Sprayed Polyurethane Foam in Construction

Presented by: Andrew B. Cole, CUFCA, Executive Director

Sprayed Polyurethane Foam (SPF)

- Types of Foams
- Comparison between open-cell and closed cell SPF physical properties
- Standards for the foam industry – both medium density closed cell and light density open cell insulation
- Building code commentary – thermal Barriers, vapour barriers, cathedral ceilings and ventilation
- About CUFCA and the quality assurance program
- Resources for code officials
### Types of Sprayed Polyurethane Foam

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealant Foams</td>
<td>“foam in the can, froth paks”</td>
</tr>
<tr>
<td>Light Density Open-Cell SPF</td>
<td>“half pound”</td>
</tr>
<tr>
<td>Medium Density Closed Cell</td>
<td>“two pound”</td>
</tr>
<tr>
<td>High Density Closed Cell</td>
<td>“three pound or more”</td>
</tr>
</tbody>
</table>

- Insulating material with an R-value of around 3.8 per inch.
- Soft to the touch
- Open cells that traps air / not a vapour barrier
- Interior application between framing members
- Expands 100 times from liquid state
- Material Standard has been developed (CAN/ULC S712.1) – Installation standard is under development
- CCMC evaluation is only method of code compliance
Medium Density - Closed Cell SPF

- Insulating material with an R-value of 5.1 – 6.2 per inch. (LTTR)
- Rigid Material
- Closed cell with insulating gas
- Interior / exterior applications
- Expands 30 times from liquid state
- Currently has two standards (product: CAN/ULC S705.1 & Installation: CAN/ULC S705.2) – since 1988 (previously CGSB standards)
- Standards are referenced in NBC and Provincial Codes (Part 5 and Part 9)
- CCMC listing of products – insulation/air barrier

Comparison

<table>
<thead>
<tr>
<th>Property</th>
<th>Medium Density – Closed Cell</th>
<th>Light Density – Open Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-value - LTTR</td>
<td>5.1 – 6 LTTR</td>
<td>3.6 – 3.8</td>
</tr>
<tr>
<td>Chemical Components</td>
<td>A – Iso / B – Resin</td>
<td>A – Iso / B – Resin</td>
</tr>
<tr>
<td>Air Barrier</td>
<td>Yes, at minimal thickness</td>
<td>Yes, &gt; 5.5 inches or more</td>
</tr>
<tr>
<td>Vapour Barrier</td>
<td>Yes, at 2 inches</td>
<td>NO</td>
</tr>
<tr>
<td>Thermal Barrier</td>
<td>Required (interior living space)</td>
<td>Required (interior living space)</td>
</tr>
<tr>
<td>Health &amp; Safety</td>
<td>Applicator/Spray Area</td>
<td>Applicator/Spray Area</td>
</tr>
<tr>
<td>Installation</td>
<td>30 times expansion</td>
<td>Full cavity</td>
</tr>
<tr>
<td></td>
<td>2 inch pass max</td>
<td></td>
</tr>
<tr>
<td>Sound</td>
<td>Blocks air leakage</td>
<td>Blocks air leakage and absorbs</td>
</tr>
<tr>
<td>VOC's</td>
<td>CAN/ULC S774/time to occupancy</td>
<td>CAN/ULC S774/time to occupancy</td>
</tr>
<tr>
<td>Application</td>
<td>Interior/exterior/below grade/open surfaces</td>
<td>Interior only between framing members</td>
</tr>
<tr>
<td>Ozone Depletion</td>
<td>Zero ODP</td>
<td>Zero ODP</td>
</tr>
</tbody>
</table>
Building Code

- **2005 National Building Code and Provincial Codes cover** “Medium Density-Closed Cell”
- American produced material NOT covered
- Light Density – Open Cell material not currently referenced – **standard will be referenced in future codes**
- Other materials NOT covered (high density roofing foams)

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Canadian Construction Materials Center

- Currently, **all manufacturers** that produce a **medium density – closed cell** material that meets the CAN/ULC S705.1 have received a CCMC listing.
- For Light Density – Open Cell, a **CCMC evaluation report** is available and should be requested
- To view any CCMC reports, go to [http://irc.nrc-nrc.gc.ca/ccmc/](http://irc.nrc-nrc.gc.ca/ccmc/)
Canadian Construction Materials Center

- What role does CCMC provide to the construction industry?
- Difference between listing and evaluation of products
  - Sprayed Foams that meet the CAN/ULC S705.1
  - Sprayed Foams that do not have standards
- What items does CCMC and the code not deal with?

Sprayed Polyurethane Foam

CAN/ULC S705.1-01
Material Standard – Medium density - closed cell

CAN/ULC S712.1-09 – Material Standard
Light density - open-cell
**CAN/ULC S705.01 Material Standard**

**Medium Density, Closed Cell**

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Requirements</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Permeance (Mandatory material only testing)</td>
<td>L/s @ 75 Pa pressure difference</td>
<td>- .02</td>
<td>CCMC Technical Guide for Air Barrier Materials</td>
</tr>
<tr>
<td>Air Permeance (Optional system testing)</td>
<td>L/s @ 75 Pa pressure difference</td>
<td>- .05</td>
<td>CCMC Technical Guide for Air Barrier Systems</td>
</tr>
<tr>
<td>Apparent Core Density</td>
<td>kg/m³</td>
<td>28 -</td>
<td>ASTM D 1622</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>kPa</td>
<td>170 -</td>
<td>ASTM D 1821</td>
</tr>
<tr>
<td>Dimensional Stability</td>
<td>%</td>
<td>-1 - +8</td>
<td>ASTM D 2126</td>
</tr>
<tr>
<td>Volume Change at:</td>
<td>%</td>
<td>-1 - +8</td>
<td>ASTM D 2126</td>
</tr>
<tr>
<td>-20°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70°C, 97 ± 3% RH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Burning Characteristics Flame Spread</td>
<td>-</td>
<td>500</td>
<td>CAN/ULC S102</td>
</tr>
<tr>
<td>Open Cell Content, Volume</td>
<td>%</td>
<td>-8</td>
<td>ASTM D 2856</td>
</tr>
<tr>
<td>Initial Thermal Resistance for a 50 mm specimen</td>
<td>m²·K/W Declare</td>
<td></td>
<td>ASTM C 177 or C518</td>
</tr>
<tr>
<td>Long Term Thermal Resistance (For a 50 mm thick specimen)</td>
<td>m²·K/W Declare</td>
<td></td>
<td>CAN/ULC-S770</td>
</tr>
<tr>
<td>Type 1</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>kPa</td>
<td>200 -</td>
<td>ASTM D 1623</td>
</tr>
<tr>
<td>Volatile Organic Emissions</td>
<td>Pass</td>
<td></td>
<td>CAN/ULC-S774</td>
</tr>
<tr>
<td>Water Absorption by Volume</td>
<td>%</td>
<td>-4</td>
<td>ASTM D 2842</td>
</tr>
<tr>
<td>Water Vapour Permeance for a 50 mm thick specimen</td>
<td>ng/(Pa·s·m²)</td>
<td>-60</td>
<td></td>
</tr>
</tbody>
</table>

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**CAN/ULC S712.01 Material Standard**

**Light Density - Open Cell**

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Requirements</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air permeance at 100 mm</td>
<td>L/(s·m²)</td>
<td>- Declare</td>
<td>ASTM 2178</td>
</tr>
<tr>
<td>Apparent core density</td>
<td>kg/m³</td>
<td>6.8 - 12</td>
<td>ASTM D 1622</td>
</tr>
<tr>
<td>Dimensional stability</td>
<td>%</td>
<td>- -1 - +15</td>
<td>ASTM D 2126</td>
</tr>
<tr>
<td>volume change at:</td>
<td>%</td>
<td>- -15 - +14</td>
<td></td>
</tr>
<tr>
<td>-20°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70°C, 97 ± 3% RH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungi resistance</td>
<td>No growth</td>
<td></td>
<td>ASTM C 1338</td>
</tr>
<tr>
<td>Open-cell content, volume</td>
<td>%</td>
<td>80 -</td>
<td>ASTM D 6226</td>
</tr>
<tr>
<td>Surface burning characteristics Flame spread</td>
<td>-</td>
<td>500</td>
<td>CAN/ULC S 102</td>
</tr>
<tr>
<td>Thermal resistance for a 50 mm specimen</td>
<td>m²·K/W Declare</td>
<td></td>
<td>ASTM C 177 or ASTM C 518</td>
</tr>
<tr>
<td>Time to occupancy</td>
<td>days</td>
<td>1 - 30</td>
<td>CAN/ULC-S774</td>
</tr>
<tr>
<td>Water absorption by volume</td>
<td>%</td>
<td>- Declare</td>
<td>ASTM D 2842</td>
</tr>
<tr>
<td>-For materials with WVP ≥ 1400</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-For materials with WVP less than 1400 and greater than 400</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water vapour permeance for a 50 mm thick specimen</td>
<td>ng/(Pa·s·m²)</td>
<td>1400 or 400 depending on water absorption</td>
<td>-</td>
</tr>
</tbody>
</table>

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- **CAN/ULC S705.01**
- **CAN/ULC S712.01**

**CAN/ULC S774**

**Volatile Organic Emissions**

Pass - CAN/ULC S774
Material Standards
Light Density, Open Cell vs. Medium Density, Closed Cell

Differences Between Standards
- Most test methods are the same for both products
- Some test methods conducted on each product that are unique to that product
  - i.e. LTTR, Compressive strength for medium density
  - i.e. Fungi resistance for open cell

Foam Colour

Medium Density – Closed Cell:
- All 2 lb. C.C. SPF in Canada that have CCMC Listings are required to have unique colour for Field Identification.
- Typically md-cc foam’s natural colour is Yellow. This would indicate a product that DOES NOT meet code.

Light Density – Open Cell:
- No requirement for colour at this time
CUFCA 2lb. Foam Colour Charts

CUFCA Foam Comparison Sheet(s)

### 2lb. Medium Density Closed Cell Foam Comparison Physical Properties

| Property          | AEROSIL | HEATLOK | LOK | DOMILEX | PULLITECH | PROLINE | STYROFOAM | CERTAPRINT | CERTAPRINT | CERTAPRINT | CERTAPRINT | CERTAPRINT | CERTAPRINT |
|-------------------|---------|---------|-----|---------|-----------|---------|-----------|------------|------------|------------|------------|------------|------------|------------|
| Density (pcf)     | 2.00    | 2.25    | 2.50| 2.50    | 2.75      | 2.75    | 2.75      | 2.75       | 2.75       | 2.75       | 2.75       | 2.75       | 2.75       |
| Tensile Strength  | UTS     | UTS     | UTS | UTS     | UTS       | UTS     | UTS       | UTS        | UTS        | UTS        | UTS        | UTS        | UTS        |
| Water Absorption  | 3%      | 3%      | 3%  | 3%      | 3%        | 3%      | 3%        | 3%         | 3%         | 3%         | 3%         | 3%         | 3%         |

**Notes:**
- The information provided is for guidance only and may be subject to change without notice.
- The data provided is for general information purposes only and may not reflect the current specifications of the products.
- Certification and testing are conducted by independent laboratories to meet relevant standards.
CUFCA Foam Comparison Sheet(s)

2lb. Medium Density Closed Cell Foam Comparison Physical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>JM Caribou III</th>
<th>Cutnell II</th>
<th>MD-C-2005</th>
<th>FOAMular RX*</th>
<th>2755R/1040M/05FCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (lb/ft³)</td>
<td>32.5</td>
<td>32.5</td>
<td>32.5</td>
<td>32.5</td>
<td>32.5</td>
</tr>
<tr>
<td>Thermal Conductivity (Btu/hr⋅ft⋅°F)</td>
<td>0.43</td>
<td>0.43</td>
<td>0.43</td>
<td>0.43</td>
<td>0.43</td>
</tr>
<tr>
<td>Water Vapor Resistance (grains/in·24 hr·mm Hg)</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Flammability</td>
<td>Class A</td>
<td>Class A</td>
<td>Class A</td>
<td>Class A</td>
<td>Class A</td>
</tr>
<tr>
<td>Fire And Combustibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoke Density</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Medium Density – Closed Cell Standard

CAN/ULC S705.2-05

Installation Standard

NATIONAL STANDARDS OF CANADA

STANDARD FOR THERMAL INSULATION – SPRAY APPLIED RIGID POLYURETHANE FOAM, MEDIUM DENSITY – APPLICATION

(bottom of the page)
SPF SQAP – Standard

ULC S718.13
Installation Standard for a Site Quality Assurance Program for Spray Polyurethane Foam

Medium Density – Closed Cell

CAN/ULC S705.2-05 Installation Standard
Requirements for:
- Installer must carry photo-identification card
- Installer must meet all installation requirements for environmental conditions, substrate preparation, application requirements and limitations
- Installer must have spill containment materials
- On-site testing (density/adhesion/cohesion)
Medium Density – Closed Cell

CAN/ULC S705.2-05 Installation Standard

- Installer must properly store material and decontaminate & dispose of empty drums properly
- Installer must conduct daily density, adhesion and cohesion testing
- Installer must complete Daily Work Record
- Installer must attach Job Site Label
- Troubleshooting (on-site QC)

Medium Density – Closed Cell

Job Site Documentation

THE SPRAY POLYURETHANE FOAM INDUSTRY'S ONLY INDEPENDENT THIRD PARTY QUALITY ASSURANCE PROGRAM
CUFCA TEST KIT

CUFCA Test Kits contain high precision measurement instruments to conduct humidity, dew point, temperature measurements along with sample coring tools for adhesion/cohesion and core density tests.

Medium Density – Closed Cell
Installer Identification

Certified Installer Card
Registered Apprentice Card
Light Density – Open Cell

CAN/ULC S712.2 Installation Standard
Requirements very similar to CAN/ULC S705.2
- In draft at ULC / SPF Task Group level
- Includes items such as on-site testing, substrate preparation, job site set-up, troubleshooting/repair, safety, documentation, etc.

Canadian Construction Materials Center
- Evaluated as thermal insulation
- Physical Property testing such as Thermal Resistance, Dimensional stability, Water Vapour Transmission, Water Absorption, Off-gassing
- Manufacturer’s Quality Assurance and third party field audits
- Limitations of Application noted in CCMC evaluation
Building Code Requirements

Thermal Barriers

- Fire Protection
  - Interior Finishes described in 9.29.4 to 9.29.9
  - Bottom Line, SPF requires a thermal barrier from adjacent spaces in a building, other than adjacent concealed spaces (wall assembly, attic/roof spaces, crawl space) – drywall is a thermal barrier

Building Code Requirements

Building Code Commentary

- Is an Extra Vapour Barrier Required
  - CAN/ULC S705.1 standard requirements
  - National Research Council Master format listing
  - National Research Council Construction Technology Update - NRC Research
  - University of Waterloo Research
  - Exova Research
Building Code Requirements

Building Code Commentary

- Is an Extra Vapour Barrier Required
  - CAN/ULC S705.1 requires material must meet Maximum 60 ng/(Pa·s·m²) using ASTM E 96 @ 50 mm thick

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<table>
<thead>
<tr>
<th>Water vapour permeance of a 50-mm-thick specimen</th>
<th>ng/(Pa·s·m²)</th>
<th>No. min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes to Table 1:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(7) To satisfy the maximum water vapour permeance requirement of 60 ng/(Pa·s·m²), a minimum thickness of 20 mm of foam insulation must be sprayed over gypsum boards and a minimum thickness of 20 mm of foam insulation must be sprayed over concrete blocks.
Building Code Requirements

Building Code Commentary
Is an Extra Vapour Barrier Required?
National Research Council Construction Technology update

Practical Recommendations
• When using medium-density (MD) foam in walls as both insulation and vapour barrier, a minimum thickness of 40 mm is recommended.

Building Code Requirements

Code Commentary
• Is an Extra Vapour Barrier Required
  • University of Waterloo research project
  • Reviews fibreglass, open-cell foam & medium density closed cell foam in wall assembly with no vapour barrier.
  • Provides test results for various climates across Canada (Vancouver, Winnipeg, Toronto) and various HDD – Heating Degree Days
Building Code Requirements

Code Commentary

- Is an Extra Vapour Barrier Required
  - Results: no additional vapour barrier required with 2 inches of md-cc foam
  - Vapour barrier required for fibreglass and open-cell foam
  - Assumes water barrier/air barrier
  - Tested wood studs (2 x 4 and 2 x 6 studs) – less than 60 ng (Exova laboratories)

Trow Opinion Letter
Building Code Requirements

Code Commentary

- Cathedral Ceilings and Required Venting / Attic Ventilation
  - Is venting required when using a md-cc foam?
  - Code indicates venting is required unless it can be shown to not have an adverse affect
  - Two issues:
    - What about incidental moisture?
    - What about shingle temperature?

- An airtight assembly is critical in this area
  - MD-CC SPF has been found to provide the required airtightness, vapour performance and protection of exterior wood sheathing.
  - Ontario Municipal Housing and Affairs Branch Opinion issued in 1995 and recent Building Code Commission rulings have indicated that venting is not required.
Building Code Requirements

Code Commentary

- Cathedral Ceilings and Required Venting
  - In the United States, unvented attics are specifically permitted in the International Residential Code (IRC) and have been since 2003.
  - What about shingle temperature?
    - CMHC research on shingle temperature and affect on temperature
    - CMHC position in regards to the affects of attic ventilation

Recent research shows that identical attics, one unvented and the other vented to code, have much the same humidity and temperature. Computer models show that attics in damp coastal climates may actually be drier with less ventilation.
University of Waterloo Study

Conclusions?
CC SPF in an unvented application will work well if installed correctly.
Regional Hygrothermal Modeling is now complete and the final paper will be available at CUFCA in June 2014.

The CUFCA Unvented Roof Study

Dr John Straube, P.Eng.
Dept of Civil Engineering
School of Architecture

University of Waterloo Study

Conclusions

• Unvented Roofs can work if
  – Airtight insulation tight to the sheathing
  – Sufficient vapor diffusion resistance (initial results suggest 2-5 US Perms, 120-300 ng/Pa/s/m²)
• Open-cell foam requires additional vapor control in colder climates, and high interior humidities
• Simulation work for this summer will tabulate limits, recommendations
Site Quality Assurance

CUFCA Site Quality Assurance Program

Field Inspection Recap

Approved Foam
Licensed Installer
Test Kit on Truck
Daily worksheet with test results
Jobsite Label
Foam Visual Inspection
Depth Validation
Site Quality Assurance

CUFCA Site Quality Assurance Program

- Chosen by a manufacturer as their SQAP delivery agent (Manufacturer MUST appoint a Third Party)
- CUFCA’s SQAP developed and implemented over 30 years of consultative work with a consortium of stakeholders and follows the ULC 718.13.
  - Includes certification, licensing, complaint resolution, manufacturer licensing, 3rd party warranty program, technical assistance

Site Quality Assurance

CUFCA Site Quality Assurance Program
Training & Certification of Installers

CUFCA’s Personnel Training & Certification Program is accredited to ISO-17024 Standards.
Site Quality Assurance

CUFCA Site Quality Assurance Program
Certified Field Inspectors

Field Inspections and Audits are conducted by our auditors in compliance with ISO-17020 standards. CUFCA is accredited to ISO-17020 for operation of Field Inspection Services.

Accredited Contractors
Contractor Identification for Building Officials
CUFCA Resources For Code Officials

CUFCA SPF Installation Guide Book

Available at No charge for regional or CBO offices.

CUFCA Resources For Code Officials

CUFCA SPF Technical Binder for SPF Installation
Resources for the Building Industry

Resources available to code officials (CUFCA)
- Product Handbook, Technical Bulletins, Research Reports, Engineering Reports, Technical Assistance, Website, Site Inspections, Depth Gauges, Foam Comparison Sheets, SPF Guides and more…

On the Web:
- www.cufca.ca (resources, approved contractors, technical information)
- www.nrc.ca/ccmc (ccmc evaluations of all products)
- www.sprayfoam.com (general information and news)
- www.buildingscience.com (good technical info)

Thank you to the BOABC