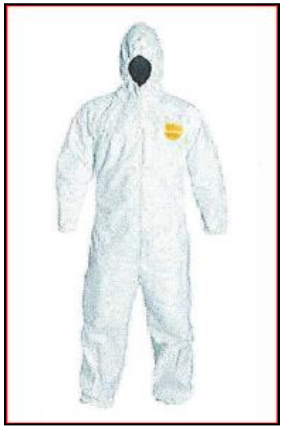
Investigation of Protective Clothing Resistance to MDI Penetration from Spray Polyurethane Foam (SPF) Overspray



Covestro LLC
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- It is and shall remain the policy of the Spray Polyurethane Foam Alliance ("SPFA"), and it is the continuing responsibility of every SPFA member company, SPFA meeting or event participant, as well as SPFA staff and leadership to comply in all respects with federal and state antitrust laws. No activity or discussion at any SPFA meeting or other function may be engaged in for the purpose of bringing about any understanding or agreement among members to (1) raise, lower or stabilize prices; (2) regulate production; (3) allocate markets; (4) encourage boycotts; (5) foster unfair or deceptive trade practices; (6) assist in monopolization; or (7) in any way violate or give the appearance of violating federal or state antitrust laws.
- Any concerns or questions regarding the meaning or applicability of this policy, as well as any concerns regarding activities or discussions at SPFA meetings should be promptly brought to the attention of SPFA's Executive Director and/or its legal counsel.

Background Information/Objective

Background:

- SPF overspray mist contains MDI
- Important to prevent direct skin contact
- What type of coverall provides adequate protection?
- Selection of a proper coverall challenging due to the variety of coveralls available from protective clothing manufacturers
- Manufactures have recommendations for coveralls when spray applying isocyanate containing paints or coatings, but not for SPF
- SPF formulations differ from isocyanate containing paints/coatings:
  - Quicker cure time with SPF (tack free 10 sec; final rise profile in 60 sec)
  - Lower organic solvent content in SPF formulations
  - Lower potential for direct liquid contact (no manual mixing/blending)

Objective: **Investigate three types of coveralls for their effectiveness to prevent skin contact with MDI during SPF application**

Overview of Study

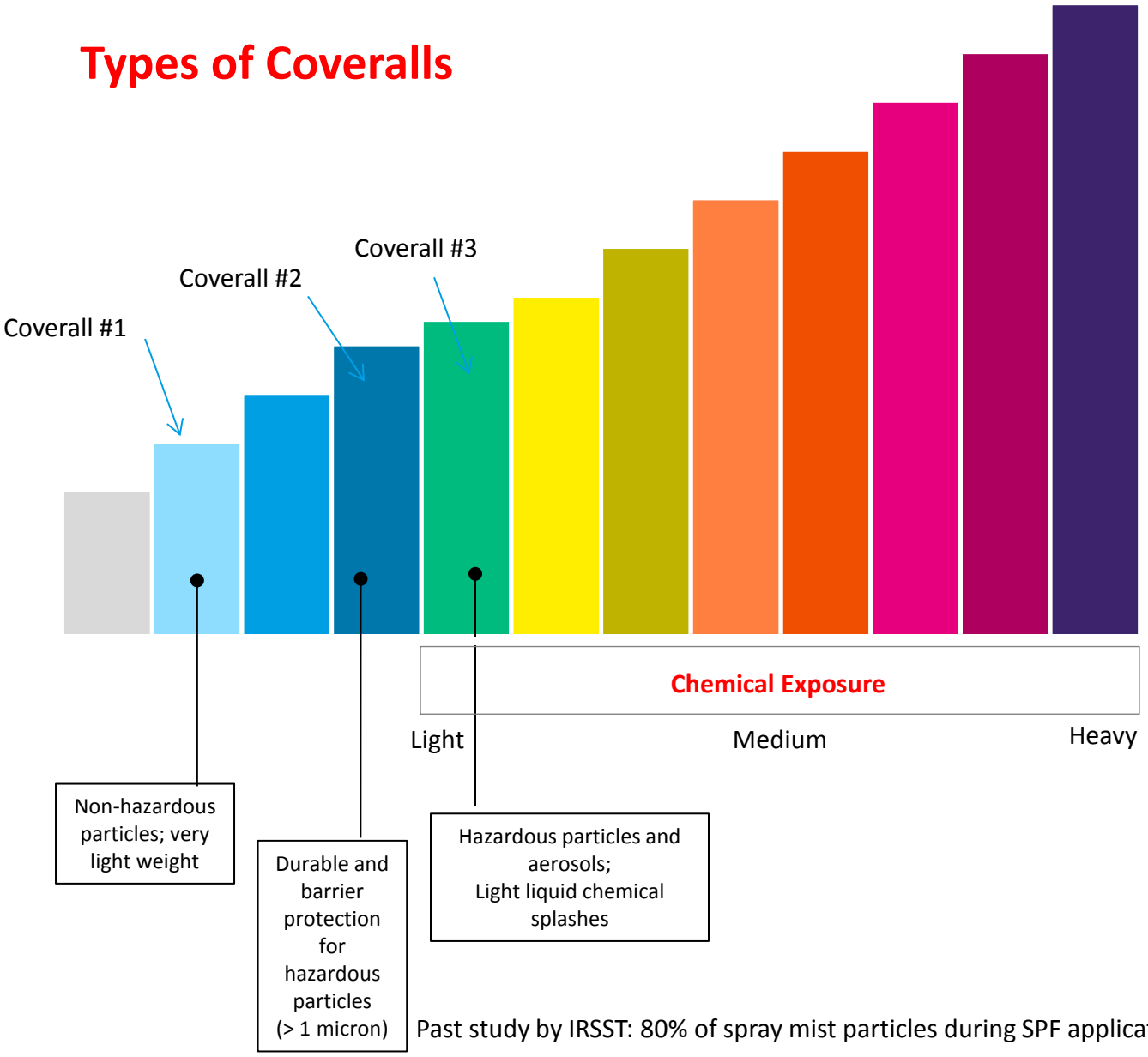
SPF Formulation and Spray Equipment

- Medium density closed cell SPF formulation (commercially available)
- A-side (pMDI), B-side (polyol): sprayed at a 1:1 ratio by volume
- High pressure spray equipment (pumps, proportioner, spray gun)
  - Pressure: 1200 psi
  - Temperature: 120˚F to 130˚F

Test Clothing Materials

- Cotton T-shirt (100% cotton, loosely knitted garment)
- Work Shirt Uniform (100% cotton, tightly knitted garment)
- Coverall #1: designed for non-hazardous particles and light duty work
- Coverall #2: designed for hazardous particles such as asbestos and for general maintenance work
- Coverall #3: designed for light chemical exposure environments and recommended for many industrial uses

Types of Coveralls



Past study by IRSST: 80% of spray mist particles during SPF application are > 10 microns

100% cotton T-shirt
(light weight woven/knitted fabric)

100% cotton work shirt
(tightly woven fabric; obtained from industrial facility)

Coverall #1

(basic light weight nonwoven material, non-hazardous dry particles)

Coverall #2

(light weight nonwoven material but more durable than #1; better barrier protection from particles)

Coverall #3

(a durable coated nonwoven material; made to handle light liquid chemical exposure environments)

Methodology

Sprayed Closed Cell SPF insulation product onto garment test patches

Used 37-mm filters treated with amine reagent (same approach used by OSHA and NIOSH for ISO air sampling)

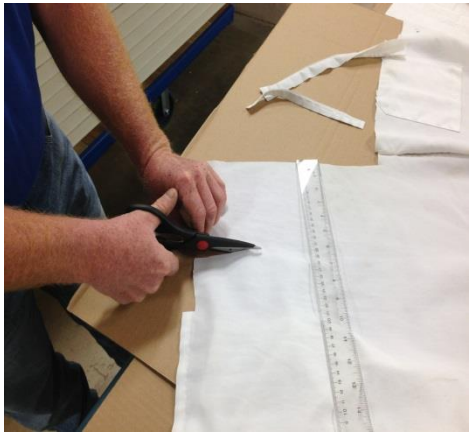
37-mm filters sandwiched between 2 pieces of each garment test patch

Desorbed filters immediately after spray with 90:10 acetonitrile/DMSO

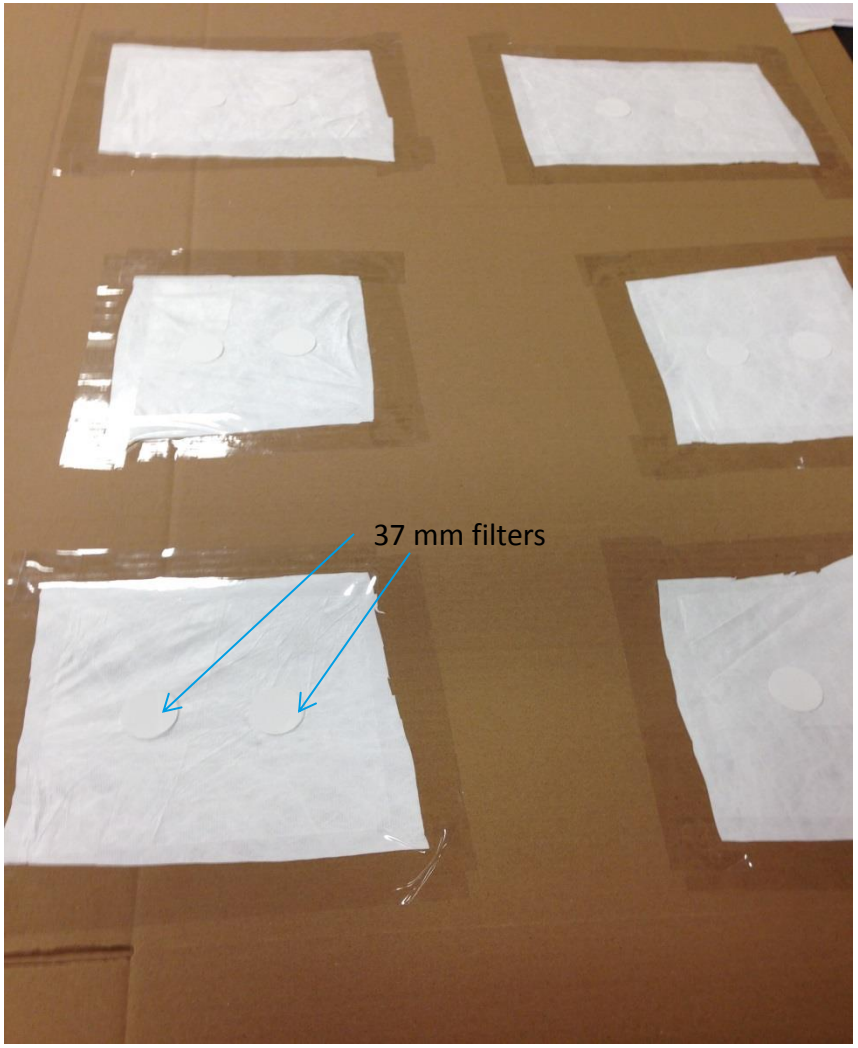
Analysis:

- 4,4'-MDI and 2,4'-MDI (monomeric isomers; 50% of A-side)
- Lab Method: US EPA CTM 036
- Instrument: Agilent triple quad LC/MS/MS
- Reporting Limit: 0.004 micrograms (µg) or 4 nanograms

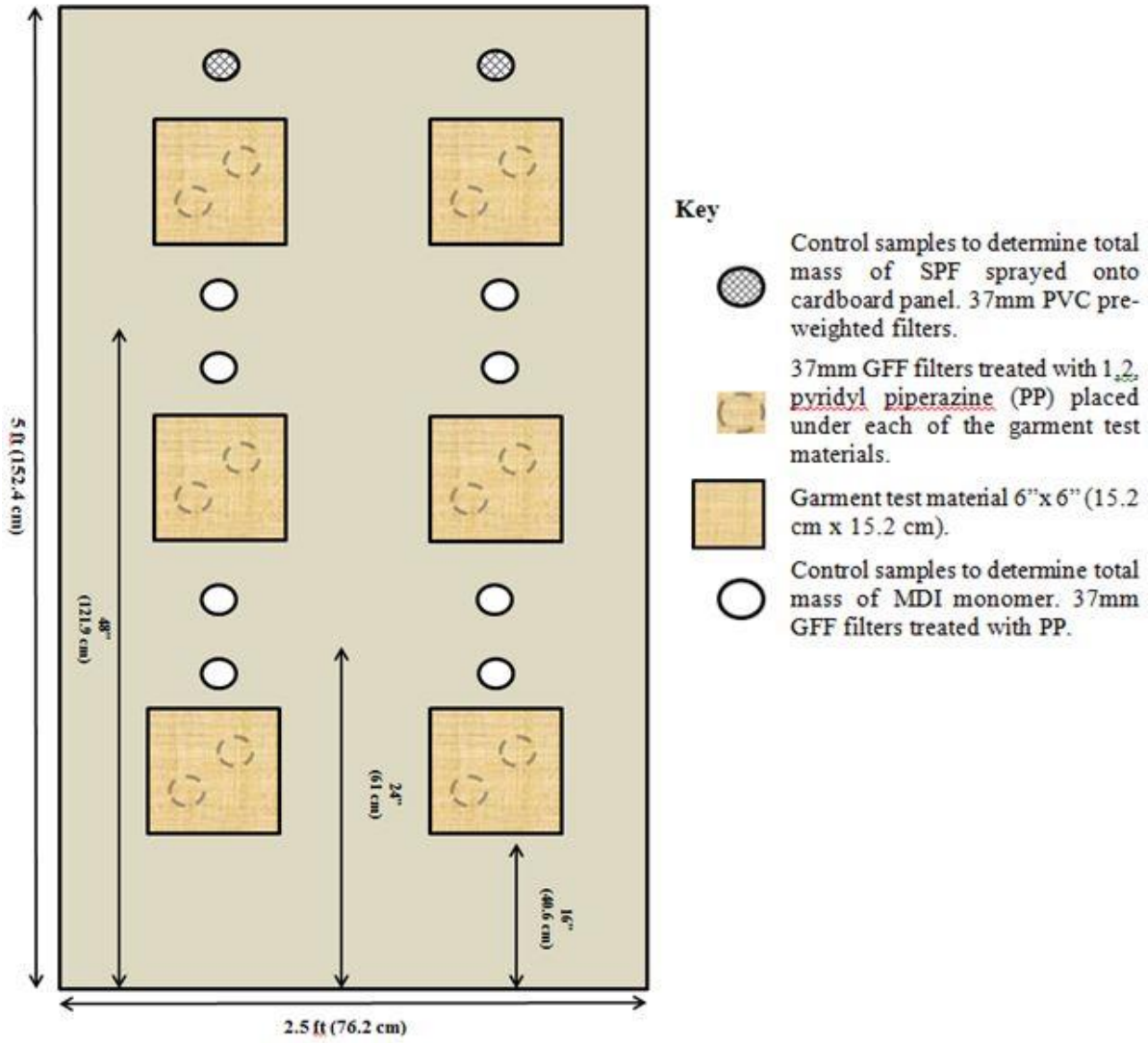
Protective Clothing Study - Set up



Cut 15 cm x 15 cm sections of clothing to form test patches; taped 6 patches onto a cardboard panel; placed 2 filters on each cloth patch; cut another 15 cm x 15 cm cloth patch and covered the filters. Filters were sandwiched between 2 cloth test patches.

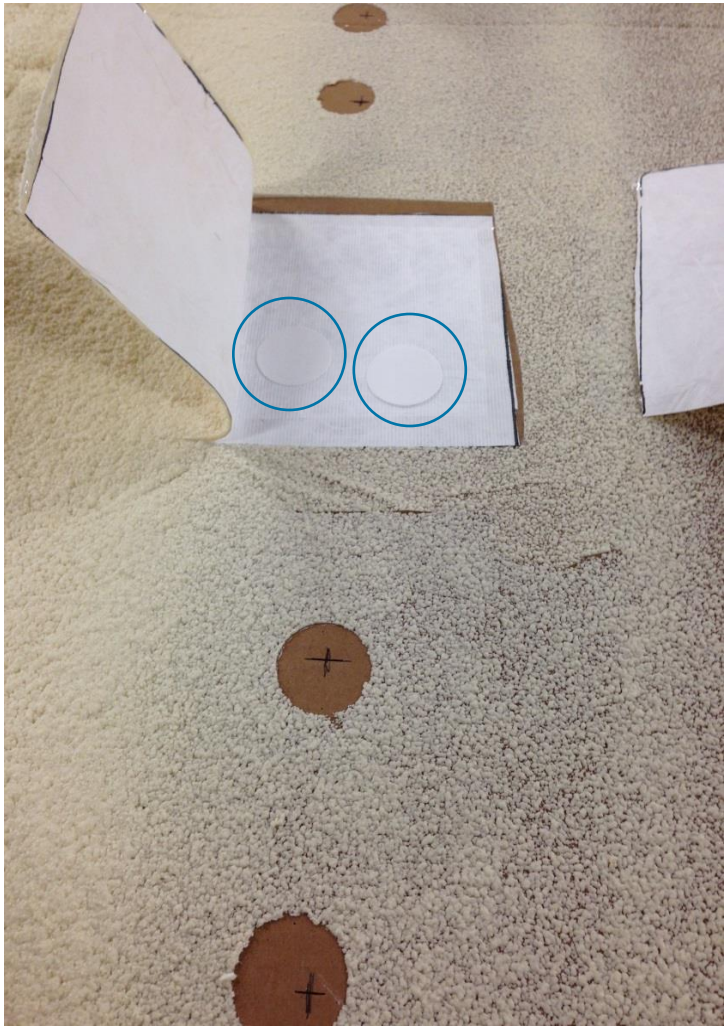


TEST PANEL


Heavy Spray Side
Light Spray Side
5 ft (152.4 cm)
48"
(121.9 cm)
24"
(61 cm)
16"
(40.6 cm)
2.5 ft (76.2 cm)
Key
Control samples to determine total mass of SPF sprayed onto cardboard panel. 37mm PVC pre-weighted filters.
37mm GFF filters treated with 1,2, pyridyl piperazine (PP) placed under each of the garment test materials.
Garment test material 6"x 6" (15.2 cm x 15.2 cm).
Control samples to determine total mass of MDI monomer. 37mm GFF filters treated with PP.

Protective Clothing Study – SPF Application

Protective Clothing Study: Post Application



No visible breakthrough; Filters outlined by blue circles.

Heavy Spray Side: 37 mm filters have been removed

100% Cotton T-shirt

Test Panel	Sample ID	Total Mass of MDI on Filter (µg)	Average Mass of MDI Under Garment Test Patch* (µg)	Average Mass of MDI on Control Filters (µg)	% Break-through
Heavy Side	1	0.026	0.105		0.084%
	1 A	0.176			
	2	0.057		124.3	
	2 A	0.142			
	3	0.222			
	3 A	0.010			
Light Side	4	NQ**	<0.008		<0.018%
	4 A	NQ			
	5	NQ		44.5	
	5 A	NQ			
	6	NQ			
	6 A	NQ			

*Total MDI = 2,4-MDI + 4,4-MDI

**NQ is Non-Quantifiable (<0.008 µg)

100% Cotton Work Shirt

Test Panel	Sample ID	Total Mass of MDI on Filter (µg)	Average Mass of MDI Under Garment Test Patch* (µg)	Average Mass of MDI on Control Filters (µg)	% Break-through
Heavy Side	1	0.017	<0.010		<0.004%
	1 A	0.010			
	2	0.011		231.8	
	2 A	NQ			
	3	NQ			
	3 A	NQ			
Light Side	4	0.015	<0.009		<0.010%
	4 A	NQ			
	5	NQ		87.3	
	5 A	NQ			
	6	NQ			
	6 A	NQ			

Coverall #1

Test Panel	Sample ID	Total Mass of MDI on Filter (µg)	Average Mass of MDI Under Garment Test Patch* (µg)	Average Mass of MDI on Control Filters (µg)	% Break-through
Heavy Side	1	0.009	<0.013		<0.009%
	1 A	0.023			
	2	NQ		139.3	
	2 A	0.014			
	3	NQ			
	3 A	0.018			
Light Side	4	0.012	<0.009		<0.010%
	4 A	NQ			
	5	NQ		87.9	
	5 A	NQ			
	6	NQ			
	6 A	NQ			

Coverall #2

Test Panel	Sample ID	Total Mass of MDI on Filter (µg)	Average Mass of MDI Under Garment Test Patch* (µg)	Average Mass of MDI on Control Filters (µg)	% Break-through
Heavy Side	1	0.009	<0.008		<0.005%
	1 A	NQ			
	2	NQ		167.1	
	2 A	NQ			
	3	NQ			
	3 A	NQ			
Light Side	4	NQ	<0.008		<0.009%
	4 A	NQ			
	5	NQ		90.9	
	5 A	NQ			
	6	NQ			
	6 A	NQ			

Coverall #3

Test Panel	Sample ID	Total Mass of MDI on Filter (µg)	Average Mass of MDI Under Garment Test Patch* (µg)	Average Mass of MDI on Control Filters (µg)	% Break-through
Heavy Side	1	NQ	<0.008		<0.005%
	1 A	NQ			
	2	NQ		147.5	
	2 A	NQ			
	3	NQ			
	3 A	NQ			
Light Side	4	NQ	<0.008		<0.012%
	4 A	NQ			
	5	NQ		66.3	
	5 A	NQ			
	6	NQ			
	6 A	NQ			

Conclusions

During SPF application, Covestro believes:

- It is best practice for SPF applicators to wear coveralls to prevent direct skin contact with spray mist containing MDI
- A durable coverall made of a non-woven fabric with barrier protection from particles > 1 micron in size provides good protection
- Coveralls designed for moderate to heavy chemical liquid contact do not appear necessary for SPF applicators

Acknowledge:

- Covestro employees: Jason Miller, Karen Mattson, Shen Tian
- International Isocyanate Institute

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