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Hanford Grout Technology Program

**The Compatibility of Various
Polymeric Liner and Pipe
Materials with Simulated
Double-Shell Slurry Feed
at 90° C**

**R. K. Farnsworth
C. R. Hymas**

August 1989

**Prepared for the U.S. Department of Energy
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**Pacific Northwest Laboratory
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HANFORD GROUT TECHNOLOGY PROGRAM

THE COMPATIBILITY OF VARIOUS POLYMERIC LINER
AND PIPE MATERIALS WITH SIMULATED **DOUBLE-**
SHELL SLURRY FEED AT 90°C

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Hanford Grout Technology Program
Task 5, Process Support

Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

The purpose of this study was to evaluate the compatibility of various polymeric liner and pipe materials with a low-level radioactive waste slurry called double-shell slurry feed (DSSF). The evaluation was necessary as part of the permitting process authorized by the Resource Conservation and Recovery Act (RCRA), PL-94-580. Materials that were examined included five flexible membrane liners (Hytrel® polyester, polyurethane, 8130 XR5®, polypropylene, and high-density polyethylene) and high-density polyethylene (HDPE) pipe.

The liner and pipe samples were immersed for 120 days in the synthetic DSSF at 90°C, the maximum expected temperature in the waste disposal scenario. Physical properties of the liner and pipe samples were measured before immersion and every 30 days after immersion, in accordance with EPA Method 9090. In addition, some of the materials were exposed to four different radiation doses after 30 days of immersion. Physical properties of these materials were measured immediately after exposure and after an additional 90 days of immersion to determine each material's response to radiation, and whether radiation exposure affected the chemical compatibility of the material. The work was performed in accordance with a quality assurance program based on ANSI/ASME NQA-1-1983.

Results from this study support the use of HDPE liner and pipe materials in the current DSSF waste disposal scenario. Of the six materials tested, only the HDPE and polypropylene liner samples, and the HDPE pipe samples, were immersed for the full 120 days. The other three materials were judged incompatible prior to 120 days of immersion. Testing of the Hytrel polyester liner was discontinued after 17 days because of the complete dissolution of the sample. Testing of the polyurethane liner was discontinued after 30 days because of severe decreases in the liner's strength and elongation properties. Testing of the 8130 XR5 liner was discontinued after 60 days

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because of swelling and severe decreases in the liner's strength and elongation properties. It is suspected that the primary cause for failure of the Hytrel, polyurethane, and XR5 liners was a temperature-accelerated hydrolysis reaction between ester components in each liner and the caustic DSSF simulant.

The HDPE liner, polypropylene liner, and HDPE pipe exhibited generally acceptable chemical compatibility. For HDPE liner, the only properties outside of the National Sanitation Foundation (NSF) -proposed criteria were puncture force and puncture elongation; both properties increased continually through the entire 120-day immersion period. For the polypropylene liner, the only properties of concern were the puncture force and the stresses at 100% and 200% elongation; none of these properties had stabilized, and they differed from their original values by over 10% after 120 days of immersion. For the HDPE pipe, only the yield stress, stress at 100% elongation, and volatiles content had not yet stabilized after 120 days of immersion. In each of these cases, the change was not suspected to be due to a chemical or temperature degradation. In addition, each material's dimensional properties (mass, thickness, length, width) remained relatively constant during the 120 days of immersion. As a result, it appears that the HDPE liner, HDPE pipe, and the polypropylene liner are chemically compatible with the 90°C waste.

Results from the radiation compatibility tests showed decreases in break elongation of up to 70% for the HDPE liner, 85% for HDPE pipe, and 95% for polypropylene materials. In addition, many of the other mechanical strength properties exhibited similar decreases. These decreases resulted from radiation-induced cross-linking in the polymer chains, which caused the materials to become more resistant to thinning. However, the decreases were only significant at exposure levels of 16 Mrad and 37 Mrad. Because of recent design changes to the disposal system, it is projected that the liner and pipe materials will be less than 14 rad after 30 years. As a result, the effect of radiation on liners and pipe in this application is expected to be negligible.

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1.0 INTRODUCTION

It is planned to dispose of low-level liquid radioactive waste at Hanford by solidification in a cement-based matrix (called grout). Flexible membrane liners will comprise part of the disposal system, in accordance with the Resource Conservation and Recovery Act (RCRA) (Public Law 94-580). As part of the permitting process, it must be demonstrated that the vault component materials are compatible with double-shell slurry feed (DSSF) grout slurry and any leachate that may be generated from the DSSF grout. Double-shell slurry feed is a low-level radioactive waste presently stored in double-shell tanks on the Hanford Site.

In 1987, compatibility tests were performed on a high-density polyethylene (HDPE) liner and three prospective vault component materials (HDPE pipe, HDPE geonet, and polypropylene geotextile) in contact with simulated DSSF. In the test, samples of each material were immersed for 150 days in concentrated DSSF at ambient temperatures and 75°C. During immersion, the materials were irradiated to simulate the temperature and radiation exposure expected in the actual DSSF grout vault. However, recent calculations showed that the actual steady-state temperature expected in disposal vaults is 90°C. It was unknown if HDPE would still be compatible at the higher temperature; therefore, additional compatibility tests were performed on the HDPE liner and pipe material, along with four other prospective liner materials: nonreinforced Hytrel® polyester, polyurethane, 8130 XR5, and polypropylene. Results from the 90°C compatibility tests are presented in this report.

In these tests, the liner samples and pipe sample were immersed for 120 days in synthetic DSSF at 90°C. In addition, the polypropylene, polyurethane, and XR5 liners were also immersed in synthetic DSSF at ambient temperatures (23 °C). Physical properties of each material were measured before immersion and after every 30 days of exposure, in accordance with the

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Environmental Protection Agency (EPA) Method 9090 Compatibility Test for Wastes and Membrane Liners (EPA 1986). In addition, some of the liner and pipe samples were exposed to four different radiation doses after 30 days of immersion. Most of the irradiated samples were evaluated immediately after exposure, although some samples were also tested after an additional 90 days of 90°C immersion to determine whether radiation exposure affected the chemical compatibility of the materials. The work was conducted in accordance with a quality assurance program based on ANSI/ASME NQA-1-1983.

Conclusions and recommendations from these tests are presented in Section 2. Procedures for preparing the materials for testing and measuring the resultant physical properties are described in Section 3. A brief description of the acceptance criteria that were used for evaluating the compatibility of each material is presented in Section 4. Results from the physical property measurements and the application of those results for evaluating vault component compatibility are presented in Section 5.

2.0 CONCLUSIONS

Various liner and pipe samples were immersed in synthetic DSSF for 120 days at 90°C. During testing, the dimensional and physical properties of the samples were compared with measured properties of unexposed samples. In addition, some of the immersed liner and pipe samples were irradiated to one of four different dose equivalents after 30 days of immersion. Properties were measured immediately after exposure and after an additional 90 days of immersion.

Conclusions from these tests are as follows:

- The HDPE liner was judged to be chemically compatible with DSSF at 90°C, based on the extremely stable dimensional properties and the small observed changes in the mechanical properties of the liner over 120 days. The only properties of concern were the liner puncture force and the liner puncture elongation. Both of these properties increased continually during the 120 days of immersion in synthetic DSSF at 90°C. It is speculated that the change in puncture force and elongation may be due to a temperature-induced increase in the crystallinity of the HDPE liner, and not a chemical degradation.
- The polypropylene liner was also judged to be chemically compatible with DSSF at 90°C because of its dimensional stability and generally stable mechanical properties. The only properties of concern were the liner puncture force, the liner puncture elongation, and the liner stress at 200% elongation. All three properties changed by over 10% without stabilizing during the 120 days of immersion. However, the changes are not extreme and were not suspected to be due to a chemical degradation.
- The other three liners are incompatible with DSSF at 90°C. Testing of the nonreinforced Hytrel polyester liner was discontinued after only 17 days when the sample was completely dissolved. Testing of the polyurethane and XR5 liners was discontinued after 30 days and 60 days, respectively, due to severe decreases in the mechanical properties of the sample. In addition, some swelling of the XR5 liner was also observed. It is suspected that the primary cause of each liner failure was a temperature-induced hydrolysis of esters (or ester components) during the 90°C immersion in synthetic DSSF.
- The chemical compatibility of the HDPE pipe over the 120 days of immersion was generally acceptable. Only the yield stress, stress at 100% elongation, and volatiles content had not yet stabilized after 120 days. Although the decrease in volatiles content is of

some concern, it is felt that the other property changes are not a concern when evaluating the compatibility of the leachate collection pipe with DSSF at 90°C.

- The effect of radiation on liner compatibility is expected to be negligible for this application. Results from the radiation compatibility tests showed significant decreases in break elongation for the HDPE and polypropylene liners. The decrease in break elongation is caused by radiation-induced cross-linking of the polymer chains, which decreases the plasticity of each liner. However, the decreases were only significant at the exposure levels of 16 Mrad and 37 Mrad. Because of recent changes in the vault design (placement of liner and pipe outside the vault), it is expected that the 30-year exposure level for the polymeric materials will be only 14 rad.
- Results from the radiation compatibility tests suggest that the HDPE liner was less susceptible to radiation damage than the polypropylene liner.

3.0 COMPATIBILITY TEST PROCEDURES

This section describes the procedures and laboratory equipment used for compatibility testing. The section is divided according to immersion test procedures, radiation exposure procedures, and procedures for measuring the dimensional and physical properties of each test material.

3.1 IMMERSION TEST PROCEDURES

Compatibility testing of the polymeric liner and pipe samples was performed in accordance with EPA Method 9090 (EPA 1986). This test method addresses only liners; however, similar procedures were used to test the HDPE pipe. The EPA 9090 test method calls for immersion in leachate, and is typically used for landfill applications. EPA Method 9090 suggests using a leachate generated from the actual waste. However, the disposal of this waste is unique in that the waste is radioactive, and the liner and piping need to be compatible with the initial grout slurry, before the grout solidifies. As a result, it was decided to immerse the materials in synthetic DSSF. This immersion represents a "worst case" situation for the following reasons:

- The waste will not come in direct contact with the liner unless a leak occurs in the vault.
- Due to the buffering of the grout formers, the pH of any separated liquids will be less than or equal to the DSSF test solution. The lowered pH decreases corrosiveness.
- During pilot-scale testing on the synthetic DSSF grout, all separated liquid (if any ever existed) was absorbed into the grout in less than 24 hours. Any separated liquid that will exist in the actual vault will most likely result from flushing of pipelines.

The DSSF simulant was prepared from nonradioactive chemicals using the procedure described in Appendix A (Claghorn 1987). The only organics in the DSSF simulant were edetates (added as tetra-sodium edetate trihydrate, 3.53 g/L) and citrates (added as tri-sodium citrate dihydrate, 2.06 g/L). Organics are a principal cause of polymer degradation or solvation. However, EDTA and citric acid are not known to attack any of the materials that were

tested. The calculated molarities of some of the chemical components in the DSSF simulant are shown in Table 3.1.

The liner and pipe samples were immersed in glass and stainless steel exposure cells that were filled with DSSF simulant. Internal stainless steel frames were placed in each cell to support and separate the samples. Special care was taken to make certain that the agitated DSSF simulant continuously contacted the surfaces of each sample. Each cell was agitated using a magnetic stirrer and covered with close-fitting lids to prevent the evaporation of water and volatile organic materials.

The six materials were scheduled for 120 days of immersion in the synthetic, nonradioactive DSSF at 90°C. The 90°C immersion temperature represents the maximum liner and pipe temperatures expected in the DSSF grout vaults. This elevated temperature results from grout curing and radiolytic heating. The non-HDPE liners that were tested were also immersed in the synthetic DSSF at ambient temperatures, in accordance with EPA Method 9090 guidelines. EPA Method 9090 requires that the compatibility tests be conducted at 23°C, and either 50°C or the maximum temperature expected during service (whichever is greater). Immersion tests of the HDPE liner and pipe at ambient temperatures were not performed in this study, however, as they were previously performed in earlier DSSF component compatibility tests. Only results from the 90°C immersion tests should be used to determine compatibility, since the ambient immersion test results are not representative of the expected slurry temperatures in the DSSF grout vault.

The dimensional and mechanical properties of each sample were measured before testing and after every 30 days of immersion. The measured property values were then compared with the original, unexposed sample values to determine if the material was degrading during immersion. Details on the various property measurements are given in Section 3.3.

Throughout testing, samples of DSSF simulant from each immersion cell were chemically analyzed for total organic carbon (TOC). Samples were taken every 30 days to ensure that the organic content of the DSSF simulant was not being changed by the tests. A decrease in TOC concentration may indicate that a component is absorbing organic materials from the waste, which is

TABLE 3.1. Expected Molarity of Various Chemicals
in DSSF Simulant (Claghorn 1987)

<u>Chemicals</u>	<u>Molarity</u>
Ag	1.50×10^{-3}
Al	7.50×10^{-1}
As	4.08×10^{-7}
Ba	4.54×10^{-3}
Cl	1.09×10^{-1}
Ca	5.00×10^{-3}
Cd	7.00×10^{-5}
Cu(II)	1.00×10^{-4}
SO ₄	5.03×10^{-2}
Fe(III)	2.57×10^{-2}
PO ₄	5.95×10^{-2}
Hg	1.47×10^{-5}
K	2.49×10^{-1}
OH	2.05
F	2.96×10^{-2}
Mn	5.00×10^{-2}
Mo	5.00×10^{-4}
Na	5.30
B ₄ O ₇	2.43×10^{-3}
CO ₃	1.50×10^{-1}
Cr ₂ O ₇	1.11×10^{-2}
NO ₃	2.49
NO ₂	5.00×10^{-1}
Ni	5.00×10^{-4}
Pb	1.24×10^{-5}
Se	5.50×10^{-5}
Zn	2.49×10^{-2}
Edetate	8.10×10^{-3}
Citrate	7.00×10^{-3}

undesirable. Decreases in TOC concentration could also indicate volatilization. If any decreases in cell TOC concentration were observed, the DSSF simulant in that cell was replaced. However, no simulant changeouts were required during these tests since no decreases in TOC were noted (see Section 5.1).

3.2 RADIATION EXPOSURE PROCEDURES

Each liner and pipe sample was also evaluated for radiation compatibility. This evaluation was necessary to determine how the materials will stand up to the radiation exposure that would likely be encountered in actual grout vaults.

To prepare for radiation compatibility testing, the liner and pipe samples were placed in the 90°C immersion cells for 30 days. The samples were then exposed to one of three or four different levels of radiation while they were immersed in the DSSF simulant. Table 3.2 gives the exposure breakdown for each of the test materials. The four radiation levels were approximately equivalent to 0.6 Mrad, 3.6 Mrad, 16 Mrad, and 39 Mrad. These levels are

TABLE 3.2. Radiation Exposure Breakdown for Each Test Material

Material	Radiation Exposure ^(a)			
	0.6 Mrad	3.6 Mrad	16 Mrad	39 Mrad
Polypropylene Liner	Y ^(b)	Y	Y	Y ^(b)
HDPE Liner	Y ^(b)	Y	Y	Y ^(b)
8130 XR5 Liner ^(c)	Y	Y	Y	Y
Polyurethane Liner ^(d)	N	N	N	N
Hytrel Polyester Liner ^(e)	N	N	N	N
HDPE Pipe	N	Y	Y	Y

(a) Y - material exposed, N - material not exposed

(b) Material evaluated immediately and after 90 more days of immersion

(c) Testing stopped after 60 days

(d) Testing stopped after 30 days

(e) Material dissolved after 17 days

representative of vault dose equivalents of 120 days, 2 years, 10 years, and 30 years, respectively, for liners and pipes that are inside a vault.

Selection of a 30-year dose as the bracketing exposure value was based on guidelines from RCRA, which specify that disposal facilities must be monitored for 30 years after closure (Public Law 94-580). It should be noted, however, that the purpose of a 30-year post-closure period is to permit drainage of a landfill that has been exposed to precipitation. In the planned grout disposal scenario, there may not be a need for a drainage system to be functional for 30 years because of the presence of infiltration barriers above the grout vault. In addition, the revised vault design (with the liner and pipe outside the concrete vault) results in a negligible 30-year liner and pipe dose equivalent of less than 14 rad.(a)

The rate and type of radiation exposure differed from the low-level constant rate of alpha, beta, and gamma radiation that would be expected in actual service. In general, however, radiation damage is only dependent on total dose, not dose rate or type of radiation (Bolt and Carroll 1963; Harrington 1963; Mattia and Luh 1971).

Physical and dimensional properties of each exposed sample were measured immediately after exposure. The results were then compared with the unexposed sample properties after 30 days of immersion at 90°C. In addition, samples of a few selected materials at exposures of 0.6 Mrad and 39 Mrad were reimmersed for 90 more days at 90°C before their properties were measured (see Table 3.2). Results from these measurements were used to determine if the chemical or temperature-induced degradation is influenced by low or high levels of radiation exposure. This information was necessary to determine if radiation effects and chemical compatibility could be evaluated separately.

3.3 SAMPLE PREPARATION AND MEASUREMENT PROCEDURES

Five liner and one pipe material were evaluated during these tests. Specific descriptions of each material are shown below:

-
- (a) This calculation was performed by assuming that the predominant gamma emitter in the waste was ^{137}mBa (or ^{137}Cs) and that 3 feet of concrete (nonreinforced) was between the liner and the grout source.

1. Hytrel polyester liner - 40 mil Hytrel 7246, Bixby International Corp., **Newport**, Massachusetts.
2. Polyurethane liner - 60 mil Polyurethane (AVANCORR-STP-A, **elasto-meric**), Associated Technologies Inc., Richland, Washington.
3. 8130 XR5 liner - 35 mil, Style 8130 XR5 (DC7 Black), **Seamon** Corp., Industrial Fabric Div., Wooster, Ohio.
4. Polypropylene liner - 170 mil bonded polypropylene, Schlegel Lining Technology North America Inc., **Conroe**, Texas.
5. HDPE liner - 60 mil HDPE, **Gundle** Corp., Houston Texas.
6. HDPE pipe - 6-inch schedule 40 HDPE, cell classification (Driscopipe-8600) - **Phillips** Driscopipe, Inc., Richardson, Texas.

The HDPE liner and pipe material was selected for testing because of its wide acceptance as a flexible membrane liner (FML) material and its excellent chemical resistant properties. Polypropylene was selected as a prospective liner material because of its chemical similarity to HDPE. However, at elevated temperature its physical properties are supposedly superior to that of HDPE. The other three liner materials were recommended for DSSF compatibility testing by liner experts.

The physical and mechanical properties of each material were measured in accordance with EPA Method 9090 (Table 3.3). Currently, this method only addresses measurement procedures specific to liners. However, tests of other polymeric components used in **leachate** collection and leak detection systems are also recommended by current EPA regulations. Therefore, measurement procedures for the HDPE pipe were developed to determine how the pipe was affected by waste immersion, radiation, and temperature. Suggested general procedures for leachate collection pipes are discussed in a supplementary guidance memorandum to EPA Method 9090 (Weddle 1986).

The physical properties of the nonirradiated materials were evaluated at 30-day intervals, after the immersion tests had begun. Properties of the irradiated material samples were evaluated as described in Section 3.2. Physical properties of the unexposed samples were also evaluated, as prescribed in EPA Method 9090. Measurement of the unexposed sample properties served as a baseline for each property evaluation.

TABLE 3.3. Immersion Test Procedures for Each Test Material

Material/Property	Procedures
<u>Liners:</u>	
Dimensional (Length, Width, Thickness and Mass)	See EPA Method 9090 (EPA 1986)
Tear Resistance	ASTM D1004 for Polypropylene, HDPE, and 8130 XR5 ASTM D624 for Polyurethane
Puncture Resistance (Force and Elongation)	FTMS 101C , Method 2065 (U.S.G.S.A. 1980)
Tensile Properties (Yield Stress and Elong., Break Strength and Elong., Stress at 100% , 200% Elong.)	ASTM D638 Type II for HDPE and Polyurethane ASTM D638 Type IV for Polypropylene ASTM D751 Method B for 8130 XR5
Specific Gravity	ASTM D792 Method A
Hardness	ASTM D2240 , Duro D
Modulus of Elasticity	ASTM D882 Method A for HDPE ASTM D638 Type IV for Poly- propylene (Using Yield Stress and Elong.)
Volatiles Content	Matrecon Test Method 1 (EPA 1988)
Extractables Content	Matrecon Test Method 2 (EPA 1988)
Environmental Stress	NSF Standard 54 Appendix D, Procedure K (NSF 1985)
Hydrostatic Tests	ASTM D751 Method A, Procedure 1, for 8130 XR5
<u>Pipe:</u>	
Dimensions (Mass, Width & Thickness)	See EPA Method 9090 (EPA 1986)
Specific Gravity	ASTM D792 Method A
Tensile Properties (Yield Stress & Elong., Break Strength & Elong., Stress at 100% , 200% Elong.)	ASTM D638 Type IV
Hardness	ASTM D2240 , Duro D
Volatiles Content	Matrecon Test Method 1 (EPA 1988)
Extractables Content	Matrecon Test Method 2 (EPA 1988)
Modulus of Elasticity	ASTM D638 Type IV (Using Yield Stress and Elong.)

After the samples were removed from the sample cells, they were rinsed in deionized water and blotted dry. The samples were then placed in labeled polyethylene bags to prevent further drying. Physical tests and dimensional measurements of each material were performed within 24 hours after removing each sample from the immersion test cell. This procedure was necessary to make certain that the volatile concentration within each component did not change between removal and testing.

Tensile, tear, and puncture tests for the sample materials were performed using an **ATS^(a)** Model 11028 Universal Test Machine. This machine is capable of measuring the load applied to a sample specimen as the machine moves at a constant rate. A plot of the sample load versus sample elongation is generated for each test. From these plots, the various stress, strength, and **elongation** properties are determined for each material at each exposure condition.

(a) ATS is a registered trademark of Applied Test Systems, Butler, Pennsylvania.

4.0 PROPOSED ACCEPTANCE CRITERIA

The service life of liners cannot be accurately predicted based on short-term tests. Instead, the criteria used to evaluate liners and other components is stability of physical properties during short-term immersion. For example, if a property continually increases with exposure, the exposure may be causing a structural or chemical change, which may indicate instability over the long term. If a property changes initially, but then remains constant during further exposure, it could be considered stable. However, such a liner may be incompatible if initial changes are so large that they prevent the liner from performing its intended function. Tests to determine volatiles content, extractables content, and weight changes can indicate if the liner is gaining or losing components, either of which could indicate incompatibility.

For HDPE liners, various acceptance criteria have been suggested. One supplier and installer of HDPE sheeting determined HDPE compatibility by testing liner samples for 30 days at 70°C. Their main criteria were that the liner properties remain above the minimum acceptable properties for HDPE sheeting. Weight changes greater than 3%, or other property changes greater than 10%, were additional grounds for rejection. Other suppliers of HDPE sheeting have suggested 120-day testing, with weight changes greater than 5% or other property changes greater than 15% as grounds for rejection.

For these HDPE liner tests, the acceptance criteria suggested by the National Sanitation Foundation (NSF) (Bellen, Corry, and Thomas 1988) was used. The published NSF criteria for HDPE liners are as follows:

- stability of weight change and mechanical properties with time
- a stabilized weight gain of not more than 3%
- a breaking factor (or strength) at least 80% of the initial value, and equal to or greater than the minimum as-received value in the material properties table of NSF Standard 54 (NSF 1985)
- percent elongation at break at least 80% of the initial value, and equal to or greater than the minimum as-received value in the material property table of NSF Standard 54 (NSF 1985)

- yield strength at least **80%** of the initial value and equal to or greater than the minimum as-received value in the material property table of NSF Standard **54** (NSF 1985)
- elongation change at yield no more than **20%** in either direction, and elongation value equal to or greater than the minimum as-received value in the material property table of NSF Standard **54** (NSF 1985)
- tear resistance at least 80% of the initial value, and equal to or greater than the minimum as-received value in the material property table of NSF Standard **54** (NSF 1985)
- modulus of elasticity at least 70% of the initial value, and equal to or greater than the minimum as-received value in the material property table of NSF Standard **54** (NSF 1985).

Table 4.1 gives the minimum as-received property values for 60-gauge HDPE liners (NSF 1985). The measured property values for unexposed HDPE liner samples are included with each minimum property value for comparison. Specific exceptions to the NSF-proposed requirements are discussed in the results, where appropriate.

Acceptance criteria for the HDPE pipe and the other prospective liners have not been established. Therefore, the primary acceptance specification for all other polymeric materials is property stability. In addition, a general acceptance specification of **±25%** of the unexposed property values was used for reporting purposes. This value was based on the mean acceptance criteria for all flexible membrane liners tested by the NSF (Bellen, Corry, and Thomas 1988). However, the **25%** damage criteria is not specific to the other materials and should only be used for informational purposes.

Acceptance criteria for radiation compatibility also have not yet been developed. However, since the lifetime dosage can be simulated by accelerating the exposure rate, stability of properties should not be considered as a criterion. Instead, the criteria should be based on the required properties at the end of the service period. Calculations have shown that the 30-year dose to the vault liner and pipe in the current DSSF disposal scenario is only **14** rad. Although direct exposure of the liner and pipe to any leachate would cause some increase in the dose, it is expected that the increase in dose would be less than two orders of magnitude. As a result, the effect of

TABLE 4.1. Minimum Property Specifications for 60-Gauge HDPE Liners

<u>Property</u>	<u>Minimum Specification</u>	<u>As-Received Value</u>	<u>Ratio of As-Received Value to Minimum Specification</u>
Thickness	0.060 in.	0.068 in.	1.13
Specific Gravity	0.940 g/cm ³	0.951 g/cm ³	1.01
Yield Strength			
With Grain	120 lb/in.	187.3 lb/in.	1.56
X-Grain	120 lb/in.	199.3 lb/in.	1.66
Break Strength			
With Grain	180 lb/in.	266.0 lb/in.	1.48
X-Grain	180 lb/in.	255.6 lb/in.	1.42
Yield Elongation	10%	22%	2.20
Break Elongation			
With Grain	500%	1378%	2.76
X-Grain	500%	1350%	2.70
Modulus of Elasticity			
With Grain	80,000 lb/in. ²	N/A ^(a)	N/A ^(a)
X-Grain	80,000 lb/in. ²	N/A ^(a)	N/A ^(a)
Tear Resistance			
With Grain	39 lb	57.0 lb	1.90
X-Grain	30 lb	53.0 lb	1.77
Dimensional Stability	±3%	< 1%observed	
Time to Environmental Stress Crack, h	500	2880 observed	

(a) Procedures used to measure elastic modulus by NSF (ASTM D638) are different than those specified by EPA 9090 test method (ASTM D882). Therefore, the minimum NSF-specified elastic modulus is not applicable.

radiation exposure on the liner properties is expected to be minimal. Nevertheless, radiation test results for exposures of 0.6 Mrad, 3.6 Mrad, 16 Mrad, and 39 Mrad are included in the report for informational purposes.

5.0 TEST RESULTS

Of the six materials tested, only the HDPE liner, the polypropylene liner, and the HDPE pipe survived the entire 120-day immersion test. Tests of the other liners (Hytrel polyester, polyurethane, and 8130 XR5) were terminated before 60 days for reasons ranging from loss of strength to complete dissolution of the material.

Section 5.1 identifies the actual component concentrations for the synthetic DSSF slurry and describes the immersion test conditions (cell temperature, radiation dose exposures, and cell TOC concentrations). Sections 5.2 and 5.3 present the test results for the HDPE liner samples and the polypropylene samples, respectively. Results from compatibility testing of the HDPE pipe samples are presented in Section 5.4. Section 5.5 presents the initial results from immersion testing of the Hytrel polyester, polyurethane, and 8130 XR5 liners. Where applicable, each section contains separate discussions on chemical compatibility and radiation effects. Tables showing the raw data and measured physical properties of each vault component during testing are in Appendices B through F.

Each section that discusses liners contains a table that summarizes the test results. In addition, the sections contain figures for each measured property. The figures are plotted with error bars that are equivalent to the standard deviation of the data, in accordance with EPA Method 9090 guidelines.^(a)

5.1 TEST CONDITION OBSERVATIONS

5.1.1 Waste Composition

After preparing the synthetic DSSF, it was analyzed using inductively coupled plasma (ICP) spectroscopy. Table 5.1 presents a comparison between the actual inorganic waste concentrations and their target concentrations as calculated by Claghorn (1987) and Richmond (1988). However, the major differences between the target and measured concentrations were primarily

(a) For conditions where only one data point was measured (i.e. sample weight), the figure has no error bars at that point.

TABLE 5.1. Inorganic Composition of Synthetic DSSF

<u>Component</u>	<u>Measured Molarity</u>	<u>Expected Molarity</u>	
		<u>Claghorn 1988</u>	<u>Richmond 1988</u>
Ag	1.8×10^{-3}	1.50×10^{-3}	5.18×10^{-5}
Al	0.47	0.75	0.578
Ba	4.7×10^{-3}	4.54×10^{-3}	4.35×10^{-5}
Ca	5.5×10^{-3}	5.00×10^{-4}	1.17×10^{-3}
Cd	6.55×10^{-5}	7.00×10^{-5}	1.39×10^{-4}
Cl	8.0×10^{-2}	0.109	9.9×10^{-2}
Cr	3.0×10^{-2}	2.22×10^{-2}	7.46×10^{-3}
Cu	5.25×10^{-5}	1.00×10^{-4}	7.16×10^{-5}
F	$<4.5 \times 10^{-2}$	2.96×10^{-2}	1.98×10^{-2}
Fe	2.73×10^{-2}	2.52×10^{-2}	3.49×10^{-4}
Hg	1.3×10^{-5}	1.47×10^{-5}	2.33×10^{-5}
K	0.21	0.249	0.233
Mn	4.8×10^{-2}	5.00×10^{-2}	1.70×10^{-4}
Mo	3.1×10^{-4}	5.00×10^{-4}	3.52×10^{-4}
Na	6.0	5.3	5.65
NO ₂	1.9	0.500	0.961
NO ₃	1.5	2.49	1.64
Ni	5.10×10^{-4}	5.00×10^{-4}	4.65×10^{-4}
P	4.3×10^{-2}	6.00×10^{-2}	5.75×10^{-2}
Pb	7.5×10^{-6}	1.24×10^{-5}	3.95×10^{-4}
Se	3.4×10^{-5}	5.50×10^{-5}	--
SO ₄	0.11	5.03×10^{-2}	2.03×10^{-2}
Zn	1.6×10^{-2}	2.49×10^{-2}	1.79×10^{-4}

with the trace component, and are not expected to affect testing. As a result, the DSSF simulant was not adjusted any further.

The cell TOC concentrations for each liner and pipe material were measured before testing and after every 30 days to determine whether the immersion fluid needed to be replenished. Table 5.2 shows the TOC concentration for the six different test materials. All of the TOC concentrations in the

TABLE 5.2. Total Organic Carbon Content (ppm) in Each Immersion Test Cell

<u>Material and Cell Condition</u>	<u>Immersion Period (days)^(a)</u>				
	<u>0</u>	<u>30</u>	<u>60</u>	<u>90</u>	<u>120</u>
<u>HDPE Liner</u>					
90°C (nonirradiated)	3200	3490	-	-	-
90°C (irradiated)	3000	3580	-	-	-
90°C (all samples)	-	-	4910	4634	5040
<u>Polypropylene Liner</u>					
90°C (nonirradiated)	2910	2960	-	-	-
90°C (irradiated)	2990	3230	-	-	-
90°C (all samples)	-	-	2950	4200	4790
Ambient cell	2890	3490	2850	2980	2540
<u>HDPE Pipe</u>					
90°C (nonirradiated)	3560	3780	-	-	-
90°C (irradiated)	2470	2830	-	-	-
90°C (all samples)	-	-	4420	4660	4880
<u>8130 XR5 Liner</u>					
90°C (nonirradiated)	2960	5050	(b)	(b)	(b)
90°C (irradiated)	2890	4960	(b)	(b)	(b)
Ambient cell	2980	3310	(b)	(b)	(b)
<u>Polyurethane Liner</u>					
90°C cell	2913	3580	(b)	(b)	(b)
Ambient cell	2820	2990	(b)	(b)	(b)

(a) All of the 90°C immersion samples (irradiated and nonirradiated) are combined in the same cell after irradiation at 30 days immersion.

(b) Cell immersion test terminated before TOC sample was taken.

90°C cells show an increase, particularly for the 8130 XRS material after the first 30 days of immersion. Decreases in liner volatile and extractable contents may be responsible for increased TOC concentrations. However, the fluctuations in the TOC measurements may indicate sampling variation rather than slurry concentration. Since the TOC concentrations were not decreasing, the simulants in the cells were not changed during the tests.

5.1.2 Cell Temperatures

During the compatibility tests, the temperature of each immersion cell was measured hourly to determine if the cell temperatures were being controlled within a $\pm 2^{\circ}\text{C}$ temperature range, as called for in EPA Method 9090 (EPA 1986). The percentage of time that temperatures exceeded $\pm 5^{\circ}\text{C}$ and $\pm 10^{\circ}\text{C}$ is identified in Table 5.3. As this table shows, the 90°C exposure cells were outside of the range a number of times. Of the three acceptable compatibility tests, however, the maximum amount of time that each of the 90°C cells were outside of the range was less than 4.5% of the total immersion time. In addition, there were only three periods where a significant ($>\pm 10^{\circ}\text{C}$) temperature excursion occurred in any cell. Therefore, the small number of temperature excursions that occurred during testing should not significantly influence the compatibility testing results. The three significant temperature excursion periods are described below:

- The first major temperature excursion occurred in the 90°C cell that contained the irradiated HDPE liner. The excursion occurred between days 5 and 7 of the immersion tests, and was caused by loss of agitation over the weekend. The loss of agitation resulted in a cell temperature gradient of at least 5 to 15°C for 48 hours, reaching a maximum temperature of at least 105°C. Upon resuming agitation, the recorded cell temperature dropped below 85°C for 3 hours, reaching a minimum temperature of 75°C.
- The second major excursion occurred overnight in the 90°C cell that contained the unirradiated polypropylene liners. This excursion occurred between days 42 and 43 of immersion testing. During this excursion, the cell temperature dropped below 85°C for 11 hours and reached a minimum temperature of 50°C. No reason was found for this temperature excursion.

The final temperature excursion occurred in the 90°C cell that contained both irradiated and unirradiated polypropylene liners. The excursion occurred during the final 2 to 4 days of immersion testing, and was caused by failure of the cell temperature controller. Within this period, the immersion cell temperature

TABLE 5.3. Temperature Excursion Record for Each Test Material

<u>Test Material/Condition</u>	<u>Total Hours (Days)</u>	<u>Temperature Excursion Periods</u>			
		<u>>5°C</u>		<u>>10°C</u>	
		<u>Hours</u>	<u>%</u>	<u>Hours</u>	<u>-%-</u>
<u>HDPE Liner</u>	2880 (120)				
90°C		9	0.3	0	0
Irradiated		131	4.5	47	1.6
<u>Polypropylene Liner</u>	2880 (120)				
90°C		96	3.3	42	1.5
Irradiated		59	2.0	27	0.9
Ambient		0	0	0	0
<u>HDPE Pipe</u>	2880 (120)				
90°C		11	0.4	0	0
Irradiated		10	0.3	0	0
<u>XR5 Liner^(a)</u>	1440 (60)				
90°C		14	1.0	0	0
Irradiated		0	0	0	0
Ambient		38	2.6	0	0
<u>Polyurethane Liner^(b)</u>	720 (30)				
90°C		53	7.4	39	5.4
Ambient		177	25	0	0

(a) XR5 tests discontinued after 60 days.

(b) Polyurethane tests discontinued after 30 days.

dropped below 85°C for 14 hours, reaching a minimum temperature of 75°C, and rose above 95°C for 27 hours, reaching a maximum temperature of 106°C.

5.1.3 Radiation Exposures

The test materials were irradiated by exposing each material to a high-energy gamma source. The different exposure levels were achieved by exposing each material to the gamma source for different time periods. Chromic dosimetry strips were used at two time periods during testing to interpolate (and extrapolate) the exact exposure rates of the high-energy gamma source during each material exposure.

The first dosimetry measurement was taken while exposing the XR5 liner. The exposure rate was 0.8 Mrad/h. To determine the rate during the other material exposures, a second dosimetry measurement was taken 85 days after the first measurement. The exposure rate was 0.73 Mrad/h. The results from dosimetry measurements were then used to interpolate or extrapolate the exposure rate for each material at the time of exposure. The calculated exposure rates for the XR5 liner, polypropylene liner, HDPE liner, and HDPE pipe radiation tests were 0.8 Mrad/h, 0.76 Mrad/h, 0.74 Mrad/h, and 0.71 Mrad/h, respectively. To determine the total exposure level for a particular material, each exposure rate was then multiplied by the total exposure period for that material. The results from this analysis are shown in Table 5.4.

TABLE 5.4. Radiation Exposure Levels for Each Irradiated Cell Material

<u>Test Material</u>	<u>Exposure Rate (Mrad/h)</u>	<u>Exposure Time (h)</u>	<u>Measured Dose (Mrad)</u>	<u>Projected Dose (Mrad)</u>
8130 XR5 Liner	0.80	0.717	0.57	0.604
		4.2	3.36	3.57
		19.57	15.66	16.1
		45.47	36.38	38.9
Polypropylene Liner	0.76	0.85	0.646	0.604
		4.367	3.32	3.57
		21.70	16.5	16.1
		49.28	37.4	38.9
HDPE Liner	0.74	0.80	0.59	0.604
		4.18	3.10	3.57
		21.62	16.0	16.1
		50.0	37.0	38.9
HDPE Pipe	0.71	4.53	3.22	3.57
		22.5	16.0	16.1
		52.28	37.1	38.9

As shown in Table 5.4, the actual exposure levels differed from the desired exposure levels by up to 13%. For reporting purposes, the means of each exposure level were used. These levels were 0.6 Mrad, 3.3 Mrad, 16 Mrad, and 37 Mrad.

5.2 HDPE LINER RESULTS

The raw and tabulated data for the HDPE liner compatibility tests are shown in Appendix B. The discussion of these results is presented in separate sections on chemical/temperature compatibility and radiation compatibility. Ambient temperature immersions were not performed on the HDPE liner material in this test because they were performed on other HDPE liners during earlier DSSF immersion tests.

5.2.1 Cell Immersion Testing

The results from chemical/temperature compatibility testing of the HDPE liner are shown in Table 5.5 and Figures 5.1 through 5.9. The HDPE liner appears compatible with the DSSF slurry at 90°C. The results correspond with other sources that show HDPE's resistance to chemical attack and degradation at temperatures under 90°C (Wallder et al. 1950; Biggs 1953; Gordon 1966; Sweeting 1971).

Figure 5.1 shows the dimensional changes in the HDPE liner. As shown, the length, thickness, and weight of the liner samples were not significantly changed during the 120 days of immersion. This indicates that the HDPE liner will not absorb volatile or extractable materials that cause the polymeric material to swell and increase in weight. In addition, it appears that the liner does not shrink or release significant quantities of material. The observations are substantiated by the small changes observed in the HDPE liner volatile and extractables contents, and the small observed change in liner specific gravity (see Figures 5.2, 5.3, and 5.4). In addition, visual observation of the immersed samples and the environmental stress cracking samples did not indicate any change in the material. The results imply that the liner is resistant to chemical attack by the DSSF at 90°C, and should retain its ability to resist permeation.

TABLE 5.5. 120-Day Test Results for HDPE Liner Immersed in DSSF at 90°C

Property and Units		Non-Irradiated Liner Samples			
		30 Day	60 Day	90 Day	120 Day
Yield Strength (% change)	-md-(a)	6.0	1.1	7.6	5.4
	-td-	2.9	0.5	2.0	2.5
Yield Elongation (% change)	-md-	12.1	10.6	12.1	15.2
	-td-	4.5	0.0	6.1	4.5
Break Strength (% change)	-md-	-1.6	-0.1	-3.2	10.5
	-td-	7.6	7.6	2.8	25.2
Break Elongation (% change)	-md-	2.7	3.0	5.2	12.7
	-td-	9.2	8.2	1.2	21.5
Stress at 100% Elongation (% change)	-md-	10.1	9.5	10.2	9
	-td-	2.1	0.7	3.5	1.7
Stress at 200% Elongation (% change)	-md-	4.2	0.5	5.8	2.7
	-td-	3.4	1.0	5.2	3.7
Modulus (% change)	-md-	-18.5	-1.3	-1.1	-5.4
	-td-	-9.6	-0.3	-15.9	-0.7
Tear Strength (% change)	-md-	-3.0	0.9	0.04	1.9
	-td-	-4.8	-4.5	6.2	-0.4
Specific Gravity (% change)		0.8	0.3	0.3	0.6
Puncture Force (% change)		-3.1	1.5	3.6	9.1
Puncture Elongation (% change)		-3.7	14.9	22.2	33.5
Hardness, Duro D (liner virgin 60.2)		61.0	57.9	61.7	59.5
Dimensional Changes (%) (l,w,thk,wt)		≤0.5	≤0.5	≤0.8	≤0.8
Volatiles (%) (virgin liner = 0.250%)		0.199	0.170	0.200	0.177
Extractables (%) (virgin 0.132)		0.362	0.412	0.804	0.673

(a) -md- = machine direction, -td- = transverse direction

The effects of immersion on liner tensile resistance, tear strength, elastic modulus, and hardness are shown in Figures 5.5, 5.6, 5.7, and 5.8.

In general, these properties show more significant changes during testing than do the dimensional and specific gravity properties. However, in all cases, the properties stabilized within the NSF-specified HDPE liner criteria (see Section 4) during the 120 days of immersion testing.

The only changes of concern were the changes in puncture force and puncture elongation properties (see Figure 5.9). These properties continued to increase through the entire 120 days of immersion, without stabilizing. This is not in accord with the NSF-specified criteria of property stability (see Section 4). However, the two combined property increases suggest that the immersed HDPE liner is more resistant to puncture than the nonimmersed HDPE liner after 120 days of testing. The increased puncture resistance of the immersed HDPE liner may be due to an increase in the crystallinity of HDPE. Previous studies have shown an increase in the crystallinity of HDPE at elevated temperatures (Mitchell 1986). As a result, the puncture resistance properties should not affect the conclusion of HDPE liner compatibility with the DSSF slurry.

5.2.2 Radiation Testing

Results from radiation testing of the HDPE liner are shown in Figures 5.10 through 5.16. The radiation exposure did not change the dimensions of the HDPE liner samples (see Figure 5.10). However, significant decreases (>25%) were observed in the HDPE liner's break strength and break elongation at radiation exposures of 16 Mrad and 37 Mrad [see Figures 5.12(c) and 5.12(d)]. In addition, significant increases (>25%) were observed in the liner's 100% and 200% elongation stresses at a radiation exposure level of 37 Mrad [see Figures 5.12(e) and 5.12(f)]. It is suspected that the property changes are due to cross-linking in the irradiated HDPE (Charlsey 1960a). Since the 30-year dose equivalent for the revised vault design is only 14 rad, the actual changes to the HDPE liner will be negligible.

Upon examining the data from the 0.6 Mrad and 37 Mrad irradiated samples that were re-immersed for 90 days at 90°C (see Appendix B), it was found that radiation exposure did not appear to affect HDPE liner chemical degradation rates in the 90°C DSSF slurry. This conclusion supports the assumption that HDPE liner chemical compatibility and radiation compatibility can be evaluated separately.

(a) Sample Length

(b) Sample Thickness

(c) Sample Weight

FIGURE 5.1. Effect of DSSF Immersion on HDPE Liner Dimensions and Weight

FIGURE 5.2. Effect of DSSF Immersion on HDPE Liner Volatiles Content

FIGURE 5.3. Effect of DSSF Immersion on HDPE Liner Extractables Content

FIGURE 5.4. Effect of DSSF Immersion on HDPE Liner Specific Gravity

(a) Yield Stress

(b) Yield Elongation

(c) Break Strength

(d) Break Elongation

(e) Stress at 100% Elongation

(f) Stress at 200% Elongation

FIGURE 5.5. Effect of DSSF Immersion on HDPE Liner Tensile Properties

FIGURE 5.6. Effect of DSSF Immersion on HDPE Liner Tear Strength

FIGURE 5.7. Effect of DSSF Immersion on HDPE Liner Elastic Modulus

FIGURE 5.8. Effect of DSSF Immersion on HDPE Liner Hardness

(a) Puncture Force

(b) Puncture Elongation

FIGURE 5.9. Effect of DSSF Immersion on HDPE Liner Puncture Resistance

(a) Sample Length

(b) Thickness

(c) Sample Weight

FIGURE 5.10. Effect of Radiation on HDPE Liner Dimensions

FIGURE 5.11. Effect of Radiation on HDPE Liner Volatiles Content

(a) Yield Stress

(b) Yield Elongation

(c) Break Strength

(d) Break Elongation

(e) Stress at 100% Elongation

(f) Stress at 200% Elongation

FIGURE 5.12. Effect of Radiation on HDPE Liner Tensile Properties

FIGURE 5.13. Effect of Radiation on HDPE Liner Tear Strength

(a) Puncture Force

(b) Puncture Elongation

FIGURE 5.14. Effect of Radiation on HDPE Liner Puncture Resistance

FIGURE 5.15. Effect of Radiation on HDPE Liner Elastic Modulus

FIGURE 5.16. Effect of Radiation on HDPE Liner Hardness

5.3 POLYPROPYLENE LINER RESULTS

The raw and tabulated data for the polypropylene liner compatibility tests are shown in Appendix C. The discussion of these results is presented as chemical/temperature compatibility and radiation compatibility. Ambient temperature immersions were performed on the polypropylene liner material in this test, and those results are included in Appendix C. However, the ambient test results are not discussed in the body of the report because the ambient temperature data is not useful in evaluating liner compatibility.

5.3.1 Cell Immersion Testing

The results from chemical/temperature compatibility testing of the polypropylene liner are shown in Table 5.6 and Figures 5.17 through 5.24. The polypropylene liner's compatibility with DSSF slurry at 90°C was more questionable than the HDPE liner's compatibility since the liner property changes were more significant for polypropylene liners than for HDPE liners. Cooke and Rebenfeld (1988) have shown polypropylene to be more sensitive to thermal oxidative breakdown than polyethylene because of the C-H linkages with tertiary carbon atoms. However, it is believed that a polypropylene liner should also be compatible with the DSSF slurry at 90°C.

Figure 5.17 shows the dimensional changes in the polypropylene liner samples. As shown, the length, thickness, and weight of the liner samples were not significantly changed during 120 days of immersion.^(a) This indicates that the polypropylene liner will not absorb volatile or extractable materials that cause the polymeric material to swell and increase in weight. In addition, it appears that the liner does not shrink or release significant quantities of material. The observations are substantiated by the small changes in volatile and extractables contents, and the small change in specific gravity during immersion (see Figures 5.18, 5.19, and 5.20). Visual observations of the polypropylene liner samples (including the environmental stress cracking samples) found no sign of chemical degradation in the samples during immersion. The results imply that the polypropylene liner is resistant to chemical attack by the DSSF at 90°C, and should retain its ability to resist permeation.

The effects of testing on the polypropylene liner's tensile resistance, tear strength, puncture resistance, and hardness are shown in Figures 5.21, 5.22, 5.23, and 5.24. In contrast with the stable dimensional properties, 5 of the 11 properties from these figures (yield elongation, break elongation, elastic modulus, puncture force, and puncture elongation) were outside of the qualitative criteria that were developed for nonirradiated, non-HDPE liner

(a) The large standard deviations for thickness are indicative of a large variation in the thickness of the sample material not an inaccuracy in thickness measurement techniques. The variation in liner thickness was also negative.

TABLE 5.6. 120-Day Test Results for Polypropylene Liners Immersed in DSSF at 90°C

Property and Units		Non-Irradiated Liner Samples			
		30 Day	60 Day	90 Day	120 Day
Yield Strength (% change)	-md- (a)	-8.6	-4.0	-8.7	-4.8
	-td-	-11.5	-7.9	-9.9	-4.4
Yield Elongation (% change)	-md-	36.8	35.4	23.7	46.3
	-td-	41.8	37.3	31.7	21.1
Break Strength (% change)	-md-	10.7	13.6	12.2	12.2
	-td-	2.8	2.3	6.1	10.1
Break Elongation (% change)	-md-	104.1	112	129.7	30.0
	-td-	29.8	-6.7	-11.8	14.1
Stress at 100% Elongation (% change)	-md-	21.9	22	15.6	14.4
	-td-	3.3	13.3	6.6	20.6
Stress at 200% Elongation	-md-	5.1	4.2	2.6	6.6
	-td-	0.9	2.1	5.5	8.6
Elastic Modulus	-md-	-32.9	-29.1	-26.2	-35
	-td-	-37.6	-32.8	-31.5	-21
Tear Strength (% change)	-md-	-0.6	9.1	8.4	4.4
	-td-	3.6	14.0	11.9	7.3
Specific Gravity (% change)		0.1	0.4	0.1	-0.1
Puncture Force (% change)		-2.5	-0.4	-2.7	-11.6
Puncture Elongation (% change)		-40.1	-38.7	-31.8	-17.4
Hardness, Duro D units (virgin 68.6)		66.8	69.3	69.1	67.3
Dimensional (% change) (b) (1,w,thk,wt)		<0.6	<0.6	<0.6	<1.1
Volatiles, wt% of Sample (0.01% virgin)		0.0779	0.628	0.1112	0.0132
Extractables (wt%)		0.397	0.599	0.423	0.727

(a) -md- = machine direction, -td- = transverse direction.

(b) Values listed indicate the magnitude of the largest change.

material. However, it is believed that any concern over these properties should be minor. The reasons for this are described in the following paragraphs.

The yield elongation of the polypropylene liner increased by 40% during the first 30 days of immersion, but remained stable during the final 90 days of immersion[see Figure 5.21(a)]. It is **believed** that the increase is a direct result of the temperature of the DSSF slurry, not an indication of degradation. Since the yield elongation was stabilized after 60 days of immersion, the concern over this deviation was minor.

The break elongations of the polypropylene liner varied from **+130%** to -12% during the 120 days of **90°C** immersion[see Figure 5.21(b)]. However, the thickness of the polypropylene material (170 mil) probably eliminated the **potential** for any useful data on break elongation. From visual observations, it appeared that the **liner** would break during tensile testing upon encountering a flaw or nick in the liner material.

The **liner elastic** modulus decreased 30% to 35% during the first 90 days of immersion testing, but remained **stable** thereafter[see Figure 21(g)] . This decrease is caused by the increase in yield **elongation** of the **liner** over the same 30-day period. Likewise, concern over this deviation is **also** minor.

The **liner** puncture force appeared to decrease 10% without stabilizing over the last 60 days of immersion[see Figure 23(a)]. This decrease was accompanied by a significant fluctuation in puncture elongation during immersion[see Figure 23(b)]. **Although** these changes may cause more concern than do changes to the other properties, it is suspected that the changes in puncture resistance are also related to the thick, nonuniform nature of the polypropylene liners. It is recommended that any additional testing of liner materials be done using a more uniform liner sample.

5.3.2 Radiation Testing

Results from radiation testing are shown in Figures 5.25 through 5.31. As with HDPE, radiation exposure did not change the sample dimensions(see Figure 5.25). Significant changes were observed in the liner's tensile properties, tear strength, and puncture elongation at exposures of 16 Mrad and 37 Mrad(see Figures 5.27, 5.28, and 5.29). Since the 30-year dose

equivalent for the DSSF liner is only 14 rad, however, the effect of radiation exposure should be negligible.

In general, the effect of radiation on a liner's mechanical properties appears to be greater for polypropylene than for HDPE. This is in accordance with previous studies that have shown polypropylene to be less resistant to radiation damage than HDPE. The decrease may be due to the increased amount of chain fracturing that occurs as the polypropylene cross-links during irradiation. In contrast, irradiated HDPE cross-links with very little main chain fracture (Charlesby 1960b).

The data from the 0.6 Mrad and 37 Mrad irradiated samples that were re-immersed for 90 days at 90°C (see Appendix C) showed that radiation exposure did not influence the polypropylene liner's chemical degradation rates in the 90°C DSSF slurry. The only property that was significantly influenced was the liner's modulus of elasticity (see Figure 5.31). However, this property is somewhat suspect since it is calculated from the yield stress and elongation of the liner material rather than the initial tangent of the yield stress curve, as specified in ASTM D638 (ASTM D638 was not used because of the difficulty in accurately measuring the initial tangent of the tensile test curve). The data further support the study assumption that the chemical compatibility and radiation compatibility of a liner can be evaluated separately.

(a) Sample Length

(b) Thickness

(c) Sample Weight

FIGURE 5.17. Effect of DSSF Immersion on Polypropylene Liner Dimensions and Weight

FIGURE 5.18. Effect of DSSF Immersion on Polypropylene Liner Volatiles Content

FIGURE 5.19. Effect of DSSF Immersion on Polypropylene Liner Extractables Content

FIGURE 5.20. Effect of DSSF Immersion on Polypropylene Liner Specific Gravity

(a) Yield Stress

(b) Yield Elongation

(c) Break Strength

(d) Break Elongation

(e) Stress at 100% Elongation

(f) Stress at 200% Elongation

FIGURE 5.21. Effect of DSSF Immersion on Polypropylene Liner Tensile Properties

(g) Elastic Modulus

FIGURE 5.21. (contd)

FIGURE 5.22. Effect of DSSF Immersion on Polypropylene Liner Tear Strength

(a) Puncture Force

(b) Puncture Elongation

FIGURE 5.23. Effect of DSSF Immersion on Polypropylene Liner Puncture Resistance

FIGURE 5.24. Effect of DSSF Immersion on Polypropylene Liner Hardness

(a) Sample Length

(b) Thickness

(c) Sample Weight

FIGURE 5.25. Effect of Radiation on Polypropylene Liner Dimensions and Weight

FIGURE 26. Effect of Radiation on Polypropylene Liner Volatiles Content

(a) Yield Stress

(b) Yield Elongation

(c) Liner Break Strength

(d) Break Elongation

FIGURE 5.27. Effect of Radiation on Polypropylene Liner Tensile Properties

(e) Stress at 100% Elongation

(f) Stress at 200% Elongation

(g) Elastic Modulus

FIGURE 5.27. (contd)

FIGURE 5.28. Effect of Radiation on Polypropylene Liner Tear Strength

(a) Puncture Force

(b) Puncture Elongation

FIGURE 5.29. Effect of Radiation on Polypropylene Liner Puncture Resistance

FIGURE 5.30. Effect of Radiation on Polypropylene Liner Hardness

FIGURE 5.31. Effect of Dose on Polypropylene Elastic Modulus Over Time

5.4 HDPE PIPE RESULTS

The raw and tabulated data for the HDPE pipe compatibility tests are shown in Appendix D. Ambient temperature immersions were not performed on the HDPE pipe in this test since they were performed on the HDPE pipe during previous DSSF immersion tests.

5.4.1 Cell Immersion Testing

The results from chemical/temperature compatibility testing of the HDPE pipe are shown in Table 5.7 and Figures 5.32 through 5.37. In general, the HDPE pipe appeared to be compatible with the DSSF slurry at 90°C. The concerns that existed with the HDPE pipe were similar to those for the polypropylene liner, and may be due to the pipe thickness (300 mil).

Figure 5.32 shows the dimensional changes in the HDPE pipe samples. The length, thickness, and weight of the pipe samples were not significantly changed during 120 days of immersion at 90°C, which indicates that the pipe will not absorb volatile or extractable materials that cause the polymeric material to swell and increase in weight. In addition, it appears that the pipe does not shrink or release significant quantities of material. Although the volatile and extractable contents of the HDPE pipe decreased by over 50% from their original values during the 120 days of immersion (see Figures 5.33 and 5.34), it is believed that these changes were of only minor concern. The results imply that the HDPE pipe is generally resistant to chemical attack by the DSSF at 90°C. The conclusion of chemical compatibility is substantiated

TABLE 5.7. 120-Day Tests of HDPE Pipe Immersed in DSSF at 90°C

Property and Units	30 Day	60 Day	90 Day	120 Day
Yield Strength^(a) (% change)	-0.7	2.7	4.0	8.3
Yield Elongation^(a) (% change)	-1.8	9.9	9.2	9.2
Break Strength^(a) (% change)	-7.7	-20.4	-24.5	-0.6
Break Elongation^(a) (% change)	-11.5	-19.6	-32.0	-3.3
100% Elongation Stress^(a) (% change)	1.3	3.8	5.4	11.2
200% Elongation Stress^(a) (% change)	3.9	4.2	8.0	6.9
Modulus^(a) (% change)	1.2	-6.6	-4.6	-0.7
Specific Gravity (% change)	-0.2	0.0	-0.1	0.3
Hardness, Duro D (66.6 virgin)	65.7	66.5	66.7	67.1
% Dimensional (% change) (l,w,thk,wt)	<0.4	±0.1	<0.2	<0.6
% Volatiles (virgin pipe = 0.086)	0.098	0.070	0.048	0.041
% Extractables (virgin = 0.739)	0.638	0.620	0.744	0.273

(a) Tests on pipe were run by removing a tensile sample from the pipe wall in the circumferential direction.

by the small change in specific gravity during immersion (see Figure 5.35). In addition, a visual observation of the pipe samples (including the environmental stress cracking samples) did not find any change in the material during immersion.

The effects of 90°C immersion on the tensile properties and hardness of the HDPE pipe are shown in Figures 5.36 and 5.37. The tensile properties of the pipe were evaluated by compressing thin pipe samples into two halves and taking one specimen from each half. It was believed that compressing the pipe sample would not change the tensile properties of the pipe in the areas where the specimens were taken.

As with the strength and elongation properties for the polypropylene liner, a substantial portion of the HDPE pipe properties were outside of the qualitative criteria for nonradioactive, non-HDPE liner material. Any

concerns over these properties are probably minor because of the thickness of the pipe material and the different function of the leachate collection pipe. In addition, concerns over pipe compatibility should primarily relate to its compatibility during the first 60 days of testing for the following reasons: 1) the DSSF grout slurry solidifies within 48 hours, with any remaining liquid removed after 60 days; and 2) the potential for leachate runoff from the vault after 60 days is negligible. The properties that were outside of the suggested criteria are described in the following paragraphs.

The yield stress of the pipe increased by 8% of its original value without stabilization after 120 days of immersion [see Figure 5.36(b)]. Although the material has not yet stabilized, it is believed that the increased yield stress would make the pipe more structurally resistant to failure from a compressive load.

The break elongation of the pipe decreased by over 30% during the immersion period [see Figure 5.36(c)]. However, this decrease is probably caused by the 300-mil thickness of the HDPE pipe sample. As with the polypropylene, the pipe appeared to thin and break upon encountering a flaw or nick during tensile testing. The poor break elongation data is substantiated by the large standard deviations of the data.

The liner stress at 100% elongation appeared to increase by 11% without stabilization over the 120-day immersion period [see Figure 5.36(e)]. As with the unstable yield elongation properties, the increase in stress is thought to make the pipe more resistant to elongation, and should be of minor concern in evaluating pipe compatibility with the DSSF at 90°C.

5.4.2 Radiation Testing

Results from radiation compatibility testing of the HDPE pipe are shown in Figures 5.38 through 5.41. The results were similar to those for the HDPE liner, although the decreases in break strength and elongation, and the increases in stress at 100% and 200% elongation, were somewhat greater. These differences may have been caused by the different types of HDPE material that were used in the liner and pipe samples.

As with the polypropylene and HDPE liner, the effect of radiation on the DSSF leachate collection pipe should be minor, since the 30-year dose equivalent from the DSSF grout is negligible. In addition, there were no significant changes in HDPE liner dimensions or volatiles content up to exposures of 37 Mrad. Therefore, the HDPE liner is thought to be compatible with the radioactive DSSF.

No extended immersion tests were performed on the irradiated HDPE pipe. However, it is suspected that the HDPE liner test results will support the assumption that radiation exposure does not influence the chemical degradation rate of the HDPE pipe.

(a) Sample Width

(b) Thickness

(c) Sample Weight

FIGURE 5.32. Effect of DSSF Immersion on HDPE Pipe Dimensions and Weight

FIGURE 5.33. Effect of DSSF Immersion on HDPE Pipe Volatiles Content

FIGURE 5.34. Effect of DSSF Immersion on HDPE Pipe Extractables Content

FIGURE 5.35. Effect of DSSF Immersion on HDPE Pipe Specific Gravity

(a) Yield Stress

(b) Yield Elongation

(c) Break Strength

(d) Break Elongation

(e) Stress at 100% Elongation

(f) Stress at 200% Elongation

FIGURE 5.36. Effect of DSSF Immersion on HDPE Pipe Tensile Properties

(g) Elastic Modulus

FIGURE 5.36. (contd)

FIGURE 5.37. Effect of DSSF Immersion on HDPE Pipe Hardness

(a) Sample Width

(b) Thickness

(c) Sample Weight

FIGURE 5.38. Effect of Radiation on HDPE Pipe Dimensions and Weight

FIGURE 5.39. Effect of Radiation on HDPE Pipe Volatiles Content

(a) Yield Stress

(b) Yield Elongation

(c) Break Strength

(d) Break Elongation

FIGURE 5.40. Effect of Radiation on HDPE Pipe Tensile Properties

(e) Stress at 100% Elongation

(f) Stress at 200% Elongation

(g) Elastic Modulus

FIGURE 5.40. (contd)

FIGURE 5.41. Effect of Radiation on HDPE Pipe Hardness

5.5 FAILED LINER RESULTS

Of the five liner materials that were tested, three materials failed before the 120-day immersion tests were complete: 8130 XR5, polyurethane, and Hytrel polyester. A discussion of each material, their reason for failure, and the data that were generated during the test is presented below.

5.5.1 8130 XR5

The 8130 XR5 liner is a blend of polyvinyl chloride (PVC), and a high molecular weight elastomer called **Elvaloy**[®]. The PVC and Elvaloy are chemically bonded to one another. The XR5 liner is also reinforced with polyester fabric to increase its material strength.

The XR5 liner was immersed in the DSSF slurry at ambient temperatures and 90°C. After 11 days of immersion, a strong odor was detected, and preliminary dimensional measurements of the 90°C XR5 sample were performed. The results showed decreases of 3% in weight and thickness after only 11 days of immersion. From vendor communications, it was determined that the strong odor was probably due to a release of acetic acid from the XR5, and some degradation of the liner surface was anticipated. However, the vendor also expected that the liner degradation would stop after the first layer was dissolved. Based on these comments, it was decided to continue the XR5 test to at least 60 days.

Raw and tabulated data for the XR5 liner are shown in Appendix E. Table 5.8 summarizes these results. Testing was discontinued after 60 days because the 90°C material was swelling in thickness and increasing in weight. The swelling and weight gain was accompanied by a 78% reduction in extractables content after only 30 days, and 29% to 42% decreases in the materials' strength and elongation properties after 60 days (see Table 5.8).

The XR5 material was also irradiated to different exposures to evaluate radiation compatibility (see Appendix E). The results showed that the material is relatively resistant to radiation damage, with puncture elongation exhibiting the greatest change in value (a 36% decrease) between the

[®] Elvaloy is a registered trademark of E. I. Du pont de Nemours Corporation, Wilmington, Delaware.

TABLE 5.8. 60-Day Test Results for XR5 Liner Immersed in DSSF at 90°C

Property and Units		Non-Irradiated Liner Samples	
		30 Day	60 Day
Break Strength ^(a) (% change)	-wg-	-13	-38
	-cg-	-9.9	-34
Break Elongation (% change)	-wg-	-28	-38
	-cg-	-40	-40
Specific Gravity (% change)		0.9	2.7
Puncture Force (% change)		-31	-37
Puncture Elongation (% change)		-7.7	-42
Hydrostatic Resistance (% change)		-21	-29
Hardness, Duro D (53, virgin)		51.3	53.2
Sample Length (% change)		<1.5	<1.5
Sample Thickness (% change)		-1.0	6.5
Sample Weight (% change)		-1.4	3.2
Volatiles (%) (0.37%, virgin)		8.1	9.2
Extractables (%) (21.3%, virgin)		4.6	5.4

(a) wg - with grain-direction, cg - cross-grain direction

120-day and the 2-year dose. However, the property was stable at higher exposure levels.

It is suspected that the polyester reinforcement in the XR5 material is the primary cause of the premature liner failure. Polyesters have been known to hydrolyze in high-temperature, extremely caustic conditions as occurs in synthetic DSSF at 90°C immersion temperatures (Cooke and Rebenfeld 1988). It is suspected that the hydrolysis reaction gradually dissolves the XR5 liner reinforcement, decreasing the mechanical properties of the liner and (see Table 5.8).

5.5.2 Polyurethane

The polyurethane liner was selected because of its potential for application as a spray-on liner in the grout vault. However, the liner that was tested in this study was provided as pre-cast sheets.

The polyurethane liner was immersed in the DSSF at both ambient temperatures and **90°C**. Within the first 13 days of immersion, the **90°C** material changed from a shiny black to a dull gray. However, a preliminary dimensional analysis of the samples did not indicate any significant dimensional changes after 13 days. The loss of color was attributed to the release of an organic dye in the polyurethane. The loss of organic dye was not expected to affect the resistance of polyurethane to chemical degradation or radiation damage.

Raw and tabulated data for the polyurethane liner samples are shown in Appendix F. Table 5.9 summarizes these results. The polyurethane immersion tests were discontinued when it was found that the samples had suffered severe decreases in strength, and **elongation** properties after only 30 days of immersion at **90°C** (see Appendix F). In addition, the samples were extremely porous, precluding their use as a potential liner material.

It is believed that the chemical degradation of polyurethane may be due to the ester component in the polyurethane structure. In the extremely caustic conditions that exist in the DSSF slurry, the ester radicals will hydrolyze. The ester hydrolysis reaction is accelerated at high immersion temperatures and results in severe decreases in the strength of the polyurethane sample.

5.5.3 Hytrel Polyester

The fifth liner material that was to be tested was reinforced Hytrel polyester (**7246**), a blend of polyethers and polyesters. While awaiting shipment, nonreinforced Hytrel polyester was immersed in DSSF slurry at 90°C.

Preliminary dimensional measurements showed decreases of 10% to 11% in the thickness and weight of the immersed liner samples after only 3 days of

TABLE 5.9. 30-Day Test Results for Polyurethane Liner Immersed in DSSF at 90°C

Property and Units		30-Day Nonirradiated Sample Property
Break Strength (% change) (a)	-md- -td-	-88 -92
Break Elongation (% change)	-md- -td-	-81 -78
Stress at 100% Elongation (% change)	-md- -td-	-68 -71
Tear Strength (% change)	-md- -td-	-55 -61
Specific Gravity (% change)		4.1
Puncture Force (% change)		-79
Puncture Elongation (% change)		-33
Hardness, Duro D (40.4, virgin)		64.7 (Duro A)
Sample Length (% change)		<1.3
Sample Thickness (% change)		-1.7
Sample Weight		10
Volatiles (%) (0.644, virgin)		13.7

(a) md - machine direction; td - transverse direction

immersion. Within 13 days of immersion, the Hytrel 7246 samples had completely dissolved. As a result, Hytrel polyester, in both its reinforced and nonreinforced forms, is incompatible with the DSSF slurry at 90°C.

As with the polyurethane and XR5, the primary cause for the failure of the Hytrel liner was the temperature-accelerated ester hydrolysis reaction. This information was verified by the vendor.

6.0 REFERENCES

Bellen, G., R. Corry, and M. L. Thomas. 1988. Development of Chemical Compatibility Requirements for Assessing Flexible Membrane Liners, Volume 1. Prepared for the U.S. Environmental Protection Agency by National Sanitation Foundation, Ann Arbor, Michigan.

Biggs, B. S. 1953. "Aging of Polyethylene," in Proceedings of the NBS Semicentennial Symposium on Polymer Degradation Mechanisms, pp. 137-145. National Bureau of Standards Circular 525, Washington D.C.

Bolt, R. O. and J. G. Carroll. 1963. "General Radiation Effects of Elastomeric Material." In Radiation Effects on Organic Materials, pp. 252-256. Academic Press, New York, New York.

Charlesby, A. 1960a. "Polyethylene." In Atomic Radiation and Polymers, pp. 198-257. Pergamon Press, New York, New York.

Charlesby, A. 1960b. "Other Crosslinking Polymers." In Atomic Radiation and Polymers, pp. 323. Pergamon Press, New York, New York.

Claghorn, R. D. 1987. Compositional Limits for Grout Feed: Double-Shell Slurry Feed and Retrieved Double-Shell Slurry Formulation Experiments. RHO-RE-EV-96, Rockwell Hanford Operations, Richland, Washington.

Cooke, T. F., and L. Rebenfeld. 1988. "Effect of Chemical Composition and Physical Structure of Geotextiles on Their Durability," in Geotextiles and Geomembranes Vol. 7, pp 7-22, Elsevier Science Publishers Ltd., England.

EPA. 1986. "Method 9090: Compatibility Test for Wastes and Membrane Liners." In Test Methods for Evaluating Solid Waste, Vol. 1A: Laboratory Manual, Physical/Chemical Methods. 3rd ed., SW-846. Environmental Protection Agency, Washington, D.C.

EPA. 1988. Lining of Waste Containment and Other Impoundment Facilities. EPA/600/2-88/052. Environmental Protection Agency, Cincinnati, Ohio.

Gordon, N. R. 1966. "The Effects of Radiation on Plastics." BNWL-SA-659, Pacific Northwest Laboratory, Richland, Washington.

Harrington, R. 1957. "Elastomers for Use in Radiation Fields (Part 1)," Rubber Age 81(6):971-980.

Mattia, R. F. and D. R. Luh. 1971. "Radiation Resistance of EPDM, Polychloroprene, and Chlorosulfonated Polyethylene." Contribution No. 286, presented at the 1971 Tri-State Regional Meeting of the Massachusetts, Connecticut, and Rhode Island Rubber Groups, May 13, 1971, Auburn, Massachusetts.

Mitchell, D. H. 1986. Geomembrane Selection Criteria for Uranium Tailings Ponds. NUREG/CR-3974 (PNL-5224), Prepared for the U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, Richland, Washington.

NSF. 1985. Standard Number 54: Flexible Membrane Liners. Rev. Standard. National Sanitation Foundation, Ann Arbor, Michigan.

Resource Conservation and Recovery Act of 1976. Public Law 94-580, 42 USC 6901-6907 et. seq., 1976.

Richmond, W. G. 1988. Methods and Data for Use In Determining Source Terms for the Grout Disposal Program. SD-WM-TI-355, Westinghouse Hanford Company, Richland, Washington.

Sweeting, O. J. 1971. "Polyethylene." In The Science and Technology of Polymer Films, pp. 132-183. Wiley-Interscience, New York, New York.

U.S.G.S.A. 1980. Method 2065: Puncture Resistance and Elongation Test (1/8-Inch Probe Method). In: Federal Test Method Standard 101C. U.S. General Services Administration, Washington, D.C.

Wallder, V. T., W. J. Clarke, J. B. DeCoste, and J. B. Howard. 1950. "Weathering Studies on Polyethylene: Wire and Cable Applications." In Industrial and Engineering Chemistry 42(11): 2320-2325.

Weddle, B. R. August 7, 1986. "Supplementary Guidance on Determining Liner/Leachate Collection System Compatibility." Memorandum from EPA Permits and States Programs Division, Washington, D.C., to Hazardous Waste Management Division Directors, Regions I-IX.

APPENDIX A

SYNTHETIC WASTE PREPARATION PROCEDURE FOR DOUBLE-SHELL SLURRY FEED

APPENDIX A

SYNTHETIC WASTE PREPARATION PROCEDURE FOR DOUBLE-SHELL SLURRY FEED

This appendix describes the procedure used by Westinghouse Laboratories to create the synthetic DSSF.

- I. Add 60 gallons of process water to 250 gallon tank.
- II. Turn on heaters and agitator and heat to 70°C.
- III. Add the following chemicals.

- A. 16.3 g $\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$
- B. 3.1 g $\text{Pb}(\text{NO}_3)_2$ (98%)
- C. 3.8 g $\text{Hg}(\text{NO}_3)_2 \cdot \text{H}_2\text{O}$
- D. 193 g AgNO_3
- E. 7.7 kg $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$
- F. 9.5 kg $\text{Mn}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$
- G. 5.6 kg $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ (98%)
- H. 110 g $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
- I. 900 g $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$
- J. 213.0 kg $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$
- K. 700 g $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$

Note: All of the above components should be soluble.

- IV. In separate container add 5 gallons water and add the following:

- A. 4.4 kg H_3PO_4
- B. 3.9 kg H_2SO_4
- C. 0.071 g As_2O_5
- D. 4.6 g SeO_2
- E. 55 g MoO_3

- V. Add acid solution to original solution

Note: The soluble phosphates, sulfates, arsenates, molybdates, and selenites will precipitate.

VI. Add the following chemicals:

- A. 1.3 kg KF
- B. 12.1 g CuSO₄
- C. 2.5 kg Na₂Cr₂O₇•2H₂O

Note: The insoluble fluorides and chromates will precipitate.

VII. In separate container add 5 gallons water and dissolve the following:

- A. 840 g BaCl₂ 2H₂O
- B. 4.42 kg NaCl
- C. Add above to tank contents.

Note: BaSO₄ and AgCl will precipitate.

VIII. Slowly add:

- A. 9.3 kg KOH
- B. 132.20 kg NaOH

Note: As caustic components are added, compounds of the following elements will precipitate.

As, Cd, Pb, Ag, Cu, Fe, Mn, Zn, Ni, Ca, and Al

(As excess caustic is added, the Al and Zn will redissolve as the aluminate and silicate complexes.)

IX. Add to tank contents:

- A. 26.1 kg NaNO₂
- B. 12.0 kg Na₂CO₃

Note: If there are any cations left of Ca, Ni, Zn, Mn, Pb, Cd, or Ba, they will precipitate as the carbonates.

- C. 2.73 kg EDTA (Tetra sodium salt trihydrate)
- D. 1.56 kg Citric acid (Tri sodium salt dihydrate)
- E. 900 g Colloidal Silica

X. Add sufficient water to bring to 200 gallons.

XI. Turn off heaters and allow to cool while stirring to keep solids suspended.

XII. After the solution has cooled, adjust volume to 200 gallons by adding additional water if necessary.

APPENDIX B

RAW AND TABULATED DATA FOR HDPE LINER TESTING

Linear Dimensional Data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	HDPE LINER (DSSF,90) DIMENSIONAL DATA SUMMARY															
2	UNIRRADIATED								IRRADIATED							
3	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120				
4	% Change Length (90°)	0.00	-0.49	-0.49	-0.82	-0.82	-0.5025	-0.87002	-0.8579	-0.2476	-0.7414	-0.16474				
5	ST DEV	0.28535	0.28535	0.28535	0.28535	0.28535	0.50251	0.290126	0.28488	0.24752	0.37748	0				
6	% Change Width (90°)	0.00	-0.18	-0.18	-0.18	-0.18	-0.6233	-0.62333	-0.363	-0.1818	-0.3826	-0.45331				
7	ST DEV	0.61859	0.30929	0.30929	0.30929	0.30929	0	0	0	0.27273	0.15703	0				
8	% Change Thick (90°)	0.00	0.04	0.18	-0.04	0.33	0.14235	0.320285	1.19231	0.19157	0.84811	0.308404				
9	ST DEV	0.40304	0.36833	0.514	0.39634	0.43908	1.26522	1.11102	2.83604	0.84291	0.95887	0.894726				
10	% Change Weight (90°)	0.00	-0.07	-0.03	-0.38	-0.41	-0.1649	-0.29883	-0.1577	-0.0349	-0.071	-0.19521				
11	DATA FOR PLOTS															
12	UNIRRADIATED								IRRADIATED							
13	Days	0	30	60	90	120	Virgin	30	120	Virgin	30	Virgin	30	Virgin	30	Virgin
14	Ave. Length (90°)	202	201	201	201	201	199	198	197.667	202.667	201.333	202	201.5	202.3333	200.8333	202
15	Ave. Width (90°)	187	186	186	186	186	187.167	186	186	183.667	183	183.3333	183	183.8333	183.1667	183
16	Days	0	30	60	90	120	Virgin	30	120	Virgin	30	Virgin	30	Virgin	30	Virgin
17	Ave. Thick (90°)	68	68	68	68	68	69	70.25	70.35	70.475	65	65.775	65.25	65.375	64.85	65.4
18	Days	0	30	60	90	120	Virgin	30	120	Virgin	30	Virgin	30	Virgin	30	Virgin
19	Sample Wt. (90°)	60.8	60.7	60.7	60.5	60.5	60.64	60.54	60.48	57.07	56.98	57.3	57.28	56.35	56.31	56.24
20	DIMENSIONAL MEASUREMENTS 90°															
21	Days	0	30	60	90	120										
22	Length side a-b (mm)	202	201	201	200	200										
23	Length side c-d (mm)	202	201	201	201	201										
24	Length through center (mm)	203	202	202	201	201										
25	Average Length (mm)	202	201	201	201	201										
26	ST DEV (mm)	0.57735	0.57735	0.57735	0.57735	0.57735										
27	Width side b-c (mm)	188	187	187	187	187										
28	Width side d-a (mm)	186	186	186	186	186										
29	Width through center (mm)	188	186	186	186	186										
30	Average Length (mm)	187	186	186	186	186										
31	ST DEV (mm)	1.1547	0.57735	0.57735	0.57735	0.57735										
32	Thickness corner a (mil)	68.6	68.4	68.7	68.4	68.4										
33	Thickness corner b (mil)	68.5	68.6	68.8	68.5	68.8										
34	Thickness corner c (mil)	68	68.4	68.1	68.4	68.8										
35	Thickness corner d (mil)	68.2	68	68.2	67.9	68.2										
36	Average Thickness (mil)	68	68	68	68	69										
37	ST DEV (mm)	0.27538	0.25168	0.35119	0.2708	0.3										
38	DIMENSIONAL MEASUREMENTS, IRRADIATED															
39	Irradiation Exposure (120 -d)	120-d	120-d	120-d	(2-year)	2-year	(10-year)	10-year	(30-year)	30-year	30-year	30-year				
40	Immersion Period (days)	Virgin	30	120	Virgin	30	Virgin	30	Virgin	30	Virgin	30	120			
41	Length side a-b (mm)	198	197	197	202	201	202	201.5	203	201.5	202					
42	Length side c-d (mm)	200	199	198	204	202	203	202	202.5	201	202					
43	Length through center (mm)	199	198	198	202	201	201	201	201.5	200	202					
44	Average Length (mm)	199	198	198	203	201	202	202	202	201	202					
45	ST DEV (mm)	1	1	0.57735	1.1547	0.57735	1	0.5	0.76376	0.76376	0					
46	Width side b-c (mm)	188	186	186	183	183	183	183	184	183	183					
47	Width side d-a (mm)	187	186	186	184	183	184	183.5	184	183.5	183					
48	Width through center (mm)	186.5	186	186	184	183	183	182.5	183.5	183	183					
49	Average Length (mm)	187	186	186	184	183	183	183	184	183	183					
50	ST DEV (mm)	0.76376	0	0	0.57735	0	0.57735	0.5	0.28868	0.28868	0					
51	Thickness corner a (mil)	70.6	71	71.1	63.9	63.8	64.7	64.9	64.5	64.5	65					
52	Thickness corner b (mil)	70.9	71.1	71	64.1	64.9	65.9	66.1	64.8	65.5	64.3					
53	Thickness corner c (mil)	69.8	70.1	70.4	66	67.4	65.2	65	65.1	65.7	65.7					
54	Thickness corner d (mil)	69.7	69.2	69.4	66	67	65.2	65.5	65	65.9	65.2					
55	Average Thickness (mil)	70	70	70	65	65	65	65	65	65	65					
56	ST DEV (mm)	0.59161	0.88882	0.78049	1.15758	1.71343	0.49329	0.55	0.28458	0.82183	0.58023					
57	Liner Weight (grams)															
58		60.64	60.54	60.48	57.07	56.98	57.3	57.28	56.35	56.31	56.24					

Liner Volatiles Data

	A	B	C	D	E	F	G	H	I	J	K	L	
1				HDPE LINER (DSS9F.90) VOLATILES SUMMARY									
2				UNIRRADIATED					Irradiated				
3	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120	
4													
5	% Chg. Volatiles (90°)	0.0	8.8	-7.1	9.0	-3.8	87.8551	-9.32557	17.7189	4.80079	-2.0392	-14.272	
6													
7				PLOT DATA									
8				Unirradiated					Irradiated				
9	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120	
10	% Volatiles (90°)	0.18315	0.19928	0.17021	0.19988	0.17652	0.34406	0.166071	0.2156	0.19194	0.17942	0.15701	
11	stdev	0.00349	0.01524	0.08313	0.00027	0.04394	0.15852	0.005273	0.00657	0.01499	0.00752	0.00679	
12													
13	Virgin Material	AMBIENT READINGS											
14	Specimen No.	1	2	3	4	AVG	ST DEV						
15													
16	"Wet" weight (g)	3.0487	3.0372	3.0415	3.1595								
17	"Dried" weight (g)	3.0432	3.0315	3.0359	3.1538								
18	Weight difference (g)	0.0055	0.0057	0.0056	0.0057								
19	% Volatiles	0.1804	0.18767	0.18412	0.18041	0.18315	0.00349						
20													
21	30-Day	<- - - - 90° - - - ->											
22	Specimen No.	1	2	3	4	AVG	ST DEV						
23													
24	"Wet" weight (g)	3.2275	3.1137	3.1409									
25	"Dried" weight (g)	3.221	3.108	3.1342									
26	Weight difference (g)	0.0065	0.0057	0.0067									
27	% Volatiles	0.20139	0.18306	0.21331	0.19926	0.01524							
28													
29	60-Day	<- - - - 90° - - - ->											
30	Specimen No.	1	2	3	4	AVG	ST DEV						
31													
32	"Wet" weight (g)	3.1674	3.4149	3.2527									
33	"Dried" weight (g)	3.163	3.4105	3.2448									
34	Weight difference (g)	0.0044	0.0044	0.0079									
35	% Volatiles	0.13892	0.12885	0.24288	0.17021	0.06313							
36													
37	90-Day	<- - - - 90° - - - ->											
38	Specimen No.	1	2	3	4	AVG	ST DEV						
39													
40	"Wet" weight (g)	3.2583	3.2021										
41	"Dried" weight (g)	3.2518	3.1957										
42	Weight difference (g)	0.0065	0.0064										
43	% Volatiles	0.19949	0.19987	0.19968	0.00027								
44													
45	120-Day	<- - - - 90° - - - ->											
46	Specimen No.	1	2	3	4	AVG	ST DEV						
47													
48	"Wet" weight (g)	3.2954	3.3383	3.1947									
49	"Dried" weight (g)	3.2888	3.3341	3.1882									
50	Weight difference (g)	0.0066	0.0042	0.0065									
51	% Volatiles	0.20028	0.12581	0.20346	0.17652	0.04394							
52													
53	120-day Exposure	<- - - 30 Day - - ->						<- - - 120 Day - - - ->					
54	Specimen No.	1	2	3	4	AVG	ST DEV	1	2	3	4	AVG	ST DEV
55													
56	"Wet" weight (g)	3.2074	3.0868	3.2823				3.2031	3.2391				
57	"Dried" weight (g)	3.1992	3.0791	3.265				3.1979	3.2336				
58	Weight difference (g)	0.0082	0.0077	0.0173				0.0052	0.0055				
59	% Volatiles	0.25566	0.24945	0.52707	0.34406	0.15852	0.16234	0.1698	0.16607	0.00527			
60													
61	2-year Exposure	<- - - 30 Day - - ->											
62	Specimen No.	1	2	3	4	AVG	ST DEV						
63													
64	"Wet" weight (g)	2.9141	3.0501	3.2281									
65	"Dried" weight (g)	2.9078	3.0436	3.2213									
66	Weight difference (g)	0.0065	0.0065	0.0068									
67	% Volatiles	0.22305	0.21311	0.21065	0.2156	0.00657							
68													
69	10-year Exposure	<- - - 30 Day - - ->											
70	Specimen No.	1	2	3	4	AVG	ST DEV						
71													
72	"Wet" weight (g)	3.2098	3.0895	3.2235				2.9896	3.0543	3.1974			
73	"Dried" weight (g)	3.2033	3.0841	3.2171				2.9849	3.0493	3.1926			
74	Weight difference (g)	0.0065	0.0054	0.0064				0.0047	0.005	0.0048			
75	% Volatiles	0.2025	0.17479	0.19854	0.19194	0.01499							
76													
77	30-year Exposure	<- - - 30 Day - - ->						<- - - 120 Day - - - ->					
78	Specimen No.	1	2	3	4	AVG	ST DEV	1	2	3	4	AVG	ST DEV
79													
80	"Wet" weight (g)	3.0543	3.2156	3.2054				2.9896	3.0543	3.1974			
81	"Dried" weight (g)	3.0488	3.2096	3.1999				2.9849	3.0493	3.1926			
82	Weight difference (g)	0.0055	0.006	0.0055				0.0047	0.005	0.0048			
83	% Volatiles	0.18007	0.18659	0.17159	0.17942	0.00752	0.15721	0.163704	0.15012	0.15701	0.00679		

Liner Extractables Data

	A	B	C	D	E	F	G	H
1		HDPE LINER (DSSF,90) EXTRACTABLES SUMMARY						
2								
3	Days	0	30	60	90	120		
4								
5	% Chag. Extractables (90°)	0.0	-43.2	-35.4	26.2	5.7		
6								
7								
8				PLOT DATA				
9	Days	0	30	60	90	120		
10	% Extractables (90°)	0.63667	0.36193	0.411606	0.80359	0.67325		
11	ST.DEV	0.02021	0.02971	0.066158	0.06489	0.01799		
12								
13	VirgIn Material		AMBIENT READINGS					
14	Specimen No.	1	2	3	4	5	AVG	stddev
15								
16	"Dried" weight (g)	8.4029	6.1538					
17	"Extracted" weight (g)	8.3482	6.1155					
18	Weight difference (g)	0.0547	0.0383					
19	% Extractables	0.65097	0.62238				0.636673	0.02021
20								
21	30-Day	<- - - - 90° - - - ->						
22	Specimen No.	1	2	AVG/STDEV				
23								
24	"Dried" weight (g)	6.0584	6.1305					
25	"Extracted" weight (g)	6.0352	6.1096					
26	Weight difference (g)	0.0232	0.0209					
27	% Extractables	0.38294	0.34092	0.361929				
28				0.029713				
29	60-Day	<- - - - 90° - - - ->						
30	Specimen No.	1	2	AVG/STDEV				
31								
32	"Dried" weight (g)	6.4138	6.3044					
33	"Extracted" weight (g)	6.3844	6.2814					
34	Weight difference (g)	0.0294	0.023					
35	% Extractables	0.45839	0.36482	0.411606				
36				0.066158				
37	90-Day	<- - - - 90° - - - ->						
38	Specimen No.	1	2	AVG/STDEV				
39								
40	"Dried" weight (g)	6.4009	6.5452					
41	"Extracted" weight (g)	6.3524	6.4896					
42	Weight difference (g)	0.0485	0.0556					
43	% Extractables	0.75771	0.84948	0.803592				
44				0.064892				
45	120-Day	<- - - - 90° - - - ->						
46	Specimen No.	1	2	AVG/STDEV				
47								
48	"Dried" weight (g)	6.404	6.4726					
49	"Extracted" weight (g)	6.3617	6.4282					
50	Weight difference (g)	0.0423	0.0444					
51	% Extractables	0.66052	0.68597	0.673247				
52				0.017992				

Liner Specific Gravity Data

	A	B	C	D	E	F	G	H
4								
5	% Sp gr 23/23 (90°)	0.0	0.8	0.3	0.3	0.6		
6	ST. DEV.	0.04563	0.62896	0.09656	0.02789	0.09018		
7								
8				PLOT DATA				
9	Days	0	30	60	90	120		
10	Sp gr 23/23 (90°)	0.95114	0.95917	0.95384	0.9541	0.95657		
11								
12								
13	Virgin Material		AMBIENT READINGS					
14	Specimen No.	1	2	3	4	AVG	ST DEV	
15								
16	Weight in air (g)	3.0487	3.0372	3.0415	3.1595			
17	Weight immersed (g)	4.3711	4.3682	4.3697	4.363			
18	Weight of sinker (g)	4.5258	4.5258	4.5258	4.5258			
19	Sp gr 23/23	0.95171	0.95067	0.95118	0.951	0.95114	0.00043	
20								
21	30-Day	< - - - 90° - - - >						
22	Specimen No.	1	2	3	AVG	ST DEV		
23								
24	Weight in air (g)	3.2275	3.1137	3.1409				
25	Weight immersed (g)	4.4404	4.4422	4.407				
26	Weight of sinker (g)	4.5644	4.5644	4.5644				
27	Sp gr 23/23	0.963	0.96224	0.95228	0.95917	0.00598		
28								
29	60-Day	< - - - 90° - - - >						
30	Specimen No.	1	2	3	AVG	ST DEV		
31								
32	Weight in air (g)	3.1674	3.4149	3.2527				
33	Weight immersed (g)	4.3724	4.3597	4.3634				
34	Weight of sinker (g)	4.5226	4.5242	4.5244				
35	Sp gr 23/23	0.95464	0.95404	0.95284	0.95384	0.00092		
36								
37	90-Day	< - - - 90° - - - >						
38	Specimen No.	1	2	3	AVG	ST DEV		
39								
40	Weight in air (g)	3.258	3.202	3.268				
41	Weight immersed (g)	4.367	4.371	4.366				
42	Weight of sinker (g)	4.524	4.524	4.524				
43	Sp gr 23/23	0.95403	0.9544	0.95388	0.9541	0.00027		
44								
45	120-Day	< - - - 90° - - - >						
46	Specimen No.	1	2	3	AVG	ST DEV		
47								
48	Weight in air (g)	3.2954	3.3383	3.1947				
49	Weight immersed (g)	4.3592	4.3628	4.3691				
50	Weight of sinker (g)	4.5125	4.5125	4.5125				
51	Sp gr 23/23	0.95558	0.95708	0.95704	0.95657	0.00086		

Liner Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
1			HDPE LINER (DSSF.00) TENSILE SUMMARY									
2			Unirradiated						Irradiated			
3	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
4												
5	% Chg. Elong. at Yield											
6	with grain, 90°C	0.0	12.1	10.6	12.1	15.2	18.2	10.6	10.6	4.5	3.0	3.0
7	STDEV	4.5	6.9	2.6	11.4	2.6	0.0	5.2	2.6	0.0	5.2	2.6
8	cross grain, 90°C	0.0	4.5	0.0	6.1	4.5	9.1	4.5	2.3	-3.0	-7.6	-1.5
9	STDEV	0.0	0.0	0.0	2.6	0.0	4.5	0.0	2.3	2.6	2.6	2.6
10	% Chg. Elong. at Break											
11	with grain, 90°C	0.0	2.7	3.0	5.2	12.7	3.7	-6.1	-0.9	-30.4	-69.6	-60.8
12	STDEV	3.0	1.2	1.1	17.0	8.7	6.4	13.2	5.5	6.7	10.3	0.0
13	cross grain, 90°C	0.0	9.2	8.2	1.2	21.5	4.1	7.7	6.6	-48.1	-56.6	-65.9
14	STDEV	1.4	4.2	0.8	2.6	11.1	4.9	4.3	0.6	10.8	1.9	12.2
15	% Chg Yield Strength											
16	with grain, 90°C	0.0	6.0	1.1	7.6	5.4	3.4	6.7	7.4	12.7	16.2	7.0
17	STDEV	2.3	0.1	1.5	2.3	1.6	1.2	1.9	0.9	1.2	0.7	0.8
18	cross grain, 90°C	0.0	2.9	0.5	2.0	2.5	1.8	0.5	6.7	11.1	11.9	6.2
19	STDEV	2.5	1.4	1.8	0.0	1.5	2.9	1.1	1.3	0.4	2.0	1.3
20	% Chg Break Strength											
21	with grain, 90°C	0.0	-1.6	-0.1	-3.2	10.5	-2.2	-5.6	-3.4	-14.4	-29.4	-26.1
22	STDEV	3.1	1.3	0.8	0.4	8.9	7.1	14.2	6.4	6.9	7.0	1.1
23	cross grain, 90°C	0.0	7.6	7.6	2.8	25.2	-1.7	9.9	3.6	-30.4	-21.4	-24.1
24	STDEV	1.8	4.5	0.6	2.9	15.1	5.0	5.4	0.8	10.8	4.3	6.1
25	% Chg Stress 100% Elong.											
26	with grain, 90°C	0.0	10.1	9.5	10.2	9.0	7.5	5.9	9.2	11.6	27.0	22.4
27	STDEV	1.5	4.7	11.1	5.5	7.3	8.2	1.8	5.2	1.1	1.4	0.8
28	cross grain, 90°C	0.0	2.1	0.7	3.5	1.7	3.5	2.8	7.5	17.9	27.8	23.7
29	STDEV	2.7	1.0	1.3	1.4	2.2	1.5	1.2	0.4	2.1	1.1	3.3
30	% Chg Stress 200% Elong.											
31	with grain, 90°C	0.0	4.2	0.5	5.8	2.7	1.3	2.1	3.6	13.1	23.6	20.1
32	STDEV	0.9	1.0	1.1	0.8	1.1	4.8	1.7	2.9	0.6	2.8	2.8
33	cross grain, 90°C	0.0	3.4	1.0	5.2	3.7	3.3	3.7	7.1	19.0	28.0	26.9
34	STDEV	2.5	0.6	0.6	3.3	1.8	1.5	0.8	0.6	2.1	1.7	2.2
35												
36			TENSILE PLOTS									
37			Unirradiated						Irradiated			
38	% Elong. at Yield											
39	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
40	with grain, 90°C	22	24.6667	24.3333	24.6667	25.3333	26	24.33333	24.3333	23	22.66667	22.66667
41	cross grain, 90°C	22	23	22	23.3333	23	24	23	22.5	21.3333	20.33333	21.66667
42	% Elong. at Break											
43	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
44	with grain, 90°C	1378	1415.33	1420	1450	1553.33	1429.33	1293.333	1365.67	959	419	540
45	cross grain, 90°C	1350	1474.33	1461	1366.67	1640	1405.33	1453.333	1441.33	700.333	586	460
46	Yield Strength (psi)											
47	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
48	with grain, 90°C	2737.11	2900.91	2766.13	2944.99	2884.22	2829.46	2920.484	2939.97	3085.88	3181.241	2928.911
49	cross grain, 90°C	2907.22	2991.34	2920.5	2965.8	2981.21	2959.18	2921.364	3101.47	3229.19	3253.672	3087.916
50	Break Strength (psi)											
51	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
52	with grain, 90°C	3887.56	3825.15	3882.79	3762.75	4294.93	3802.13	3669.075	3755.2	3328.65	2746.334	2872.557
53	cross grain, 90°C	3728.45	4013.51	4009.96	3834.53	4666.46	3664.09	4095.96	3869.92	2593.7	2929.428	2829.462
54	Stress at 100% elong.											
55	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
56	with grain, 90°C	1999.27	2201.97	2188.64	2203.5	2178.56	2148.25	2117.968	2183.46	2236.08	2540.072	2447.765
57	cross grain, 90°C	1971.4	2012.28	1986.18	2039.9	2005.68	2040.78	2027.235	2120.2	2323.53	2519.421	2439.425
58	Stress at 200% elong.											
59	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
60	with grain, 90°C	2046.09	2131.28	2056.32	2184.43	2101.89	2073.56	2089.455	2120.75	2314.59	2528.126	2458.062
61	cross grain, 90°C	1995.1	2062.67	2015.46	2098.76	2068.24	2060.61	2068.678	2135.97	2374.75	2553.911	2530.955
62												
63												
64	Virgin Material (with grain)	TENSILE MEASUREMENTS AMBIENT										
65	Specimen No.	1	2	3	4	5	Average	St. Dev				
66												
67	Neck Thick (mil)	68.6	69.7	67.5	68.4	67.2						
68	Neck Thick (mil)	68.8	69.9	67.9	68.5	67.1						
69	Neck Thick (mil)	68.7	70	67.8	68.3	67.9						
70	Neck Thick (mil)	68.5	70	67.6	68.8	67.2						
71	Average (mil)	69	70	68	69	67	68.42	0.929403				
72	St. Dev. (mil)	0.1291	0.14142	0.18257	0.21602	0.36988						
73	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
74	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
75	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
76	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
77	Average (in)	0.250	0.250	0.250	0.250	0.250	0.25	0				
78	St. Dev. (mil)	0	0	0	0	0						
79	Elongation at Yield (in)	0.21	0.21	0.22	0.23	0.23						
80	% Elongation at Yield	21	21	22	23	23	22	1				
81	Elongation at Break (in)	13.3	13.6	14.1	13.6	14.3						
82	% Elongation at Break	1330	1360	1410	1360	1430	1378	40.86563				
83												
84	Load at Yield (lb)	48.7	47.7	46.5	45.7	45.5						
85	Yield Stress (psi)	2637.6	2729.6	2747.4	2668.4	2702.3	2737.11	63.56189				
86	Load at Break (lb)	65.1	67.1	67.8	64.6	67.8						

Liner Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
87	Break Strength (psi)	3793.2	3839.8	4005.9	3772.3	4026.7	3887.56	120.274				
88												
89	Load at 100% Elong. (lb)	35	35	34	34	33						
90	Stress at 100% Elong.(psi)	2039.3	2002.9	2008.9	1985.4	1959.9	1999.27	29.37341				
91	Load at 200% Elong. (lb)	35	36	35	35	34						
92	Stress at 200% Elong.(psi)	2039.3	2060.1	2067.9	2043.8	2019.3	2046.09	18.98786				
93												
94												
95												
96												
97	Virgin Material (cross grain)	TENSILE MEASUREMENTS AMBIENT										
98	Specimen No.	1	2	3	4	5	Average	St. Dev				
99												
100	Neck Thick (mil)	65.7	69.6	68.9	68.7	69.3						
101	Neck Thick (mil)	65.7	69.4	69.2	68.2	69.5						
102	Neck Thick (mil)	65.3	69.3	69.9	69	69.4						
103	Neck Thick (mil)	65.8	69.7	70.2	69.1	69.1						
104	Average (mil)	66	70	70	69	69	68.55	1.561207				
105	StDev (mil)	0.22174	0.18257	0.60277	0.40415	0.17078						
106	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
107	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
108	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
109	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
110	Average (in)	0.250	0.250	0.250	0.250	0.250	0.25	0				
111	StDev (mil)	0	0	0	0	0						
112	Elongation at Yield (in)	0.22	0.22	0.22	0.22	0.22						
113	% Elongation at Yield	22	22	22	22	22	22	0				
114	Elongation at Break (in)	13.6	13.6	13.3	13.3	13.7						
115	% Elongation at Break	1360	1360	1330	1330	1370	1350	18.70829				
116												
117	Load at Yield (lb)	46.3	52	50.2	49.2	51.5						
118	Yield Stress (psi)	2822.1	2992.8	2887.1	2862.5	2971.5	2907.22	72.6358				
119	Load at Break (lb)	61.1	65.1	64.8	62.4	66.1						
120	Break Strength (psi)	3724.2	3746.8	3726.8	3630.5	3813.9	3728.45	65.68311				
121												
122	Load at 100% Elong. (lb)	31	35	34	34	35						
123	Stress at 100% Elong.(psi)	1889.5	2014.4	1955.4	1978.2	2019.5	1971.4	52.82965				
124	Load at 200% Elong. (lb)	32	36	34	34	35						
125	Stress at 200% Elong.(psi)	1950.5	2071.9	1955.4	1978.2	2019.5	1995.1	50.86803				
126												
127												
128												
129												
130	30 DAY WITH GRAIN	* * * * 90° C * * * *										
131		1	2	3	AG	STDEV						
132												
133	Neck Thick (mil)	66.8	65.1	67.8								
134	Neck Thick (mil)	66.8	65.3	67.7								
135	Neck Thick (mil)	66.1	65.4	67.8								
136	Neck Thick (mil)	66.2	64.9	68.2								
137	Average (mil)	66	65	68								
138												
139	Neck Width (in)	0.25	0.25	0.25								
140	Neck Width (in)	0.25	0.25	0.25								
141	Neck Width (in)	0.25	0.25	0.25								
142	Neck Width (in)	0.25	0.25	0.25								
143	Average (in)	0.250	0.250	0.250								
144												
145	Elongation at Yield (in)	0.25	0.23	0.26								
146	% Elongation at Yield	25	23	26	24.6667	1.52753						
147	Elongation at Break (in)	13.99	14.15	14.32								
148	% Elongation at Break	1399	1415	1432	1415.33	16.5025						
149												
150	Load at Yield (lb)	48.2	47.3	49.2								
151	Yield Strength (psi)	2900.3	2903.0	2899.4	2900.9	1.8						
152	Load at Break (lb)	62.6	62.9	65.3								
153	Break Strength (psi)	3766.8	3880.4	3848.3	3825.2	50.9						
154												
155	Load at 100% Elong. (lb)	36.5	34.4	39								
156	Stress at 100% Elong.(psi)	2196.3	2111.2	2298.3	2202.0	93.7						
157	Load at 200% Elong. (lb)	35.2	35.1	36								
158	Stress at 200% Elong.(psi)	2118.1	2154.2	2121.5	2131.3	19.9						
159												
160												
161												
162	30 DAY CROSS GRAIN	* * * * 90° C * * * *										
163		1	2	3	AG	STDEV						
164												
165												
166	Neck Thick (mil)	62.8	65.8	63								
167	Neck Thick (mil)	62.5	64	62.2								
168	Neck Thick (mil)	64	63.1	62.8								
169	Neck Thick (mil)	65.3	62.9	64.9								
170	Average (mil)	64	64	63								
171												
172	Neck Width (in)	0.25	0.25	0.25								

Liner Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
173	Neck Width (in)	0.25	0.25	0.25								
174	Neck Width (in)	0.25	0.25	0.25								
175	Neck Width (in)	0.25	0.25	0.25								
176	Average (in)	0.250	0.250	0.250								
177												
178	Elongation at Yield (in)	0.23	0.23	0.23								
179	% Elongation at Yield	23	23	23	23	0						
180	Elongation at Break (in)	14.87	15.24	14.12								
181	% Elongation at Break	1487	1524	1412	1474.33	57.0643						
182												
183	Load at Yield (lb)	47	47.7	48								
184	Yield Strength (psi)	2953.7	2983.6	3036.8	2991.3	42.1						
185	Load at Break (lb)	64.3	66.6	60.6								
186	Break Strength (psi)	4040.8	4165.8	3833.9	4013.5	187.6						
187												
188	Load at 100% Elong. (lb)	31.7	32.5	31.8								
189	Stress at 100% Elong.(psi)	1992.1	2032.8	2011.9	2012.3	20.4						
190	Load at 200% Elong. (lb)	32.8	32.8	32.8								
191	Stress at 200% Elong.(psi)	2061.3	2051.6	2075.1	2062.7	11.8						
192												
193												
194												
195												
196	60 DAY WITH GRAIN											
197		1	2	3	AG	ST DEV						
198												
199	Neck Thick (mil)	70.9	69.9	70.2								
200	Neck Thick (mil)	71	69.6	70								
201	Neck Thick (mil)	70.9	70	69.7								
202	Neck Thick (mil)	70.9	69.5	70.1								
203	Average (mil)	71	70	70	70.225							
204												
205	Neck Width (in)	0.25	0.25	0.25								
206	Neck Width (in)	0.25	0.25	0.25								
207	Neck Width (in)	0.25	0.25	0.25								
208	Neck Width (in)	0.25	0.25	0.25								
209	Average (in)	0.250	0.250	0.250	0.25							
210												
211	Elongation at Yield (in)	0.24	0.24	0.25								
212	% Elongation at Yield	24	24	25	24.3333	0.57735						
213	Elongation at Break (in)	14.13	14.09	14.38								
214	% Elongation at Break	1413	1409	1438	1420	15.7162						
215												
216	Load at Yield (lb)	49.7	47.5	48.5								
217	Yield Strength (psi)	2803.0	2724.0	2771.4	2766.1	39.7						
218	Load at Break (lb)	68.6	67.3	68.6								
219	Break Strength (psi)	3868.88	3859.5	3920	3882.8	32.6						
220												
221	Load at 100% Elong. (lb)	40	35	40.3								
222	Stress at 100% Elong.(psi)	2255.9	2007.2	2302.9	2188.6	158.9						
223	Load at 200% Elong. (lb)	36.3	36.3	35.7								
224	Stress at 200% Elong.(psi)	2047.2	2081.7	2040.0	2056.3	22.3						
225												
226												
227												
228												
229	60 DAY CROSS GRAIN											
230		1	2	3	AG	ST DEV						
231												
232	Neck Thick (mil)	63.1	63.7	65.7								
233	Neck Thick (mil)	63.4	63.1	64.6								
234	Neck Thick (mil)	63.8	64.1	63.7								
235	Neck Thick (mil)	63.9	63.2	63.1								
236	Average (mil)	64	64	64								
237												
238	Neck Width (in)	0.25	0.25	0.25								
239	Neck Width (in)	0.25	0.25	0.25								
240	Neck Width (in)	0.25	0.25	0.25								
241	Neck Width (in)	0.25	0.25	0.25								
242	Average (in)	0.250	0.250	0.250								
243												
244	Elongation at Yield (in)	0.22	0.22	0.22								
245	% Elongation at Yield	22	22	22	22	0						
246	Elongation at Break (in)	14.65	14.69	14.49								
247	% Elongation at Break	1465	1469	1449	1461	10.583						
248												
249	Load at Yield (lb)	46.5	45.5	47.7								
250	Yield Strength (psi)	2926.8	2865.0	2969.6	2920.5	52.6						
251	Load at Break (lb)	63.4	64.1	64.3								
252	Break Strength (psi)	3990.58	4036.21	4003.11	4010.0	23.6						
253												
254	Load at 100% Elong. (lb)	31.2	32	31.8								
255	Stress at 100% Elong.(psi)	1963.8	2015.0	1979.8	1986.2	26.2						
256	Load at 200% Elong. (lb)	32.2	32	32.2								
257	Stress at 200% Elong.(psi)	2026.8	2015.0	2004.7	2015.5	11.0						
258												

Liner Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
259												
260												
261												
262	90 DAY WITH GRAIN * * * * 90° C * * * *											
263		1	2	3	AVG	ST DEV						
264												
265	Neck Thick (mil)	69.5	68.5	68.8								
266	Neck Thick (mil)	69.5	68.5	68.9								
267	Neck Thick (mil)	69.7	68.9	68.7								
268	Neck Thick (mil)	69.8	68.9	68.2								
269	Average (mil)	70	69	69								
270												
271	Neck Width (in)	0.25	0.25	0.25								
272	Neck Width (in)	0.25	0.25	0.25								
273	Neck Width (in)	0.25	0.25	0.25								
274	Neck Width (in)	0.25	0.25	0.25								
275	Average (in)	0.250	0.250	0.250								
276												
277	Elongation at Yield (in)	0.22	0.27	0.25								
278	% Elongation at Yield	22	27	25	24.8667	2.51661						
279	Elongation at Break (in)	13.3	13	17.2								
280	% Elongation at Break	1330	1300	1720	1450	234.307						
281												
282	Load at Yield (lb)	52.4	49.5	50.5								
283	Yield Strength (psi)	3010.4	2882.1	2942.5	2945.0	64.2						
284	Load at Break (lb)	65.6	64.3	64.8								
285	Break Strength (psi)	3768.78	3743.61	3775.67	3762.7	16.8						
286												
287	Load at 100% Elong. (lb)	37	40	37								
288	Stress at 100% Elong.(psi)	2125.7	2329.0	2155.9	2203.5	109.7						
289	Load at 200% Elong. (lb)	38	37	37								
290	Stress at 200% Elong.(psi)	2183.1	2154.3	2155.9	2164.4	16.2						
291												
292												
293												
294	90 DAY CROSS GRAIN * * * * 90° C * * * *											
295		1	2	3	AVG	ST DEV						
296												
297	Neck Thick (mil)	67.7	68.5	68.9								
298	Neck Thick (mil)	67.8	68.5	68.2								
299	Neck Thick (mil)	68	67.9	68.2								
300	Neck Thick (mil)	67.3	67.6	67.1								
301	Average (mil)	68	68	68								
302												
303	Neck Width (in)	0.25	0.25	0.25								
304	Neck Width (in)	0.25	0.25	0.25								
305	Neck Width (in)	0.25	0.25	0.25								
306	Neck Width (in)	0.25	0.25	0.25								
307	Average (in)	0.250	0.250	0.250								
308												
309	Elongation at Yield (in)	0.23	0.24	0.23								
310	% Elongation at Yield	23	24	23	23.3333	0.57735						
311	Elongation at Break (in)	13.3	13.7	14								
312	% Elongation at Break	1330	1370	1400	1366.67	35.1188						
313												
314	Load at Yield (lb)	50.2	50.5	50.5								
315	Yield Strength (psi)	2966.0	2965.1	2966.2	2965.8	0.6						
316	Load at Break (lb)	63.1	65.3	67.1								
317	Break Strength (psi)	3728.21	3834.13	3941.26	3834.5	106.5						
318												
319	Load at 100% Elong. (lb)	34	35	35								
320	Stress at 100% Elong.(psi)	2008.9	2055.0	2055.8	2039.9	26.9						
321	Load at 200% Elong. (lb)	35	35	37								
322	Stress at 200% Elong.(psi)	2067.9	2055.0	2173.3	2098.8	64.9						
323												
324												
325												
326												
327	120 DAY WITH GRAIN * * * * 90° C * * * *											
328		1	2	3	AVG	ST DEV						
329												
330	Neck Thick (mil)	67.1	69.6	69.3								
331	Neck Thick (mil)	68	69.2	69								
332	Neck Thick (mil)	68.1	69.9	69.1								
333	Neck Thick (mil)	67.8	70	69.1								
334	Average (mil)	68	70	69								
335												
336	Neck Width (in)	0.25	0.25	0.25								
337	Neck Width (in)	0.25	0.25	0.25								
338	Neck Width (in)	0.25	0.25	0.25								
339	Neck Width (in)	0.25	0.25	0.25								
340	Average (in)	0.250	0.250	0.250								
341												
342	Elongation at Yield (in)	0.25	0.26	0.25								
343	% Elongation at Yield	25	26	25	25.3333	0.57735						
344	Elongation at Break (in)	14.7	15	16.9								

Liner Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
345	% Elongation at Break	1470	1500	1690	1553.33	119.304						
346												
347	Load at Yield (lb)	48.5	49.7	50.7								
348	Yield Strength (psi)	2865.6	2853.2	2933.8	2884.2	43.4						
349	Load at Break (lb)	88.3	72.5	81								
350	Break Strength (psi)	4035.45	4162.18	4687.16	4294.9	345.5						
351												
352	Load at 100% Elong. (lb)	35	37	40.5								
353	Stress at 100% Elong. (psi)	2067.9	2124.1	2343.6	2178.6	145.6						
354	Load at 200% Elong. (lb)	36	36.5	36								
355	Stress at 200% Elong. (psi)	2127.0	2095.4	2083.2	2101.9	22.6						
356												
357												
358												
359												
360	120 DAY CROSS GRAIN	* * * * 90° C * * * *										
361		1	2	3	AVG	ST DEV						
362												
363	Neck Thick (mil)	65.2	64.8	63.8								
364	Neck Thick (mil)	63.9	64.1	62.8								
365	Neck Thick (mil)	63.5	63.1	62.9								
366	Neck Thick (mil)	63.9	64.1	63.8								
367	Average (mil)	64	64	63								
368												
369	Neck Width (in)	0.25	0.25	0.25								
370	Neck Width (in)	0.251	0.25	0.25								
371	Neck Width (in)	0.25	0.25	0.25								
372	Neck Width (in)	0.25	0.25	0.25								
373	Average (in)	0.250	0.250	0.250								
374												
375	Elongation at Yield (in)	0.23	0.23	0.23								
376	% Elongation at Yield	23	23	23	23	0						
377	Elongation at Break (in)	17.5	17	14.7								
378	% Elongation at Break	1750	1700	1470	1640	149.332						
379												
380	Load at Yield (lb)	47	48	47.7								
381	Yield Strength (psi)	2931.8	2998.8	3013.0	2981.2	43.4						
382	Load at Break (lb)	80.4	79.5	83.6								
383	Break Strength (psi)	5015.2	4966.81	4017.37	4666.5	562.6						
384												
385	Load at 100% Elong. (lb)	31.5	32	32.5								
386	Stress at 100% Elong. (psi)	1964.9	1999.2	2052.9	2005.7	44.3						
387	Load at 200% Elong. (lb)	32.5	33.5	33								
388	Stress at 200% Elong. (psi)	2027.3	2092.9	2084.5	2068.2	35.7						
389												
390												
391												
392												
393	120-d Irrad., (With Grain	* * * * 30 day Exp. * * * *			* * * * 120 day Exp. * * * *							
394	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
395												
396	Neck Thick (mil)	65.1	66.3	65.6			70.2	69.2	68.1			
397	Neck Thick (mil)	65.5	66.5	66.1			70.7	69.5	67.7			
398	Neck Thick (mil)	64.9	66.8	66			70.8	69	68			
399	Neck Thick (mil)	64.6	66.7	65.8			70.8	69.1	67.8			
400	Average (mil)	65	67	66			71	69	68			
401												
402	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
403	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
404	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
405	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
406	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
407												
408	Elongation at Yield (in)	0.26	0.26	0.26			0.23	0.25	0.25			
409	% Elongation at Yield	26	26	26	26	0	23	25	25	24.3333	1.154701	
410	Elongation at Break (in)	15.16	13.4	14.32			12.6	11.3	14.9			
411	% Elongation at Break	1516	1340	1432	1429.33	88.0303	1260	1130	1490	1293.33	182.3001	
412												
413	Load at Yield (lb)	45.5	47.7	46.5			52.5	50.5	48.7			
414	Yield Strength (psi)	2798.9	2865.9	2823.5	2829.5	33.9	2973.5	2919.1	2868.9	2920.5	52.3	
415	Load at Break (lb)	66.6	59.1	61.9			62.6	55.2	72.5			
416	Break Strength (psi)	4096.89	3550.88	3758.63	3802.1	275.6	3545.49	3190.751	4270.99	3889.1	550.6	
417												
418	Load at 100% Elong. (lb)	38	34.2	33.8			38	36	36			
419	Stress at 100% Elong. (psi)	2337.6	2054.8	2052.4	2148.3	164.0	2152.2	2080.9	2120.8	2118.0	35.7	
420	Load at 200% Elong. (lb)	31.9	35.2	35.3			37	35.5	36			
421	Stress at 200% Elong. (psi)	1962.3	2114.9	2143.5	2073.6	97.4	2095.6	2052.0	2120.8	2089.5	34.8	
422												
423												
424	120-d Irrad., (X-Grain)	* * * * 30 day Exp. * * * *			* * * * 120 day Exp. * * * *							
425	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
426												
427	Neck Thick (mil)	66.8	66.6	68			65	63	64.6			
428	Neck Thick (mil)	67.4	67.2	67.2			64.1	64.2	64.2			
429	Neck Thick (mil)	67.8	67.9	66.8			62.6	65	64.7			
430	Neck Thick (mil)	68.2	67.5	66.6			63.2	65	63.7			

Liner Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
431	Average (mil)	68	67	67			64	64	64			
432												
433	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
434	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
435	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
436	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
437	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
438												
439	Elongation at Yield (in)	0.23	0.25	0.24			0.23	0.23	0.23			
440	% Elongation at Yield	23	25	24	24	1	23	23	23	23	0	
441	Elongation at Break (in)	13.65	14.82	13.69			14.1	14.3	15.2			
442	% Elongation at Break	1365	1482	1369	1405.33	66.4254	1410	1430	1520	1453.33	58.59465	
443												
444	Load at Yield (lb)	51.5	48.5	49.5			46.5	47.5	46.5			
445	Yield Strength (psi)	3049.6	2882.6	2945.3	2959.2	84.3	2918.5	2954.9	2892.7	2921.4	31.4	
446	Load at Break (lb)	59.9	65.3	59.9			64.1	63.4	69.5			
447	Break Strength (psi)	3547	3881.13	3564.15	3664.1	188.2	4020.38	3944.012	4323.48	4096.0	200.7	
448												
449	Load at 100% Elong. (lb)	35	33.9	34.2			32	32.5	33			
450	Stress at 100% Elong. (psi)	2072.5	2014.9	2035.0	2040.8	29.3	2007.1	2021.8	2052.9	2027.2	23.4	
451	Load at 200% Elong. (lb)	35	34.1	35			33	33	33.5			
452	Stress at 200% Elong. (psi)	2072.5	2026.7	2082.6	2060.8	29.8	2069.8	2052.9	2084.0	2068.9	15.6	
453												
454												
455												
456	2-yr Irrad.. (With Grain)	30 day Exp.										
457	Specimen No.	1	2	3	AG	ST DEV						
458												
459	Neck Thick (mil)	65.8	64.7	64.2								
460	Neck Thick (mil)	65.6	65.5	64								
461	Neck Thick (mil)	65.5	63.7	63.9								
462	Neck Thick (mil)	65.9	64.5	63.9								
463	Average (mil)	66	65	64								
464												
465	Neck Width (in)	0.25	0.25	0.25								
466	Neck Width (in)	0.25	0.25	0.25								
467	Neck Width (in)	0.25	0.25	0.25								
468	Neck Width (in)	0.25	0.25	0.25								
469	Average (in)	0.250	0.250	0.250								
470												
471	Elongation at Yield (in)	0.24	0.24	0.25								
472	% Elongation at Yield	24	24	25	24.3333	0.57735						
473	Elongation at Break (in)	14.49	12.99	13.49								
474	% Elongation at Break	1449	1299	1349	1365.87	76.3763						
475												
476	Load at Yield (lb)	48	47.3	47.5								
477	Yield Strength (psi)	2922.4	2928.8	2968.8	2940.0	25.1						
478	Load at Break (lb)	66.3	57.6	58.6								
479	Break Strength (psi)	4036.53	3566.56	3662.5	3755.2	248.3						
480												
481	Load at 100% Elong. (lb)	37.8	34	34.3								
482	Stress at 100% Elong. (psi)	2301.4	2105.3	2143.8	2183.5	103.9						
483	Load at 200% Elong. (lb)	34.5	33.5	35								
484	Stress at 200% Elong. (psi)	2100.5	2074.3	2187.5	2120.8	59.3						
485												
486												
487	2-yr Irrad.. (X-Grain)	30 day Exp.										
488	Specimen No.	1	2	3	AG	ST DEV						
489												
490	Neck Thick (mil)	66.8	67.8	66.7								
491	Neck Thick (mil)	67.8	68.1	68.4								
492	Neck Thick (mil)	68.2	68.1	68.2								
493	Neck Thick (mil)	67.9	67.1	66.9								
494	Average (mil)	68	68	68								
495												
496	Neck Width (in)	0.25	0.25	0.25								
497	Neck Width (in)	0.25	0.25	0.25								
498	Neck Width (in)	0.25	0.25	0.25								
499	Neck Width (in)	0.25	0.25	0.25								
500	Average (in)	0.250	0.250	0.250								
501												
502	Elongation at Yield (in)	0.26	0.225	0.231								
503	% Elongation at Yield	221	22.5	23	22.5	0.5						
504	Elongation at Break (in)	14.49	14.43	14.321								
505	% Elongation at Break	1449	1443	1432	1441.33	8.62168						
506												
507	Load at Yield (lb)	53.2	52.2	52								
508	Yield Strength (psi)	3144.4	3080.8	3079.2	3101.5	37.2						
509	Load at Break (lb)	65.8	65.8	64.8								
510	Break Strength (psi)	3889.18	3883.44	3837.16	3869.9	28.5						
511												
512	Load at 100% Elong. (lb)	36	35.8	35.8								
513	Stress at 100% Elong. (psi)	2127.8	2112.9	2119.9	2120.2	7.5						
514	Load at 200% Elong. (lb)	36	36.1	36.3								
515	Stress at 200% Elong. (psi)	2127.8	2130.6	2149.5	2136.0	11.6						
516												

Liner Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
517												
518												
519	10-yr Irrad., (With Grain)	*** 30 day Exp. ***										
520	Specimen No.	1	2	3	AVG	STDEV						
521												
522	Neck Thick (mil)	65.3	67.3	66.7								
523	Neck Thick (mil)	65	67.6	66								
524	Neck Thick (mil)	65.2	67.7	66.4								
525	Neck Thick (mil)	64.6	67.5	67								
526	Average (mil)	65	68	67								
527												
528	Neck Width (in)	0.25	0.25	0.25								
529	Neck Width (in)	0.25	0.25	0.25								
530	Neck Width (in)	0.25	0.25	0.25								
531	Neck Width (in)	0.25	0.25	0.25								
532	Average (in)	0.250	0.250	0.250								
533												
534	Elongation at Yield (in)	0.23	0.23	0.23								
535	% Elongation at Yield	23	23	23	23	0						
536	Elongation at Break (in)	9.1	10.65	9.02								
537	% Elongation at Break	910	1065	902	959	91.8858						
538												
539	Load at Yield (lb)	49.7	52.7	51.2								
540	Yield Strength (psi)	3057.3	3121.8	3078.5	3085.9	32.9						
541	Load at Break (lb)	51.5	61.4	52.9								
542	Break Strength (psi)	3168.01	3637.17	3180.76	3328.6	267.3						
543												
544	Load at 100% Elong. (lb)	36	38.1	37.2								
545	Stress at 100% Elong.(psi)	2214.5	2256.9	2236.8	2236.1	21.2						
546	Load at 200% Elong. (lb)	37.4	39.1	38.7								
547	Stress at 200% Elong.(psi)	2300.7	2316.2	2326.9	2314.6	13.2						
548												
549												
550	10-yr Irrad., (X-Grain)	*** 30 day Exp. ***										
551	Specimen No.	1	2	3	AVG	STDEV						
552												
553	Neck Thick (mil)	66	69.2	66.4								
554	Neck Thick (mil)	67.8	68.8	68.1								
555	Neck Thick (mil)	67.8	68.2	68								
556	Neck Thick (mil)	67.6	66.9	67.8								
557	Average (mil)	67	68	68								
558												
559	Neck Width (in)	0.25	0.25	0.25								
560	Neck Width (in)	0.25	0.25	0.25								
561	Neck Width (in)	0.25	0.25	0.25								
562	Neck Width (in)	0.25	0.25	0.25								
563	Average (in)	0.250	0.250	0.250								
564												
565	Elongation at Yield (in)	0.21	0.22	0.21								
566	% Elongation at Yield	21	22	21	21.3333	0.57735						
567	Elongation at Break (in)	5.65	6.82	6.54								
568	% Elongation at Break	565	682	654	700.333	145.37						
569												
570	Load at Yield (lb)	54.4	54.9	54.7								
571	Yield Strength (psi)	3233.3	3216.4	3237.9	3229.2	11.3						
572	Load at Break (lb)	39.9	40.1	51.7								
573	Break Strength (psi)	2371.47	2349.32	3060.3	2593.7	404.2						
574												
575	Load at 100% Elong. (lb)	39	39	40								
576	Stress at 100% Elong.(psi)	2318.0	2284.9	2367.7	2323.5	41.7						
577	Load at 200% Elong. (lb)	40	39.8	40.8								
578	Stress at 200% Elong.(psi)	2377.4	2331.7	2415.1	2374.8	41.7						
579												
580												
581												
582	30-yr Irrad., (With Grain)	*** 30 day Exp. ***						*** 120 day Exp. ***				
583	Specimen No.	1	2	3	AVG	STDEV		1	2	3	AVG	STDEV
584												
585	Neck Thick (mil)	66.5	67.2	68.4			64.9	63.8	63.8			
586	Neck Thick (mil)	68.5	67.2	68.5			63.9	63.2	63.3			
587	Neck Thick (mil)	66.1	67.4	68.6			63.8	63.5	63.8			
588	Neck Thick (mil)	66.3	67.2	68.8			64.1	63	63.7			
589	Average (mil)	66	67	69			64	63	64			
590												
591	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
592	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
593	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
594	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
595	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
596												
597	Elongation at Yield (in)	0.24	0.22	0.22			0.23	0.23	0.22			
598	% Elongation at Yield	24	22	22	22.6667	1.1547	23	23	22	22.6667	0.57735	
599	Elongation at Break (in)	5.82	3.32	3.43			5.4	5.4	5.4			
600	% Elongation at Break	582	332	343	419	141.269	540	540	540	540	0	
601												
602	Load at Yield (lb)	52.4	53.7	54.7			46.7	46.3	47			

Linear Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
603	Yield Strength (psi)	3159.0	3194.1	3190.7	3181.2	19.3	2910.4	2922.3	2953.7	2928.9	22.2	
604	Load at Break (lb)	50.7	43	45			45.5	46.3	45.5			
605	Break Strength (psi)	3058.52	2557.62	2624.86	2748.3	270.7	2836	2922.288	2859.38	2872.8	44.6	
606												
607	Load at 100% Elong. (lb)	41.8	42.5	44.1			39	39	39			
608	Stress at 100% Elong. (psi)	2520.0	2527.9	2572.4	2540.1	28.2	2430.9	2481.5	2450.9	2447.8	15.8	
609	Load at 200% Elong. (lb)	40.9	43.3	43.6			39.5	38	40			
610	Stress at 200% Elong. (psi)	2465.7	2575.5	2543.2	2528.1	56.4	2462.0	2398.4	2513.7	2458.1	57.8	
611												
612												
613	30-yr Irrad., (X-Grain)	* * * * 30 day Exp. * * * *					* * * * 120 day Exp. * * * *					
614	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
615												
616	Neck Thick (mil)	88.1	68.4	68			87.2	67	64.8			
617	Neck Thick (mil)	89.8	68.7	69.1			65.8	65.9	65.8			
618	Neck Thick (mil)	70.5	69.6	89.9			64.6	84.8	66.2			
619	Neck Thick (mil)	71.1	70.1	70.8			64.1	84.2	67			
620	Average (mil)	70	69	69			65	65	66			
621												
622	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
623	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
624	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
625	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
626	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
627												
628	Elongation at Yield (in)	0.2	0.21	0.2			0.21	0.22	0.22			
629	% Elongation at Yield	20	21	20	20.3333	0.57735	21	22	22	21.6667	0.57735	
630	Elongation at Break (in)	6.02	5.99	5.57			5.4	2.7	5.7			
631	% Elongation at Break	602	599	557	588	25.1595	540	270	570	480	165.2271	
632												
633	Load at Yield (lb)	55.9	57.4	56.4			50.7	51	50.2			
634	Yield Strength (psi)	3197.7	3315.5	3248.4	3253.9	59.1	3104.5	3115.7	3043.6	3087.9	38.8	
635	Load at Break (lb)	53.4	51.7	47.7			48.7	42	48.5			
636	Break Strength (psi)	3054.7	2986.28	2747.3	2929.4	161.4	2982.01	2565.865	2940.51	2829.5	229.2	
637												
638	Load at 100% Elong. (lb)	43.8	43.8	44			41	39	40			
639	Stress at 100% Elong. (psi)	2494.1	2530.0	2534.2	2519.4	22.0	2510.5	2382.6	2425.2	2439.4	65.1	
640	Load at 200% Elong. (lb)	44.2	44	45			42	41.5	41			
641	Stress at 200% Elong. (psi)	2528.4	2541.5	2591.8	2553.9	33.5	2571.8	2535.3	2485.8	2531.0	43.1	

Liner T w Data

	A	B	C	D	E	F	G	H	I	J	K	L
1				HDPE LINER (DSSF,90) TEAR SUMMARY								
2												
3	% Change in Tear Strength											
4				Unirradiated					Irradiated			
5	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
6												
7												
8	with grain, 90°C	0	-3.0654	0.9126	0.0351	1.9071	-3.7674	0.2691	-6.2244	-5.9319	-10.67	-13.478413
9	ST.DEV.	3.0885	2.0265	1.49947	0.30398	2.8962	2.64029	1.533327	0.44167	0.92866	4.34518	1.32499727
10												
11	cross grain, 90°C	0	-4.8158	-4.5014	6.24921	-0.3521	3.73444	-1.67232	6.75217	4.36313	4.86609	-6.7018735
12	ST.DEV.	1.01918	0.47465	0.76225	0.96788	1.13688	1.49703	1.338099	0.68004	0.21779	0.32668	1.28382861
13						PLOT DATA						
14				Unirradiated					Irradiated			
15	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
16	with grain (90°C)	58.98	55.2333	57.5	57	58.0667	54.8333	57.13333	53.4333	53.6	50.9	49.3
17	cross grain (90°)	53.02	50.4667	50.6333	56.3333	52.8333	55	52.13333	56.6	55.3333	55.6	49.4668667
18												
19												
20	Virgin Material (with grain)			TEAR MEASUREMENTS AMBIENT								
21	Specimen No.	1	2	3	4	5	Average	ST DEV				
22												
23	Specimen Thick (in)	0.0688	0.0707	0.0685	0.0672	0.0668						
24	Specimen Thick (in)	0.0688	0.0709	0.0679	0.0672	0.067						
25	Specimen Thick (in)	0.069	0.07	0.0686	0.0675	0.0669						
26	Specimen Thick (in)	0.0684	0.0704	0.0695	0.0669	0.0669						
27	Average (in)	0.0688	0.0705	0.0686	0.0672	0.0669	0.0684	0.001362				
28												
29	Tearing Load (lb)	57.2	59.4	57.7	55.7	54.9	57.0	1.75983				
30												
31												
32	Virgin Material (cross grain)			TEAR MEASUREMENTS AMBIENT								
33	Specimen No.	1	2	3	4	5	Average	ST DEV				
34												
35	Specimen Thick (in)	0.0675	0.0669	0.0667	0.0649	0.0655						
36	Specimen Thick (in)	0.066	0.0668	0.0647	0.0648	0.0652						
37	Specimen Thick (in)	0.0663	0.0669	0.0643	0.0645	0.0657						
38	Specimen Thick (in)	0.0656	0.0668	0.0654	0.065	0.0649						
39	Average (in)	0.0664	0.0669	0.0653	0.0648	0.0653	0.0657	0.000967				
40												
41	Tearing Load (lb)	53.5	53.7	52.7	52.5	52.7	53.0	0.54037				
42												
43												
44	30-Day (with grain)			**** 90° C ****								
45	Specimen No.	1	2	3	AG	ST DEV						
46												
47	Specimen Thick (in)	0.064	0.067	0.0671								
48	Specimen Thick (in)	0.0648	0.0671	0.0672								
49	Specimen Thick (in)	0.0655	0.0674	0.0669								
50	Specimen Thick (in)	0.0639	0.067	0.067								
51	Average (in)	0.06455	0.06713	0.06705	0.06624	0.00147						
52												
53	Tearing Load (lb)	53.9	55.9	55.9	55.2333	1.1547						
54												
55												
56	30-Day (cross grain)			**** 90° C ****								
57	Specimen No.	1	2	3	AG	ST DEV						
58												
59	Specimen Thick (in)	0.0638	0.0639	0.0631								
60	Specimen Thick (in)	0.0628	0.0629	0.0632								
61	Specimen Thick (in)	0.0632	0.0635	0.0632								
62	Specimen Thick (in)	0.0635	0.0632	0.0633								
63	Average (in)	0.0633	0.0634	0.0632	0.0633	9E-05						
64												
65	Tearing Load (lb)	50.5	50.2	50.7	50.4667	0.25166						
66												
67												
68	60-Day (with grain)			**** 90° C ****								
69	Specimen No.	1	2	3	AG	ST DEV						
70												
71	Specimen Thick (in)	0.0702	0.0682	0.068								
72	Specimen Thick (in)	0.0689	0.0675	0.0669								
73	Specimen Thick (in)	0.0685	0.0676	0.0666								
74	Specimen Thick (in)	0.0689	0.0675	0.0673								
75	Average (in)	0.0691	0.0677	0.0672	0.0680	0.001						
76												
77	Tearing Load (lb)	58.4	57.4	56.7	57.5000	0.8544						
78												
79												
80	60-Day (cross grain)			**** 90° C ****								
81	Specimen No.	1	2	3	AG	ST DEV						
82												

Liner Tear Data

	A	B	C	D	E	F	G	H	I	J	K	L
83	Specimen Thick (in)	0.0632	0.0638	0.0632								
84	Specimen Thick (in)	0.0633	0.0638	0.0632								
85	Specimen Thick (in)	0.063	0.0629	0.0635								
86	Specimen Thick (in)	0.0627	0.0631	0.0634								
87	Average (in)	0.0631	0.0634	0.0633	0.0632	0.00017						
88												
89	Tearing Load (lb)	50.2	50.7	51	50.8333	0.40415						
90												
91												
92	90-Day (with grain)	**** 90° C ****										
93	Specimen No.	1	2	3	AVG	ST DEV						
94												
95	Specimen Thick (in)	0.0668	0.067	0.0669								
96	Specimen Thick (in)	0.0668	0.0669	0.067								
97	Specimen Thick (in)	0.0668	0.0662	0.0678								
98	Specimen Thick (in)	0.0671	0.0662	0.0667								
99	Average (in)	0.0669	0.0666	0.0671	0.0669	0.00026						
100												
101	Tearing Load (lb)	57.2	56.9	56.9	57.0000	0.17321						
102												
103												
104	90-Day (cross grain)	**** 90° C ****										
105	Specimen No.	1	2	3	AVG	ST DEV						
106												
107	Specimen Thick (in)	0.0697	0.0692	0.0696								
108	Specimen Thick (in)	0.069	0.0692	0.069								
109	Specimen Thick (in)	0.0687	0.0697	0.0691								
110	Specimen Thick (in)	0.069	0.0689	0.0695								
111	Average (in)	0.0691	0.0693	0.0693	0.0692	0.0001						
112												
113	Tearing Load (lb)	55.9	56.2	56.9	56.3333	0.51316						
114												
115												
116	120-Day (with grain)	**** 90° C ****										
117	Specimen No.	1	2	3	AVG	ST DEV						
118												
119	Specimen Thick (in)	0.0649	0.0671	0.0675								
120	Specimen Thick (in)	0.0649	0.0675	0.0687								
121	Specimen Thick (in)	0.066	0.0671	0.0688								
122	Specimen Thick (in)	0.0649	0.0685	0.0675								
123	Average (in)	0.0652	0.0676	0.0681	0.0670	0.00156						
124												
125	Tearing Load (lb)	56.7	57.6	59.9	58.0667	1.65025						
126												
127												
128	120-Day (cross grain)	**** 90° C ****										
129	Specimen No.	1	2	3	AVG	ST DEV						
130												
131	Specimen Thick (in)	0.0637	0.0631	0.0629								
132	Specimen Thick (in)	0.0643	0.0647	0.0639								
133	Specimen Thick (in)	0.0639	0.065	0.0635								
134	Specimen Thick (in)	0.0638	0.0634	0.0645								
135	Average (in)	0.0639	0.0641	0.0637	0.0639	0.00018						
136												
137	Tearing Load (lb)	52.2	53.4	52.9	52.8333	0.60277						
138												
139												
140	120-d Irr. (with grain)	**** 30 Day ****					**** 120 Day ****					
141	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
142												
143	Specimen Thick (in)	0.0661	0.0634	0.0642			0.0687	0.0681	0.0679			
144	Specimen Thick (in)	0.0664	0.0635	0.0639			0.069	0.0677	0.0679			
145	Specimen Thick (in)	0.0665	0.0637	0.0632			0.0692	0.0678	0.0671			
146	Specimen Thick (in)	0.0654	0.0634	0.0637			0.069	0.0672	0.0679			
147	Average (in)	0.0661	0.0635	0.0638	0.0645	0.00143	0.0690	0.0677	0.0677	0.0681	0.00074	
148												
149	Tearing Load (lb)	56.4	53.4	54.7	54.8333	1.50444	58.1	56.9	56.4	57.1333	0.87369	
150												
151												
152	120-d Irr. (X-grain)	**** 30 Day ****					**** 120 Day ****					
153	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
154												
155	Specimen Thick (in)	0.0688	0.0672	0.0685			0.064	0.0642	0.0625			
156	Specimen Thick (in)	0.0677	0.0664	0.0665			0.0631	0.064	0.0632			
157	Specimen Thick (in)	0.0666	0.0675	0.0668			0.0642	0.0638	0.0637			
158	Specimen Thick (in)	0.0671	0.0675	0.0662			0.0639	0.064	0.0629			
159	Average (in)	0.0678	0.0672	0.0670	0.0672	0.00028	0.0638	0.0640	0.0631	0.0636	0.00049	
160												
161	Tearing Load (lb)	55.9	54.7	54.4	55.0000	0.79373	52.9	51.5	52	52.1333	0.70946	
162												
163												
164	2-yr Irr. (with grain)	**** 30 Day ****										

Liner Tear Data

	A	B	C	D	E	F	G	H	I	J	K	L
165	Specimen No.	1	2	3	AG	ST DEV						
166												
167	Specimen Thick (in)	0.0635	0.0635	0.0625								
168	Specimen Thick (in)	0.0641	0.0628	0.0623								
169	Specimen Thick (in)	0.0631	0.0625	0.0626								
170	Specimen Thick (in)	0.0627	0.0632	0.0634								
171	Average (in)	0.0634	0.0630	0.0627	0.0630	0.00033						
172												
173	Tearing Load (lb)	53.21	63.41	53.7	53.43331	0.25166						
174												
175												
176	2-yr Irr. (X-grain)	30 Day										
177	Specimen No.	1	2	3	AG	STOW						
178												
179	Specimen Thick (in)	0.0682	0.069	0.0687								
180	Specimen Thick (in)	0.069	0.0685	0.0692								
181	Specimen Thick (in)	0.0688	0.0689	0.069								
182	Specimen Thick (in)	0.0689	0.069	0.0689								
183	Average (in)	0.0687	0.0689	0.0690	0.0688	0.00011						
184												
185	Tearing Load (lb)	56.9	56.7	56.2	56.6000	0.36058						
186												
187												
188	10-yr Irr. (with grain)	30 Day										
189	Specimen No.	1	2	3	AG	ST DEV						
190												
191	Specimen Thick (in)	0.0661	0.0667	0.0674								
192	Specimen Thick (in)	0.0655	0.0662	0.0663								
193	Specimen Thick (in)	0.0656	0.067	0.0674								
194	Specimen Thick (in)	0.0657	0.0668	0.0683								
195	Average (in)	0.0657	0.0667	0.0674	0.0666	0.00082						
196												
197	Tearing Load (lb)	53.2	53.41	54.21	53.60001	0.52915						
198												
199												
200	10-yr Irr. (X-grain)	30 Day										
201	Specimen No.	1	2	3		ST DEV						
202												
203	Specimen Thick (in)	0.0687	0.0689	0.0665								
204	Specimen Thick (in)	0.0685	0.0686	0.0676								
205	Specimen Thick (in)	0.067	0.0677	0.0686								
206	Specimen Thick (in)	0.0669	0.0667	0.0683								
207	Average (in)	0.0678	0.0680	0.0678	0.0678	0.00012						
208												
209	Tearing Load (lb)	55.41	55.21	55.41	55.33331	0.11547						
210												
211												
212	30-yr Irr. (with grain)	30 Day										
213	Specimen No.	1	2	3	AG	STOW	1	2	3	AG	ST DEV	
214												
215	Specimen Thick (in)	0.0681	0.0653	0.0639			0.0668	0.0669	0.0651			
216	Specimen Thick (in)	0.0681	0.0658	0.0629			0.0668	0.0671	0.0659			
217	Specimen Thick (in)	0.068	0.0659	0.0629			0.0667	0.0669	0.0665			
218	Specimen Thick (in)	0.0674	0.0652	0.0641			0.0665	0.0665	0.066			
219	Average (in)	0.0679	0.0656	0.0635	0.0656	0.00223	0.0667	0.0669	0.0659	0.0665	0.00052	
220												
221	Tearing Load (lb)	53.7	50	49	50.9000	2.47588	50	49.4	48.5	49.3000	0.75498	
222												
223												
224	30-yr Irr. (X-grain)	30 Day										
225	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
226												
227	Specimen Thick (in)	0.071	0.0711	0.0721			0.065	0.0649	0.0653			
228	Specimen Thick (in)	0.0714	0.0712	0.0721			0.0645	0.0648	0.065			
229	Specimen Thick (in)	0.0704	0.0705	0.0705			0.0646	0.0649	0.065			
230	Specimen Thick (in)	0.0697	0.0701	0.0702			0.0649	0.0651	0.0648			
231	Average (in)	0.0706	0.0707	0.0712	0.0709	0.00032	0.0648	0.0649	0.0650	0.0649	0.00014	
232												
233	Tearing Load (lb)	55.71	55.71	55.4	55.60001	0.173211	50	48.7	49.7	49.4667	0.68069	

	A	B	C	D	E	F	G	H	I	J	K	L
1	HDPE LINER (DSSP, 90°) PUNCTURE SUMMARY											
2				Unirradiated					Irradiated			
3	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
4												
5												
6	% Chg. Punc. Force (90°)	0	-3.1065	1.45464	3.5503	9.05141	5.02959	8.357988	3.92012	7.03279	13.0424	16.2167
7	St Dev.	3.53973	0.16014	3.43125	0.92456	2.15741	5.06738	2.092032	2.88693	2.97059	1.75016	2.74579
8												
9	% Chg. Elongation (90°C)	0	-3.7267	14.9068	22.1532	33.5404	7.14286	39.75155	66.6667	14.9068	24.2236	69.2547
10	St Dev.	4.04919	5.37904	3.10559	1.79301	0	4.10831	8.783935	1.79301	1.6E-06	0	37.3317
11	PLOT DATA											
12				Unirradiated					Irradiated			
13	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
14	Punc. Force (90°)	108.16	104.8	109.733	112	117.95	113.6	117.2	112.4	115.767	122.267	125.7
15	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
16	Elongation (90°C)	0.322	0.31	0.37	0.39333	0.43	0.345	0.45	0.53667	0.37	0.4	0.545
17												
18												
19	Virgin Material	PUNCTURE MEASUREMENTS AMBIENT										
20	Specimen No.	1	2	3	4	5	AVG	ST DEV				
21												
22	Specimen Thickness (in)	0.0655	0.0699	0.0656	0.0674	0.0687						
23	Specimen Thickness (in)	0.0648	0.0695	0.0659	0.0662	0.0685						
24	Specimen Thickness (in)	0.0658	0.0694	0.0658	0.0679	0.0689						
25	Specimen Thickness (in)	0.0654	0.0694	0.0659	0.0678	0.0688						
26	Specimen Thickness (in)	0.0659	0.0698	0.0658	0.0671	0.0689						
27	Average (in)	0.0655	0.0696	0.0658	0.0673	0.0688	0.06738	0.00168				
28												
29	Puncture Force (lbf)	104.7	114.7	107.2	107.7	106.5	108.16	3.828577				
30												
31	Elongation (in)	0.32	0.33	0.33	0.33	0.3	0.322	0.013038				
32												
33												
34	30-Day	* * * * 90° C * * * *										
35	Specimen No.	1	2	3	AVG	ST DEV						
36												
37	Specimen Thickness (in)	0.0689	0.0669	0.0681								
38	Specimen Thickness (in)	0.069	0.0675	0.0687								
39	Specimen Thickness (in)	0.0691	0.0689	0.0678								
40	Specimen Thickness (in)	0.0673	0.069	0.0682								
41	Specimen Thickness (in)	0.0678	0.0680	0.0682								
42	Average (in)	0.06842	0.06806	0.0682	0.06823	0.0002						
43												
44	Puncture Force (lbf)	105	104.7	104.7	104.8	0.17321						
45												
46	Elongation (in)	0.3	0.33	0.3	0.31	0.01732						
47												
48												
49	60-Day	* * * * 90° C * * * *										
50	Specimen No.	1	2	3	AVG	ST DEV						
51												
52	Specimen Thickness (in)	0.0705	0.0684	0.0673								
53	Specimen Thickness (in)	0.0697	0.0687	0.0668								
54	Specimen Thickness (in)	0.0701	0.0674	0.0654								
55	Specimen Thickness (in)	0.0701	0.0684	0.0652								
56	Specimen Thickness (in)	0.07	0.0682	0.0671								
57	Average (in)	0.07008	0.06822	0.06636	0.06915	0.0013						
58												
59	Puncture Force (lbf)	113.6	109.4	106.2	109.733	3.71124						
60												
61	Elongation (in)	0.38	0.37	0.36	0.37	0.01						
62												
63												
64	90-Day	* * * * 90° C * * * *										
65	Specimen No.	1	2	3	AVG	ST DEV						
66												
67	Specimen Thickness (in)	0.069	0.0698	0.0708								
68	Specimen Thickness (in)	0.0688	0.0715	0.0708								
69	Specimen Thickness (in)	0.0689	0.0692	0.0709								
70	Specimen Thickness (in)	0.0686	0.0714	0.0702								
71	Specimen Thickness (in)	0.0694	0.0698	0.0702								
72	Average (in)	0.06894	0.07034	0.07058	0.06995	0.0009						
73												
74	Puncture Force (lbf)	113	112	111	112	1						
75												
76	Elongation (in)	0.4	0.39	0.39	0.39333	0.00577						
77												
78												
79	120-Day	* * * * 90° C * * * *										
80	Specimen No.	1	2	AVG	ST DEV							
81												
82	Specimen Thickness (in)	0.067	0.0682									
83	Specimen Thickness (in)	0.0661	0.0658									
84	Specimen Thickness (in)	0.0672	0.0684									
85	Specimen Thickness (in)	0.0675	0.0672									

	A	B	C	D	E	F	G	H	I	J	K	L
86	Specimen Thickness (in)	0.0673	0.067									
87	Average (in)	0.06702	0.06732	0.06717	0.0002							
88												
89	Puncture Force (lbf)	116.3	119.6	117.95	2.33345							
90												
91	Elongation (in)	0.43	0.43	0.43	0							
92												
93												
94	120-day Irrad.	* * * * 30 Day * * * *				* * * * 120 Day * * * *						
95	Specimen No.	1	2	3	AVG	ST DEV	1	2	AVG	ST DEV		
96												
97	Specimen Thickness (in)	0.0695	0.0695	0.067			0.0686	0.0675				
98	Specimen Thickness (in)	0.07	0.0696	0.065			0.0685	0.0669				
99	Specimen Thickness (in)	0.0681	0.069	0.0671			0.069	0.0684				
100	Specimen Thickness (in)	0.0677	0.0692	0.0663			0.0685	0.068				
101	Specimen Thickness (in)	0.0698	0.0698	0.0669			0.069	0.0672				
102	Average (in)	0.06902	0.06942	0.06646	0.0683	0.00161	0.06872	0.0676	0.06816	0.0008		
103												
104	Puncture Force (lbf)	117.8	115.6	107.4	113.6	5.48088	118.8	115.6	117.2	2.26274		
105												
106	Elongation (in)	0.33	0.35	0.355	0.345	0.01323	0.47	0.43	0.45	0.02828		
107												
108												
109	2-year Irrad.	* * * * 30 Day * * * *										
110	Specimen No.	1	2	3	AVG	ST DEV						
111												
112	Specimen Thickness (in)	0.0636	0.063	0.0662								
113	Specimen Thickness (in)	0.0648	0.0636	0.0665								
114	Specimen Thickness (in)	0.0659	0.065	0.0662								
115	Specimen Thickness (in)	0.0638	0.0641	0.0661								
116	Specimen Thickness (in)	0.0638	0.0633	0.0659								
117	Average (in)	0.06438	0.0638	0.06618	0.06479	0.00124						
118												
119	Puncture Force (lbf)	111.4	109.9	115.9	112.4	3.1225						
120												
121	Elongation (in)	0.53	0.54	0.54	0.53667	0.00577						
122												
123												
124	10-year Irrad.	* * * * 30 Day * * * *										
125	Specimen No.	1	2	3	AVG	ST DEV						
126												
127	Specimen Thickness (in)	0.0634	0.0666	0.0679								
128	Specimen Thickness (in)	0.0655	0.0656	0.0688								
129	Specimen Thickness (in)	0.0649	0.0664	0.0688								
130	Specimen Thickness (in)	0.0642	0.0665	0.0672								
131	Specimen Thickness (in)	0.0644	0.0667	0.0668								
132	Average (in)	0.06448	0.06636	0.0679	0.06625	0.00171						
133												
134	Puncture Force (lbf)	112.4	116.1	118.8	115.767	3.21299						
135												
136	Elongation (in)	0.37	0.37	0.37	0.37	5.3E-09						
137												
138												
139	30-year Irrad.	* * * * 30 Day * * * *										
140	Specimen No.	1	2	3	AVG	ST DEV	1	2	AVG	ST DEV		
141												
142	Specimen Thickness (in)	0.0681	0.0691	0.0678			0.0666	0.0688				
143	Specimen Thickness (in)	0.0671	0.0689	0.0649			0.0663	0.069				
144	Specimen Thickness (in)	0.0688	0.0688	0.066			0.0658	0.0691				
145	Specimen Thickness (in)	0.0688	0.0679	0.0675			0.0668	0.0684				
146	Specimen Thickness (in)	0.0678	0.0672	0.0663			0.0669	0.069				
147	Average (in)	0.06812	0.06838	0.0665	0.06767	0.00102	0.06648	0.06886	0.06767	0.0017		
148												
149	Puncture Force (lbf)	123.6	120.1	123.1	122.267	1.89297	127.8	123.6	125.7	2.96985		
150												
151	Elongation (in)	0.4	0.4	0.4	0.4	0	0.63	0.46	0.545	0.12021		

	A	B	C	D	E	F	G	H	I	J	K	L
1					Linear Modulus Data							
2					HDPE LINER (DSSF,90) MODULUS SUMMARY							
3	% Change Elastic Modulus											
4				Unirradiated					Irradiated			
5	Days	0	30	60	90	120	120d/30	120d/120	2-y/30	10-y/30	30-y/30	30-y/120
6												
7												
8	with grain, 90°C	0	-18.487	-1.3163	-1.0581	-5.4448	-11.774	-0.1635	1.56253	5.85417	1.43035	0.97408
9	ST.DEV	10.5197	5.91409	5.90165	7.84516	15.2386	0.22595	12.7102	3.73072	6.82935	8.8775	12.31
10												
11	cross grain, 90°C	0	-9.632	-0.2645	-15.876	-0.7355	-10.181	-9.0334	-1.2485	21.1662	-0.004	14.2902
12	ST.DEV	6.21403	7.34447	3.53517	2.33405	16.3703	4.28976	0.02466	4.63986	0.81898	2.59745	4.11406
13												
14				Unirradiated					Irradiated			
15	Days	0	30	60	90	120	120d/30	120d/120	2-y/30	10-y/30	30-y/30	30-y/120
16	with grain (90°C)	78820.4	64248.6	77782.9	77986.4	74528.8	69540.2	78691.6	80052	83434.7	79947.8	79588.2
17	cross grain (90°)	80914.9	73121.2	80700.9	68068.8	80319.8	72677.1	73605.5	79904.6	98041.5	80911.6	92477.8
18												
19												
20	Virgin Material (with grain)											
21	Specimen No.	1	2	3	4	5	AVG	ST DEV				
22												
23	Specimen Thick (in)	0.0701	0.0676	0.0662	0.0676	0.07						
24	Specimen Thick (in)	0.07	0.0681	0.0669	0.0675	0.0701						
25	Specimen Thick (in)	0.07	0.0679	0.0673	0.0682	0.07						
26	Specimen Thick (in)	0.0701	0.0684	0.0665	0.0671	0.0702						
27	Average (in)	0.07005	0.068	0.06673	0.0676	0.07008	0.06849	0.00142				
28												
29	Specimen Width (in)	0.5	0.5	0.5	0.5	0.5						
30	Specimen Width (in)	0.5	0.5	0.5	0.5	0.5						
31	Specimen Width (in)	0.5	0.5	0.5	0.5	0.5						
32	Specimen Width (in)	0.5	0.5	0.5	0.5	0.5						
33	Average (in)	0.5	0.5	0.5	0.5	0.5	0.5	0				
34												
35	Load (lbf)	30	30	30	30	30	30	0				
36												
37	Cross-sectional area(sq.in)	0.03503	0.034	0.03336	0.0338	0.03504	0.03425	0.00075				
38												
39	Elongation (in)	0.023	0.023	0.021	0.02	0.025	0.0224	0.00195				
40												
41	Modulus (lbf/in2)	74481	76726.3	85639.4	88757.4	68498	78820.4	8291.7				
42												
43												
44	Virgin Material (cross grain)											
45	Specimen No.	1	2	3	4	5	AVG	ST DEV				
46												
47	Specimen Thick (in)	0.0651	0.0687	0.0654	0.0685	0.0689						
48	Specimen Thick (in)	0.0658	0.0673	0.066	0.067	0.0687						
49	Specimen Thick (in)	0.0678	0.066	0.0681	0.0655	0.0678						
50	Specimen Thick (in)	0.0688	0.0648	0.0688	0.0652	0.0658						
51	Average (in)	0.06688	0.0667	0.06708	0.06655	0.0678	0.067	0.00149				
52												
53	Specimen Width (in)	0.5	0.5	0.5	0.5	0.5						
54	Specimen Width (in)	0.5	0.5	0.5	0.5	0.5						
55	Specimen Width (in)	0.5	0.5	0.5	0.5	0.5						
56	Specimen Width (in)	0.5	0.5	0.5	0.5	0.5						
57	Average (in)	0.5	0.5	0.5	0.5	0.5	0.5	0				
58												
59	Load (lbf)	30	30	30	30	30	30	0				
60												
61	Cross-sectional area(sq.in)	0.03344	0.03335	0.03354	0.03328	0.0339	0.0335	0.00024				
62												
63	Elongation (in)	0.02	0.023	0.023	0.023	0.022	0.0222	0.0013				
64												
65	Modulus (lbf/in2)	89719.6	78221.8	77784.4	78398.1	80450.5	80914.9	5028.07				
66												
67												
68	30-Day (with grain)	* * * * 90° C * * * *										
69	Specimen No.	1	2	AVG	ST DEV							
70												
71	Specimen Thick (in)	0.0656	0.0657									
72	Specimen Thick (in)	0.0655	0.0658									
73	Specimen Thick (in)	0.0656	0.0656									
74	Specimen Thick (in)	0.0658	0.0661									
75	Average (in)	0.06563	0.0658	0.06571								
76												
77	Specimen Width (in)	0.5	0.5									
78	Specimen Width (in)	0.5	0.5									

	A	B	C	D	Liner Modulus Data	G	H	I	J	K	L
7 9	Specimen Width (in)	0.5	0.5								
8 0	Specimen Width (in)	0.5	0.5								
8 1	Average (in)	0.5	0.5	0.5							
8 2											
8 3	Load (lbf)	30	30	30							
8 4											
8 5	Cross-sectional area(sq.in)	0.03281	0.0329	0.03286	6.2E-05						
8 6											
8 7	Elongation (in)	0.03	0.027	0.0285	0.00212						
8 8											
8 9	Modulus (lbf/in2)	60952.4	67544.7	64248.6	4661.51						
9 0											
9 1	30-Day (cross grain)	* * * * 90° C * * * *									
9 2	Specimen No.	1	2	AVG	ST DEV						
9 3											
9 4	Specimen Thick (in)	0.067	0.066								
9 5	Specimen Thick (in)	0.068	0.0679								
9 6	Specimen Thick (in)	0.0678	0.0677								
9 7	Specimen Thick (in)	0.0682	0.0683								
9 8	Average (in)	0.06775	0.06748	0.06761							
9 9											
10 0	Specimen Width (in)	0.5	0.5								
10 1	Specimen Width (in)	0.5	0.5								
10 2	Specimen Width (in)	0.5	0.5								
10 3	Specimen Width (in)	0.5	0.5								
10 4	Average (in)	0.5	0.5	0.5							
10 5											
10 6	Load (lbf)	30	30	30							
10 7											
10 8	Cross-sectional area(sq.in)	0.03388	0.03374	0.03381	9.7E-05						
10 9											
11 0	Elongation (in)	0.0257	0.023	0.02435	0.00191						
11 1											
11 2	Modulus (lbf/in2)	68919	77323.3	73121.2	5942.77						
11 3											
11 4											
11 5	60-Day (with grain)	* * * * 90° C * * * *									
11 6	Specimen No.	1	2	AVG	ST DEV						
11 7											
11 8	Specimen Thick (in)	0.0657	0.0663								
11 9	Specimen Thick (in)	0.0659	0.0664								
12 0	Specimen Thick (in)	0.0655	0.0663								
12 1	Specimen Thick (in)	0.0659	0.0665								
12 2	Average (in)	0.06575	0.06638	0.06606							
12 3											
12 4	Specimen Width (in)	0.5	0.5								
12 5	Specimen Width (in)	0.5	0.5								
12 6	Specimen Width (in)	0.5	0.5								
12 7	Specimen Width (in)	0.5	0.5								
12 8	Average (in)	0.5	0.5	0.5							
12 9											
13 0	Load (lbf)	30	30	30							
13 1											
13 2	Cross-sectional area(sq.in)	0.03288	0.03319	0.03303	0.00022						
13 3											
13 4	Elongation (in)	0.0245	0.0223	0.0234	0.00156						
13 5											
13 6	Modulus (lbf/in2)	74493.7	81072.2	77782.9	4651.7						
13 7											
13 8	60-Day (cross grain)	* * * * 90° C * * * *									
13 9	Specimen No.	1	2	AVG	ST DEV						
14 0											
14 1	Specimen Thick (in)	0.0634	0.0637								
14 2	Specimen Thick (in)	0.0639	0.0636								
14 3	Specimen Thick (in)	0.066	0.0632								
14 4	Specimen Thick (in)	0.0669	0.0637								
14 5	Average (in)	0.06505	0.06355	0.0643							
14 6											
14 7	Specimen Width (in)	0.5	0.5								
14 8	Specimen Width (in)	0.5	0.5								
14 9	Specimen Width (in)	0.5	0.5								
15 0	Specimen Width (in)	0.5	0.5								
15 1	Average (in)	0.5	0.5	0.5							
15 2											
15 3	Load (lbf)	30	30	30							
15 4											
15 5	Cross-sectional area(sq.in)	0.03253	0.03178	0.03215	0.00053						
15 6											

	A	B	C	D	Liner Modulus Data	G	H	I	J	K	L
157	Elongation (in)	0.0223	0.024	0.02315	0.0012						
158											
159	Modulus (lbf/in2)	82723.5	78678.2	80700.9	2860.48						
160											
161											
162	90-Day (with grain)	* * * * 90° C * * * *									
163	Specimen No.	1	2	AVG	ST DEV						
164											
165	Specimen Thick (in)	0.071	0.071								
166	Specimen Thick (in)	0.0711	0.0708								
167	Specimen Thick (in)	0.0711	0.0709								
168	Specimen Thick (in)	0.0711	0.0708								
169	Average (in)	0.07108	0.07088	0.07098							
170											
171	Specimen Width (in)	0.5	0.5								
172	Specimen Width (in)	0.5	0.5								
173	Specimen Width (in)	0.5	0.5								
174	Specimen Width (in)	0.5	0.5								
175	Average (in)	0.5	0.5	0.5							
176											
177	Load (lbf)	30	30	30							
178											
179	Cross-sectional area(sq.in)	0.03554	0.03544	0.03549	7.1E-05						
180											
181	Elongation (in)	0.0205	0.023	0.02175	0.00177						
182											
183	Modulus (lbf/in2)	82358.9	73614	77986.4	6183.58						
184											
185	90-Day (cross grain)	* * * * 90° C * * * *									
186	Specimen No.	1	2	AVG	ST DEV						
187											
188	Specimen Thick (in)	0.0672	0.0663								
189	Specimen Thick (in)	0.0663	0.0659								
190	Specimen Thick (in)	0.0656	0.0664								
191	Specimen Thick (in)	0.0669	0.0678								
192	Average (in)	0.0665	0.0666	0.06655							
193											
194	Specimen Width (in)	0.5	0.5								
195	Specimen Width (in)	0.5	0.5								
196	Specimen Width (in)	0.5	0.5								
197	Specimen Width (in)	0.5	0.5								
198	Average (in)	0.5	0.5	0.5							
199											
200	Load (lbf)	30	30	30							
201											
202	Cross-sectional area(sq.in)	0.03325	0.0333	0.03328	3.5E-05						
203											
204	Elongation (in)	0.026	0.027	0.0265	0.00071						
205											
206	Modulus (lbf/in2)	69404.3	66733.4	68068.8	1888.6						
207											
208	120-Day (with grain)	* * * * 90° C * * * *									
209	Specimen No.	1	2	AVG	ST DEV						
210											
211	Specimen Thick (in)	0.065	0.0657								
212	Specimen Thick (in)	0.0647	0.0659								
213	Specimen Thick (in)	0.0649	0.066								
214	Specimen Thick (in)	0.065	0.0652								
215	Average (in)	0.0649	0.0657	0.0653							
216											
217	Specimen Width (in)	0.5	0.5								
218	Specimen Width (in)	0.5	0.5								
219	Specimen Width (in)	0.5	0.5								
220	Specimen Width (in)	0.5	0.5								
221	Average (in)	0.5	0.5	0.5							
222											
223	Load (lbf)	30	30	30							
224											
225	Cross-sectional area(sq.in)	0.03245	0.03285	0.03265	0.00028						
226											
227	Elongation (in)	0.028	0.022	0.025	0.00424						
228											
229	Modulus (lbf/in2)	66035.7	83022	74528.8	12011.2						
230											
231	120-Day (cross grain)	* * * * 90° C * * * *									
232	Specimen No.	1	2	AVG	ST DEV						
233											
234	Specimen Thick (in)	0.0652	0.0654								

	A	B	C	D	Liner Modulus Data	G	H	I	J	K	L
235	Specimen Thick (in)	0.0652	0.0677								
236	Specimen Thick (in)	0.0681	0.0687								
237	Specimen Thick (in)	0.0691	0.0688								
238	Average (in)	0.0669	0.06765	0.06728							
239											
240	Specimen Width (in)	0.5	0.5								
241	Specimen Width (in)	0.5	0.5								
242	Specimen Width (in)	0.5	0.5								
243	Specimen Width (in)	0.5	0.5								
244	Average (in)	0.5	0.5	0.5							
245											
246	Load (lbf)	30	30	30							
247											
248	Cross-sectional area(sq.in)	0.03345	0.03383	0.03364	0.00027						
249											
250	Elongation (in)	0.02	0.025	0.0225	0.00354						
251											
252	Modulus (lbf/in2)	89686.1	70953.4	80319.8	13246						
253											
254											
255	120-d Irr. (with grain)	* * * * 30 Day * * * *				* * * * 120 Day * * * *					
256	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV		
257											
258	Specimen Thick (in)	0.0691	0.0686			0.0699	0.07				
259	Specimen Thick (in)	0.0692	0.0689			0.0698	0.0697				
260	Specimen Thick (in)	0.0693	0.0691			0.0697	0.0701				
261	Specimen Thick (in)	0.069	0.069			0.0699	0.07				
262	Average (in)	0.06915	0.0689	0.06903		0.06983	0.06995	0.06989			
263											
264	Specimen Width (in)	0.5	0.5			0.5	0.5				
265	Specimen Width (in)	0.5	0.5			0.5	0.5				
266	Specimen Width (in)	0.5	0.5			0.5	0.5				
267	Specimen Width (in)	0.5	0.5			0.5	0.5				
268	Average (in)	0.5	0.5	0.5		0.5	0.5	0.5			
269											
270	Load (lbf)	30	30	30		30	30	30			
271											
272	Cross-sectional area(sq.in)	0.03458	0.03445	0.03451	8.8E-05	0.03491	0.03498	0.03494	4.4E-05		
273											
274	Elongation (in)	0.025	0.025	0.025	0	0.024	0.02	0.022	0.00283		
275											
276	Modulus (lbf/in2)	69414.3	69666.2	69540.2	178.096	71607.6	85775.6	78691.6	10018.3		
277											
278	120-d Irr. (X-grain)	* * * * 30 Day * * * *				* * * * 120 Day * * * *					
279	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV		
280											
281	Specimen Thick (in)	0.0675	0.067			0.0655	0.0656				
282	Specimen Thick (in)	0.0662	0.0661			0.066	0.0653				
283	Specimen Thick (in)	0.0668	0.0661			0.0655	0.065				
284	Specimen Thick (in)	0.0657	0.0637			0.0638	0.065				
285	Average (in)	0.06655	0.06573	0.06614		0.0652	0.06523	0.06521			
286											
287	Specimen Width (in)	0.5	0.5			0.5	0.5				
288	Specimen Width (in)	0.5	0.5			0.5	0.5				
289	Specimen Width (in)	0.5	0.5			0.5	0.5				
290	Specimen Width (in)	0.5	0.5			0.5	0.5				
291	Average (in)	0.5	0.5	0.5		0.5	0.5	0.5			
292											
293	Load (lbf)	30	30	30		30	30	30			
294											
295	Cross-sectional area(sq.in)	0.03328	0.03286	0.03307	0.00029	0.0326	0.03261	0.03261	8.8E-06		
296											
297	Elongation (in)	0.024	0.026	0.025	0.00141	0.025	0.025	0.025	0		
298											
299	Modulus (lbf/in2)	75131.5	70222.7	72677.1	3471.06	73619.6	73591.4	73605.5	19.9528		
300											
301											
302	2-yr irr. (with grain)	* * * * 30 Day * * * *									
303	Specimen No.	1	2	AVG	ST DEV						
304											
305	Specimen Thick (in)	0.0633	0.0639								
306	Specimen Thick (in)	0.064	0.0637								
307	Specimen Thick (in)	0.0639	0.0641								
308	Specimen Thick (in)	0.0629	0.0648								
309	Average (in)	0.06353	0.06413	0.06383							
310											
311	Specimen Width (in)	0.5	0.5								
312	Specimen Width	0.5	0.5								

	A	B	C	D	Linear Modulus Data	G	H	I	J	K	L
313	Specimen Width (in)	0.5	0.5								
314	Specimen Width (in)	0.5	0.5								
315	Average (in)	0.5	0.5	0.5							
316											
317	Load (lbf)	30	30	30							
318											
319	Cross-sectional area(sq.in)	0.03176	0.03206	0.03191	0.00021						
320											
321	Elongation (in)	0.023	0.024	0.0235	0.00071						
322											
323	Modulus (lbf/in2)	82131.3	77972.7	80052	2940.57						
324											
325	2-yr Irr. (X-grain)	* * * * 30 Day * * * *									
326	Specimen No.	1	2	AVG	ST DEV						
327											
328	Specimen Thick (in)	0.0632	0.0639								
329	Specimen Thick (in)	0.0638	0.0639								
330	Specimen Thick (in)	0.0652	0.065								
331	Specimen Thick (in)	0.0662	0.0661								
332	Average (in)	0.0646	0.06473	0.06466							
333											
334	Specimen Width (in)	0.5	0.5								
335	Specimen Width (in)	0.5	0.5								
336	Specimen Width (in)	0.5	0.5								
337	Specimen Width (in)	0.5	0.5								
338	Average (in)	0.5	0.5	0.5							
339											
340	Load (lbf)	30	30	30							
341											
342	Cross-sectional area(sq.in)	0.0323	0.03236	0.03233	4.4E-05						
343											
344	Elongation (in)	0.0225	0.024	0.02325	0.00106						
345											
346	Modulus (lbf/in2)	82559.3	77249.9	79904.6	3754.34						
347											
348											
349	10-yr Irr. (with grain)	* * * * 30 Day * * * *									
350	Specimen No.	1	2	AVG	ST DEV						
351											
352	Specimen Thick (in)	0.0686	0.0689								
353	Specimen Thick (in)	0.0685	0.0688								
354	Specimen Thick (in)	0.0684	0.0691								
355	Specimen Thick (in)	0.0685	0.0683								
356	Average (in)	0.0685	0.06878	0.06864							
357											
358	Specimen Width (in)	0.5	0.5								
359	Specimen Width (in)	0.5	0.5								
360	Specimen Width (in)	0.5	0.5								
361	Specimen Width (in)	0.5	0.5								
362	Average (in)	0.5	0.5	0.5							
363											
364	Load (lbf)	30	30	30							
365											
366	Cross-sectional area(sq.in)	0.03425	0.03439	0.03432	9.7E-05						
367											
368	Elongation (in)	0.022	0.02	0.021	0.00141						
369											
370	Modulus (lbf/in2)	79628.4	87241	83434.7	5382.92						
371											
372	10-yr Irr. (X-grain)	* * * * 30 Day * * * *									
373	Specimen No.	1	2	AVG	ST DEV						
374											
375	Specimen Thick (in)	0.0693	0.0682								
376	Specimen Thick (in)	0.0689	0.0684								
377	Specimen Thick (in)	0.068	0.0676								
378	Specimen Thick (in)	0.0671	0.0665								
379	Average (in)	0.06833	0.06768	0.068							
380											
381	Specimen Width (in)	0.5	0.5								
382	Specimen Width (in)	0.5	0.5								
383	Specimen Width (in)	0.5	0.5								
384	Specimen Width (in)	0.5	0.5								
385	Average (in)	0.5	0.5	0.5							
386											
387	Load (lbf)	30	30	30							
388											
389	Cross-sectional area(sq.in)	0.03416	0.03384	0.034	0.00023						
390											

	A	B	C	D	Linear Modulus Data	G	H	I	J	K	L
391	Elongation (in)	0.018	0.018	0.018	0						
392											
393	Modulus (lbf/in ²)	97572.9	98510	98041.5	662.673						
394											
395											
396	30-yr Irr. (with grain)	* * * * 30 Day * * * *				* * * * 120 Day * * * *					
397	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV		
398											
399	Specimen Thick (in)	0.064	0.0642			0.066	0.066				
400	Specimen Thick (in)	0.064	0.0639			0.0659	0.0664				
401	Specimen Thick (in)	0.0642	0.064			0.066	0.0661				
402	Specimen Thick (in)	0.0648	0.0639			0.0661	0.0659				
403	Average (in)	0.06425	0.064	0.06413		0.066	0.0661	0.06605			
404											
405	Specimen Width (in)	0.5	0.5			0.5	0.5				
406	Specimen Width (in)	0.5	0.5			0.5	0.5				
407	Specimen Width (in)	0.5	0.5			0.5	0.5				
408	Specimen Width (in)	0.5	0.5			0.5	0.5				
409	Average (in)	0.5	0.5	0.5		0.5	0.5	0.5			
410											
411	Load (lbf)	30	30	30		30	30	30			
412											
413	Cross-sectional area(sq.in)	0.03213	0.032	0.03206	8.8E-05	0.033	0.03305	0.03303	3.5E-05		
414											
415	Elongation (in)	0.022	0.025	0.0235	0.00212	0.025	0.021	0.023	0.00283		
416											
417	Modulus (lbf/in ²)	84895.6	75000	79947.8	6997.28	72727.3	86449.1	79588.2	9702.8		
418											
419	30-yr Irr. (X-grain)	* * * * 30 Day * * * *				* * * * 120 Day * * * *					
420	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV		
421											
422	Specimen Thick (in)	0.07	0.071			0.0674	0.0656				
423	Specimen Thick (in)	0.0692	0.0699			0.067	0.0671				
424	Specimen Thick (in)	0.0682	0.0675			0.0669	0.0665				
425	Specimen Thick (in)	0.0673	0.069			0.0651	0.0671				
426	Average (in)	0.06868	0.06935	0.06901		0.0666	0.06658	0.06659			
427											
428	Specimen Width (in)	0.5	0.5			0.5	0.5				
429	Specimen Width (in)	0.5	0.5			0.5	0.5				
430	Specimen Width (in)	0.5	0.5			0.5	0.5				
431	Specimen Width (in)	0.5	0.5			0.5	0.5				
432	Average (in)	0.5	0.5	0.5		0.5	0.5	0.5			
433											
434	Load (lbf)	30	30	30		30	30	30			
435											
436	Cross-sectional area(sq.in)	0.03434	0.03468	0.03451	0.00024	0.0333	0.03329	0.03329	8.8E-06		
437											
438	Elongation (in)	0.022	0.021	0.0215	0.00071	0.010	0.02	0.0195	0.00071		
439											
440	Modulus (lbf/in ²)	79425.5	82397.8	80911.6	2101.72	94831.7	90123.9	92477.8	3328.88		

Liner Hardness Data

	A	B	C	D	E	F	G	H	I	J	K	L
1	HDPE LINER (DSSF,90) HARDNESS DATA SUMMARY											
2				UNIRRADIATED						IRRADIATED		
3	Days	0	30	60	90	120	120d/30	120d/120	2-y/30	10-y/30	30-y/30	30-y/120
4												
5	% Change Hardness (90)	0.0	-1.9	-6.8	-0.7	-4.2	-6.4	-2.1	-8.5	-4.9	-1.2	2.4
6												
7	Change in Hardness(90)	0	-1.2	-4.2	-0.4	-2.6	-4.0	-1.3	-5.3	-3.0	-0.8	1.5
8			Unirradiated			PLOT DATA			Irradiated			
9	Days	0	30	60	90	120	120d/30	120d/120	2-y/30	10-y/30	30-y/30	30-y/120
10	Ave. Hardness (90°)	62.15	61	57.9333	61.7333	59.5333	58.2	60.8667	56.8667	59.1333	61.4	63.6667
11	STDEV	1.03999	0.92582	1.57963	1.86956	0.99043	1.08239	1.18723	1.99523	0.99043	0.91026	1.9518
12												
13	Virgin Material	AMBIENT READINGS										
14	Specimen No.	1	2	3	4	Average	ST Dev					
15												
16	Durometer Point Reading	62	61	62	63							
17	Durometer Point Reading	62	60	62	63							
18	Durometer Point Reading	63	62	61	63							
19	Durometer Point Reading	61	64	62	63							
20	Durometer Point Reading	62	64	61	62							
21	Average	62	62.2	61.6	62.8	62.15	1.03999					
22												
23	30-Day			90°								
24	Specimen No.	1	2	3	AVG	STDEV						
25												
26	Durometer Point Reading	62	61	62								
27	Durometer Point Reading	60	62	60								
28	Durometer Point Reading	60	62	61								
29	Durometer Point Reading	60	60	62								
30	Durometer Point Reading	60	61	62								
31	Average	60.4	61.2	61.4	61	0.92582						
32												
33	60-Day			90°								
34	Specimen No.	1	2	3	AVG	STDEV						
35												
36	Durometer Point Reading	59	57	57								
37	Durometer Point Reading	59	57	59								
38	Durometer Point Reading	59	56	56								
39	Durometer Point Reading	59	56	59								
40	Durometer Point Reading	61	56	59								
41	Average	59.4	56.4	58	57.9333	1.57963						
42												
43	90-Day	90 MEASUREMENTS										
44	Specimen No.	1	2	3	Avg	ST DEV						
45												
46	Durometer Point Reading	63	64	61								
47	Durometer Point Reading	63	63	60								
48	Durometer Point Reading	63	62	59								
49	Durometer Point Reading	63	63	58								
50	Durometer Point Reading	63	62	59								
51	Average	63	62.8	59.4	61.7333	1.86956						
52												
53	120-Day	90 MEASUREMENTS										
54	Specimen No.	1	2	3	Avg	ST DEV						
55												
56	Durometer Point Reading	60	58	58								
57	Durometer Point Reading	59	58	60								
58	Durometer Point Reading	60	59	60								
59	Durometer Point Reading	60	60	60								
60	Durometer Point Reading	59	61	61								
61	Average	59.6	59.2	59.8	59.5333	0.99043						
62												
63	120-day Irradiation	30 Days Immersion						120 Day Immersion				
64	Specimen No.	1	2	3	Avg	ST DEV		1	2	3	Avg	ST DEV
65												
66	Durometer Point Reading	59	56	57				60	61	59		
67	Durometer Point Reading	58	60	59				61	60	60		
68	Durometer Point Reading	57	59	57				61	60	63		
69	Durometer Point Reading	58	58	59				61	60	62		

Liner Hardness Data

	A	B	C	D	E	F	G	H	I	J	K	L
7 0	Durometer Point Reading	59	59	58			63	60	62			
7 1	Average	58.2	58.4	58	58.2	1.08233	61.2	60.2	61.2	60.8667	1.187231	
7 2												
7 3	2-year Irradiation	30 Days Immersion										
7 4	Specimen No.	1	2	3	Ava	ST DEV						
7 5												
7 6	Durometer Point Reading	59	55	54								
7 7	Durometer Point Reading	59	55	55								
7 8	Durometer Point Reading	58	56	54								
7 9	Durometer Point Reading	59	57	58								
8 0	Durometer Point Reading	60	56	58								
8 1	Average	59	55.8	55.8	56.8667	1.99523						
8 2												
8 3	10-year Irradiation	30 Days Immersion										
8 4	Specimen No.	1	2	3	Ava	ST DEV						
8 5												
8 6	Durometer Point Reading	59	58	58								
8 7	Durometer Point Reading	59	60	58								
8 8	Durometer Point Reading	60	60	58								
8 9	Durometer Point Reading	59	60	60								
9 0	Durometer Point Reading	59	61	58								
9 1	Average	59.2	59.8	58.4	59.1333	0.99043						
9 2												
9 3	30-year Irradiation	30 Days Immersion					120 Day Immersion					
9 4	Specimen No.	1	2	3	Ava	ST DEV	1	2	3	A w	ST DEV	
9 5												
9 6	Durometer Point Reading	61	61	63			62	65	65			
9 7	Durometer Point Reading	62	60	61			60	65	65			
9 8	Durometer Point Reading	61	60	62			62	66	60			
9 9	Durometer Point Reading	63	61	61			65	64	62			
1 0 0	Durometer Point Reading	61	62	62			65	65	64			
1 0 1	Average	61.6	60.8	61.8	61.4	0.91026	62.8	65	63.2	63.6667	1.9518	

APPENDIX C

RAW AND TABULATED DATA FOR POLYPROPYLENE LINER TESTING

POLYPROPYLENE DIM DATA

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1																
2																
3	Days	0	30	60	90	120	120 d/30	120 d/120	2 y/30	10 y/30	30 y/30	30 y/120				
4																
5	% Change Length (amb)	0.00	-0.38	-0.56	-0.47	-0.56										
6	st dev	0.32	0.00	0.32	0.43	0.32										
7	% Change Length (90°)	0.00	-0.37	-0.56	-0.56	-1.12	0.1897533	0.189753	0.380952	0	0.18975	0.189753				
8	st dev	0	0.32435	0	0	0	0	0	0.326802	0.3268	0	0				
9	% Change Width (amb)	0.00	-0.08	-0.23	-0.15	-0.23										
10	st dev	0.13	0.27	0.27	0.23	0.27										
11	% Change Width (90°)	0.00	0.00	0.15	-0.08	-0.23	0	0	0	0	0	0				
12	st dev	0.23202	0	0.13396	0.13396	0	0	0	0.267705	0.26937	0	0				
13	% Change Thick (amb)	0.00	-0.60	0.15	0.07	-0.20										
14	st dev	14.09	14.84	13.89	14.01	14.35										
15	% Change Thick (90°)	0.00	0.29	0.19	0.12	0.13	0.3004233	0.232145	0.054444	-0.1294	0.12917	0.051666				
16	st dev	9.24196	9.05283	9.34256	9.18389	9.354	17.193277	17.36678	14.83226	4.5006	6.10493	6.272644				
17	% Change Weight (amb)	0.00	0.01	0.11	0.12	0.06										
18	% Change Weight (90°)	0.00	0.14	0.32	0.33	0.13	0.0542692	0.090449	0.0612	0.06697	0.03656	0.158411				
19																
20																
21	Days	0	30	60	90	120	120d/virgin	120 d/30	120 d/120	2y/virgin	2 y/30	10y/virgin	10 y/30	30y/virgin	30 y/30	30 y/120
22	Ave. Length (amb)	178	177	177	177	177										
23	Ave. Length (90°)	178	177	177	177	176	176	176	176	175	176	177	177	176	176	176
24	Ave. Width (amb)	216	216	215	216	215										
25	Ave. Width (90°)	216	216	216	215	215	216	216	216	216	216	214	214	214	214	214
26																
27	Ave. Thick (amb)	184	183	185	184	184										
28	Ave. Thick (90°)	188	188	188	188	188	183	184	184	184	184	193	193	194	194	194
29																
30	Sample Wt. (amb)	166.3	166.3	166.4	166.5	166.4										
31	Sample Wt. (90°)	163.7	163.9	164.2	164.2	163.9	165.8	165.9	166.0	163.4	163.5	164.3	164.4	164.1	164.2	164.4
32																
33																
34	Days	0	30	60	90	120										
35																
36	Length side a-b (mm)	177	177	176	176	176										
37	Length side c-d (mm)	178	177	177	177.5	177										
38	Length through center (mm)	178	177	177	177	177										
39	Average Length (mm)	178	177	177	177	177										
40	ST DEV (mm)	0.57735	0	0.57735	0.76376	0.57735										
41																
42	Width side b-c (mm)	216	216	216	215.5	216										
43	Width side d-a (mm)	215.5	215	215	215	215										
44	Width through center (mm)	216	216	215	216	216										
45	Average Width (mm)	216	216	215	216	215										
46	ST DEV (mm)	0.28868	0.57735	0.57735	0.5	0.57735										
47																
48	Thickness corner a (mil)	163.4	162.5	165	163.4	162.5										
49	Thickness corner b (mil)	160.4	156.8	160.1	160.9	159.7										
50	Thickness corner c (mil)	205	205	204.5	204.8	205										
51	Thickness corner d (mil)	208.5	208.6	208.8	208.7	208.6										
52	Average Thickness (mil)	184	183	185	184	184										
53	ST DEV (mm)	25.9625	27.3608	25.5999	25.8192	26.4505										
54																
55	Liner Weight(grams)	166.25	166.26	166.44	166.45	166.35										
56																
57																
58	Days	0	30	60	90	120										
59																
60	Length side a-b (mm)	178	178	177	177	176										
61	Length side c-d (mm)	178	177	177	177	176										
62	Length through center (mm)	178	177	177	177	176										
63	Average Length (mm)	178	177	177	177	176										
64	ST DEV(mm)	0	0.57735	0	0	0										
65																
66	Width side b-c (mm)	216	215.5	216	215.5	215										
67	Width side d-a (mm)	215.5	215.5	216	215	215										
68	Width through center (mm)	215	215.5	215.5	215.5	215										
69	Average Width (mm)	216	216	216	215	215										
70	ST DEV(mm)	0.5	0	0.28868	0.28868	0										
71																
72	Thickness corner a (mil)	169	170.3	169.3	169.6	169.3										
73	Thickness corner b (mil)	176.8	177.1	176.9	176.8	176.6										
74	Thickness corner c (mil)	201.5	201.8	201.3	201.2	201.5										
75	Thickness corner d (mil)	203.3	203.6	204.5	203.9	204.2										
76	Average Thickness (mil)	188	188	188	188	188										
77	ST DEV (mm)	17.3425	16.9876	17.5313	17.2336	17.5528										
78																
79	Liner Weight (grams)	163.7	163.93	164.22	164.24	163.92										
80																
81																
82	DOSE EQUIVALENT (DAY OR YR)	VIRGIN	120 d	120 d	VIRGIN	2 yr	VIRGIN	10 yr	VIRGIN	30 yr	30 yr					
83	IMMERSION TIME (DAYS)	(120 d)	30	120 (2 yr)	30 (10 yr)	30 (30 yr)										
84																
85	Length side a-b (mm)	175	176	176	175	176	176	176	175	176	176	176				
86	Length side c-d (mm)	176	176	176	175	175	177	177	176	176	176	176				
87	Length through center (mm)	176	176	176	175	176	177	177	176	176	176	176				
88	Average Length (mm)	176	176	176	175	176	177	177	176	176	176	176				
89	ST DEV (mm)	0.57735	0	0	0	0.57735	0.5773503	0.57735	0.57735	0	0	0				
90																
91	Width side b-c (mm)	216	216	216	216	216	215	215	214	214	214	214				
92	Width side d-a (mm)	216	216	216	215	215	214	214	214	214	214	214				
93	Width through center (mm)	216	216	216	216	216	214	214	214	214	214	214				
94	Average Width (mm)	216	216	216	216	216	214	214	214	214	214	214				
95	ST DEV (mm)	0	0	0	0.57735	0.57735	0.5773503	0.57735	0	0	0	0				
96																
97	Thickness corner a (mil)	207.1	207.8	207.9	158	156.5	180.8	180.3	176.8	178	177.5					
98	Thickness corner b (mil)	213.1	213.8	214	162.3	164.2	196.1	196.1	202.9	202.6	202.9					
99	Thickness corner c (mil)	156.6	156.9	156.1	208.8	208.2	195.3	195	203.2	203.1	203.1					
100	Thickness corner d (mil)	155.5	156	156	205.6	206.2	200.4	200.2	191.3	191.5	191.1					
101	Average Thickness (mil)	183	184	184	184	184	193	193	194	194	194					
102	ST DEV (mm)	31.305	31.4766	31.7942	27.2523	27.2431	8.5324869	8.692909	12.46555	11.8161	12.1407					
103																
104	Liner Weight(grams)	165.84	165.93	165.99	163.4	163.5	164.25	164.36	164.13	164.19	164.39					

POLYPROPYLENE Vol Data

	A	B	C	D	E	F	G	H	I	J	K	L
1					POLYPROPYLENE VOLATILES SUMMARY							
2			UNIRRADIATED						IRRADIATED			
3	Days	0	30	60	90	120	120 d/30	120 d/120	2 y/30	10 y/30	30 y/30	30 y/120
4												
5	% Chg. Volatiles (amb)	0.0	133.3	180.5	1278.7	437.0						
6	% Chg. Volatiles (90°)	0.0	679.5	529.2	1012.9	32.1	361.3	429.2	408.2	771.1	965.6	722.0
7												
8					PLOT DATA							
9			UNIRRADIATED						IRRADIATED			
10	Days	0	30	60	90	120	120 d/30	120 d/120	2 y/30	10 y/30	30 y/30	30 y/120
11	% Volatiles (amb)	0.00899	0.0233	0.02602	0.1377	0.05363						
12	st dev	0.00374	0.00206	0.00236	0.01366	0.00839						
13	% Volatiles (90°)	0.00999	0.07785	0.06284	0.11115	0.01319	0.04607	0.052855	0.05076	0.087	0.10642	0.0821
14		0.00374	0.03082	0.00689	0.01725	0.00751	0.00956	0.003285	0.00179	0.0141	0.05209	0.04338
15												
16	Virgin Material, Unirrad.	AMBIENT READINGS										
17	Specimen No.	1	2	3	4	5	AG	ST DEV				
18												
19	"Wet" weight (g)	4.133	4.3155	3.9804	4.4083							
20	"Dried" weight (g)	4.1326	4.3149	3.9802	4.4078							
21	Weight difference (g)	0.0004	0.0006	0.0002	0.0005							
22	% Volatiles	0.00968	0.0139	0.00502	0.01134		0.00999	0.003737				
23												
24	30-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->						
25	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
26												
27	"Wet" weight (g)	4.0071	4.2885	4.1739			3.9596	4.6416	4.2525			
28	"Dried" weight (g)	4.0061	4.2876	4.1729			3.9579	4.6369	4.2487			
29	Weight difference (g)	0.001	0.0009	0.001			0.0017	0.0047	0.0038			
30	% Volatiles	0.02496	0.02099	0.02396	0.0233	0.00206	0.04293	0.101258	0.08936	0.07785	0.03082	
31												
32	60-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->						
33	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
34												
35	"Wet" weight (g)	4.4145	4.291	4.3532			4.2878	4.3006	4.3001			
36	"Dried" weight (g)	4.4133	4.29	4.352			4.2854	4.2976	4.2974			
37	Weight difference (g)	0.0012	0.001	0.0012			0.0024	0.003	0.0027			
38	% Volatiles	0.02718	0.0233	0.02757	0.02602	0.00236	0.05597	0.069758	0.06279	0.06284	0.00689	
39												
40	90-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->						
41	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
42												
43	"Wet" weight (g)	4.2897	4.3299	4.1449			4.0317	3.7288	4.074			
44	"Dried" weight (g)	4.2839	4.3233	4.1397			4.0279	3.724	4.0695			
45	Weight difference (g)	0.0058	0.0066	0.0052			0.0038	0.0048	0.0045			
46	% Volatiles	0.13521	0.15243	0.12546	0.1377	0.01366	0.09425	0.128728	0.11046	0.11115	0.01725	
47												
48	120-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->						
49	Specimen No.	1	2	AG	ST DEV	1	2	AG	ST DEV			
50												
51	"Wet" weight (g)	3.7734	3.8613				3.8042	3.7835				
52	"Dried" weight (g)	3.7716	3.859				3.8039	3.7828				
53	Weight difference (g)	0.0018	0.0023				0.0003	0.0007				
54	% Volatiles	0.0477	0.05957	0.05363	0.00839	0.00789	0.0185	0.013194	0.00751			
55												
56	120-Day Dose, 90 C	<- - - 30-day Imm. - - ->				<- - - 120-day Imm. - - ->						
57	Specimen No.	1	2	3	AG	ST DEV	1	2	AG	ST DEV		
58												
59	"Wet" weight (g)	3.869	4.2179	4.3954			4.3536	3.9871				
60	"Dried" weight (g)	3.8668	4.2161	4.3937			4.3514	3.9849				
61	Weight difference (g)	0.0022	0.0018	0.0017			0.0022	0.0022				
62	% Volatiles	0.05686	0.04268	0.03868	0.04607	0.00956	0.05053	0.055178	0.05286	0.00328		
63												
64	2-Year Dose, 90 C	<- - - 30-day Imm. - - ->				<- - - 120-day Imm. - - ->						
65	Specimen No.	1	2	3	AG	ST DEV						
66												
67	"Wet" weight (g)	4.2623	4.1065	4.2348								
68	"Dried" weight (g)	4.2601	4.1045	4.2326								
69	Weight difference (g)	0.0022	0.002	0.0022								
70	% Volatiles	0.05162	0.0487	0.05195	0.05076	0.00179						
71												
72	10-Year Dose, 90 C	<- - - 30-day Imm. - - ->				<- - - 120-day Imm. - - ->						
73	Specimen No.	1	2	3	AG	ST DEV						
74												
75	"Wet" weight (g)	4.2305	4.1731	4.0415								
76	"Dried" weight (g)	4.2274	4.1695	4.0374								
77	Weight difference (g)	0.0031	0.0036	0.0041								
78	% Volatiles	0.07328	0.08627	0.10145	0.087	0.0141						
79												
80	30-Year Dose, 90 C	<- - - 30-day Imm. - - ->				<- - - 120-day Imm. - - ->						
81	Specimen No.	1	2	3	AG	ST DEV	1	2	AG	ST DEV		
82												
83	"Wet" weight (g)	4.5938	4.1042	4.2636			3.7243	4.0841				
84	"Dried" weight (g)	4.5863	4.1003	4.261			3.7201	4.082				
85	Weight difference (g)	0.0075	0.0039	0.0026			0.0042	0.0021				
86	% Volatiles	0.16326	0.09502	0.06098	0.10642	0.05209	0.11277	0.051419	0.0821	0.04338		

POLYPROPYLENE Extract. Data

	A	B	C	D	E	F	G	H	I	J
1	POLYPROPYLENE EXTRACTABLES SUMMARY									
2										
3	Days	0	30	60	90	120				
4										
5	% Chg. Extractables (amb)	0.0	18.5	21.4	-43.6	32.5				
6	% Chg. Extractables (90°)	0.0	-2.0	47.8	4.6	79.5				
7										
8										
9	PLOT DATA									
10	Days	0	30	60	90	120				
11	% Extractables (amb)	0.4049	0.47964	0.49173	0.228181	0.53662				
12	st dev	0.07695	0.07168	0.14918	0.026225	0.07223				
13	% Extractables (90°)	0.4049	0.39678	0.59861	0.423395	0.72686				
14	st dev	0.07695	0.0181	0.07469	0.229652	0.09874				
15										
16	Virgin Material, Unirrad.	AMBIENT READINGS								
17	Specimen No.	1	2	3	4	5	AVG	stdev		
18										
19	"Dried" weight (g)	5.6469	5.561	5.6981	5.6785					
20	"Extracted" weight (g)	5.6267	5.5393	5.6686	5.6584					
21	Weight difference (g)	0.0202	0.0217	0.0295	0.0201					
22	% Extractables	0.35772	0.39022	0.51772	0.353967		0.4049	0.076949		
23										
24	30-Day, Unirrad.	<- - - AMBIENT - - ->			<- - - 90° - - ->					
25	Specimen No.	1	2	AVG	1	2	AVG	stdev,amb	stdev,75	
26										
27	"Dried" weight (g)	5.638	5.6416		5.6156	5.6253				
28	"Extracted" weight (g)	5.6081	5.6174		5.5926	5.6037				
29	Weight difference (g)	0.0299	0.0242		0.023	0.0216				
30	% Extractables	0.53033	0.42896	0.47964	0.409573	0.38398	0.39678	0.071682	0.018098	
31										
32	60-Day, Unirrad.	<- - - AMBIENT - - ->			<- - - 90° - - ->					
33	Specimen No.	1	2	AVG	1	2	AVG	stdev,amb	stdev,75	
34										
35	"Dried" weight (g)	5.7736	5.827		5.7413	5.8996				
36	"Extracted" weight (g)	5.7513	5.7922		5.7039	5.8674				
37	Weight difference (g)	0.0223	0.0348		0.0374	0.0322				
38	% Extractables	0.38624	0.59722	0.49173	0.65142	0.5458	0.59861	0.149185	0.074685	
39										
40	90-Day, Unirrad.	<- - - AMBIENT - - ->			<- - - 90° - - ->					
41	Specimen No.	1	2	AVG	1	2	AVG	stdev,amb	stdev,75	
42										
43	"Dried" weight (g)	6.0581	6.2823		6.2139	6.0535				
44	"Extracted" weight (g)	6.0454	6.2668		6.1775	6.0377				
45	Weight difference (g)	0.0127	0.0155		0.0364	0.0158				
46	% Extractables	0.20964	0.24672	0.22818	0.585783	0.26101	0.42339	0.026225	0.229652	
47										
48	120-Day, Unirrad.	<- - - AMBIENT - - ->			<- - - 90° - - ->					
49	Specimen No.	1	2	AVG	1	2	3	AVG	stdev,amb	stdev,75
50										
51	"Dried" weight (g)	5.396	5.1728		5.1526	5.1094	5.2555			
52	"Extracted" weight (g)	5.3698	5.1424		5.12	5.0727	5.2119			
53	Weight difference (g)	0.0262	0.0304		0.0326	0.0367	0.0436			
54	% Extractables	0.48554	0.58769	0.53662	0.63269	0.71828	0.82961	0.72686	0.072227	0.09874

POLYPROPYLENE Sp.G Data

	A	B	C	D	E	F	G	H	I	J	K
1	POLYPROPYLENE SPECIFIC GRAVITY SUMMARY										
2											
3	Days	0	30	60	90	120					
4											
5	% Sp gr 23/23 (amb)	0.0	-0.2	0.2	0.3	0.2					
6	st dev	0.2	0.2	0.1	0.0	0.2					
7	% Sp gr 23/23 (90°)	0.0	0.1	0.4	0.1	-0.1					
8	st dev	0.19735	0.14112	0.0502	0.18953	0.16824					
9											
10				PLOT DATA							
11	Days	0	30	60	90	120					
12	Sp gr 23/23 (amb)	0.90164	0.89993	0.90299	0.90402	0.90326					
13	Sp gr 23/23 (90°)	0.90164	0.90214	0.90505	0.9027	0.90031					
14											
15											
16	Virgin Material, Unlrrad.	AMBIENT READINGS									
17	Specimen No.	1	2	3	4	5	AVG	ST DEV			
18											
19	Weight in air (g)	4.133	4.3155	3.9804	4.4083						
20	Weight immersed (g)	3.941	3.9344	3.9689	3.9279						
21	Weight of sinker (g)	4.4047	4.3985	4.4032	4.402						
22	Sp gr 23/23	0.89912	0.9029	0.90162	0.9029		0.90164	0.00178			
23											
24	30-Day, Unlrrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->					
25	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV
26											
27	Weight in air (g)	4.0071	4.2885	4.1739			3.9596	4.6416	4.2525		
28	Weight immersed (g)	4.1187	4.1019	4.1025			4.1458	4.0729	4.104		
29	Weight of sinker (g)	4.5717	4.569	4.5685			4.5736	4.5704	4.5727		
30	Sp gr 23/23	0.89843	0.90178	0.89957	0.89993	0.0017	0.90249	0.90319	0.90072	0.90214	0.00127
31											
32	60-Day, Unlrrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->					
33	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV
34											
35	Weight in air (g)	4.4145	4.291	4.3532			4.2878	4.3006	4.3001		
36	Weight immersed (g)	4.1092	4.1366	4.1256			4.142	4.143	4.1383		
37	Weight of sinker (g)	4.5915	4.5915	4.5915			4.5918	4.5918	4.5918		
38	Sp gr 23/23	0.90151	0.90415	0.90332	0.90299	0.00135	0.90506	0.9055	0.9046	0.90505	0.00045
39											
40	90-Day, Unlrrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->					
41	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV
42											
43	Weight in air (g)	4.2897	4.3299	4.1449			4.0317	3.7288	4.074		
44	Weight immersed (g)	4.0665	4.0596	4.0842			4.0921	4.1248	4.073		
45	Weight of sinker (g)	4.5221	4.5215	4.522			4.522	4.522	4.522		
46	Sp gr 23/23	0.90399	0.90361	0.90447	0.90402	0.00043	0.90364	0.90373	0.90073	0.9027	0.00171
47											
48	120-Day, Unlrrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->					
49	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV
50											
51	Weight in air (g)	3.773	3.861	3.68			3.804	3.783	4.518		
52	Weight immersed (g)	4.116	4.109	4.138			4.105	4.109	4.013		
53	Weight of sinker (g)	4.525	4.525	4.525			4.523	4.523	4.523		
54	Sp gr 23/23	0.9022	0.90274	0.90484	0.90326	0.0014	0.90099	0.90136	0.89857	0.90031	0.00152

POLYPROPYLENE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
1					POLYPROPYLENE TENSILE SUMMARY							
2			UNIRRADIATED						IRRADIATED			
3	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
4												
5	% Cb. Elong. at Yield											
6	with grain, amb	0.0	1.21	-1.71	-0.7	-3.0						
7	st dev	3.6	2.5	0.0	1.5	5.8						
8	with grain, 90°C	0.0	36.8	35.4	23.7	46.31	11.4	33.9	14.3	43.61	23.7	-14.8
9	st dev	3.61	12.61	3.8	3.3	0.0	3.8	3.3	25.4	48.6	2.5	#DIV/0!
10	cross grain, amb	0.0	-0.6	-1.31	-6.3	-5.51						NO YLD 2@3
11	st dev	1.2	1.2	3.6	2.4	0.0						
12	cross grain, 90°C	0.0	41.8	37.3	31.7	21.1	9.2	28.2	11.3	11.3	11.3	63.8
13	st dev	1.2	1.5	6.1	1.2	8.5	7.6	3.8	0.0	0.0	0.0	9.2
14	% Chg. Elong. at Break											
15	with grain, amb	0.0	112.0	-38.6	36.2	-20.9						
16	st dev	37.9	25.7	13.5	14.0	14.7						
17	with grain, 90°C	0.0	104.1	112.0	129.7	30.0	-44.1	48.5	58.9	-80.3	-73.6	-95.3
18	st dev	37.9	6.3	27.2	16.1	69.7	16.5	61.2	67.3	9.6	4.6	3.4
19	cross grain, amb	0.0	16.1	-42.01	6.5	-19.9						
20	st dev	42.11	17.61	21.2	25.51	9.6						
21	cross grain, 90°C	0.0	29.8	-6.7	-11.8	14.1	-34.1	-70.8	-12.9	-71.11	-86.3	-89.2
22	st dev	42.1	15.2	19.4	30.9	8.3	3.4	211	41.0	4.7	2.6	0.5
23	% Chg Yield Strength											
24	with grain, amb	0.0	0.6	10.4	6.5	6.8						
25	st dev	0.7	1.8	1.1	0.2	1.0						
26	with grain, 90°C	0.0	-8.6	-4.0	-8.7	-4.8	1.8	-3.6	-14.8	-3.8	8.6	-7.7
27	st dev	0.7	0.3	1.2	0.2	0.5	1.3	2.6	19.8	6.8	0.5	#DIV/0!
28	cross grain, amb	0.0	-0.3	10.6	1.9	2.3						NO YLD 2@3
29	st dev	0.6	0.5	0.5	0.4	1.2						
30	cross grain, 90°C	0.0	-11.5	-7.9	-9.9	-4.4	-2.0	-2.2	-6.5	-5.8	6.6	1.1
31	st dev	0.6	0.0	0.7	0.3	4.2	0.2	1.7	1.5	0.3	1.1	2.3
32	% Chg Break Strength											
33	with grain, amb	0.0	4.3	5.3	4.9	3.9						
34	st dev	1.4	2.0	2.7	2.0	3.8						
35	with grain, 90°C	0.0	10.7	13.6	12.2	12.2	5.8	10.3	-14.0	-50.5	6.3	-16.4
36	st dev	1.4	5.5	3.0	1.8	8.4	1.5	1.4	23.4	22.5	7.5	30.3
37	cross grain, amb	0.0	-0.2	1.6	-1.9	-0.8						
38	st dev	3.4	2.8	1.7	1.7	0.3						
39	cross grain, 90°C	0.0	2.8	2.3	6.1	10.1	2.3	2.0	-21.8	-4.8	-4.9	29.9
40	st dev	3.4	2.8	4.6	2.8	3.7	1.8	0.6	3.8	8.2	4.6	4.0
41	% Chg Stress 100% Elong.											
42	with grain, amb	0.0	3.5	10.3	3.5	5.2						
43	st dev	3.2	4.7	2.2	0.5	1.7						
44	with grain, 90°C	0.0	21.9	22.0	15.8	14.4	4.4	19.4	-0.5	-26.0	#VALUE!	-100.0
45	st dev	3.2	7.8	0.6	1.2	8.9	0.9	3.8	21.5	27.2	#VALUE!	0.0
46	cross grain, amb	0.0	-0.1	6.4	1.3	-0.6						
47	st dev	0.9	3.0	1.5	0.5	1.7						
48	cross grain, 90°C	0.0	3.3	13.3	6.6	20.6	11.6	4.1	1.9	-4.3	#VALUE!	#VALUE!
49	st dev	0.9	1.7	4.7	2.7	0.8	1.8	1.3	10.4	2.2	#VALUE!	#VALUE!
50	% Chg Stress 200% Elong.											
51	with grain, amb	0.0	-0.6	-0.8	2.5	0.7						
52	st dev	2.5	1.7	0.7	0.3	2.2						
53	with grain, 90°C	0.0	5.1	4.2	2.8	6.6	2.5	6.3	-13.8	#VALUE!	#VALUE!	-100.0
54	st dev	2.5	6.2	1.4	1.4	3.1	#DIV/0!	1.8	21.3	#VALUE!	#VALUE!	0.0
55	cross grain, amb	0.0	-0.2	2.0	-1.1	-1.3						
56	st dev	0.8	2.0	2.4	0.6	2.7						
57	cross grain, 90°C	0.0	0.9	2.1	5.5	8.6	6.1	#VALUE!	-6.5	#VALUE!	#VALUE!	#VALUE!
58	st dev	0.8	0.8	3.2	0.6	3.6	2.7	#VALUE!	11.3	#VALUE!	#VALUE!	#VALUE!
59	% Chg Elastic Modulus											
60	with grain, amb	0.0	-0.6	12.2	7.2	11.4						
61	st dev	3.1	1.2	1.1	1.5	6.9						
62	with grain, 90°C	0.0	-32.9	-29.1	-26.2	-35.0	-8.6239	-28.074	-25.349	-27.461	-12.248	#DIV/0!
63	st dev	3.1	6.3	2.2	2.1	0.3	2.1	1.1	18.1	21.7	1.7	#DIV/0!
64	cross grain, amb	0.0	0.2	12.1	11.1	8.2						
65	st dev	1.7	0.8	4.8	2.8	1.3						
66	cross grain, 90°C	0.0	-37.6	-32.8	-31.5	-21.0	-10.023	-23.69672	-16.075	-15.425	-4.26299	-38.25018
67	st dev	1.67297	0.62651	3.5162078	0.66700239	2.7948328	6.48289	1.1331002	1.31923	0.24125	0.980416	2.2539765
68												
69												
70			UNIRRADIATED			TENSILE PLOTS			IRRADIATED			
71	% Elong. at Yield											
72	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
73	with grain, amb	22.9	23.1667	22.5	22.75	22						
74	with grain, 90°C	22.9	31.3333	31	28.333333	33.5	25.5	30.666667	26.1667	32.875	28.33333	19.5
75	cross grain, amb	23.8	23.6667	23.5	21.833333	22.5						
76	cross grain, 90°C	23.8	33.75	32.666667	31.333333	28.833333	26	30.5	26.5	26.5	26.5	39
77	% Elong. at Break											
78	Days	0	30	60	90	120						
79	with grain, amb	307.8	652	188.83333	419	243.33333						
80	with grain, 90°C	307.6	627.667	652.166667	706.666667	400	172	456.66667	488.833	122.25	81.33333	14.5
81	cross grain, amb	616.8	715.667	357.666667	656.666667	494.16667						
82	cross grain, 90°C	616.8	800.25	575.5	543.666667	703.33333	406.167	180	537.167	178.333	84.66667	66.666667
83	Yield Strength (psi)											
84	Days	0	30	60	90	120						
85	with grain, amb	3161.96	3182.37	3489.96563	3368.69894	3377.2586						
86	with grain, 90°C	3161.96	2890.48	3035.78824	2887.33853	3009.9118	3218.48	3048.1399	2694.19	3046.64	3435.143	2917.5498
87	cross grain, amb	3217.66	3207.1	3558.73441	3279.87595	3292.7347						
88	cross grain, 90°C	3217.66	2847.8	2965.02735	2900.29475	3074.5425	3152.72	3146.0663	3007.23	3030.52	3430.47	3252.0102
89	Break Strength (psi)											
90	Days	0	30	60	90	120						
91	with grain, amb	2282.44	2380.55	2403.90212	2394.64562	2370.6786						
92	with grain, 90°C	2282.44	2525.93	2592.28443	2561.58055	2561.8197	2415.68	2517.9263	1962.24	1129.31	2427.004	1907.5604
93	cross grain, amb	2376.35	2370.62	2413.23786	2331.94084	2357.8533						
94	cross grain, 90°C	2376.35	2441.88	2432.04224	2520.72836	2617.4776	2430.23	2423.6881	1857.22	2263.36	2260.043	3087.9071

POLYPROPYLENE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
95	Stress at 100% elong.											
96	Days	0	30	60	90	120						
97	with grain, amb	2216.22	2292.85	2443.72953	2292.77407	2330.4597						
98	with grain, 90°C	2216.22	2702.08	2703.13032	2561.12873	2535.7613	2314.88	2846.7393	2204.32	1638.9	#VALUE!	0
99	cross grain, amb	2304.62	2302.36	2451.3408	2334.64472	2289.7003						
100	cross grain, 90°C	2304.62	2381.44	2612.22941	2456.95544	2778.7602	2572.41	2399.594	2348.01	2204.5	#VALUE!	#VALUE!
101	Stress at 200% elong.											
102	Days	0	30	60	90	120						
103	with grain, amb	2354.56	2339.92	2336.66784	2412.44085	2370.8077						
104	with grain, 90°C	2354.56	2474.67	2452.29468	2416.37219	2510.6019	2413.88	2502.6751	2029.74	#VALUE!	#VALUE!	0
105	cross grain, amb	2361.51	2357.25	2408.97114	2334.6548	2330.4277						
106	cross grain, 90°C	2361.51	2381.65	2412.20093	2490.31344	2563.6116	2505.01	#VALUE!	2206.95	#VALUE!	#VALUE!	#VALUE!
107	Elastic Modulus	0	30	60	90	120						
108	with grain, amb	13819.7	13738.9	15510.9583	14809.0408	15388.76						
109	with grain, 90°C	13819.7	9278.7	9798.0041	10195.7286	8984.8113	12627.9	9939.9827	10316.6	10024.6	12127.09	#DIV/0!
110	cross grain, amb	13521.8	13552	15159.3975	15028.8533	14634.377						
111	cross grain, 90°C	13521.8	8438.38	9090.60255	9256.78357	10678.786	12186.3	10317.419	11348	11435.9	12945.17	8349.5599
112												
113												
114	UNIRRAD											
115	Virgin Material (with grain)	TENSILE MEASUREMENTS AMBIENT										
116	Specimen No.	1	2	3	4	5	Average	St Dev				
117												
118	Neck Thick (mil)	157.2	195.9	184.2	196	180						
119	Neck Thick (mil)	157.4	194	185.5	196.1	177.1						
120	Neck Thick (mil)	158	191	185.7	195.8	172.4						
121	Neck Thick (mil)	161.2	190.2	187.3	198.4	171						
122	Average (mil)	158	193	186	197	175	181.705	14.250779				
123	St. Dev. (mil)	1.86458	2.64874	1.27115433	1.29357388	4.1676332						
124	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
125	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
126	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
127	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
128	Average (in)	0.250	0.250	0.250	0.250	0.250	0.25	0				
129	St. Dev. (mil)	0	0	0	0	0						
130	Elongation at Yield (in)	0.44	0.45	0.45	0.47	0.48						
131	% Elongation at Yield	22	22.5	22.5	23.5	24	22.9	0.8215838				
132	Elongation at Break (in)	6.88	3.74	9.81	5.31	5.02						
133	% Elongation at Break	344	187	490.5	265.5	251	307.6	116.50933				
134												
135	Load at Yield (lb)	125	150.8	146.6	156.7	139.1						
136	Yield Stress (psi)	3155.8	3129.0	3158.2	3189.0	3177.2	3161.86	23.163473				
137	Load at Break (lb)	92	108	107	111	100						
138	Break Strength (psi)	2322.5	2241.0	2305.1	2259.5	2284.1	2282.44	33.039439				
139	"YIELD" Modulus (psi)	14343.5	13908.8	14036.4735	13573.7101	13238.163	13819.7	426.50986				
140	Load at 100% Elong (lb)	90	102	106	110	95						
141	Stress at 100% Elong (psi)	2272.0	2116.5	2283.6	2239.2	2169.9	2216.22	71.194818				
142	Load at 200% Elong (lb)	96		110	115	100						
143	Stress at 200% Elong (psi)	2423.5		2369.7	2341.0	2284.1	2354.56	58.113717				
144												
145												
146												
147	UNIRRAD											
148	Virgin Material (cross grain)	TENSILE MEASUREMENTS AMBIENT										
149	Specimen No.	1	2	3	4	5	Average	St Dev				
150												
151	Neck Thick (mil)	195.5	202	199.4	198.2	199.2						
152	Neck Thick (mil)	197.2	200.5	199.6	200.1	200.5						
153	Neck Thick (mil)	201	195	199.8	198.8	198.7						
154	Neck Thick (mil)	203.1	198.6	202	199.8	199.8						
155	Average (mil)	199	199	200	199	200	199.44	1.9940438				
156	StDev (mil)	3.47083	3.02255	1.21106014	0.88081402	0.7767453						
157	Neck Width (in)	0.253	0.25	0.25	0.25	0.25						
158	Neck Width (in)	0.249	0.25	0.25	0.25	0.25						
159	Neck Width (in)	0.25	0.25	0.25	0.25	0.25						
160	Neck Width (in)	0.252	0.25	0.25	0.25	0.25						
161	Average (in)	0.251	0.250	0.250	0.250	0.250	0.2502	0.0008335				
162	StDev (mil)	0.00183	0	0	0	0						
163	Elongation at Yield (in)	0.48	0.48	0.47	0.47	0.48						
164	% Elongation at Yield	24	24	23.5	23.5	24	23.8	0.2738613				
165	Elongation at Break (in)	15.8	17	3.82	11.63	13.41						
166	% Elongation at Break	790	850	191	581.5	670.5	616.6	259.71893				
167												
168	Load at Yield (lb)	159.5	160.7	161.7	161.2	159.7						
169	Yield Stress (psi)	3190.1	3229.7	3230.8	3236.5	3201.2	3217.66	20.661021				
170	Load at Break (lb)	123	118.9	115	114	122						
171	Break Strength (psi)	2460.0	2389.6	2297.7	2288.9	2445.5	2376.35	80.313698				
172	"YIELD" Modulus (psi)	13291.9	13457.3	13747.9542	13772.5174	13338.345	13521.6	226.21236				
173	Load at 100% Elong (lb)	114	114	116	116	115						
174	Stress at 100% Elong (psi)	2280.0	2291.2	2317.7	2329.0	2305.2	2304.62	19.696539				
175	Load at 200% Elong (lb)	118	117		119	117						
176	Stress at 200% Elong (psi)	2360.0	2351.5		2389.3	2345.3	2361.51	19.464401				
177												
178												
179												
180	UNIRRAD											
181	30-Day (with grain)	**** AMBIENT ****					**** 90° C ****					
182	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
183												
184	Neck Thick (mil)	196.8	198.3	195			184.1	170	176			
185	Neck Thick (mil)	198.3	200.8	195.5			180.2	168.5	172.6			
186	Neck Thick (mil)	199.5	199.2	195.5			180.1	170	172.8			
187	Neck Thick (mil)	200.5	198.2	195.2			183.1	171.9	174.8			
188	Average (mil)	199	199	195			182	170	174			

POLYPROPYLENE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
189												
190	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
191	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
192	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
193	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
194	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
195												
196	Elongation at Yield (in)	0.45	0.47	0.47			0.58	0.66	0.66			
197	% Elongation at Yield	22.5	23.5	23.5	23.1666667	0.5773503	28	33	33	31.3333	2.886751	
198	Elongation at Break (in)	14.59	11.43	13.1			12.33	12.33	13			
199	% Elongation at Break	729.5	571.5	655	652	79.04271	616.5	616.5	650	627.667	19.34123	
200												
201	Load at Yield (lb)	155.2	158.7	158			131	122.8	126.3			
202	Yield Strength (psi)	3123.1	3187.9	3236.0	3182.4	56.7	2881.1	2887.7	2902.8	2890.5	11.0	
203	Load at Break (lb)	119	116	118			110	106	116			
204	Break Strength (psi)	2394.7	2330.2	2416.8	2380.8	45.0	2419.2	2492.7	2665.9	2525.9	126.7	
205	*YIELD* Modulus (psi)	13880.6	13565.7	13770.4132	13738.9	159.8	10289.6	8750.6458	8795.8	9278.7	875.8	
206	Load at 100% Elong (lb)	108	118	114			115	115	125			
207	Stress at 100% Elong (psi)	2173.3	2370.4	2334.9	2292.9	105.0	2529.2	2704.3	2872.7	2702.1	171.8	
208	Load at 200% Elong (lb)	114	118	115			105	110	110			
209	Stress at 200% Elong (psi)	2294.1	2370.4	2355.4	2339.9	40.4	2309.3	2586.7	2528.0	2474.7	146.2	
210												
211												
212												
213	UNIRRAD											
214	30-Day (cross grain)	*** AMBIENT ***					*** 90° C ***					
215	Specimen No	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
216												
217	Neck Thick (mil)	194.2	194.3	195.3			199.5	200.2				
218	Neck Thick (mil)	192.8	193.8	194			199	198.7				
219	Neck Thick (mil)	194	195	197.1			196.8	199.3				
220	Neck Thick (mil)	196	197	198.3			193.2	198.8				
221	Average (mil)	194	195	196			197	199				
222												
223	Neck Width (in)	0.25	0.25	0.25			0.25	0.25				
224	Neck Width (in)	0.25	0.25	0.25			0.25	0.25				
225	Neck Width (in)	0.25	0.25	0.25			0.25	0.25				
226	Neck Width (in)	0.25	0.25	0.25			0.25	0.25				
227	Average (in)	0.250	0.250	0.250			0.250	0.250				
228												
229	Elongation at Yield (in)	0.47	0.48	0.47			0.67	0.68				
230	% Elongation at Yield	23.5	24	23.5	23.6666667	0.2886751	33.5	34		33.75	0.353553	
231	Elongation at Break (in)	12.83	16.8	13.31			14.68	17.33				
232	% Elongation at Break	641.5	840	665.5	715.666667	108.34244	734	866.5		800.25	93.69165	
233												
234	Load at Yield (lb)	155.2	157.2	157			140.3	141.9				
235	Yield Strength (psi)	3195.9	3224.2	3201.2	3207.1	15.0	2846.9	2848.7		2847.8	1.2	
236	Load at Break (lb)	113	114	120			118	124				
237	Break Strength (psi)	2326.9	2338.2	2446.8	2370.6	66.2	2394.4	2489.3		2441.9	67.1	
238	*YIELD* Modulus (psi)	13599.5	13434.2	13622.2272	13552.0	102.6	8498.28	8378.4781		8438.4	84.7	
239	Load at 100% Elong (lb)	108	115	114			116	120				
240	Stress at 100% Elong (psi)	2223.9	2358.7	2324.5	2302.4	70.0	2353.8	2409.0		2381.4	39.0	
241	Load at 200% Elong (lb)	117	113	115			118	118				
242	Stress at 200% Elong (psi)	2409.3	2317.7	2344.8	2357.9	47.1	2394.4	2368.9		2381.7	18.1	
243												
244												
245												
246	UNIRRAD											
247	60-Day (with grain)	*** AMBIENT ***					*** 90° C ***					
248	Specimen No	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
249												
250	Neck Thick (mil)	187.6	190.2	185.7			188.1	193.9	193.4			
251	Neck Thick (mil)	187.5	190.9	180.7			187.9	193	193			
252	Neck Thick (mil)	187.3	190.9	179.7			187.9	192.8	192.9			
253	Neck Thick (mil)	187.9	190.9	180.6			187.9	193.3	192.5			
254	Average (mil)	188	191	182			188	193	193	191.383		
255												
256	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
257	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
258	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
259	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
260	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250	0.25		
261												
262	Elongation at Yield (in)	0.45	0.45	0.45			0.63	0.63	0.6			
263	% Elongation at Yield	22.5	22.5	22.5	22.5	0	31.5	31.5	30	31	0.866025	
264	Elongation at Break (in)	4.32	4.19	2.82			11.76	12.43	14.94			
265	% Elongation at Break	216	209.5	141	188.833333	41.552176	588	621.5	747	652.167	83.81875	
266												
267	Load at Yield (lb)	164.2	164.5	159.8			144.4	144.9	146.4			
268	Yield Strength (psi)	3501.5	3450.0	3518.4	3490.0	35.6	3073.2	2999.2	3035.0	3035.8	37.0	
269	Load at Break (lb)	111	113	112.4			125	122	125			
270	Break Strength (psi)	2367.05	2369.9	2474.74886	2403.8	61.4	2660.28	2525.2264	2591.34	2592.3	67.5	
271	*YIELD* Modulus (psi)	15562.4	15333.3	15637.2032	15511.0	158.3	9758.06	9521.3454	10116.6	9798.0	299.8	
272	Load at 100% Elong (lb)	115	114	113			127	130	131			
273	Stress at 100% Elong (psi)	2452.4	2390.9	2488.0	2443.7	49.1	2702.8	2690.8	2715.7	2703.1	12.5	
274	Load at 200% Elong (lb)	109	112	-----			115	117	120			
275	Stress at 200% Elong (psi)	2324.4	2348.9		2336.7	17.3	2447.5	2421.7	2487.7	2452.3	33.2	
276												
277												
278												
279	UNIRRAD											
280	60-Day (cross grain)	*** AMBIENT ***					*** 90° C ***					
281	Specimen No	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
282												

POLYPROPYLENE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
283	Neck Thick (mil)	188.9	189	189			203.1	199.7	202.5			
284	Neck Thick (mil)	188.1	189.9	188.9			200.8	198.6	201			
285	Neck Thick (mil)	188.5	190.1	189.5			200	197.2	199.2			
286	Neck Thick (mil)	187.9	190.4	189.2			200.9	198.2	200.1			
287	Average (mil)	188	190	190	189		201	198	201			
288												
289	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
290	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
291	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
292	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
293	Average (in)	0.250	0.250	0.250	0.250		0.250	0.250	0.250			
294												
295	Elongation at Yield (in)	0.45	0.48	0.48			0.62	0.67	0.67			
296	% Elongation at Yield	22.5	24	24	23.5	0.6660254	31	33.5	33.5	32.6667	1.443378	
297	Elongation at Break (in)	7.65	4.32	9.49			12.4	13.33	8.8			
298	% Elongation at Break	382.5	216	474.5	357.666667	131.02703	620	666.5	440	575.5	119.6275	
299												
300	Load at Yield (lb)	168.5	168.5	168.2			150.3	146.9	147.8			
301	Yield Strength (psi)	3578.4	3550.2	3547.6	3558.7	17.1	2988.1	2961.3	2945.7	2965.0	21.4	
302	Load at Break (lb)	112	114	116.6			127	122	116			
303	Break Strength (psi)	2378.55	2401.9	2459.26707	2413.2	41.5	2524.85	2459.3675	2311.91	2432.0	109.1	
304	*YIELD* Modulus (psi)	15904.2	14792.4	14781.6153	15159.4	645.0	9638.94	8839.7624	8793.1	9090.6	475.4473	
305	Load at 100% Elong. (lb)	115	115	116			133	134	125			
306	Stress at 100% Elong. (psi)	2442.3	2423.0	2488.8	2451.3	33.8	2644.1	2701.3	2491.3	2612.2	108.6	
307	Load at 200% Elong. (lb)	111	114	117			117	121	124			
308	Stress at 200% Elong. (psi)	2357.3	2401.9	2467.7	2409.0	55.5	2326.0	2439.2	2471.4	2412.2	76.3	
309												
310												
311												
312	UNIRRAD											
313	90-Day (with grain)	*** AMBIENT ***					*** 90° C ***					
314	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
315												
316	Neck Thick (mil)	182.1	186				202.9	202.5	205			
317	Neck Thick (mil)	182.8	187				204.1	201.7	204.5			
318	Neck Thick (mil)	182	186.6				205.5	200	203.5			
319	Neck Thick (mil)	181.2	184.7				206.1	198.5	202.3			
320	Average (mil)	182	186	#DIV/0!			205	201	204			
321												
322	Neck Width (in)	0.25	0.25				0.25	0.25	0.25			
323	Neck Width (in)	0.25	0.25				0.25	0.25	0.25			
324	Neck Width (in)	0.25	0.25				0.25	0.25	0.25			
325	Neck Width (in)	0.25	0.25				0.25	0.25	0.25			
326	Average (in)	0.250	0.250	#DIV/0!			0.250	0.250	0.250			
327												
328	Elongation at Yield (in)	0.46	0.45				0.57	0.55	0.58			
329	% Elongation at Yield	23	22.5		22.75	0.3535534	28.5	27.5	29	28.3333	0.763763	
330	Elongation at Break (in)	7.77	8.99				14.83	13	14.57			
331	% Elongation at Break	388.5	449.5		419	43.133514	741.5	650	728.5	706.667	49.50337	
332												
333	Load at Yield (lb)	153.5	156.5				147.3	145.1	147.3			
334	Yield Strength (psi)	3373.2	3364.2		3368.7	6.3	2879.1	2892.2	2890.7	2887.3	7.2	
335	Load at Break (lb)	107.5	112.9				133	128.8	128.3			
336	Break Strength (psi)	2362.31	2426.98		2394.8	45.7	2599.58	2567.3352	2517.85	2561.6	41.2	
337	*YIELD* Modulus (psi)	14665.9	14952.2		14808.0	202.4	10102	10517.232	9967.98	10195.7	286.4	
338	Load at 100% Elong. (lb)	104	107				130	130	130			
339	Stress at 100% Elong. (psi)	2285.4	2300.1		2292.8	10.4	2540.9	2591.3	2551.2	2561.1	26.6	
340	Load at 200% Elong. (lb)	110	112				123	120	125			
341	Stress at 200% Elong. (psi)	2417.3	2407.6		2412.4	6.8	2404.1	2391.9	2453.1	2416.4	32.4	
342												
343												
344												
345	UNIRRAD											
346	90-Day (cross grain)	*** AMBIENT ***					*** 90° C ***					
347	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
348												
349	Neck Thick (mil)	202.9	202.7	202.6			201.5	192.7	204.1			
350	Neck Thick (mil)	201	200.5	200.8			200.1	195.7	201.5			
351	Neck Thick (mil)	198.3	197.7	198.1			198.4	197.3	200.3			
352	Neck Thick (mil)	198	195.3	195.9			195	199.6	197.5			
353	Average (mil)	200	199	199			199	196	201			
354												
355	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
356	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
357	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
358	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
359	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
360												
361	Elongation at Yield (in)	0.45	0.43	0.43			0.62	0.63	0.63			
362	% Elongation at Yield	22.5	21.5	21.5	21.8333333	0.5773503	31	31.5	31.5	31.3333	0.288675	
363	Elongation at Break (in)	14.9	15	9.5			9.32	15.22	8.08			
364	% Elongation at Break	745	750	475	656.666667	157.34781	466	761	404	543.667	190.752	
365												
366	Load at Yield (lb)	163.9	163.7	162.7			144.1	141.9	146.1			
367	Yield Strength (psi)	3285.4	3289.6	3264.6	3279.9	13.4	2900.1	2891.1	2909.6	2900.3	9.3	
368	Load at Break (lb)	118.6	114.9	115.1			122	127	126.5			
369	Break Strength (psi)	2377.35	2308.97	2309.50589	2331.9	99.3	2455.35	2587.5462	2519.29	2520.7	66.1	
370	*YIELD* Modulus (psi)	14601.7	15300.6	15184.2325	15028.9	374.4	9355.24	9178.1727	9236.93	9256.8	90.2	
371	Load at 100% Elong. (lb)	116	116	117			125	121	120			
372	Stress at 100% Elong. (psi)	2325.2	2331.1	2347.6	2334.6	11.6	2515.7	2465.3	2389.8	2457.0	63.4	
373	Load at 200% Elong. (lb)	116	117	116			123	123	125			
374	Stress at 200% Elong. (psi)	2325.2	2351.2	2327.6	2334.7	14.3	2475.5	2506.0	2489.4	2490.3	15.3	
375												
376												

POLYPROPYLENE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
377												
378	UNIRRAD											
379	120-Day (with grain)	*** AMBIENT ***						*** 90° C ***				
380	Specimen No.	1	2	3	AG	ST DEV		1	2	3	AG	ST DEV
381												
382	Neck Thick (mil)	200.9	195	197.1			194.6	197	203.3			
383	Neck Thick (mil)	201	195.6	197.4			193.9	197	202.8			
384	Neck Thick (mil)	200.6	196.1	197.8			194	197.5	202.5			
385	Neck Thick (mil)	200.2	196	198			194.6	198.1	202			
386	Average (mil)	201	196	198			194	197	203			
387												
388	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
389	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
390	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
391	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
392	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
393												
394	Elongation at Yield (in)	0.42	0.43	0.47			0.67	0.67	0.67			
395	% Elongation at Yield	21	21.5	23.5	22	1.3228757	33.5	33.5	33.5	33.5	0	
396	Elongation at Break (in)	4	4.8	5.8			7	4.3	12.7			
397	% Elongation at Break	200	240	290	243.333333	45.092498	350	215	635	400	214.4178	
398												
399	Load at Yield (lb)	171.1	163.7	166.7			146.1	149.3	151.8			
400	Yield Strength (psi)	3410.5	3346.4	3374.9	3377.3	32.1	3008.1	3025.3	2996.3	3009.91	14.6	
401	Load at Break (lb)	117	113	122			120	120	141			
402	Break Strength (psi)	2332.13	2309.95	2469.94812	2370.7	86.7	2470.72	2431.6109	2783.12	2561.8	192.7	
403	*YIELD* Modulus (psi)	16240.4	15564.5	14361.3656	15388.8	951.8	8979.42	9030.8337	8944.18	8984.8	43.6	
404	Load at 100% Elong. (lb)	115	114	117			124	115	138			
405	Stress at 100% Elong.(psi)	2292.3	2330.4	2368.7	2330.5	38.2	2553.1	2330.3	2723.9	2535.8	197.4	
406	Load at 200% Elong. (lb)	117	115	120			125	120	128			
407	Stress at 200% Elong.(psi)	2332.1	2350.8	2429.5	2370.8	51.6	2573.7	2431.6	2526.5	2510.6	72.4	
408												
409												
410												
411	UNIRRAD											
412	120-Day (cross grain)	*** AMBIENT ***						*** 90° C ***				
413	Specimen No.	1	2	3	AG	ST DEV		1	2	3	AG	ST DEV
414												
415	Neck Thick (mil)	195.7	199	194.2			199.5	197.8	198.3			
416	Neck Thick (mil)	195.1	196.3	194			199.1	196.9	197.4			
417	Neck Thick (mil)	195.4	194.8	194			197.9	198	196.4			
418	Neck Thick (mil)	197.3	195	197.1			197.9	199	197.2			
419	Average (mil)	196	196	195			199	197	198			
420												
421	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
422	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
423	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
424	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
425	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
426												
427	Elongation at Yield (in)	0.45	0.45	0.45			0.53	0.6	0.6			
428	% Elongation at Yield	22.5	22.5	22.5	22.5	0	26.5	30	30	28.8333	2.020726	
429	Elongation at Break (in)	8.83	9.66	11.16			14.5	14.8	12.9			
430	% Elongation at Break	441.5	483	558	494.166667	59.047297	725	740	645	703.333	51.07184	
431												
432	Load at Yield (lb)	160.5	163.7	159			146.1	152.6	158.2			
433	Yield Strength (psi)	3277.6	3336.1	3264.5	3292.7	38.2	2932.3	3093.0	3198.4	3074.5	134.0	
434	Load at Break (lb)	115	116	115			129	134	126			
435	Break Strength (psi)	2348.44	2364.03	2361.09329	2357.9	8.3	2589.06	2715.9868	2547.38	2617.5	87.8	
436	*YIELD* Modulus (psi)	14567.1	14827.3	14508.7472	14634.4	169.6	11065.1	10309.94	10661.3	10678.8	377.9	
437	Load at 100% Elong. (lb)	110	114	112			139	136	138			
438	Stress at 100% Elong.(psi)	2246.3	2323.3	2299.5	2289.7	39.4	2789.8	2756.5	2790.0	2778.8	19.3	
439	Load at 200% Elong. (lb)	115	117	110			127	131	123			
440	Stress at 200% Elong.(psi)	2348.4	2384.4	2258.4	2330.4	64.9	2548.9	2655.2	2486.7	2563.6	85.2	
441												
442												
443												
444												
445	120-D DOSE 90C (WG)	*** 30 DAY IMM. ***						*** 120 DAY IMM. ***				
446	Specimen No.	1	2	3	AG	ST DEV		1	2	3	AG	ST DEV
447												
448	Neck Thick (mil)	202.3	196.9	196.8			161.8	175.2	185.6			
449	Neck Thick (mil)	201.2	197.8	198.4			161.4	174.5	184.2			
450	Neck Thick (mil)	200.4	197.4	199.9			161.1	174.8	184.4			
451	Neck Thick (mil)	197.9	195.6	200.3			161.8	176	184.8			
452	Average (mil)	200	197	199			162	175	185			
453												
454	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
455	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
456	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
457	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
458	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
459												
460	Elongation at Yield (in)	0.5	0.53	0.5			0.6	0.83	0.81			
461	% Elongation at Yield	25	26.5	25	25.5	0.8660254	30	31.5	30.5	30.6667	0.763763	
462	Elongation at Break (in)	3.66	2.33	4.33			11.6	11	4.8			
463	% Elongation at Break	183	116.5	216.5	172	50.899411	580	550	240	456.667	188.2374	
464												
465	Load at Yield (lb)	159.2	160.5	160			119.3	135.7	142.7			
466	Yield Strength (psi)	3176.9	3260.1	3218.5	3218.5	41.6	2953.0	3104.4	3087.1	3048.1	82.9	
467	Load at Break (lb)	122.1	117	121			103	110	115			
468	Break Strength (psi)	2436.5	2376.54	2434.0	2415.7	33.9	2549.5	2516.4427	2487.83	2517.9	30.9	
469	*YIELD* Modulus (psi)	12707.4	12302.4	12874.0258	12627.9	294.0	9843.23	9855.1593	10121.6	9940.0	157.4	
470	Load at 100% Elong. (lb)	115	115	115			105	120	120			

POLYPROPYLENE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
471	Stress at 100% Elong.(psi)	2294.8	2335.9	2313.3	2314.7	20.6	2599.0	2745.2	2596.0	2646.7	85.3	
472	Load at 200% Elong.(lb)			120			103	108	115			
473	Stress at 200% Elong.(psi)			2413.9	2413.9	#DIV/0!	2549.5	2470.7	2467.8	2502.7	41.5	
474												
475												
476												
477												
478	120-D DOSE 90C (XG)	* * * * 30 DAY IMM. * * * *					* * * * 120 DAY IMM. * * * *					
479	Specimen No.	1	2	3	AG	STDEV	1	2	3	AG	STDEV	
480												
481	Neck Thick (mil)	198.4	199.2	196.1			186.2	189	186.9			
482	Neck Thick (mil)	195.7	199.8	194.3			187.2	189.8	187.5			
483	Neck Thick (mil)	196.4	198.1	195.1			186.7	189.2	187			
484	Neck Thick (mil)	197.7	197.4	195.2			182.8	189.3	183			
485	Average (mil)	197	199	195			186	189	186			
486												
487	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
488	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
489	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
490	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
491	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
492												
493	Elongation at Yield (in)	0.48	0.55	0.53			0.6	0.63	0.6			
494	% Elongation at Yield	2.4	27.5	26.5	26	1.8027756	30	31.5	30	30.5	0.866025	
495	Elongation at Break (in)	6.2	7.67	8.5			3.8	3.7	3.3			
496	% Elongation at Break	410	383.5	425	406.166667	21.013884	190	185	165	180	13.22876	
497												
498	Load at Yield (lb)	155.5	156.7	153.5			145.9	151.6	143.9			
499	Yield Strength (psi)	3156.6	3155.7	3145.9	3152.7	5.9	3142.3	3203.0	3093.0	3146.1	55.1	
500	Load at Break (lb)	118	123	118			113	114	113			
501	Break Strength (psi)	2395.33	2477.03	2418.34251	2430.2	42.1	2433.71	2408.5567	2428.8	2423.7	13.3	
502	*YIELD* Modulus (psi)	13152.3	11475.3	11871.3008	12186.3	876.8	10474.3	10168.12	10309.9	10317.4	153.2	
503	Load at 100% Elong.(lb)	125	130	125			111	114	114			
504	Stress at 100% Elong.(psi)	2537.4	2618.0	2561.8	2572.4	41.3	2390.6	2408.8	2450.3	2399.6	30.6	
505	Load at 200% Elong.(lb)	120	125	125			NA	NA	NA			
506	Stress at 200% Elong.(psi)	2435.9	2517.3	2561.8	2505.0	63.8	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
507												
508												
509	2-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *										
510	Specimen No.	1	2	3	AG	STDEV						
511												
512	Neck Thick (mil)	288.2	190.1	189.9								
513	Neck Thick (mil)	288.3	190	189.5								
514	Neck Thick (mil)	290.1	191.3	189.2								
515	Neck Thick (mil)	280.8	188.9	189.1								
516	Average (mil)	289	190	189								
517												
518	Neck Width (in)	0.25	0.25	0.25								
519	Neck Width (in)	0.25	0.25	0.25								
520	Neck Width (in)	0.25	0.25	0.25								
521	Neck Width (in)	0.25	0.25	0.25								
522	Average (in)	0.250	0.250	0.250								
523												
524	Elongation at Yield (in)	0.53	0.51	0.53								
525	% Elongation at Yield	26.5	25.5	26.5	26.1666667	0.5773503						
526	Elongation at Break (in)	12.33	5	12								
527	% Elongation at Break	616.5	250	600	488.833333	207.0002						
528												
529	Load at Yield (lb)	142.6	144.3	145.6								
530	Yield Strength (psi)	1971.3	3036.7	3074.6	2694.2	626.3						
531	Load at Break (lb)	98.0	112.0	103.0								
532	Break Strength (psi)	1354.8	2357.0	2175.0	1862.2	533.9						
533	*YIELD* Modulus (psi)	7438.92	11908.8	11602.1425	10316.6	2496.8						
534	Load at 100% Elong.(lb)	120	115	120								
535	Stress at 100% Elong.(psi)	1658.9	2420.1	2534.0	2204.3	475.8						
536	Load at 200% Elong.(lb)	105	110	110								
537	Stress at 200% Elong.(psi)	1451.5	2314.9	2322.8	2029.7	500.8						
538												
539												
540												
541												
542	2-YR DOSE 90C (XG)	* * * * 30 DAY IMM. * * * *										
543	Specimen No.	1	2	3	AG	STDEV						
544												
545	Neck Thick (mil)	189.8	190.1	190								
546	Neck Thick (mil)	189.9	190	192.3								
547	Neck Thick (mil)	189.2	190.9	191.4								
548	Neck Thick (mil)	186.9	191.2	190.9								
549	Average (mil)	189	191	191								
550												
551	Neck Width (in)	0.25	0.25	0.25								
552	Neck Width (in)	0.25	0.25	0.25								
553	Neck Width (in)	0.25	0.25	0.25								
554	Neck Width (in)	0.25	0.25	0.25								
555	Average (in)	0.250	0.250	0.250								
556												
557	Elongation at Yield (in)	0.53	0.53	0.53								
558	% Elongation at Yield	26.5	26.5	26.5	26.5	0						
559	Elongation at Break (in)	4.8	14.1	13.33								
560	% Elongation at Break	240	705	666.5	537.166667	258.07283						
561												
562	Load at Yield (lb)	143.3	144.6	141.1								
563	Yield Strength (psi)	3033.6	3035.4	2952.7	3007.2	47.3						
564	Load at Break (lb)	83	92	90								

POLYPROPYLENE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
565	Break Strength (psi)	1757.08	1931.25	1883.33769	1857.2	90.0						
566	*YIELD* Modulus (psi)	11447.6	11454.4	11142.0943	11348.0	178.4						
567	Load at 100% Elong. (lb)	105	125	105								
568	Stress at 100% Elong. (psi)	2222.8	2624.0	2197.2	2348.0	239.3						
569	Load at 200% Elong. (lb)	90	110	115								
570	Stress at 200% Elong. (psi)	1905.3	2309.1	2406.5	2207.0	265.8						
571												
572												
573	10-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *										
574	Specimen No.	1	2	3	4	AG	ST DEV					
575												
576	Neck Thick (mil)	198.9	180.1	193	183.5							
577	Neck Thick (mil)	199.6	180.6	193.9	185.7							
578	Neck Thick (mil)	201	179.4	195.1	188.4							
579	Neck Thick (mil)	201.5	180	196	187.4							
580	Average (mil)	200	180	195	186							
581												
582	Neck Width (in)	0.25	0.25	0.25	0.25							
583	Neck Width (in)	0.25	0.25	0.25	0.25							
584	Neck Width (in)	0.25	0.25	0.25	0.25							
585	Neck Width (in)	0.25	0.25	0.25	0.25							
586	Average (in)	0.250	0.250	0.250	0.250							
587												
588	Elongation at Yield (in)	0.99	0.55	0.56	0.53*							
589	% Elongation at Yield	49.5	27.5	28	26.5	32.875	11.1009					
590	Elongation at Break (in)	3.29	2.41	2.07	2.01*							
591	% Elongation at Break	164.5	120.5	103.5	100.5	122.25	29.5113					
592												
593	Load at Yield (lb)	137.4	138.9	157	145.6							
594	Yield Strength (psi)	2744.6	3086.2	3228.8	3127.0	3046.6447	210.118					
595	Load at Break (lb)	48.0	42	92	36*							
596	Break Strength (psi)	918.9	933.2	1892.0	773.2	1129.3101	513.595					
597	*YIELD* Modulus (psi)	5544.58	11222.7	11531.3992	11799.924	10024.648	2996.01*					
598	Load at 100% Elong. (lb)	108	78	92	36							
599	Stress at 100% Elong. (psi)	2157.3	1733.1	1892.0	773.2	1638.8953	603.104					
600	Load at 200% Elong. (lb)											
601	Stress at 200% Elong. (psi)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!					
602												
603												
604												
605												
606	10-YR DOSE 90C (XG)	* * * * 30 DAY IMM. * * * *										
607	Specimen No.	1	2	3	AG	ST DEV						
608												
609	Neck Thick (mil)	200.9	198.5	206.1								
610	Neck Thick (mil)	201.1	199.6	204.6								
611	Neck Thick (mil)	204.1	202	201.3								
612	Neck Thick (mil)	208	204	201.1								
613	Average (mil)	204	201	203								
614												
615	Neck Width (in)	0.25	0.25	0.25								
616	Neck Width (in)	0.25	0.25	0.25								
617	Neck Width (in)	0.25	0.25	0.25								
618	Neck Width (in)	0.25	0.25	0.25								
619	Average (in)	0.250	0.250	0.250								
620												
621	Elongation at Yield (in)	0.53	0.53	0.53								
622	% Elongation at Yield	26.5	26.5	26.5	26.5	0						
623	Elongation at Break (in)	3.83	2.9	3.97*								
624	% Elongation at Break	191.5	145	198.5	178.333333	29.078916						
625												
626	Load at Yield (lb)	154	152.8	153.7								
627	Yield Strength (psi)	3026.7	3040.4	3024.5	3030.5	8.6						
628	Load at Break (lb)	110.8	125	108								
629	Break Strength (psi)	2177.62	2487.25	2125.19985	2263.4	195.7						
630	*YIELD* Modulus (psi)	11421.3	11473.3	11413.1103	11435.9	32.6						
631	Load at 100% Elong. (lb)	115	110	110								
632	Stress at 100% Elong. (psi)	2260.2	2188.8	2164.6	2204.5	49.7						
633	Load at 200% Elong. (lb)											
634	Stress at 200% Elong. (psi)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!						
635												
636												
637	30-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *										
638	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
639												
640	Neck Thick (mil)	194.6	192.3	191.8			192.2	194.1	192.5			
641	Neck Thick (mil)	194.5	193.2	191.2			193.7	195.2	194.1			
642	Neck Thick (mil)	190.8	194.1	191.2			194.1	194.7	195			
643	Neck Thick (mil)	189	193.9	191.5			193.8	193.4	194.1			
644	Average (mil)	192	193	191			193	194	194			
645												
646	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
647	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
648	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
649	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
650	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
651												
652	Elongation at Yield (in)	0.56	0.56	0.58			0.39					
653	% Elongation at Yield	28	28	29	28.3333333	0.5773503	19.5	0	0	19.5	#DIV/0!	
654	Elongation at Break (in)	1.46	1.47	1.95*			0.53	0.17	0.17			
655	% Elongation at Break	73	73.5	97.5	81.3333333	14.002976	26.5	8.5	8.5	14.5	10.3923	
656												
657	Load at Yield (lb)	164.2	166.6	164.7			141.1					
658	Yield Strength (psi)	3417.7	3446.2	3441.6	3435.1	15.3	2917.5	0.0	0.0	2917.5	#DIV/0!	

POLYPROPYLENE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
659	Load at Break (lb)	115.0	110	125			130	80.7	66.8			
660	Break Strength (psi)	2393.7	2275.4	2612.0	2427.0	170.8	2688.03	1660.921	1373.73	1907.6	691.0	
661	"YIELD" Modulus (psi)	12206.1	12307.7	11867.4371	12127.1	230.5	14961.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
662	Load at 100% Elong. (lb)											
663	Stress at 100% Elong. (psi)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.0	0.0	0.0	0.0	0.0	
664	Load at 200% Elong. (lb)											
665	Stress at 200% Elong. (psi)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.0	0.0	0.0	0.0	0.0	
666												
667												
668												
669												
670	30-YR DOSE @0C (XG)	* * * * 30 DAY IMM * * * *					* * * * 120 DAY IMM * * * *					
671	Specimen No	1	2	3	AG	STDEV	1	2	3	AG	STDEV	
672												
673	Neck Thick (mil)	202.8	201.9	202.3			181.5	180	184.9			
674	Neck Thick (mil)	199.8	199.1	200.9			181	178.8	184.8			
675	Neck Thick (mil)	197.8	198.8	199.8			181	181	186.2			
676	Neck Thick (mil)	196.4	196.1	197.6			185.1	185.3	186.8			
677	Average (mil)	199	199	200			182	181	186			
678												
679	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
680	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
681	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
682	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25			
683	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250			
684												
685	Elongation at Yield (in)	0.53	0.53	0.53			0.8	0.73	0.81			
686	% Elongation at Yield	26.5	26.5	26.5	26.5	0	40	36.5	40.5	39	2.179449	
687	Elongation at Break (in)	1.42	1.96	1.7			1.3	1.3	1.4			
688	% Elongation at Break	71	98	85	84.8666667	13.503086	65	65	70	66.6667	2.886751	
689												
690	Load at Yield (lb)	171.3	168.7	173.1			148.3	143.9	154.3			
691	Yield Strength (psi)	3440.6	3391.4	3459.4	3430.5	35.1	3256.7	3175.3	3324.1	3252.0	74.5	
692	Load at Break (lb)	117	114	107			140	136	148			
693	Break Strength (psi)	2349.99	2291.75	2138.3962	2260.0	109.3	3074.39	3000.9654	3188.37	3087.9	94.4	
694	"YIELD" Modulus (psi)	12983.5	12797.7	13054.3602	12945.2	132.6	8141.64	8699.4142	8207.62	8349.6	304.8	
695	Load at 100% Elong. (lb)											
696	Stress at 100% Elong. (psi)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
697	Load at 200% Elong. (lb)											
698	Stress at 200% Elong. (psi)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.0	#VALUE!	#VALUE!	

POLYPROPYLENE Tear Data

	A	B	C	D	E	F	G	H	I	J	K	L
1				POLYPROPYLENE TEAR SUMMARY								
2												
3	% Change in Tear Strength											
4				UNIRRADIATED					IRRADIATED			
5	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
6												
7	with grain, ambient	0	-2.7217	2.23505	2.642449	1.69185						
8	st dev	5.56322	3.73965	4.0855	1.804579	0.50963						
9	with grain, 90°C	0	-0.5941	9.09297	8.391331	4.36259	2.07861	6.874894	-1.4542	-11.798	-31.127	-27.550501
10	st dev	5.56322	1.31137	2.7974	0.553015	0.57615	1.38545	3.939966	1.60872	2.37941	1.80458	2.79877289
11	cross grain, ambient	0	-5.4054	4.36556	7.72713	4.00699						
12	st dev	4.08969	0.35576	2.01732	0.504609	2.35502						
13	cross grain, 90°C	0	3.55878	13.9797	11.89548	7.34615	4.20869	4.320739	-1.9542	-12.532	-28.78	-29.92246
14	st dev	4.08969	0.58739	0.60633	0.432237	1.27267	0.4754	0.317723	1.11761	0.85572	5.79297	0.85395361
15				PLOT DATA								
16				UNIRRADIATED					IRRADIATED			
17	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
18	with grain (amb)	147.275	143.267	150.567	151.1667	149.767						
19	with grain (90°C)	147.275	146.4	160.667	159.8333	153.7	150.333	157.4	145.133	129.9	101.433	106.7
20	cross grain (amb)	148.74	140.7	155.233	160.2333	154.7						
21	cross grain (90°)	148.74	154.033	169.533	166.4333	159.667	155	155.1667	145.833	130.1	105.933	104.233333
22												
23	UNIRRAD.											
24	Virgin Material (with grain)	TEAR MEASUREMENTS AMBIENT										
25	Specimen No.	1	2	3	4	5	Average	ST DEV				
26												
27	Specimen Thick (in)	0.196	0.186	0.1961	0.1963							
28	Specimen Thick (in)	0.199	0.1816	0.2021	0.1961							
29	Specimen Thick (in)	0.2007	0.1789	0.1979	0.1977							
30	Specimen Thick (in)	0.1977	0.1824	0.1973	0.2051							
31	Average (in)	0.1984	0.1822	0.1984	0.1988		0.1944	0.007779				
32												
33	Tearing Load (lb)	153	135.2	149.3	151.6		147.3	8.193239				
34												
35	UNIRRAD.											
36	Virgin Material (cross grain)	TEAR MEASUREMENTS AMBIENT										
37	Specimen No.	1	2	3	4	5	Average	ST DEV				
38												
39	Specimen Thick (in)	0.1978	0.1925	0.1865	0.2009	0.2053						
40	Specimen Thick (in)	0.1918	0.1872	0.1858	0.1989	0.2043						
41	Specimen Thick (in)	0.1892	0.1869	0.1852	0.1978	0.2025						
42	Specimen Thick (in)	0.193	0.1859	0.1851	0.1975	0.2033						
43	Average (in)	0.1930	0.1881	0.1857	0.1988	0.2039	0.1939	0.007176				
44												
45	Tearing Load (lb)	147.8	144.1	142.6	151.5	157.7	148.7	6.083009				
46												
47	UNIRRAD.											
48	30-Day (with grain)	***** AMBIENT *****					***** 90° C *****					
49	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
50												
51	Specimen Thick (in)	0.1935	0.1842	0.1972			0.187	0.1913	0.1872			
52	Specimen Thick (in)	0.193	0.1841	0.197			0.1865	0.1907	0.1869			
53	Specimen Thick (in)	0.1929	0.1822	0.1969			0.188	0.1928	0.1873			
54	Specimen Thick (in)	0.1924	0.1858	0.1974			0.1863	0.1901	0.1869			
55	Average (in)	0.19295	0.18408	0.19713	0.191383	0.00666	0.18695	0.191225	0.18708	0.18842	0.00243	
56												
57	Tearing Load (lb)	143.6	137.6	148.6	143.2667	5.50757	144.3	148.1	146.8	146.4	1.93132	
58												
59	UNIRRAD.											
60	30-Day (cross grain)	***** AMBIENT *****					***** 90° C *****					
61	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
62												
63	Specimen Thick (in)	0.194	0.1955	0.1933			0.193	0.1941	0.1928			
64	Specimen Thick (in)	0.1939	0.1956	0.1935			0.1935	0.1949	0.1927			
65	Specimen Thick (in)	0.194	0.1955	0.193			0.1937	0.1949	0.1929			
66	Specimen Thick (in)	0.1938	0.1965	0.1937			0.1935	0.1936	0.1923			
67	Average (in)	0.1939	0.1958	0.1934	0.1944	0.00126	0.1934	0.1944	0.1927	0.1935	0.00085	
68												
69	Tearing Load (lb)	140.1	141.1	140.9	140.7	0.52815	155	153.8	153.3	154.033	0.87369	
70												
71	UNIRRAD.											
72	60-Day (with grain)	***** AMBIENT *****					***** 90° C *****					
73	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
74												
75	Specimen Thick (in)	0.1962	0.192	0.191			0.201	0.1964	0.1929			
76	Specimen Thick (in)	0.1958	0.1917	0.1908			0.2	0.1957	0.1934			
77	Specimen Thick (in)	0.1949	0.1919	0.1902			0.1999	0.1944	0.1935			
78	Specimen Thick (in)	0.1957	0.1918	0.1903			0.2001	0.196	0.194			
79	Average (in)	0.1957	0.1919	0.1906	0.1927	0.00264	0.2003	0.1956	0.1935	0.1964	0.00347	
80												
81	Tearing Load (lb)	156	151.6	144.1	150.5667	6.01692	165	160.2	156.8	160.667	4.11987	
82												

POLYPROPYLENE Tear Data

	A	B	C	D	E	F	G	H	I	J	K	L
83	UNIRRAD.											
84	60-Day (cross grain)	***** AMBIENT *****						***** 90° C *****				
85	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
86												
87	Specimen Thick (in)	0.1968	0.1964	0.197			0.207	0.206	0.2067			
88	Specimen Thick (in)	0.1952	0.1988	0.196			0.2073	0.2062	0.2066			
89	Specimen Thick (in)	0.1957	0.1977	0.1959			0.2075	0.2065	0.207			
90	Specimen Thick (in)	0.1964	0.1965	0.1971			0.2069	0.2065	0.207			
91	Average (in)	0.1960	0.1969	0.1965	0.1965	0.00041	0.2072	0.2063	0.2068	0.2068	0.00044	
92												
93	Tearing Load (lb)	154.6	158.5	152.6	155.2333	3.00058	170.4	169.6	168.6	169.5	0.90185	
94												
95	UNIRRAD.											
96	90-Day (with grain)	***** AMBIENT *****						***** 90° C *****				
97	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
98												
99	Specimen Thick (in)	0.19	0.1888	0.1896			0.1945	0.198	0.1934			
100	Specimen Thick (in)	0.19	0.1875	0.1899			0.1957	0.1984	0.1932			
101	Specimen Thick (in)	0.1903	0.1874	0.19			0.1959	0.1986	0.1934			
102	Specimen Thick (in)	0.1917	0.1882	0.1905			0.1949	0.198	0.1936			
103	Average (in)	0.1905	0.1880	0.1900	0.1895	0.00134	0.1953	0.1983	0.1934	0.1956	0.00245	
104												
105	Tearing Load (lb)	152.8	148.1	152.6	151.2	2.65769	160.2	160	158.7	159.6	0.81445	
106												
107	UNIRRAD.											
108	90-Day (cross grain)	***** AMBIENT *****						***** 90° C *****				
109	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
110												
111	Specimen Thick (in)	0.2049	0.2074	0.2037			0.2067	0.2032	0.205			
112	Specimen Thick (in)	0.2045	0.2063	0.204			0.2078	0.2042	0.2059			
113	Specimen Thick (in)	0.2042	0.2058	0.2044			0.2078	0.2045	0.2058			
114	Specimen Thick (in)	0.2039	0.206	0.204			0.2084	0.2047	0.2054			
115	Average (in)	0.2044	0.2064	0.2040	0.2049	0.00127	0.2077	0.2042	0.2055	0.2058	0.00178	
116												
117	Tearing Load (lb)	159.5	161	160.2	160.2	0.75056	166.7	165.7	166.9	166.4	0.64291	
118												
119	UNIRRAD.											
120	120-Day (with grain)	***** AMBIENT *****						***** 90° C *****				
121	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
122												
123	Specimen Thick (in)	0.1943	0.1948	0.195			0.1926	0.1912	0.1953			
124	Specimen Thick (in)	0.1952	0.1947	0.1952			0.1932	0.1903	0.197			
125	Specimen Thick (in)	0.201	0.1951	0.1955			0.1935	0.1912	0.1962			
126	Specimen Thick (in)	0.2007	0.1946	0.1952			0.1933	0.1902	0.1961			
127	Average (in)	0.1978	0.1948	0.1952	0.1959	0.00162	0.1932	0.1907	0.1962	0.1933	0.00272	
128												
129	Tearing Load (lb)	148.1	151.1	150.1	149.7667	1.52753	153.1	154.3		153.7000	0.84853	
130												
131	UNIRRAD.											
132	120-Day (cross grain)	***** AMBIENT *****						***** 90° C *****				
133	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
134												
135	Specimen Thick (in)	0.2031	0.2036	0.2042			0.1952	0.1962	0.1961			
136	Specimen Thick (in)	0.2032	0.203	0.2051			0.1954	0.1965	0.1959			
137	Specimen Thick (in)	0.2041	0.2031	0.2042			0.1953	0.1966	0.196			
138	Specimen Thick (in)	0.2037	0.2052	0.205			0.1954	0.1964	0.1959			
139	Average (in)	0.2035	0.2037	0.2046	0.2040	0.00059	0.1953	0.1964	0.1960	0.1959	0.00053	
140												
141	Tearing Load (lb)	154	151.8	158.5	154.7000	3.50286	161	160.5	157.5	159.6667	1.89297	
142												
143												
144	120D DOSE 90C (WG)	***** 30 D IMM. *****						***** 120 D IMM. *****				
145	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
146												
147	Specimen Thick (in)	0.1951	0.1918	0.1958			0.1965	0.1971	0.1923			
148	Specimen Thick (in)	0.194	0.1925	0.1958			0.1968	0.1962	0.1917			
149	Specimen Thick (in)	0.1953	0.193	0.1964			0.1977	0.1956	0.1938			
150	Specimen Thick (in)	0.1965	0.1924	0.1955			0.1967	0.1978	0.195			
151	Average (in)	0.1952	0.1924	0.1958	0.1945	0.00181	0.1967	0.1967	0.1920	0.1951	0.00268	
152												
153	Tearing Load (lb)	150.8	148.1	152.1	150.3	2.04042	164	153.1	155.1	157.4000	5.80259	
154												
155												
156	120D DOSE 90C (XG)	***** 30 D IMM. *****						***** 120 D IMM. *****				
157	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
158												
159	Specimen Thick (in)	0.1994	0.2035				0.1935	0.1924	0.1942			
160	Specimen Thick (in)	0.2015	0.202				0.1937	0.1935	0.1944			
161	Specimen Thick (in)	0.202	0.2032				0.1938	0.1935	0.1942			
162	Specimen Thick (in)	0.2015	0.2034				0.1938	0.1938	0.194			
163	Average (in)	0.2011	0.2030		0.2021	0.00136	0.1937	0.1933	0.1942	0.1937	0.00045	
164												

POLYPROPYLENE Tear Data

	A	B	C	D	E	F	G	H	I	J	K	L
165	Tearing Load (lb)	154.5	155.5		155.0	0.70711	155.7	154.8	155	155.1667	0.47258	
166												
167												
168	2 Y DOSE 90C (WG)	* * * * 30 D IMM. * * * *										
169	Specimen No.	1	2	3	AVG	ST DEV						
170												
171	Specimen Thick (in)	0.2021	0.1974	0.1961								
172	Specimen Thick (in)	0.2052	0.1974	0.196								
173	Specimen Thick (in)	0.2011	0.1971	0.1948								
174	Specimen Thick (in)	0.2016	0.1976	0.1952								
175	Average (in)	0.2025	0.1974	0.1955	0.1985	0.00361						
176												
177	Tearing Load (lb)	146.6	142.4	146.4	145.1	2.36925						
178												
179												
180	2 Y DOSE 90C (XG)	* * * * 30 D IMM. * * * *										
181	Specimen No.	1	2	3	AVG	ST DEV						
182												
183	Specimen Thick (in)	0.1994	0.2008	0.1972								
184	Specimen Thick (in)	0.2008	0.2021	0.1952								
185	Specimen Thick (in)	0.1975	0.2006	0.1969								
186	Specimen Thick (in)	0.1978	0.1994	0.197								
187	Average (in)	0.1989	0.2007	0.1966	0.1987	0.00208						
188												
189	Tearing Load (lb)	145.6	147.61	144.3	145.8	1.66236						
190												
191												
192	10 Y DOSE 90C (WG)	* * * * 30 D IMM. * * * *										
193	Specimen No.	1	2	3	AVG	ST DEV						
194												
195	Specimen Thick (in)	0.195	0.1991	0.1937								
196	Specimen Thick (in)	0.1933	0.1989	0.1947								
197	Specimen Thick (in)	0.1937	0.1986	0.1933								
198	Specimen Thick (in)	0.1956	0.1993	0.1923								
199	Average (in)	0.1944	0.1990	0.1935	0.1956	0.00294						
200												
201	Tearing Load (lb)	126.5	133.5	129.7	129.9	3.50428						
202												
203												
204	10 Y DOSE 90C (XG)	* * * * 30 D IMM. * * * *										
205	Specimen No.	1	2	3	AVG	ST DEV						
206												
207	Specimen Thick (in)	0.1972	0.1982									
208	Specimen Thick (in)	0.1989	0.2024									
209	Specimen Thick (in)	0.1988	0.2002									
210	Specimen Thick (in)	0.2009	0.1998									
211	Average (in)	0.1990	0.2002		0.1996	0.00085						
212												
213	Tearing Load (lb)	129.4	131		130.11	1.272791						
214												
215												
216	30 Y DOSE 90C (WG)	* * * * 30 D IMM. * * * *					* * * * 120 D IMM. * * * *					
217	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
218												
219	Specimen Thick (in)	0.2078	0.2009	0.1971			0.1882	0.191	0.1912			
220	Specimen Thick (in)	0.2049	0.2001	0.1965			0.1862	0.1898	0.1902			
221	Specimen Thick (in)	0.205	0.1991	0.1959			0.188	0.1909	0.1909			
222	Specimen Thick (in)	0.2037	0.2018	0.1977			0.1872	0.1903	0.192			
223	Average (in)	0.2054	0.2005	0.1968	0.2009	0.00429	0.1874	0.1905	0.1911	0.1897	0.00188	
224												
225	Tearing Load (lb)	104.5	99.8	100	101.4	2.65789	111.4	105	103.7	106.7000	4.12189	
226												
227												
228	30 Y DOSE 90C (XG)	* * * * 30 D IMM. * * * *					* * * * 120 D IMM. * * * *					
229	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
230												
231	Specimen Thick (in)	0.2061	0.2029	0.2079			0.1881	0.1891	0.1881			
232	Specimen Thick (in)	0.2055	0.2023	0.2089			0.1877	0.1882	0.188			
233	Specimen Thick (in)	0.2058	0.2023	0.2089			0.1872	0.189	0.1881			
234	Specimen Thick (in)	0.206	0.2021	0.2076			0.1877	0.18887	0.1881			
235	Average (in)	0.2059	0.2024	0.2083	0.2055	0.00298	0.1877	0.1888	0.1881	0.1882	0.00057	
236												
237	Tearing Load (lb)	98	104.7	115.1	105.9	8.61646	103.5	105.7	103.5	104.2333	1.27017	

	A	B	C	D	E	F	G	H	I	J	K	L
1					POLYPROPYLENE PUNCTURE SUMMARY							
2			UNIRRADIATED						IRRADIATED			
3	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
4												
5	% Chg. Punc. Force (amb)	0	0.01465	2.79758	0.82837	0.332						
6	st dev	3.32307	5.07393	12.9477	2.18486	6.07611						
7	% Chg. Punc. Force (90°)	0	-2.4509	-0.4248	-2.6544	-11.573	5.02718	22.37574	0.8121	2.43954	16.3867	12.7331
8	st dev	3.32307	1.15098	5.51785	0.72101	2.36294	12.7383	2.088162	6.67294	9.40155	1.44201	8.68631
9	% Chg. Elongation (amb)	0	-44.914	-46.792	-36.776	-31.455						
10	st dev	2.36302	1.08423	1.08423	1.08423	3.9837						
11	% Chg. Elongation (90°C)	0	-40.094	-38.654	-31.768	-17.371	-41.158	-23.6307	-44.288	-11.737	-44.914	-16.119
12	st dev	2.36302	2.16574	4.72603	2.16845	1.87793	2.16845	3.909232	2.86859	0	2.16845	4.72603
13			UNIRRADIATED						IRRADIATED			
14												
15	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
16	Punc. Force (amb)	409.64	409.7	421.1	413.033	411						
17	Punc. Force (90°)	409.64	399.6	407.9	398.767	362.233	430.233	501.3	412.967	419.633	476.767	461.8
18	Days	0	30	60	90	120						
19	Elongation (amb)	0.5325	0.29333	0.28333	0.33667	0.365						
20	Elongation (90°C)	0.5325	0.319	0.32667	0.36333	0.44	0.31333	0.406667	0.29667	0.47	0.29333	0.44667
21												
22												
23	Virgin Material, Unirrad.	PUNCTURE MEASUREMENTS AMBIENT										
24	Specimen No.	1	2	3	4	5	AVG	ST DEV				
25												
26	Specimen Thickness (in)	0.1948	0.1841	0.1922	0.192	0.1957						
27	Specimen Thickness (in)	0.1939	0.1798	0.1918	0.1933	0.1941						
28	Specimen Thickness (in)	0.1938	0.1839	0.192	0.192	0.1903						
29	Specimen Thickness (in)	0.1949	0.1799	0.1921	0.1929	0.1958						
30	Specimen Thickness (in)	0.1943	0.1828	0.1905	0.1925	0.195						
31	Average (in)	0.1943	0.1821	0.1917	0.1925	0.1942	0.19098	0.004829				
32												
33	Puncture Force (lbf)	415.7	386.9	409.4	413.4	422.8	409.64	13.6126				
34												
35	Elongation (in)		0.53	0.55	0.52	0.53	0.5325	0.012583				
36												
37												
38	30-Day, Unirrad.	***** AMBIENT *****				***** 90° C *****						
39	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
40												
41	Specimen Thickness (in)	0.2	0.2002	0.1875			0.1926	0.1995	0.2018			
42	Specimen Thickness (in)	0.1986	0.199	0.1883			0.1925	0.1976	0.2028			
43	Specimen Thickness (in)	0.2	0.2001	0.1831			0.1926	0.1976	0.2018			
44	Specimen Thickness (in)	0.1992	0.1994	0.1851			0.1937	0.1994	0.2001			
45	Specimen Thickness (in)	0.1993	0.199	0.1856			0.1933	0.2002	0.2019			
46	Average (in)	0.19945	0.19968	0.186	0.19504	0.00672	0.19294	0.19886	0.20168	0.19783	0.0039	
47												
48	Puncture Force (lbf)	421.8	421.6	385.7	409.7	20.7849	397.5	396.3	405	399.6	4.71487	
49												
50	Elongation (in)	0.29	0.3	0.29	0.29333	0.00577	0.307	0.33	0.32	0.319	0.01153	
51												
52												
53	60-Day, Unirrad.	***** AMBIENT *****				***** 90° C *****						
54	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
55												
56	Specimen Thickness (in)	0.1653	0.1975	0.1994			0.1995	0.19	0.2013			
57	Specimen Thickness (in)	0.1737	0.1984	0.1989			0.1998	0.1869	0.201			
58	Specimen Thickness (in)	0.1708	0.1935	0.1992			0.1991	0.1859	0.2017			
59	Specimen Thickness (in)	0.1673	0.1974	0.1995			0.2002	0.1888	0.2016			
60	Specimen Thickness (in)	0.172	0.1983	0.1991			0.2001	0.1897	0.2014			
61	Average (in)	0.16982	0.19702	0.19922	0.18869	0.01638	0.19974	0.18826	0.2014	0.19647	0.0072	
62												
63	Puncture Force (lbf)	361.2	440	462.1	421.1	53.0388	415.4	382.5	425.8	407.9	22.6033	
64												
65	Elongation (in)	0.29	0.28	0.28	0.28333	0.00577	0.3	0.33	0.35	0.32667	0.02517	
66												
67												
68	90-Day, Unirrad.	***** AMBIENT *****				***** 90° C *****						
69	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
70												
71	Specimen Thickness (in)	0.1925	0.1905	0.1941			0.1983	0.1957	0.1975			
72	Specimen Thickness (in)	0.1937	0.1925	0.1941			0.1987	0.1935	0.1984			
73	Specimen Thickness (in)	0.1941	0.19	0.1938			0.197	0.189	0.199			
74	Specimen Thickness (in)	0.1933	0.1875	0.1942			0.1969	0.1926	0.1981			
75	Specimen Thickness (in)	0.1923	0.1879	0.194			0.1975	0.1961	0.1975			
76	Average (in)	0.19318	0.18968	0.19404	0.1923	0.00231	0.19768	0.19338	0.1981	0.19639	0.0026	
77												
78	Puncture Force (lbf)	419.4	402.8	416.9	413.033	8.95005	395.9	398.6	401.8	398.767	2.95353	
79												
80	Elongation (in)	0.34	0.33	0.34	0.33667	0.00577	0.35	0.37	0.37	0.36333	0.01155	
81												
82												
83	120-Day, Unirrad.	***** AMBIENT *****				***** 90° C *****						
84	Specimen No.	1	2	AVG	ST DEV	1	2	3	AVG	ST DEV		
85												

	A	B	C	D	E	F	G	H	I	J	K	L
86	Specimen Thickness (in)	0.1939	0.181		POLYPROPYLENE	Puncture						
87	Specimen Thickness (in)	0.1937	0.1857			0.1841	0.1752	0.1808				
88	Specimen Thickness (in)	0.194	0.1814			0.172	0.172	0.1728				
89	Specimen Thickness (in)	0.1935	0.1858			0.1789	0.1728	0.1763				
90	Specimen Thickness (in)	0.1935	0.1861			0.1834	0.175	0.1781				
91	Average (in)	0.19372	0.184	0.18886	0.00687	0.18058	0.17344	0.17672	0.17691	0.0036		
92												
93	Puncture Force (lbf)	428.6	393.4	411	24.8902	370.3	351.5	364.9	362.233	9.67953		
94												
95	Elongation (in)	0.38	0.35	0.365	0.02121	0.45	0.43	0.44	0.44	0.01		
96												
97												
98	120-day Dose, 90 C	* * * * 30 d Imm. * * * *				* * * 120 d Imm. * * *						
99	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
100												
101	Specimen Thickness (in)	0.2064	0.2042	0.1801			0.202	0.208	0.2027			
102	Specimen Thickness (in)	0.2069	0.2063	0.1993			0.2032	0.206	0.2028			
103	Specimen Thickness (in)	0.2079	0.2026	0.1992			0.2045	0.2061	0.2005			
104	Specimen Thickness (in)	0.2079	0.2042	0.1789			0.206	0.2092	0.2032			
105	Specimen Thickness (in)	0.205	0.2065	0.18			0.2029	0.2075	0.2029			
106	Average (in)	0.20682	0.20476	0.1875	0.19969	0.01061	0.20372	0.20736	0.20242	0.2045	0.0026	
107												
108	Puncture Force (lbf)	461.7	459	370	430.233	52.1811	492.9	510	501	501.3	8.55395	
109												
110	Elongation (in)	0.3	0.32	0.32	0.31333	0.01155	0.39	0.4	0.43	0.40667	0.02082	
111												
112	2-Year Dose, 90 C	* * * * 30 d Imm. * * * *										
113	Specimen No.	1	2	3	AVG	ST DEV						
114												
115	Specimen Thickness (in)	0.1862	0.2044	0.2044								
116	Specimen Thickness (in)	0.1861	0.2091	0.2049								
117	Specimen Thickness (in)	0.19	0.2031	0.2018								
118	Specimen Thickness (in)	0.1875	0.2094	0.2013								
119	Specimen Thickness (in)	0.1895	0.2089	0.2042								
120	Average (in)	0.18786	0.20698	0.20332	0.19939	0.01015						
121												
122	Puncture Force (lbf)	384.2	438.6	416.1	412.967	27.335						
123												
124	Elongation (in)	0.28	0.31	0.3	0.29667	0.01528						
125												
126	10-Year Dose, 90 C	* * * * 30 d Imm. * * * *										
127	Specimen No.	1	2	3	AVG	ST DEV						
128												
129	Specimen Thickness (in)	0.2106	0.2169	0.2063								
130	Specimen Thickness (in)	0.2102	0.219	0.1978								
131	Specimen Thickness (in)	0.2103	0.2178	0.192								
132	Specimen Thickness (in)	0.2108	0.2158	0.1943								
133	Specimen Thickness (in)	0.2117	0.2165	0.2								
134	Average (in)	0.21072	0.2172	0.19808	0.20867	0.00972						
135												
136	Puncture Force (lbf)	462.9	389.1	406.9	419.633	38.5125						
137												
138	Elongation (in)	0.47	0.47	0.47	0.47	0						
139												
140	30-Year Dose, 90 C	* * * * 30 d Imm. * * * *										
141	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV	
142												
143	Specimen Thickness (in)	0.1998	0.2045	0.2001			0.1766	0.1935	0.1867			
144	Specimen Thickness (in)	0.1997	0.2047	0.2032			0.1788	0.1925	0.1901			
145	Specimen Thickness (in)	0.2024	0.2048	0.2029			0.1805	0.1945	0.1913			
146	Specimen Thickness (in)	0.1998	0.2047	0.2031			0.1775	0.1904	0.194			
147	Specimen Thickness (in)	0.2039	0.204	0.2002			0.179	0.1923	0.19			
148	Average (in)	0.20112	0.20454	0.2019	0.20252	0.00179	0.17848	0.19264	0.19042	0.18718	0.0076	
149												
150	Puncture Force (lbf)	470.7	482.5	477.1	476.767	5.90706	421	486.4	478	461.8	35.5826	
151												
152	Elongation (in)	0.28	0.3	0.3	0.29333	0.01155	0.45	0.42	0.47	0.44667	0.02517	

POLYPROPYLENE Hard. Data

	A	B	C	D	E	F	G	H	I	J	K	L
1					POLYPROPYLENE HARDNESS DATA SUMMARY							
2			UNIRRADIATED						IRRADIATED			
3	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
4												
5	% Change Hardness (amb)	0.0	-1.7	-1.0	-2.3	-1.7						
6												
7	% Change Hardness (90°)	0.0	-2.6	1.1	0.7	-1.9	2.5	0.2	-2.2	-1.4	2.9	5.6
8												
9					PLOT DATA							
10			UNIRRADIATED						IRRADIATED			
11	Days	0	30	60	90	120	120-d/30	120-d/120	2-y/30	10-y/30	30-y/30	30-y/120
12	Ave. Hardness (amb)	68.6	67.4667	67.9333	67	67.4						
13	st dev	1.87504	2.09989	2.05171	2.10442	0.98561						
14	Ave. Hardness (90°)	68.6	66.8	69.3333	69.0667	67.2667	70.3333	68.73333	67.0667	67.6667	70.6	72.4667
15	st dev	1.87504	1.78085	1.78085	1.33452	1.38701	1.91485	1.667619	1.62422	1.44749	1.35225	1.76743
16	UNIRRAD.											
17	Virgin Material	AMBIENT READINGS										
18	Specimen No.	1	2	3	4	Avg	STDEV					
19												
20	Durometer Point Reading	66	69	71	66							
21	Durometer Point Reading	67	70	70	69							
22	Durometer Point Reading	66	71	70	69							
23	Durometer Point Reading	68	71	70	67							
24	Durometer Point Reading	68	70	69	65							
25	Average	67	70.2	70	67.2	68.6	1.87504					
26												
27	30-Day, Unirrad.	AMBIENT MEASUREMENTS						90C MEASUREMENTS				
28	Specimen No.	1	2	3	Avg	STDEV		1	2	3	Ave	STDEV
29												
30	Durometer Point Reading	68	67	65				69	68	67		
31	Durometer Point Reading	70	67	65				69	65	65		
32	Durometer Point Reading	71	68	65				68	65	66		
33	Durometer Point Reading	69	67	66				68	64	64		
34	Durometer Point Reading	71	68	65				68	68	68		
35	Average	69.8	67.4	65.2	67.4667	2.09989	68.4	66	66	66.8	1.78085	
36												
37	60-Day, Unirrad.	AMBIENT MEASUREMENTS						90 C MEASUREMENTS				
38	Specimen No.	1	2	3	Ave	STDEV		1	2	3	Ave	STDEV
39												
40	Durometer Point Reading	71	68	65				69	71	67		
41	Durometer Point Reading	69	68	64				70	68	68		
42	Durometer Point Reading	69	67	66				70	68	70		
43	Durometer Point Reading	71	68	66				70	70	70		
44	Durometer Point Reading	68	69	70				68	71	70		
45	Average	69.6	68	66.2	67.9333	2.05171	69.4	69.6	69	69.3333	1.78085	
46												
47	90-Day, Unirrad.	AMBIENT MEASUREMENTS						90 MEASUREMENTS				
48	Specimen No.	1	2	3	Avg	ST DEV		1	2	3	Avg	ST DEV
49												
50	Durometer Point Reading	68	63	69				69	71	69		
51	Durometer Point Reading	69	63	68				70	71	68		
52	Durometer Point Reading	67	66	69				68	69	68		
53	Durometer Point Reading	68	64	67				69	70	67		
54	Durometer Point Reading	68	67	69				67	71	69		
55	Average	68	64.6	68.4	67	2.10442	68.6	70.4	68.2	69.0667	1.33452	
56												
57	120-Day, Unirrad.	AMBIENT MEASUREMENTS						90 MEASUREMENTS				
58	Specimen No.	1	2	3	Avg	ST DEV		1	2	3	Avg	ST DEV
59												
60	Durometer Point Reading	67	67	68				68	68	68		
61	Durometer Point Reading	69	67	65				66	70	68		
62	Durometer Point Reading	69	68	67				68	69	65		
63	Durometer Point Reading	68	67	67				66	67	65		
64	Durometer Point Reading	67	67	68				67	67	67		
65	Average	68	67.2	67	67.4	0.98561	67	68.2	66.6	67.2667	1.38701	
66												
67	120-d Dose, 90C	30 D IMM. MEASUREMENTS						120 D IMM. MEASUREMENTS				
68	Specimen No.	1	2	3	Avg	ST DEV		1	2	3	Avg	ST DEV
69												

POLYPROPYLENE Hard. Data

	A	B	C	D	E	F	G	H	I	J	K	L
7 0	Durometer Point Reading	72	72	70			71	69	69			
7 1	Durometer Point Reading	70	71	71			71	69	67			
7 2	Durometer Point Reading	69	72	72			69	66	67			
7 3	Durometer Point Reading	71	70	65			70	68	66			
7 4	Durometer Point Reading	70	68	72			69	69	71			
7 5	Average	70.4	70.6	70	70.3333	1.91485	70	68.2	68	68.7333	1.66762	
7 6												
7 7	2-YR Dose. 90C	30 D IMM. MEASUREMENTS										
7 8	Specimen No.	1	2	3	Avg	ST DEV						
7 9												
8 0	Durometer Point Reading	65	71	66								
8 1	Durometer Point Reading	67	67	65								
8 2	Durometer Point Reading	65	69	66								
8 3	Durometer Point Reading	67	68	67								
8 4	Durometer Point Reading	68	68	67								
8 5	Average	66.41	68.61	66.21	67.06671	1.62426						
8 6												
8 7	10-YR Dose. 90C	30 D IMM. MEASUREMENTS										
8 8	Specimen No.	1	2	3	Avg	ST DEV						
8 9												
9 0	Durometer Point Reading	68	68	67								
9 1	Durometer Point Reading	71	69	68								
9 2	Durometer Point Reading	68	68	65								
9 3	Durometer Point Reading	68	65	68								
9 4	Durometer Point Reading	68	67	67								
9 5	Average	68.6	67.4	67	67.6667	1.44749						
9 6												
9 7	30-YR Dose. 90C	30 D IMM. MEASUREMENTS					120 D IMM. MEASUREMENTS					
9 8	Specimen No.	1	2	3	Avg	ST DEV	1	2	3	Avg	ST DEV	
9 9												
10 0	Durometer Point Reading	68	72	71			70	69	74			
10 1	Durometer Point Reading	68	71	72			72	72	74			
10 2	Durometer Point Reading	70	71	71			71	72	73			
10 3	Durometer Point Reading	71	72	69			73	72	74			
10 4	Durometer Point Reading	72	71	70			71	75	75			
10 5	Average	69.8	71.4	70.6	70.6	1.35225	71.4	72	74	72.4667	1.76743	

APPENDIX D

RAW AND TABULATED DATA FOR HDPE PIPE TESTING

PIPE DIM. DATA

	A	B	C	D	E	F	G	H	I	J	K	L
1	HDPE PIPE (DSSF,90) DIMENSIONAL DATA SUMMARY											
2	UNIRRADIATED						IRRADIATED					
3	Days	0	30	60	90	120	2 yr/30	10 yr/30	30 yr/30			
4	% Change Width (90°)	0.00	0.24	0.00	0.00	-0.05	0.02	0.10	0.08			
5	stdev	0.36	0.43	0.39	0.41	0.41	2.78	2.81	3.54			
6	% Change Thick (90°)	0.00	-0.33	0.00	0.08	0.58	0.25	0.37	0.58			
7	stdev	1.83	2.48	2.19	2.17	1.91	2.47	2.55	2.45			
8	% Change Weight (90°)	0.00	0.35	-0.02	-0.13	-0.22	0.22	0.16	0.16			
9												
10												
11	DATA FOR PLOTS											
12	UNIRRADIATED						IRRADIATED					
13	Days	0	30	60	90	120	2 yr/virgin	2 yr/30	10y/virgin	10 yr/30	30y/virgin	30 yr/30
14												
15	Ave. Width (90°)	1	1	1	1	1	1	1	1	1	1	1
16												
17												
18	Ave. Thick (90)	304	303	304	304	306	305	306	305	306	302	304
19												
20												
21	Sample Wt. (90)	98.4	98.7	98.4	98.3	98.2	54.6	54.7	48.9	49.0	55.6	55.7
22												
23												
24	9090 DIMENSIONAL MEASUREMENTS 90°											
25	Days	0	30	60	90	120						
26												
27	Width, Top (mil)	1.05	1.05	1.049	1.05	1.05						
28	Width, Above Center (mil)	1.055	1.059	1.058	1.058	1.058						
29	Width, Center (mil)	1.053	1.059	1.053	1.051	1.05						
30	Width, Below Center (mil)	1.059	1.059	1.057	1.058	1.057						
31	Width, Bottom (mil)											
32												
33	Average Width (mil)	1.05425	1.05675	1.05425	1.05425	1.05375						
34	St. Dev. Width (mil)	0.00377	0.0045	0.00411	0.00435	0.00435						
35												
36	Thickness, Top (mil)	298	294	298	297	300						
37	Thickness, Above Center (mil)	309	308	309	308	310						
38	Thickness, Center (mil)	308	310	310	311	311						
39	Thickness, Below Center (mil)	300	299	298	300	301						
40	Thickness, Bottom (mil)											
41												
42	Average Thickness (mil)	303.75	302.75	303.75	304	305.5						
43	St. Dev. Thickness (mil)	5.56028	7.54431	6.65207	6.58281	5.8023						
44												
45	Liner Weight (grams)	98.4	98.74	98.38	98.27	98.18						
46												
47												
48	IRRADIATION EXPOSURE SAMPLES 90C											
49	DOSE EQUIVALENT (DAY OR YR)	VIRGIN	2 yr	VIRGIN	10 yr	VIRGIN	30 yr					
50	IMMERSION TIME (DAYS)	(2 yr)	30 (10 yr)	30 (30 yr)	30							
51												
52	Width, Top (mil)	1.145	1.144	1.066	1.066	1.24	1.238					
53	Width, Above Center (mil)	1.139	1.14	1.051	1.055	1.234	1.232					
54	Width, Center (mil)	1.149	1.151	1.02	1.022	1.19	1.2					
55	Width, Below Center (mil)	1.21	1.209	1.005	1.003	1.147	1.145					
56	Width, Bottom (mil)											
57												
58	Average Width (mil)	1.16075	1.161	1.0355	1.0365	1.20275	1.20375					
59	St. Dev. Width (mil)	0.03309	0.03232	0.02793	0.02913	0.04334	0.0425705					
60												
61	Thickness, Top (mil)	297	297	311	313	312	313					
62	Thickness, Above Center (mil)	302	303	311.5	312	304	307					
63	Thickness, Center (mil)	311	310	301	302	298	299					
64	Thickness, Below Center (mil)	311	314	296	297	295	297					
65	Thickness, Bottom (mil)											
66												
67	Average Thickness (mil)	305.25	306	304.875	306	302.25	304					
68	St. Dev. Thickness (mil)	6.94622	7.52773	7.64172	7.78888	7.5	7.393691					
69												
70	Liner Weight (grams)	54.56	54.68	48.94	49.02	55.58	55.67					

PIPE Vol. Data

	A	B	C	D	E	F	G	H	I
1				HDPE PIPE (DSSF,90) VOLATILES SUMMARY					
2			UNIRRADIATED				IRRADIATED		
3	Days	0	30	60	90	120	2 y/30	10 y/30	30 y/30
4									
5									
6	% Chg. Volatiles (90°)	0.0	15.1	-18.0	-44.4	-51.8	211.5	11.4	16.2
7									
8						PLOT DATA			
9			UNIRRADIATED				IRRADIATED		
10	Days	0	30	60	90	120	2 y/30	10 y/30	30 y/30
11	% Volatiles (90°)	0.08552	0.09841	0.07011	0.04759	0.04118	0.2664	0.095239	0.09935
12	stdev	0.00476	0.00797	0.00838	0.00301	0.00531	0.09152	0.011238	0.00929
13									
14	Virgin Material, Unirrad.		AMBIENT READINGS						
15	Specimen No.	1	2	3	4	5	AVG	ST DEV	
16									
17	"Wet" weight (g)	8.3075	7.5204	7.6973	9.1592	6.8456			
18	"Dried" weight (g)	8.3002	7.5144	7.6902	9.1516	6.8398			
19	Weight difference (g)	0.0073	0.006	0.0071	0.0076	0.0058			
20	% Volatiles	0.08787	0.07978	0.09224	0.08298	0.08473	0.08552	0.004762	
21									
22	30-Day, Unirrad.	<- - - - 90° - - - ->							
23	Specimen No.	1	2	3	AVG	ST DEV			
24									
25	"Wet" weight (g)	5.4496	5.5948	5.4039					
26	"Dried" weight (g)	5.4446	5.5888	5.3987					
27	Weight difference (g)	0.005	0.006	0.0052					
28	% Volatiles	0.09175	0.10724	0.09623	0.09841	0.00797			
29									
30	60-Day, Unirrad.	<- - - - 90° - - - ->							
31	Specimen No.	1	2	3	AVG	ST DEV			
32									
33	"Wet" weight (g)	7.4305	6.5935	4.3227					
34	"Dried" weight (g)	7.4259	6.5889	4.3193					
35	Weight difference (g)	0.0046	0.0046	0.0034					
36	% Volatiles	0.06191	0.06977	0.07865	0.07011	0.00838			
37									
38	90-Day, Unirrad.	<- - - - 90° - - - ->							
39	Specimen No.	1	2	3	AVG	ST DEV			
40									
41	"Wet" weight (g)	7.8664	8.4585	5.747					
42	"Dried" weight (g)	7.8624	8.4547	5.7443					
43	Weight difference (g)	0.004	0.0038	0.0027					
44	% Volatiles	0.05085	0.04493	0.04698	0.04759	0.00301			
45									
46	120-Day, Unirrad.	<- - - - 90° - - - ->							
47	Specimen No.	1	2	3	AVG	ST DEV			
48									
49	"Wet" weight (g)	6.2288	7.6849	7.9878					
50	"Dried" weight (g)	6.2261	7.6822	7.9842					
51	Weight difference (g)	0.0027	0.0027	0.0036					
52	% Volatiles	0.04335	0.03513	0.04507	0.04118	0.00531			
53									
54	2-Year Dose, 90 C	<- - - 30-day Imm. - - ->							

PIPE Vol. Data

	A	B	C	D	E	F	G	H	I
5 5	Specimen No.	1	2	3	AVG	ST DEV			
5 6									
5 7	"Wet" weight (g)	6.4188	4.9825	5.4794					
5 8	"Dried" weight (g)	6.3956	4.9696	5.4696					
5 9	Weight difference (g)	0.0232	0.0129	0.0098					
6 0	% Volatiles	0.36144	0.25891	0.17885	0.2664	0.09152			
6 1									
6 2	10-Year Dose, 90 C	<- - - 30-day Imm. - - ->							
6 3	Specimen No.	1	2	3	AVG	ST DEV			
6 4									
6 5	"Wet" weight (g)	7.5439	8.0376	6.8554					
6 6	"Dried" weight (g)	7.5368	8.029	6.8496					
6 7	Weight difference (g)	0.0071	0.0086	0.0058					
6 8	% Volatiles	0.09412	0.107	0.0846	0.09524	0.01124			
6 9									
7 0	30-Year Dose, 90 C	<- - - 30-day Imm. - - ->							
7 1	Specimen No.	1	2	3	AVG	ST DEV			
7 2									
7 3	"Wet" weight (g)	8.857	7.5128	6.9983					
7 4	"Dried" weight (g)	8.8486	7.5058	6.9906					
7 5	Weight difference (g)	0.0084	0.007	0.0077					
7 6	% Volatiles	0.09484	0.09317	0.11003	0.09935	0.00929			

PIPE Extract. Data

	A	B	C	D	E	F	G	H
1	HDPE PIPE (DSSF,90) EXTRACTABLES SUMMARY							
2								
3	Days	0	30	60	90	120		
4								
5								
6	% Chag. Extractables (90°)	0.0	-13.7	-16.1	0.6	-63.1		
7								
8								
9				PLOT DATA				
10	Days	0	30	60	90	120		
11	% Extractables (90°)	0.73886	0.63751	0.61972	0.743562	0.27276		
12	stdev	0.15298	0.02833	0.0477	0.128781	0.01362		
13								
14	Virgin Material, Unlrrad.	AMBIENT READINGS						
15	Specimen No.	1	2	3	4	5	AVG	stdev
16								
17	"Dried" weight (g)	5.987	6.26	5.9846	6.2061			
18	"Extracted" weight (g)	5.954	6.211	5.9297	6.1624			
19	Weight difference (g)	0.033	0.049	0.0549	0.0437			
20	% Extractables	0.55119	0.78275	0.91735	0.704146		0.73886	0.152981
21								
22	30-Day, Unlrrad.	<- - - - 90° - - - ->						
23	Specimen No.	1	2	AVG STDEV				
24								
25	"Dried" weight (g)	5.4445	5.5548					
26	"Extracted" weight (g)	5.4087	5.5205					
27	Weight difference (g)	0.0358	0.0343					
28	% Extractables	0.65754	0.61748	0.63751	0.028327			
29								
30	60-Day, Unlrrad.	<- - - - 90° - - - ->						
31	Specimen No.	1	2	AVG STDEV				
32								
33	"Dried" weight (g)	5.7509	6.8865					
34	"Extracted" weight (g)	5.7172	6.8415					
35	Weight difference (g)	0.0337	0.045					
36	% Extractables	0.586	0.65345	0.61972	0.047699			
37								
38	90-Day, Unlrrad.	<- - - - 90° - - - ->						
39	Specimen No.	1	2	AVG STDEV				
40								
41	"Dried" weight (g)	7.341	8.9741					
42	"Extracted" weight (g)	7.2931	8.8992					
43	Weight difference (g)	0.0479	0.0749					
44	% Extractables	0.6525	0.83462	0.74356	0.128781			
45								
46	120-Day, Unlrrad.	<- - - - 90° - - - ->						
47	Specimen No.	1	2	AVG STDEV				
48								
49	"Dried" weight (g)	9.7736	10.9831					
50	"Extracted" weight (g)	9.746	10.9542					
51	Weight difference (g)	0.0276	0.0289					
52	% Extractables	0.28239	0.26313	0.27276	0.01362			

PIPE Sp. G. Data

	A	B	C	D	E	F	G	H
1	HDPE PIPE (DSSF,90) SPECIFIC GRAVITY SUMMARY							
2								
3	Days	0	30	60	90	120		
4	% Sp gr 23/23 (90°)	0.0	-0.2	0.0	-0.1	0.3		
5		0.02941	0.18858	0.12248	0.25443	0.02699		
6								
7				PLOT DATA				
8	Days	0	30	60	90	120		
9								
10	Sp gr 23/23 (90°)	0.95869	0.95724	0.95846	0.95795	0.96141		
11								
12								
13	Virgin Material, Unirrad.	AMBIENT READINGS						
14	Specimen No.	1	2	3	4	5	AVG	ST DEV
15								
16	Weight in air (g)	8.3075	7.5204	7.6973	9.1592			
17	Weight immersed (g)	4.825	4.856	4.8465	4.7854			
18	Weight of sinker (g)	5.1794	5.1806	5.1805	5.1804			
19	Sp gr 23/23	0.95909	0.95862	0.95841	0.95866		0.95869	0.00028
20								
21	30-Day, Unirrad.	<- - - - 90° - - - ->						
22	Specimen No.	1	2	3	AVG	ST DEV		
23								
24	Weight in air (g)	5.4496	5.5948	5.4039				
25	Weight immersed (g)	4.277	4.2801	4.267				
26	Weight of sinker (g)	4.5195	4.5195	4.5195				
27	Sp gr 23/23	0.9574	0.95897	0.95536	0.95724	0.00181		
28								
29	60-Day, Unirrad.	<- - - - 90° - - - ->						
30	Specimen No.	1	2	3	AVG	ST DEV		
31								
32	Weight in air (g)	7.4305	6.5935	4.3227				
33	Weight immersed (g)	4.1944	4.233	4.3418				
34	Weight of sinker (g)	4.5228	4.5228	4.5228				
35	Sp gr 23/23	0.95767	0.9579	0.95981	0.95846	0.00117		
36								
37	90-Day, Unirrad.	<- - - - 90° - - - ->						
38	Specimen No.	1	2	3	AVG	ST DEV		
39								
40	Weight in air (g)	7.8664	8.4585	5.747				
41	Weight immersed (g)	4.184	4.1714	4.2546				
42	Weight of sinker (g)	4.5238	4.5238	4.5238				
43	Sp gr 23/23	0.95859	0.96	0.95525	0.95795	0.00244		
44								
45	120-Day, Unirrad.	<- - - - 90° - - - ->						
46	Specimen No.	1	2	3	AVG	ST DEV		
47								
48	Weight in air (g)	6.2288	7.6849	7.9878				
49	Weight immersed (g)	4.2708	4.2154	4.2037				
50	Weight of sinker (g)	4.5228	4.5228	4.5228				
51	Sp gr 23/23	0.96112	0.96154	0.96159	0.96141	0.00026		

PIPE Tensile Data

	A	B	C	D	E	F	G	H	I
1									
2			HDPE PIPE (DSSF,90) TENSILE SUMMARY						
3			UNIRRADIATED					IRRADIATED	
4	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
5	% Chg. Elong. at Yield	0.0	-1.8	9.9	9.2	9.2	-1.1	2.6	-1.1
6	stdev	2.8	3.4	3.8	3.4	5.5	6.2	3.4	0.0
7	% Chg. Elong. at Break	0.0	-11.5	-19.6	-32.0	-3.3	-17.2	-59.8	-84.9
8	stdev	5.4	11.5	23.1	31.9	11.3	23.0	17.3	4.0
9	% Chg Yield Strength	0.0	-0.7	2.7	4.0	8.3	2.7	7.2	11.4
10	stdev	1.2	1.2	1.3	4.2	2.3	1.6	4.4	1.1
11	% Chg Break Strength	0.0	-7.7	-20.4	-24.5	-0.6	-14.2	-31.6	-31.0
12	stdev	6.7	11.7	24.8	25.7	9.6	26.8	9.2	1.5
13	% Chg Stress 100% Elong.	0.0	1.3	3.8	5.4	11.2	3.1	16.5	32.9
14	stdev	1.0	0.6	1.7	7.9	5.5	0.8	3.3	3.5
15	% Chg Stress 200% Elong.	0.0	3.9	4.2	8.0	6.9	8.9	17.6	31.5
16	stdev	1.8	2.6	2.6	3.0	1.5	0.1	5.0	#DIV/0!
17	% Chg Elastic Modulus	0.0	1.2	-6.6	-4.6	-0.7	4.0	4.4	12.6
18	stdev	2.3	4.2	2.3	6.9	3.6	8.2	2.6	1.1
19									
20									
21						TENSILE PLOTS			
22			UNIRRADIATED					IRRADIATED	
23	% Elong. at Yield								
24	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
25									
26	with grain, 90°C	22.75	22.3333	25	24.8333	24.8333	22.5	23.33333	22.5
27									
28	% Elong. at Break								
29	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
30									
31	with grain, 90°C	1270.25	1124.5	1021.67	863.833	1228.33	1051.5	511	191.75
32									
33	Yield Strength (psi)								
34	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
35									
36	with grain, 90°C	2927.27	2906.68	3005.65	3045.61	3171.51	3006.02	3137.075	3262.22
37									
38	Break Strength (psi)								
39	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
40									
41	with grain, 90°C	3920.21	3619.16	3121.95	2960.21	3895.43	3365.12	2681.014	2704.34
42									
43	Stress at 100% elong.								
44	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
45									
46	with grain, 90°C	1995.92	2021.54	2072.09	2102.73	2218.94	2057.71	2325.357	2652.06
47									
48	Stress at 200% elong.								
49	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
50									
51	with grain, 90°C	1989.13	2066.78	2072.7	2147.71	2127.35	2166.18	2339.096	2615.59
52									
53	Elastic Modulus	0	30	60	90	120	2-y/30	10-y/30	30-y/30
54									
55	with grain, 90°C	12873	13026.7	12029.1	12282.3	12785.7	13393.1	13444.59	14498.8
56									
57									
58									
59	UNIRRAD.								
60	Virgin Material		TENSILE MEASUREMENTS						
61	Specimen No.	1	2	3	4	5	Average	St. Dev	
62									
63	Neck Thick (mil)	293	297	303	289				
64	Neck Thick (mil)	293	293	302	291				
65	Neck Thick (mil)	295	293	299	295				
66	Neck Thick (mil)	300	291	298	298				
67	Average (mil)	295.25	293.5	300.5	293.25		295.625	4.112988	
68	St. Dev. (mil)	3.30404	2.51661	2.38048	4.03113	#DIV/0!			
69	Neck Width (in)	0.25	0.25	0.25	0.25				

PIPE Tensile Data

	A	B	C	D	E	F	G	H	I
7 0	Neck Width (in)	0.25	0.25	0.25	0.25				
7 1	Neck Width (in)	0.25	0.25	0.25	0.25				
7 2	Neck Width (in)	0.25	0.25	0.25	0.25				
7 3	Average (in)	0.250	0.250	0.250	0.250		0.25	0	
7 4	St. Dev. (mil)	0	0	0	0	#DIV/0!			
7 5	Elongation at Yield (in)	0.45	0.46	0.44	0.47				
7 6	% Elongation at Yield	22.5	23	22	23.5		22.75	0.645497	
7 7	Elongation at Break (in)	26.44	23.38	25.82	25.98				
7 8	% Elongation at Break	1322	1169	1291	1299		1270.25	68.76712	
7 9									
8 0	Load at Yield (lb)	218.2	215.7	216.2	215.2				
8 1	Yield Stress (psi)	2956.14	2939.69	2877.87	2935.38		2927.27	34.12649	
8 2	Load at Break (lb)	301.9	258.9	303.9	294.5				
8 3	Break Strength (psi)	4090.09	3528.45	4045.26	4017.05		3920.21	262.9014	
8 4	"YIELD" Modulus (psi)	13138.4	12781.3	13081.2	12491		12873	298.97	
8 5	Load at 100% Elong. (lb)	148	146	148	148				
8 6	Stress at 100% Elong.(psi)	2005.08	1989.78	1970.05	2018.76		1995.92	20.91526	
8 7	Load at 200% Elong. (lb)	150	147	147	144				
8 8	Stress at 200% Elong.(psi)	2032.18	2003.41	1956.74	1964.19		1989.13	35.25045	
8 9									
9 0									
9 1	UNIRRAD.								
9 2	30-Day (with grain)	* * * * 90° C * * * *							
9 3	Specimen No.	1	2	3	AVG	ST DEV			
9 4									
9 5	Neck Thick (mil)	304	300	289					
9 6	Neck Thick (mil)	306	299	291					
9 7	Neck Thick (mil)	305	296	290					
9 8	Neck Thick (mil)	302	294	286					
9 9	Average (mil)	304.25	297.25	289					
1 0 0									
1 0 1	Neck Width (in)	0.25	0.25	0.25					
1 0 2	Neck Width (in)	0.25	0.25	0.25					
1 0 3	Neck Width (in)	0.25	0.25	0.25					
1 0 4	Neck Width (in)	0.25	0.25	0.25					
1 0 5	Average (in)	0.250	0.250	0.250					
1 0 6									
1 0 7	Elongation at Yield (in)	0.45	0.43	0.46					
1 0 8	% Elongation at Yield	22.5	21.5	23	22.3333	0.76376			
1 0 9	Elongation at Break (in)	20.32	21.33	25.82					
1 1 0	% Elongation at Break	1016	1066.5	1291	1124.5	146.387			
1 1 1									
1 1 2	Load at Yield (lb)	218	218	211					
1 1 3	Yield Strength (psi)	2866.06	2933.56	2920.42	2906.68	35.8			
1 1 4	Load at Break (lb)	246	260	298					
1 1 5	Break Strength (psi)	3234.18	3498.74	4124.57	3619.16	457.245			
1 1 6	"YIELD" Modulus (psi)	12738.1	13644.5	12697.5	13026.7	535.412			
1 1 7	Load at 100% Elong. (lb)	153	150	147					
1 1 8	Stress at 100% Elong.(psi)	2011.5	2018.5	2034.6	2021.54	11.8			
1 1 9	Load at 200% Elong. (lb)	153	157	150					
1 2 0	Stress at 200% Elong.(psi)	2011.5	2112.7	2076.12	2066.78	51.2			
1 2 1									
1 2 2									
1 2 3	UNIRRAD.								
1 2 4	60-Day (with grain)	* * * * 90° C * * * *							
1 2 5	Specimen No.	1	2	3	AVG	ST DEV			
1 2 6									
1 2 7	Neck Thick (mil)	289.4	301.8	295.7					
1 2 8	Neck Thick (mil)	287	305.7	299.3					
1 2 9	Neck Thick (mil)	289.7	304.9	298					
1 3 0	Neck Thick (mil)	289.2	305.9	299.8					
1 3 1	Average (mil)	289	305	298					
1 3 2									
1 3 3	Neck Width (in)	0.25	0.25	0.25					
1 3 4	Neck Width (in)	0.25	0.25	0.25					
1 3 5	Neck Width (in)	0.25	0.25	0.25					
1 3 6	Neck Width (in)	0.25	0.25	0.25					
1 3 7	Average (in)	0.250	0.250	0.250					
1 3 8									

PIPE Tensile Data

	A	B	C	D	E	F	G	H	I
139	Elongation at Yield (in)	0.49	0.49	0.52					
140	% Elongation at Yield	24.5	24.5	26	25	0.86603			
141	Elongation at Break (in)	14.3	21	26					
142	% Elongation at Break	715	1050	1300	1021.67	293.527			
143									
144	Load at Yield (lb)	217	226	226.9					
145	Yield Strength (psi)	3005.3	2968.1	3043.6	3005.6	37.8			
146	Load at Break (lb)	150	250.6	298					
147	Break Strength (psi)	2077.4	3291.1	3997.3	3121.9	971.1			
148	*YIELD* Modulus (psi)	12266.4	12114.6	11706.1	12029.1	289.8			
149	Load at 100% Elong. (lb)	147	160	155					
150	Stress at 100% Elong.(psi)	2035.8	2101.3	2079.1	2072.1	33.3			
151	Load at 200% Elong. (lb)	148	155	159					
152	Stress at 200% Elong.(psi)	2049.7	2035.6	2132.8	2072.7	52.5			
153									
154									
155	UNIRRAD.								
156	90-Day (with grain)	* * * * 90° C * * * *							
157	Specimen No.	1	2	3	AVG	ST DEV			
158									
159	Neck Thick (mil)	289	307	308					
160	Neck Thick (mil)	289	312	307					
161	Neck Thick (mil)	287	311	306					
162	Neck Thick (mil)	289	303	305					
163	Average (mil)	289	308	307					
164									
165	Neck Width (in)	0.25	0.25	0.25					
166	Neck Width (in)	0.25	0.25	0.25					
167	Neck Width (in)	0.25	0.25	0.25					
168	Neck Width (in)	0.25	0.25	0.25					
169	Average (in)	0.250	0.250	0.250					
170									
171	Elongation at Yield (in)	0.5	0.48	0.51					
172	% Elongation at Yield	25	24	25.5	24.8333	0.76376			
173	Elongation at Break (in)	25.8	16.33	9.7					
174	% Elongation at Break	1290	816.5	485	863.833	404.582			
175									
176	Load at Yield (lb)	218	245	224.9					
177	Yield Strength (psi)	3022.5	3179.2	2935.1	3045.6	123.7			
178	Load at Break (lb)	295.3	201.9	166					
179	Break Strength (psi)	4094.3	2620.0	2166.4	2960.2	1008.0			
180	*YIELD* Modulus (psi)	12090.1	13246.8	11510.1	12282.3	884.2			
181	Load at 100% Elong. (lb)	150	175	150					
182	Stress at 100% Elong.(psi)	2079.7	2270.9	1957.6	2102.7	157.9			
183	Load at 200% Elong. (lb)	155	170	160					
184	Stress at 200% Elong.(psi)	2149.0	2206.0	2088.1	2147.7	59.0			
185									
186									
187	UNIRRAD.								
188	120-Day (with grain)	* * * * 90° C * * * *							
189	Specimen No.	1	2	3	AVG	ST DEV			
190									
191	Neck Thick (mil)	293.9	304	293.2					
192	Neck Thick (mil)	293.6	307	294					
193	Neck Thick (mil)	292.6	303.7	294.8					
194	Neck Thick (mil)	292	307	296					
195	Average (mil)	293	305	295					
196									
197	Neck Width (in)	0.25	0.25	0.25					
198	Neck Width (in)	0.25	0.25	0.25					
199	Neck Width (in)	0.25	0.25	0.25					
200	Neck Width (in)	0.25	0.25	0.25					
201	Average (in)	0.250	0.250	0.250					
202									
203	Elongation at Yield (in)	0.5	0.47	0.52					
204	% Elongation at Yield	25	23.5	26	24.8333	1.25831			
205	Elongation at Break (in)	25	21.5	27.2					
206	% Elongation at Break	1250	1075	1360	1228.33	143.73			
207									

PIPE Tensile Data

	A	B	C	D	E	F	G	H	I
208	Load at Yield (lb)	229.6	239	239.3					
209	Yield Strength (psi)	3134.2	3130.1	3250.3	3171.5	68.2			
210	Load at Break (lb)	295.1	265.1	308.2					
211	Break Strength (psi)	4028.3	3471.9	4186.1	3895.4	375.2			
212	"YIELD" Modulus (psi)	12536.8	13319.4	12501	12785.7	462.5			
213	Load at 100% Elong. (lb)	165	160	170					
214	Stress at 100% Elong.(psi)	2252.4	2095.4	2309.0	2218.9	110.6			
215	Load at 200% Elong. (lb)	155	165	155					
216	Stress at 200% Elong.(psi)	2115.9	2160.9	2105.3	2127.3	29.6			
217									
218									
219	2-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *							
220	Specimen No.	1	2	3	AVG	ST DEV			
221									
222	Neck Thick (mil)	294.3	299.6						
223	Neck Thick (mil)	291.2	299.4						
224	Neck Thick (mil)	288	299.2						
225	Neck Thick (mil)	286.8	297.7						
226	Average (mil)	290	299	#DIV/0!					
227									
228	Neck Width (in)	0.25	0.25						
229	Neck Width (in)	0.25	0.25						
230	Neck Width (in)	0.25	0.25						
231	Neck Width (in)	0.25	0.25						
232	Average (in)	0.250	0.250	#DIV/0!					
233									
234	Elongation at Yield (in)	0.43	0.47						
235	% Elongation at Yield	21.5	23.5		22.5	1.41421			
236	Elongation at Break (in)	25.16	16.9						
237	% Elongation at Break	1258	845		1051.5	292.035			
238									
239	Load at Yield (lb)	220.4	222.2						
240	Yield Strength (psi)	3039.2	2972.8		3006.0	46.9			
241	Load at Break (lb)	298	195.9						
242	Break Strength (psi)	4109.3	2621.0		3365.1	1052.4			
243	"YIELD" Modulus (psi)	14135.9	12650.3		13393.1	1050.5			
244	Load at 100% Elong. (lb)	150	153						
245	Stress at 100% Elong.(psi)	2068.4	2047.0		2057.7	15.2			
246	Load at 200% Elong. (lb)	157	162						
247	Stress at 200% Elong.(psi)	2165.0	2167.4		2166.2	1.7			
248									
249									
250	10-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *							
251	Specimen No.	1	2	3	AVG	ST DEV			
252									
253	Neck Thick (mil)	305.5	314.8	300.1					
254	Neck Thick (mil)	300.5	314.2	299					
255	Neck Thick (mil)	295.6	314.7	304					
256	Neck Thick (mil)	294.9	315.3	303.8					
257	Average (mil)	299	315	302					
258									
259	Neck Width (in)	0.25	0.25	0.25					
260	Neck Width (in)	0.25	0.25	0.25					
261	Neck Width (in)	0.25	0.25	0.25					
262	Neck Width (in)	0.25	0.25	0.25					
263	Average (in)	0.250	0.250	0.250					
264									
265	Elongation at Yield (in)	0.48	0.45	0.47					
266	% Elongation at Yield	24	22.5	23.5	23.3333	0.76376			
267	Elongation at Break (in)	6.53	15.1	9.03					
268	% Elongation at Break	326.5	755	451.5	511	220.359			
269									
270	Load at Yield (lb)	236.8	235.8	245					
271	Yield Strength (psi)	3166.6	2996.7	3248.0	3137.1	128.2			
272	Load at Break (lb)	181	243.5	190.7					
273	Break Strength (psi)	2420.4	3094.5	2528.1	2681.0	362.1			
274	"YIELD" Modulus (psi)	13194	13318.5	13821.2	13444.6	332.1			
275	Load at 100% Elong. (lb)	177	177	178					
276	Stress at 100% Elong.(psi)	2366.9	2249.4	2359.8	2325.4	65.9			

PIPE Tensile Data

	A	B	C	D	E	F	G	H	I
277	Load at 200% Elong. (lb)	180	175	180					
278	Stress at 200% Elong.(psi)	2407.0	2224.0	2386.3	2339.1	100.2			
279									
280									
281	30-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *							
282	Specimen No.	1	2	3	4	AVG	STDEV		
283									
284	Neck Thick (mil)	308.1	299.7	290.2	292.6				
285	Neck Thick (mil)	305.2	300	293.1	291.8				
286	Neck Thick (mil)	301	304.4	296.5	294.8				
287	Neck Thick (mil)	299.8	307.1	300.8	294.7				
288	Average (mil)	304	303	295	293				
289									
290	Neck Width (in)	0.25	0.25	0.25	0.25				
291	Neck Width (in)	0.25	0.25	0.25	0.25				
292	Neck Width (in)	0.25	0.25	0.25	0.25				
293	Neck Width (in)	0.25	0.25	0.25	0.25				
294	Average (in)	0.250	0.250	0.250	0.250				
295									
296	Elongation at Yield (in)	0.45	0.45	0.45	0.45				
297	% Elongation at Yield	22.5	22.5	22.5	22.5	22.5	0		
298	Elongation at Break (in)	3.82	5.15	2.65	3.72				
299	% Elongation at Break	191	257.5	132.5	186	191.75	51.2095		
300									
301	Load at Yield (lb)	249	243.5	242.5	239.5				
302	Yield Strength (psi)	3281.4	3216.6	3286.5	3264.3	3262.2	31.8		
303	Load at Break (lb)	199.4	204.8	199.9	203.6				
304	Break Strength (psi)	2627.8	2705.4	2709.1	2775.0	2704.3	60.2		
305	*YIELD* Modulus (psi)	14584.2	14296.2	14606.5	14508.1	14498.8	141.5		
306	Load at 100% Elong. (lb)	196	197	199	200				
307	Stress at 100% Elong.(psi)	2583.0	2602.4	2696.9	2726.0	2652.1	70.0		
308	Load at 200% Elong. (lb)		198						
309	Stress at 200% Elong.(psi)		2615.6			2615.6	#DIV/0!		

PIPE Hard. Data

	A	B	C	D	E	F	G	H	I
1	HDPE PIPE (DSSF,90) HARDNESS DATA SUMMARY								
2		UNIRRADIATED						IRRADIATED	
3	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
4									
5									
6									
7	% Change Hardness (90°)	0.0	-1.3	-0.1	0.1	0.7	-4.6	0.8	1.4
8									
9						PLOT DATA			
10		UNIRRADIATED						IRRADIATED	
11	Days	0	30	60	90	120	2-y/30	10-y/30	30-y/30
12	Ave. Hardness (90°)	66.6	65.7333	66.5333	66.6667	67.0667	63.55	67.15	67.5
13	stdev	1.18766	1.70992	1.72654	1.58865	2.18654	2.43818	2.109502	1.76218
14									
15	UNIRRAD.								
16	Virgin Material	AMBIENT READINGS							
17	Specimen No.	1	2	3	4	AVE	STDEV		
18									
19	Durometer Point Reading	66	66	65	65				
20	Durometer Point Reading	68	66	69	69				
21	Durometer Point Reading	66	66	67	67				
22	Durometer Point Reading	67	65	68	66				
23	Durometer Point Reading	66	67	66	67				
24	Average	66.6	66	67	66.8	66.6	1.18766		
25									
26	30-Day, Unirrad.	90C MEASUREMENTS							
27	Specimen No.	1	2	3	AVE	STDEV			
28									
29	Durometer Point Reading	64	68	65					
30	Durometer Point Reading	64	65	66					
31	Durometer Point Reading	67	68	67					
32	Durometer Point Reading	66	64	64					
33	Durometer Point Reading	67	63	68					
34	Average	65.6	65.6	66	65.7333	1.70992			
35									
36	60-Day, Unirrad.	90C MEASUREMENTS							
37	Specimen No.	1	2	3	AVE	STDEV			
38									
39	Durometer Point Reading	69	68	63					
40	Durometer Point Reading	68	68	68					
41	Durometer Point Reading	67	64	67					
42	Durometer Point Reading	66	67	66					
43	Durometer Point Reading	67	64	66					
44	Average	67.4	66.2	66	66.5333	1.72654			
45									
46	90-Day, Unirrad.	90C MEASUREMENTS							
47	Specimen No.	1	2	3	AVE	STDEV			
48									
49	Durometer Point Reading	66	66	69					
50	Durometer Point Reading	68	68	68					
51	Durometer Point Reading	66	69	64					
52	Durometer Point Reading	65	66	67					
53	Durometer Point Reading	68	65	65					
54	Average	66.6	66.8	66.6	66.6667	1.58865			
55									

PIPE Hard. Data

	A	B	C	D	E	F	G	H	I
5 6	120-Day, Unirrad.		90C MEASUREMENTS						
5 7	Specimen No.	1	2	3	Ave	STDEV			
5 8									
5 9	Durometer Point Reading	69	67	68					
6 0	Durometer Point Reading	69	69	67					
6 1	Durometer Point Reading	63	70	69					
6 2	Durometer Point Reading	65	65	65					
6 3	Durometer Point Reading	67	64	69					
6 4	Average	66.6	67	67.6	67.0667	2.18654			
6 5									
6 6	2-YR Dose, 90C	30 D IMM. MEASUREMENTS							
6 7	Specimen No.	1	2	3	4	Avg	ST DEV		
6 8									
6 9	Durometer Point Reading	66	62	60	65				
7 0	Durometer Point Reading	61	62	66	66				
7 1	Durometer Point Reading	61	63	65	64				
7 2	Durometer Point Reading	66	67	65	58				
7 3	Durometer Point Reading	65	64	64	61				
7 4	Average	63.8	63.6	64	62.8	63.55	2.43818		
7 5									
7 6	10-YR Dose, 90C	30 D IMM. MEASUREMENTS							
7 7	Specimen No.	1	2	3	4	Avg	ST DEV		
7 8									
7 9	Durometer Point Reading	68	68	67	68				
8 0	Durometer Point Reading	70	65	68	67				
8 1	Durometer Point Reading	67	69	64	63				
8 2	Durometer Point Reading	66	67	63	67				
8 3	Durometer Point Reading	67	70	69	70				
8 4	Average	67.6	67.8	66.2	67	67.15	2.1095		
8 5									
8 6	30-YR Dose, 90C	30 D IMM. MEASUREMENTS							
8 7	Specimen No.	1	2	3	4	Avg	ST DEV		
8 8									
8 9	Durometer Point Reading	71	68	70	66				
9 0	Durometer Point Reading	65	66	69	69				
9 1	Durometer Point Reading	68	66	67	69				
9 2	Durometer Point Reading	68	67	68	66				
9 3	Durometer Point Reading	66	70	66	65				
9 4	Average	67.6	67.4	68	67	67.5	1.76218		

APPENDIX E

RAW AND TABULATED DATA FOR 8130 XR5 LINER TESTING

XR5 DIMENSIONAL DATA

	A	B	C	D	E	F	G	H	I	J	K	L
1	8130 XR5 DIMENSIONAL DATA SUMMARY											
2		UNIRRADIATED			IRRADIATED							
3	Days	0	30	60	120 d/30	2 y/30	10 y/30	30 y/30				
4												
5	% Change Length (amb)	0.00	0.00	0.00								
6	% Change Length (90°)	0.00	-1.51	-1.51	-1.6886	-2.178	-1.24283	-1.2334				
7												
8	% Change Width (amb)	0.00	0.00	0.00								
9	% Change Width (90°)	0.00	-0.16	0.00	-0.1653	-0.4112	-0.328407	-0.32841				
10												
11	% Change Thick (amb)	0.00	-0.62	-0.83								
12	% Change Thick (90°)	0.00	-0.98	6.46	0	4.98246	0.0709723	0.41958				
13												
14	% Change Weight (amb)	0.00	0.65	1.96								
15	% Change Weight (90°)	0.00	-1.37	3.18	1.11746	5.80089	0.789266	0.510334				
16	DATA FOR PLOTS											
17		UNIRRADIATED			IRRADIATED							
18	Days	0	30	60	120d/virg	120 d/30	2yr/virgin	2 y/30	10y/virgin	10 y/30	30y/virgi	30 y/30
19	Ave. Length (amb)	176	176	176								
20	Ave. Length (90°)	177	174	174	177.667	175	176	172	174	172	176	174
21	Ave. Width (amb)	199	199	199								
22	Ave. Width (90°)	207	207	207	201.667	201	203	202	203	202	203	202
23												
24	Ave. Thick (amb)	36	36	36								
25	Ave. Thick (90)	36	35	38	35.375	35	36	37	35	35	36	36
26												
27	Sample Wt. (amb)	38.7	39.0	39.5	38.48	38.9	38.3	40.5	38.0	38.3	39.2	39.4
28	Sample Wt. (90)	39.3	38.8	40.6								
29												
30	9090 DIMENSIONAL MEASUREMENTS AMBIENT											
31	Days	0	30	60								
32												
33	Length side a-b (mm)	177	177	177								
34	Length side c-d (mm)	176	176	176								
35	Length through center (mm)	175	175	175								
36	Average Length (mm)	176	176	176								
37	ST DEV (mm)	1	1	1								
38												
39	Width side b-c (mm)	196	196	196								
40	Width side d-a (mm)	203	203	203								
41	Width through center (mm)	199	199	199								
42	Average Width (mm)	199	199	199								
43	ST DEV (mm)	3.51188	3.51188	3.51188								
44												
45	Thickness corner a (mil)	36.5	36.2	36								
46	Thickness corner b (mil)	36.3	36.2	36.1								
47	Thickness corner c (mil)	36.1	35.9	35.9								
48	Thickness corner d (mil)	35.9	35.6	35.6								
49	Average Thickness (mil)	36	36	36								
50	ST DEV (mm)	0.2582	0.28723	0.21602								
51												
52	Liner Weight(grams)	38.7	38.95	39.46								
53												
54	9090 DIMENSIONAL MEASUREMENTS 90°											
55	Days	0	30	60								
56												
57	Length side a-b (mm)	179	176	176								
58	Length side c-d (mm)	175	173	173								
59	Length through center (mm)	177	174	174								
60	Average Length (mm)	177	174	174								
61	ST DEV(mm)	2	1.52753	1.52753								
62												
63	Width side b-c (mm)	207	207	207								
64	Width side d-a (mm)	207	207	207								
65	Width through center (mm)	208	207	208								
66	Average Length (mm)	207	207	207								
67	ST DEV(mm)	0.57735	0	0.57735								
68												
69	Thickness corner a (mil)	35	34.8	37.3								
70	Thickness corner b (mil)	35	34.8	36.8								
71	Thickness corner c (mil)	36.3	35.8	40								
72	Thickness corner d (mil)	36.2	35.7	37.6								
73	Average Thickness (mil)	36	35	38								
74	ST DEV (mm)	0.72284	0.55	1.42215								
75												

XRS DIMENSIONAL MTA

	A	B	C	D	E	F	G	H	I	J	K	L
7 6	Liner Weight (grams)	39.321	38.78	40.571								
7 7												
7 8		IRRADIATION EXPOSURE SAMPLES 90C										
7 9	DOSE EQUIVALENT (DAY OR YR)	VIRGIN	120 d	VIRGIN	2 yr	VIRGIN	1 Ovr	VIRGIN	30 yr			
8 0	IMMERSION TIME (DAYS)	(120 D)	30	(2 yr)	30	(10 yr)	30	(30 yr)	30			
8 1												
8 2	Length side a-b (mm)	177	174	179	172	175	172.5	177	174			
8 3	Length side c-d (mm)	179	176	175	172	174	172	175	173.5			
8 4	Length through center (mm)	177	174	174	172.5	174	172	175	173			
8 5	Average Length (mm)	178	175	176	172	174	172	176	174			
8 6	ST DEV (mm)	1.1547	1.1547	2.64575	0.28868	0.57735	0.2886751	1.154701	0.5			
8 7												
8 8	Width side b-c (mm)	200	200	203	202	203	202	204	204			
9	Width side d-a (mm)	204	203	202	202	203	203	202	201			
9 0	Width through center (mm)	201	201	203	201.5	203	202	203	202			
9 1	Average Width (mm)	202	201	203	2021	203	202	2031	2021			
9 2	ST DEV (mm)	2.08167	1.527531	0.57735	0.288681	0	0.57735031	1	1.527525			
9 3												
9 4	Thickness corner a (mil)	35.5	35.5	36.1	37.2	35	35	36	36			
9 5	Thickness corner b (mil)	35.5	35.5	35.9	38	35.4	35.4	36.2	36.2			
9 6	Thickness corner c (mil)	35.2	35.3	35.2	37.5	35.51	35.5	35.5	35.7			
9 7	Thickness corner d (mil)	35.3	35.2	35.3	36.9	35	35.1	35.3	35.7			
9 8	Average Thickness (mil)	35	35	36	37	35	35	36	36			
9 9	ST DEV (mm)	0.15	0.15	0.44253	0.46904	0.263	0.2380476	0.420317	0.244949			
1 0 0												
1 0 1	Liner Weight(grams)	38.48	38.91	38.27	40.49	38.01	38.31	39.19	39.39			

XR5 Volatiles Data

	A	B	C	D	E	F	G	H	I
1	8130 XR5 VOLATILES SUMMARY								
2	UNIRRADIATED				IRRADIATED				
3	Days	0	30	60	120 d/30	2 y/30	10 y/30	30 y/30	
4									
5	% Chg. Volatiles (amb)	0.0	468.2	396.4					
6	% Chg. Volatiles (90°)	0.0	2074.0	2378.3	1133.5	2734.7	1956.6	1918.6	
7									
8	PLOT DATA								
9	UNIRRADIATED				IRRADIATED				
10	Days	0	30	60	120 d/30	2 y/30	10 y/30	30 y/30	
11	% Volatiles (amb)	0.37212	2.11446	1.84717					
12	% Volatiles (90°)	0.37212	8.08981	9.22244	4.59007	10.5484	7.65309	7.511654	
13									
14									
15	Virgin Material, Unirrad.	AMBIENT READINGS							
16	Specimen No.	1	2	3	4	5	AVG	ST DEV	
17									
18	"Wet" weight (g)	2.1496	2.1592	2.143	2.1447				
19	"Dried" weight (g)	2.1402	2.1505	2.1388	2.135				
20	Weight difference (g)	0.0094	0.0087	0.0042	0.0097				
21	% Volatiles	0.43729	0.40293	0.19599	0.45228		0.37212	0.119226	
22									
23	30-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - 90° - - ->			
24	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
25									
26	"Wet" weight (g)	2.1952	2.183			2.1549	2.193		
27	"Dried" weight (g)	2.1443	2.1413			1.9898	2.0062		
28	Weight difference (g)	0.0509	0.0417			0.1651	0.1868		
29	% Volatiles	2.3187	1.91022	2.11446	0.28884	7.66161	8.51801	8.08981	0.60557
30									
31	60-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - 90° - - ->			
32	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
33									
34	"Wet" weight (g)	2.1212	2.1344			2.2388	2.2383		
35	"Dried" weight (g)	2.0807	2.0963			2.0226	2.0416		
36	Weight difference (g)	0.0405	0.0381			0.2162	0.1967		
37	% Volatiles	1.9093	1.78504	1.84717	0.08786	9.65696	8.78792	9.222439	0.6145
38									
39									
40	120-Day Dose, 90 C	<- - - 30-day Imm. - - ->							
41	Specimen No.	1	2	AVG	ST DEV				
42									
43	"Wet" weight (g)	2.1937	2.118						
44	"Dried" weight (g)	2.0904	2.0233						
45	Weight difference (g)	0.1033	0.0947						
46	% Volatiles	4.70894	4.4712	4.59007	0.16811				
47									
48	2-Year Dose, 90 C	<- - - 30-day Imm. - - ->							
49	Specimen No.	1	2	AVG	ST DEV				
50									
51	"Wet" weight (g)	2.299	2.3007						
52	"Dried" weight (g)	2.0622	2.0523						
53	Weight difference (g)	0.2368	0.2484						
54	% Volatiles	10.3001	10.7967	10.5484	0.35114				
55									
56	10-Year Dose, 90 C	<- - - 30-day Imm. - - ->							
57	Specimen No.	1	2	AVG	ST DEV				
58									
59	"Wet" weight (g)	2.218	2.2128						
60	"Dried" weight (g)	2.0454	2.0463						
61	Weight difference (g)	0.1726	0.1665						
62	% Volatiles	7.78179	7.5244	7.65309	0.182				
63									
64	30-Year Dose, 90 C	<- - - 30-day Imm. - - ->							
65	Specimen No.	1	2	AVG	ST DEV				
66									
67	"Wet" weight (g)	2.2035	2.1712						
68	"Dried" weight (g)	2.032	2.014						
69	Weight difference (g)	0.1715	0.1572						
70	% Volatiles	7.78307	7.24024	7.51165	0.38384				

XR5 Extractables Data

	A	B	C	D	E	F	G	H
1		8130 XR5 EXTRACTABLES SUMMARY						
2								
3	Days	0	30	60				
4								
5	% Chg. Extractables (amb)	0.0	-6.8	-18.1				
6	% Chg. Extractables (90°)	0.0	-78.4	-74.4				
7								
8								
9		PLOT DATA						
10	Days	0	30	60				
11	% Extractables (amb)	21.2617	19.8132	17.4218				
12	% Extractables (90°)	21.2617	4.59054	5.43809				
13								
14								
15	Virgin Material, Unirrad.		AMBIENT READINGS					
16	Specimen No.	1	2	3	4	5	AVG	stddev
17								
18	"Dried" weight (g)	4.3292	4.336	4.2991	4.3271			
19	"Extracted" weight (g)	3.4325	3.394	3.3886	3.3998			
20	Weight difference (g)	0.8967	0.942	0.9105	0.9273			
21	% Extractables	20.7128	21.7251	21.1789	21.43006		21.2617	0.715775
22								
23	30-Day, Unirrad.	<- - - AMBIENT - - ->			<- - - - 90° - - - ->			
24	Specimen No.	1	2	AVG	1	2	AVG	
25								
26	"Dried" weight (g)	4.2919	4.3298		3.978	3.9729		
27	"Extracted" weight (g)	3.4265	3.4871		3.7872	3.7987		
28	Weight difference (g)	0.8654	0.8427		0.1908	0.1742		
29	% Extractables	20.1636	19.4628	19.8132	4.79638	4.38471	4.59054	
30								
31	60-Day, Unirrad.	<- - - AMBIENT - - ->			<- - - - 90° - - - ->			
32	Specimen No.	1	2	AVG	1	2	AVG	
33								
34	"Dried" weight (g)	4.1603			4.0922	4.089		
35	"Extracted" weight (g)	3.4355			3.8707	3.8656		
36	Weight difference (g)	0.7248			0.2215	0.2234		
37	% Extractables	17.4218		17.4218	5.412736	5.46344	5.43809	

XR5 SPECIFIC GRAVITY DATA

	A	B	C	D	E	F	G	H	I
1	8130 XR5 SPECIFIC GRAVITY SUMMARY								
2									
3	Days	0	30	60					
4									
5	% Sp gr 23/23 (amb)	0.0	0.9	0.0					
6	% Sp gr 23/23 (90°)	0.0	0.9	2.7					
7									
8									
9		PLOT DATA							
10	Days	0	30	60					
11	Sp gr 23/23 (amb)	1.21755	1.2282	1.21761					
12	Sp gr 23/23 (90°)	1.21755	1.22857	1.25027					
13									
14									
15	Virgin Material, Unirrad.	AMBIENT READINGS							
16	Specimen No.	1	2	3	4	5	AVG	ST DEV	
17									
18	Weight in air (g)	2.1496	2.1592	2.143	2.1447				
19	Weight immersed (g)	7.4968	7.4947	7.4923	7.4986				
20	Weight of sinker (g)	7.1116	7.1116	7.1116	7.1116				
21	Sp gr 23/23	1.21832	1.2157	1.21602	1.22017		1.21755	0.0021	
22									
23	30-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->			
24	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
25									
26	Weight in air (g)	2.1952	2.183			2.1549	2.193		
27	Weight immersed (g)	7.5079	7.5175			7.4961	7.536		
28	Weight of sinker (g)	7.106	7.106			7.1116	7.1116		
29	Sp gr 23/23	1.22411	1.23229	1.2282	0.00578	1.21718	1.23996	1.22857	0.01611
30									
31	60-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->			
32	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
33									
34	Weight in air (g)	2.1212	2.1344			2.2388	2.2383		
35	Weight immersed (g)	4.7916	4.7662			4.824	4.85		
36	Weight of sinker (g)	4.3999	4.3976			4.389	4.389		
37	Sp gr 23/23	1.22648	1.20874	1.21761	0.01254	1.24116	1.25938	1.25027	0.01289

XR5 Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
1			8130 XR5 TENSILE SUMMARY									
2			UNIRRADIATED			IRRADIATED						
3	Days	0	30	60	120-d/30	2-y/30	10-y/30	30-y/30				
4												
5	% Chg. Elong. at Break											
6	with grain, amb	0.0	27.3	-19.8								
7	with grain, 90°C	0.0	-28.3	-37.8	-34.6	-26.9	-27.6	-30.4				
8	cross grain, amb	0.0	6.7	-4.3								
9	cross grain, 90°C	0.0	-39.6	-40.0	-39.1	-36.6	-35.0	-41.1				
10												
11	% Chg Break Strength											
12	with grain, amb	0.0	-2.8	-10.2								
13	with grain, 90°C	0.0	-12.9	-38.1	-27.9	-20.3	-21.4	-23.7				
14	cross grain, amb	0.0	-22.7	21.5								
15	cross grain, 90°C	0.0	-9.9	-33.9	-17.2	-16.2	-8.6	-22.1				
16												
17			TENSILE PLOTS									
18			UNIRRADIATED			IRRADIATED						
19												
20	% Elong. at Break											
21	Days	0	30	60								
22	with grain, amb	47.4	60.3333	38								
23	with grain, 90°C	47.4	34	29.5	31	34.6667	34.3333	33				
24	cross grain, amb	66.2	70.6667	63.3333								
25	cross grain, 90°C	66.2	40	39.75	40.3333	42	43	39				
26												
27	Break Strength (ppi)											
28	Days	0	30	60								
29	with grain, amb	350.56	340.9	314.867								
30	with grain, 90°C	350.56	305.5	217.1	252.733	279.233	275.567	267.6333				
31	cross grain, amb	312.12	241.367	379.3								
32	cross grain, 90°C	312.12	281.367	206.425	258.5	261.7	285.3	243.2333				
33												
34	UNIRRAD.											
35	Virgin Material (with grain)	TENSILE MEASUREMENTS AMBIENT										
36	Specimen No.	1	2	3	4	5	Average	St Dev				
37												
38	Neck Thick (mil)	36	36	36.1	36.2	36.1						
39	Neck Thick (mil)	36.1	36	36.2	36.1	36						
40	Neck Thick (mil)	36	36.1	36.1	36.1	35.8						
41	Neck Thick (mil)	36	36	36.1	36	36						
42	Average (mil)	36	36	36	36	36	36.05	0.088852				
43	St. Dev. (mil)	0.05	0.05	0.05	0.08165	0.12583						
44	Neck Width (in)	1	1	1	1	1						
45	Neck Width (in)	1	1	1	1	1						
46	Neck Width (in)	1	1	1	1	1						
47	Neck Width (in)	1	1	1	1	1						
48	Average (in)	1.000	1.000	1.000	1.000	1.000	1	0				
49	St. Dev. (mil)	0	0	0	0	0						
50												
51	Elongation at Break (in)	0.43	0.49	0.48	0.49	0.48						
52	% Elongation at Break	43	49	48	49	48	47.4	2.50998				
53												
54	Load at Break (lb)	341.1	364.4	366.6	342.8	337.9						
55	Break Strength (ppi)	341.1	364.4	366.6	342.8	337.9	350.56	13.77327				
56												
57												
58	UNIRRAD.											
59	Virgin Material (cross grain)	TENSILE MEASUREMENTS AMBIENT										
60	Specimen No.	1	2	3	4	5	Average	St Dev				
61												
62	Neck Thick (mil)	35.1	35.2	35.1	35.1	34.9						
63	Neck Thick (mil)	35.3	35.2	35	35.2	34.9						
64	Neck Thick (mil)	35.5	35.6	35.2	35.5	34.8						
65	Neck Thick (mil)	35.5	35.4	35	35.5	34.9						
66	Average (mil)	35	35	35	35	35	35.195	0.24165				
67	StDev (mil)	0.19149	0.19149	0.09574	0.20616	0.05						
68	Neck Width (in)	1	1	1	1	1						
69	Neck Width (in)	1	1	1	1	1						
70	Neck Width (in)	1	1	1	1	1						
71	Neck Width (in)	1	1	1	1	1						
72	Average (in)	1.000	1.000	1.000	1.000	1.000	1	0				
73	StDev (mil)	0	0	0	0	0						
74												
75	Elongation at Break (in)	0.58	0.62	0.78	0.62	0.71						
76	% Elongation at Break	58	62	78	62	71	66.2	8.136338				
77												
78	Load at Break (lb)	274.4	314.6	314.8	328.9	327.9						
79	Break Strength (ppi)	274.4	314.6	314.8	328.9	327.9	312.12	22.17379				
80												
81												
82	UNIRRAD.											
83	30-Day (with grain)	***** AMBIENT *****					***** 90° C *****					
84	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
85												
86	Neck Thick (mil)	35.5	35.4	35.8			35.2	35.2	35.5			
87	Neck Thick (mil)	35.4	35.6	35.7			35.2	35	35.5			
88	Neck Thick (mil)	35.8	35.6	35.6			35.5	35.3	35.4			
89	Neck Thick (mil)	35.6	35.5	35.5			35.5	35.3	35.4			
90	Average (mil)	36	36	36			35	35	35			
91												
92	Neck Width (in)	1	1	1			1	1	1			
93	Neck Width (in)	1	1	1			1	1	1			
94	Neck Width (in)	1	1	1			1	1	1			

XR5 Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
95	Neck Width (in)	1	1	1			1	1	1			
96	Average (in)	1.000	1.000	1.000			1.000	1.000	1.000			
97												
98	Elongation at Break (in)	0.57	0.66	0.58			0.34	0.33	0.35			
99	% Elongation at Break	57	66	58	60.3333	4.93288	34	33	35	34	1	
100												
101	Load at Break (lb)	336.4	350.7	335.6			293.8	299.9	322.8			
102	Break Strength (ppi)	336.4	350.7	335.6	340.9	8.5	293.8	299.9	322.8	305.5	15.3	
103												
104												
105	UNIRRAD.											
106	30-Day (cross grain)	***** AMBIENT *****					***** 90° C *****					
107	Specimen No.	1	2	3	AG	ST DEV	1	2	3	AG	ST DEV	
108												
109	Neck Thick (mil)	35	35.5	35.5			35.1	35.1	35.1			
110	Neck Thick (mil)	35	35.4	35.4			34.9	35	35.1			
111	Neck Thick (mil)	35.3	35.1	35			35	35	34.9			
112	Neck Thick (mil)	35.1	35.1	35.1			35.1	34.9	35.1			
113	Average (mil)	35	35	35			35	35	35			
114												
115	Neck Width (in)	1	1	1			1	1	1			
116	Neck Width (in)	1	1	1			1	1	1			
117	Neck Width (in)	1	1	1			1	1	1			
118	Neck Width (in)	1	1	1			1	1	1			
119	Average (in)	1.000	1.000	1.000			1.000	1.000	1.000			
120												
121	Elongation at Break (in)	0.82	0.7	0.6			0.38	0.39	0.43			
122	% Elongation at Break	82	70	60	70.6667	11.0151	38	39	43	40	2.645751	
123												
124	Load at Break (lb)	272.1	241.5	210.5			278.6	275.7	289.8			
125	Break Strength (ppi)	272.1	241.5	210.5	241.4	30.8	278.6	275.7	289.8	281.367	7.446028	
126												
127												
128	UNIRRAD.											
129	60-Day (with grain)	***** AMBIENT *****					***** 90° C *****					
130	Specimen No.	1	2	3	AG	ST DEV	1	2	3	4	AG	ST DEV
131												
132	Neck Thick (mil)	35.1	35.2	35.4			36.1	35.2	35.5	35.9		
133	Neck Thick (mil)	35.2	35.1	35.3			36.1	35.5	35.6	35.9		
134	Neck Thick (mil)	35.2	35.4	35.5			36.2	35.4	35.9	35.8		
135	Neck Thick (mil)	35.2	35.2	35.5			35.9	35.2	35.6	35.8		
136	Average (mil)	35	35	35			36	35	36	36		
137												
138	Neck Width (in)	1	1	1			1	1	1	1		
139	Neck Width (in)	1	1	1			1	1	1	1		
140	Neck Width (in)	1	1	1			1	1	1	1		
141	Neck Width (in)	1	1	1			1	1	1	1		
142	Average (in)	1.000	1.000	1.000			1.000	1.000	1.000	1.000		
143												
144	Elongation at Break (in)	0.4	0.35	0.39			0.25	0.33	0.3	0.3		
145	% Elongation at Break	40	35	39	38	2.64575	25	33	30	30	29.5	3.316625
146												
147	Load at Break (lb)	327.7	302.1	314.8			177.1	273.2	229.9	188.2		
148	Break Strength (ppi)	327.7	302.1	314.8	314.9	12.8	177.1	273.2	229.9	188.2	217.1	43.8
149												
150												
151	UNIRRAD.											
152	60-Day (cross grain)	***** AMBIENT *****					***** 90° C *****					
153	Specimen No.	1	2	3	AG	ST DEV	1	2	3	4	AG	ST DEV
154												
155	Neck Thick (mil)	35	34.8	35			35.5	35.9	36.8	36		
156	Neck Thick (mil)	34.8	34.9	34.9			36.2	36.1	37	36.3		
157	Neck Thick (mil)	34.5	35	34.9			36	36.2	36.3	36.1		
158	Neck Thick (mil)	35.2	34.8	35			36.2	36.1	36.8	36.7		
159	Average (mil)	35	35	35	35		36	36	37	36		
160												
161	Neck Width (in)	1	1	1			1	1	1	1		
162	Neck Width (in)	1	1	1			1	1	1	1		
163	Neck Width (in)	1	1	1			1	1	1	1		
164	Neck Width (in)	1	1	1			1	1	1	1		
165	Average (in)	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000		
166												
167	Elongation at Break (in)	0.52	0.54	0.84			0.39	0.44	0.33	0.43		
168	% Elongation at Break	52	54	84	63.3333	17.9258	39	44	33	43	39.75	4.99166
169												
170	Load at Break (lb)	364.8	383.7	389.4			235.8	236.3	117.6	236		
171	Break Strength (ppi)	364.8	383.7	389.4	379.3	12.9	235.8	236.3	117.6	236	206.425	59.21702
172												
173												
174	120-D DOSE 90C (WG)	***** 30 DAY IMM. *****										
175	Specimen No.	1	2	3	AG	ST DEV						
176												
177	Neck Thick (mil)	35.9	35.6	35.7								
178	Neck Thick (mil)	35.9	35.6	35.6								
179	Neck Thick (mil)	35.8	35.5	35.6								
180	Neck Thick (mil)	35.7	35.4	35.8								
181	Average (mil)	36	36	36								
182												
183	Neck Width (in)	1	1	1								
184	Neck Width (in)	1	1	1								
185	Neck Width (in)	1	1	1								
186	Neck Width (in)	1	1	1								
187	Average (in)	1.000	1.000	1.000								
188												

XR5 Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
189	Elongation at Break (in)	0.28	0.34	0.31								
190	% Elongation at Break	28	34	31	31	3						
191												
192	Load at Break (lb)	209.8	292.3	256.1								
193	Break Strength (ppi)	209.8	292.3	256.1	252.7	41.4						
194												
195												
196	120-D DOSE 90C (XG)	* * * * 30 DAY IMM. * * * *										
197	Specimen No.	1	2	3	AG	ST DEV						
198												
199	Neck Thick (mil)	35	35.2	34.5								
200	Neck Thick (mil)	35	35.4	34.5								
201	Neck Thick (mil)	34.8	35.3	34.4								
202	Neck Thick (mil)	35	35.2	34.3								
203	Average (mil)	35	35	34								
204												
205	Neck Width (in)	1	1	1								
206	Neck Width (in)		1	1								
207	Neck Width (in)	1	1	1								
208	Neck Width (in)	1	1	1								
209	Average (in)	1.000	1.000	1.000								
210												
211	Elongation at Break (in)	0.39	0.39	0.43								
212	% Elongation at Break	39	39	43	40.3333	2.3094						
213												
214	Load at Break (lb)	248.4	259.1	268								
215	Break Strength (ppi)	248.4	259.1	268	258.5	9.8						
216												
217												
218	2-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *										
219	Specimen No.	1	2	3	AG	ST DEV						
220												
221	Neck Thick (mil)	37.2	37.4	38								
222	Neck Thick (mil)	37.2	37.6	37.8								
223	Neck Thick (mil)	37	37.9	37.8								
224	Neck Thick (mil)	38	38	38								
225	Average (mil)	37	38	38								
226												
227	Neck Width (in)	1	1	1								
228	Neck Width (in)	1	1	1								
229	Neck Width (in)	1	1	1								
230	Neck Width (in)	1	1	1								
231	Average (in)	1.000	1.000	1.000								
232												
233	Elongation at Break (in)	0.36	0.34	0.34								
234	% Elongation at Break	36	34	34	34.6667	1.1547						
235												
236	Load at Break (lb)	298.7	260.8	278.2								
237	Break Strength (ppi)	298.7	260.8	278.2	279.2	19.0						
238												
239												
240	2-YR DOSE 90C (XG)	* * * * 30 DAY IMM. * * * *										
241	Specimen No.	1	2	3	AG	ST DEV						
242												
243	Neck Thick (mil)	36.2	36	35.7								
244	Neck Thick (mil)	36.8	36.2	36								
245	Neck Thick (mil)	36.3	36.1	35.8								
246	Neck Thick (mil)	36.3	36.1	35.7								
247	Average (mil)	36	36	36								
248												
249	Neck Width (in)	1	1	1								
250	Neck Width (in)	1	1	1								
251	Neck Width (in)	1	1	1								
252	Neck Width (in)	1	1	1								
253	Average (in)	1.000	1.000	1.000								
254												
255	Elongation at Break (in)	0.43	0.41	0.42								
256	% Elongation at Break	43	41	42	42	1						
257												
258	Load at Break (lb)	269.2	259.8	256.1								
259	Break Strength (ppi)	269.2	259.8	256.1	261.7	6.8						
260												
261												
262	10-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *										
263	Specimen No.	1	2	3	AG	ST DEV						
264												
265	Neck Thick (mil)	34.5	34.6	35								
266	Neck Thick (mil)	34.6	34.5	34.9								
267	Neck Thick (mil)	34.6	34.5	34.9								
268	Neck Thick (mil)	34.2	34.5	34.6								
269	Average (mil)	34	35	35								
270												
271	Neck Width (in)	1	1	1								
272	Neck Width (in)	1	1	1								
273	Neck Width (in)	1	1	1								
274	Neck Width (in)	1	1	1								
275	Average (in)	1.000	1.000	1.000								
276												
277	Elongation at Break (in)	0.35	0.34	0.34								
278	% Elongation at Break	35	34	34	34.3333	0.57735						
279												
280	Load at Break (lb)	273.9	283.8	269								
281	Break Strength (ppi)	273.9	283.8	269.0	275.6	7.5						
282												

XRS Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L
283												
284	10-YR DOSE 90C (XG)	* * * * 30 DAY IMM. * * * *										
285	Specimen No.	1	2	3	A/G	ST DEV						
286												
287	Neck Thick (mil)	34.8	35									
288	Neck Thick (mil)	34.9	35									
289	Neck Thick (mil)	34.9	34.9									
290	Neck Thick (mil)	34.8	35									
291	Average (mil)	35	35	#DIV/0!								
292												
293	Neck Width (in)	1	1									
294	Neck Width (in)	1	1									
295	Neck Width (in)	1	1									
296	Neck Width (in)	1	1									
297	Average (in)	1.000	1.000	#DIV/0!								
298												
299	Elongation at Break (in)	0.44	0.42									
300	% Elongation at Break	44	42		43	1.41421						
301												
302	Load at Break (lb)	286.3	284.3									
303	Break Strength (ppi)	286.3	284.3		285.3	1.4						
304												
305												
306	30-YR DOSE 90C (WG)	* * * * 30 DAY IMM. * * * *										
307	Specimen No.	1	2	3	A/G	ST DEV						
308												
309	Neck Thick (mil)	34.7	34.6	35								
310	Neck Thick (mil)	34.7	34.9	35								
311	Neck Thick (mil)	34.7	34.9	35.1								
312	Neck Thick (mil)	34.7	35	35.2								
313	Average (mil)	35	35	35								
314												
315	Neck Width (in)	1	1	1								
316	Neck Width (in)	1	1	1								
317	Neck Width (in)	1	1	1								
318	Neck Width (in)	1	1	1								
319	Average (in)	1.000	1.000	1.000								
320												
321	Elongation at Break (in)	0.34	0.34	0.31								
322	% Elongation at Break	34	34	31	33	1.73205						
323												
324	Load at Break (lb)	287.8	295.7	219.4								
325	Break Strength (ppi)	287.8	295.7	219.4	267.6	42.0						
326												
327												
328	30-YR DOSE 90C (XG)	* * * * 30 DAY IMM. * * * *										
329	Specimen No.	1	2	3	A/G	ST DEV						
330												
331	Neck Thick (mil)	35.7	35.7	35.3								
332	Neck Thick (mil)	35.4	35.3	35								
333	Neck Thick (mil)	35.1	35.3	35.4								
334	Neck Thick (mil)	35.1	35.2	35.5								
335	Average (mil)	35	35	35								
336												
337	Neck Width (in)	1	1	1								
338	Neck Width (in)	1	1	1								
339	Neck Width (in)	1	1	1								
340	Neck Width (in)	1	1	1								
341	Average (in)	1.000	1.000	1.000								
342												
343	Elongation at Break (in)	0.38	0.42	0.37								
344	% Elowation at Break	38	42	37	39	2.64575						
345												
346	Load at Break (lb)	246.7	259.6	223.4								
347	Break Strength (ppi)	246.7	259.6	223.4	243.2	18.3						

	A	B	C	D	E	F	G	H	I
1			8130 XR5 PUNCTURE SUMMARY						
2			UNIRRADIATED		IRRADIATED				
3	Days	0	30	60	120-d/30	2-y/30	10-y/30	30-y/30	
4									
5	% Chg. Punc. Force (amb)	0	1.33101	8.06528					
6									
7	% Chg. Punc. Force (90°)	0	-31.469	-37.49	-27.349	-24.497	-25.685	-25.4872	
8									
9	% Chg. Elongation (amb)	0	-7.0513	15.3846					
10									
11	% Chg. Elongation (90°C)	0	-7.6923	-42.308	2.5641	-35.897	-38.462	-35.8974	
12									
13			PLOT DATA						
14			UNIRRADIATED		IRRADIATED				
15	Days	0	30	60	120-d/30	2-y/30	10-y/30	30-y/30	
16	Punc. Force (amb)	126.22	127.9	136.4					
17	Punc. Force (90°)	126.22	86.5	78.9	91.7	95.3	93.8	94.05	
18	Days	0	30	60					
19	Elongation (amb)	0.39	0.3625	0.45					
20	Elongation (90°C)	0.39	0.36	0.225	0.4	0.25	0.24	0.25	
21									
22									
23	Virgin Material, Unirrad.		PUNCTURE MEASUREMENTS AMBIENT						
24	Specimen No.	1	2	3	4	5	AVG	ST DEV	
25									
26	Specimen Thickness (in)	0.035	0.0349	0.0355	0.0349	0.035			
27	Specimen Thickness (in)	0.035	0.035	0.0351	0.0355	0.035			
28	Specimen Thickness (in)	0.0351	0.0352	0.0355	0.0352	0.0354			
29	Specimen Thickness (in)	0.0349	0.035	0.0352	0.0351	0.0353			
30	Specimen Thickness (in)	0.0352	0.0349	0.0352	0.0356	0.0352			
31	Average (in)	0.0350	0.0350	0.0353	0.0353	0.0352	0.03516	0.00021	
32									
33	Puncture Force (lbf)	146.1	105.4	121.8	123.1	134.7	126.22	15.24687	
34									
35	Elongation (in)	0.4	0.37	0.38	0.39	0.41	0.39	0.015811	
36									
37									
38	30-Day, Unirrad.	* * * * * AMBIENT * * * * *				* * * * * 90° C * * * * *			
39	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
40									
41	Specimen Thickness (in)	0.0348	0.0356			0.0359	0.0357		
42	Specimen Thickness (in)	0.0347	0.0356			0.0356	0.0358		
43	Specimen Thickness (in)	0.035	0.0353			0.0356	0.0357		
44	Specimen Thickness (in)	0.0348	0.0353			0.0359	0.0355		
45	Specimen Thickness (in)	0.0348	0.0352			0.0358	0.0356		
46	Average (in)	0.03483	0.03545	0.03514	0.00044	0.03576	0.03566	0.03571	0.0001
47									
48	Puncture Force (lbf)	130.5	125.3	127.9	3.67696	82.2	90.8	86.5	6.08112
49									
50	Elongation (in)	0.375	0.35	0.3625	0.01768	0.34	0.38	0.36	0.02828
51									
52									
53	60-Day, Unirrad.	* * * * * AMBIENT * * * * *				* * * * * 90° C * * * * *			
54	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
55									
56	Specimen Thickness (in)	0.0353	0.035			0.0363	0.0362		
57	Specimen Thickness (in)	0.0352	0.0348			0.0363	0.0361		
58	Specimen Thickness (in)	0.0351	0.0348			0.0366	0.0362		
59	Specimen Thickness (in)	0.0353	0.0348			0.036	0.0363		
60	Specimen Thickness (in)	0.0352	0.0348			0.0358	0.036		
61	Average (in)	0.03522	0.03484	0.03503	0.00027	0.0362	0.03616	0.03618	0.0000
62									
63	Puncture Force (lbf)	131.7	141.1	136.4	6.6468	78.9	78.9	78.9	0
64									
65	Elongation (in)	0.43	0.47	0.45	0.02828	0.23	0.22	0.225	0.00707

	A	B	C	D	E	F	G	H	I
6 6				XRF Puncture Data					
6 7									
6 8	120-day Dose, 90 C	* * * * 30 d Imm. * * * *							
6 9	Specimen No.	1	2	AVG	ST DEV				
7 0									
7 1	Specimen Thickness (in)	0.036	0.0364						
7 2	Specimen Thickness (in)	0.0361	0.0365						
7 3	Specimen Thickness (in)	0.036	0.0363						
7 4	Specimen Thickness (in)	0.0361	0.0364						
7 5	Specimen Thickness (in)	0.0363	0.0362						
7 6	Average (in)	0.0361	0.03636	0.03623	0.00018				
7 7									
7 8	Puncture Force (lbf)	90.3	93.1	91.7	1.9799				
7 9									
8 0	Elongation (in)	0.39	0.41	0.4	0.01414				
8 1									
8 2	2-Year Dose, 90 C	* * * * 30 d Imm. * * * *							
8 3	Specimen No.	1	2	AVG	ST DEV				
8 4									
8 5	Specimen Thickness (in)	0.0373	0.0374						
8 6	Specimen Thickness (in)	0.0363	0.0376						
8 7	Specimen Thickness (in)	0.0364	0.0379						
8 8	Specimen Thickness (in)	0.0363	0.0374						
8 9	Specimen Thickness (in)	0.037	0.0374						
9 0	Average (in)	0.03666	0.03754	0.0371	0.00062				
9 1									
9 2	Puncture Force (lbf)	93.6	97	95.3	2.40416				
9 3									
9 4	Elongation (in)	0.25	0.25	0.25	0				
9 5									
9 6	10-Year Dose, 90 C	* * * * 30 d Imm. * * * *							
9 7	Specimen No.	1	2	AVG	ST DEV				
9 8									
9 9	Specimen Thickness (in)	0.0354	0.0352						
10 0	Specimen Thickness (in)	0.0355	0.035						
10 1	Specimen Thickness (in)	0.0351	0.0349						
10 2	Specimen Thickness (in)	0.0351	0.0354						
10 3	Specimen Thickness (in)	0.0352	0.0348						
10 4	Average (in)	0.03526	0.03506	0.03516	0.00014				
10 5									
10 6	Puncture Force (lbf)	95.8	91.8	93.8	2.82843				
10 7									
10 8	Elongation (in)	0.24	0.24	0.24	0				
10 9									
11 0	30-Year Dose, 90 C	* * * * 30 d Imm. * * * *							
11 1	Specimen No.	1	2	AVG	ST DEV				
11 2									
11 3	Specimen Thickness (in)	0.0359	0.0354						
11 4	Specimen Thickness (in)	0.036	0.0358						
11 5	Specimen Thickness (in)	0.0357	0.0353						
11 6	Specimen Thickness (in)	0.0357	0.0355						
11 7	Specimen Thickness (in)	0.0357	0.0358						
11 8	Average (in)	0.0358	0.03556	0.03568	0.00017				
11 9									
12 0	Puncture Force (lbf)	94.8	93.3	94.05	1.06066				
12 1									
12 2	Elongation (in)	0.25	0.25	0.25	0				

XR5 Hardness Data

	A	B	C	D	E	F	G	H	I	J	K
1	8130 XR5 HARDNESS DATA SUMMARY										
2		UNIRRADIATED			IRRADIATED						
3	Days	0	30	60	120-d/30	2-y/30	10-y/30	30-y/30			
4											
5	% Change Hardness (amb)	0.0	-1.5	-3.9							
6											
7	% Change Hardness (90°)	0.0	-3.3	0.4	8.0	5.1	11.9	15.1			
8											
9		PLOT DATA									
10		UNIRRADIATED			IRRADIATED						
11	Days	0	30	60	120-d/30	2-y/30	10-y/30	30-y/30			
12	Ave. Hardness (amb)	53	52.2	50.9333							
13	Ave. Hardness (90°)	53	51.2667	53.2	56.8	55.2667	58.8667	60.53333			
14											
15	UNIRRAD.										
16	Virgin Material	AMBIENT READINGS									
17	Specimen No.	1	2	3	Avg	STDEV					
18											
19	Durometer Point Reading	53	54	54							
20	Durometer Point Reading	54	51	53							
21	Durometer Point Reading	54	51	53							
22	Durometer Point Reading	55	52	50							
23	Durometer Point Reading	54	54	53							
24	Average	54	52.4	52.6	53	1.41421					
25											
26	30-Day, Unirrad.	AMBIENT MEASUREMENTS					90C MEASUREMENTS				
27	Specimen No.	1	2	3	Avg	STDEV	1	2	3	Ave	STDEV
28											
29	Durometer Point Reading	52	50	54			51	54	52		
30	Durometer Point Reading	49	53	53			49	51	49		
31	Durometer Point Reading	49	54	54			49	52	53		
32	Durometer Point Reading	53	52	54			50	54	49		
33	Durometer Point Reading	51	50	55			51	53	52		
34	Average	50.8	51.8	54	52.2	1.97122	50	52.8	51	51.2667	1.79151
35											
36	60-Day, Unirrad.	AMBIENT MEASUREMENTS					90 C MEASUREMENTS				
37	Specimen No.	1	2	3	Ave	STDEV	1	2	3	Ave	STDEV
38											
39	Durometer Point Reading	52	51	50			51	59	54		
40	Durometer Point Reading	53	50	49			48	58	54		
41	Durometer Point Reading	55	51	48			46	55	53		
42	Durometer Point Reading	51	49	51			55	58	51		
43	Durometer Point Reading	53	52	49			49	54	53		
44	Average	52.8	50.6	49.4	50.9333	1.86956	49.8	56.8	53	53.2	1.79151
45											
46	120-d Dose, 90C	30 D IMM. MEASUREMENTS									
47	Specimen No.	1	2	3	Avg	ST DEV					
48											
49	Durometer Point Reading	55	55	56							
50	Durometer Point Reading	54	56	58							
51	Durometer Point Reading	58	57	56							
52	Durometer Point Reading	59	60	58							
53	Durometer Point Reading	57	56	57							
54	Average	56.6	56.8	57	56.8	1.61245					
55											
56	2-YR Dose, 90C	30 D IMM. MEASUREMENTS									
57	Specimen No.	1	2	3	Avg	ST DEV					
58											
59	Durometer Point Reading	55	55	54							
60	Durometer Point Reading	55	54	55							
61	Durometer Point Reading	58	56	58							
62	Durometer Point Reading	56	54	56							
63	Durometer Point Reading	53	55	55							
64	Average	55.4	54.8	55.6	55.2667	1.38701					

XR5 Hardness Data

	A	B	C	D	E	F	G	H	I	J	K
6 5											
6 6	10-YR Dose, 90C	30 D IMM. MEASUREMENTS									
6 7	Specimen No.	1	2	3	Avg	ST DEV					
6 8											
6 9	Durometer Point Reading	58	60	58							
7 0	Durometer Point Reading	58	61	60							
7 1	Durometer Point Reading	61	59	60							
7 2	Durometer Point Reading	57	58	59							
7 3	Durometer Point Reading	59	56	59							
7 4	Average	58.6	58.8	59.2	58.8667	1.40746					
7 5											
7 6	30-YR Dose, 90C	30 D IMM. MEASUREMENTS									
7 7	Specimen No.	1	2	3	Avg	ST DEV					
7 8											
7 9	Durometer Point Reading	60	61	61							
8 0	Durometer Point Reading	59	62	59							
8 1	Durometer Point Reading	61	60	58							
8 2	Durometer Point Reading	62	63	60							
8 3	Durometer Point Reading	61	62	59							
8 4	Average	60.6	61.6	59.4	60.5333	1.40746					

XR5 HYDROSTATIC RESISTANCE DATA

	A	B	C	D	E	F	G
1	8130 XR5 HYDROSTATIC RESISTANCE DATA SUMMARY						
2							
3	Days	0	30	60			
4							
5	% Change Hydrostatic Res. (amb)	0.00	-1.47	-6.77			
6	% Change Hydrostatic Res. (90°)	0.00	-20.53	-28.91			
7							
8	Hydrostatic Resistance (psi)	DATA FOR PLOTS					
9	Days	0	30	60			
10							
11	Ave. Hydrostatic Res. (Amb)	698	688	651			
12							
13	Ave. Hydrostatic Res. (90°)	698	555	496			
14							
15							
16	HYDROSTATIC RES. MEASUREMENTS: AMBIENT						
17	Days	0	0	AVE/0	STDEV/0	30	60
18							
19	Hydrostatic Res. (psi)	730	660			655	640
20	Hydrostatic Res. (psi)	715	660			735	680
21	Hydrostatic Res. (psi)	750	680			725	715
22	Hydrostatic Res. (psi)	730	665			760	675
23	Hydrostatic Res. (psi)	750	670			625	500
24	Hydrostatic Res. (psi)	730	700			740	685
25	Hydrostatic Res. (psi)	675	675			625	695
26	Hydrostatic Res. (psi)	690	665			670	625
27	Hydrostatic Res. (psi)	690	700			675	700
28	Hydrostatic Res. (psi)	750	670			665	590
29	Ave. Hydrostatic Res. (psi)	721	674.5	697.75	32.1377	687.5	650.5
30	St. Dev., Hyd. Res. (psi)					48.8905	65.2538
31							
32							
33	HYDROSTATIC RES. MEASUREMENTS: 90°						
34	Days	0	0	AVE	STDEV	30	60
35							
36	Hydrostatic Res. (psi)	730	660			595	475
37	Hydrostatic Res. (psi)	715	660			570	510
38	Hydrostatic Res. (psi)	750	680			610	475
39	Hydrostatic Res. (psi)	730	665			520	525
40	Hydrostatic Res. (psi)	750	670			520	560
41	Hydrostatic Res. (psi)	730	700			540	500
42	Hydrostatic Res. (psi)	675	675			555	445
43	Hydrostatic Res. (psi)	690	665			565	495
44	Hydrostatic Res. (psi)	690	700			535	500
45	Hydrostatic Res. (psi)	750	670			535	475
46	Ave. HYDROSTATIC RES. (PSI)	721	674.5	697.75	32.1377	554.5	496
47	STDEV HYDROSTATIC RES. (PSI)					30.5914	31.7805

APPENDIX F

RAW AND TABULATED DATA FOR POLYURETHANE LINER TESTING

POLYURETHANE DIM. DATA

	A	B	C	D
1	POLYURETHANE DIMENSIONAL DATA SUMMARY			
2		UNIRRADIATED		
3	Days	0	30	
4				
5	% Change Length (amb)	0.00	0.00	
6	% Change Length (90°)	0.00	0.56	
7				
8	% Change Width (amb)	0.00	0.00	
9	% Change Width (90°)	0.00	1.30	
10				
11	% Change Thick (amb)	0.00	0.37	
12	% Change Thick (90°)	0.00	-1.66	
13				
14	% Change Weight (amb)	0.00	1.01	
15	% Change Weight (90°)	0.00	9.98	
16		DATA FOR PLOTS		
17		UNIRRADIATED		
18	Days	0	30	
19	Ave. Length (amb)	201	201	
20	Ave. Length (90°)	178	179	
21	Ave. Width (amb)	178	178	
22	Ave. Width (90°)	205	207	
23				
24	Ave. Thick (amb)	61	61	
25	Ave. Thick (90)	59	58	
26				
27	Sample Wt. (amb)	48.6	49.1	
28	Sample Wt. (90)	45.1	49.6	
29				
30	9090 DIMENSIONAL MEASUREMENTS AMBIENT			
31	Days	0	30	
32				
33	Length side a-b (mm)	201	201	
34	Length side c-d (mm)	201	201	
35	Length through center (mm)	201	201	
36	Average Length (mm)	201	201	
37	ST DEV (mm)	0	0	
38				
39	Width side b-c (mm)	176	176	
40	Width side d-a (mm)	179	179	
41	Width through center (mm)	178	178	
42	Average Width (mm)	178	178	
43	ST DEV (mm)	1.52753	1.52753	
44				
45	Thickness corner a (mil)	57	57.2	
46	Thickness corner b (mil)	62.1	61.9	
47	Thickness corner c (mil)	62.1	62.5	
48	Thickness corner d (mil)	60.9	61.41	

POLYURETHANE DIM. DATA

	A	B	C	D
4 9	Average Thickness (mil)	61	61	
5 0	ST DEV (mm)	2.41713	2.40901	
5 1				
5 2	Liner Weight(grams)	48.62	49.11	
5 3				
5 4	9090 DIMENSIONAL MEASUREMENTS 90°			
5 5	Days	0	30	
5 6				
5 7	Length side a-b (mm)	178	179	
5 8	Length side c-d (mm)	178	179	
5 9	Length through center (mm)	178	179	
6 0	Average Length (mm)	178	179	
6 1	ST DEV(mm)	0	0	
6 2				
6 3	Width side b-c (mm)	205	207	
6 4	Width side d-a (mm)	205	208	
6 5	Width through center (mm)	204	207	
6 6	Average Length (mm)	205	207	
6 7	ST DEV(mm)	0.57735	0.57735	
6 8				
6 9	Thickness corner a (mil)	55.2	53.5	
7 0	Thickness corner b (mil)	54.6	53.9	
7 1	Thickness corner c (mil)	61.3	61	
7 2	Thickness corner d (mil)	63.3	62.1	
7 3	Average Thickness (mil)	59	58	
7 4	ST DEV (mm)	4.3566	4.55732	
7 5				
7 6	Liner Weight (grams)	45.09	49.59	

POLYURETHANE VOL DATA

	A	B	C	D	E	F	G	H	I
1	POLYURETHANE VOLATILES SUMMARY								
2		UNIRRADIATED							
3	Days	0	30						
4									
5	% Chg. Volatiles (amb)	0.0	117.5						
6	% Chg. Volatiles (90°)	0.0	2026.3						
7									
8		PLOT DATA							
9		UNIRRADIATED							
10	Days	0	30						
11	% Volatiles (amb)	0.64434	1.40113						
12	% Volatiles (90°)	0.64434	13.7005						
13									
14									
15	Virgin Material, Unirrad.		AMBIENT READINGS						
16	Specimen No.	1	2	3	4	5	AVG	ST DEV	
17									
18	"Wet" weight (g)	2.0052	2.2343	1.93	2.1907				
19	"Dried" weight (g)	1.9933	2.2192	1.917	2.1768				
20	Weight difference (g)	0.0119	0.0151	0.013	0.0139				
21	% Volatiles	0.59346	0.67583	0.67358	0.6345		0.64434	0.038867	
22									
23	30-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->			
24	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
25									
26	"Wet" weight (g)	2.8487	2.3806			2.2849	2.3655		
27	"Dried" weight (g)	2.8086	2.3474			1.9654	2.0481		
28	Weight difference (g)	0.0401	0.0332			0.3195	0.3174		
29	% Volatiles	1.40766	1.39461	1.40113	0.00923	13.9831	13.4179	13.70049	0.39967

POLYURETHANE Extract. Data

	A	B	C	D	E	F	G	H
1	POLYURETHANE EXTRACTABLES SUMMARY							
2								
3	Days	0	30					
4								
5	% Chg. Extractables (amb)	0.0	111.8					
6	% Chag. Extractables (90°)	0.0	#DIV/0!					
7								
8	PLOT DATA							
9	Days	0	30					
10	% Extractables (amb)	2.49835	5.29223					
11	% Extractables (90°)	2.49835	#DIV/0!					
12								
13								
14	Virgin Material, Unirrad.		AMBIENT READINGS					
15	Specimen No.	1	2	3	4	5	AVG	stddev
16								
17	"Dried" weight (g)	4.3523	4.6063	4.1847	4.3423			
18	"Extracted" weight (g)	4.2284	4.5054	4.0649	4.2514			
19	Weight difference (g)	0.1239	0.1009	0.1198	0.0909			
20	% Extractables	2.84677	2.19048	2.86281	2.093361		2.49835	0.464069
21								
22	30-Day, Unirrad.	<- - - AMBIENT - - ->			<- - - 90° - - ->			
23	Specimen No.	1	2	AVG	1	2	AVG	
24								
25	"Dried" weight (g)	5.6193	5.5778					
26	"Extracted" weight (g)	5.4	5.2051					
27	Weight difference (g)	0.2193	0.3727		0	0		
28	% Extractables	3.90262	6.68185	5.29223	#DIV/0!	#DIV/0!	#DIV/0!	

POLYURETHANE Sp. G. Data

	A	B	C	D	E	F	G	H	I
1	POLYURETHANE SPECIFIC GRAVITY SUMMARY								
2									
3	Days	0	30						
4									
5	% Sp gr 23/23 (amb)	0.0	1.7						
6	% Sp gr 23/23 (90°)	0.0	4.1						
7									
8									
9	PLOT DATA								
10	Days	0	30						
11	Sp gr 23/23 (amb)	0	0.86371						
12	Sp gr 23/23 (90°)	0	0.88424						
13									
14									
15	Virgn Material, Unirrad.		AMBIENT READINGS						
16	Specimen No.	1	2	3	4	5	AVG	ST DEV	
17									
18	Weight in air (g)	2.2343	1.93	2.1907					
19	Weight immersed (g)	4.0515	4.0407	4.0395					
20	Weight of sinker (g)	4.4176	4.4176	4.4176					
21	Sp gr 23/23	0.85921	0.83662	0.85281			0.84955	0.01164	
22									
23	30-Day, Unirrad.	<- - - AMBIENT - - ->				<- - - - 90° - - - ->			
24	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
25									
26	Weight in air (g)	2.8487	2.3806			2.2844	2.3655		
27	Weight immersed (g)	3.9118	4.0372			4.1175	4.0884		
28	Weight of sinker (g)	4.3896	4.3896			4.4075	4.4075		
29	Sp gr 23/23	0.85637	0.87106	0.86371	0.01039	0.88735	0.88114	0.88424	0.0044

POLYURETHANE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	POLYURETHANE TENSILE SUMMARY												
2	UNIRRADIATED												
3	Days	0	30										
4	% Chg. Elong. at Break												
5	with grain, amb	0.0	43.8										
6	with grain, 90°C	0.0	-80.9										
7	cross grain, amb	0.0	-2.6										
8	cross grain, 90°C	0.0	-77.6										
9	% Chg Break Strength												
10	with grain, amb	0.0	-4.3										
11	with grain, 90°C	0.0	-88.1										
12	cross grain, amb	0.0	-22.3										
13	cross grain, 90°C	0.0	-92.0										
14	% Chg Stress 100% Elong.												
15	with grain, amb	0.0	-32.4										
16	with grain, 90°C	0.0	-68.3										
17	cross grain, amb	0.0	-11.0										
18	cross grain, 90°C	0.0	-71.0										
19	% Chg Stress 200% Elong.												
20	with grain, amb	0.0	-33.2										
21	with grain, 90°C	0.0	-100.0										
22	cross grain, amb	0.0	-13.2										
23	cross grain, 90°C	0.0	#REF!										
24	DATA FOR PLOTS												
25	UNIRRADIATED												
26	% Elong. at Break							IRRADIATED					
27	Days	0	30										
28	with grain, amb	386.2	555.333										
29	with grain, 90°C	386.2	73.6667										
30	cross grain, amb	428	417										
31	cross grain, 90°C	428	96										
32	Break Strength (psi)												
33	Days	0	30										
34	with grain, amb	2152.26	2059.29										
35	with grain, 90°C	2152.26	255.952										
36	cross grain, amb	2291.9	1781.84										
37	cross grain, 90°C	2291.9	183.737										
38	Stress at 100% elong.												
39	Days	0	30										
40	with grain, amb	789.139	533.644										
41	with grain, 90°C	789.139	249.766										
42	cross grain, amb	711.172	632.981										
43	cross grain, 90°C	711.172	206.289										
44	Stress at 200% elong.												
45	Days	0	30										
46	with grain, amb	1204.84	805.311										
47	with grain, 90°C	1204.84	0										
48	cross grain, amb	1099.57	954.22										
49	cross grain, 90°C	1099.57	#REF!										
50													
51	UNIRRAD.												
52	Virgin Material (with grain)	TENSILE MEASUREMENTS AMBIENT											
53	Specimen No.	1	2	3	4	5	Average	St. Dev					
54													
55	Neck Thick (mil)	57.8	57.3	57.9	59.8	53.5							
56	Neck Thick (mil)	58.7	56.7	58.1	61.3	53.7							
57	Neck Thick (mil)	59.3	55.9	58.3	61.4	55.8							
58	Neck Thick (mil)	59	55.8	57.9	61.6	56							
59	Average (mil)	59	56	58	61	55	57.79	2.29551					
60	St. Dev. (mil)	0.64807	0.70887	0.19149	0.82614	1.33292							
61	Neck Width (in)	0.25	0.25	0.25	0.25	0.25							
62	Neck Width (in)	0.25	0.25	0.25	0.25	0.25							
63	Neck Width (in)	0.25	0.25	0.25	0.25	0.25							
64	Neck Width (in)	0.25	0.25	0.25	0.25	0.25							
65	Average (in)	0.250	0.250	0.250	0.250	0.250	0.25	0					
66	St. Dev. (mil)	0	0	0	0	0							
67													
68	Elongation at Break (in)	3.65	3.53	4.77	4.08	3.28							
69	% Elongation at Break	365	353	477	408	328	386.2	58.43543					
70													
71	Load at Break (lb)	30.9	27.4	38.8	34.1	24.7							
72	Break Strength (psi)	2105.6	1942.4	2673.6	2235.1	1804.6	2152.26	333.8144					
73													
74	Load at 100% Elong. (lb)	12	11	11	12	11							
75	Stress at 100% Elong. (psi)	817.7	779.8	758.0	786.6	803.7	789.139	22.8745					
76	Load at 200% Elong. (lb)	19	17	16	18	17							
77	Stress at 200% Elong. (psi)	1294.7	1205.1	1102.5	1179.8	1242.0	1204.84	71.69127					
78													
79													
80	UNIRRAD.												
81	Virgin Material (cross grain)	TENSILE MEASUREMENTS AMBIENT											
82	Specimen No.	1	2	3	4	5	Average	St. Dev					
83													
84	Neck Thick (mil)	53.7	53.2	52	45	43.7							
85	Neck Thick (mil)	53.6	52.5	51.9	45.2	44.4							
86	Neck Thick (mil)	52.6	52.5	52.3	45.7	44.4							
87	Neck Thick (mil)	52.7	51.9	53	45.2	44.9							
88	Average (mil)	53	53	52	45	44	49.52	3.989011					
89	StDev (mil)	0.58023	0.53151	0.49666	0.29861	0.49329							
90	Neck Width (in)	0.25	0.25	0.25	0.25	0.25							
91	Neck Width (in)	0.25	0.25	0.25	0.25	0.25							
92	Neck Width (in)	0.25	0.25	0.25	0.25	0.25							
93	Neck Width (in)	0.25	0.25	0.25	0.25	0.25							
94	Average (in)	0.250	0.250	0.250	0.250	0.250	0.25	0					

POLYURETHANE Tensile Data

	A	B	C	D	E	F	G	H	I	J	K	L	M
95	StDev (mil)	0	0	0	0	0							
96													
97	Elongation at Break (in)	4.2	4.2	4	4.3	4.7							
98	% Elongation at Break	420	420	400	430	470	428	25.88436					
99													
100	Load at Break (lb)	28.1	28.4	29.9	25.7	29.1							
101	Break Strength (psi)	2114.8	2162.8	2286.8	2270.6	2624.6	2291.9	199.5009					
102													
103	Load at 100% Elong. (lb)	9	9	10	8	8							
104	Stress at 100% Elong. (psi)	677.3	685.4	764.8	706.8	721.5	711.172	34.69397					
105	Load at 200% Elong. (lb)	14	14	15	13	12							
106	Stress at 200% Elong. (psi)	1053.6	1066.2	1147.2	1148.5	1082.3	1099.57	45.26248					
107													
108													
109	UNIRRAD.												
110	30-Day (with grain)	***** AMBIENT *****				***** 90° C *****							
111	Specimen No.	1	2	3	A/G	ST DEV	1	2	3	A/G	ST DEV		
112													
113	Neck Thick (mil)	66	65	66.2			65.9	63.3	65.8				
114	Neck Thick (mil)	64.9	65	66			65	64.9	65.1				
115	Neck Thick (mil)	65.4	65	67.5			63	66.1	62.1				
116	Neck Thick (mil)	67.1	65.2	71.2			61.1	65.6	60.9				
117	Average (mil)	66	65	68			64	65	63				
118													
119	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25				
120	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25				
121	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25				
122	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25				
123	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250				
124													
125	Elongation at Break (in)	5.67	5.73	5.26			0.74	0.8	0.67				
126	% Elongation at Break	567	573	526	555.333	25.5799	74	80	67	73.6667	6.506407		
127													
128	Load at Break (lb)	35.1	31.6	35.6			4.2	4.2	3.9				
129	Break Strength (psi)	2132.1	1943.1	2102.6	2059.3	101.7	263.5	258.6	245.8	256.0	9.2		
130													
131	Load at 100% Elong. (lb)	9	8.5	9			4	4	4				
132	Stress at 100% Elong. (psi)	546.7	522.7	531.8	533.6	12.1	251.0	246.2	252.1	249.8	3.1		
133	Load at 200% Elong. (lb)	13	13	14									
134	Stress at 200% Elong. (psi)	789.7	799.4	826.9	805.3	19.3	0.0	0.0	0.0	0.0	0.0		
135													
136													
137	UNIRRAD.												
138	30-Day (cross grain)	***** AMBIENT *****				***** 90° C *****							
139	Specimen No.	1	2	3	A/G	ST DEV	1	2	3	A/G	ST DEV		
140													
141	Neck Thick (mil)	59.8	63.5	49.1			49.4	50.1	57.6				
142	Neck Thick (mil)	58.8	63.9	50.9			49.3	50.8	56.5				
143	Neck Thick (mil)	59.5	65.2	50.2			49	51.9	56.8				
144	Neck Thick (mil)	60	65.1	49.9			48.5	51	55.9				
145	Average (mil)	60	64	50			49	51	57				
146													
147	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25				
148	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25				
149	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25				
150	Neck Width (in)	0.25	0.25	0.25			0.25	0.25	0.25				
151	Average (in)	0.250	0.250	0.250			0.250	0.250	0.250				
152													
153	Elongation at Break (in)	4.27	4.47	3.77			0.87	1	1.01				
154	% Elongation at Break	427	447	377	417	36.0555	87	100	101	96	7.81025		
155													
156	Load at Break (lb)	27.2	30.9	20			1.7	2.2	3.4				
157	Break Strength (psi)	1827.8	1918.5	1599.2	1781.8	164.5	138.6	172.7	239.9	183.7	51.5		
158													
159	Load at 100% Elong. (lb)	9.5	10	8				2.2	3.4				
160	Stress at 100% Elong. (psi)	638.4	620.9	639.7	633.0	10.5		172.7	239.9	206.3	47.5		
161	Load at 200% Elong. (lb)	14	15.5	12									
162	Stress at 200% Elong. (psi)	940.8	962.4	959.5	954.2	11.7	0.0	0.0	0.0	0.0	0.0	*200% NOT AVAILABLE	

POLYURETHANET ea Data

	A	B	C	D	E	F	G	H	I	J	K
1	POLYURETHANE TEAR SUMMARY										
2											
3	% Change in Tear Strength										
4		UNIRRADIATED									
5	Days	0	30								
6											
7	with grain, ambient	0	-14.676								
8											
9	with grain, 90°C	0	-55.063								
10											
11	cross grain, ambient	0	2.86935								
12											
13	cross grain, 90°C	0	-60.928								
14											
15		PLOT DATA									
16		UNIRRADIATED									
17	Days	0	30								
18	with grain (amb)	11.72	10								
19	with grain (90°C)	11.72	5.26667								
20	cross grain (amb)	10.92	11.2333								
21	cross grain (90°)	10.92	4.26667								
22											
23	UNIRRAD.										
24	Virgin Material (with grain)	TEAR MEASUREMENTS AMBIENT									
25	Specimen No.	1	2	3	4	5	Average	ST DEV			
26											
27	Specimen Thick (in)	0.053	0.0555	0.0583	0.0592	0.0612					
28	Specimen Thick (in)	0.0505	0.0532	0.055	0.0564	0.0588					
29	Specimen Thick (in)	0.0496	0.0525	0.0535	0.0544	0.0569					
30	Specimen Thick (in)	0.0497	0.0506	0.0526	0.0554	0.0581					
31	Average (in)	0.0507	0.0530	0.0549	0.0564	0.0588	0.0547	0.003357			
32											
33	Tearing Load (lb)	11.6	11.6	11.3	11.8	12.3	11.7	0.370135			
34											
35	UNIRRAD.										
36	Virgin Material (cross grain)	TEAR MEASUREMENTS AMBIENT									
37	Specimen No.	1	2	3	4	5	Average	ST DEV			
38											
39	Specimen Thick (in)	0.045	0.0528	0.0549	0.0501	0.0455					
40	Specimen Thick (in)	0.0446	0.0515	0.055	0.0537	0.0452					
41	Specimen Thick (in)	0.0446	0.0505	0.0551	0.054	0.047					
42	Specimen Thick (in)	0.0448	0.0539	0.0545	0.0514	0.0477					
43	Average (in)	0.0448	0.0522	0.0549	0.0523	0.0464	0.0501	0.004106			
44											
45	Tearing Load (lb)	9.9	11.3	11.8	11.3	10.3	10.9	0.78867			
46											
47	UNIRRAD.										
48	30-Day (with grain)	*** AMBIENT ***					*** 90° C ***				
49	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV
50											
51	Specimen Thick (in)	0.0639	0.0655	0.0638			0.0616	0.0583	0.0652		
52	Specimen Thick (in)	0.0632	0.0655	0.0637			0.0624	0.0605	0.0643		
53	Specimen Thick (in)	0.0624	0.0658	0.0631			0.0637	0.0625	0.062		
54	Specimen Thick (in)	0.0622	0.0659	0.0637			0.0653	0.0633	0.0594		
55	Average (in)	0.06293	0.06568	0.06358	0.06406	0.00144	0.06325	0.06115	0.06273	0.06238	0.00109
56											
57	Tearing Load (lb)	10.1	10.3	9.6	10	0.36056	6.1	4.6	5.1	5.26667	0.76376
58											
59	UNIRRAD.										
60	30-Day (cross grain)	*** AMBIENT ***					*** 90° C ***				
61	Specimen No.	1	2	3	AVG	ST DEV	1	2	3	AVG	ST DEV
62											
63	Specimen Thick (in)	0.0649	0.0651	0.0662			0.0557	0.0571	0.0571		
64	Specimen Thick (in)	0.0642	0.0655	0.0659			0.0562	0.058	0.0579		
65	Specimen Thick (in)	0.0629	0.0656	0.0656			0.0574	0.0575	0.0579		
66	Specimen Thick (in)	0.0642	0.0655	0.0661			0.0565	0.0574	0.058		
67	Average (in)	0.0641	0.0654	0.0660	0.0651	0.00098	0.0565	0.0575	0.0577	0.0572	0.00068
68											
69	Tearing Load (lb)	13	10.6	10.1	11.2333	1.55027	4.2	4.2	4.4	4.26667	0.11547

	A	B	C	D	E	F	G	H	I
1	POLYURETHANE PUNCTURE SUMMARY								
2		UNIRRADIATED							
3	Days	0	30						
4									
5	% Chg. Punc. Force (amb)	0	-8.8159						
6									
7	% Chg. Punc. Force (90°)	0	-79.311						
8									
9	% Chg. Elongation (amb)	0	2.94118						
10									
11	% Chg. Elongation (90°C)	0	-32.941						
12									
13		PLOT DATA							
14		UNIRRADIATED							
15	Days	0	30						
16	Punc. Force (amb)	92.56	84.4						
17	Punc. Force (90°)	92.56	19.15						
18	Days	0	30						
19	Elongation (amb)	0.85	0.875						
20	Elongation (90°C)	0.85	0.57						
21									
22									
23	Virgin Material, Unirrad.		PUNCTURE MEASUREMENTS AMBIENT						
24	Specimen No.	1	2	3	4	5	AVG	ST DEV	
25									
26	Specimen Thickness (in)	0.0652	0.0599	0.0573	0.0553	0.0481			
27	Specimen Thickness (in)	0.0648	0.0617	0.0572	0.055	0.0508			
28	Specimen Thickness (in)	0.0652	0.0609	0.0549	0.0542	0.0515			
29	Specimen Thickness (in)	0.068	0.0609	0.0566	0.0545	0.0517			
30	Specimen Thickness (in)	0.0658	0.0586	0.0577	0.054	0.0471			
31	Average (in)	0.0658	0.0604	0.0567	0.0546	0.0498	0.05748	0.00563	
32									
33	Puncture Force (lbf)	99.7	96.5	89.6	86.9	90.1	92.56	5.323345	
34									
35	Elongation (in)	0.8	0.82	0.82	0.82	0.99	0.85	0.07874	
36									
37									
38	30-Day, Unirrad.	* * * * AMBIENT * * * *			* * * * 90° C * * * *				
39	Specimen No.	1	2	AVG	ST DEV	1	2	AVG	ST DEV
40									
41	Specimen Thickness (in)	0.0594	0.059			0.0603	0.0575		
42	Specimen Thickness (in)	0.0628	0.0613			0.0605	0.0532		
43	Specimen Thickness (in)	0.0607	0.0622			0.0605	0.0565		
44	Specimen Thickness (in)	0.0658	0.0654			0.0564	0.0575		
45	Specimen Thickness (in)	0.0645	0.0637			0.0602	0.0547		
46	Average (in)	0.06218	0.06198	0.06208	0.00014	0.05958	0.05588	0.05773	0.0026
47									
48	Puncture Force (lbf)	90.6	78.2	84.4	8.76812	20.3	18	19.15	1.62635
49									
50	Elongation (in)	0.87	0.88	0.875	0.00707	0.58	0.56	0.57	0.01414

POLYURETHANE Hard. Data

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	POLYURETHANE HARDNESS DATA SUMMARY												
2		UNIRRADIATED											
3	Days	0	30										
4													
5	% Change Hardness (amb)	0.0	-11.7										
6													
7	% Change Hardness (90°)	0.0	60.2										
8		*USED DURO A											
9		PLOT DATA											
10		UNIRRADIATED											
11	Days	0	30										
12	Ave. Hardness (amb)	40.4	35.6667										
13	Ave. Hardness (90°)	40.4	64.7333										
14													
15	UNIRRAD.												
16	Virgin Material	AMBIENT READINGS											
17	Specimen No.	1	2	3	AVE	STDEV							
18													
19	Durometer Point Reading	37	40	40									
20	Durometer Point Reading	41	40	40									
21	Durometer Point Reading	39	39	41									
22	Durometer Point Reading	42	42	40									
23	Durometer Point Reading	43	40	42									
24	Average	40.4	40.2	40.6	40.4	1.50238							
25													
26	30-Day, Unirrad.	AMBIENT MEASUREMENTS						90C MEASUREMENTS					
27	Specimen No.	1	2	3	AVE	STDEV	1	2	3	AVE	STDEV		
28													
29	Durometer Point Reading	35	38	33			65	64	65				
30	Durometer Point Reading	34	35	39			65	64	67				*USED DURO A HEAD
31	Durometer Point Reading	36	35	35			66	64	65				
32	Durometer Point Reading	36	33	39			63	64	64				
33	Durometer Point Reading	34	35	38			63	66	66				
34	Average	35	35.2	36.8	35.6667	1.98806	64.4	64.4	65.4	64.7333	1.16292		

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