	X	X	1	X	X	X	X	-	-	1	-	-	X
Olive Oil	Yellow to Green Liquid	1	1	1	2	2	2	X	X	X	2	1	X	2	1	2	2	1	1	1	2	1
Ortho-Dichlorobenzene (also meta and para)	Colorless Liquid	1	2	-	X	X	X	X	X	X	X	1	X	X	1	X	-	1	1	-	1	-
Ortho-xylene (1,2 Dimethylbenzene)	Clear Colorless Liquid	1	X	X	X	X	X	X	X	X	X	1	X	X	X	X	-	-	-	-	-	-
OS 45 Hydraulic Fluid (Silicate Ester Base)	Liquid	1	-	-	-	X	2	X	X	1	X	1	2	-	-	-	-	-	-	-	-	-
Oxalic Acid	Transparent Crystals	1	-	2	-	-	-	-	1	-	-	-	-	-	-	-	X	2	1	2	X	1
Oxalic Acid (50%)	Crystals in H2O	1	2	1	2	2	X	X	X	X	2	1	2	1	X	X	-	-	-	-	-	-
Oxygen	Colorless Gas	1	1	-	1	1	2	2	2	-	1	1	1	1	-	-	-	-	-	-	-	-
Oxygen, Refrigerated Liquid	Liquid @ 200 PSIG @ -146°C	NO HOSE AVAILABLE															-	-	-	-	-	-
Ozone	Gas	1	2	2	1	1	X	X	X	2	2	2	2	1	2	1	1	1	1	1	1	1
P																						
Paint (Emulsion or Latex)	Liquid	1	1	1	1	2	2	-	-	-	-	1	-	-	1	1	-	-	-	-	-	-
Paint (Inorganic)	Liquid	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	-
Paint (Oil or Solvent Based)	Liquid or Paste	1	1	-	X	X	2	X	X	-	X	1	X	-	1	-	-	-	-	-	-	-
Paint Remover	Liquid or Paste	1	2	-	X	X	X	X	X	X	X	1	X	-	X	-	-	-	-	-	-	-
Paint Resin	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Palm Oil	Yellow to Brown Solid	1	1	-	-	-	1	X	X	2	2	-	2	-	-	-	1	1	1	1	1	-
Palmitic Acid (Hexadecanoic Acid)	Crystals in Hot Alcohols	1	1	1	2	2	2	X	X	2	2	1	X	1	-	-	1	2	1	1	X	1
Papermakers Alum (Aluminum Ammonium Sulfate)	In Water	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paraffin (Aliphatic Hydrocarbon)	Varies from Gas to Waxy Solid	1	1	1	X	X	1	X	X	2	X	1	X	1	-	-	2	1	1	-	1	-
Paraformaldehyde	White Solid - Flakes or Powder	1	-	-	-	-	2	-	1	2	-	-	-	-	-	1	-	1	1	1	-	-
Paraldehyde	Colorless Liquid	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paranox (Detergent, Disperser; Exxon)	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parapol (Liquid Polyisobutylene; Exxon)	Liquid	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Peanut Oil	Yellow to Green Liquid	1	1	-	2	-	1	-	-	2	X	-	-	-	-	2	1	1	1	1	1	1
Pelargonic Acid	Colorless to Yellow Oil	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentachloroethane	Colorless Liquid	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Pentachlorophenol In Oil	In Oil (Wood Preservative)	1	1	1	X	X	X	X	X	X	1	1	-	-	-	X	-	-	-	-	-	-
Pentaerythritol (Monopentaerythritol)	White Powder	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentane	Colorless Liquid	1	X	X	X	X	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-
Pentanol (Methyl Propyl Carbinol)	Colorless Liquid	1	1	1	1	1	-	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-
Pentanone (Methyl Propyl Ketone)	Water White Liquid	1	-	-	-	2	X	-	X	X	2	X	X	-	-	X	-	-	-	-	-	-
Pentasol (Amyl alcohols, primary and secondary)	Liquid	1	2	2	2	2	2	2	2	2	2	1	2	1	1	2	1	1	1	1	1	-
Perchloric Acid (70%)	70% or Less with H2O	1	2	1	2	-	-	2	2	2	2	1	2	-	X	X	-	2	1	-	-	1
Perchloroethylene	Colorless Liquid	1	2	-	X	X	X	X	X	X	X	1	X	2	2	X	1	1	1	-	X	-
Petroleum Coke	Solid Pellets	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum Distillate	Liquid	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Petroleum Ether (Naptha)	Liquid	1	1	-	X	X	2	X	X	X	X	1	X	1	-	X	2	1	1	-	1	-
Petroleum Naphtha (Toluene/cyclohexane/Xylene)	Liquid	1	X	X	X	X	X	X	X	X	X	1	X	X	X	X	-	-	-	-	-	-
Petroleum Naphtha Flash Point Over 200 Degrees	Liquid	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Petroleum Oils (Refined)	Liquid	1	1	1	X	X	1	X	X	2	X	1	2	-	1	1	-	-	-	-	-	-
Petroleum Oils (Sour)	Liquid	1	1	1	X	X	1	X	X	2	X	1	X	-	-	2	-	-	-	-	-	-
Petroleum Paraffin Wax	Solid with low Melt Points	1	2	2	X	X	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Phenol (Carbolic Acid)	White or Pink Crystals	1	2	-	2	2	X	X	X	X	2	1	X	1	X	X	X	1	1	2	X	-
Phenol Acid	95% or less with H2O	1	2	2	2	2	X	X	X	X	2	1	X	1	X	X	X	1	1	_	X	-
Phenolates	-	1	-	-	-	-	X	-	-	X	-	2	X	-	2	-	-	-	-	-	-	-
Phenolsulfonic Acid	Yellow to Brown Liquid	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-

Gates Chemical Rating System

NOTE: Ratings are for the effect on the *polymer only*.

"1" Preferred: Constant Contact — This chemical is expected to have minor or no effect on the Polymer. Hose approved for continuous contact. Environmental changes such as temperature, concentration, etc., may promote increased degradation.

"2" Acceptable: Intermittent Contact — This polymer should give reasonably satisfactory service. Due to the nature of this chemical, and under prolonged continuous exposure, the rubber may show minor to moderate deterioration and/or solution discoloration. Hose in-tended for transfer service only. Environmental changes such as temperature, concentration, etc., may promote increased degradation.

"X" Not Recommended — The polymer is unsatisfactory for this chemical and should not be used.

"-" (Dash) — Insufficient or no data available for this material. Testing is advised.

NOTE 1. The above ratings as applied to the Chemical Resistance Table are intended as guides only. They are compiled from the best data available to us. Ratings shown in the table are based on 100% concentrated or saturated solutions, unless otherwise noted, and up to 100 F (+38°C), unless otherwise stated.

NOTE 2. If unusual conditions exist, a polymer test in the fluid is suggested.

NOTE 3. Where a chemical listed in the Resistance Table is soluble in a solvent other than water, the solvent should also be checked for its suitability with the polymer.

NOTE 4. Discoloration of fluids conveyed in the hose. There are no generally accepted standard tests for measuring or rating discoloration of fuids passing through a hose. The amount of discoloration that can be tolerated is usually established by the user on the basis of application. Obviously, products such as paint must be conveyed through a hose that has very good non-discoloring characteristics. If the product is not visually affected, then the hose is satisfactory. For some products, the discoloration may be objectionable from a visual standpoint. Also, the concentration of the particles causing the discoloration may be objectionable if they affect the final use of the product.

Some of the more common methods of checking discoloration are:

1. Allowing the fluid to remain in a sample piece of hose for a specific period and expected operating temperature, then inspecting visually for discoloration.

2. Testing fluid as in No.1 above and then passing it through filter paper to check foreign content.

3. A more refined test can be made with a spectrophotometer. This instrument measures light transmission through the fluid before and after immersion tests with rubber stocks. This gives a relative rating expressed in percent, the original fluid being rated at 100%.

If discoloration of the product becomes a serious problem for a specific application, contact Denver Product Application for a recommendation. Phone (303) 744-5070.

NOTE 5. Fluid permeation through the tube wall needs to be considered. A tube material may show no sign of degradation, however hose failure can occur if material permeates through the tube to degrade adhesive layers or reinforcement.

Hose Coupling Material — Gates recommends hose couplings made of six materials: Iron or Carbon Steel, 304SS, 316SS, Aluminum, Brass and Polypropylene. The Chemical Resistance Table includes columns showing the suitability of a specific coupling material for the chemicals listed. In most instances, at least one coupling material is rated for each chemical. For certain chemicals, other metallic alloys or plastics than those shown in the table are required. These are generally available from coupling manufacturers, but are not stocked by Gates.

ENGINEERING

Chemical Resistance Chart

PLASTICS | ELASTOMERS | ALLOYS

CHEMICALS		APPROX. SP. GR. AT 100% CONCENTRATION	PVC	CPVC	POLYPROPYLENE (PP)	POLYVINYLIDENE FLUORIDE (PVDF)	POLYETHYLENE (PE)	POLYETHYLENE-CROSS LINKED (XLPE)	RYTON	TEFLON	EPOXY	VINYLESTER	POLYSULFONE	VITON	EPDM	NEOPRENE	BUNA N (NITRILE)	HYPALON	316 STAINLESS STEEL	304 STAINLESS STEEL	TITANIUM	HASTELLOY C
Oils, Silicone					A						A			A		A	A		A	A		
Oils, Vegetable*			A	A	A	A			A					A			A					
Oleic Acid (Red Oil)		0.895	A	B	A	A	D	D	A	A	A	A		B	C	B	B	B	A	A		B
Oleum			D	D	D	D		D	D	A	D	D		D	D	D	D	D	A			
Orange Extract					A	A	A	A		A												
Oxalic Acid	$(COOH)_2$	1.7	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	B	A	C	B
Oxygen Gas			A	A	A	A			A	A			A	A	A	A	C	A				
Ozone			B	B	C	A	C	C	A			A		A	A	B	D	A				
Palmitic Acid 10%			A	A	A	A	B		A	A	A	A		A	B	C	A	C				
Palmitic Acid 70%			C	A	A		B		A	A	A	A		A	B	C	A	C				
Paraffin			A	A	A	A				A	A			B	D	B	A	D	A	A		
Pentane (Amyl Hydride)										A	A			A	D	B	A	B	C	C		B
Peracetic Acid 40%		1.15	D	D	D	A				A				A	B							
Perchloric Acid 10%			A	A	A	A	A	A	A	A	D			A	B	D	D	D				
Perchloric Acid 70%	$HClO_4$	1.764	D	D	A	A			D	A	D			A	A	D	D	D				
Perchloroethylene	$(CCl_2)_2$	1.6	D	D	C	A			A	A	B	D		A	D	D	D	D	A	A		
Perphosphate			A	A	A					A				A	A							
Petrolatum (Petroleum Jelly)			A	A	A	A				A	A			A	C	B	A	B	A			
Petroleum (Sour)*			A											A	D		A					
Petroleum Oils			A	A	B	A				A				A	D	C	A	C				
Phenols 100% (Carbolic Acid)	C_6H_5OH	1.1	D	A	A	A	B	D	A	A	D	D		B	C	D	D	C	A	A	C	A
Phenylacetate		1.073								A				D	B	D	D	C				
Phenylhydrazine			D	D	D	A				A				C	C	D	D	D				
Phenylhydrazine Hydrochloride			A	A	D	A																
Phosgene Gas			D	D	C	A			A					D	A	C	D					
Phosgene Liquid		1.392	D	D	D	C			A					D	A	C	D					
Phosphoric Acid 10%			A	A	A	A		A	A	A	C	A		A	A	C	C	A	A	D	B	A
Phosphoric Acid 20%			A	A	A	A				A			A	A	A	B	C	A				
Phosphoric Acid 40%			A		A		B		A	A	A			A	B	D	D		A	B	A	A
Phosphoric Acid 50%			A	A	A	A	A	A	A	A	C	A	A	A	A	C	C	B	B	D	B	A
Phosphoric Acid 80%			A	A	A	A				A				A	A							
Phosphoric Acid 85%		1.8	A	A	A	B	B	A	A	A	C	A		A	A	C	C	B	B	D	C	A
Phosphoric Acid 100%			A		A		C	A	A	A	C	A	A	A	B	D	D	C	B	C	B	A
Phosphoric Acid Crude	H_3PO_4	1.834					C		A	A	C	A		A	B	D	C	A	C	D	C	A
Phosphorus Oxychloride		1.675								A		D				D		D				
Phosphorus Red			A	A	A	A			A	A												
Phosphorus Trichloride	PCl_3	1.574	D	D	C	A	A		D	A				C	C	D	D		A	A		
Phosphorus Yellow			A	A	A	A		A	A	A						C						
Photographic Developer			A	A	A	A	B	A			A			A		A	A		A	C	A	A
Photographic Solutions*			A	A	A	A	A	A	A	A				A			A					
Phthalic Acid (Terephthalic Acid)			D	D	D	A				A				A	A							
Phthalic Anhydride	$C_6H_4(CO)_2O$		D	D	D					A	B	A		A	A		C		B	A		A
Pickle Brine			A	A	A	A										A		A				
Pickling Solutions*			A	A	A	A				A				B	C	D	D	D				

A = Excellent, No Effect B = Good, Minor Effect C = Fair, Data Not Conclusive, Testing Recommended D = Not Recommended

HARRINGTON

Warren- Rupp

CHEMICAL	FORMULA	ELASTOMERS: RUPPLON®	NEOPRENE	BUNA-N	E.P.D.M.	VITON®	BLUE GYLON®	TEFLON®/TUFFRUPP®	METAL PARTS: ALUMINUM	CAST IRON	STAINLESS STEEL	HASTELLOY-C®	PLASTICS: POLYPROPYLENE	DELRIN® (ACETAL)	KYNAR® (PVDF)	CPVC - PVC	NYLON	RYTON®
Oxalic Acid	$(COOH)_2$	•	B	C	A	C	A	A	B	X	10%B	B	A	X	A 120°	A	B	A
Ozone	O_3	A	B	X	A	A	A	A	10%A	10%A	A	A	X	C	A	X	X	
Paints & Solvents		•	X	X	•	•	•	A	X	•	A	A						
Paint Thinner, DUCO	Hydrocarbons	X	C	A	X	B	•	A	X	•	A	A	X					
Palm Oil	Mixture of terpenes	•	C	A	•	A	•	A	•	A	A	A						
Palmitic Acid	$CH_3(CH_2)_{14}COOH$	A	C	B	B	B	A	A	B	B	A	•	A		A	B	C	
Paraffins (Paraffin Oil)	Hydrocarbons	•	•	A	•	•	•	A	A	•	A	A	A	A		A	A	
Paraformaldehyde	$(CH_2O)_n$	•	B	B	•	C	•	A	10%A	A	A	A						
Paraldehyde	$C_6H_{12}O_3$	•	B	C	A	X	•	A	A	A	A	A						
Peanut Oil	Glycerides of fatty acids	C	B	A	X	A	•	A	•	A	A	A						
Pentachloroethane (Pentalin)	Cl_2CHCCl_3	•	X	X	•	A	•	A	X	A	A	A						
Pentachlorophenol (PCP)	C_6Cl_5OH	•	X	X	X	A	•	A	A	A	A	A						
Pentane (Amyl Hydride)	C_5H_{12}	•	B	A	X	A	•	A	A	B	B	•				C	A	
Peppermint Oil		•	X	X	•	A	•	A	•	•	A	•						
Perchloric Acid	$HClO_4$	•	B	X	B	A	A	70%A	X	X	B	•		C	A	X	X	A
Perchloroethylene (Tetrachloroethylene)	C_2Cl_4	X	X	X	X	A	•	A	X	B	10%A	B	X	A	A	X	C	A
Petroleum (Crude Oil) (Sour)	Hydrocarbons	C	C	B	X	A	A	A	B	B	A	A	B	A	A	C	A	
Phenethyl Alcohol (Benzyl Carbinol)	$C_6H_5(CH_2)_2OH$	X	X	X	B	X	•	A	A	A	A	A						
Phenol (Carbolic Acid)	C_6H_5OH	X	C	X	C	A	•	A	B	A	B	A	C	X	A 150°	A	X	A

Warren-Rupp

CHEMICAL	FORMULA	ELASTOMERS: RUPPLON®	NEOPRENE	BUNA-N	E.P.D.M.	VITON®	BLUE GYLON®	TEFLON®/TUFFRUPP®	METAL PARTS: ALUMINUM	CAST IRON	STAINLESS STEEL	HASTELLOY-C®	PLASTICS: POLYPROPYLENE	DELRIN® (ACETAL)	KYNAR® (PVDF)	CPVC - PVC	NYLON	RYTON®
Phenol Sulfonic Acid	$C_6H_4(OH)SO_3H$	•	•	X	•	X	•	A	B	B	B	•				B		
Phenyl Acetate	$CH_3COOC_6H_5$	X	X	X	B	X	•	A	•	•	•	•						
Phenylbenzene	C_6H_5	—	X	X	—	A	—	A	—	—	—	—						
Phenyl Ethyl Ether (Phenetole)	$C_6H_5OC_2H_5$	•	X	X	X	C	•	A	•	•	•	•						
Phenyl Hydrazine	$C_6H_5NHNH_2$	•	X	X	X	A	•	A	A	X	•	•	X		A 120°			
Phorone (Diisopropylidene Acetone)	$C_9H_{14}O$	•	X	X	C	A	•	A	•	•	•	•						
Phosphoric Acid — 10%	H_3PO_4	A	B	A	A	A	•	A	X	X	A	•	A 120°		A		X	A
Phosphoric Acid — 20%	H_3PO_4	A	B	C	A	A	•	A	X	X	A 212°	A	A 120°		A		X	A
Phosphoric Acid — 50%	H_3PO_4	A	B	X	B	A	X	A	X	X	A	C	A 120°		A		X	A
Phosphoric Acid (Conc.)	H_3PO_4	C	B	X	B	A	•	A	X	X	A 212°	•	A 120°		A		X	A
Phosphorus Oxychloride	$POCl_3$	•	X	•	•	•	•	A	B	B	B	B						
Phosphorus Trichloride	PCl_3	•	X	X	A	A	•	A	C	B	A	A	A		A	X		A
Photographic Developer		—	A	A	—	A	—	—	C	X	A	A	A	C	A	A	B	A
Pickling Solution		C	X	•	X	B	•	A	•	•	•	A						
Picric Acid (Carbazotic Acid)	$(NO_2)_3C_6H_2OH$	B	B	B	B	A	•	A	A	C	A	B	B		A	X	X	
Pine Oil (Yarmor)	Cyclic terpene alcohols	•	X	B	X	A	•	A	A	B	A	•						
Pinene	$C_{10}H_{16}$	C	X	B	X	A	•	A	•	•	•	•						
Piperidine	$C_5H_{11}N$	•	X	X	X	X	•	A	•	•	•	•						
Plating Solution — Cadmium		•	B	B	•	•	•	A	•	•	A	•	A		B	B	A	

RATING KEY: (A) EXCELLENT (B) GOOD (C) FAIR TO POOR (X) NOT RECOMMENDED (•) OR (—) NO DATA AVAILABLE
Data limited to % concentration and/or temperature °F shown. Where not shown temperature is 70°F Ambient.

A=May be used for Continuous Service
B=May be used for Intermittent Service
X=Do not Use
I=Insufficient Data

River/Bend Transfer Systems, LLC

Chemical	Temperature	UHMWPE	EPDM	LDPE
Nitro Benzene	100	A	X	A
Nitrogen Gas	100	A	A	A
Nitrous Oxide	100	A	A	A
Nonenes	100	A	X	A
Octadecanoic Acid	100	B	B	A
Octane	100	A	X	B
Octanol	100	A	X	A
Octyl Acetate	100	A	I	A
Octyl Alcohol	100	A	X	A
Octyl Aldehyde	100	A	I	A
Octyl Amine	100	A	I	A
Octyl Carbinol	100	A	A	A
Octylene Glycol	100	A	A	A
Oil Petroleum	100	B	X	A
Oleic Acid	100	A	X	A
Oleum	100	X	X	X
Organic Fatty Acids	100	A	X	A
Orthodichlorobenzene	100	A	X	A
Orthodichlorobenzol	100	A	X	A
Orthoxylene	100	B	X	A
Oxalic Acid	100	A	B	I
Oxygen*				
Ozone	100	A	A	I
Palmitic Acid	100	A	B	B
Papermakers Alum	150	A	A	A
Paradichlorobenzol	100	B	X	A
Paraffin	150	A	X	X
Paraldehyde	100	A	B	A
Paraxylene	100	A	X	A
Pelargonic Acid	100	A	I	A
Pentachloroethane	100	A	X	A
Pentane	100	X	X	B
Pentanol	100	A	A	A
Pentanone	100	A	I	A
Perchloroethylene	100	B	X	A
Petroleum Ether (Ligroin)	100	A	X	A
Petroleium -Crude	100	A	X	A
Petroleum Oils	100	A	X	A

* NO HOSE RECOMMENDED FOR THIS APPLICATION
** SPECIAL HOSE REQUIRED

Source: Goodyear Hose Products, Industrial Hydraulic Hose Catalog

Nibco

CHEMICAL RESISTANCE GUIDE FOR VALVES AND FITTINGS

CHEMICALS AND FORMULA	CONCENTRATION	PLASTICS AND ELASTOMERS AT MAXIMUM TEMPERATURE (°F)											METALS																	
		ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUORO-CARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Oleic Acid $CH_3(CH_2)_7CH:CH(CH_2)_7COOH$			185	150	140	250	250	B to 70	100	C	B to 70	85		A	B	B	A		B	B	C			B	A	A	A	A		A
Oleum $xH_2SO_4 \cdot ySO_3$				C	C	C	150	C	C	C	C	100			C	C	C	C	C	C	C				A		A	C		A
Olive Oil						250	350		140	B to 100	140	150		A	A	A	A	A	A	A	A	A		A	A	A	A	A	A	
Oxalic Acid $HOOCCOOH \cdot 2H_2O$	50%		185	180	140	125	300	210	C		100	185	C		C	C	C		C	C	C	C	C	B	A	A	A	A		A
Oxygen (Gas) O_2			185	150	140	230	406	210	B to 70	140	140	185	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Ozone O_3					140	225	300	210	C	140	C	185	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Palm Oil						200	200	C	140	C		70			C	C			C	C	C		C		A		A	A		
Palmitic Acid $CH_3(CH_2)_{14}COOH$	10%		73	180	140	250	300	70	100	C	C	185		A	B	B	B	A	B	B	B		B	B	A	A	A	A		
Palmitic Acid $CH_3(CH_2)_{14}COOH$	70%		73	180	73	250	300		100	C	C	185		A	B	B	B	A	B	B	B		B	B	A	A	A	A		
Paraffin $C_{36}H_{74}$		B to 70			140	250	250	C	100		140	300		A	A	A	A		B	A	A	B	B	A	A	A	A	A	A	A
Peanut Oil						250	250		100			150			A	A			A	A			A		A		A			
n-Pentane $CH_3(CH_2)_3CH_3$		C					100	C	100			100	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Peracetic Acid CH_3COOOH	40%				73																									
Perchloric Acid $HClO_4$	10%		185	73	73	200	250	140	C	70	70	185							C						A		A	A		
Perchloric Acid $HClO_4$	70%		185	73	73	125		70	C	C	C	185							C						B		B	A		
Perchloroethylene $Cl_2C:CCl_2$						275	200	C	C	C	C	70			B	B			B	B	B		B	A	A	A	A	A		A
Perphosphate					73		250	70	70			100																		
Phenol C_6H_5OH		C	73	73	C	125		70	C	C	C	200			A	A	C		C	C	C		C	A	A	A	A	A		A
Phenylhydrazine $C_6H_5NHNH_2$					C	125	B to 70	C	C	C	70	185																		
Phosphate Esters									C		C	100			C	C			C	C			C		A		A	A		
Phosphoric Acid H_3PO_4	10%		210	180	140	275	300	140	C	200	140	200	C	C	C	C	C	C	C	C	C	C	C	B	A	A	A	C		
Phosphoric Acid H_3PO_4	50%		210	180	140	275	300	70	C	200	140	200	C	C	C	C	C	C	C	C	C	C	C	B	A	A	A	C		
Phosphoric Acid H_3PO_4	85%		73	180	140	275	300	70	C	200	C	200	C	C	C	C	C	C	C	C	C	C	C	B	A	B	A	C		
Phosphoric Anhydride P_2O_5											70		B								C				A		A			
Phosphorus (Red)					140	75	300																		A		A			
Phosphorus (Yellow)					73		300																							
Phosphorus Pentoxide P_2O_5					73	200		140					C				C				B				A		A			

NIBCO CHEMICAL RESISTANCE GUIDE FOR VALVES & FITTINGS

INTRODUCTION

This chemical resistance guide has been compiled to assist the piping system designer in selecting chemical resistant materials. The information given is intended as a guide only. Many conditions can affect the material choices. Careful consideration must be given to temperature, pressure and chemical concentrations before a final material can be selected.

Plastics and elastomers physical characteristics are more sensitive to temperature than metals. For this reason, a rating chart has been developed for each.

MATERIAL RATING FOR PLASTICS & ELASTOMERS

Temp. in °F	= "A" rating, maximum temperature which material is recommended, resistant under normal conditions
B to Temp. in °F	= Conditional resistance, consult factory
C	= Not recommended
Blank	= No data available

MATERIAL RATINGS FOR METALS

A	= Recommended, resistant under normal conditions
B	= Conditional, consult factory
C	= Not recommended
Blank	= No data available

Temperature maximums for plastics, elastomers and metals should always fall within published temp/pressure ratings for individual valves.

This guide considers the resistance of the total valve assembly as well as the resistance of individual trim and fitting materials. The rating assigned to the valve body plus trim combinations is always that of the least resistant part. In the cases where the valve body is the least resistant, there may be conditions under which the rate of corrosion is slow enough and the mass of the body large enough to be usable for a period of time. Such use should always be determined by test before installation of the component in a piping system.

In the selection of a butterfly valve for use with a particular chemical, the liner, disc, and stem must be resistant. All three materials should carry a rating of "A". The body of a properly functioning butterfly valve is isolated from the chemicals being handled and need not carry the same rating.

THERMOPLASTICS & ELASTOMERS

ABS — (Acrylonitrile-Butadiene-Styrene) Class 4-2-2 conforming to ASTM D1788 is a time proven material. The smooth inner surface and superior resistance to deposit formation makes ABS drain, waste, and vent material ideal for residential and commercial sanitary systems. The residential DWV system can be exposed in service to a wide temperature span. ABS-DWV has proven satisfactory for use from –40°F to 180°F. These temperature variations can occur due to ambient temperature or the discharge of hot liquids into the system. ABS-DWV is very resistant to a wide variety of materials ranging from sewage to commercial household chemical formulations. ABS-DWV is joined by solvent cementing or threading and can easily be connected to steel, copper, or cast iron through the use of transition fittings.

CPVC — (Chlorinated Polyvinyl Chloride) Class 23447-B, formerly designated Type IV, Grade 1 conforming to ASTM D-1784 has physical properties at 73°F similar to those of PVC, and its chemical resistance is similar to or generally better than that of PVC. CPVC, with a design stress of 2000 psi and maximum service temperature of 210°F, has proven to be an excellent material for hot corrosive liquids, hot and cold water distribution, and similar applications above the temperature range of PVC. CPVC is joined by solvent cementing, threading or flanging.

P.P. (Polypropylene) — (PP) Type 1 Polypropylene is a polyolefin which is lightweight and generally high in chemical resistance. Although Type 1 polypropylene conforming to ASTM D-2146 is slightly lower in physical properties compared to PVC, it is chemically resistant to organic solvents as well as acids and alkalies. Generally, polypropylene should not be used in contact with strong oxidizing acids, chlorinated hydrocarbons, and aromatics. With a design stress of 1000 psi at 73°F, polypropylene has gained wide acceptance where its resistance to sulfur-bearing compounds is particularly useful in salt water disposal lines, crude oil piping, and low pressure gas gathering systems. Polypropylene has also proved to be an excellent material for laboratory and industrial drainage where mixtures of acids, bases, and solvents are involved. Polypropylene is joined by the thermo-seal fusion process, threading or flanging. At 180°F., P.P. should be used for drainage only.

PVC — (Polyvinyl Chloride) Class 12454-B, formerly designated Type 1, Grade 1. PVC is the most frequently specified of all thermoplastic materials. It has been used successfully for over 30 years in such areas as chemical processing, industrial plating, chilled water distribution, deionized water lines, chemical drainage, and irrigation systems. PVC is characterized by high physical properties and resistance to corrosion and chemical attack by acids, alkalies, salt solutions, and many other chemicals. It is attacked, however, by polar solvents such as ketones, some chlorinated hydrocarbons and