



Test Report No. T6202-00-1 Issue 1  
ASTM F739-07 "Permeation of Liquids and Gases through Protective  
Clothing Material under Continuous Contact"  
Diving Unlimited International Inc.  
Red/Black PU laminated Fabric  
4 March 2011



Certificate 1722.01

Approved by:

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Physical / Analytical Scientist

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1148 Delevan Dr.,  
San Diego, CA 92102-2499  
USA

Date: 4 March 2011  
Report: T6202-00-1  
Issue: 1  
Page: 1 of 8

**Summary:**

A Red/Black PU laminated fabric (diving suit material), submitted by Diving Unlimited International Inc. was evaluated for its permeation resistance against five chemical solutions selected by the client. The tests were performed in accordance with ASTM F 739-07. The data and graphical presentations of triplicate tests are attached.

**Objective:**

Testing to: ASTM F739-07, "Standard Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact"

**Materials:**

One (1) sheet of Red/Black PU laminated fabric, 410 White, 210 Den NY, Model # 807020

Date submitted by client:	25 February 2011
Date testing authorized:	28 February 2011
Dates of tests:	28 February 2011 through 3 March 2011
Model No./Name:	Model # 807020, Lot # 029780-00
Physical Description:	Red over Black PU laminated fabric
Batch/Lot #:	029780-00
Manufacturer/Supplier:	Not Available
ICS Sample ID:	1-X

**Equipment and Reagents:**

*Gas Chromatograph*, SRI 8610C GC-FID (EQ0424)  
*Syringe Pump*, (EQ0369)  
*Digital Flow Meter*, (EQ0356)  
*Permeation Cells*; ASTM, 2inch, Glass  
*Micrometer*, Mitutoyo (EQ0461)  
*Analytical Balance*, Mettler (EQ0397)  
*Punch*; Arch 3 inch  
*Peristaltic Pump*, (EQ-0377-1-4)  
*Data Logger with Smart Q Sensor Conductivity electrodes*  
*Nitrogen Gas*, 99.99%  
*Hydrogen Gas*, 99.99%  
Aqueous 10 % acetone solution (by volume), Acetone, Spectrum Chemicals, (CAS # 67-64-1)  
Aqueous saturated dichloromethane solution, *Dichloromethane*, Fisher Scientific (CAS # 75-09-2)  
Aqueous saturated *n*-Hexane solution, (*n*-Hexane, Fisher Scientific, (CAS # 110-54-3)  
Aqueous 10 % sulfuric acid solution (by volume), *Sulfuric Acid*, Fisher Scientific, (CAS # 7664-93-9)  
Aqueous saturated toluene solution, *Toluene*, Acros Organics, (CAS # 108-88-3)

**Procedure:**

The guidelines of good laboratory practice were adhered to for all tests. All tests were conducted under standard laboratory conditions unless otherwise specified. Materials for assessment were inventoried, numbered (if needed) and logged upon receipt. Samples were randomly selected from the material provided. Testing procedures as specified within ASTM F739-07 were followed unless otherwise indicated.

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Date: 4 March 2011  
 Report: T6202-00-1  
 Issue: 1  
 Page: 2 of 8

**Procedure, continued:**

The test samples were prepared by cutting 3-inch diameter swatches from the test fabric. The chemical permeation test was then carried out in triplicate for 480 minutes against each test chemical, using 2-inch ASTM permeation cells. The permeation of the volatile organic compounds was measured by a flame ionization detector in an open-loop configuration. Permeation of the sulfuric acid solution was measured by a conductivity detector in a closed-loop configuration.

Test chemicals: 10% acetone and 10% sulfuric acid solutions were prepared by diluting the neat chemical by volume, in distilled water. Water saturated solutions of dichloromethane, n-hexane and toluene were prepared by vigorously agitating an excess of each of the solvents in distilled water, allowing the immiscible layers to separate and decanting the aqueous fraction for use as the challenge chemical. The aqueous fraction was then saturated with the organic solvent at ambient temperature.

**Results:**

The results for the permeation resistance of Red/Black PU laminated fabric, as assessed to ASTM F739-07 are summarized in Table I. The data and graphical presentations of triplicate tests are provided in the following pages. In the following data tables, the initial breakthrough time (first when the lowest detectable permeation rate is evident), the normalized breakthrough time (first when the permeation rate of 0.1  $\mu\text{g}/\text{cm}^2/\text{min}$  for open-loop system is detected), and the Steady State Permeation Rate are reported. During the 480 minutes test period, if a stable permeation rate was not reached, the Steady State Permeation Rate was not calculated. The cumulative permeation ( $< 6.0\mu\text{g}$  in 1hour period), as outlined in NFPA 1951-07, section 8.45.4; “Chemical Permeation Resistance” was used as the pass/fail criteria for the fabric.

**Table I**  
 Permeation Resistance of Red/Black PU Laminated Fabric (ASTM F739-07)

Chemical Challenge	Average Normalized Breakthrough Time (min)	Average Steady State Permeation ( $\mu\text{g}/\text{cm}^2$ )	Cumulative Permeation per Hour ( $\mu\text{g}/\text{cm}^2$ )	Results NFPA 1951 ( $< 6.0 \mu\text{g}/\text{hr}$ )
10 % Acetone in water	>480	ND	0	Pass
Dichloromethane in water	24	NA	2.6	Pass
N-Hexane in water	>480	ND	0	Pass
10% Sulfuric acid in water	>480	ND	0	Pass
Toluene in water	>480	ND	0	Pass

Note: ND = Not Detected during the 480 minutes test, NA = Not Attained during the 480 minutes test

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 USA

Date: 4 March 2011  
 Report: T6202-00-1  
 Issue: 1  
 Page: 3 of 8

**Data / Results:**

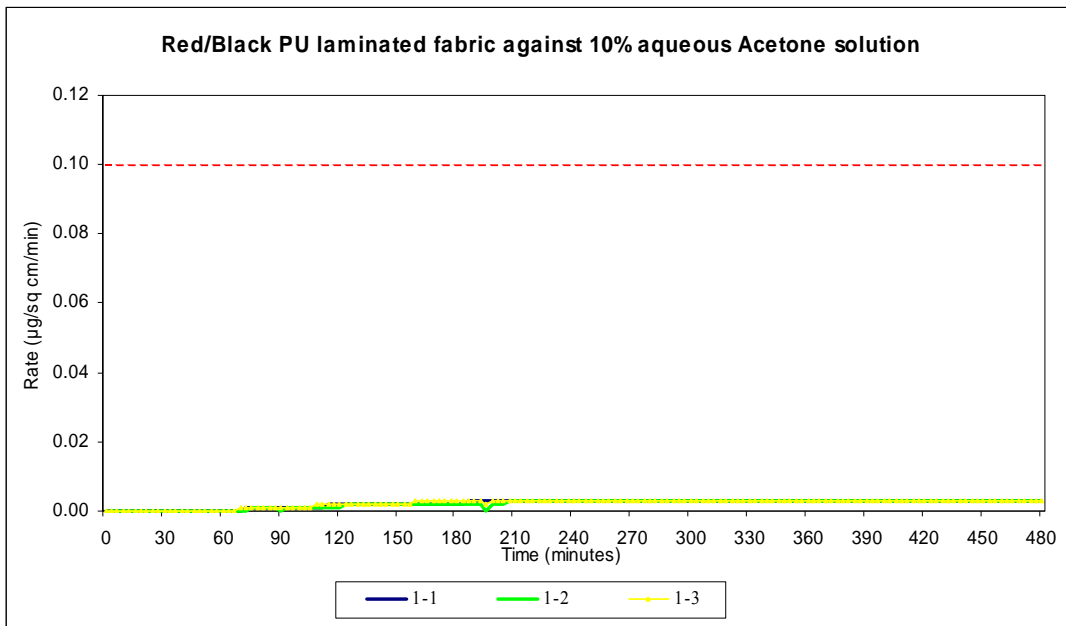
**Red/Black PU laminated fabric against 10 % aqueous Acetone solution**

<i>Challenge Chemical:</i>	Acetone	<i>Collection System:</i>	Open-loop
<i>CAS No.:</i>	67-64-1	<i>Chemical Contact</i>	Continuous
<i>Chemical Source:</i>	Spectrum Chemicals	<i>Collection Medium:</i>	Nitrogen Gas
<i>Chemical State:</i>	Liquid	<i>Collection Flow Rate:</i>	100 mL/min
<i>Concentration:</i>	10 %	<i>Specimen Area</i>	19.5 cm <sup>2</sup>
<i>Minimum Detection:</i>	0.04 µg/cm <sup>2</sup> /min	<i>Analytical Method:</i>	GC-FID
<i>Sample Type:</i>	PU laminated fabric	<i>Sampling Frequency:</i>	3 min.
<i>Condition:</i>	New	<i>Post Test Conditions:</i>	No change
<i>Sampling Location:</i>	Not Applicable	<i>Test Duration:</i>	480 min
<i>Temp. Nominal:</i>	22.0 °C	<i>Temp. Range:</i>	21.5 – 22.5 °C

<b>Results</b>	<b>1-1</b>	<b>1-2</b>	<b>1-3</b>	<b>Average</b>
Initial Breakthrough Time (min.)	>480	>480	>480	>480
Initial Breakthrough Rate (µg/cm <sup>2</sup> /min)	ND	ND	ND	ND
ASTM Normalized Breakthrough Time (min)	>480	>480	>480	>480
ASTM Steady State Permeation Rate (µg/cm <sup>2</sup> /min)	ND	ND	ND	ND
NFPA Cumulative Permeation/1Hr (µg/cm <sup>2</sup> )	0	0	0	0
Thickness (mm)	0.436	0.435	0.433	0.435
Weight Per Area (g / m2)	1127.2	1129.4	1122.1	1126.3

Note: ND = Not Detected during the 480 minutes test, NA = Not Attained during the 480 minutes test

**Permeation Graph:**



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 USA

Date: 4 March 2011  
 Report: T6202-00-1  
 Issue: 1  
 Page: 4 of 8

**Data / Results:**

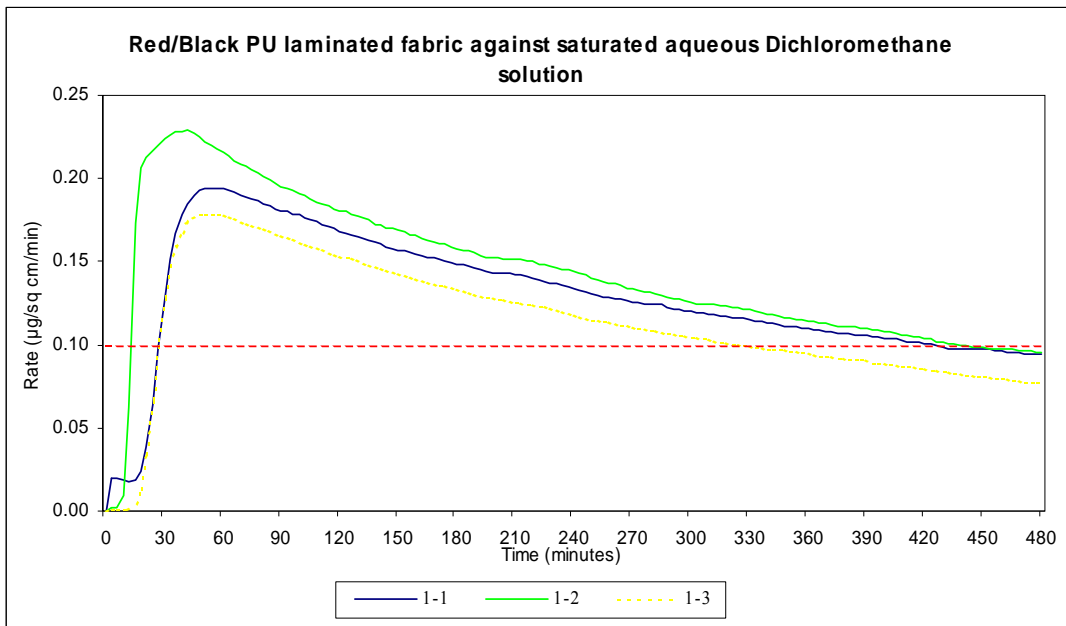
**Red/Black PU laminated fabric against saturated aqueous Dichloromethane solution**

<i>Challenge Chemical:</i>	Dichloromethane	<i>Collection System:</i>	Open-loop
<i>CAS No.:</i>	75-09-2	<i>Chemical Contact</i>	Continuous
<i>Chemical Source:</i>	Fisher Scientific	<i>Collection Medium:</i>	Nitrogen Gas
<i>Chemical State:</i>	Liquid	<i>Collection Flow Rate:</i>	100 mL/min
<i>Concentration:</i>	Aqueous Extract	<i>Specimen Area</i>	19.5 cm <sup>2</sup>
<i>Minimum Detection:</i>	0.007 µg/cm <sup>2</sup> /min	<i>Analytical Method:</i>	GC-FID
<i>Sample Type:</i>	PU laminated fabric	<i>Sampling Frequency:</i>	3 min.
<i>Condition:</i>	New	<i>Post Test Conditions:</i>	No change
<i>Sampling Location:</i>	Not Applicable	<i>Test Duration:</i>	480 min
<i>Temp. Nominal:</i>	22.0 °C	<i>Temp. Range:</i>	21.5 – 22.5 °C

<b>Results</b>	<b>1-1</b>	<b>1-2</b>	<b>1-3</b>	<b>Average</b>
Initial Breakthrough Time (min.)	6.0	9.0	18.0	11
Initial Breakthrough Rate (µg/cm <sup>2</sup> /min)	0.0	0.0	0.0	0
ASTM Normalized Breakthrough Time (min)	30.0	15.0	27.0	24
ASTM Steady State Permeation Rate (µg/cm <sup>2</sup> /min)	NA	NA	NA	NA
NFPA Cumulative Permeation/1Hr (µg/cm <sup>2</sup> )	2.3	3.6	2.1	2.6
Thickness (mm)	0.435	0.434	0.433	0.434
Weight Per Area (g / m <sup>2</sup> )	1117.6	1116.3	1113.6	1115.8

Note: ND = Not Detected during the 480 minutes test, NA = Not Attained during the 480 minutes test

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Date: 4 March 2011  
 Report: T6202-00-1  
 Issue: 1  
 Page: 5 of 8

**Data / Results:**

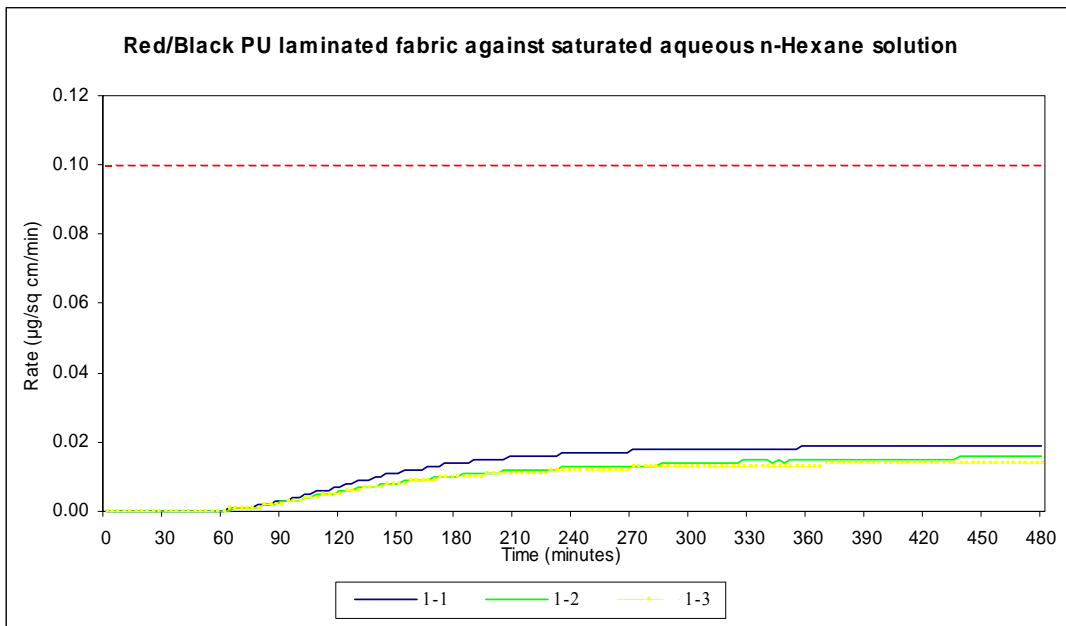
**Red/Black PU laminated fabric against saturated aqueous n-Hexane solution**

<i>Challenge Chemical:</i>	n-Hexane	<i>Collection System:</i>	Open-loop
<i>CAS No.:</i>	110-54-3	<i>Chemical Contact</i>	Continuous
<i>Chemical Source:</i>	Acros Organics	<i>Collection Medium:</i>	Nitrogen Gas
<i>Chemical State:</i>	Liquid	<i>Collection Flow Rate:</i>	100 mL/min
<i>Concentration:</i>	Aqueous extract	<i>Specimen Area</i>	19.5 cm <sup>2</sup>
<i>Minimum Detection:</i>	0.04 µg/cm <sup>2</sup> /min	<i>Analytical Method:</i>	GC-FID
<i>Sample Type:</i>	PU laminated fabric	<i>Sampling Frequency:</i>	3 min.
<i>Condition:</i>	New	<i>Post Test Conditions:</i>	No change
<i>Sampling Location:</i>	Not Applicable	<i>Test Duration:</i>	480 min
<i>Temp. Nominal:</i>	22.0 °C	<i>Temp. Range:</i>	21.5 – 22.5 °C

<b>Results</b>	<b>1-1</b>	<b>1-2</b>	<b>1-3</b>	<b>Average</b>
Initial Breakthrough Time (min.)	>480	>480	>480	>480
Initial Breakthrough Rate (µg/cm <sup>2</sup> /min)	ND	ND	ND	ND
ASTM Normalized Breakthrough Time (min)	>480	>480	>480	>480
ASTM Steady State Permeation Rate (µg/cm <sup>2</sup> /min)	ND	ND	ND	ND
NFPA Cumulative Permeation/1Hr (µg/cm <sup>2</sup> )	0	0	0	0
Thickness (mm)	0.435	0.439	0.434	0.436
Weight Per Area (g / m <sup>2</sup> )	1115.8	1125.3	1112.7	1118.0

Note: ND = Not Detected during the 480 minutes test, NA = Not Attained during the 480 minutes test

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 USA

Date: 4 March 2011  
 Report: T6202-00-1  
 Issue: 1  
 Page: 6 of 8

**Data / Results:**

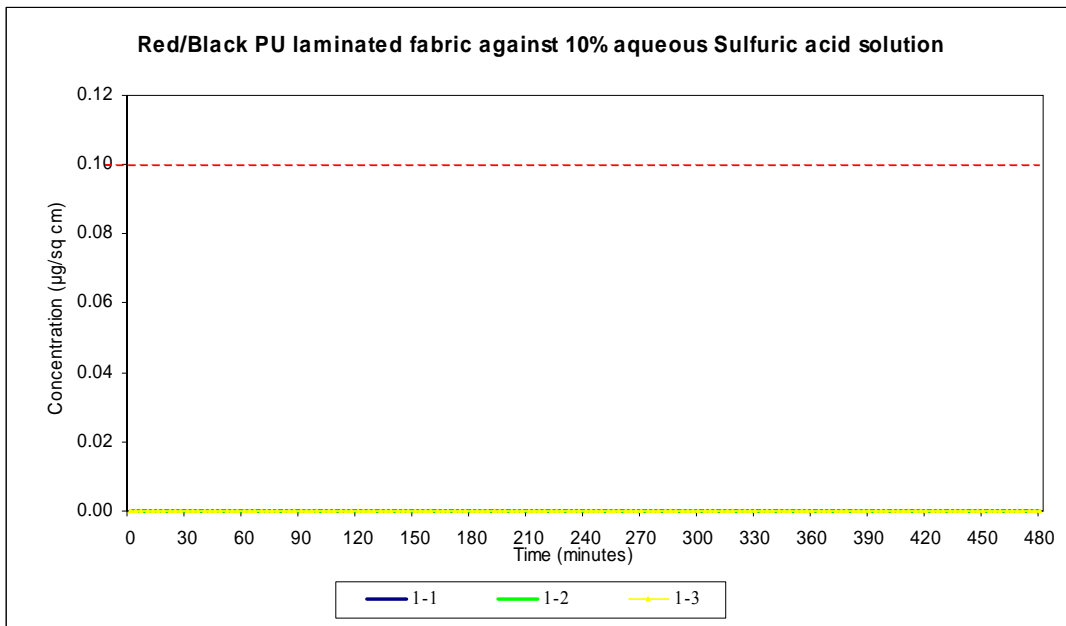
**Red/Black PU laminated fabric against 10% aqueous Sulfuric acid solution**

<i>Challenge Chemical:</i>	Sulfuric acid	<i>Collection System:</i>	Closed-loop
<i>CAS No.:</i>	7664-93-9	<i>Chemical Contact</i>	Continuous
<i>Chemical Source:</i>	Fisher Scientific	<i>Collection Medium:</i>	Distilled water
<i>Chemical State:</i>	Liquid	<i>Collection Flow Rate:</i>	Not Applicable
<i>Concentration:</i>	10.0 %	<i>Specimen Area</i>	19.5 cm <sup>2</sup>
<i>Minimum Detection</i>	0.06 µg/cm <sup>2</sup>	<i>Analytical Method:</i>	Conductivity
<i>Sample Type:</i>	PU laminated fabric	<i>Sampling Frequency:</i>	2 min.
<i>Condition:</i>	New	<i>Post Test Conditions:</i>	No change
<i>Sampling Location:</i>	Not Applicable	<i>Test Duration:</i>	480 minutes
<i>Temp. Nominal:</i>	22.0 °C	<i>Temp. Range:</i>	21.5 – 22.5 °C

<b>Results</b>	<b>1-1</b>	<b>1-2</b>	<b>1-3</b>	<b>Average</b>
Initial Breakthrough Time (min.)	>480	>480	>480	>480
Initial Breakthrough Conc. (µg/cm <sup>2</sup> )	ND	ND	ND	ND
ASTM Normalized Breakthrough Time (min)	>480	>480	>480	>480
ASTM Steady State Permeation (µg/cm <sup>2</sup> )	ND	ND	ND	ND
NFPA Cumulative Permeation/1Hr (µg/cm <sup>2</sup> )	0	0	0	0
Thickness (mm)	0.435	0.433	0.430	0.433
Weight Per Area (g / m2)	1119.9	1119.5	1098.4	1112.6

Note: ND = Not Detected during the 480 minutes test, NA = Not Attained during the 480 minutes test

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 USA

Date: 4 March 2011  
 Report: T6202-00-1  
 Issue: 1  
 Page: 7 of 8

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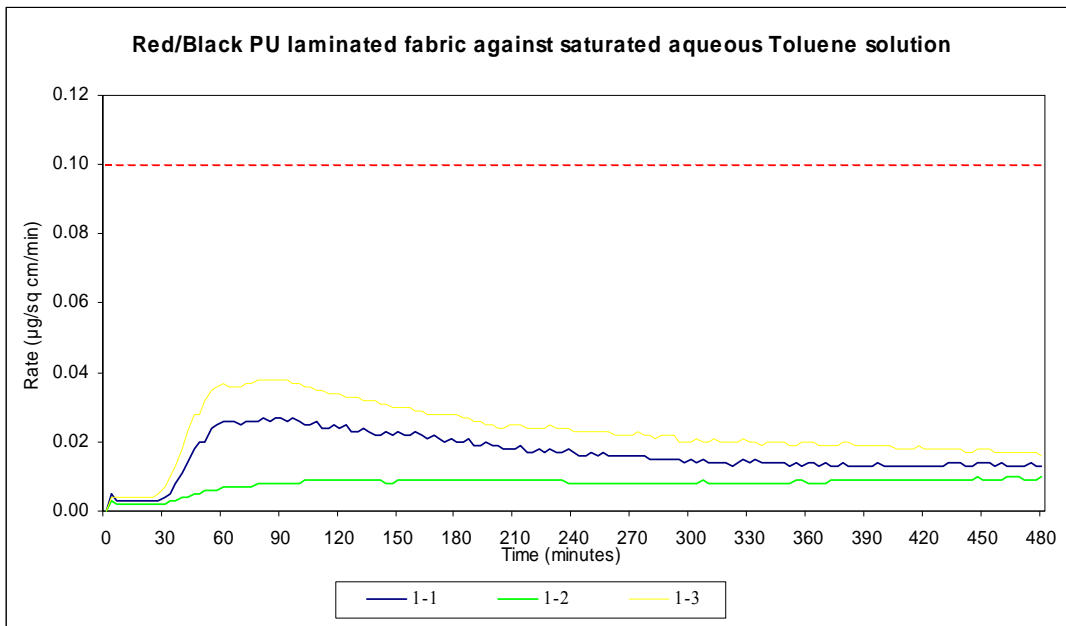
**Red/Black PU laminated fabric against saturated aqueous Toluene solution**

<i>Challenge Chemical:</i>	Toluene	<i>Collection System:</i>	Open-loop
<i>CAS No.:</i>	108-88-3	<i>Chemical Contact</i>	Continuous
<i>Chemical Source:</i>	Acros Organics	<i>Collection Medium:</i>	Nitrogen Gas
<i>Chemical State:</i>	Liquid	<i>Collection Flow Rate:</i>	100 mL/min
<i>Concentration:</i>	Aqueous extract	<i>Specimen Area</i>	19.5 cm <sup>2</sup>
<i>Minimum Detection:</i>	0.04 µg/cm <sup>2</sup> /min	<i>Analytical Method:</i>	GC-FID
<i>Sample Type:</i>	PU laminated fabric	<i>Sampling Frequency:</i>	3 min.
<i>Condition:</i>	New	<i>Post Test Conditions:</i>	No change
<i>Sampling Location:</i>	Not Applicable	<i>Test Duration:</i>	480 min
<i>Temp. Nominal:</i>	22.0 °C	<i>Temp. Range:</i>	21.5 – 22.5 °C

<b>Results</b>	<b>1-1</b>	<b>1-2</b>	<b>1-3</b>	<b>Average</b>
Initial Breakthrough Time (min.)	>480	>480	>480	>480
Initial Breakthrough Rate (µg/cm <sup>2</sup> /min)	ND	ND	ND	ND
ASTM Normalized Breakthrough Time (min)	>480	>480	>480	>480
ASTM Steady State Permeation Rate (µg/cm <sup>2</sup> /min)	NA	NA	NA	NA
NFPA Cumulative Permeation/1Hr (µg/cm <sup>2</sup> )	0	0	0	0
Thickness (mm)	0.421	0.423	0.420	0.421
Weight Per Area (g / m <sup>2</sup> )	1087.3	1092.6	1087.2	1089.0

Note: ND = Not Detected during the 480 minutes test, NA = Not Attained during the 480 minutes test

**Permeation Graph:**





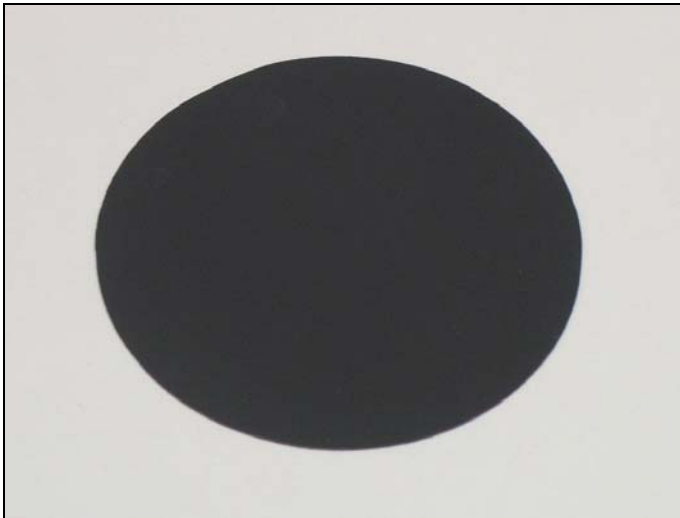
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USA

Date: 4 March 2011  
Report: T6202-00-1  
Issue: 1  
Page: 8 of 8

**Photographs:**



**Figure 1:** Red/Black PU laminated fabric



**Figure 2:** Swatch removed for permeation test

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23. All costs associated with compliance with any subpoena (s) for documents, testimony in a court of law, or for any other purpose relating to work performed by ICS in connection with work performed for that Client, shall be paid by Client. Client shall also pay ICS's then existing standard fee for consulting, deposition and trial testimony and all expenses related thereto.
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