Industry Study of the Compatibility of Spray Polyurethane Foam with CPVC

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Agenda

- **CPVC background**
  - **What, where, how, why it is used**
- **Goal of program**
- **Test procedure**
  - **Current**
  - **Proposed**
- **Test in Progress**
- **Timeline to solution**
- **Summary**
- **Acknowledgements**

Background

What Is CPVC?

- First produced by Lubrizol Advanced Materials, Inc. (formerly BF Goodrich Performance Materials) in the late 1950's.
- PVC homopolymer subjected to chlorination reaction
- Chlorine atoms surrounding the carbon backbone help protect the chain from attack
- Improving the plastic's
  - Temperature
  - Chemical resistance

Where is it used?

- Most commonly used to manufacture pipe and pipe fittings for fire suppression systems, potable water distribution, as well as corrosive fluid handling and are recognized by all model building codes.

- Covered by:
  - NFPA 13D Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes
  - NFPA 13R Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes

2009 IRC Code Change

SECTION R313
FIRE SPRINKLER SYSTEMS

R313.1 General. Effective January 1, 2011, an approved automatic fire sprinkler system shall be installed in new one and two-family dwellings and townhouses in accordance with NFPA 13D.

CPVC and Polyurethane Foam Today

As pour foam

Urecon's patented "U.I.P"® process includes a layer of rigid polyurethane foam insulation, bonded directly to the entire pipe surface.

As spray foam

Applied directly to the surface of CPVC pipe and fittings as insulation, fire stop, construction gap filler

How does CPVC fail?

By chemical attack

Environmental Stress Cracking (ESC)

- A mechanism by which ***organic chemicals*** create an ***extremely localized weakening*** at the surface of a part which permits the propagation of a crack. with glossy fractured surfaces that occurs in regions of high mechanical stress

- Such as natural or synthetic ester oils, nonionic surfactants, alcohols, glycols

How does CPVC fail?

By physical stress

Mechanical Stress Cracking (MSC)

- The result of the piping being installed under high stress situations.
- External or internal cracks in a plastic caused by tensile stresses less than that of its short-term mechanical strength.
- Pipe exposed to elevated temperatures.
  - The polyurethane chemical reaction is exothermic, which depending upon foam thicknesses, can reach temperatures in excess of 200 °F

What has caused recent concern?

Acrylic fire caulks containing phosphate ester flame retardants yielding ESC and failures in the field

↓

SPF contains phosphate ester flame retardants and natural oil polyols in raw materials

↓

Lubrizol issues precautionary statement

↓

SPF installation impacted

Lubrizol Cautionary Statement

"We are currently investigating chemical compatibility of polyurethane foams with our CPVC brands. This process will take several months to investigate. Thus, at this time, we cannot say whether such products are compatible with CPVC. While ***we are not aware of a CPVC failure that was the result of chemical incompatibility*** with properly applied polyurethane foams, when polyurethane foams are not properly applied there is the potential for excess heat that can lead to ballooning of the pipe and a subsequent failure."

SPF Installations Begin to be Challenged in the Field

Industry Research Program

Begins

Goal of the Program

Goals of Research

- Demonstrate that there is no chemical/physical impact to the performance and longevity of CPVC piping and fittings when it is in contact with spray polyurethane foam.
  - *By*
    - Evaluating the chemical, thermal and physical compatibility of SPF with CPVC piping and fittings
    - Have the data reviewed and a summary report issued by an independent third party.
- Develop an appropriate test procedure for SPF products to reflect field installation conditions

What are the current compatibility tests for CPVC?

ISO 22088

Determination of resistance to environmental stress cracking (ESC)

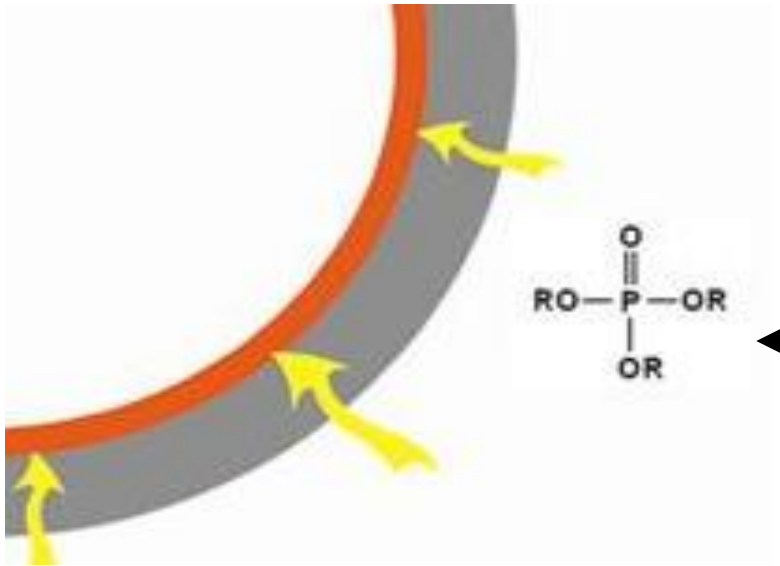
ASTM D543

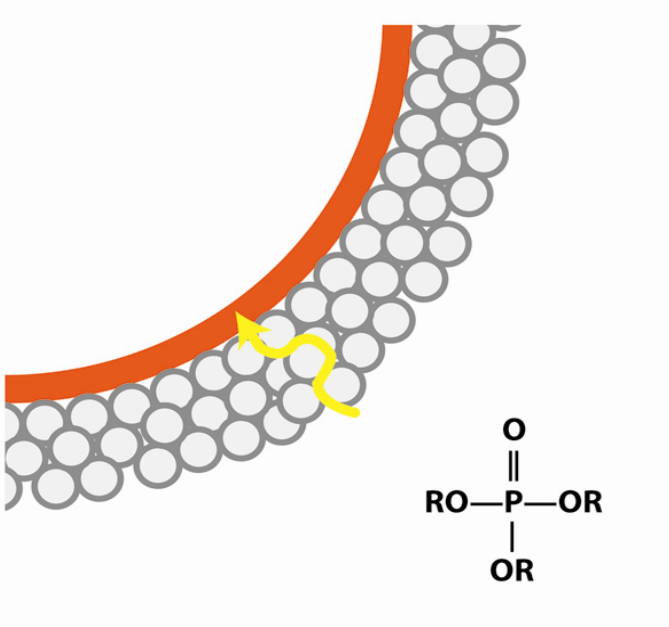
Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents

Limitations

Both involve continuous immersion or direct application in possible chemical materials

Can these methods predict spray foam compatibility?





Current method characteristics		***Spray foam application***
Involves significant level of exposure	⟷	Limited contact surface area
Lengthy duration of liquid content	⟷	Short duration of liquid contact
Designed for homogeneous material	⟷	Non-homogeneous
Clear migration pathway	⟷	Blocked migration pathway

SPRAY POLYURETHANE FOAM ALLIANCE

SPFA

Development of Field Oriented Test Method

Proposed Alternative Test Procedure

Duplicate field conditions- compare to standard performance

- Encasing a pipe/fitting setup in minimum of 1 inch of polyurethane foam.
- Placed under hydrostatic pressure @ ***150 °F***
- Monitor pipe and fittings for stress cracking, pipe rupture, or leakage

Accelerate testing

- Samples tested under range of conditions simulating 6000 hrs service

Hours in Chamber	Pipe Pressure, PSI
3000	210
6000	210

Analyze impact on piping

- Analyze pipe surface & foam for phosphate migration or concentration

Program Funding- $$ & Labor

- SPFA- allocated in 2008 budget for research program
- CPI- provided grant through Rigid Foams Committee
- Systems houses providing lab services and raw materials
- Suppliers coordinating program and providing raw materials
- Lubrizol providing testing, piping, laboratory equipment for program

Review of the Test in Progress

Setup → Testing → Results → Reporting

TEST VARIABLES

- Type of foam: ***Prepared from industry generic formulations***
  - Medium density Closed Cell
  - Low density Open Cell
  - Closed cell One Component

- Type of flame retardant: ***Based upon industry survey***
  - TCPP - (Tris(2-chloroisopropyl)phosphate)- ***Most widely used***
  - TEP - (Triethyl phosphate)- ***Most aggressive in soak test***
  - TDCP - (Tris (1,3-dichloroisopropyl) phosphate blend) -***Used in one component foams only***

- Flame retardant concentration: ***Use levels based upon industry survey***

- Thickness of the foam – ***Ranges based upon application from 1 inch to 4 inches***

- Soy and non-soy polyol based***- Two commercial systems included***
  - Natural oil polyols (NOP) are gaining widespread use in the polyurethanes industry. NOPs are fully reacted products and chemically do not resemble the agricultural products they are derived from.

Variables vs Foam Type

Foam Type	Closed cell foam 2 pcf density	Open cell foam- 0.5 pcf density	One component foam (OCF)	Soy based foam systems
Variables	•Thickness •Flame retardant: TCPP/ TEP •Flame retardant concentration	•Flame retardant: TCPP/ TEP •Flame retardant concentration	•Flame retardant: TCPP/ TDCPP •Flame retardant concentration	•Thickness •Soy based Polyol

Setup

Samples

Utilizing partial factorial

High and low point per variable

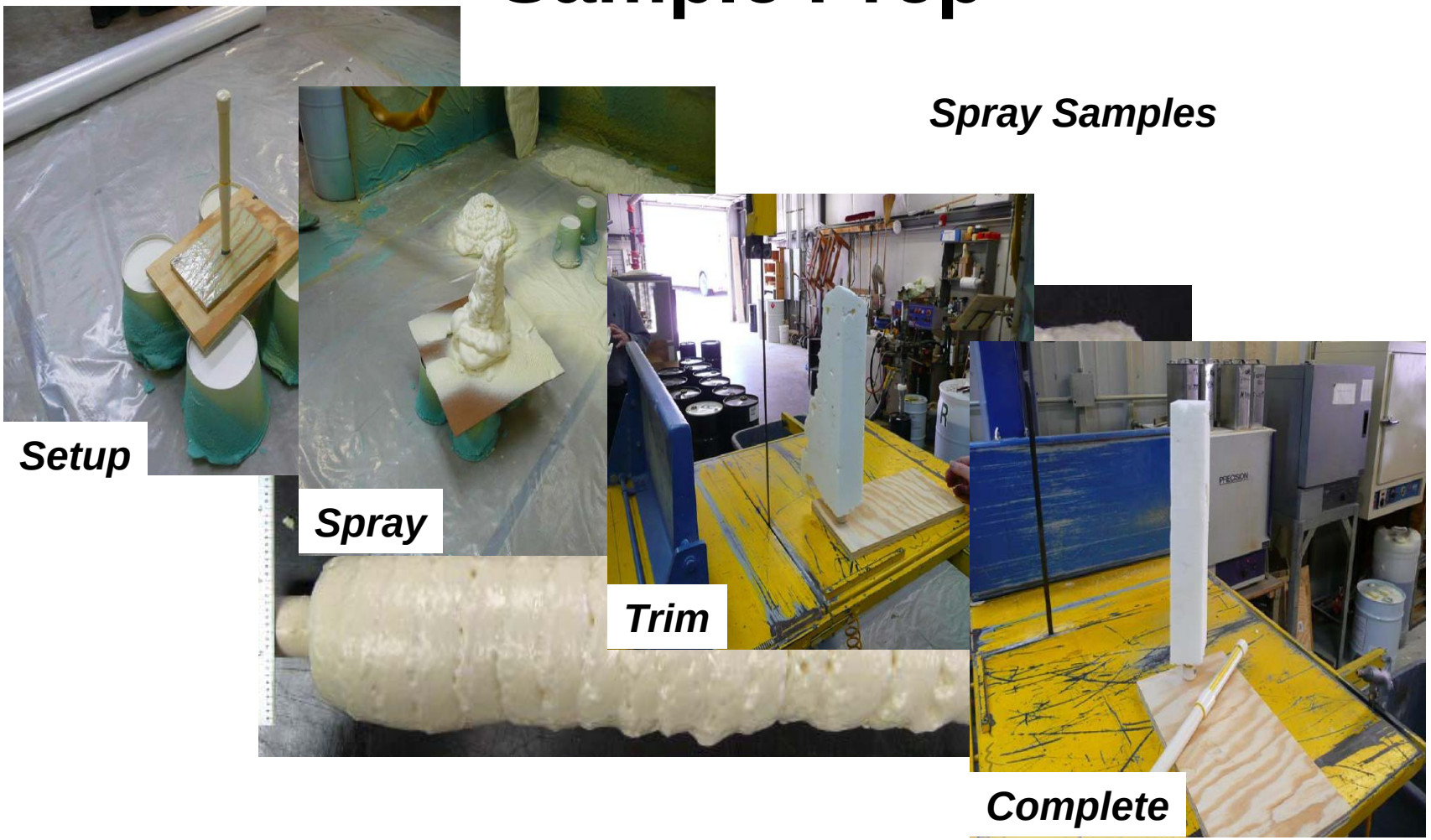
Single analysis per condition

Testing pipe controls without foam

Type of foam	Fame Retardant (FR)	Concentration FR, wt% polyol side	Thickness Foam, in	Sample Test Schedule			
				Initial	1 mo	3000 hr	6000 hr
Closed cell	TCPP	10	4	X	X	X	X
	TCPP	10	2	X	X	X	X
	TCPP	4	4	X	X	X	X
	TCPP	4	2	X	X	X	X
	TEP	10	4	X	X	X	X
	TEP	10	2	X	X	X	X
	TEP	4	4	X	X	X	X
Open Cell	TCPP	50		X	X	X	X
	TCPP	15		X	X	X	X
	TEP	50		X	X	X	X
	TEP	15		X	X	X	X
OCF	TCPP	5	¾” +/-	X	X	X	X
	TCPP	10	¾” +/-	X	X	X	X
	TDCPP	10	¾” +/-	X	X	X	X
	No Phos-ester	0	¾” +/-	X	X	X	X
BIO-POLYOL	Open cell-Biobased			X	X	X	X
	Closed cell-Demilec			X	X		X

Sample Prep

Spray Samples



Setup

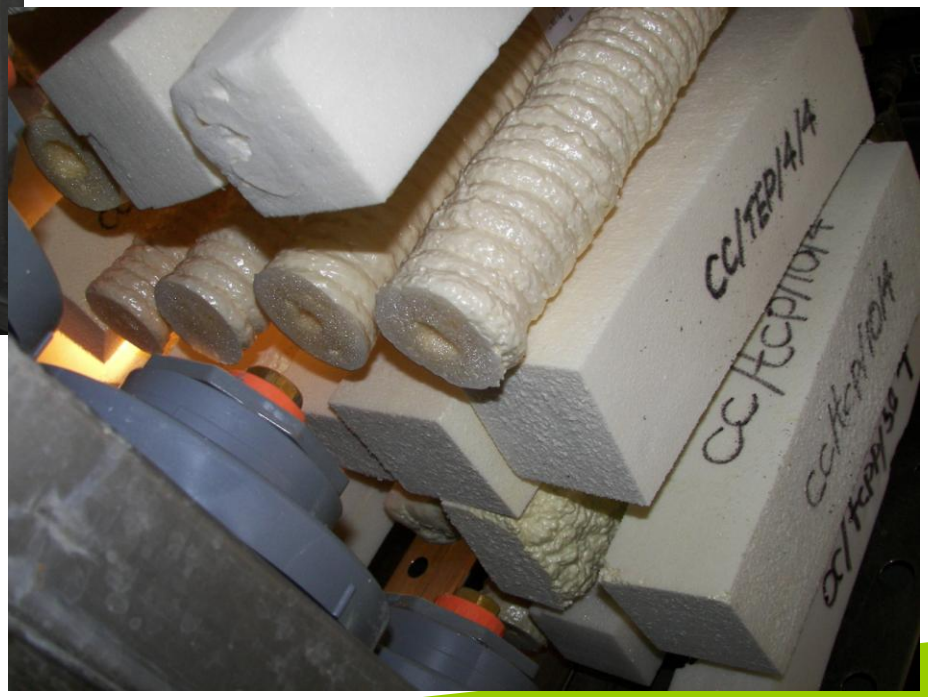
Sample Preparation

139 samples prepared by 4 facilities

Type	# For testing including initial	# In Test Chamber	# Extra for shipment damage	# extra for application improvement	Total #
Closed Cell Foam	28	21	14	14	**56**
Open Cell Foam	16	12	8	8	**32**
One Component	16	12	8	8	**32**
Soy – Open	4	3	3	3	**10**
Soy – Closed	3	2	3	3	**9**
Total	**67**	**50**	**36**	**36**	**139**

Thank you to
Demilec USA, LLC, BioBased® Insulation, NCFI Polyurethanes, Clayton Corp. for providing laboratory services

Samples In Test Chamber



Testing Underway- Timeline

4/08 **First testing begins**

9/08 **Present project at CPI**

9/08 **Results to date**

Currently there are no signs of catastrophic cpvc pipe failure due to the application of SPF

Test Restarted

1/09 **3200 hr samples out**

5/09 **6000 hr samples out**

7/09 **Final report issued**

Reporting & Communication Plan

Final Report

- Test protocol and study report 3rd party reviewed
  Jim Paschal, PE
    - James Paschal Engineering and Forensic Consulting, LLC
    - Chairperson of ASTM Committee on CPVC Testing
    - 30 years

- Peer review of study by plastics and foam industry
- Independent evaluation of the data

External Communication

- CPI paper on program
- Letter for building inspectors
- Publication in Spray Foam Magazine
- Publication on SPFA website
- Preparation of industry white paper for use with trades and CPVC industry

Summary

- ***CPVC and SPF used extensively together in building envelope***
- ***Concern raised about certain raw materials used in SPF – Lubrizol issues cautionary statement***
- ***Current test protocol used by industry does not apply to SPF***
- ***Alternative test protocol developed by plastics and foam industry consensus***
- ***Testing is ongoing- have refined it with industry agreement***
- ***Initial test results no signs of catastrophic cpvc pipe failure due to the application of SPF***

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Thank You!!!