Update on Compatibility Testing of Spray Polyurethane Foam with CPVC

Mary Bogdan
Honeywell

Clarence Tolbert
NCFI

Rick Duncan
SPFA

Kevin Daugherty
Lubrizol

“The information provided herein are believed to be accurate and reliable, but are presented without guarantee or warranty of any kind, express or implied. User assumes all risk and liability for use of the information and results obtained. Statements or suggestions concerning possible use of materials and processes are made without representation or warranty that any such use is free of patent infringement, and are not recommendations to infringe any patent. The user should not assume that all safety measures are indicated herein, or that other measures may not be required.”
Agenda

- CPVC Background
- Goal of Programs
- Study 1 - ESC & Screening Thermal Compatibility
- Study 2 - Expanded Thermal Testing
- Summary
- Acknowledgements
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 CPVC used?

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

- Covered by–NFPA 13D/ NFPA 13R: Standard for the Installation of Sprinkler Systems in One-and Two-Family Dwellings and Manufactured Homes
Where is CPVC used?

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.
Where is CPVC used?

CPVC and Polyurethane Foam Today

- As pour foam...
  One product 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, construction gap filler and, in some cases, a fire block/retardant
How does CPVC fail?

Environmental Stress Cracking (ESC)

By chemical attack under loading

- A mechanism by which certain organic chemicals cause extremely localized weakening at the surface of a part that permits the propagation of a crack. The crack exhibits glossy fractured surfaces occurring in regions of mechanical stress (e.g., pressure loads)

- Organic fluids, such as natural or synthetic ester oils, nonionic surfactants, alcohols, glycols may cause ESC
How does CPVC fail?

Mechanical Stress Cracking (MSC)

Results when piping is installed under high loading/stress

- Presence of external or internal cracks in a plastic can cause failure by tensile stresses less than that of its short-term mechanical strength

- Compounded by exposure to elevated temperatures.
  - The polyurethane chemical reaction is exothermic, which depending upon foam thicknesses, can reach temperatures in excess of 200 °F
What is the present concern?

Chain of Events

- Acrylic fire-stop caulks containing phosphate ester flame retardants are known to cause ESC field failures of CPVC
- SPF contains phosphate ester flame retardants and natural oil polyols
- Lubrizol issues precautionary statement regarding application of SPF on CPVC pipe and fittings
What is the present concern?

Chain of Events

**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.”

Lubrizol issues precautionary statement regarding application of SPF on CPVC pipe and fittings

Several jurisdictions ban SPF installation over CPVC piping and fittings
The Lubrizol statement cites 2 areas of concern:

- Environmental Stress Cracking due to chemical incompatibility specifically phosphate esters
- Pipe deformation due to exotherm from SPF reaction
Industry Research Programs Begin

Two Programs:
1. Focus is on ESC and general screening for impact of foam exotherm
2. More refined study defining conditions which would cause pipe/fitting deformation due to exotherm

Goal of the Programs:
Demonstrate the chemical/physical/thermal impact on the performance and longevity of CPVC piping and fittings when it is in contact with spray polyurethane foam.
STUDY 1

Industry consensus study with Lubrizol with 3rd party evaluation of results

Focus:
Evaluate potential for ESC and impact of exotherm under standard industry application conditions
Study 1:

Discussion Points

- Test Procedure
  - Current
  - Proposed
- Test Program
- Test Results
- Conclusion
Current chemical compatibility tests for CPVC:

- **ISO 22088**
  Determination of resistance to environmental stress cracking (ESC)

- **ASTM D543**

**Limitations**
Both involve continuous immersion or direct application in possible chemical materials
Study 1:

Review of Test Methods

Do these methods accurately reflect interaction or predict compatibility?

Current method
- involves significant level of exposure
- Lengthy duration of liquid content
- Clear migration pathway
- Designed for homogeneous material

Spray foam application
- Limited contact surface area
- Short duration of liquid contact
- Blocked migration pathway
- Non-homogeneous
Study 1: Development of Field Test Method

Alternative Test Procedure:

- Duplicated field conditions and compared to standard performance
  - Encased a Blazemaster pipe/fitting setup in minimum of 1 inch of polyurethane foam (Note: not under pressure or filled at time of foam application)
  - Placed under hydrostatic pressure @ 150 °F
  - Monitor pipe and fittings for stress cracking, pipe rupture, or leakage

- Analyzed impact on piping
  - Inspect pipe surface & analyze foam for phosphate migration or concentration

<table>
<thead>
<tr>
<th>Duration in Chamber (hrs)</th>
<th>Pipe Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000</td>
<td>210</td>
</tr>
<tr>
<td>6000</td>
<td>210</td>
</tr>
</tbody>
</table>
Study 1:
Development of Field Test Method

Test Variables:

- **Type of foam**: *Prepared from industry generic formulations*
  - Medium density (MD) Closed Cell Spray Foam
  - Low density (LD) Open Cell Spray Foam
  - Closed cell One Component

- **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.

- **Type of flame retardant**: *Based upon industry survey*
  - TCPP -(Tris(2-chloroisopropyl)phosphate)-Most widely used
  - TEP -(Triethyl phosphate)-Most aggressive in soak test
  - TDCPP -(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*
### Study 1:

#### Development of Field Test Method

**Test Variables:**

<table>
<thead>
<tr>
<th>Foam Type</th>
<th>Medium Density (MD) Closed-Cell Spray Foam (2 pcf)</th>
<th>Low Density (LD) Open-Cell Spray Foam (0.5 pcf)</th>
<th>One-Component Foam (OCF)</th>
<th>Natural-oil polyol (NOP) spray foam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>• Thickness</td>
<td>• FR Type (TCPP/TEP)</td>
<td>• FR Type (TCPP/TDCPP)</td>
<td>• Thickness</td>
</tr>
<tr>
<td></td>
<td>• FR Type (TCPP/TEP)</td>
<td>• FR Conc.</td>
<td>• FR Conc.</td>
<td>• Soy-Based Polyol</td>
</tr>
<tr>
<td></td>
<td>• FR Conc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Variables:**

- Thickness
- FR Type (TCPP/TEP)
- FR Conc.
- FR Type (TCPP/TDCPP)
- FR Conc.
- Thickness
- Soy-Based Polyol

**Test Variables:**
## Study 1:

### Samples:
- **DoX** - Utilizing partial factorial designs
- **High and low point variables**
- **Single analysis per condition**
- **Testing pipe controls without foam**

### Foam Type and Flame Retardant (FR) Type Table:

<table>
<thead>
<tr>
<th>Foam Type</th>
<th>Flame Retardant (FR) Type</th>
<th>FR Conc. (W% polyol side)</th>
<th>Foam Thickness (in)</th>
<th>Sample Test Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>TCPP</td>
<td>10</td>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TCPP</td>
<td>10</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TCPP</td>
<td>4</td>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TCPP</td>
<td>4</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TEP</td>
<td>10</td>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TEP</td>
<td>10</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TEP</td>
<td>4</td>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td>LD</td>
<td>TCPP</td>
<td>50</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TCPP</td>
<td>15</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TEP</td>
<td>50</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TEP</td>
<td>15</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>OCF</td>
<td>TCPP</td>
<td>5*</td>
<td>¾” +/-</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TCPP</td>
<td>10*</td>
<td>¾” +/-</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>TDCPP</td>
<td>10*</td>
<td>¾” +/-</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No PhosEster</td>
<td>0*</td>
<td>¾” +/-</td>
<td>X</td>
</tr>
<tr>
<td>NOP</td>
<td>LD BioBased</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>MD Demilec</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

* concentration of FR on complete product for OCF (single package products)

** actual test durations were 4500 and 6200 hours, the time at which specimens were removed from test chambers
Study 1:

Development of Field Test Method

Sample Preparation:

Setup  
Spray  
Trim  
Complete  
OCF
### Study 1:

## Development of Field Test Method

### Sample Preparation:

<table>
<thead>
<tr>
<th>Foam Type</th>
<th># Initial Testing</th>
<th># in Test Chamber</th>
<th># for Shipment Damage</th>
<th># for application improvement</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>28</td>
<td>21</td>
<td>14</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td>LD</td>
<td>16</td>
<td>12</td>
<td>8</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>OCF</td>
<td>16</td>
<td>12</td>
<td>8</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>NOP LD</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>NOP MD</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>57</strong></td>
<td><strong>50</strong></td>
<td><strong>36</strong></td>
<td><strong>36</strong></td>
<td><strong>139</strong></td>
</tr>
</tbody>
</table>
Study 1:
Development of Field Test Method

Samples in Chamber:
Study 1:
Development of Field Test Method

Sample Removal:

- Samples removed after ~3000 hrs and ~6000 hrs of exposure
- Four tests performed on removed samples
  1. Phosphate detection in foam
  2. Phosphate detection in pipe
  3. Visual/microscopic inspection of outer surface
  4. Rupture testing and microscopic inspection
Study 1:
Development of Field Test Method

1. Phosphate Detection in Foam:

- Foam Removed from pipe
- Foam material prepared and analyzed using GC method for FR identification
- Inductively Coupled Plasma analysis (ICP) was used to determine %P in the foam
Study 1:
Development of Field Test Method

2. Phosphate Detection in Pipe:
- CPVC material taken from outer surface of pipe
- Extracted with \(~1\text{ml}\) of methanol on hot plate for 15 minutes
- Solvent reduced to \(~0.5\text{ml}\) by evaporation and extract separated from CPVC particles
- \(~0.5\text{ml}\) of tetrahydrofuran added to methanol extract identification
- Analyzed by positive ion electrosopy (ESI-MS)
Study 1:

Development of Field Test Method

3. Microscopic Evaluation of Pipe:

- Foam carefully removed from pipe surface using coping saw and utility knife
- Cleaned using razor blade
- Surfaces examined visually and microscopically for indications of ESC
- None of the specimens exhibited any indication of ESC along the outer surface
Study 1:

Development of Field Test Method

4. Rupture-Testing of Pipe:

- ESC may be overlooked by visual and microscopic inspection in some cases
- ESC may be opened and specimens failed by over-pressurization of the piping
- All specimens ruptured at 1300-1600 psi
- Ruptured specimens were sectioned and microscopically inspected for ESC
# Test Results

## 3000 hr:

- FR detected in foam and in pipe
- NO ESC found in any samples
- All samples passed rupture test
- No exotherm deformation found in any samples

<table>
<thead>
<tr>
<th>Foam Type</th>
<th>Actual Test Duration (hrs)</th>
<th>Flame Retardant (FR) Type</th>
<th>FR Conc. (W% polyol side)</th>
<th>Foam Thickness (in)</th>
<th>Test Results</th>
<th>P in Foam</th>
<th>P in Pipe</th>
<th>ESC</th>
<th>Rupture</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>4506</td>
<td>TCPP</td>
<td>10</td>
<td>4</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TCPP</td>
<td>4</td>
<td>2</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TEP</td>
<td>10</td>
<td>4</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
<tr>
<td>LD</td>
<td>4506</td>
<td>TCPP</td>
<td>50</td>
<td></td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TCPP</td>
<td>15</td>
<td></td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TEP</td>
<td>50</td>
<td></td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TEP</td>
<td>15</td>
<td></td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
<tr>
<td>OCF</td>
<td>4506</td>
<td>TDCPP</td>
<td>10*</td>
<td>¾” +/-</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
<tr>
<td>NOP LD</td>
<td>3695</td>
<td></td>
<td></td>
<td></td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>PASS</td>
<td></td>
</tr>
</tbody>
</table>

* concentration of FR on complete product for OCF (single package products)
## Test 1: Test Results

### 6000 hr:
- FR detected in foam and in pipe
- NO ESC found in any samples
- All samples passed rupture test
- No exotherm deformation found in any samples

**FOOTNOTES:**
- † 3000 hr test shows FR, no testing done at 6000 hr.
- † † Testing in progress
- † † † Confirming test results

<table>
<thead>
<tr>
<th>Foam Type</th>
<th>Actual Test Duration (hrs)</th>
<th>Flame Retardant (FR) Type</th>
<th>FR Conc. (W% polyol side)</th>
<th>Foam Thickness (in)</th>
<th>Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>6092</td>
<td>TCPP</td>
<td>10</td>
<td>4</td>
<td>YES  † NO  PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TCPP</td>
<td>10</td>
<td>2</td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TCPP</td>
<td>4</td>
<td>4</td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TCPP</td>
<td>4</td>
<td>2</td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TEP</td>
<td>10</td>
<td>4</td>
<td>YES  † NO  PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TEP</td>
<td>10</td>
<td>2</td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TEP</td>
<td>4</td>
<td>4</td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td>LD</td>
<td>6092</td>
<td>TCPP</td>
<td>50</td>
<td></td>
<td>YES  † NO  PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TCPP</td>
<td>15</td>
<td></td>
<td>YES  † NO  PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TEP</td>
<td>50</td>
<td></td>
<td>YES  † NO  PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TEP</td>
<td>15</td>
<td></td>
<td>YES  † NO  PASS</td>
</tr>
<tr>
<td>OCF</td>
<td>6092</td>
<td>TCPP</td>
<td>5* 3/4&quot; +/-</td>
<td></td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TCPP</td>
<td>10* 3/4&quot; +/-</td>
<td></td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>TDCPP</td>
<td>10* 3/4&quot; +/-</td>
<td></td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td></td>
<td>6092</td>
<td>No PhsEstr</td>
<td>10* 3/4&quot; +/-</td>
<td></td>
<td>NO NO NO PASS</td>
</tr>
<tr>
<td>NOP LD</td>
<td>6092</td>
<td></td>
<td></td>
<td></td>
<td>YES YES NO PASS</td>
</tr>
<tr>
<td>NOP MD</td>
<td>6092</td>
<td></td>
<td></td>
<td></td>
<td>YES YES NO PASS</td>
</tr>
</tbody>
</table>

* concentration of FR on complete product for OCF (single package products)
Final Report- In progress/ Independent data evaluation complete

Test protocol and study report 3rd party reviewed

Jim Paschal, PE
James Paschal Engineering and Forensic Consulting, Inc.
Chairperson of ASTM Committee on CPVC Testing
20 years
Peer review of study by plastics and foam industry
Independent evaluation of the data

Letter able to be used now
Found on www.sprayfoam.org

November 18, 2009

Re: Spray Polyurethane Foam (SPF) products compatibility with CPVC piping

The use of spray polyurethane foam (SPF) sealants and insulation in walls and ceiling spaces, and chlorinated poly(vinyl chloride) (CPVC) piping for domestic water and fire suppression systems, is becoming much more prevalent within the building construction industry. This has led to some concern that the SPF products may have an adverse effect on the CPVC piping and cause premature failure of the piping system. One such effect is known as environmental stress cracking or ESC. ESC may occur when the CPVC piping is exposed to an incompatible substance while under stress. ESC can result in cracking and failure of the piping at pressures much lower than the rated pressure.

Spray Polyurethane Foam Alliance (SPFA) members, working with a major supplier of CPVC materials, commissioned a study last year to investigate the potential for ESC.

The results of the study show that all of the SPF products tested, including open-cell SPF, closed-cell SPF, one-component foams, and foams made from natural-oil based materials do not cause ESC and are compatible in direct contact with CPVC piping systems.

Some SPF products contain phosphate ester flame-retardants. There are some phosphate esters which are considered to be ESC agents for CPVC, and as such, would be of concern when exposing the CPVC to these chemicals. This study was designed and conducted to first develop a test method to assess SPF products, and then used that method to determine the effect these products would have on CPVC. The existing test methods for chemical compatibility cannot be directly applied to SPF because the liquid precursors are not necessarily representative of the finished foam product. The test method developed for this study included applying the foam to CPVC piping at specified thicknesses and subjecting the piping/foam assemblies to elevated temperatures and stress to accelerate any ESC that may occur. A test duration of 8,000 hours was chosen based on other standard methods that utilize durations of 720 to 3,000 hours. That is, the testing was carried out for two to eight times longer than what would normally be used for this type of evaluation.

The SPF products used in the study were considered to be “worst-case” generic formulations which contained the potential ESC agents (phosphate ester flame retardants) at maximum concentrations used within the industry, and also at typical concentrations. The types of foams included medium density closed-cell foam, low-density open-cell foam, and closed-cell one-component foams. The three primary flame retardants and maximum use concentrations were identified and tested in each of the foams.

Details of this study can be obtained by contacting SPFA at (800) 523-6154.

Sincerely,

James R. Paschal, P.E.
James R. Paschal, P.E., LEED AP
jam@PaschalEngineering.com
Test 1:

External Communication

- CPI paper on program - Complete
- Letter for building inspectors - Complete
- Publication in Spray Foam Magazine - In April
- Publication on SPFA website - Complete
- Preparation of industry white paper for use with trades and CPVC industry - In progress
- Proposed modification to ASTM test method to incorporate this procedure as an alternative to testing raw components - Not started
Test 1:

External Communication

- SPFA provided $23k for research program
- CPI provided grant of $10k through Rigid Foams Committee
- SPFA supplier members provided lab services, raw materials and coordinated and supervised research program
- Lubrizol provided testing, piping, laboratory equipment for program
Independent study conducted by NCFI with Lubrizol

**Focus:**

Identify conditions necessary to cause pipe deformation due to SPF exotherm-
propose industry test method from results
Study 2:

Discussion Points

- Defining test conditions
- What are standard conditions?
- What are the critical variable in the installation?
- Deform CPVC pipe - how far do you need to go
  - Impact of foam - type/ thickness/ # passes
  - Impact of pipe test conditions (i.e. pressurization)
- What we learned
- A test method
- Conclusion
Study 2:

Defining Test Conditions

Goal:
See what it takes for a CPVC pipe to fail using commercial foam

The procedure:
- Prepare a pipe/fitting setup and secure in test box
- Have thermal couple on surface of pipe
- Apply foam onto pipe
- Monitor pipe and fittings for foam exotherm stress cracking, pipe rupture, or leakage

Analyze the results:
- Prior to foaming, inspect pipe surface & record pipe trueness (straightness) and diameter
- After foaming measure pipe trueness and looks for signs of distortion, and measure trueness and diameter

A Test Method Established
Study 2:

Samples Prepared & Testing

- # Samples
  - Total 56
    - 24 Open Cell - LD Foam
    - 32 Closed Cell - MD Foam

- Testing
  - NCFI prepared all foam samples and did temperature and trueness & pipe diameter measurements
  - Lubrizol rupture tested pipes after foam was removed
Study 2:

What are industry standard conditions?

Example:

Pipe
BlazeMaster® 1.0”

Leak Test Conditions
Pipe under 100psi pressure filled with water

Foam
Closed cell- Manufacturer max recommendation 2”/pass
Open Cell- Manufacturer max recommendation 12 “

The Reference- Standard Conditions
Study 2: Variables

The foam:
- Type of foam: *Utilize Commercial Formulation*
  - Medium density (MD) Closed Cell Spray Foam
  - Low density (LD) Open Cell Spray Foam
- Number of foam passes: *Ranges based upon application from 1 to 6*
- Pass thickness: Ranges based upon application from 2 to 12 inches
- Total foam thickness: *Ranges based upon application from 4 to 12 inches*

The pipe – BlazeMaster® and FlowGuard Gold® various diameters

The pipe pressure
- *Material*: Air or Water (75 °F or 110 °F)
- *Pressure*: Ranges from Atmospheric to 225 psi

Extreme Testing Some Conditions up to 6x’s Recommended Conditions
## Study 2: Results - Medium Density (MD) Closed-Cell Spray Foam (2pcf)

### Conditions used with BlazeMaster® and FlowGuard Gold®

<table>
<thead>
<tr>
<th>Conditions used with BlazeMaster® and FlowGuard Gold®</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended Installation Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>□ Thickness:</td>
<td>0% pipe rupture</td>
</tr>
<tr>
<td>2 x 2” / 6 x 2 “</td>
<td>0% pipe distortion</td>
</tr>
<tr>
<td>□ Pressure:</td>
<td></td>
</tr>
<tr>
<td>□ Water : 100 psi</td>
<td></td>
</tr>
<tr>
<td>□ Atmosphere</td>
<td></td>
</tr>
<tr>
<td><strong>Not Recommended Installation Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>□ Thickness:</td>
<td></td>
</tr>
<tr>
<td>1 x 4 “ (4X’s Recommended Conditions)</td>
<td></td>
</tr>
<tr>
<td>1 x 12” (6X’s Recommended Conditions)</td>
<td></td>
</tr>
<tr>
<td>• Pressure</td>
<td></td>
</tr>
<tr>
<td>□ Air : &gt;Atmosphere to 225 psi (Not Recommended)</td>
<td></td>
</tr>
<tr>
<td>□ Water : &gt;100 psi to 225 psi (Up to 2.5 X’s Recommended Conditions)</td>
<td></td>
</tr>
<tr>
<td><strong>Excessive foam thickness is an issue</strong></td>
<td></td>
</tr>
<tr>
<td>15% of 1 x 4 “ failed</td>
<td></td>
</tr>
<tr>
<td>33% of 12 “ failed</td>
<td></td>
</tr>
<tr>
<td><strong>12% air pressurized failed</strong></td>
<td></td>
</tr>
<tr>
<td>0% water failures even above recommended pressure</td>
<td></td>
</tr>
</tbody>
</table>
### Conditions used with BlazeMaster® and FlowGuard Gold®

<table>
<thead>
<tr>
<th>Recommended Installation Conditions</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness:</td>
<td>0% pipe rupture</td>
</tr>
<tr>
<td>1 x 6”/ 2 x 6”/ 1 x 12”</td>
<td>0% pipe distortion</td>
</tr>
<tr>
<td>Pressure:</td>
<td></td>
</tr>
<tr>
<td>Water : 100 psi</td>
<td></td>
</tr>
<tr>
<td>Atmosphere</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Not Recommended Installation Conditions</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Pressure</td>
</tr>
<tr>
<td></td>
<td>Air : &gt;Atmosphere to 225 psi</td>
</tr>
<tr>
<td></td>
<td>( Not Recommended)</td>
</tr>
<tr>
<td></td>
<td>Water : &gt;100 psi to 225 psi</td>
</tr>
<tr>
<td></td>
<td>( Up to 2.5 X’s Recommended Conditions)</td>
</tr>
</tbody>
</table>

Study 2: Results-Low Density (LD) Open-Cell Spray Foam (.05pcf)
Study 2:

What we learned?

- Exotherm and pressurization with air are critical variables which impact pipe failures.
- MD SPF applied beyond recommended thicknesses per pass can result in distortion and weakening of CPVC pipe.
- Pipes tested with water had significantly lower exotherm and showed no signs of distortion or weakening.
- LD SPF experienced no failures—exotherms were significantly lower than with MD foams.
Study 2:
Development of a Field Test Method

The Method:
Test a ½” diameter CPVC pipe which meets ASTM D-2846 (stamped on pipe), @ a line pressure of 50 psi or atmospheric pressure

The Process:
Measure pipe diameter and trueness
Place pipe in box
Attach thermocouple to pipe
Pressurize pipe to 50 psi
Or run at atmospheric pressure
Spray the foam
Measure the exotherm
Remove pipe measure trueness and diameter
Pass
Exotherm < 200F
Diameter ≤0.628”
Pipe remains True
Study 2:

Test Program Resources & Funding

- NCFI provided lab services, raw materials and coordinated and supervised research program

- Lubrizol provided testing, and piping for program
Summary

Study 1

- Initial and Accelerated aging studies after more than 6000 hrs show:
  - Measurable levels of FR in foam and CPVC
  - No indications of ESC by visual or microscopic inspection or by rupture testing
  - No sign of exotherm impact on piping or fittings

- Communication of results in progress
Summary

Study 2

- Under manufacturer recommended application conditions the exotherm from the application of spray polyurethane foam to pipe does not cause deformation or rupture of CPVC pipes
- As a result of this study there is a test method to allow contractors and manufactures to insure that excessive exothermic temperatures are not reached during installation of spray polyurethane foam
- Communication of results in progress
Polyurethane (Spray-On) Foams

In understanding spray polyurethane foams there are two general areas of concern for CPVC pipe and fittings: (1) chemical compatibility and (2) potential damage to pipes and fittings due to high exothermic temperatures during installation. These spray polyurethane foams have different cell structures, different flame retardants, reach different curing temperatures and require different installation thicknesses to obtain the required $r$-value. All of these factors must be considered when using spray foams.

In 2009, Lubrizol assisted the Spray Polyurethane Foam Alliance (SPFA) to determine if chemical compatibility issues exist with FlowGuard® Gold®, BlazeMaster® and Corzan® CPVC pipe and fittings. SPFA findings, although not comprehensive, conclude that those spray polyurethane foams tested did not pose a chemical compatibility problem. In addition, Lubrizol is unaware of a CPVC failure that was the result of chemical incompatibility with spray polyurethane foams. For more information on the SPFA testing, please contact them at (800) 523-6154 or visit their web site at www.sprayfoam.org.

With respect to chemical compatibility, one must always check with the spray foam manufacturer to have them provide assurance that the formulation that they are manufacturing is not incompatible with CPVC.

In a separate, unrelated study also in 2009, Lubrizol conducted testing with a manufacturer of spray polyurethane foam to better understand the effects of high exothermic temperatures on FlowGuard® and BlazeMaster® CPVC pipe and fittings. These findings demonstrated that temperatures can exceed the softening point of dry CPVC pipe and fittings. This study found that, for the products tested, the spray pass thickness of the manufacturer’s nominal two pound density spray polyurethane closed cell foam should not exceed a maximum of two inches per single pass.

Because polyurethane spray foams’ resulting exothermic temperatures and chemical compatibility characteristics can vary to some extent, Lubrizol recommends that you consult with the manufacturer of the polyurethane spray foam to be installed.

For the manufacturer’s nominal half pound density spray polyurethane open cell foam, Lubrizol found that spray pass thickness should not exceed a maximum of six inches per single pass.

This study found that, for the products tested, the spray pass thickness of the manufacturer’s nominal two pound density spray polyurethane closed cell foam should not exceed a maximum of two inches per single pass. Lubrizol also found in this study that repeated two inch passes (layers) separated by 10 minute intervals provided sufficient time for the spray polyurethane foam to cool. For the manufacturer’s nominal half pound density spray polyurethane open cell foam, Lubrizol found that spray pass thickness should not exceed a maximum of six inches per single pass.

Because polyurethane spray foams’ resulting exothermic temperatures and chemical compatibility characteristics can vary to some extent, Lubrizol recommends that you consult with the manufacturer of the polyurethane spray foam to be installed.
# Acknowledgments

## SPFA Supplier Sponsors

- BASF - The Chemical Company
- BaySystems
- BioBased Insulation
- SWD Corbond
- FOMO
- Demilec (USA) LLC
- Honeywell
- Huntsman
- Icynene
- NCFI Polyurethanes
- RIC
- Henry
- Albemarle
- Convenience Products
- Gaco Western
- ICL Industrial Products

## SPFA Contractor Sponsors

- 5-Star Performance Insulation, inc.
- Mason Knowles Consulting
- Houlden Contracting, Inc.
- Insulated Roofing Contractors
- The Insulation Man

## Industry Association Sponsors

- Spray Polyurethane Foam Alliance
- American Chemistry Council

**Note:** The above sponsors are indicative of the various companies and organizations that support the industry. The list may not be exhaustive and may vary depending on the specific event or publication.