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Chemical Compatibility Screening Test Results

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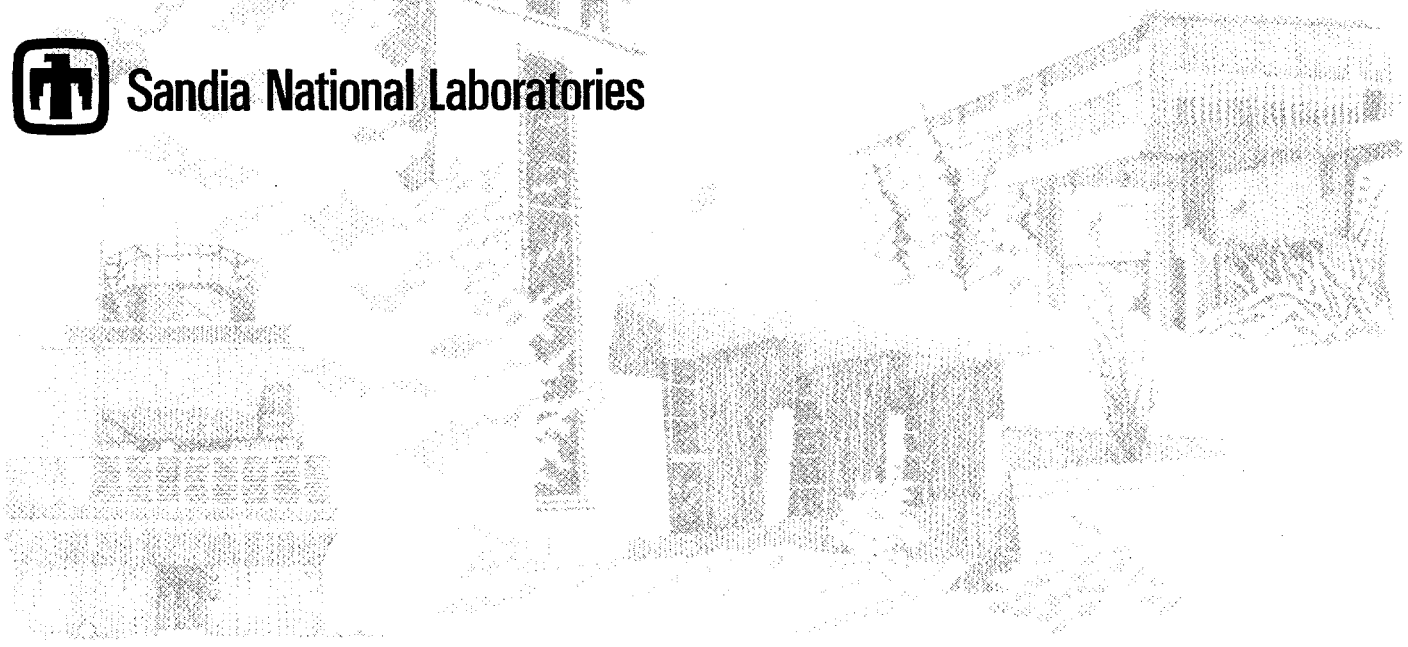

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CHEMICAL COMPATIBILITY SCREENING TEST RESULTS

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ABSTRACT

A program for evaluating packaging components that may be used in transporting mixed-waste forms has been developed and the first phase has been completed. This effort involved the screening of ten plastic materials in four simulant mixed-waste types. These plastics were butadiene–acrylonitrile copolymer rubber, cross-linked polyethylene (XLPE), epichlorohydrin rubber, ethylene–propylene rubber (EPDM), fluorocarbon (Viton or Kel-F), polytetrafluoroethylene, high-density polyethylene (HDPE), isobutylene–isoprene copolymer rubber (butyl), polypropylene, and styrene–butadiene rubber (SBR). The selected simulant mixed wastes were (1) an aqueous alkaline mixture of sodium nitrate and sodium nitrite; (2) a chlorinated hydrocarbon mixture; (3) a simulant liquid scintillation fluid; and (4) a mixture of ketones. The testing protocol involved exposing the respective materials to 286,000 rads of gamma radiation followed by 14-day exposures to the waste types at 60°C. The seal materials were tested using vapor transport rate (VTR) measurements while the liner materials were tested using specific gravity as a metric. For these tests, a screening criterion of 0.9 g/hr/m^2 for VTR and a specific gravity change of 10% was used. Based on this work, it was concluded that while all seal materials passed exposure to the aqueous simulant mixed waste, EPDM and SBR had the lowest VTRs. In the chlorinated hydrocarbon simulant mixed waste, only Viton passed the screening tests. In both the simulant scintillation fluid mixed waste and the ketone mixture simulant mixed waste, none of the seal materials met the screening criteria. For specific gravity testing of liner materials, the data showed that while all materials with the exception of polypropylene passed the screening criteria, Kel-F, HDPE, and XLPE offered the greatest resistance to the combination of radiation and chemicals.

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CHEMICAL COMPATIBILITY SCREENING TEST RESULTS

Executive Summary

The Chemical Compatibility Test Plan & Procedure Report (CCTP&PR) describes a program for evaluating packaging components that may be used in transporting mixed waste. The first phase of this experimental program has been completed. This effort involved screening ten plastic materials with a combination of radiation and four different simulant mixed-waste types. The plastics used were butadiene–acrylonitrile copolymer rubber (nitrile), cross-linked polyethylene (XLPE), epichlorohydrin rubber (EPI), ethylene–propylene rubber (EPDM), fluorocarbon (Viton or Kel-F), polytetrafluoroethylene (Teflon), high-density polyethylene (HDPE), isobutylene–isoprene copolymer rubber (butyl), polypropylene (PP), and styrene–butadiene rubber (SBR). The simulant mixed wastes were (1) an aqueous alkaline mixture of sodium nitrate and sodium nitrite; (2) a chlorinated hydrocarbon mixture; (3) a simulant scintillation fluid; and (4) a mixture of ketones.

The testing protocol involved exposing the plastic materials to 286,000 rads of gamma radiation followed by 14-day exposures to the waste types at 60°C. The seal materials or rubbers were tested using vapor transport rate (VTR) measurements, while materials suitable for liner applications were tested using specific gravity measurements. For these tests, a screening criteria of 0.9 g/hr/m^2 for VTR and a specific gravity change of 10% was used as a metric. Those materials that failed to meet these criteria were judged to have failed the screening tests and will be excluded in the next phase of this experimental program—comprehensive testing.

Based on this work, it was concluded that while all seal materials passed exposure to the aqueous simulant mixed waste, EPDM and SBR had the lowest VTRs. In the chlorinated hydrocarbon simulant mixed waste, only Viton passed the screening tests. In both the simulant scintillation fluid mixed waste and the ketone mixture simulant mixed waste, none of the seal materials met the screening criteria. In the specific gravity testing of liner materials, the data showed that while all materials, with the exception of polypropylene, passed the screening criteria, Kel-F, HDPE, and XLPE offered the greatest resistance to the combination of radiation and chemicals.

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Introduction

The Chemical Compatibility Program developed in the Transportation Systems Department at Sandia National Laboratories (SNL), New Mexico, was described in considerable detail in a 1993 Department of Energy (DOE) milestone document titled, "Chemical Compatibility Test Plan & Procedure Report (CCTP&PR)".[1]

The report presented a comprehensive discussion of chemical compatibility studies on plastic materials that could be used as liners and seals in transportation containers. It also provided a broad overview of the issues that need to be addressed in any program that undertakes chemical compatibility evaluations. It provided general information and proposed a number of tests and procedures for carrying out such a program. Because none of the current SNL packaging concepts have received approval, a program was developed to test various properties of a broad range of liner and seal materials.

This report presents the results of the first phase of this experimental program, which involved screening the responses of five candidate liner and six seal materials to four simulant mixed wastes. Since mixed wastes by definition are composed of radioactive and hazardous constituents, a simulant waste needed to have both of these components present to effectively mimic real mixed wastes. This was accomplished by designing the testing program so that the candidate materials were first exposed to gamma radiation followed by exposure to four waste types.

The materials screened were ten plastics having a known chemical resistance to a large number of classes of chemicals. The term "plastic" as used in this report refers to polymeric materials, which include both seals and liner materials. The plastics selected were butadiene–acrylonitrile copolymer (nitrile rubber), cross-linked polyethylene, epichlorohydrin, ethylene–propylene rubber, fluorocarbon, polytetrafluoroethylene, high-density polyethylene, isobutylene–isoprene copolymer (butyl rubber), polypropylene, and styrene–butadiene rubber.

The main threats to seals and liners from the anticipated wastes are judged to come from strong aqueous bases, chlorinated solvents, hydrocarbon solvents, and ketones. Thus, any seal or liner materials used in packaging must be resistant to samples containing strong bases, chlorinated solvents, hydrocarbons, and/or ketones. Because few polymers are resistant to all these materials, it is possible that different polymers will be chosen as container components for the different waste streams being transported.

Because of the wide variety of waste compositions found throughout the DOE complex, it is not possible to choose one specific simulant waste composition. In addition, since no specific transportation container has been selected or has been specified for certain waste compositions, it is neither possible nor prudent to select a very specific waste composition. However, there is sufficient information in the open literature and DOE reports to provide some guidance on the quantities and characteristics of the largest waste streams found within the DOE complex. Based on this rationale, four simulant mixed-waste compositions were selected. These are described in further detail below.

To simulate some of the tank wastes at the Hanford site, a simple aqueous solution was developed, consisting of 2 molar sodium nitrate, 0.7 molar sodium nitrite, 2 molar sodium hydroxide, 5.5 molar sodium carbonate, 0.1 molar cesium chloride, and 0.1 molar strontium chloride. The nitrate/nitrite species combination represents oxidizing chemical species while the hydroxide anion provides a simulation for the corrosive nature of the tank wastes. The cesium and strontium constituents simulate the radioactive component in this large Hanford waste stream. While more complex simulants could have been chosen to represent this waste stream, this

investigator's opinion is that this particular aqueous solution adequately represents the hazardous characteristics of the tank wastes required for compatibility evaluations.

To simulate the sizable inventories of chlorinated hydrocarbon mixed wastes, a solution of 50% by volume of trichloroethylene, 25% chlorobenzene, 24% carbon tetrachloride, and 1% cerium (III) 2-ethyl hexanoate was selected. This mixture of chemicals is believed to qualitatively represent the chlorinated solvent waste streams at the DOE sites. Similarly, to simulate scintillation fluids and/or fuel hydrocarbons, a solution of 33% toluene, 33% xylene, and 32% dioxane with 1% water was used. The water component is meant to simulate the tritiated water found in some mixed wastes. Finally, to simulate ketones, a solution of 60% methyl ethyl ketone and 39% methyl isobutyl ketone containing 1% cerium acetyl acetonate hydrate was used. Note that ketone solvents were frequently used in the nuclear fuel reprocessing cycle.

The selection of these simulants was based on a qualitative picture of the mixed-waste inventories and the relative volumes of these wastes. Their compositions were chosen with emphasis on the hazardous characteristics of the chemicals themselves. For the purpose of this evaluation, the term "hazardous characteristics" describes the effects of the wastes on the materials. Since the aqueous simulant waste has both oxidizing and corrosive characteristics, it can oxidize and can cause base hydrolysis of the polymeric materials. Both of these mechanisms have the potential to lead to degradation of plastics. Similarly, chlorinated solvents, aromatic solvents, and ketones can swell polymeric materials, which may ultimately compromise some of their material properties. The selection was consistent with the generic chemical mixtures described by Riley et al.[2] The CCTP&PR describes a testing program whose implementation is not dependent on the precise composition of the simulant. If alternative or more appropriate simulants have been overlooked, the testing program can be modified by revising the CCTP&PR.

The screening tests involved testing a large number of samples exposed to simulated wastes under harsh conditions such as elevated temperatures, high concentrations of chemicals, relatively high radiation doses, and relatively long exposure of the samples under these conditions. Temperatures of 60°C (140°F), high concentrations of pure chemicals, exposing materials to 286,000 rads of gamma radiation prior to exposure to the chemicals, and 14-day test durations were part of the testing program. While these parameters do not represent the harshest conditions available for testing, they have a combination of regulatory and technical basis.

Specific gravity and permeability were used as the criteria for determining whether a material passed or failed the screening tests. Any candidate liner material exhibiting a change in specific gravity greater than 10% would be determined to be not resistant to the combination of radiation and chemical exposure. Specific gravity values can easily be converted to density values by dividing the specific gravity value by the density of water. Similarly, candidate seal materials having vapor transmission rates (VTR) greater than 0.9 g/hr/m^2 were determined to be not resistant to the combination of radiation and chemical exposure owing to the excessive permeation of waste components through them. Thus density changes and VTR were the metrics used to screen the candidate materials. Note that the screening criteria were taken from literature[3] that dealt with the evaluation of landfill liner materials. These criteria, therefore, have their basis in U.S. Environmental Protection Agency regulations applicable to the long-term integrity of waste containment systems and not to U.S. Department of Transportation (DOT) regulations applicable to transportation containers. However, DOT regulations such as those specified for Type A packages, i.e., 49 CFR 173 - Appendix B,[4] define packages having permeation rates greater than 0.5% as failing to meet that test criterion. The permeation rates cited in 10 CFR 173 are in fact percent weight change over the length of the tests. Since one of the input parameters in calculating VTR is weight change, the DOT regulatory values can also be obtained from the VTR data.

The input parameters were evaluated with the use of standardized test methods such as those developed by the American Society for Testing and Materials (ASTM). For specific gravity

changes, ASTM D792[5] was used. In evaluating permeation rates, ASTM D814[6] was used. The number of materials requiring more complete evaluation was reduced because some of the materials did not pass certain acceptance criteria.

Experimental

Sample Preparation

Standardized test methods were used to cut, condition, and test the materials. Appendix A gives information on the materials used. The specific geometry of the material samples is given by the ASTM test method. The samples were cut with an expulsion press (Part # 22-16-00) manufactured by Testing Machines Inc. (Amityville, NY) together with the respective expulsion dies. For example, the rectangular (1 in. × 2 in. × 0.125 in.) samples required for specific gravity measurements were cut in the expulsion press fitted with an expulsion straight-edge die (Part #23-10-06). Similarly, the circular samples (2.69 in. diameter × 0.125 in. thick) required for VTR measurements were cut in the expulsion press fitted with an expulsion die specifically designed for ASTM D814 testing (Part # 23-00-00). The press and dies permit multiple samples of uniform dimensions to be cut. The individual samples were checked to ensure that none had nicks or other imperfections prior to their use. For conditioning of plastics, ASTM D618[7] recommends testing at a standard temperature of 23°C (73.4°F) and a relative humidity of 50% for at least 24 hr prior to the testing process. Accordingly, all specimens were stored at 23°C and 50% relative humidity for 24 hr prior to testing. This was achieved by storing the cut samples in a desiccator (Fisher Scientific, Part # 08-615) filled with magnesium nitrate hexahydrate (Fisher Scientific, Part # M46-500, 500 g) and saturated with water. The procedures for generating this constant relative humidity are described in ASTM E104.[8] During conditioning, the samples were stacked on top of each other and separated by a metal spiral (Slinky Jr., James Industries, Inc., Part # 126).

Sample Identification

Two separate marking schemes were used to identify a sample. One scheme was used for the VTR samples and another for the specific gravity samples. The samples used in VTR studies were marked with a marking pen (Speedball®, Painters Metallic™, Silver 7330-Fine) on the side that would not be directly exposed to the chemicals. A four- to seven-character labeling code was used. The first to third characters gave information on the material type. The following characters were used to designate seal materials:

B = butyl rubber, ECH = epichlorohydrin, E = ethylene–propylene rubber, V = fluorocarbon rubber (Viton), N = butadiene–acrylonitrile copolymer (nitrile), and G = styrene–butadiene rubber.

The second or fourth character designated the sample number. Since VTR studies involved three samples per waste, this character was either 1, 2, or 3. The third or fifth characters identified the waste type. The following characters were used to designate waste types for seal materials:

AQ = simulant aqueous mixed waste, CHC = simulant chlorinated hydrocarbon mixed waste, SCI = simulant scintillation fluid, and KET = simulant ketone fluid mixed waste.

The liner material samples evaluated by specific gravity determinations were marked by stamping a three-character code onto the top surface of each sample. A standard 1/8-in. character size punch set was used. As above, the first character gave information on the material type. The following characters were used to designate liner materials:

E = polyethylene, X = cross-linked polyethylene, P = polypropylene, F = fluorocarbon (Kel-F), T = polytetrafluoroethylene (Teflon).

The second character corresponded to the sample number. For specific gravity evaluations, four samples were required per waste. These characters were the numerals 1, 2, 3, or 4. Finally, the fourth character specified the waste type. The following characters were used to designate the waste type for liner materials:

A = simulant aqueous waste, C = simulant chlorinated mixed waste, S = simulant scintillation fluid, and K = simulant ketone fluid mixed waste.

Sample Irradiation

The precut liner and conditioned seal samples were first exposed to gamma radiation from an underwater ^{60}Co source at SNL[9] using a watertight stainless steel canister (volume ~ 4 liters). All the samples of one candidate material required for each of the four simulant waste streams were placed in the canister. This involved 12 samples for VTR measurements or 20 samples for specific gravity measurements. The samples were loaded into a metal basket in the same configuration that was used to condition the samples, i.e., the samples were stacked on top of each other and separated by a metal spiral. The basket was inserted into the canister and the canister was sealed. The loaded canister was lowered into the pool to a depth of 6 ft, purged with a slow steady flow (~ 30 ml/min) of dry air, and allowed to come to thermal equilibrium at 60°C. Once thermal equilibrium was obtained, the canister was lowered into its irradiation location in the pool and the exposure timing was started to obtain the desired radiation dose. The highest dose rate currently available at Sandia's Low Intensity Cobalt Array (LICA) Facility is ~210 krad/hr. Thus for a screening study where a gamma (γ) dose of 286,000 rad was required, the samples were exposed for approximately 1.5 hr. After the samples received the calculated radiation dose, the canister was removed from the pool. The samples were surveyed by SNL Health Physics personnel and returned to us for the remainder of the testing. Typically no more than 24 hr elapsed between the time the samples were exposed to radiation and when they were exposed to the simulant wastes.

Sample Exposure to Chemicals

The general exposure protocol involved placing the required number of specimens (four for specific gravity) for each plastic material into containers (cells) containing the waste type and exposing them to the wastes for 14 days at 60°C. Different material specimens may be exposed at the same time in the same exposure cell provided that sufficient waste is present for exposure of the surface area. For relatively insoluble materials, ASTM D543[10] recommends about 10 ml/in^2 (~1.6 ml/cm^2). For elastomeric materials, the test method recommends about 40 ml/in^2 (~6.2 ml/cm^2). Since two separate tests constituted the screening tests, two different types of exposure cells were used.

Specific Gravity Measurements

Specific gravity was used to evaluate the liner materials. The four specimens were bundled together using nylon cable ties. Metal pins provided space between the specimens. This allowed the simulant waste to reach all surfaces of the material. Figure 1 shows the bundled specific gravity specimens prior to exposure to the simulant wastes. Figure 2 shows a cell containing five different liner materials in the simulant chlorinated hydrocarbon mixture. As can be seen in Fig. 2, the exposure cell consisted of a tapered pint canning jar (Kerr Group, Inc., Los Angeles, CA, Part # 70610-00518). The jar was loaded with the five bundled test specimens and then filled with 300 ml of the test solution. The metal lid and band were attached to the jar and tightened. This cell was immersed in a water bath (the large beaker shown in Fig. 2) maintained at 70°C. After

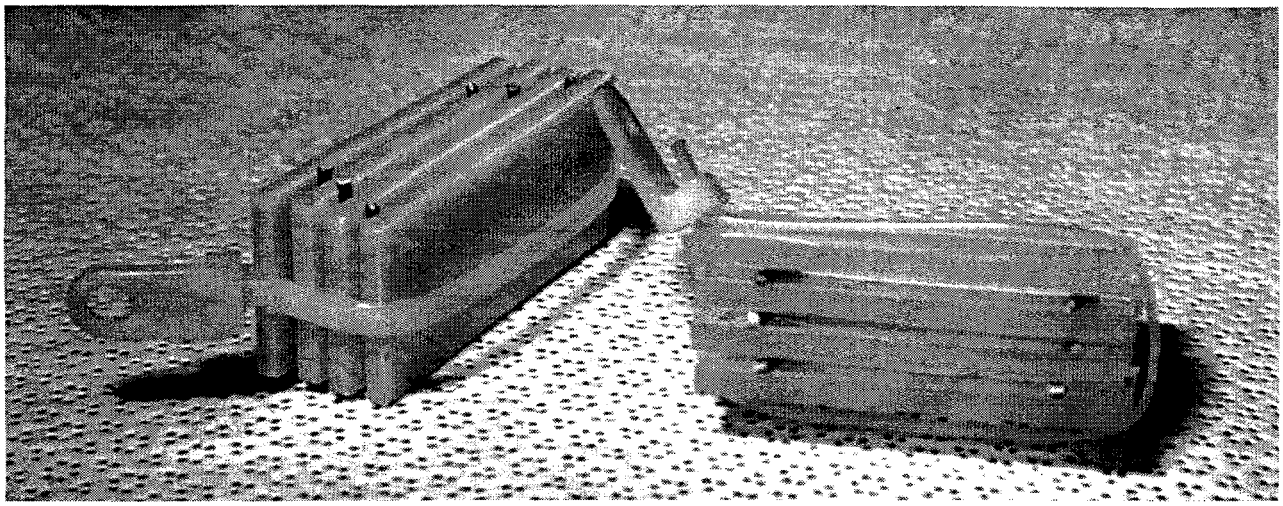

Fig. 1. Bundled test specimens for specific gravity evaluations. Note metal spacers and cable ties.

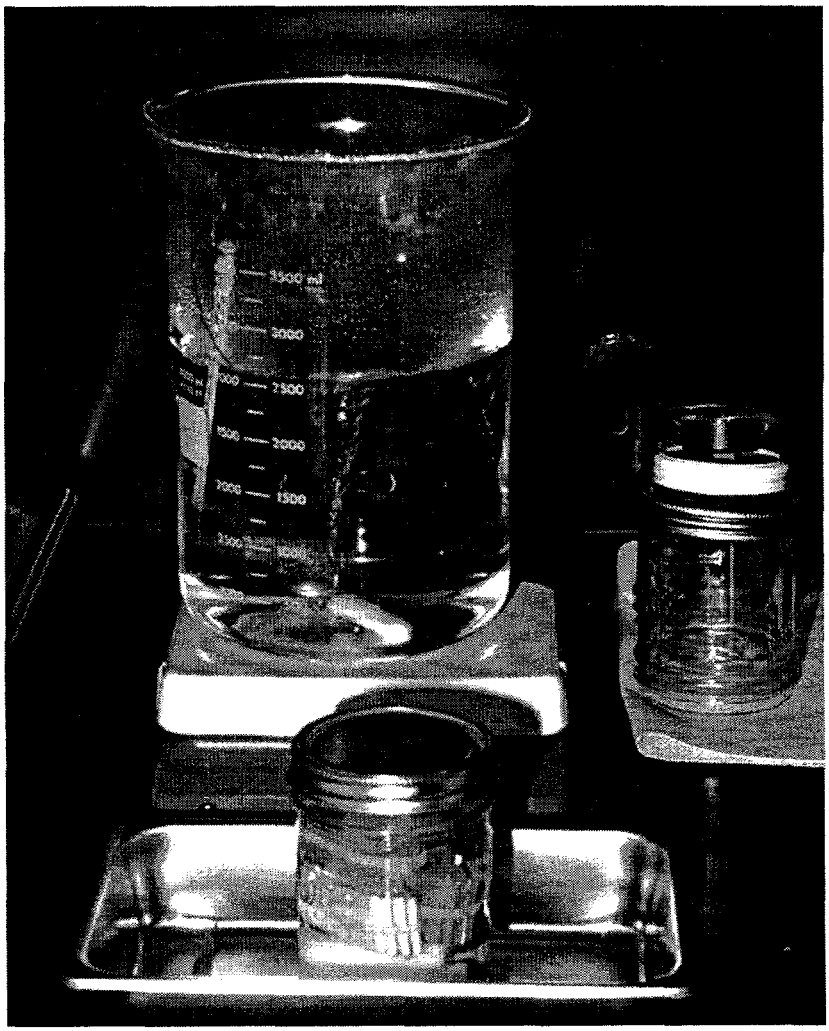

Fig. 2. Exposure cell containing five liner materials in lower portion of photograph.

approximately 1 min of immersion or until the rate of bubble evolution from the canning jar subsided, the jar was removed from the water bath, the metal band was tightened, and the jar was placed in secondary container which was then put in an oven (Blue M, Model OV-490A-2) maintained at 60°C.

Before exposure to radiation and the simulant chemical waste, density measurements were performed in accordance with ASTM D792 methods. After the bundled samples had been subjected to the 14-day exposure at 60°C, the jar containing the samples was opened and the sample bundles were removed. The samples exposed to the aqueous simulant mixed waste were rinsed with deionized water and the samples exposed to the solvent-based chemicals were rinsed with acetone. After the samples were air dried, their specific gravity was again determined. This was performed in accordance with the previous test method. These measurements involved the use of a specially designed attachment to the analytical balance that was obtained from Mettler-Toledo Inc. through Fisher Scientific (Density Kit, Fisher Scientific, Part No.01-910-28). A component of this density kit was a spiral wire platform. The samples were attached to this component by clamping them between the wire spirals with a metal paper clip. This arrangement provided a relatively secure attachment. It also made it easy to determine specific gravity for samples that had a specific gravity less than that of water. If the attachment were not secured, such samples would begin to float in the water and thereby prevent accurate determination of specific gravity.

VTR Measurements

VTR measurements were performed according to the procedures described in ASTM D814. A general description of the methodology is given here. For specific experimental details, the ASTM standard test method should be consulted. Figure 3 shows three VTR cells consisting of the three specimens of seal materials in half-pint Mason jars (Kerr Group, Inc., Los Angeles, CA, Part # 70610-00105B). Each of the jars was filled with approximately 200 ml of the test solution. The seal specimen and metal band were loosely attached. The three jars were placed in an upright configuration (seal and metal band facing up) in a thermostatically controlled oven at 60°C. These jars were held at this temperature for 1 hr. They were then removed from the oven, sealed tightly, and weighed on an analytical balance (Mettler-Toledo Inc., Hightstown, NJ, Model AT200 or PM2000). The weight of each jar was recorded and the jars were returned to the oven. At this time, however, the jars were placed in the oven in an inverted configuration, i.e., with the seal and metal band facing down. The jars were removed from the oven and reweighed after 24 hr. They were then returned to the oven and kept in the oven for the remainder of the 14 days. Figure 4 shows the oven with VTR and specific gravity experiments in progress. After this period, the jars were removed from the oven and reweighed.

Note that where flammable and toxic organic materials were used (e.g., the simulant scintillation fluids, the ketone simulants, and the simulant chlorinated hydrocarbon mixture), the jars were placed in a metal paint can (Wellborn Paint Mfg. Co., unlined paint can, gallon capacity, Part # 3239001) and the can was sealed. These precautions were required for the following safety reasons. Since the oven was not rated to handle flammable liquids, a means to minimize the evolution of flammable vapors had to be developed. This was accomplished by confining any potentially generated vapors in a sealed secondary containment vessel (paint can). <u>While we were able to complete the screening studies in this manner, once comprehensive testing is under way, explosion-proof ovens will need to be acquired. The acquisition of such ovens will require capital equipment funding!</u>

Fig. 3. Vapor transmission rate (VTR) cells.

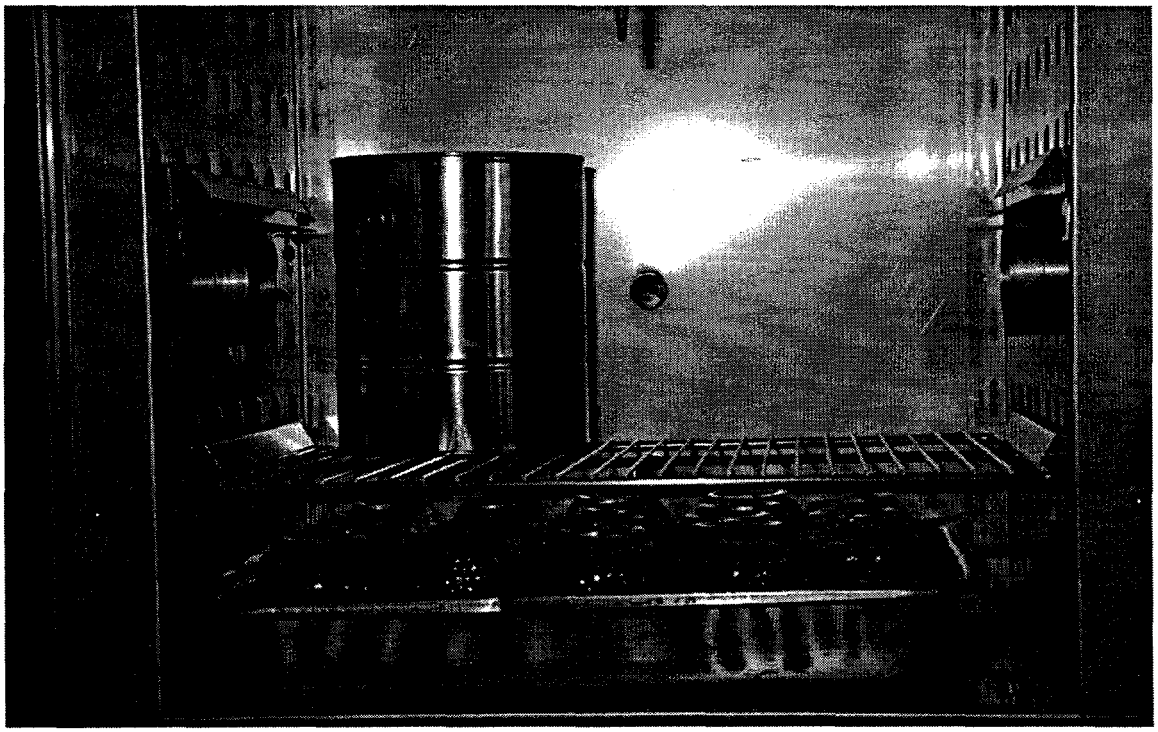

Fig. 4. Oven with VTR and specific gravity testing in progress.

Data Analysis

The ASTM test methods for VTR and specific gravity tests describe the methodology for determining the numerical values of these measurements. While such calculations could be performed for each data point entered, the use of commercial spreadsheet software made these calculations significantly easier. In this testing program, Microsoft® EXCEL was used not only to enter the data but also to perform data analysis. In addition to the usual arithmetic operations, the software determined averages and calculated statistical values such as standard deviations. Examples of calculations for VTR and specific gravity are shown in Tables 1 and 2.

Table 1. VTR data input and analysis.

	A	B	C	D	E	F
1	**Exposure Duration:1 day**	**Exposure Temp.:**		**Waste Type:**		
2	Specimen	**# 1**	**# 2**	**# 3**	**AVE.**	**STD. DEV.**
3	Weight of Jar/Lid/Specimen (gm)				=AVE(B3:D3)	
4	Weight of Jar/Lid/Specimen/Waste (grn)				=AVE(B4:D4)	
5	Weight of Jar after time duration (24 hr)				=AVE(B5:D5)	
6	Weight Difference (gm)	=B4-B5	=C4-C5	=D4-D5	=AVE(B6:D6)	
7	Time (hours)	24	24	24	24	
8	Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
9	Radius of Specimen (meter)	=B8/1000	=C8/1000	=D8/1000	=E8/1000	
10	Area of Specimen (m^2)	=3.14*(B9^2)	=3.14*(C9^2)	=3.14*(D9^2)	=AVE(B10:D10)	
11	VTR (g/hr/m^2)	=B6/(B7*B10)	=C6/(C7*C10)	=D6/(D7*D10)	=AVE(B11:D11)	=SD(B11:D11)
12						
13	**Exposure Duration: 14 days**	**Exposure Temp.:**		**Waste Type:**		
14	Specimen	**# 1**	**# 2**	**# 3**	**AVE.**	**STD. DEV.**
15	Weight of Jar after Time Duration (gm)				=AVE(B15:D15)	
16	Weight Difference (gm)	=B4-B15	=C4-C15	=D4-D15	=AVE(B16:D16)	
17	Time (hours)	336	336	336	336	
18	Radius of specimen (mm)	68.33	68.33	68.33	68.33	
19	Radius of Specimen (meter)	=B18/1000	=B18/1000	=D18/1000	=E18/1000	
20	Area of Specimen (m^2)	=3.14*(B19^2)	=3.14*(C19^2)	=3.14*(D19^2)	=AVE(B20:D20)	
21	VTR (g/hr/m^2)	=B16/(B17*B20)	=C16/(C17*C20)	=D16/(D17*D20)	=AVE(B21:D21)	=SD(B21:D21)
22						

Table 2. Specific gravity input and analysis.

	A	B	C	D	E	F	G
1	**DATA SUMMARY**						
2	**Days**	**0**	**14**				
3	Ave. Specific Gravity 23/23 C	=F13	=F21				
4							
5	% Specific Gravity Change	0	=F24				
6	Standard Deviation	=G13	=G24				
7							
8	**Exposure Duration: 0 days**	**Exposure Temp.:**		**Waste Type:**			
9	Specimen	**#1**	**#2**	**#3**	**#4**	**AVERAGE**	**STD. DEV.**
10	Mass in air (g)					=AVE(B10:E10)	
11	App. mass of specimen (g)					=AVE(B11:E11)	
12	App. mass of wire/sinker (g)					=AVE(B12:E12)	
13	Specific Gravity 23/23 C	=(B10)/(B10+B12-B11)	=(C10)/(C10+C12-C11)	=(D10)/(D10+D12-D11)	=(E10)/(E10+E12-E11)	=AVE(B13:E13)	=SD(B13:E13)
14	Density (g/cc)	=B13*0.9976	=C13*0.9976	=D13*0.9976	=E13*0.9976	=F13*0.9976	=SD(B14:E14)
15							
16	**Exposure Duration: 14 days**	**Exposure Temp.:**		**Waste Type:**			
17	Specimen	**#1**	**#2**	**#3**	**#4**	**AVE.**	**STD. DEV.**
18	Mass in air (g)					=AVE(B18:E18)	
19	App. mass of specimen (g)					=AVE(B19:E19)	
20	App. mass of wire/sinker (g)					=AVE(B20:E20)	
21	Specific Gravity 23/23 C	=(B18)/(B18+B20-B19)	=(C18)/(C18+C20-C19)	=(D18)/(D18+D20-D19)	=(E18)/(E18+E20-E19)	=AVE(B21:E21)	=SD(B21:E21)
22	Density (g/cc)	=B21*0.9976	=C21*0.9976	=D21*0.9976	=E21*0.9976	=F21*0.9976	=G21*0.9976
23							
24	% Specific Gravity Change	=(B21-B13)/B13	=(C21-C13)/C13	=(D21-D13)/D13	=(E21-E13)/E13	=AVE(B24:E24)	=SD(B24:E24)
25							

Results

The purpose of the Chemical Compatibility Program is to provide a scientifically defensible methodology for measuring the chemical compatibility of polymeric liner and seal materials with simulated mixed wastes. These are materials that may be used in current and future container designs for transportation of hazardous and mixed wastes throughout the DOE complex. The approach for developing this program was to assess the current state of chemical compatibility testing technology and direct thinking toward routes that might lead to satisfactory, comprehensive, and reliable chemical compatibility data for use by the U.S. DOE in its Transportation Management Division.

The candidate liner and seal materials that are known to be chemically resistant to the expected waste forms are those that were selected for testing. Since their selection was based on a general survey of the literature, the chemical compatibility program attempted to experimentally validate their suitability. In addition, since the literature, for the most part, describes the effects of either chemicals or radiation and not a combination of these environments, the results of combined testing could be substantially different than those in the literature. Our results are summarized below.

VTR Measurements

VTR testing measures the rate of vapor transmission of a volatile liquid through a seal material. This type of testing provides a steady-state measure of the rate of vapor and liquid transmission through relatively thin plastics. While the calculated values of VTR cannot be directly converted to traditional permeability values, they can be used to obtain a figure of merit for permeability. For the purposes of the screening tests, these values of VTR were used as a criterion for determining whether the material passed or failed the exposure protocol.

Figure 5 shows the results of the screening of six seal materials, in triplicate, in the aqueous simulant mixed waste for 14 days at 60°C. As can be seen from the data, all materials exhibited VTR values below 1 g/hr/m^2, i.e., all seal materials passed this screening test. While the exact VTR values are not obvious from the figure, their actual values can be found in Appendix B of this report. In addition, the data presented in this figure show that both EPDM and SBR exhibited the lowest VTR. These results suggest that either material could be used to construct packaging for transporting aqueous, caustic waste containing large concentrations of sodium nitrate and sodium nitrite. This suggests that seals from these materials might be suitable in packagings intended to transport Hanford tank waste. Depending on other factors, such as cost of the seal materials, a further down-selection of seal materials is possible.

Figure 6 shows the results of similar screening in chlorinated hydrocarbon simulant mixed waste. As can be seen in the figure, all materials, with the exception of Viton, had VTR values greater than 1 g/hr/m^2. Since the pass/fail criterion was 0.9 or ~1 g/hr/m^2, only the latter material passed the screening test, with an average VTR of 0.25 g/hr/m^2.

Figure 7 presents the results in simulant scintillation fluid mixed waste. All materials failed the screening tests. A close inspection of the data in the figure reveals that butyl and Viton had two samples with relatively low values (< 10 g/hr/m^2) of VTR and one sample with high vapor transmission rates. Since the average value from the three samples was used to establish whether the material passed or failed the screening tests, these materials, while not passing, still had the lowest VTR values. Specifically, Viton exhibited the lowest VTR value, 14.2 g/hr/m^2.

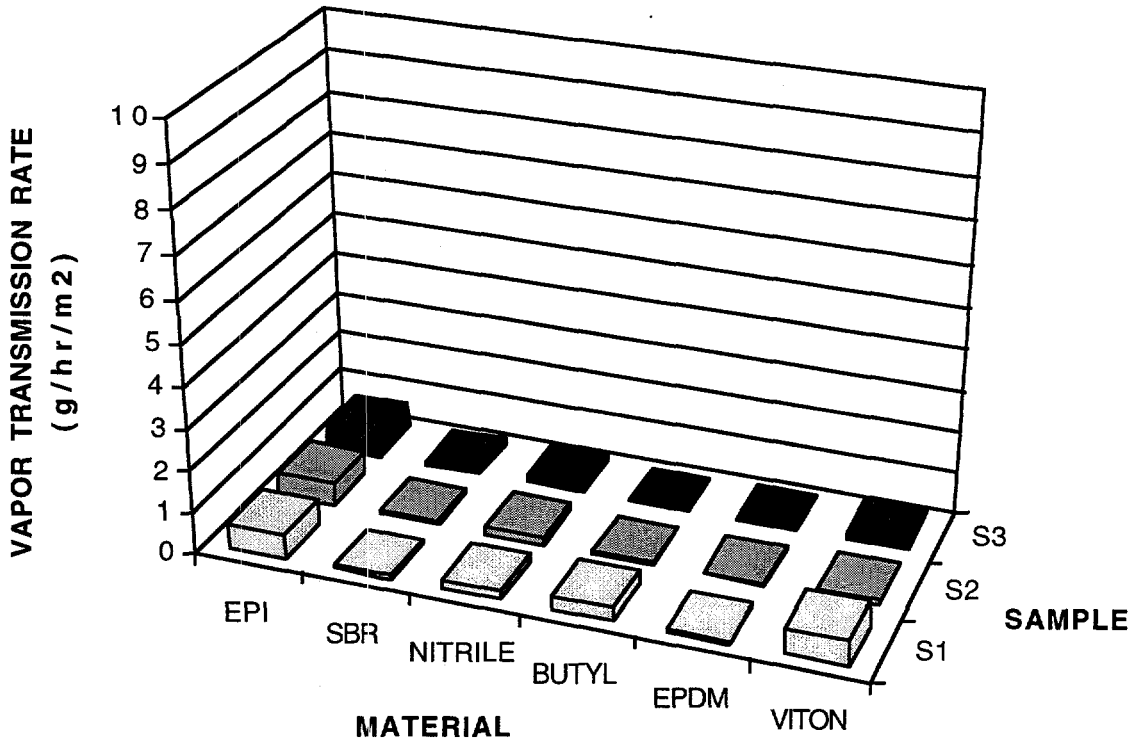

Fig. 5. VTR of aqueous simulant mixed waste through seal materials at 60°C.

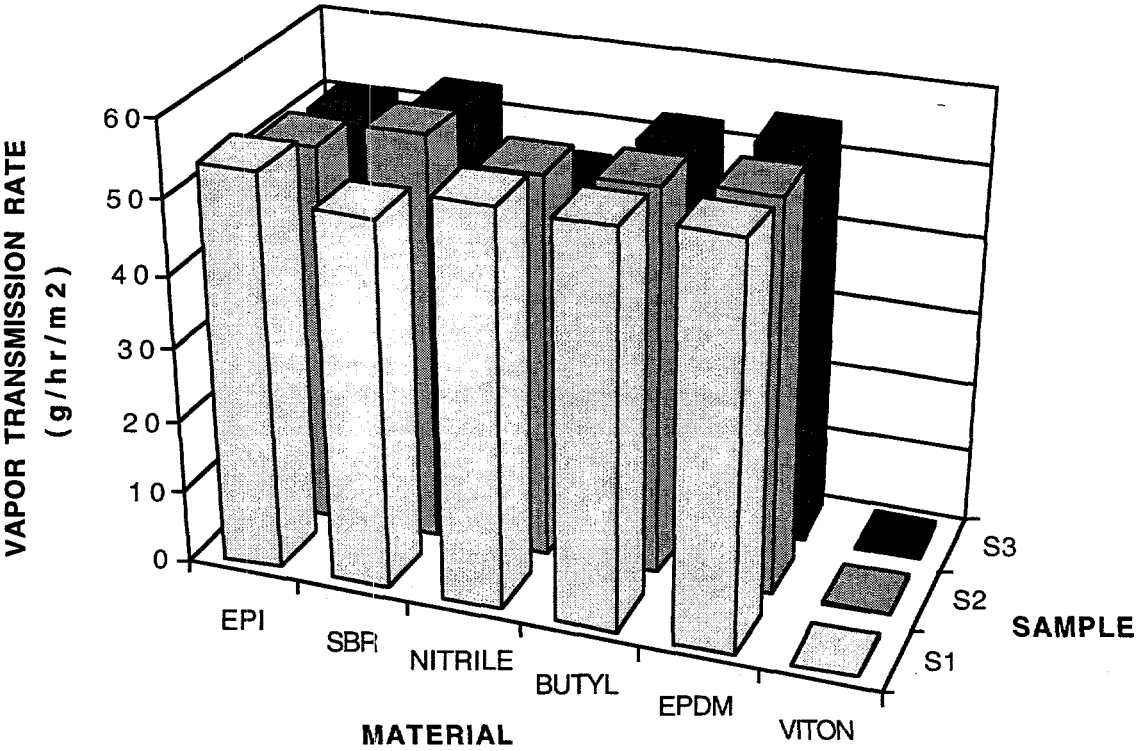

Fig. 6. VTR of chlorinated hydrocarbon simulant mixed waste through seal materials at 60°C. (Note change in scale from previous figure.)

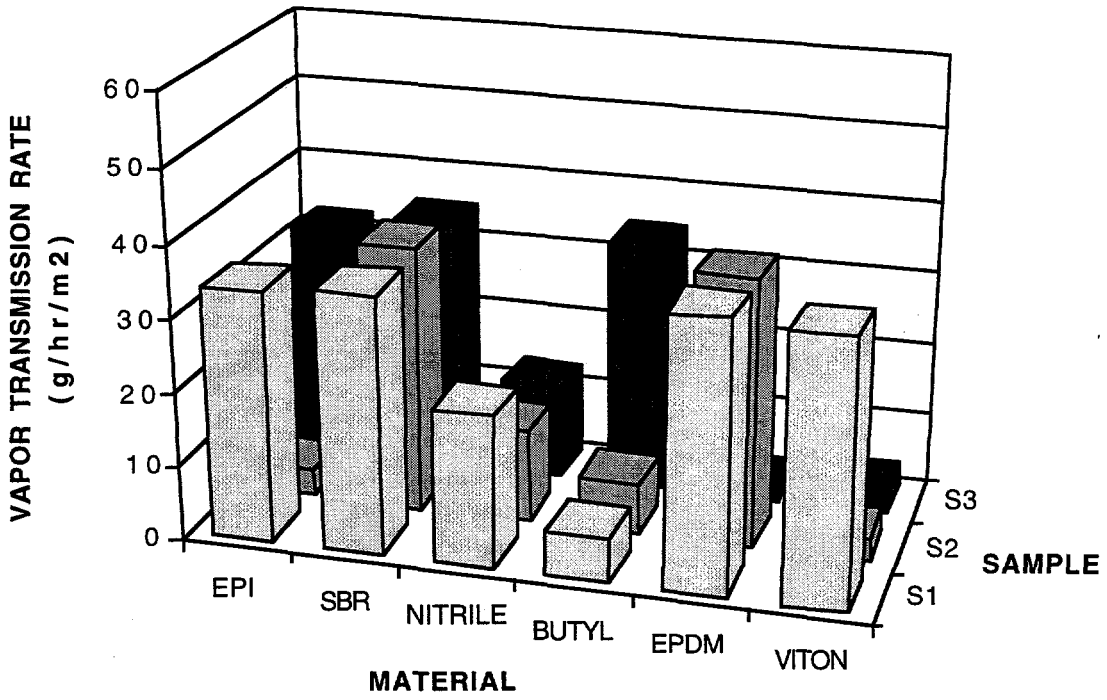

Fig. 7. VTR of simulant scintillation fluid mixed waste through seal materials at 60°C.

Figure 8 shows the results of VTRs of ketone mixture simulant wastes through seal materials at 60°C. While none of these materials passed these screening tests, butyl rubber came closest to passing the tests. This material had a VTR of 1.5 g/hr/m^2. The data show that EPDM also had relatively low VTR values. In Appendix B it can be seen that this material had values of 4.0 g/hr/m^2.

While all seal material passed exposure to radiation and aqueous simulant mixed waste, EPDM rubber exhibited the lowest VTR (0.05 g/hr/m^2). When exposed to radiation and chlorinated hydrocarbon simulant mixed wastes, only Viton passed these screening tests, with a value of 0.25 g/hr/m^2. As mentioned earlier, none of the seal materials tested passed the screening tests in either simulant scintillation fluid mixed waste or the ketone mixture simulant waste. However, Viton and EPDM had the lowest VTR values, respectively, in these wastes. These results are consistent with chemical compatibility data reported in the literature. However, since these screening tests combined radiation and chemical effects, it can be concluded that radiation effects, i.e., γ-radiation at a dose of 286,000 rads, play little, if any role in the resistance of these materials to these chemicals. It should, however, be mentioned that a different conclusion might be reached on the effects of a combination of radiation and chemical exposure if some other evaluation criterion is used. For example, if changes in tensile property had been selected instead of VTR values, different conclusions might be reached. The determination of which effect—radiation or chemical—predominates will be undertaken in the next phase of this testing program.

Specific Gravity Measurements

Specific gravity testing provides a direct measurement of the density of the materials. Since density values reflect possible physical changes in materials, these measurements can give some indication of whether the material has changed in mass and/or in volume. These changes in turn

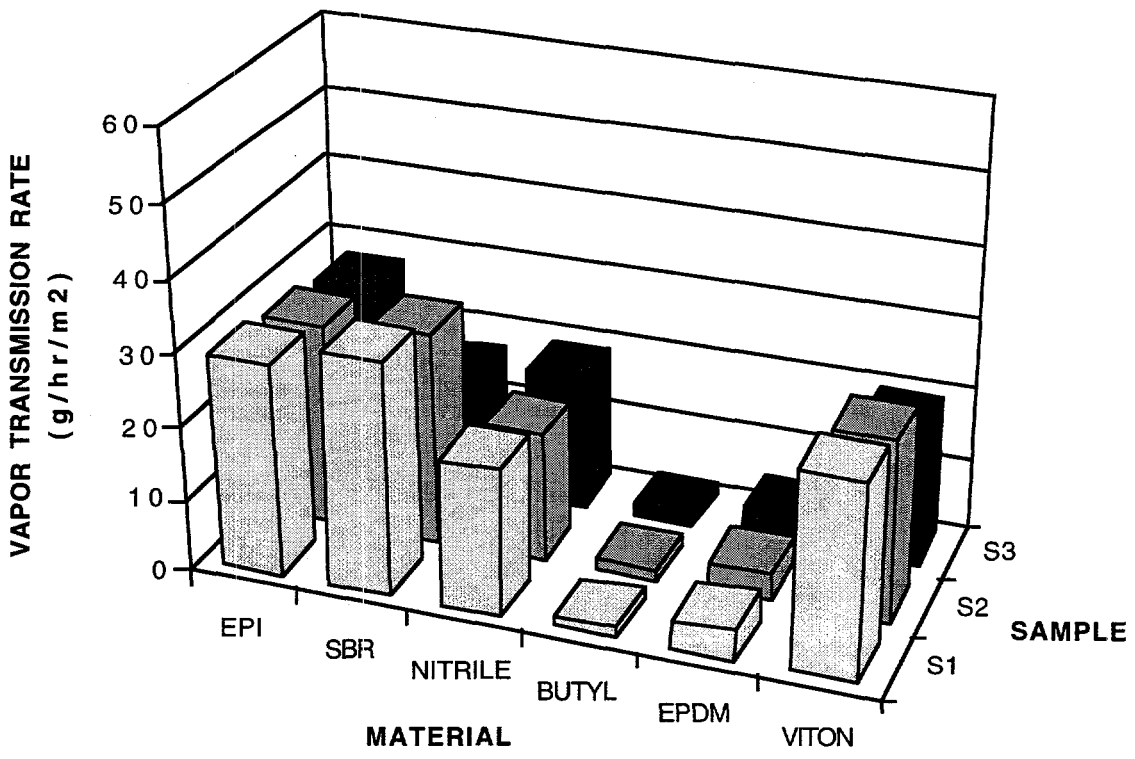

Fig. 8. VTR of ketone mixture simulant mixed waste through seal materials at 60°C.

might indicate whether the chemicals to which the material has been exposed have affected the material's composition. For example, some of the components of a material, such as plasticizers or other vital constituents, might be leached out of it.

A change in the density of the material might also indicate swelling, i.e., dimensional or volume changes in the material. Such dimensional changes are important when selecting appropriate liner materials for packagings because these materials might constitute a structural component in the package. If such materials are exhibiting undesirable dimensional changes, these changes could affect the performance of the package.

The specific gravity data for liner materials are presented in Figures 9–12. The data show that all liner materials, with the exception of polypropylene, passed the screening tests in the four simulant waste types. The detailed results are discussed below.

Figure 9 shows the specific gravity changes in the liner materials exposed to radiation and the aqueous simulant mixed waste at 60°C. Several features in the data should be noted. In spite of the fact that most materials exhibited a positive change in the specific gravity, HDPE, Kel-F, and Teflon each had one sample found to have negative changes in specific gravity. The samples that exhibited this behavior can be recognized in the graph by a completely blackened area. While this result was also found in the three other waste types, we only discuss the phenomenon for this particular mixed waste. Since the determination of specific gravity by ASTM D792 involves only the measurement of sample mass, a negative value for specific gravity would suggest that the affected samples had a mass loss. However, a close examination of the data given in Appendix B for the affected samples revealed that they actually had an increase in mass. Without additional measurements on these materials, the origin of the negative change in specific gravity can only be

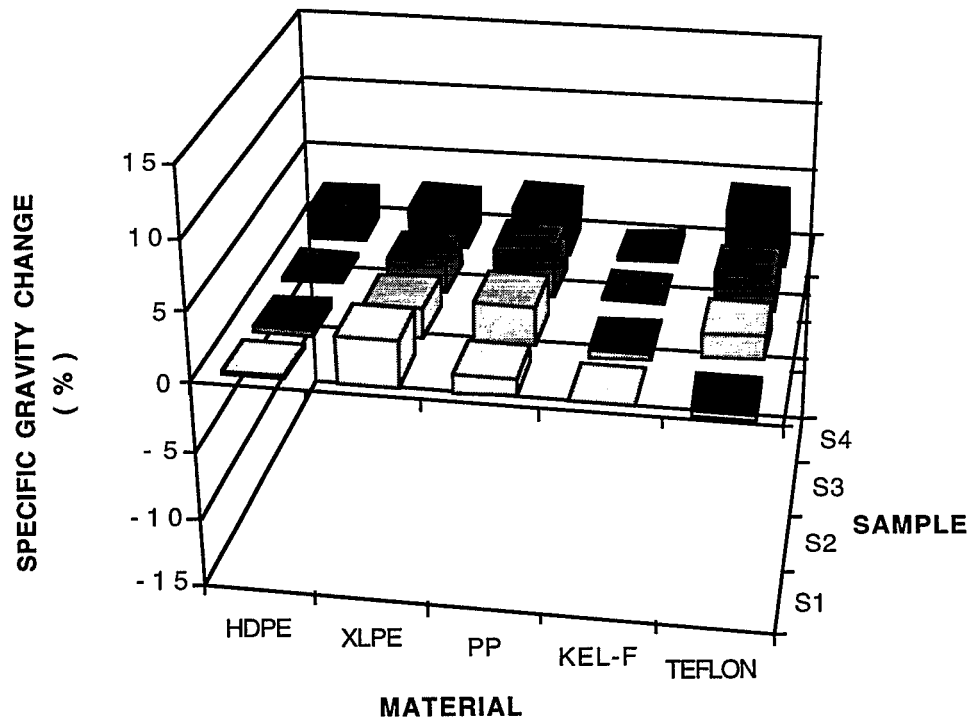

Fig. 9. Specific gravity changes in aqueous simulant mixed waste by liner materials at 60°C.

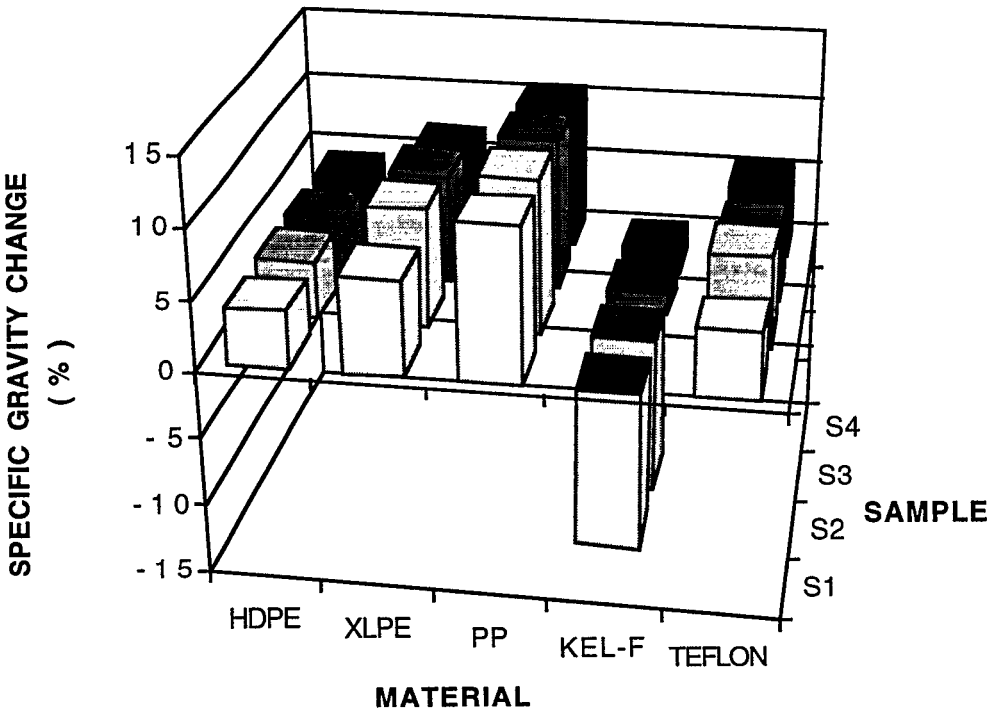

Fig. 10. Specific gravity changes in chlorinated hydrocarbon simulant waste by liner materials at 60°C.

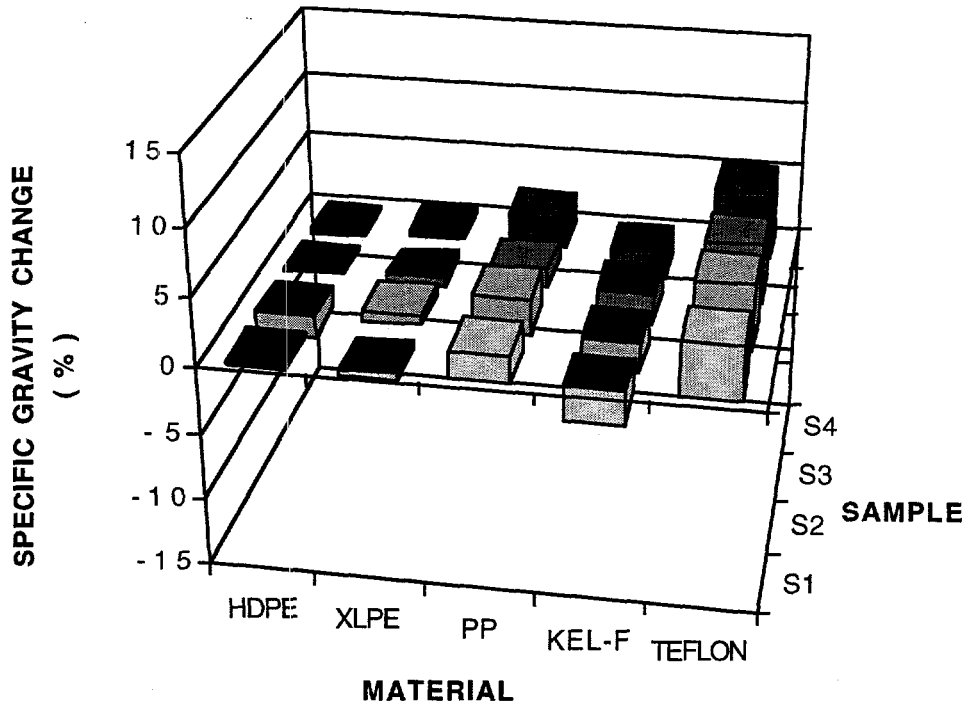

Fig. 11. Specific gravity changes in simulant scintillation fluid mixed waste by liner materials at 60°C.

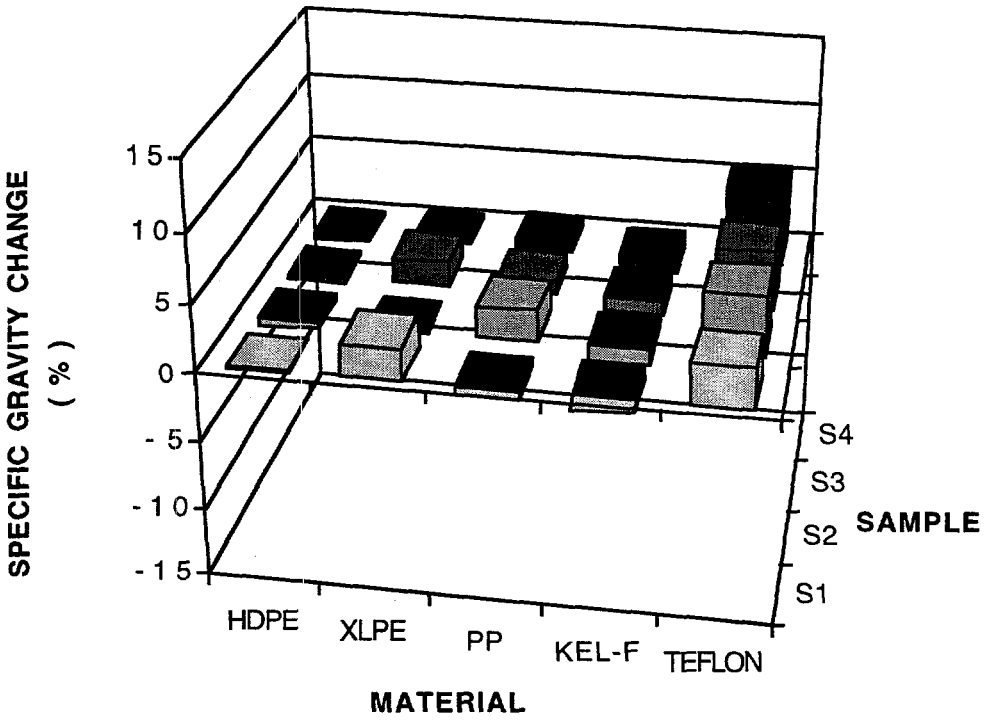

Fig. 12. Specific gravity changes in ketone mixture simulant mixed waste by liner materials at 60°C.

speculated upon. One possibility is that the mass gain observed is due to adsorption. In such a process, the sorbed species causes a greater increase in the volume of the sample. If the volume component of the sample increases to a greater extent than the mass, a net decrease in the specific gravity would be observed. Since the test method did not involve dimensional measurements, it was not possible to confirm this hypothesis. Another explanation of this effect is that during the exposure to the wastes, a component of the material was leached from the sample. This preferential leaching could be masked by the simultaneous uptake of chemical species. It is not unreasonable that the desorbed species could have a greater specific gravity than the adsorbed species. To confirm either of these speculations, additional testing would be required. What is certain in the data shown in Fig. 9 is that Kel-F exhibited the lowest percent change, i.e., –0.08%.

Figure 10 shows the change in specific gravity of liner materials exposed to radiation and chlorinated hydrocarbon simulant mixed waste at 60°C. As previously mentioned, polypropylene failed to pass the 10% criterion. This material exhibited a change in specific gravity of 10.9%. The material with the greatest resistance to radiation and these chemicals, as indicated by the smallest change in specific gravity, was HDPE. This material had a change of 4.12%. It is interesting that the fluorocarbon material was the only material in this waste to exhibit negative specific gravity changes of –6.43%.

Figure 11 shows the changes in specific gravity of liner materials exposed to simulant scintillation fluid mixed waste at 60°C. In this waste, the cross-linked polyethylene (XLPE) exhibited the greatest resistance to radiation and chemicals, with a change of only –0.02%. While not as good as XLPE, HDPE also had a rather low change in specific gravity of –0.60%.

Finally, Fig. 12 gives the change in specific gravity of liner materials exposed to a ketone mixture simulant mixed waste at 60°C. For this waste type, the HDPE material appeared to have the greatest resistance to radiation and chemicals, exhibiting a change of only –0.6% in specific gravity.

To summarize the specific gravity testing data, while all materials with the exception of polypropylene (in chlorinated hydrocarbons) passed the screening criteria of a change in specific gravity of 10% or less, Kel-F, HDPE, and XLPE offered the greatest resistance to the combination of radiation and chemicals. However, since the meaning of negative changes in specific gravity is not understood at this time, the selection of these materials is somewhat tentative.

As was established by the VTR measurements, the results of the specific gravity measurements are consistent with what has been generally reported in the literature about the chemical resistance of materials used in liner applications. However, this work has demonstrated that the candidate materials are resistant not only to chemicals alone but also to a combination of radiation and chemicals. Since such data are not available in the literature, this work provides valuable information to supplement that present in the chemical compatibility literature.

With the completion of these screening tests, we will begin comprehensive testing of the seal and liner materials in the aqueous simulant mixed waste. In addition to VTR and specific gravity measurements, this testing will involve eight additional testing methods. This expanded testing program will use γ-radiation doses of 143,000, 286,000, 571,000, and 3,672,000 rads, exposure times of 7, 14, 28, and 180 days, and exposure temperatures of 18, 50, and 60°C with the aqueous waste form.

Conclusions

A program for evaluating the transportation packaging components that may be used in transporting mixed waste forms has been developed and the first phase has been completed. This effort involved screening ten plastic materials in four simulant mixed waste types. The seal materials or rubbers were tested using vapor transport rate (VTR) measurements, while the liner materials were tested using specific gravity as a metric. For these tests, a screening criteria of 0.9 g/hr/m^2 for VTR and a change in specific gravity of 10% was used. Those materials that failed to meet these criteria were judged to have failed the screening tests and will be excluded in the next phase of this experimental program.

Based on this work, it was concluded that while all seal materials passed exposure to the aqueous simulant mixed waste, EPDM and SBR had the lowest VTRs. In the chlorinated hydrocarbon simulant mixed waste, only Viton passed the screening tests. In both the simulant scintillation fluid mixed waste and the ketone mixture simulant mixed waste, none of the seal materials met the screening criteria. For specific gravity testing of liner materials, the data showed that while all materials with the exception of polypropylene passed the screening criteria, Kel-F, HDPE, and XLPE were found to offer the greatest resistance to the combination of radiation and chemicals.

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APPENDIX A

Materials Information

Seal Materials

Material	Supplier	Compound No.	Batch
Butyl rubber	Parker Seal Group O-Ring Division 2360 Palumbo Drive P.O. Box 11751 Lexington, KY 40512 (606) 269-2351	B0612-70	316104 Test Slabs*
Ethylene–propylene rubber	Parker Seal Group	E0540-80*	315917
Epichlorohydrin	Southwest Seal and Supply 1413 1st Street NW Albuquerque, NM 87102-1533 (505) 247-0265	ECH-50*	N/A**
Fluorocarbon (Viton)	Parker Seal	V0884-75*	312292
Butadiene–acrylonitrile rubber	Parker Seal	N0674-70*	N/A
Styrene–butadiene rubber	Parker Seal	G0244-70*	312922

Liner Materials

Material	Supplier	Compound No.	Batch
Cross-linked polyethylene	Regal Plastics 3455 Princeton NE Albuquerque, NM 87107 (505) 884-2651	TIVAR 88+	N/A
High-density polyethylene	Regal Plastics	PLA 11785++	N/A
Fluorocarbon (Kel-F)	Regal Plastics	5055++	N/A
Polypropylene	Regal Plastics	PLA 3801++	N/A
Polytetrafluoroethylene (Teflon)	Regal Plastics	PLA 7625++	N/A

* Test slabs consisted of 6 in. × 6 in. × 0.125 in. thick sheet stock material

** N/A = not available

\+ This material was only available in 0.25-in. thick sheet stock. The material was machined at SNL to a thickness of 0.125 in. as required by the test method.

++ These materials were available in 0.125 in. sheet stock from the supplier

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APPENDIX B

VTR Data for Butyl Rubber and Simulant Aqueous Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**B1AQ**	**B2AQ**	**B3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	204.663	163.265	163.457	177.128	
Weight of Jar/Lid/Specimen/Waste (g)	424.0	400.1	413.2	412.4	
Weight of Jar/Lid/Specimen/Waste, 1 day	424.0	400.1	413.4	412.5	
Weight Difference (g)	0.0	0.0	-0.2	-0.1	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.0	0.0	-0.6	-0.2	0.3
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**B1AQ**	**B2AQ**	**B3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	422.32	399.87	413.18	411.79	
Weight Difference (g)	1.7	0.2	0.0	0.6	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.34	0.05	0.0	0.1	0.2

VTR Data for Epichlorohydrin and Simulant Aqueous Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**ECH1AQ**	**ECH2AQ**	**ECH3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	184.630	166.681	166.637	172.649	
Weight of Jar/Lid/Specimen/Waste (g)	407.3	402.3	413.7	407.8	
Weight of Jar/Lid/Specimen/Waste, 1 day	407.3	402.3	413.7	407.8	
Weight Difference (g)	0.0	0.0	0.0	0.0	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.0	0.0	0.0	0.0	0.0
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**ECH1AQ**	**ECH2AQ**	**ECH3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	404.488	399.542	410.803	404.944	
Weight Difference (g)	2.8	2.8	2.9	2.8	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.57	0.56	0.59	0.57	0.014

VTR Data for Ethylene Propylene Rubber and Simulant Aqueous Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**E1AQ**	**E2AQ**	**E3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	182.250	164.942	165.292	170.828	
Weight of Jar/Lid/Specimen/Waste (g)	411.9	403.2	400.5	405.2	
Weight of Jar/Lid/Specimen/Waste, 1 day	411.9	403.2	400.5	405.2	
Weight Difference (g)	0.0	0.0	0.0	0.0	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.0	0.0	0.0	0.0	0.0
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**E1AQ**	**E2AQ**	**E3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	411.61	402.93	400.31	404.95	
Weight Difference (g)	0.3	0.3	0.2	0.3	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.06	0.06	0.04	0.05	0.01

VTR Data for Fluorocarbon Rubber (Viton) and Simulant Aqueous Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**V1AQ**	**V2AQ**	**V3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	213.517	175.682	175.779	188.33	
Weight of Jar/Lid/Specimen/Waste (g)	438.3	428.4	425.3	430.7	
Weight of Jar/Lid/Specimen/Waste, 1 day	438.4	428.6	425.5	430.8	
Weight Difference (g)	-0.1	-0.2	-0.2	-0.2	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	-0.3	-0.6	-0.6	-0.5	0.2
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**V1AQ**	**V2AQ**	**V3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	435.28	427.64	424.52	429.15	
Weight Difference (g)	3.0	0.8	0.8	2	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.61	0.2	0.2	0.3	0.3

VTR Data for Butadiene–Acrylonitrile Copolymer (Nitrile Rubber) and Simulant Aqueous Mixed Waste

Exposure Duration:1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**N1AQ**	**N2AQ**	**N3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	183.791	164.942	165.287	171.340	
Weight of Jar/Lid/Specimen/Waste (g)	406.6	409.6	416.1	410.8	
Weight of Jar/Lid/Specimen/Waste, 1 day	406.6	409.6	416.0	410.7	
Weight Difference (g)	0.0	0.0	0.1	0.0	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.0	0.0	0.3	0.1	0.2
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**N1AQ**	**N2AQ**	**N3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	405.501	408.795	415.246	409.847	
Weight Difference (g)	1.1	0.8	0.9	0.9	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.22	0.2	0.2	0.2	0.03

VTR Data for Styrene–Butadiene Rubber and Simulant Aqueous Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**G1AQ**	**G2AQ**	**G3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	164.783	164.074	164.814	164.557	
Weight of Jar/Lid/Specimen/Waste (g)	413.2	406.6	406.9	408.9	
Weight of Jar/Lid/Specimen/Waste, 1 day	413.4	406.8	407.0	409.1	
Weight Difference (g)	-0.2	-0.2	-0.1	-0.2	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	-0.6	-0.6	-0.3	-0.5	0.2
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**AQUEOUS**	
Specimen	**G1AQ**	**G2AQ**	**G3AQ**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	412.80	406.23	406.47	408.50	
Weight Difference (g)	0.4	0.4	0.4	0.4	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.08	0.07	0.09	0.08	0.01

VTR Data for Butyl Rubber and Chlorinated Hydrocarbon Simulant Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**B1CHC**	**B2CHC**	**B3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	163.164	164.079	163.466	163.570	
Weight of Jar/Lid/Specimen/Waste (g)	428.0	424.4	420.5	424.3	
Weight of Jar after time duration (24 hr)	178.5	179.3	179.7	179.2	
Weight Difference (g)	249.5	245.1	240.8	245.1	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	709.1	696.6	684.4	696.7	12.36
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**B1CHC**	**B2CHC**	**B3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	163.2	164.1	163.5	163.6	
Weight Difference (g)	264.8	260.3	257.0	260.7	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	53.76	52.85	52.18	52.93	0.7952

VTR for Epichlorohydrin and Chlorinated Hydrocarbon Simulant Mixed Waste

Exposure Duration: 1day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**ECH1CHC**	**ECH2CHC**	**ECH3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	166.913	166.709	166.285	166.636	
Weight of Jar/Lid/Specimen/Waste (g)	432.8	420.8	416.0	423.2	
Weight of Jar after time duration (24 hr)	415.1	404.7	167.2	329.0	
Weight Difference (g)	17.7	16.1	248.8	94.2	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	50.3	45.8	707.1	267.7	381
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**ECH1CHC**	**ECH2CHC**	**ECH3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	166.9	166.7	166.3	166.6	
Weight Difference (g)	265.9	254.1	249.7	256.6	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	53.98	51.58	50.69	52.08	1.698

VTR Data for Ethylene Propylene Rubber and Chlorinated Hydrocarbon Simulant Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**E1CHC**	**E2CHC**	**E3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	172.952	171.959	172.639	172.517	
Weight of Jar/Lid/Specimen/Waste (g)	440.7	436.8	438.0	438.5	
Weight of Jar after time duration (24 hr)	186.9	189.3	390.1	255.4	
Weight Difference (g)	253.8	247.5	47.9	183.1	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	721.3	703.4	136	520.3	333
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**E1CHC**	**E2CHC**	**E3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	173.0	172.0	172.6	172.5	
Weight Difference (g)	267.7	264.8	265.4	266.0	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	54.35	53.76	53.87	54.00	0.3147

VTR Data for Fluorocarbon Rubber (Viton) and Chlorinated Hydrocarbon Simulant Mixed Waste

Exposure Duration: 1day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**V1CHC**	**V2CHC**	**V3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	182.848	182.130	182.300	182.426	
Weight of Jar/Lid/Specimen/Waste (g)	432.3	466.1	443.6	447.3	
Weight of Jar after time duration (24 hr)	433.0	466.8	444.3	448.0	
Weight Difference (g)	-0.7	-0.7	-0.7	-0.7	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	-2.	-2.	-2.	-2.	0
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**V1CHC**	**V2CHC**	**V3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	431.1	464.8	442.4	446.1	
Weight Difference (g)	1.2	1.3	1.2	1.2	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.24	0.26	0.24	0.25	0.012

VTR Data for Butadiene–Acrylonitrile Copolymer and Chlorinated Hydrocarbon Simulant Mixed Waste

Exposure Duration:1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**N1CHC**	**N2CHC**	**N3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	172.140	171.582	172.181	171.968	
Weight of Jar/Lid/Specimen/Waste (g)	438.3	429.2	395.3	420.9	
Weight of Jar after time duration (24 hr)	423.5	414.3	173.1	337.0	
Weight Difference (g)	14.8	14.9	222.2	84.0	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	42.1	42.3	631.5	238.6	340.2
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**N1CHC**	**N2CHC**	**N3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	172.1	171.6	172.2	172.0	
Weight Difference (g)	266.2	257.6	223.1	249.0	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	54.03	52.30	45.29	50.54	4.626

VTR Data for Styrene–Butadiene Rubber and Chlorinated Hydrocarbon Simulant Mixed Waste

Exposure Duration:1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**G1CHC**	**G2CHC**	**G3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	171.734	171.304	171.299	171.446	
Weight of Jar/Lid/Specimen/Waste (g)	419.4	442.9	433.8	432.0	
Weight of Jar after time duration (24 hr)	301.4	417.4	174.4	297.7	
Weight Difference (g)	118.0	25.5	259.4	134.3	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	335.4	72.5	737.2	381.7	334.8
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**CHC**	
Specimen	**G1CHC**	**G2CHC**	**G3CHC**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	171.7	171.3	171.3	171.4	
Weight Difference (g)	247.7	271.6	262.5	260.6	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	50.28	55.14	53.29	52.90	2.452

VTR Data for Butyl Rubber and Simulant Scintillation Fluids Mixed Waste

Exposure Duration: 1day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**B1SCI**	**B2SCI**	**B3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	163.683	164.110	163.616	163.803	
Weight of Jar/Lid/Specimen/Waste (g)	341.7	337.4	337.3	338.8	
Weight of Jar after time duration (24 hr)	338.5	334.7	334.4	335.9	
Weight Difference (g)	3.2	2.7	2.9	2.9	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	9.1	7.7	8.2	8.3	0.7
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**B1SCI**	**B2SCI**	**B3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	310.8	303.1	169.4	261.1	
Weight Difference (g)	30.9	34.3	167.9	77.7	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	6.3	7.0	34.1	15.8	15.9

VTR Data for Epichlorohydrin and Simulant Scintillation Fluids Mixed Waste

Exposure Duration: 1day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**ECH1SCI**	**ECH2SCI**	**ECH3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	166.172	166.679	166.336	166.396	
Weight of Jar/Lid/Specimen/Waste (g)	352.9	338.4	343.8	345.0	
Weight of Jar after time duration (24 hr)	338.4	324.2	329.8	330.8	
Weight Difference (g)	14.5	14.2	14.0	14.2	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	41.2	40.4	39.8	40.5	0.715
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**ECH1SCI**	**ECH2SCI**	**ECH3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	184.8	320.3	184.2	229.8	
Weight Difference (g)	168.1	18.1	159.6	115.3	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	34.13	3.67	32.40	23.40	17.1

VTR Data for Ethylene Propylene Copolymer Rubber and Simulant Scintillation Fluids Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**E1SCI**	**E2SCI**	**E3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	172.288	172.194	164.518	169.667	
Weight of Jar/Lid/Specimen/Waste (g)	353.9	352.9	334.5	347.1	
Weight of Jar after time duration (24 hr)	182.4	279.9	336.3	266.2	
Weight Difference (g)	171.5	73.0	-1.8	80.9	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	487.4	207.5	-5.1	229.9	247.0
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**E1SCI**	**E2SCI**	**E3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	172.3	172.2	323.7	222.7	
Weight Difference (g)	181.6	180.7	10.8	124.4	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	36.87	36.68	2.19	25.25	19.97

VTR Data for Fluorocarbon Rubber (Viton) and Simulant Scintillation Fluids Mixed Waste

Exposure Duration: 1day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**V1SCI**	**V2SCI**	**V3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	175.654	182.463	174.255	177.457	
Weight of Jar/Lid/Specimen/Waste (g)	354.6	364.9	350.6	356.7	
Weight of Jar after time duration (24 hr)	354.4	364.5	350.1	356.3	
Weight Difference (g)	0.2	0.4	0.5	0.4	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	0.6	1	1	1.0	0.43
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**V1SCI**	**V2SCI**	**V3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	176.3	349.0	334.5	286.6	
Weight Difference (g)	178.3	15.9	16.1	70.1	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	36.20	3.23	3.27	14.23	19.02

VTR Data for Butadiene–Acrylonitrile Copolymer and Simulant Scintillation Fluids Mixed Waste

Exposure Duration: 1day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**N1SCI**	**N2SCI**	**N3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	164.502	163.974	164.626	164.367	
Weight of Jar/Lid/Specimen/Waste (g)	343.7	343.4	339.0	342.0	
Weight of Jar after time duration (24 hr)	333.2	332.8	327.9	331.3	
Weight Difference (g)	10.5	10.6	11.1	10.7	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	29.8	30.1	31.5	30.5	0.914
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**N1SCI**	**N2SCI**	**N3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	241.3	281.0	275.5	265.9	
Weight Difference (g)	102.4	62.4	63.5	76.1	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	20.79	12.7	12.9	15.4	4.63

VTR Data for Styrene–Butadiene Rubber and Simulant Scintillation Fluids Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**G1SCI**	**G2SCI**	**G3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	164.154	164.419	171.628	166.734	
Weight of Jar/Lid/Specimen/Waste (g)	336.8	343.1	342.0	340.6	
Weight of Jar after time duration (24 hr)	316.8	210.1	322.3	283.1	
Weight Difference (g)	20.0	133.0	19.7	57.6	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	56.8	378.0	56.0	163.6	185.7
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**SCI**	
Specimen	**G1SCI**	**G2SCI**	**G3SCI**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	163.6	164.4	171.0	166.3	
Weight Difference (g)	173.2	178.7	171.0	174.3	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	35.16	36.27	34.71	35.38	0.8030

VTR Data for Butyl Rubber and the Ketone Mixture Simulant Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**KET**	
Specimen	**B1KET**	**B2KET**	**B3KET**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	164.067	163.716	163.835	163.873	
Weight of Jar/Lid/Specimen/Waste (g)	314.1	309.5	315.4	313.0	
Weight of Jar after time duration (24 hr)	314.3	309.7	315.6	313.2	
Weight Difference (g)	-0.2	-0.2	-0.2	-0.2	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	-0.6	-0.6	-0.6	-0.6	0.0
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**KET**	
Specimen	**B1KET**	**B2KET**	**B3KET**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	306.4	302.2	308.0	305.5	
Weight Difference (g)	7.7	7.3	7.4	7.5	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	1.6	1.5	1.5	1.5	0.042

VTR Data for Epichlorohydrin and the Ketone Mixture Simulant Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**KET**	
Specimen	**ECH1KET**	**ECH2KET**	**ECH3KET**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	166.344	166.387	165.912	166.214	
Weight of Jar/Lid/Specimen/Waste (g)	312.4	307.3	309.9	309.9	
Weight of Jar after time duration (24 hr)	304.2	300.2	300.7	301.7	
Weight Difference (g)	8.2	7.1	9.2	8.2	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	23	20	26	23	3.0
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**KET**	
Specimen	**ECH1KET**	**ECH2KET**	**ECH3KET**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	166.34	168.40	176.50	172.5	
Weight Difference (g)	146.1	138.9	133.4	136.2	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	29.7	28.2	27.1	28.3	1.29

VTR Data for Ethylene Propylene Rubber and the Ketone Mixture Simulant Mixed Waste

Exposure Duration: 1 day	**Exposure Temperature:**	**60°C**	**Waste Type:**	**KET**	
Specimen	**E1KET**	**E2KET**	**E3KET**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	164.149	164.653	164.529	164.444	
Weight of Jar/Lid/Specimen/Waste (g)	309.0	307.4	307.5	308.0	
Weight of Jar after time duration (24 hr)	307.9	306.4	306.6	307.0	
Weight Difference (g)	1.1	1.0	0.9	1.0	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	3.1	2.8	2.6	2.8	0.3
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**KET**	
Specimen	**E1KET**	**E2KET**	**E3KET**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	288.9	288.0	288.3	288.4	
Weight Difference (g)	20.1	19.4	19.2	19.6	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	4.1	3.9	3.9	4.0	0.1

VTR Data for Fluorocarbon Rubber (Viton) and the Ketone Mixture Simulant Mixed Waste

Exposure Duration:1 day	**Exposure Temperature:**	**KET**	**Waste Type:**	**KET**	
Specimen	**V1KET**	**V2KET**	**V3KET**	**AVE.**	**STD. DEV.**
Weight of Jar/Lid/Specimen (g)	175.285	174.766	175.065	175.039	
Weight of Jar/Lid/Specimen/Waste (g)	308.5	298.1	269.6	292.1	
Weight of Jar after time duration (24 hr)	177.0	176.7	177.0	176.9	
Weight Difference (g)	131.5	121.4	92.6	115.2	
Time (hr)	24	24	24	24	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	373.7	345.0	263.2	327.3	57.4
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type:**	**KET**	
Specimen	**V1KET**	**V2KET**	**V3KET**	**AVE.**	**STD. DEV.**
Weight of Jar after Time Duration (g)	175.3	174.8	175.1	175.0	
Weight Difference (g)	133.2	123.3	94.5	117.0	
Time (hr)	336	336	336	336	
Radius of Specimen (mm)	68.33	68.33	68.33	68.33	
Radius of Specimen (m)	0.06833	0.06833	0.06833	0.06833	
Area of Specimen (m^2)	0.0147	0.0147	0.0147	0.0147	
VTR ($g/hr/m^2$)	27.0	25.0	19.2	23.8	4.1

Specific Gravity Data for Cross-linked Polyethylene Exposed to Simulant Aqueous Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.9147	0.9382				
% Specific Gravity Change	0.00%	2.57%				
Standard Deviation	0.0057	0.0054				
Exposure Duration: 0 days	**Exposure Temperature:**	**23°C**	**Waste Type: AQUEOUS**			
Specimen	**1 - X1A**	**2 - X2A**	**3 - X3A**	**4 - X4A**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.8426	3.8488	3.8457	3.8427	3.84495	
Apparent mass of specimen (g)	4.6343	4.6943	4.6845	4.6689	4.67050	
Apparent mass of wire/sinker (g)	5.0287	5.0298	5.0289	5.0287	5.02903	
Specific Gravity 23/23°C	0.9069	0.9198	0.9178	0.9144	0.9147	0.0057
Density (g/cc)	0.9047	0.9176	0.9156	0.9122	0.9125	0.0057
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type: AQUEOUS**			
Specimen	**1-X1A**	**2-X2A**	**3-X3A**	**4-X4A**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.8437	3.8494	3.8466	3.8443	3.8460	
Apparent mass of specimen (g)	4.7713	4.7819	4.7768	4.7820	4.7780	
Apparent mass of wire/sinker (g)	5.0310	5.0309	5.0309	5.0319	5.0312	
Specific Gravity 23/23°C	0.9367	0.9392	0.9380	0.9390	0.9382	0.0011
Density (g/cc)	0.9345	0.9370	0.9358	0.9367	0.9360	0.0011
% Specific Gravity Change	3.29%	2.11%	2.20%	2.69%	2.57%	0.54%

Specific Gravity Data for Fluorocarbon (Kel-F) Exposed to Simulant Aqueous Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	2.1292	2.1275				
% Specific Gravity Change	0.00%	-0.08%				
Standard Deviation	0.0035	0.0035				
Exposure Duration: 0 days	**Exposure Temperature:**	**23°C**	**Waste Type: AQUEOUS**			
Specimen	**1 - F1A**	**2 - F2A**	**3 - F3A**	**4 - F4A**	**AVE.**	**STD. DEV.**
Mass in air (g)	9.2863	9.5367	9.2350	9.5672	9.4063	
Apparent mass of specimen (g)	9.4524	9.5748	9.4232	9.5944	9.5112	
Apparent mass of wire/sinker (g)	4.5203	4.5211	4.5206	4.5288	4.5227	
Specific Gravity 23/23°C	2.1327	2.1273	2.1316	2.1253	2.1292	0.0035
Density (g/cc)	2.1276	2.1222	2.1265	2.1202	2.1241	0.0035
Exposure Duration: 14 days	**Exposure Temperature:**	**60°C**	**Waste Type: AQUEOUS**			
Specimen	**1-F1A**	**2-F2A**	**3-F3A**	**4-F4A**	**AVE.**	**STD. DEV.**
Mass in air (g)	9.2865	9.5375	9.2357	9.5677	9.4069	
Apparent mass of specimen (g)	9.9632	10.0572	9.9354	10.1046	10.0151	
Apparent mass of wire/sinker (g)	5.0298	5.0297	5.0301	5.0305	5.0300	
Specific Gravity 23/23°C	2.1333	2.1147	2.1328	2.1292	2.1275	0.0087
Density (g/cc)	2.1282	2.1097	2.1276	2.1241	2.1224	0.0087
% Specific Gravity Change	0.03%	-0.59%	0.05%	0.18%	-0.08%	0.35%

Specific Gravity Data for Polyethylene Exposed to Simulant Aqueous Mixed Waste

DATA SUMMARY						
Days	0	14				
Average Specific Gravity 23/23°C	0.9580	0.9628				
% Specific Gravity Change	0.00%	0.51%				
Standard Deviation	0.0086	0.0121				
Exposure Duration: 0 days	Exposure Temperature: 23°C		Waste Type: AQUEOUS			
Specimen	1 - E1A	2 - E2A	3 - E3A	4 - E4A	AVE.	STD. DEV.
Mass in air (g)	3.6709	3.6652	3.6505	3.6319	3.6546	
Apparent mass of specimen (g)	4.3808	4.3752	4.3906	4.3159	4.3656	
Apparent mass of wire/sinker (g)	4.5257	4.5252	4.5267	4.5261	4.5259	
Specific Gravity 23/23°C	0.9620	0.9607	0.9641	0.9453	0.9580	0.0086
Density (g/cc)	0.9597	0.9584	0.9617	0.9430	0.9557	0.0086
Exposure Duration: 14 days	Exposure Temperature: 60°C		Waste Type: AQUEOUS			
Specimen	1-E1A	2-E2A	3-E3A	4-E4A	AVE.	STD. DEV.
Mass in air (g)	3.6721	3.6663	3.6521	3.6331	3.6559	
Apparent mass of specimen (g)	4.8938	4.8586	4.9028	4.9044	4.8899	
Apparent mass of wire/sinker (g)	5.0318	5.0311	5.0318	5.0305	5.0313	
Specific Gravity 23/23°C	0.9638	0.9551	0.9659	0.9665	0.9628	0.0053
Density (g/cc)	0.9615	0.9528	0.9636	0.9641	0.9605	0.0053
% Specific Gravity Change	0.18%	-0.58%	0.19%	2.24%	0.51%	1.21%

Specific Gravity Data for Polypropylene Exposed to Simulant Aqueous Mixed Waste

DATA SUMMARY						
Days	0	14				
Average Specific Gravity 23/23°C	0.8848	0.9081				
% Specific Gravity Change	0.00%	2.64%				
Standard Deviation	0.0034	0.0102				
Exposure Duration: 0 days	Exposure Temperature: 23°C		Waste Type: AQUEOUS			
Specimen	1 - P1A	2 - P2A	3 - P3A	4 - P4A	AVE.	STD. DEV.
Mass in air (g)	3.5539	3.5551	3.5553	3.5570	3.5553	
Apparent mass of specimen (g)	4.5839	4.5759	4.5512	4.5565	4.5669	
Apparent mass of wire/sinker (g)	5.0297	5.0300	5.0299	5.0294	5.0298	
Specific Gravity 23/23°C	0.8885	0.8867	0.8813	0.8827	0.8848	0.0034
Density (g/cc)	0.8864	0.8846	0.8792	0.8805	0.8827	0.0034
Exposure Duration: 14 days	Exposure Temperature: 60°C		Waste Type: AQUEOUS			
Specimen	1-P1A	2-P2A	3-P3A	4-P4A	AVE.	STD. DEV.
Mass in air (g)	3.5548	3.5561	3.5565	3.5624	3.5575	
Apparent mass of specimen (g)	4.6325	4.6839	4.6840	4.6858	4.6716	
Apparent mass of wire/sinker (g)	5.0321	5.0310	5.0310	5.0322	5.0316	
Specific Gravity 23/23°C	0.8989	0.9111	0.9111	0.9114	0.9081	0.0061
Density (g/cc)	0.8968	0.9089	0.9089	0.9092	0.9059	0.0061
% Specific Gravity Change	1.17%	2.74%	3.38%	3.25%	2.64%	1.02%

Specific Gravity Data for Teflon Exposed to Simulant Aqueous Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	2.1487	2.1911				
% Specific Gravity Change	0.00%	1.99%				
Standard Deviation	0.0458	0.0185				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: Aqueous**			
Specimen	**1 - T1A**	**2 - T2A**	**3 - T3A**	**4 - T4A**	**AVE.**	**STD. DEV.**
Mass in air (g)	8.6789	8.6530	8.6246	8.6214	8.6445	
Apparent mass of specimen (g)	9.2408	9.2122	9.5322	9.6054	9.3977	
Apparent mass of wire/sinker (g)	4.5247	4.5258	5.0301	5.0292	4.7775	
Specific Gravity 23/23°C	2.1901	2.1815	2.0921	2.1313	2.1487	0.0458
Density (g/cc)	2.1848	2.1762	2.0871	2.1262	2.1436	0.0457
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: AQUEOUS**			
Specimen	**1-T1A**	**2-T2A**	**3-T3A**	**4-T4A**	**AVE.**	**STD. DEV.**
Mass in air (g)	8.6787	8.6536	8.6258	8.6225	8.6452	
Apparent mass of specimen (g)	9.7316	9.7846	9.6309	9.766	9.7283	
Apparent mass of wire/sinker (g)	5.0310	5.0306	5.0247	5.0316	5.0295	
Specific Gravity 23/23°C	2.1816	2.2191	2.1459	2.2177	2.1911	0.0347
Density (g/cc)	2.1764	2.2138	2.1408	2.2123	2.1858	0.0347
% Specific Gravity Change	-0.39%	1.73%	2.57%	4.05%	1.99%	1.85%

Specific Gravity Data for Cross-linked Polyethylene Exposed to Simulant Chlorinated Hydrocarbon Mixed Waste

DATA SUMMARY						
Days	0	14				
Average Specific Gravity 23/23°C	0.9313	1.0006				
% Specific Gravity Change	0.00%	7.44%				
Standard Deviation	0.0071	0.0086				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: CHC**			
Specimen	1 - X1C	2 - X2C	3 - X3C	4 - X4C	AVE.	STD. DEV.
Mass in air (g)	3.8492	3.8417	3.8694	3.8448	3.8513	
Apparent mass of specimen (g)	4.7703	4.7127	4.7292	4.7735	4.7464	
Apparent mass of wire/sinker (g)	5.0298	5.0332	5.0301	5.0293	5.0306	
Specific Gravity 23/23°C	0.9368	0.9230	0.9278	0.9376	0.9313	0.0071
Density (g/cc)	0.9346	0.9208	0.9256	0.9354	0.9291	0.0071
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type:CHC**			
Specimen	1-X1C	2-X2C	3-X3C	4-X4C	AVE.	STD. DEV.
Mass in air (g)	4.7390	4.7325	4.7402	4.7014	4.7283	
Apparent mass of specimen (g)	5.0371	5.0371	5.0342	5.032	5.0351	
Apparent mass of wire/sinker (g)	5.0325	5.0317	5.0322	5.0327	5.0323	
Specific Gravity 23/23°C	1.0010	1.0011	1.0004	0.9999	1.0006	0.0006
Density (g/cc)	0.9986	0.9987	0.9980	0.9975	0.9982	0.0006
% Specific Gravity Change	6.85%	8.47%	7.82%	6.64%	7.44%	0.86%

Specific Gravity Data for Fluorocarbon (Kel-F) Exposed to Simulant Chlorinated Hydrocarbon Mixed Waste

DATA SUMMARY						
Days	0	14				
Average Specific Gravity 23/23°C	2.12509	1.98832				
% Specific Gravity Change	0.00%	-6.43%				
Standard Deviation	0.0031	0.0550				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: CHC**			
Specimen	1 - F1C	2 - F2C	3 - F3C	4 - F4C	AVE.	STD. DEV.
Mass in air (g)	9.3350	9.7100	9.3883	9.5285	9.4905	
Apparent mass of specimen (g)	9.4686	9.6715	9.4875	9.5659	9.5484	
Apparent mass of wire/sinker (g)	4.5217	4.5241	4.5230	4.5264	4.5238	
Specific Gravity 23/23°C	2.1273	2.1282	2.1222	2.1226	2.1251	0.0031
Density (g/cc)	2.1222	2.1231	2.1171	2.1175	2.1200	0.0031
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: CHC**			
Specimen	1-F1C	2-F2C	3-F3C	4-F4C	AVE.	STD. DEV.
Mass in air (g)	9.7972	10.2051	9.8570	10.0182	9.9694	
Apparent mass of specimen (g)	9.6404	9.8420	10.1695	10.2455	9.9744	
Apparent mass of wire/sinker (g)	5.0326	5.0328	5.0311	5.0319	5.0321	
Specific Gravity 23/23°C	1.8879	1.8913	2.0890	2.0851	1.9883	0.1140
Density (g/cc)	1.8834	1.8867	2.0840	2.0801	1.9836	0.1137
% Specific Gravity Change	-11.25%	-11.13%	-1.57%	-1.77%	-6.43%	5.50%

Specific Gravity Data for Polyethylene Exposed to Simulant Chlorinated Hydrocarbon Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.9648	1.0046				
% Specific Gravity Change	0.00%	4.12%				
Standard Deviation	0.0003	0.0004				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: CHC**			
Specimen	**1 - E1C**	**2 - E2C**	**3 - E3C**	**4 - E4C**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.6196	3.7098	3.7088	3.7069	3.6863	
Apparent mass of specimen (g)	4.3938	4.3892	4.3919	4.3906	4.3914	
Apparent mass of wire/sinker (g)	4.5246	4.5250	4.5265	4.5267	4.5257	
Specific Gravity 23/23°C	0.9651	0.9647	0.9650	0.9646	0.9648	0.0003
Density (g/cc)	0.9628	0.9624	0.9627	0.9623	0.9625	0.0002
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: CHC**			
Specimen	**1-E1C**	**2-E2C**	**3-E3C**	**4-E4C**	**AVE.**	**STD. DEV.**
Mass in air (g)	4.1093	4.2230	4.2202	4.2085	4.1903	
Apparent mass of specimen (g)	5.0506	5.0522	5.0529	5.0490	5.0512	
Apparent mass of wire/sinker (g)	5.0316	5.0320	5.0319	5.0325	5.0320	
Specific Gravity 23/23°C	1.0046	1.0048	1.0050	1.0039	1.0046	0.0005
Density (g/cc)	1.0022	1.0024	1.0026	1.0015	1.0022	0.0005
% Specific Gravity Change	4.09%	4.16%	4.15%	4.08%	4.12%	0.04%

Specific Gravity Data for Polypropylene Exposed to Simulant Chlorinated Hydrocarbon Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.8877	0.9842				
% Specific Gravity Change	0.00%	10.87%				
Standard Deviation	0.0022	0.0030				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: CHC**			
Specimen	**1 - P1C**	**2 - P2C**	**3 - P3C**	**4 - P4C**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.5606	3.5736	3.5774	3.5728	3.57110	
Apparent mass of specimen (g)	4.5757	4.5678	4.5780	4.5910	4.57813	
Apparent mass of wire/sinker (g)	5.0300	5.0298	5.0303	5.0296	5.02993	
Specific Gravity 23/23°C	0.8868	0.8855	0.8878	0.8907	0.88770	0.0022
Density (g/cc)	0.8847	0.8834	0.8856	0.8885	0.8856	0.0022
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: CHC**			
Specimen	**1-P1C**	**2-P2C**	**3-P3C**	**4-P4C**	**AVE.**	**STD. DEV.**
Mass in air (g)	4.4767	4.4833	4.4883	4.4753	4.4809	
Apparent mass of specimen (g)	4.9630	4.9603	4.9590	4.9591	4.9604	
Apparent mass of wire/sinker (g)	5.0327	5.0323	5.0326	5.0324	5.0325	
Specific Gravity 23/23°C	0.9847	0.9842	0.9839	0.9839	0.9842	0.0004
Density (g/cc)	0.9823	0.9818	0.9815	0.9815	0.9818	0.0004
% Specific Gravity Change	11.03%	11.14%	10.83%	10.47%	10.87%	0.30%

Specific Gravity Data for Teflon Exposed to Simulant Chlorinated Hydrocarbon Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	2.1047	2.2206				
% Specific Gravity Change	0.00%	5.51%				
Standard Deviation	0.0151	0.0079				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: CHC**			
Specimen	**1 -T1C**	**2 -T2C**	**3 - T3C**	**4 - T4C**	**AVE.**	**STD. DEV.**
Mass in air (g)	8.5959	8.5977	8.5944	8.6001	8.5970	
Apparent mass of specimen (g)	9.5684	9.4993	9.5520	9.5483	9.5420	
Apparent mass of wire/sinker (g)	5.0303	5.0285	5.0292	5.0312	5.0298	
Specific Gravity 23/23°C	2.1184	2.0833	2.1108	2.1063	2.1047	0.0151
Density (g/cc)	2.1133	2.0783	2.1058	2.1013	2.0997	0.0151
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: CHC**			
Specimen	**1-T1C**	**2-T2C**	**3-T3C**	**4-T4C**	**AVE.**	**STD. DEV.**
Mass in air (g)	8.6485	8.6495	8.6449	8.6489	8.6480	
Apparent mass of specimen (g)	9.7836	9.7872	9.7831	9.7870	9.7852	
Apparent mass of wire/sinker (g)	5.0317	5.0315	5.0316	5.0320	5.0317	
Specific Gravity 23/23°C	2.2195	2.2214	2.2204	2.2211	2.2206	0.0008
Density (g/cc)	2.2142	2.2160	2.2151	2.2158	2.2153	0.0008
% Specific Gravity Change	4.77%	6.62%	5.19%	5.45%	5.51%	0.79%

Specific Gravity Data for Cross-linked Polyethylene Exposed to Simulant Scintillation Fluids Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.9307	0.9306				
% Specific Gravity Change	0.00%	-0.02%				
Standard Deviation	0.0049	0.0064				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: SCI**			
Specimen	**1 - X1S**	**2 - X2S**	**3 - X3S**	**4 - X4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.8430	3.8509	3.8444	3.8490	3.8468	
Apparent mass of specimen (g)	4.7314	4.7320	4.7755	4.7356	4.7436	
Apparent mass of wire/sinker (g)	5.0303	5.0305	5.0291	5.0301	5.0300	
Specific Gravity 23/23°C	0.9278	0.9281	0.9381	0.9289	0.9307	0.0049
Density (g/cc)	0.9256	0.9258	0.9359	0.9267	0.9285	0.0049
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: SCI**			
Specimen	**1-X1S**	**2-X2S**	**3-X3S**	**4-X4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	4.2549	4.2583	4.2498	4.2530	4.2540	
Apparent mass of specimen (g)	4.6732	4.7330	4.7308	4.7328	4.7175	
Apparent mass of wire/sinker (g)	5.0319	5.0329	5.0350	5.0399	5.0349	
Specific Gravity 23/23°C	0.9223	0.9342	0.9332	0.9327	0.9306	0.0056
Density (g/cc)	0.9200	0.9320	0.9310	0.9304	0.9283	0.0056
% Specific Gravity Change	-0.60%	0.66%	-0.52%	0.40%	-0.02%	0.64%

Specific Gravity Data for Fluorocarbon (Kel-F) Exposed to Simulant Scintillation Fluids Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	2.1291	2.0792				
% Specific Gravity Change	0.00%	-2.34%				
Standard Deviation	0.0008	0.0019				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: SCI**			
Specimen	**1 - F1S**	**2 - F2S**	**3 - F3S**	**4 - F4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	9.5099	9.5246	9.3710	9.3128	9.4296	
Apparent mass of specimen (g)	9.5702	9.5787	9.4935	9.4648	9.5268	
Apparent mass of wire/sinker (g)	4.5274	4.5257	4.5259	4.5251	4.5260	
Specific Gravity 23/23°C	2.1289	2.1300	2.1281	2.1296	2.1291	0.0008
Density (g/cc)	2.1238	2.1249	2.1230	2.1245	2.1240	0.0008
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: SCI**			
Specimen	**1-F1S**	**2-F2S**	**3-F3S**	**4-F4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	9.6969	9.7144	9.5610	9.5000	9.6181	
Apparent mass of specimen (g)	10.0544	10.0676	9.9967	9.9687	10.0219	
Apparent mass of wire/sinker (g)	5.0296	5.0310	5.0289	5.0291	5.0297	
Specific Gravity 23/23°C	2.0755	2.0767	2.0816	2.0832	2.0792	0.0037
Density (g/cc)	2.0705	2.0717	2.0766	2.0782	2.0742	0.0037
% Specific Gravity Change	-2.51%	-2.50%	-2.19%	-2.18%	-2.34%	0.19%

Specific Gravity Data for Polyethylene Exposed to Simulant Scintillation Fluids Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.9649	0.9592				
% Specific Gravity Change	0.00%	-0.60%				
Standard Deviation	0.0002	0.0062				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: SCI**			
Specimen	**1 - E1S**	**2 - E2S**	**3 - E3S**	**4 - E4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.7088	3.7205	3.7248	3.7374	3.7229	
Apparent mass of specimen (g)	4.3905	4.3909	4.3892	4.3910	4.3904	
Apparent mass of wire/sinker (g)	4.5251	4.5266	4.5256	4.5257	4.5258	
Specific Gravity 23/23°C	0.9650	0.9648	0.9647	0.9652	0.9649	0.0002
Density (g/cc)	0.9627	0.9625	0.9624	0.9629	0.9626	0.0002
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: SCI**			
Specimen	**1-E1S**	**2-E2S**	**3-E3S**	**4-E4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.9567	3.9727	3.9783	3.9848	3.9731	
Apparent mass of specimen (g)	4.8737	4.8206	4.8722	4.8703	4.8592	
Apparent mass of wire/sinker (g)	5.0280	5.0293	5.0281	5.0283	5.0284	
Specific Gravity 23/23°C	0.9625	0.9501	0.9623	0.9619	0.9592	0.0061
Density (g/cc)	0.9602	0.9478	0.9600	0.9596	0.9569	0.0060
% Specific Gravity Change	-0.26%	-1.53%	-0.25%	-0.35%	-0.60%	0.62%

Specific Gravity Data for Polypropylene Exposed to Simulant Scintillation Fluids Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.8932	0.9110				
% Specific Gravity Change	0.00%	2.00%				
Standard Deviation	0.0037	0.0045				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: SCI**			
Specimen	**1 - P1S**	**2 - P2S**	**3 - P3S**	**4 - P4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.5824	3.5965	3.5971	3.5990	3.5938	
Apparent mass of specimen (g)	4.6005	4.5848	4.6232	4.5946	4.6008	
Apparent mass of wire/sinker (g)	5.0312	5.0306	5.0302	5.0307	5.0307	
Specific Gravity 23/23°C	0.8927	0.8897	0.8984	0.8919	0.8932	0.0037
Density (g/cc)	0.8905	0.8876	0.8962	0.8898	0.8910	0.0037
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: SCI**			
Specimen	**1-P1S**	**2-P2S**	**3-P3S**	**4-P4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.9797	4.0065	4.0037	4.0003	3.9976	
Apparent mass of specimen (g)	4.6400	4.6389	4.6358	4.6382	4.6382	
Apparent mass of wire/sinker (g)	5.0288	5.0281	5.0284	5.0290	5.0286	
Specific Gravity 23/23°C	0.9110	0.9115	0.9107	0.9110	0.9110	0.0003
Density (g/cc)	0.9088	0.9093	0.9085	0.9088	0.9089	0.0003
% Specific Gravity Change	2.05%	2.44%	1.37%	2.14%	2.00%	0.45%

Specific Gravity Data for Teflon Exposed to Simulant Scintillation Fluids Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	2.1152	2.2134				
% Specific Gravity Change	0.00%	4.65%				
Standard Deviation	0.0088	0.0052				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: SCI**			
Specimen	**1 - T1S**	**2 - T2S**	**3 - T3S**	**4 - T4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	8.6090	8.6175	8.7172	8.6824	8.6565	
Apparent mass of specimen (g)	9.5915	9.5727	9.6231	9.5855	9.5932	
Apparent mass of wire/sinker (g)	5.0315	5.0293	5.0285	5.0283	5.0294	
Specific Gravity 23/23°C	2.1262	2.1152	2.1145	2.1047	2.1152	0.0088
Density (g/cc)	2.1211	2.1101	2.1094	2.0997	2.1101	0.0088
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type:SCI**			
Specimen	**1-T1S**	**2-T2S**	**3-T3S**	**4-T4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	8.6266	8.6357	8.7378	8.7033	8.6759	
Apparent mass of specimen (g)	9.7667	9.7786	9.8283	9.8065	9.7950	
Apparent mass of wire/sinker (g)	5.0392	5.0412	5.0446	5.0302	5.0388	
Specific Gravity 23/23°C	2.2125	2.2152	2.2098	2.2163	2.2134	0.0029
Density (g/cc)	2.2071	2.2099	2.2045	2.2110	2.2081	0.0029
% Specific Gravity Change	4.06%	4.73%	4.51%	5.30%	4.65%	0.52%

Specific Gravity Data for Cross-linked Polyethylene Exposed to Ketone Mixture Simulant Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.9166	0.9267				
% Specific Gravity Change	0.00%	1.11%				
Standard Deviation	0.0071	0.0115				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: KETONE**			
Specimen	**1 - X1K**	**2 - X2K**	**3 - X3K**	**4 - X4K**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.8582	3.8463	3.8547	3.8582	3.8544	
Apparent mass of specimen (g)	4.6408	4.6794	4.6721	4.7213	4.6784	
Apparent mass of wire/sinker (g)	5.0280	5.0297	5.0300	5.0295	5.0293	
Specific Gravity 23/23°C	0.9088	0.9165	0.9150	0.9260	0.9166	0.0071
Density (g/cc)	0.9066	0.9143	0.9128	0.9238	0.9144	0.0071
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: KETONE**			
Specimen	**1-X1K**	**2-X2K**	**3-X3K**	**4-X4K**	**AVE.**	**STD. DEV.**
Mass in air (g)	4.0025	3.9896	3.9980	4.0009	3.9978	
Apparent mass of specimen (g)	4.7294	4.6630	4.7337	4.7257	4.7130	
Apparent mass of wire/sinker (g)	5.0293	5.0289	5.0288	5.0298	5.0292	
Specific Gravity 23/23°C	0.9303	0.9160	0.9313	0.9294	0.9267	0.0072
Density (g/cc)	0.9281	0.9138	0.9290	0.9271	0.9245	0.0072
% Specific Gravity Change	2.37%	-0.06%	1.77%	0.36%	1.11%	0.01147

Specific Gravity Data for Fluorocarbon (Kel-F) Exposed to Ketone Mixture Simulant Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	2.1291	2.0792				
% Specific Gravity Change	0.00%	-2.34%				
Standard Deviation	0.0008	0.0019				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: KETONE**			
Specimen	**1 - F1S**	**2 - F2S**	**3 - F3S**	**4 - F4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	9.5099	9.5246	9.3710	9.3128	9.4296	
Apparent mass of specimen (g)	9.5702	9.5787	9.4935	9.4648	9.5268	
Apparent mass of wire/sinker (g)	4.5274	4.5257	4.5259	4.5251	4.5260	
Specific Gravity 23/23°C	2.1289	2.1300	2.1281	2.1296	2.1291	0.0008
Density (g/cc)	2.1238	2.1249	2.1230	2.1245	2.1240	0.0008
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: KETONE**			
Specimen	**1-F1S**	**2-F2S**	**3-F3S**	**4-F4S**	**AVE.**	**STD. DEV.**
Mass in air (g)	9.6969	9.7144	9.5610	9.5000	9.6181	
Apparent mass of specimen (g)	10.0544	10.0676	9.9967	9.9687	10.0219	
Apparent mass of wire/sinker (g)	5.0296	5.0310	5.0289	5.0291	5.0297	
Specific Gravity 23/23°C	2.0755	2.0767	2.0816	2.0832	2.0792	0.0037
Density (g/cc)	2.0705	2.0717	2.0766	2.0782	2.0742	0.0037
% Specific Gravity Change	-2.51%	-2.50%	-2.19%	-2.18%	-2.34%	0.19%

Specific Gravity Data for Polyethylene Exposed to Ketone Mixture Simulant Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.9633	0.9607				
% Specific Gravity Change	0.00%	-0.27%				
Standard Deviation	0.0029	0.0024				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: KETONE**			
Specimen	**1 - E1K**	**2 - E2K**	**3 - E3K**	**4 - E4K**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.7506	3.7722	3.7437	3.7459	3.75310	
Apparent mass of specimen (g)	4.3656	4.3904	4.3876	4.3901	4.38343	
Apparent mass of wire/sinker (g)	4.5262	4.5264	4.5263	4.5274	4.52658	
Specific Gravity 23/23°C	0.9589	0.9652	0.9643	0.9646	0.96326	0.0029
Density (g/cc)	0.9566	0.9629	0.9620	0.9623	0.9610	0.0029
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: KETONE**			
Specimen	**1-E1K**	**2-E2K**	**3-E3K**	**4-E4K**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.8529	3.8754	3.8461	3.8481	3.8556	
Apparent mass of specimen (g)	4.8687	4.8742	4.8728	4.8725	4.8721	
Apparent mass of wire/sinker (g)	5.0299	5.0307	5.0299	5.0288	5.0298	
Specific Gravity 23/23°C	0.9598	0.9612	0.9608	0.9610	0.9607	0.0006
Density (g/cc)	0.9575	0.9589	0.9585	0.9587	0.9584	0.0006
% Specific Gravity Change	0.09%	-0.42%	-0.36%	-0.38%	-0.27%	0.24%

Specific Gravity Data for Polyproylene Exposed to Ketone Mixture Simulant Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	0.8951	0.9020				
% Specific Gravity Change	0.00%	0.78%				
Standard Deviation	0.0113	0.0116				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: KETONE**			
Specimen	**1 - P1K**	**2 - P2K**	**3 - P3K**	**4 - P4K**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.5966	3.6070	3.6062	3.6051	3.6037	
Apparent mass of specimen (g)	4.6764	4.5650	4.6149	4.5723	4.6072	
Apparent mass of wire/sinker (g)	5.0304	5.0301	5.0297	5.0298	5.0300	
Specific Gravity 23/23°C	0.9104	0.8858	0.8968	0.8874	0.8951	0.0113
Density (g/cc)	0.9082	0.8837	0.8947	0.8853	0.8930	0.0113
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: KETONE**			
Specimen	**1-P1K**	**2-P2K**	**3-P3K**	**4-P4K**	**AVE.**	**STD. DEV.**
Mass in air (g)	3.7930	3.8029	3.8023	3.8005	3.7997	
Apparent mass of specimen (g)	4.6294	4.6325	4.6309	4.5748	4.6169	
Apparent mass of wire/sinker (g)	5.0294	5.0303	5.0302	5.0298	5.0299	
Specific Gravity 23/23°C	0.9046	0.9053	0.9050	0.8931	0.9020	0.0059
Density (g/cc)	0.9024	0.9031	0.9028	0.8909	0.8998	0.0059
% Specific Gravity Change	-0.64%	2.20%	0.91%	0.64%	0.78%	1.16%

Specific Gravity Data for Teflon Exposed to Ketone Mixture Simulant Mixed Waste

DATA SUMMARY						
Days	**0**	**14**				
Average Specific Gravity 23/23°C	2.1252	2.2173				
% Specific Gravity Change	0.00%	4.34%				
Standard Deviation	0.0225	0.0108				
Exposure Duration: 0 days	**Exposure Temperature: 23°C**		**Waste Type: KETONE**			
Specimen	**1 - T1K**	**2 - T2K**	**3 - T3K**	**4 - T4K**	**AVE.**	**STD. DEV.**
Mass in air (g)	8.6296	8.6352	8.6440	8.6571	8.6415	
Apparent mass of specimen (g)	9.6532	9.5974	9.6069	9.5608	9.6046	
Apparent mass of wire/sinker (g)	5.0309	5.0290	5.0296	5.0292	5.0297	
Specific Gravity 23/23°C	2.1535	2.1233	2.1256	2.0984	2.1252	0.0225
Density (g/cc)	2.1483	2.1182	2.1205	2.0934	2.1201	0.0224
Exposure Duration: 14 days	**Exposure Temperature: 60°C**		**Waste Type: KETONE**			
Specimen	**1-T1K**	**2-T2K**	**3-T3K**	**4-T4K**	**AVE.**	**STD. DEV.**
Mass in air (g)	8.6448	8.6508	8.6595	8.6733	8.6571	
Apparent mass of specimen (g)	9.7782	9.7790	9.7835	9.7910	9.7829	
Apparent mass of wire/sinker (g)	5.0310	5.0289	5.0306	5.0302	5.0302	
Specific Gravity 23/23°C	2.2180	2.2178	2.2166	2.2168	2.2173	0.0007
Density (g/cc)	2.2127	2.2124	2.2113	2.2115	2.2120	0.0007
% Specific Gravity Change	3.00%	4.45%	4.28%	5.64%	4.34%	1.08%

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