Evaluation of Hose-in-Hose Transfer Line Service Life for Hanford's Interim Stabilization Program

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U.S. Department of Energy Contract DE-AC06-96RL13200

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Abstract: This document presents a determination for the amount of expected service life from the Hose-in-Hose Transfer Line in 241-S, 241-SX, 241-U, 241-BY and 241-BX Tank Farms.

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	evaluations for HIHTL of BY and BX tank farms. Defines the shelf life and service life.		

EVALUATION OF HOSE-IN-HOSE TRANSFER LINE SERVICE LIFE FOR HANFORD'S INTERIM STABILIZATION PROGRAM

March 5, 2001

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APPENDICES

EVALUATION OF HOSE-IN-HOSE TRANSFER LINE SERVICE LIFE FOR HANFORD'S INTERIM STABILIZATION PROGRAM

1.0 INTRODUCTION

RPP-6153, *Engineering Task Plan for Hose-in-Hose Transfer System for the Interim Stabilization Program* (Torres, 2000a), defines the programmatic goals, functional requirements, and technical criteria for the development and subsequent installation of waste transfer line equipment to support Hanford's Interim Stabilization Program. RPP-6028, *Specification for Hose in Hose Transfer Lines for Hanford's Interim Stabilization Program* (Torres, 2000b), has been issued to define the specific requirements for the design, manufacture, and verification of transfer line assemblies for specific waste transfer applications associated with Interim Stabilization. Included in RPP-6028 are tables defining the chemical constituents of concern to which transfer lines will be exposed.

Current Interim Stabilization Program planning forecasts that the at-grade transfer lines will be required to convey pumpable waste for as much as three years after commissioning, RPP-6028 Section 3.2.7. Performance Incentive Number ORP-05 requires that all the Single Shell Tanks be Interim Stabilized by September 30, 2003. The Tri-Party Agreement (TPA) milestone M-41-00, enforced by a federal consent decree, requires all the Single Shell Tanks to be Interim stabilized by September 30, 2004. By meeting the Performance Incentive the TPA milestone is met. 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.

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. A three year service life meets the design goal included in the hose specification, RPP-6028 (Torres, 2000b). 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.

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 Ethylene-Propylene Diene Monomer (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-MP-5824, *Integrated Biological Control Management Plan* (Johnson, 2000).

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 Attachment 2 of RBHS's letter of 6/8/00, which specifies the suitability of the selected material for the process pressure and temperature conditions as specified in RPP-6028. Limiting values of process pressure and temperature in the documentation are equal to or exceed the values specified in RPP-6028 Section 3.2 (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

	Inner Hose		Outer Hose	
	Required	Per Catalog	Required	Per Catalog
Working Pressure	375 psi	375 psi	60 psi	200 psi
Working Temperature	-25 to 130 F	-40 to 180 F	-25 to 130 F	-40 to 180F

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.

The flow rate of waste being transferred from the single shell tanks for Interim Stabilization is very low, less than 5 gpm. A high flow rate, greater than 100 gpm, would raise a concern about abrasive erosion. The waste being transferred from the Single Shell Tanks follows HNF-SD-WM-OCD-015, *Tank Waste Compatibility Program* (Fowler, 2000), which requires that waste streams have $< 5\%$ solids by volume and a SpG ≤ 1.35 or an evaluation is required. Considering the characteristics of the waste, the low flow rate and the transfer line material, no damage to the hose due to abrasive erosion is expected.

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 includes a CHG Interoffice Memorandum, file number 7M100-00-001, dated 10/4/00, issued by Data Development and Interpretation. The table enclosed in this memorandum is the *Chemical Constituents of Undiluted Waste for 241-BY Farm.* The hose manufacturer, Granford Manufacturing Inc., was most concerned with Sodium Hydroxide since the concentration is much higher than the rest of the chemicals. The table for BY farm states that Sodium Hydroxide is 144,00 mg/L, which is the less than the amount in S/SX farm of 211,000 mg/L. Therefore, this evaluation can also be applied to conditions encountered by the Interim Stabilization waste transfers in BY and BX farms. We can thus conclude that hose material is suitable for continuous duty under exposure to chemical concentrations and process temperatures that bound the application parameters defined in RPP-6028, Tables 3-1, 3-2 & 3-3, for Interim Stabilization.

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, Ethylene-Propylene Diene Monomer (EPDM – the material specified for hose construction in RPP-6028) 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 in the Interim Stabilization Program to be 100 Rad/hr, the computation of exposure time to achieve threshold dose is as follows:

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

3.0 OTHER CONSIDERATIONS

The outer hose is a safety significant item that would confine leaks from the inner hose and route 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. 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 Hose & Hose Assembly 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, its 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 the minimum of a three year service life per RPP-6028 Section 3.2.7, has been met. 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.

The service life of the transfer lines is recorded in drawing H-14-103928 for continuous lines and H-14-103929 for jointed lines. The Interim Stabilization Performance Incentive is to complete Interim Stabilization of Single Shell Tanks by September 30, 2003 which is within the specified service life of the transfer lines.

5.0 REFERENCES

Fowler, K. D., 2000, HNF-SD-WM-OCD-015, Rev. 3, *Tank Waste Transfer Compatibility Program.*

Johnson, A. R. and Austin, B. A., 2000, HNF-MP-5824, Rev. 0, *Integrated Biological Control Management Plan*

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

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.*

APPENDIX A

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
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

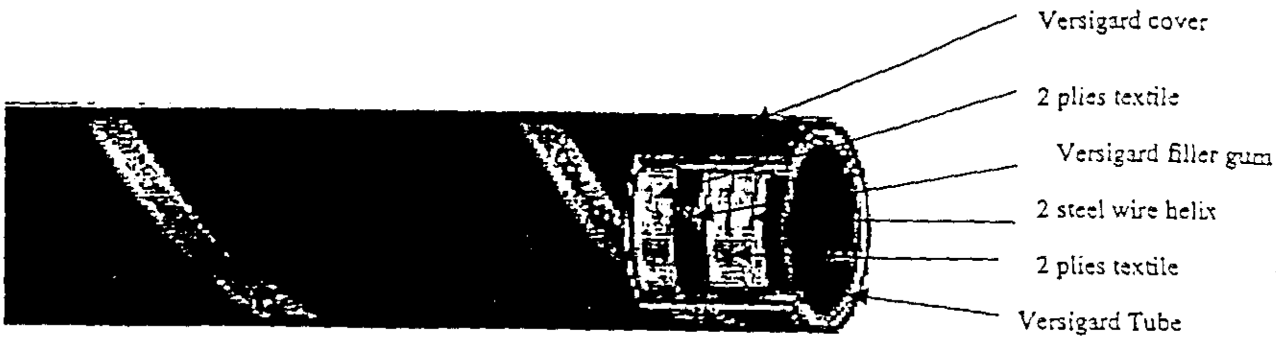
CERTIFICATE

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

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

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

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 Compatability.

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

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 # S69893 (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
20128742	54641806401000	Langlois 2x100 S-037 EPDM S&D	96119	96119
20118228	54641806402500	Langlois 2x250 S-037 EPDM S&D	96119	96119
20128743	54641812301000	Langlois 4x100 S-037 EPDM S&D	96141	96141
20118692	54641812302500	Langlois 4x250 S-037 EPDM S&D	96141	96141

Shelf Life

The estimated shelf life for Goodyear EPDM Suction and Discharge hose, manufactured under purchase order #S69893, is seven (7) years from the date of manufacture (August 6, 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, eng.
Title	R&D Manager
Date	Tuesday, August 29, 2000

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.

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	546-596-064

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

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.

CERTIFICATION	
Signed	[signature]
Name	Lynn Dion
Title	Quality Assurance
Date	November 16, 2000

COMPONENT CONFORMANCE

EPDM S&D Hose built in nov. 10,2000: #BATCH#7903143DE LOT#:2243260000001
DELIVERY NUMBER:40236934 SHIPMENT NUMBER:861919

Material number(s):	20133153	Quantity:	1
Operator #:	540		
Build Date:	nov. 10,2000		
Size:	2"		
EPDM Rubber Tube Lot #:	79244		
EPDM Rubber Cover Lot #:	79244		
Electricity test	98,000 ohms		
Cure:	n/a		

COMPONENT CONFORMANCE

EPDM S&D Hose built in nov. 10,2000: #BATCH#7903143DC LOT#:2243270000002
DELIVERY NUMBER:40236256 SHIPMENT NUMBER:861843

Material number(s):	20133154	Quantity:	1
Operator #:	276		
Build Date:	nov. 10,2000		
Size:	2"		
EPDM Rubber Tube Lot #:	79244		
EPDM Rubber Cover Lot #:	79244		
Electricity test	279,000 ohms		
Cure:	n/a		

EPDM S&D Hose built in nov. 10,2000: #BATCH#7903143DD LOT#:2243270000001
DELIVERY NUMBER:40236256 SHIPMENT NUMBER:861843

Material number(s):	20133154	Quantity:	1
Operator #:	510		
Build Date:	nov. 10,2000		
Size:	2"		
EPDM Rubber Tube Lot #:	79244		
EPDM Rubber Cover Lot #:	79244		
Electricity test	162,000 ohms		
Cure:	n/a		

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	546-596-123

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

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.

CERTIFICATION	
Signed	[signature]
Name	Lynn Dion
Title	Quality Assurance
Date	November 16, 2000

COMPONENT CONFORMANCE

EPDM S&D Hose built in nov. 10,2000: #BATCH#7903154DC LOT#:2243280000001
DELIVERY NUMBER:40236934 SHIPMENT NUMBER:861919

Material number(s):	20133155	Quantity:	1
Operator #:	540		
Build Date:	nov. 10,2000		
Size:	4"		
EPDM Rubber Tube Lot #:	79252		
EPDM Rubber Cover Lot #:	79252		
Electricity test	60,000 ohms		
Cure:	n/a		

COMPONENT CONFORMANCE

EPDM S&D Hose built in nov. 10,2000: #BATCH#7903155AA LOT#:2243290000002
DELIVERY NUMBER:40236934 SHIPMENT NUMBER:861919

Material number(s):	20133156	Quantity:	1
Operator #:	235		
Build Date:	nov. 10,2000		
Size:	4"		
EPDM Rubber Tube Lot #:	79244		
EPDM Rubber Cover Lot #:	79244		
Electricity test	107,000 ohms		
Cure:	n/a		

EPDM S&D Hose built in nov. 10,2000: #BATCH#7903155AB LOT#:2243290000001
DELIVERY NUMBER:40236934 SHIPMENT NUMBER:861919

Material number(s):	20133156	Quantity:	1
Operator #:	540		
Build Date:	nov. 10,2000		
Size:	4"		
EPDM Rubber Tube Lot #:	79244		
EPDM Rubber Cover Lot #:	79244		
Electricity test	120,000 ohms		
Cure:	n/a		

River Bend Hose Specialty, Inc.
Shelf Life-Storage Recommendations
Hose in Hose Transfer Line

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 50 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. The length of the transfer hose is protected with insulation painted with UV protective paint, and care should be taken to insure that the insulation remains in place.
- 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 beneath the insulation 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.

Signed [signature]	
Name	James Betz
Title	President
Date 2/14/01	

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
tél. : (450) 375-5050 ext. 256 | fax : (450) 375-6254

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 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

CHG Interoffice Memo File No. 74B20-00-047
Chemical Characteristics for Liquid Waste in U Tank Farm

CHG Interoffice Memo File No. 74B20-00-048
Chemical Characteristics for Liquid Waste in S and SX Tank Farms

CHG Interoffice Memo File No. 7M100-00-001
Chemical Characteristics for Liquid Waste in BY Tank Farms

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 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

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