



Building Solutions



The Detection of Stud Line Cracking in Metal Stud Walls

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Collaboration for Cold Weather Spray-Applied Polyurethane Foam (SPF) Insulation

■ Dow Building Solutions (DBS)

The DBS business offers a broad line of [product solutions](#) while addressing the issues most important to builders and home buyers including:

- [energy efficiency, moisture resistance and durability](#)

■ Dow Polyurethanes

Dow's polyurethane products and [fully-formulated polyurethane systems](#) are used for a broad range of applications including

- [construction](#), infrastructure repair, wind energy solutions, automotive, appliance, furniture, bedding and shoe soles to decorative molding, athletic equipment and more

■ Center for Surface Transportation Technology, National Research Council of Canada

CSTT is improving the reliability, safety and competitiveness of rail and road transportation equipment and systems by providing clients with

- [climatic simulation](#), vehicular engineering research and development, computer modeling and analysis, field testing and vehicle performance testing

Why Choose Spray Foam (SPF) Insulation

■ Fast Application

- No measuring and cutting required for odd shapes and narrow spaces
- Saves labor during installation
- Foam forms and stays exactly where you put it



■ Safe for the Environment

- Contains no formaldehyde
- Contains no ozone depleting chemicals
- Does not release toxic gasses
- Requires less energy to produce than the leading cavity insulation



■ Energy Efficiency

- Highest R-value/inch cavity insulation
- Air barrier functionality to reduce air infiltration
- Can qualify for "green building" certification points (i.e. LEED, NAHB)
- Reduce heating and cooling fuel needs, and thus reduce global warming emissions



Installation Method for Medium Density SPF to Wall Cavities



Starting materials



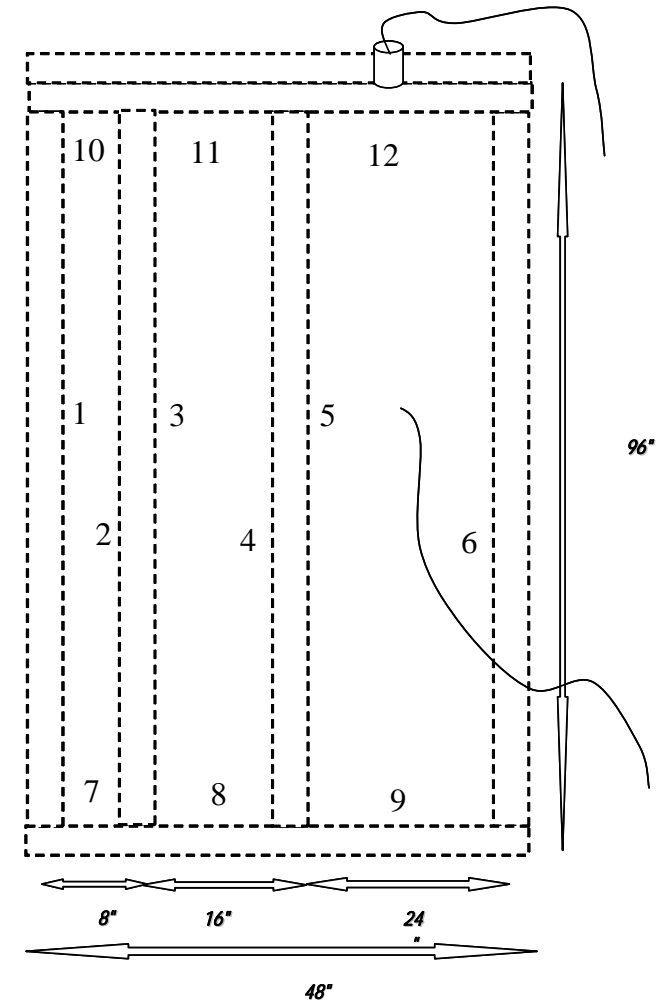
Wall insulation example
Picture frame technique



Delivery method

Mock Wall Construction

- 4x8 ft wall
 - Three unevenly sized cavities – 8, 16 and 24 inch OC
 - Footer sat on concrete floor
 - Type T thermocouple at center of 24 inch OC cavity, 1 inch into cavity
- Commercial Wall
 - 2 x 3-5/8 inch, 16 gauge steel studs
 - THERMAX™ brand insulation sheathing
 - Extra metal stud at header to simulate construction practices
 - Foam Deflection Force Gauge (FDFG) at position 12 for Commercial Walls only
- Residential Wall
 - 1.5 x 3.5 (2x4) inch pine studs
 - OSB sheathing or
 - STYROFOAM™ residential sheathing



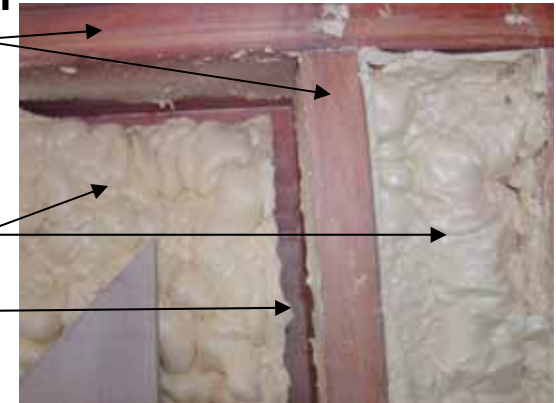
Problem Statements

- Stud line cracking occurs if spray-apply polyurethane system at too low of substrate temperature
 - Poorer moisture/vapor barrier
 - Poorer air and particulate barrier
- Difficult to observe stud line cracking for typical commercial building walls using c-channel studs

Wood header and stud

SPF

Crack



Example of improperly applied foam – too cold



Steel foam interface
Flat side of stud



Steel foam interface
Cavity side of stud



Steel foam interface
Cut-away view

Hypothesis

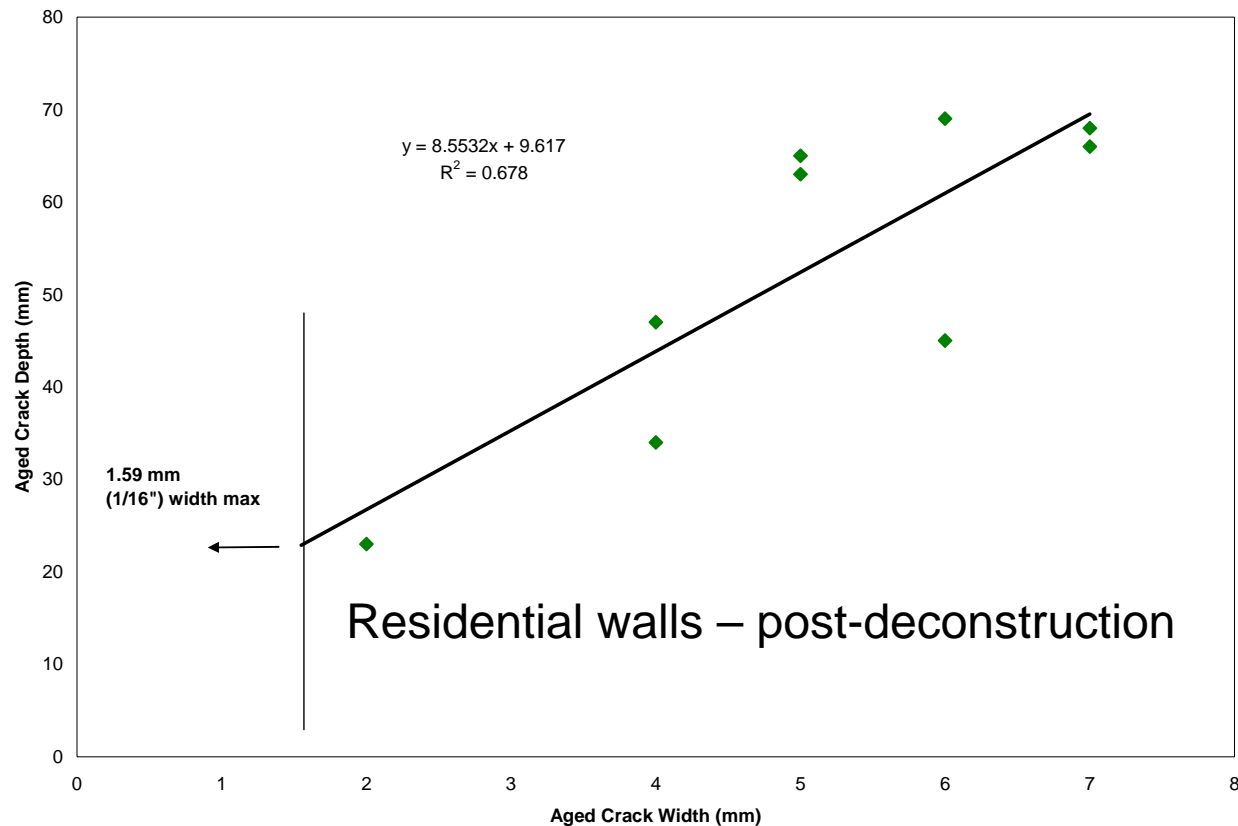
- Stud line cracking can be avoided at the lowest desired substrate temperature through formulation changes (not the point of the story)

Potential Analysis Techniques (stud line cracking – point of the story)

- Define success – then find the appropriate measuring tool
- Wood stud walls as model for metal studs
 - Compare metal stud foam delamination with wood stud foam delamination
 - ↳ Adhesive failure – wood vs steel
 - ↳ Time and place of cracking – wood vs steel
- Delamination sounds
- Deconstruct spray-applied walls and look for cracks
- Install a pressure sensor to evaluate foam rise and shrink forces of the foam – a Foam Deflection Force Gauge (FDFG)

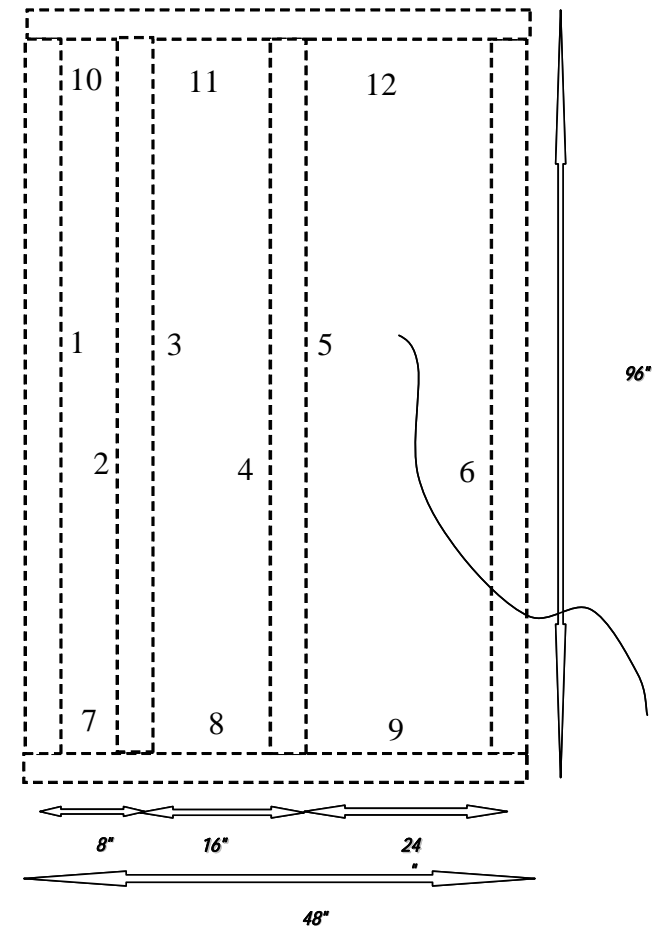
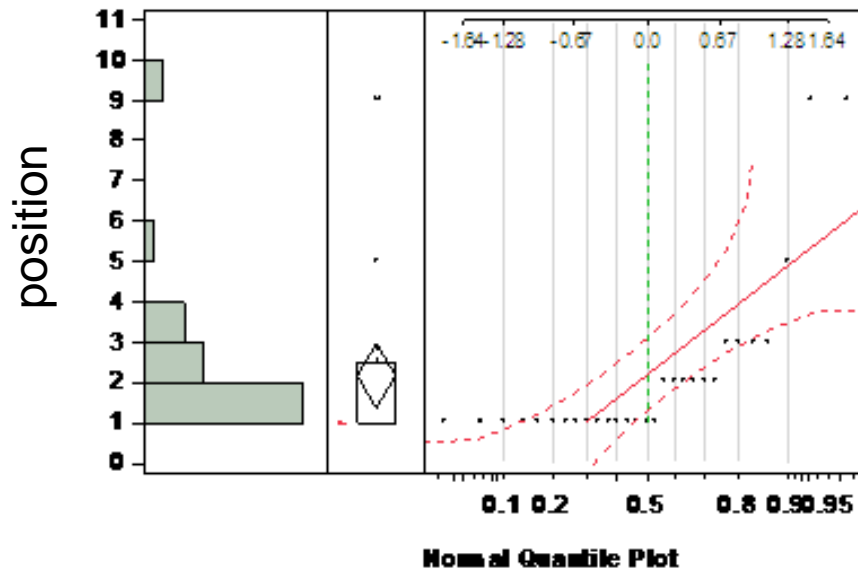
Define Success

- Residential – visual crack < 1/16 inch
- Commercial – no delamination from FDFG

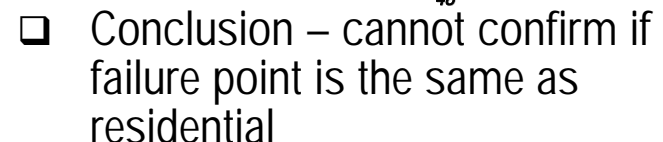
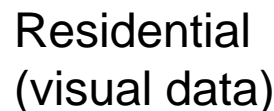


Stud Line Failures – Compare Wood vs Metal Stud

- Residential wall (wood) – where does failure occur?
 - When failure occurs, cracking generally starts at position 2
 - Generally if cracking has occurred at 10, then there are cracks at positions 1-9
 - Most cracking for formulations evaluated ended in positions 2 or 3 – see chart below



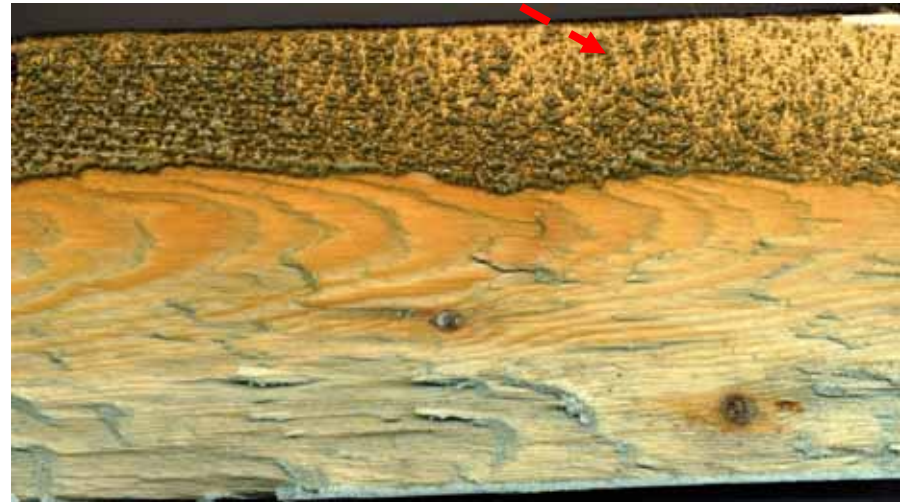
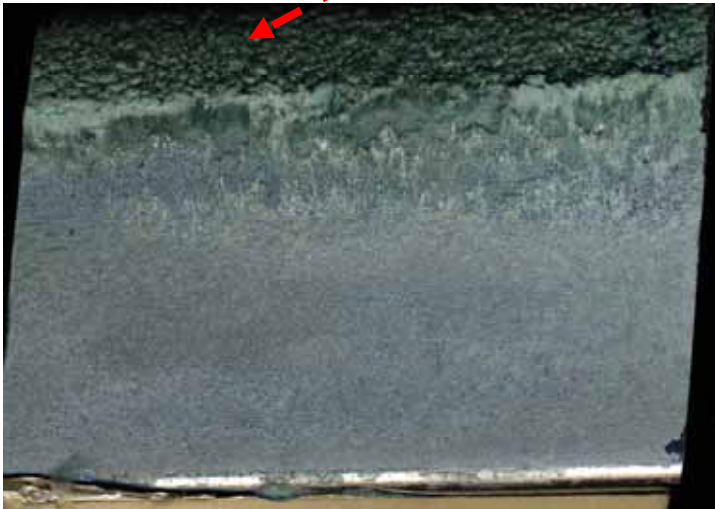
- Commercial Wall (metal) – where does failure occur?
 - Time (min) to failure similar between commercial (FDFG) and residential walls (visual) – generally within 35 minutes
 - Positions 1, 2, 4, 6-12 were visually inaccessible



Failure Comparison – Post Deconstruction Analysis

- Delamination Failure - Metal
 - Metal studs delamination primarily cohesively
 - Except when metal stud had ice – adhesive failure
- Delamination Failure – Wood
 - Primarily adhesive failure
 - Exception was cohesive failure where mechanical interlocks possible

Overspray at stud edge and face



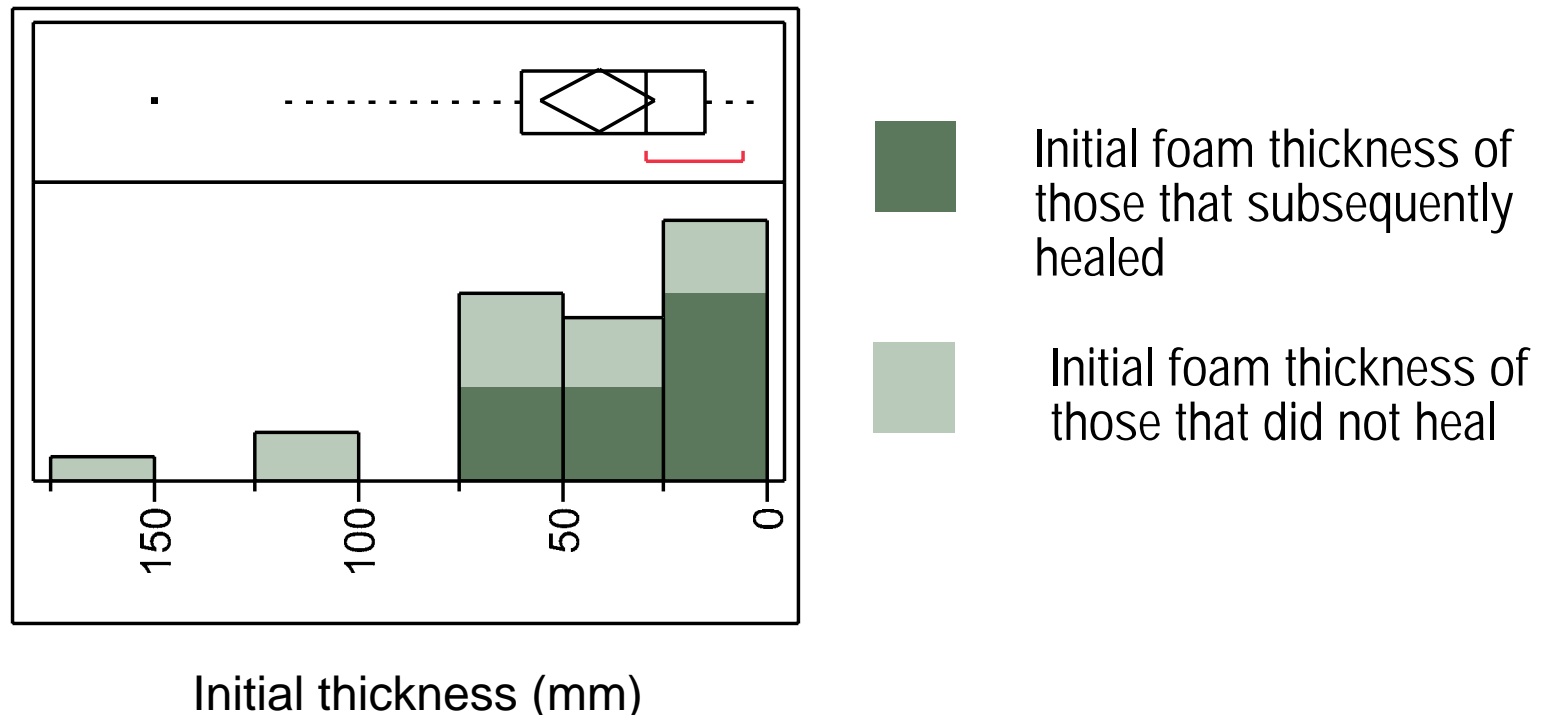
Failure Analysis – Delamination Sounds

- Previous work with spray-applied walls
 - Small sounds = narrow cracks
 - Loud sounds = large cracks ($> 1/16$ inch)
 - Qualitative
 - Dissimilar construction components rub when heating and cooling
 - And which wall made the sound?

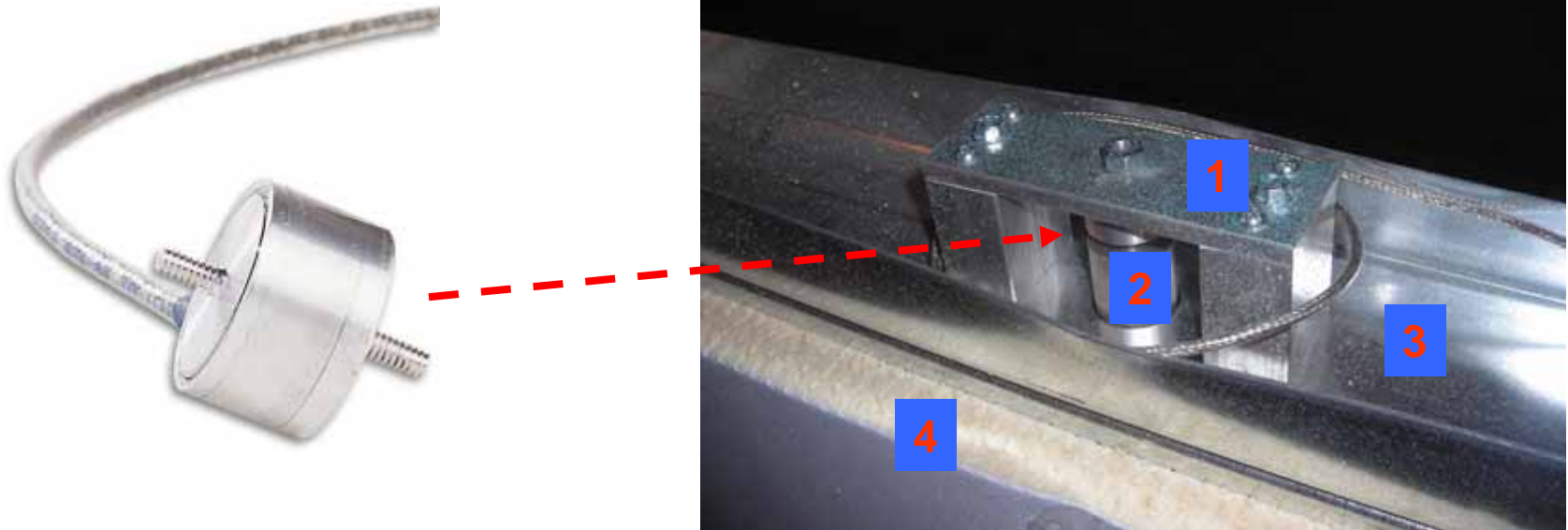


Failure Comparison – Post Deconstruction Analysis

- Observation of wood stud walls after 1 month associated with shipping
 - Cracks were not visible in 11 out of 23 original cracked walls
 - Cracks that healed had started at $< 1/16$ inch
 - Suspect foam expansion when removed from Climatic Chamber
- Conclusion – deconstruction analysis would potentially give false positives – incorrect crack width and number of cracks



Foam Deflection Force Gauge Construction

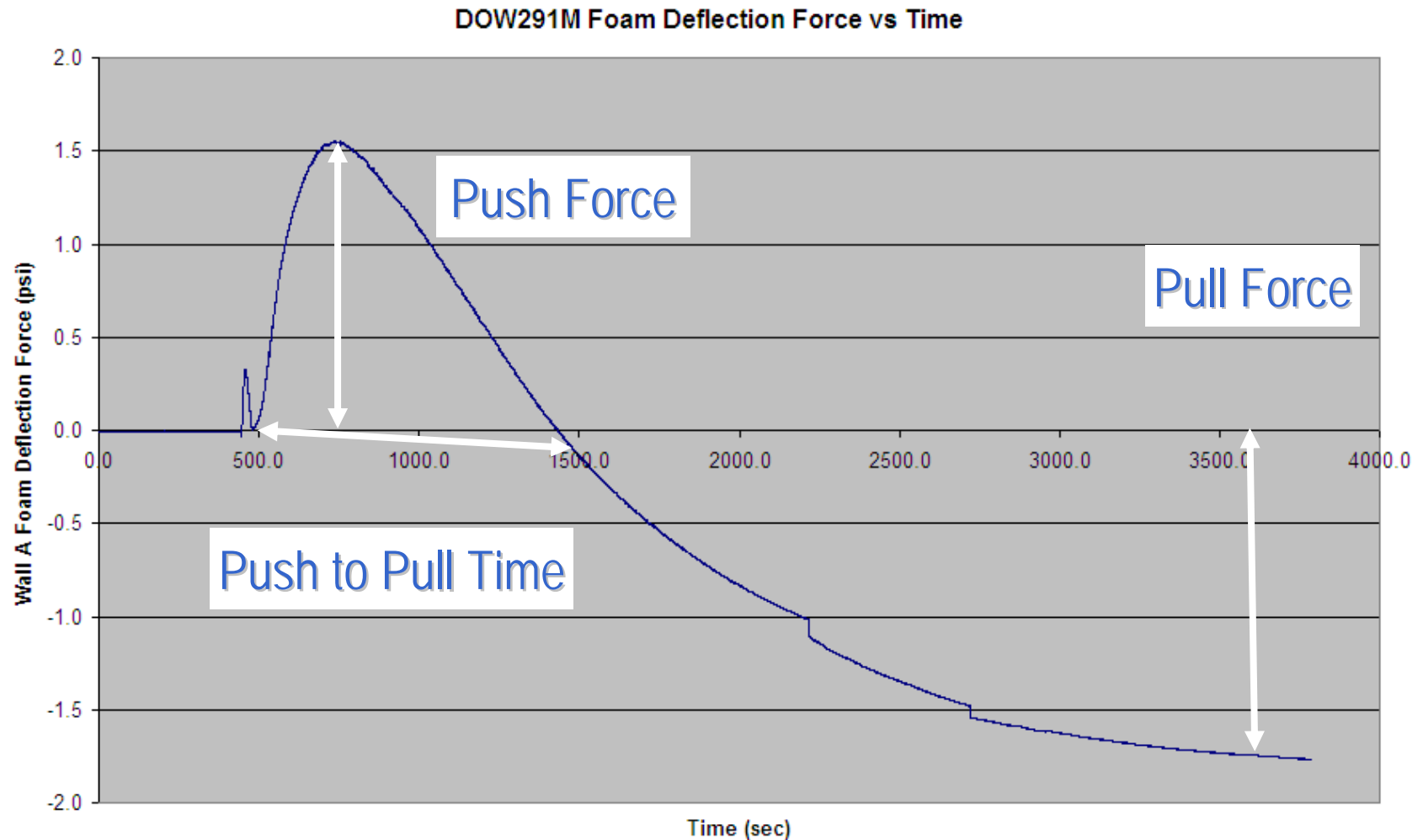


Omega's LCFA-5

- strain gauge transducer
- Four-arm Wheatstone Bridge
(strain changes resistance)
- 5 LB \pm 1% full scale
- aluminum construction

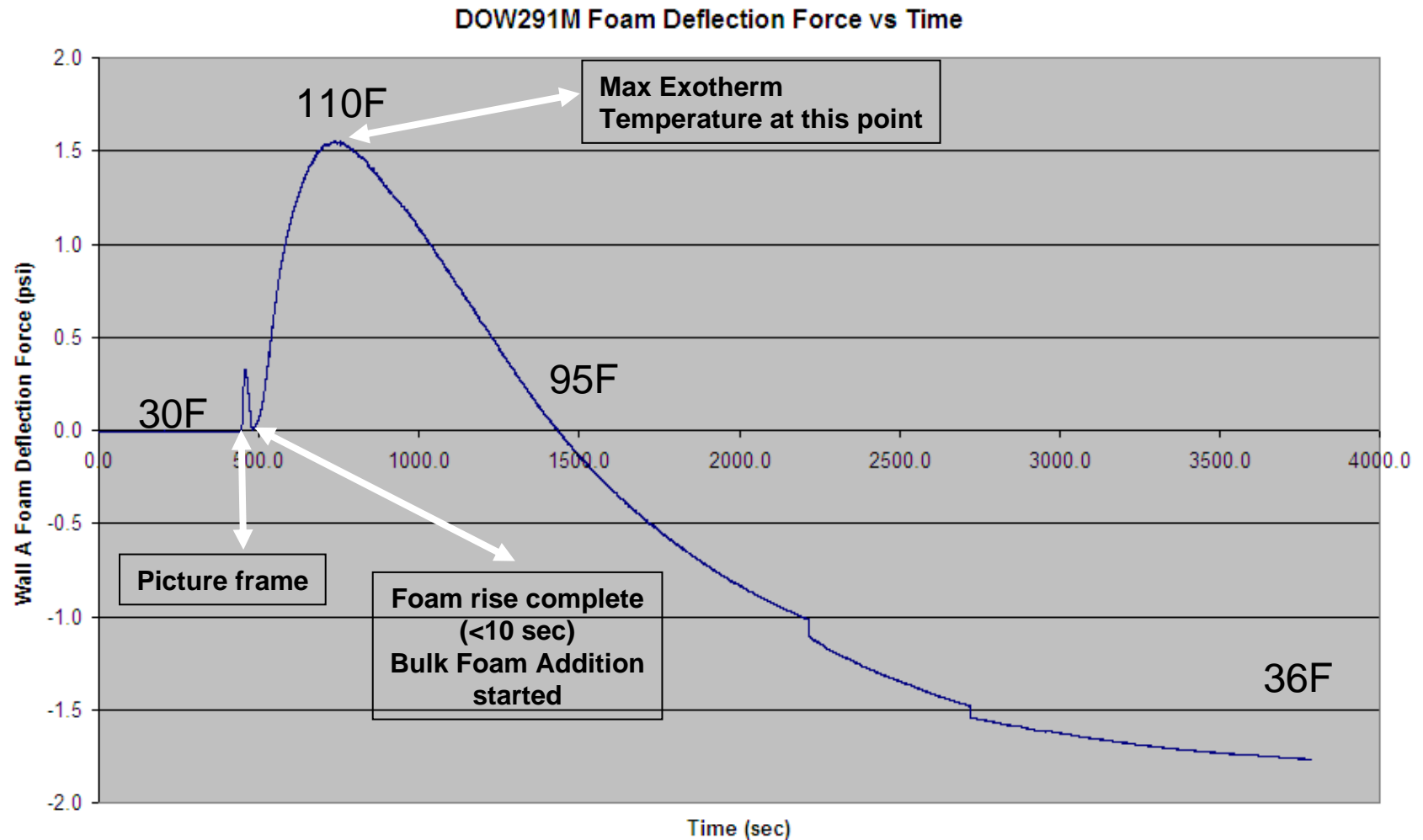
1. Bracket with supports
2. Cylinder attached to LCFA-5 and sitting flush with hole
3. C-channel header
4. THERMAX™ brand isocyanurate insulation sheathing

Foam Deflection Force Gauge Data Description



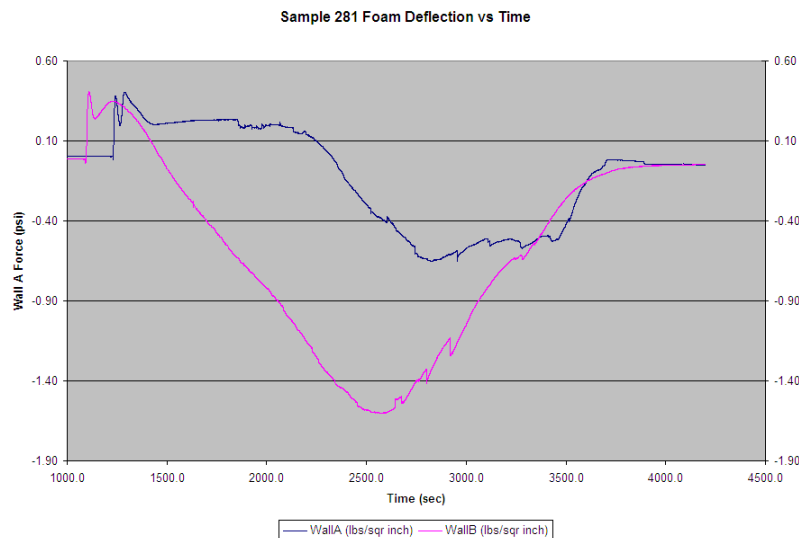
Push to pull time evaluated from time zero to time to -0.1 psi (tensile pull)

Foam Deflection Force Gauge Data Description

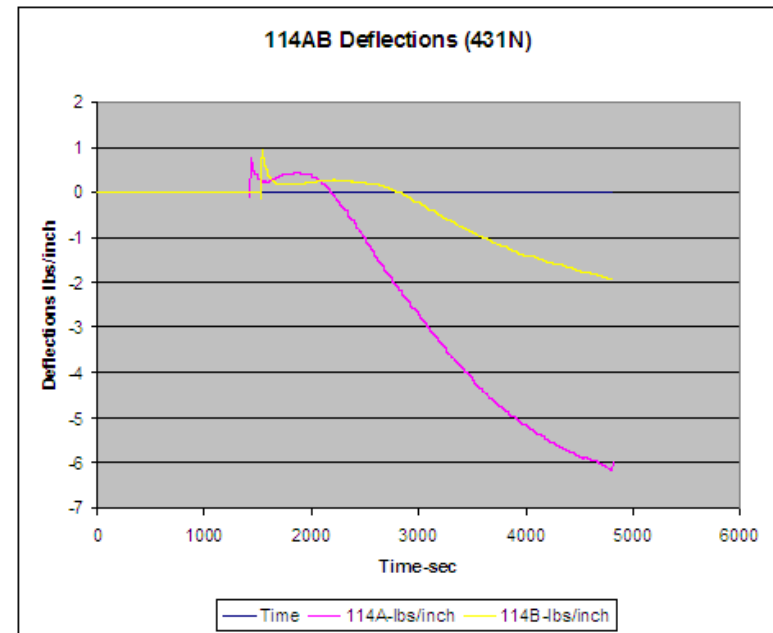


Foam Deflection Force Gauge – Source of Errors

- Lateral Forces – foaming pressure pushes cylinder sideways against hole edge, as pull pressure becomes strong enough, the foam drags the cylinder down across the edge
- Under coverage of foam – more foam added on one wall versus the second leading to different absolute pressure values although the same pass/fail



Lateral forces



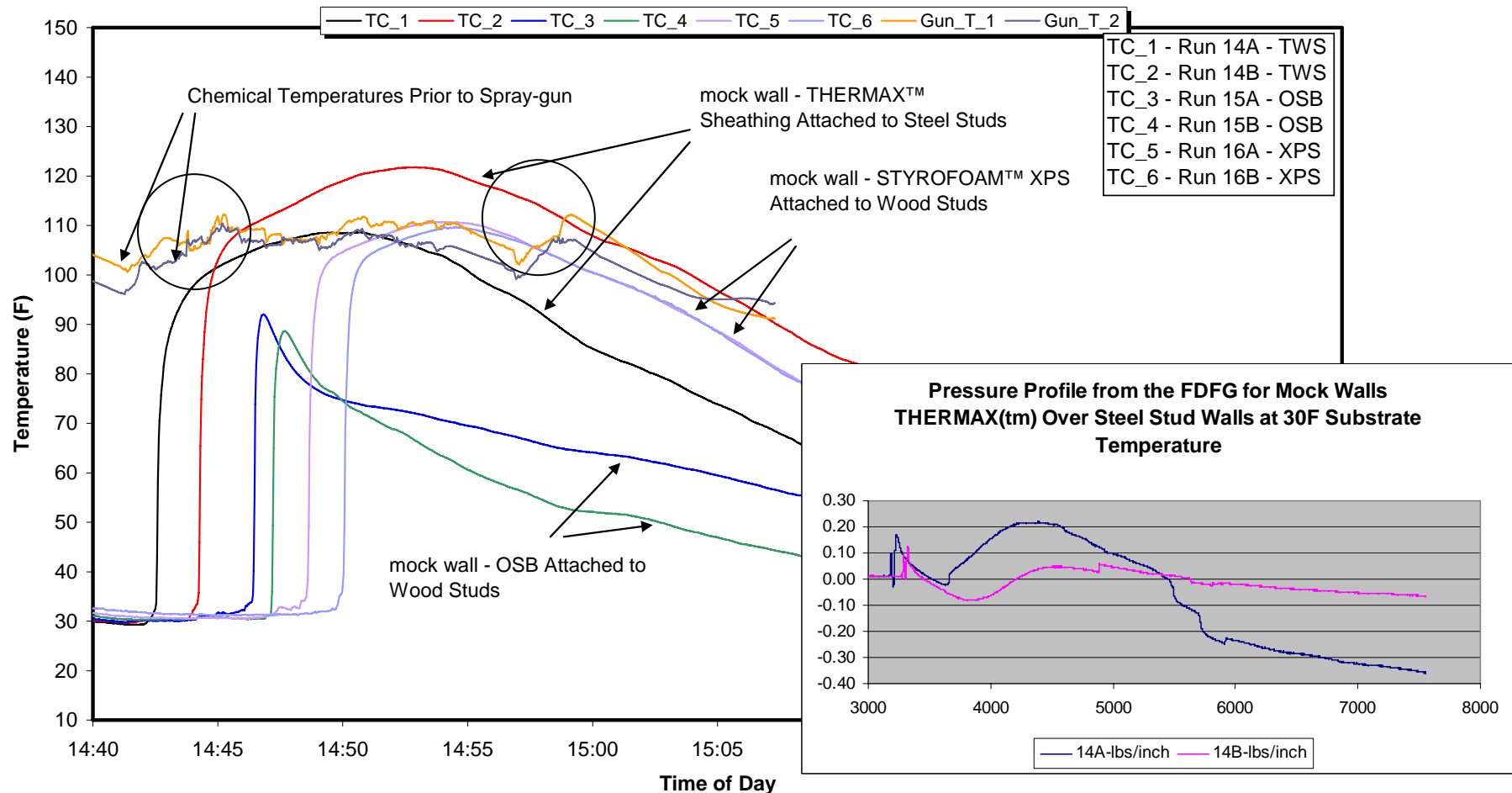
Variable cavity fill

Foam Deflection Force Gauge – Example of Chemical Temperature Affect on Max Foam Temperature and Pressure Profile

DOW CHEMICAL CLIMATE ROOM TESTS

May 25, 2009, Runs 14, 15 & 16

DOW 381, OAT = 30°F



Conclusion

- The Force Deflection Force Gauge (FDFG) was able to detect foam compressive and tensile forces
 - Differing environmental conditions
 - System temperature differences
 - Formulation differences
- The foam continues to build internal pressure after rise as the exotherm temperature increases
- As the foam cools, tensile forces can lead to delamination from the FDFG – considered a failure of the foam system
- The FDFG was able to detect failure through delamination indicating crack $> 1/16$ of an inch
- Wood and metal stud mock walls did not always correlate with stud line cracking – there would have been up to 25% formulation false positives without the FDFG
- The system chosen for commercialization performs well in the field to the design minimum temperature



CSTT – Centre for Surface Transportation Technology

- On site since 1965 – 45 acres
- Cost recoverable technology centre of NRC since 1995
- Consulting Engineering organization
 - Civilian, OGD and military clients
 - Road
 - Rail
 - Climatic
- 120 specialized staff including
 - ↳ Engineers
 - ↳ Project managers
 - ↳ technologists



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Dow Building Solutions

Websites

STYROFOAM™ Spray Polyurethane Foam Insulation: www.sprayfoamatdow.com

THERMAX™ Wall System: www.thermaxwallsystem.com

Technical Support

Customers can contact CIG with questions: 1-866-583-BLUE (2583)

Other Websites

Center for the Polyurethanes Industry: www.polyurethane.org

International Residential Code (IRC): www.iccsafe.org

International Code Council (ICC): www.iccsafe.org/e/category.html

NAHB Green Building Program: www.nahbgreen.org

Spray Polyurethane Foam Alliance: www.sprayfoam.org

LEED for Homes:
<http://www.usgbc.org/displaypage.aspx?cmspageid=147>

Federal Trade Commission, "Labeling and Advertising of Home Insulation":
<http://www.ftc.gov/bcp/rulemaking/rvalue/16cfr460.shtm>

Code College Online Video Training:
http://www.codecollegenetwork.com/video_center/