2025 SPRAYFOAM Convention & Expo
Daytona Beach, FL February 9-12

# Shrinkage and Delamination

## Things You Need to Know

*TOM HARRIS*

*TOM HARRIS PUR CONSULTING, LLC*

# Tom Harris
# President, Tom Harris PUR Consulting, LLC

Tom is a 44-year veteran of the spray foam industry, is a graduate of Ryerson University's Chemical Engineering program, advanced studies in Business Management, Polymer Chemistry and Building Science. Tom has held various positions from Development Chemist, Technical Manager, Global Marketing Manager, Business Manager and Vice President of Building Science and Innovation in Canada and the United States with some of the biggest names in our industry including BASF, Honeywell, Demilec and Huntsman.

Tom's SPFA efforts include Chairman of the Consultants Committee, member of the Building Envelope Committee, Advocacy Committee, Training Committee and Geotech Committee.

As an independent consultant Tom is here to help you succeed.

tom@letstalkpur.com
763-772-3881



SPFA
SPRAY POLYURETHANE FOAM ALLIANCE

# SPFA Antitrust Policy

*"Our policy is to comply with all federal, state and local laws, including the antitrust laws. It is expected that all company member representatives involved in SPFA activities and SPFA staff will be sensitive to the unique legal issues involving trade associations and, accordingly, will take all measures necessary to comply with U.S. antitrust laws and similar foreign competition laws."*

*It is a per se violation of the federal antitrust laws for competitors to agree on prices, limitation of supplies, allocation of customers or territory, or boycotts. "Per se" means that no legal defense can be used to mitigate this automatic violation.*

*Even an agreement by competitors that is for the good of society and our industry may be a violation of the antitrust laws if it could affect competition.*

*If a topic of antitrust concern is raised at any time during a meeting, note your objection for the record. If the topic continues to be discussed, you should leave the room immediately and contact SPFA's general counsel and your company's attorney for further guidance.*

*Ensure that every SPFA meeting, where members are present, has an agenda, the agenda is followed, and minutes are kept by SPFA staff of the proceedings.*

*Understanding and acting on the requirements of U.S. and foreign antitrust and competition laws sometimes can be difficult. If you have a question about the propriety of activities or discussions in SPFA, you are encouraged immediately to contact your company's legal counsel and SPFA management.*

# Today's Presentation

**Learning Objectives**

Identify the primary causes of delamination

Why do things shrink

How and why does SPF shrink

Factors that affect shrinkage

Ways to reduce potential shrinkage issues

# Primary Causes of Delamination

Stresses on the foam are greater than the adhesive strength

- During Application/Curing Phase (short term)
- Product In-Use Phase (medium term)

Compounded by Reduced Initial Adhesion

# Stress of Cooling/Curing

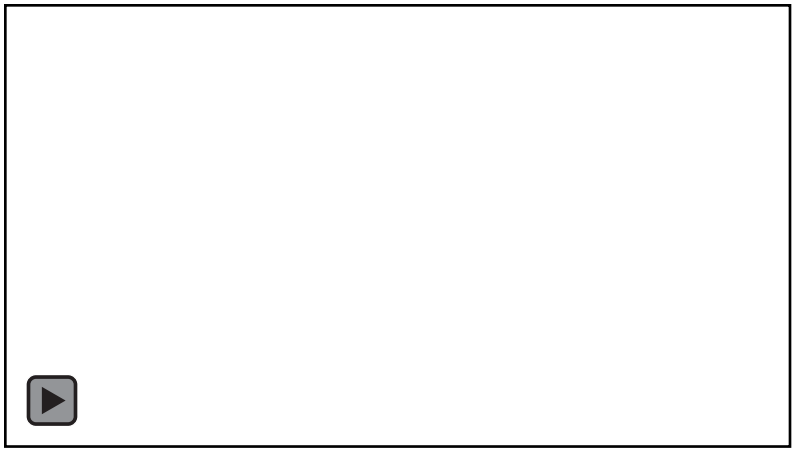
# Why do things Shrink

Clothes shrink due to the fibers becoming closer together in hot water and the stress of washing.  We was the air out of them….

Most materials shrink due to a loss of heat energy – they get smaller as they cool….

All molecules vibrate, and make space, based on the amount of heat energy they contain.  We measure the energy (entropy) and call the measurement temperature.

# Why do things Shrink

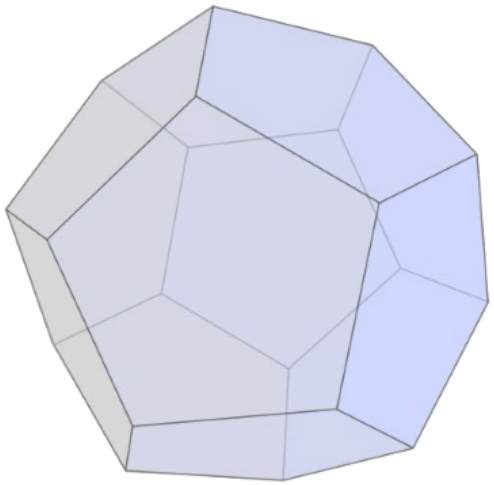


# Why do things Shrink

PUR foam evolves from a liquid to a cellular solid.

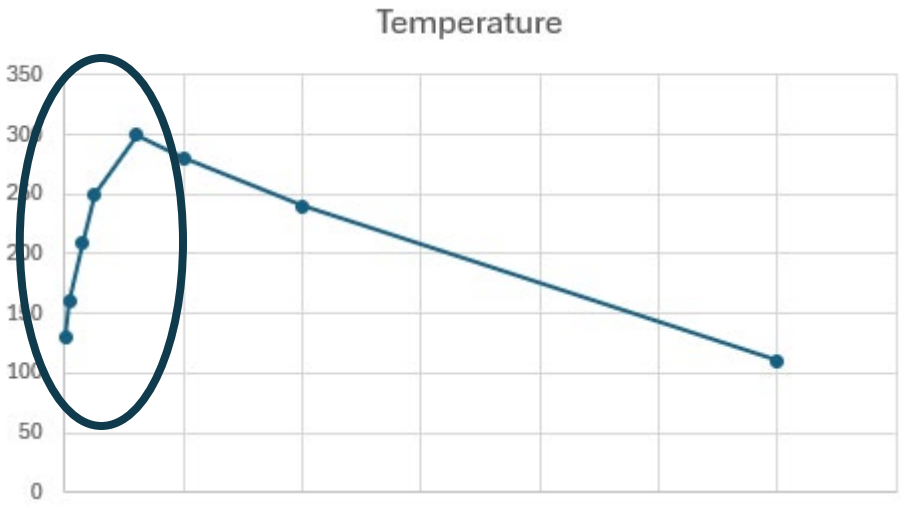
Its rigid
The cells are fixed

But…they are formed at high temperature…….



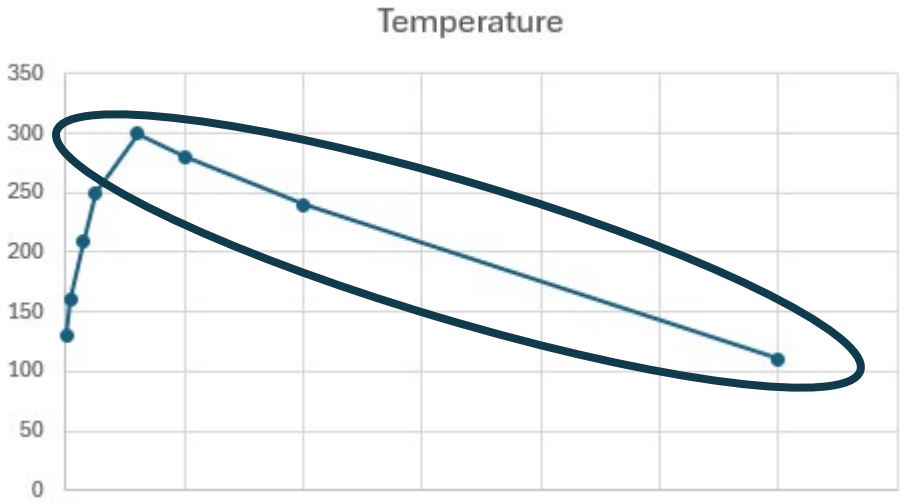
Core temperature of SPF minutes after creation
Is around 300 F.

# Why do things Shrink



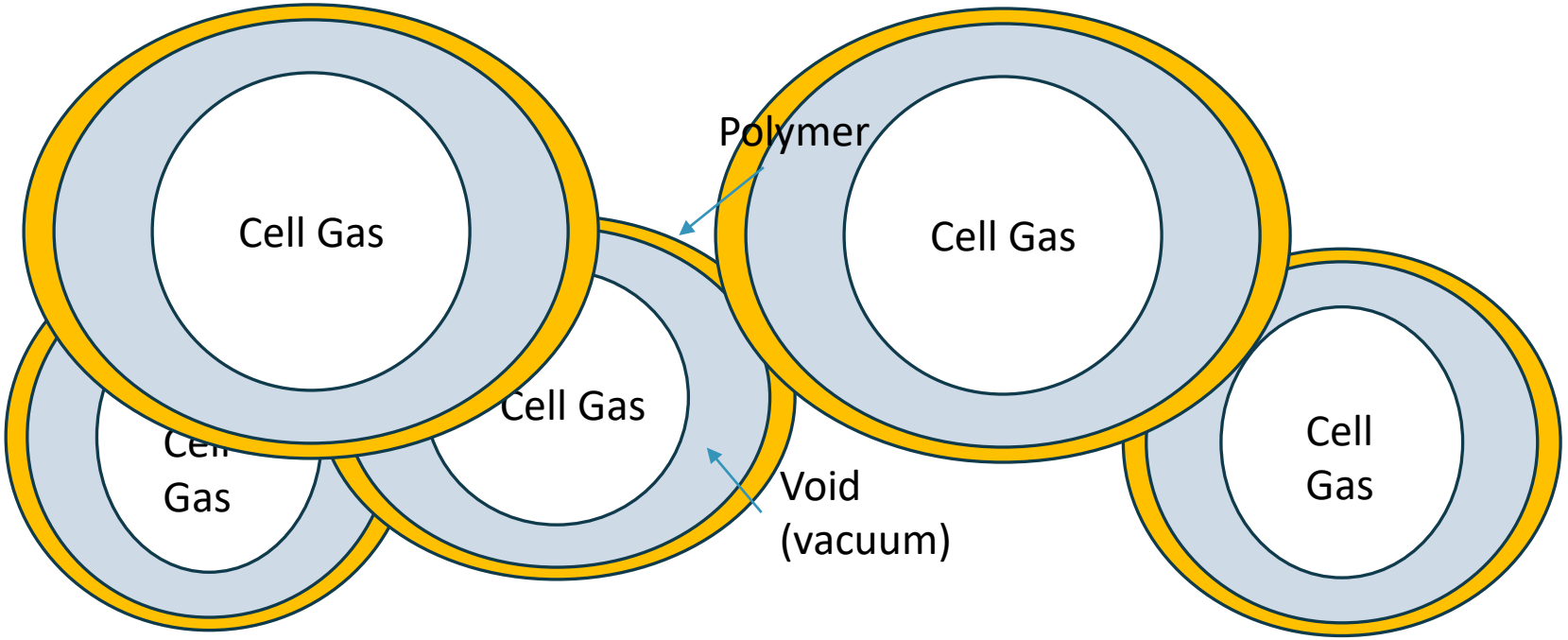

Cellular polymer is created at high temperature.
Exothermic (produces heat) reaction.

# Why do things Shrink



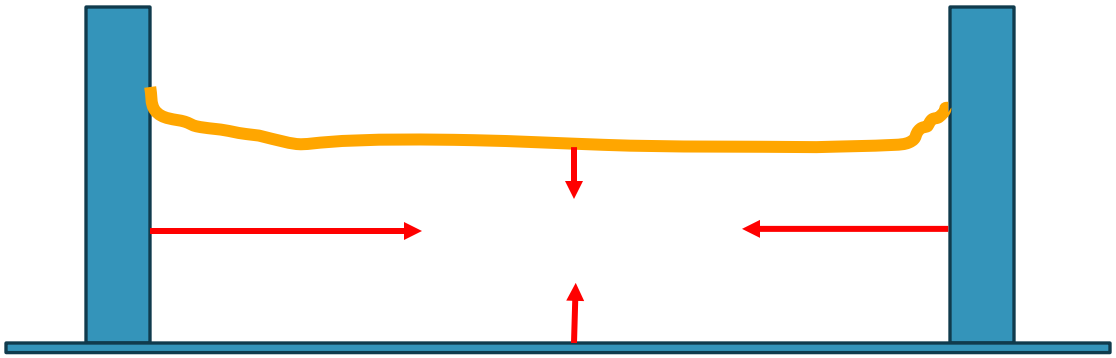

Cellular polymer cools over a period of time but the size of the cell is fixed when it was at a high temperature.

# Why do things Shrink



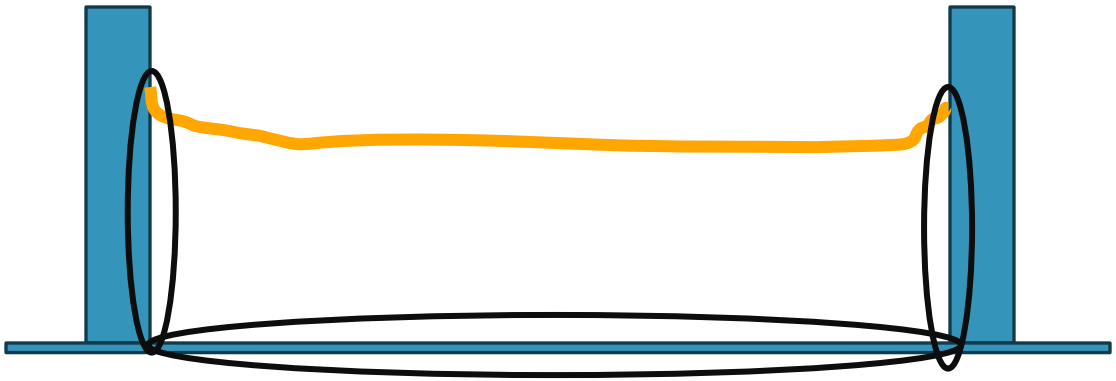

After cooling, we have a slightly negative pressure in the cells because the polymer was a “fixed” size when it was created ***at the higher temperature***.

# Why do things Shrink



The negative pressure puts a stress on each cell and the foam wants to shrink to equalize the pressure inside the cell (foam) with the pressure outside the cell (foam).

# Why do things Shrink



The adhesion of the foam to the substrate is usually strong enough to withstand the forces of cooling – and the foam doesn't delaminate or crack.

# What causes delamination

The stress of cooling is greater than the adhesion of substrate.

# What causes delamination

The stress of cooling is greater than the adhesion of substrate.

# What causes delamination

The stress of cooling is exaggerated by;

Excessive, single pass applications

Low density, closed cell SPF (Mechanical Strength)

Poorly mixed foam

# What causes delamination

The stress of cooling is exaggerated by;

Daytime to nighttime temperature difference (thermal shock)

Cool nights add extra stress to the foam

Metal substrates most vulnerable

# What causes delamination

Reduced adhesion of the foam to the substrate

Excessive single pass applications (top section of foam shears across the substrate)

Moisture in/on the substrate (heaters add moisture to the air)

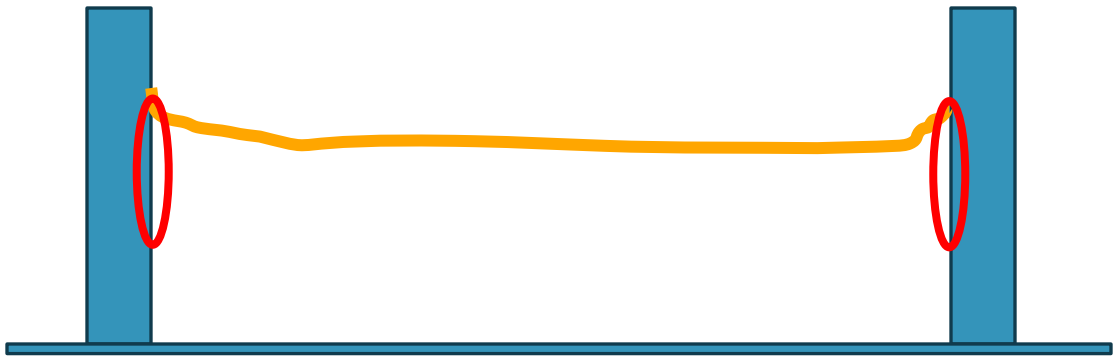
Surface contamination (wax, form oil, dust)

High Stress + Low Adhesion = Delamination

# What causes delamination

**Reduced adhesion of the foam to the substrate**

Excessive single pass applications (top section of foam shears across the substrate)



High Stress + No Adhesion = Delamination

# What causes delamination

What if we have good adhesion?

The stress is going to be stored in the foam or released by the foam if it's not strong enough.

High Stress + Good Adhesion = Center Line Crack

# What causes center line cracks

The stress of cooling is too great for the foam – with great adhesion…..

Excessive single pass applications

Weak foam structure (reflected in mechanical properties)

- anisotropic affect
- low density

High Stress + Great Adhesion = Crack

# Reduced Initial Adhesion

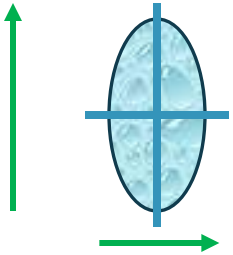
**Reduced Adhesion can be a result of;**

| | | |
|---|---|---|
| Moisture on substrate | 19% or greater | |
| Release agent on substrate | Dust/Dirt | |
| | Wax/Form oil | (LVL, Glulam, X-lam lumber) |
| | Old Paint | (Metal Bldgs) |
| High Humidity application | >85% RH | Looks resin rich |
| Poorly mixed foam | | |
| System Creep | SPF moves sideways along substrate | |
| Too thick single pass for formulation | Rising foam is tack-free before rise is complete (Shear) | |

# The Role of Application Technique

**Application affects cell orientation**

How cells are formed will affect their strength.  Anisotropic nature.



One axis is longer than the other – stronger than the other.

Strength (compressive strength - ASTM D1621) is measured in two directions – parallel to rise and perpendicular to rise

Parallel to rise is always stronger
Perpendicular to rise is always weaker

| **Compressive Strength**: ASTMD-1621 | |
|---|---|
| Parallel @ 10% - | 26 psi (179 kPa) |
| Perpendicular @ 10% - | 16 psi (110 kPa) |

SPFA
SPRAY POLYURETHANE FOAM ALLIANCE

# The Role of Application Technique

**Application affects cell orientation**

Strength (compressive strength - ASTM D1621) is measured in two directions – parallel to rise and perpendicular to rise

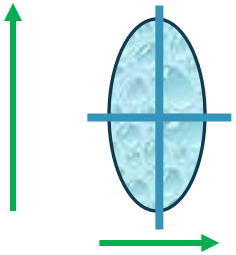
| | |
|---|---|
| **Compressive Strength**: ASTMD-1621 | |
| Parallel @ 10% - | 26 psi (179 kPa) |
| Perpendicular @ 10% - | 16 psi (110 kPa) |

Spray Foam Product Standards acknowledge this fact.

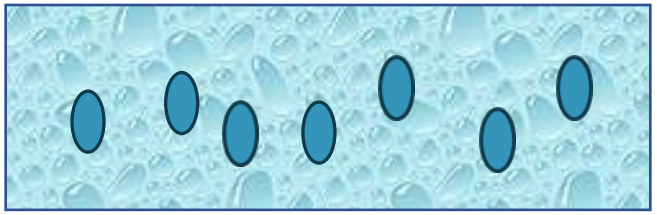
| | | |
|---|---|---|
| Canadian Standard S705.1 | Measures volume change “unattached” | 3/8/14% |
| ASTM C 1029 | Max. Linear change “attached” | 9% |

# The Role of Application Technique

**Application affects cell orientation**



Foam responds to the stress in the weakest direction – it shrinks where there are elongated cells.

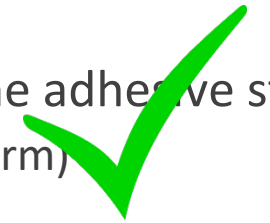


Relationship between formulation and application

# Primary Causes of Delamination

Stresses on the foam are greater than the adhesive strength

- During Application/Curing Phase (short term)
- Product In-Use Phase (medium term)



Compounded by Reduced Initial Adhesion

# Primary Causes of Delamination

Stresses on the foam are greater than the adhesive strength

- ~~During Application/Curing Phase~~ (short term)
- Product In-Use Phase (medium term)

Compounded by Reduced Initial Adhesion

# Primary Causes of Delamination

**Medium Term – Product in Use Phase**

Difference in Temperature through the insulation – “Delta T”

Cycling of Delta T – how fast, how big a delta

Physical movement of the substrate works the bond

- Coefficient of thermal expansion
- Wind
- Physical abrasion

# Primary Causes of Delamination

**Medium Term – Product in Use Phase**

If the controlled environment can connect with the uncontrolled environment, condensation, rot, mold and energy loss will occur.

If the foam is then “free floating” the dimensional change is much higher than if adhered to a substrate.

# Primary Causes of Delamination

**Medium Term – Product in Use Phase**

If the controlled environment can connect with the uncontrolled environment, condensation, rot, mold and energy loss will occur.

If the foam is then “free floating” the dimensional change is much higher than if adhered to a substrate.

# Primary Causes of Delamination

**Medium Term – Product in Use Phase**

The “dimensional Stability” under specific environmental conditions is represented by the ASTM test D 2126 “Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging”.

Report volume change in 24 hrs., 7 days, 28 days

Conditions of -40F, 158F, 158F 97%RH

Test does NOT reflect real world application

# Summary

Delamination is the result of adhesion loss under stress

Center line cracks are a result of stress response coupled with good adhesion

Stress is applied to foam during cooling/curing phase – short term

Medium and long term stress is applied during the use phase

Adhesion can be reduced for a number of application factors

Elongated cells and density are contributing factors to delamination