

abaa2024 building enclosure conference

What is High Temperature?

Benjamin Meyer, AIA
Siplast

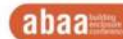
Luke Geoffrion, Ph.D.
Siplast

AIA
Continuing
Education
Provider



What is High Temperature?

This presentation aims to answer a few questions: what does 'high temperature' mean; are the standards that are currently being used enough to support those claims; and do materials that claim high temperature have the best chance of meeting the physical requirements of today's built environment? Existing standards addressing elements of elevated temperature, such as accelerated aging, sample conditioning (AAMA 711 section 5.5), and visual assessment (ASTM D1970 section 7.6) are generally inadequate and incomplete. This presentation looks at common standards and claims regarding "high-temperature" and put them in the context of their respective applications.



Learning Objectives

1. Define 'high temperature' for building enclosure materials and applications
2. Understand the standards that are currently being used for high-temperature
3. Demonstrate the connection between high-temperature exposure and the performance of materials in these applications.
4. Understanding the importance of specifications and designing for high-temperature applications.



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R&D Supervisor -
Innovation
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Outline

- Define 'high temperature'
- Understand the standards
- High-temperature exposure and materials
- Spec and design for high-temperature



Define 'high temperature'

Standards



ASTM D1970

Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection

ASTM D5147

Standard Test Methods for Sampling and Testing Modified Bituminous Sheet Material

ASTM D1204

Linear Dimensional Changes of Nonrigid Thermoplastic Sheetting or Film at Elevated Temperature

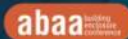
AAMA 711

Specification for Self Adhering Flashing Used for Installation of Exterior Wall Fenestration Products



High Temperature Stability Elements

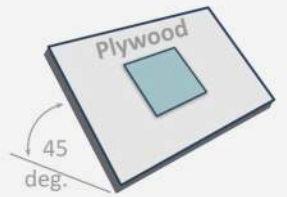
| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
| | | ASTM D1970 | | | |



High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
| | | ASTM D1970 | | | |

General Information:
Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection



| Substrate | Test Angle | Temperature | Exposure Time | Reporting Criteria |
|-----------|------------|-------------|---------------|--------------------|
| Plywood | 45° | 70C/158F | 14 days | Adhesive flow |

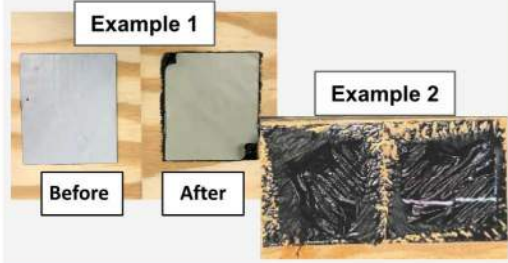


High Temperature Stability Elements

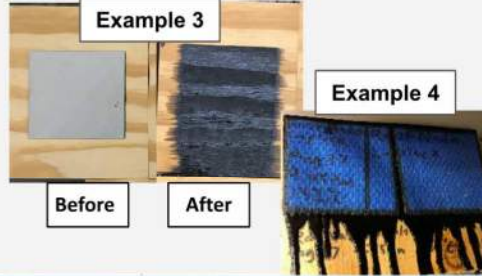
| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|

ASTM D1970

Typical Passing Result



Typical Failing Result



High Temperature Stability Elements

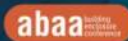
| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
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High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|

ASTM D5147



High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|

ASTM D5147

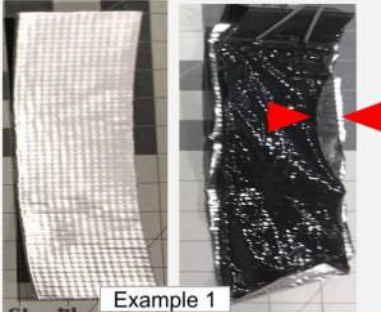

General Information:

Standard Test Methods for Sampling and Testing Modified Bituminous Sheet Material

| Substrate | Test Angle | Temperature | Exposure Time | Reporting Criteria |
|-----------|------------|---------------|-----------------------|-------------------------|
| None | 90° | <121 C (250F) | Varies, until failure | Adhesive Flow/ dripping |



High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|--|---------------|---|----------------------|--------------------|
| | | | | | ASTM D1204 |
| |  | |  | | |
| | | | | | |



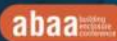
High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
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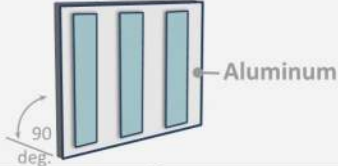


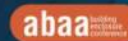
High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
| | | AAMA 711 | | | |
| | | | | | |
| | | | | | |



High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---|----------------------|--------------------|-----------------------|---------------------------|--------------------|
| | | AAMA 711 | | | |
| <p>General Information: Specification for Self Adhering Flashing Used for Installation of Exterior Wall Fenestration Products</p>  | | | | | |
| Substrate | Test Angle | Temperature | Exposure Time | Reporting Criteria | |
| Anodized Aluminum | 90 | 80C (176F) | 7 days | peel adhesion | |



High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|---------------------|----------------------|---------------|-----------------------|----------------------|--------------------|
| AAMA 711 | | | | | |
| Example 1 | | | Example 2 | | |
| Unconditioned | | Conditioned | | Unconditioned | |
| | | | | Conditioned | |

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High Temperature Stability Elements

| Service Temperature | Substrate Conditions | Adhesive Flow | Substrate Orientation | Adhesive Performance | Topsheet Stability |
|-------------------------|----------------------|-------------------|-----------------------|----------------------|--------------------|
| | | ASTM D1970 | | | |
| | | | AAMA 711 | | |
| | | ASTM D5147 | | ASTM D1204 | |
| Current Analysis | | | | | |

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'High temperature' Assessment

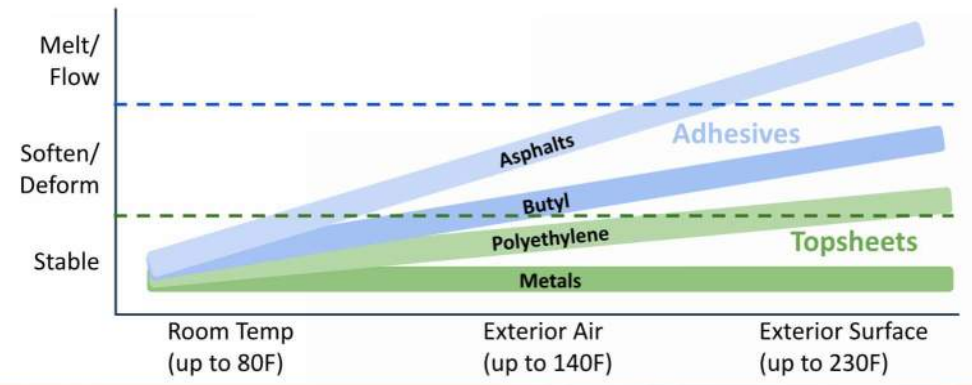
Exposure beyond the expected "service temperature" using accelerate aging to identify resistance to long-term effects of heat and durability.

Performance evaluated on difficult, expected application conditions addressing substrate porosity, application orientation, and material changes.

Goal:
The entire product (top sheet and adhesive assembly) can withstand exposure and continue to perform its function without detrimental impacts to the installed product.

Material Temperature Impacts

"The maximum temperature of a dark horizontal roof situated close to the south wall of a very high building could be as high as 230°F."



https://web.mit.edu/parmstr/Public/NRCan/CanBidgDigest/cb047_e.html

Material Selection in Analysis

8 key benchmark adhered materials that are currently sold into the industry. Published 'high temp' 65 C (150 F) to 150 C (302 F)

- Adhesives:
 - 5 asphaltic-based "HT" adhesives
 - 3 butyl based
- Topsheets:
 - 7 utilized HDPE
 - 1 utilized reinforced LDPE
 - 4 included Aluminum foil surface

- Testing performed by Siplast
- 3-5 samples of each material was tested over a two year period.
- Images shown throughout are representative samples

Analysis Overview

Part 1: Materials with current standards (ASTM D1970 & AAMA 711, level 3)

Part 2: Impact of substrate - Orientation and materials (ASTM D1970)

Part 3: Combined Learning Analysis - High Temp Stability Elements

- Substrate Conditions
- Adhesive Performance
- Adhesive Flow
- Topsheet Stability
- Substrate Orientation

Analysis Overview

Part 1: Materials with current standards (ASTM D1970 & AAMA 711, level 3)

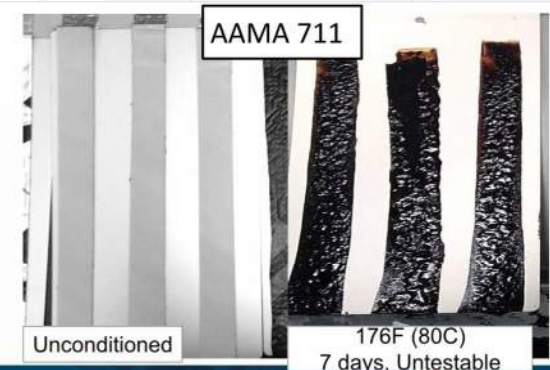
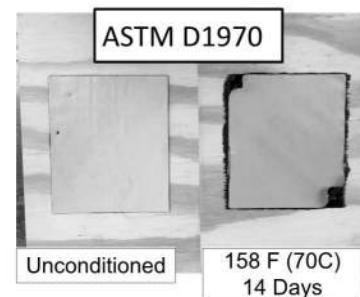
Part 2: Impact of substrate - Orientation and materials (ASTM D1970)

Part 3: Combined Learning Analysis - High Temp Stability Elements

- Substrate Conditions
- Adhesive Performance
- Adhesive Flow
- Topsheet Stability
- Substrate Orientation

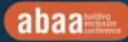
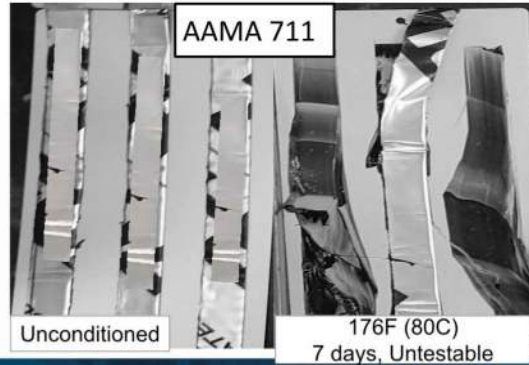
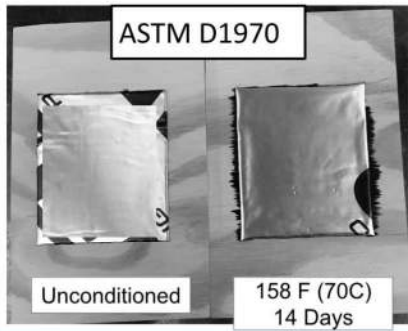
Analysis Part 1: Materials with current standards

| Material | Temperature Claim | Claim Based on | Top Sheet | Adhesive |
|----------|-------------------|--------------------------------|----------------------|--------------------|
| A | 205 F (96 C) | Softening point 205 F (96.1 C) | HDPE Composite Facer | rubberized asphalt |



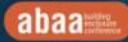
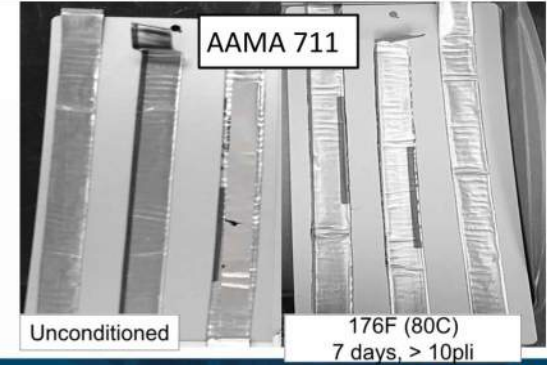
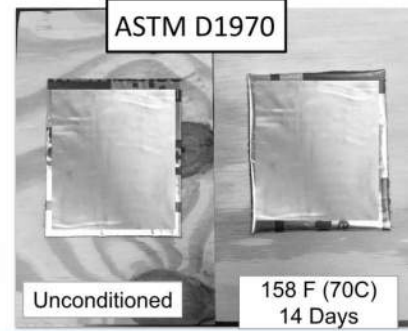
Analysis Part 1: Materials with current standards

| Material | Temperature Claim | Claim Based on | Top Sheet | Adhesive |
|----------|-------------------|----------------|--|--------------------------------|
| B | 150 F (65 C) | Not reported | laminated to aluminum foil HDPE composite facer | Rubberized asphalt adhesive |



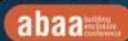
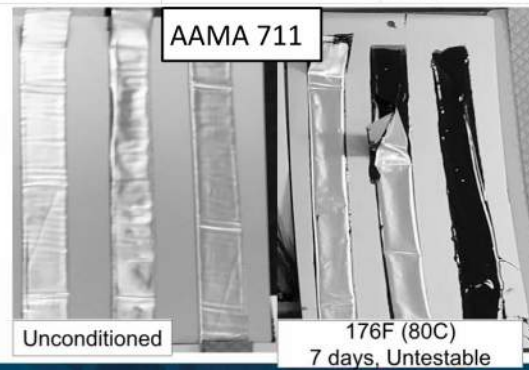
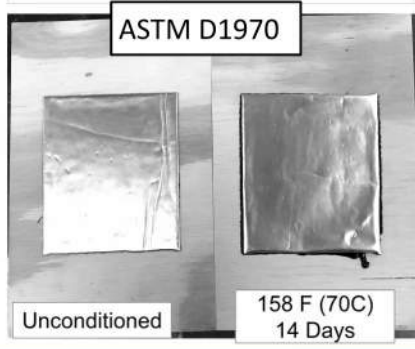
Analysis Part 1: Materials with current standards

| Material | Temperature Claim | Claim Based on | Top Sheet | Adhesive |
|----------|-------------------|----------------|---------------------------------------|--------------------------------|
| C | 150 F (65 C) | Not Reported | Cross laminated HDPE aluminum foil | rubberized asphalt adhesive |



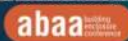
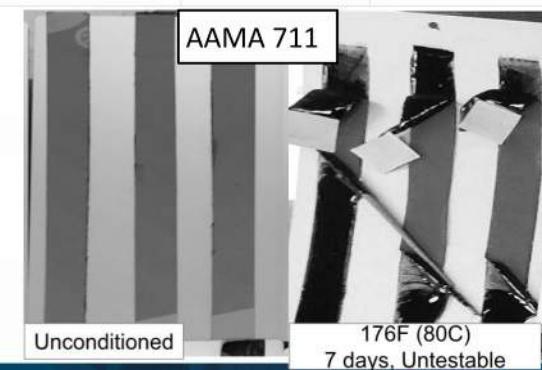
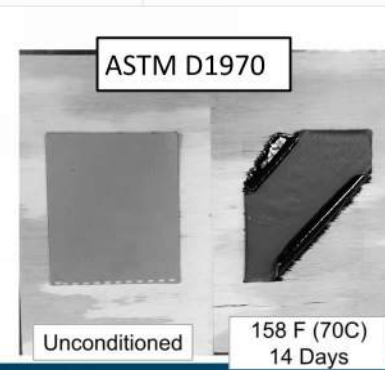
Analysis Part 1: Materials with current standards

| Material | Temperature Claim | Claim Based on | Top Sheet | Adhesive |
|----------|-------------------|----------------|---------------------|-----------------------|
| D | None | Not Reported | Aluminum Faced film | rubberized asphalt |



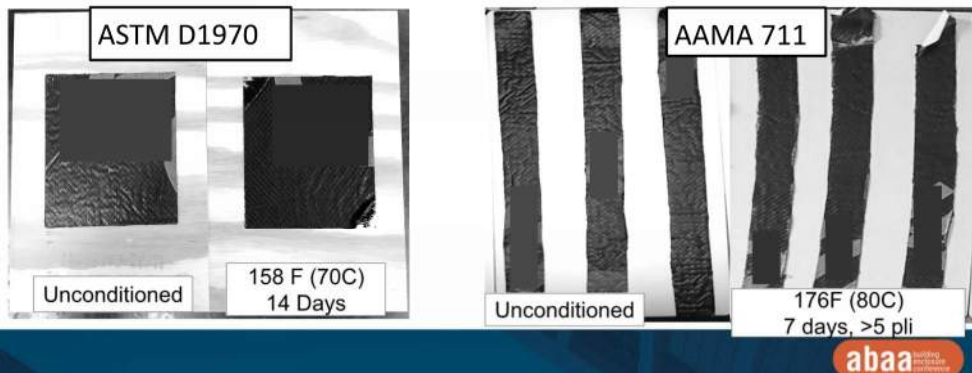
Analysis Part 1: Materials with current standards

| Material | Temperature Claim | Claim Based on | Top Sheet | Adhesive |
|----------|----------------------|----------------------------|--------------------|------------------------------------|
| E | 200-212 F (95-100 C) | ASTM D1204 & ASTM D5147 | thermoplastic film | SBS Rubberized asphalt compound |



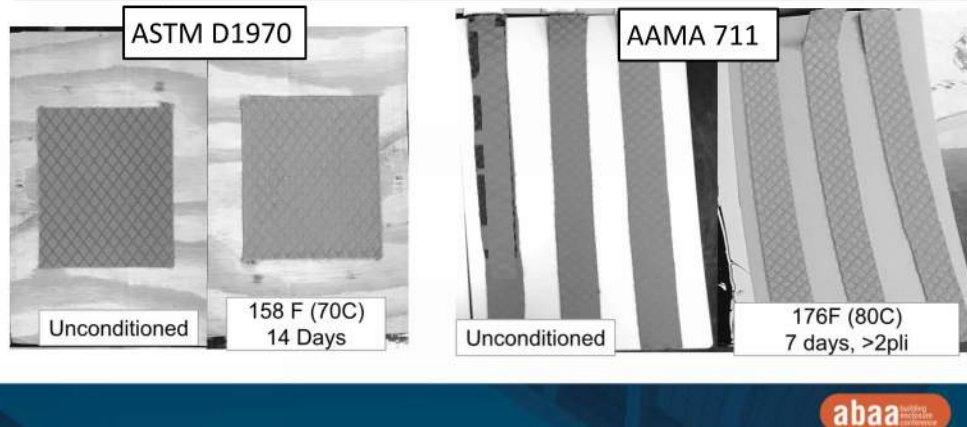
Analysis Part 1: Materials with current standards

| Material | Temperature Claim | Claim Based on | Top Sheet | Adhesive |
|----------|-------------------|----------------|--|----------------------------------|
| F | 300 F (150 C) | Not Reported | High density cross-laminated polyethylene film | butyl rubber adhesive no asphalt |



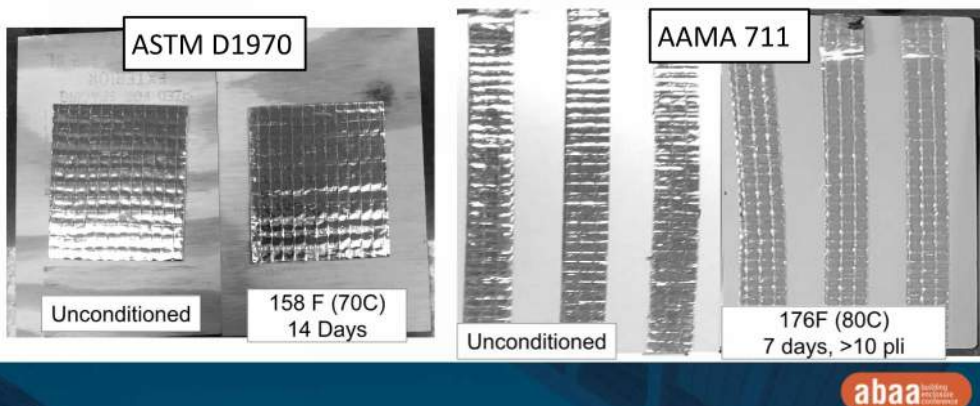
Analysis Part 1: Materials with current standards

| Material | Temperature Claim | Claim Based on | Top Sheet | Adhesive |
|----------|-------------------|----------------|----------------|----------|
| G | 300 F (150 C) | ASTM D1970 | laminated film | Butyl |



Analysis Part 1: Materials with current standards

| Material | Temperature Claim | Claim Based on | Top Sheet | Adhesive |
|----------|-------------------|-------------------|--|----------|
| H | 240 F (115 C) | Modified AAMA 711 | True aluminum faced LDPE Reinforced laminate | Butyl |



Summary of Analysis Part 1: Materials with current standards

- Not good correlation between ASTM D1970 and AAMA 711
 - Substrate Conditions and orientation are inconsistent
 - Imperfect measurements of success for ASTM D1970
 - > project specification?
 - AAMA Temperature classification (Type 1, 2, 3) stop below many common temperature thresholds.
- Some materials aren't testable for peel adhesion at published temperatures on vertical surfaces

Analysis Overview

Part 1: Materials with current standards (ASTM D1970 & AAMA 711, level 3)

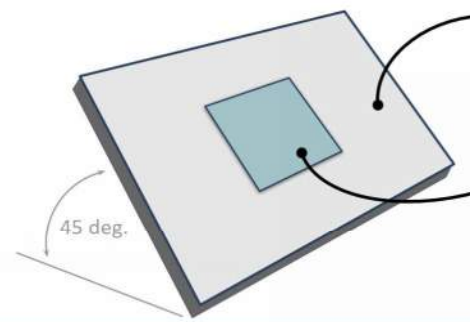
Part 2: Impact of substrate - Orientation and materials (ASTM D1970)

Part 3: Combined Learning Analysis - High Temp Stability Elements

- Substrate Conditions
- Adhesive Performance
- Adhesive Flow
- Topsheet Stability
- Substrate Orientation

Analysis Part 2: Impact of substrate (ASTM D1970)

ASTM D1970 Method at the standard's temperature exposure of 158F (70C) for 14 days - "Visual" method

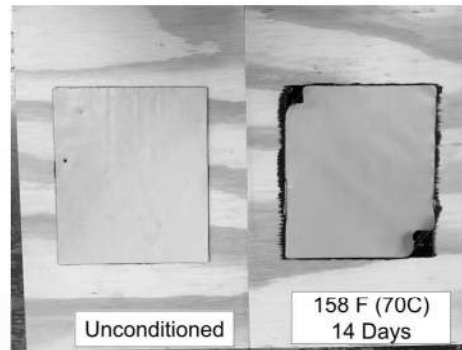
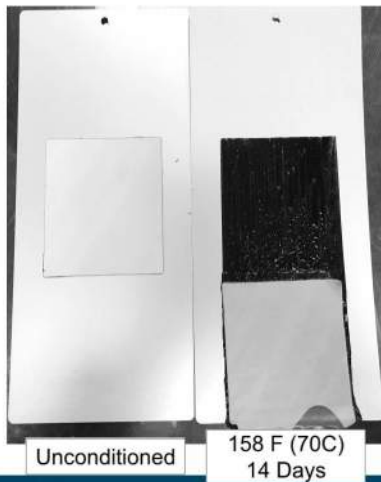


- Compare two substrates:
- APA Grade 1 Plywood (ASTM D1970 Standard)
 - Anodized aluminum

- Compare Samples A-H:
- Different substrates in the same conditions

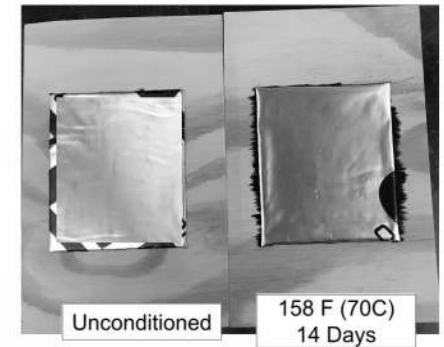
Analysis Part 2: Impact of substrate (ASTM D1970)

Material A

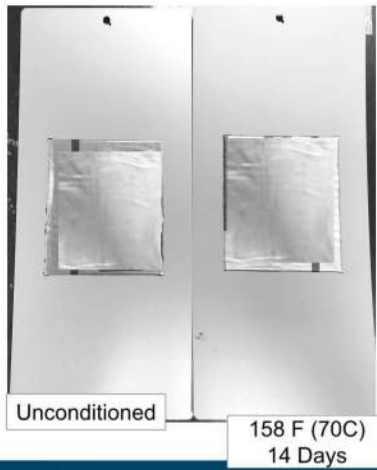


Analysis Part 2: Impact of substrate (ASTM D1970)

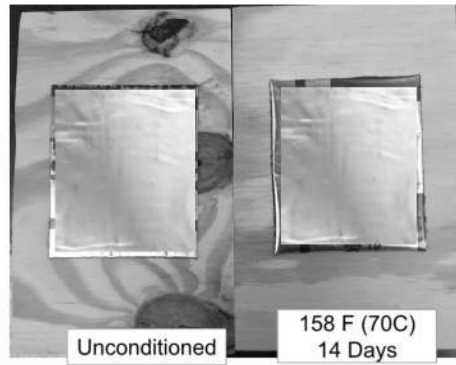
Material B



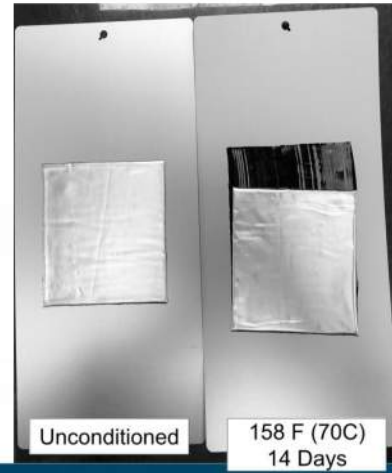
Analysis Part 2: Impact of substrate (ASTM D1970)



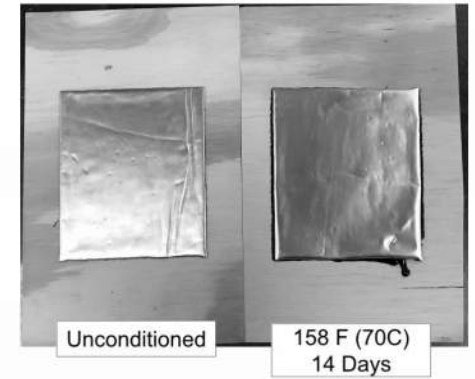
Material C



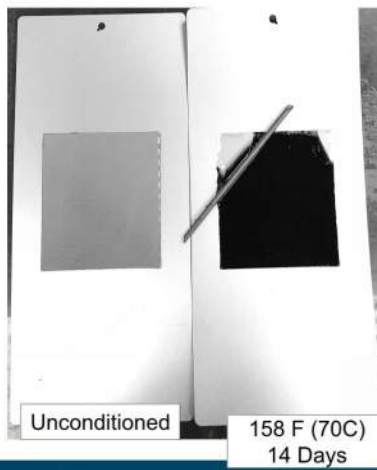
Analysis Part 2: Impact of substrate (ASTM D1970)



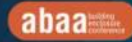
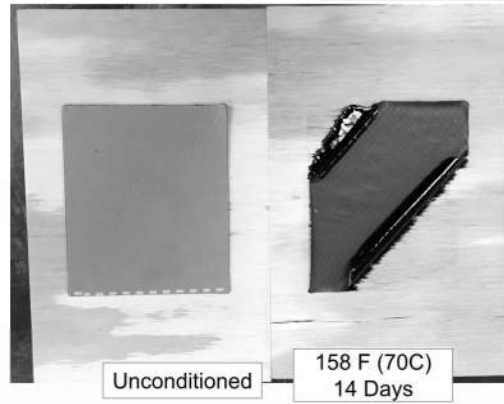
Material D



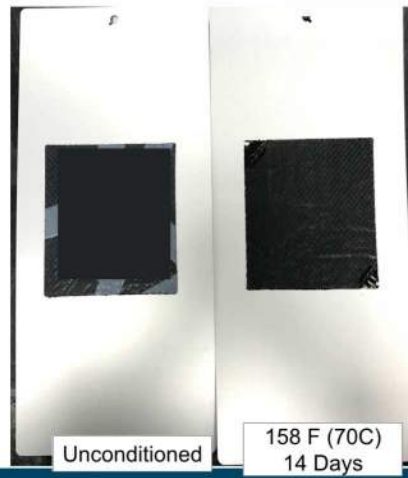
Part 2: Impact of substrate - Orientation and materials (ASTM D1970)



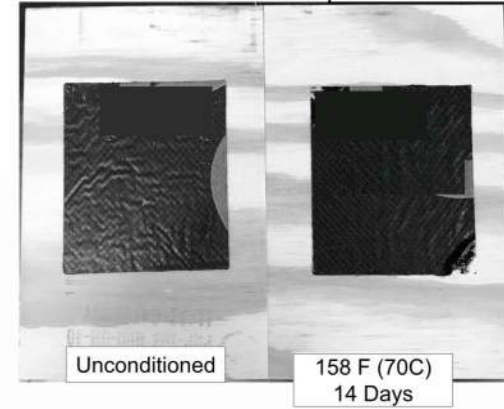
Material E



Analysis Part 2: Impact of substrate (ASTM D1970)

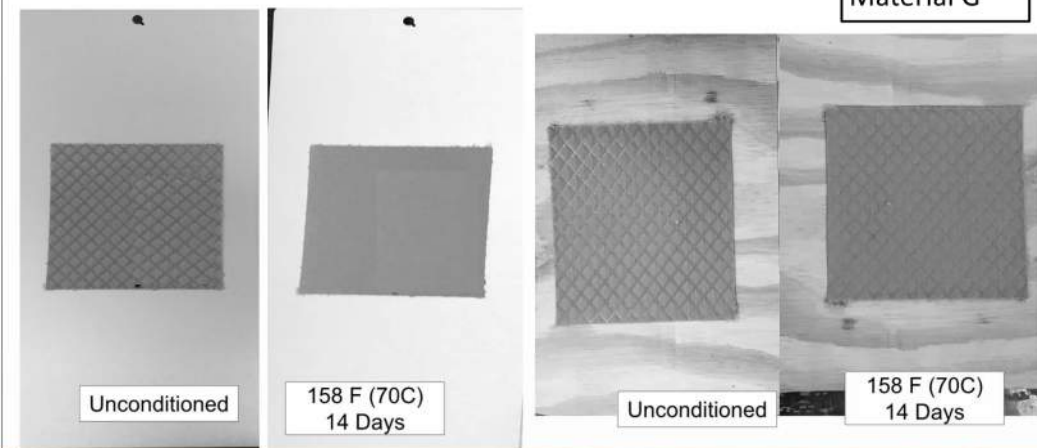


Material F



Analysis Part 2: Impact of substrate (ASTM D1970)

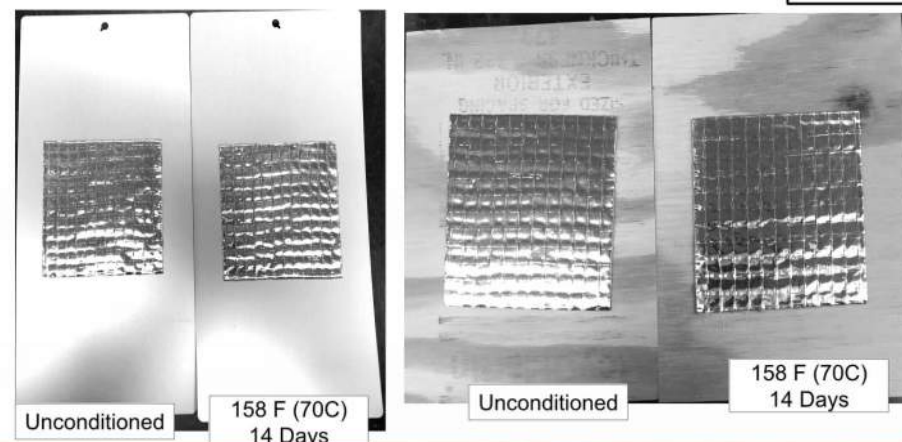
Material G



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Analysis Part 2: Impact of substrate (ASTM D1970)

Material H



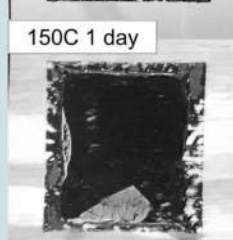
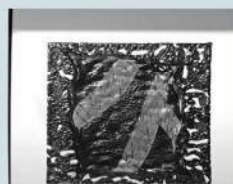
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Analysis Part 2: Impact of substrate (ASTM D1970)

Summary:

- Porosity of the substrate can make a difference in performance
- 7 of the 8 materials make some claim about temperature exposure above 70C in ASTM D1970 →
- Elevated temperatures impact the soundness of the topsheet significantly, even if butyl resists flow

ASTM D1970 at 300F (150C)
Material F



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Analysis Overview

Part 1: Materials with current standards (ASTM D1970 & AAMA 711, level 3)

Part 2: Impact of substrate - Orientation and materials (ASTM D1970)

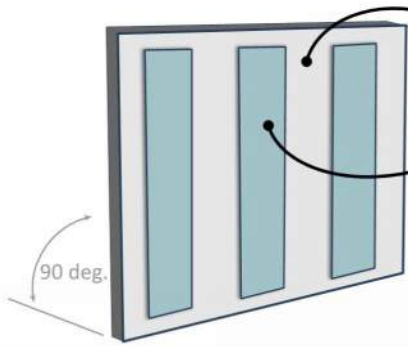
Part 3: Combined Learning Analysis - High Temp Stability Elements

- Substrate Conditions
- Adhesive Performance
- Adhesive Flow
- Topsheet Stability
- Substrate Orientation

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Analysis Part 3: Combined High Temp Elements

AAMA 711 Method at accelerated exposure of 240F (115C) for 7 days - Peel values after conditioning

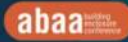


Substrate:

- Non-porous Substrate
- Vertical Orientation

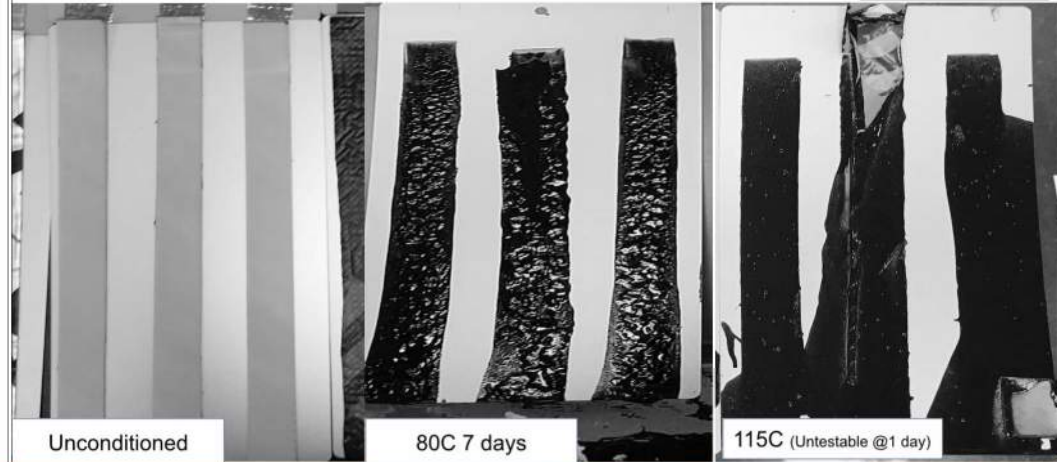
Compare Multiple Samples A-H:

- Adhesive Flow
- Adhesive Performance
- Topsheet Stability



Analysis Part 3: Combined High Temp Elements

Material A



Unconditioned

80C 7 days

115C (Unstable @ 1 day)

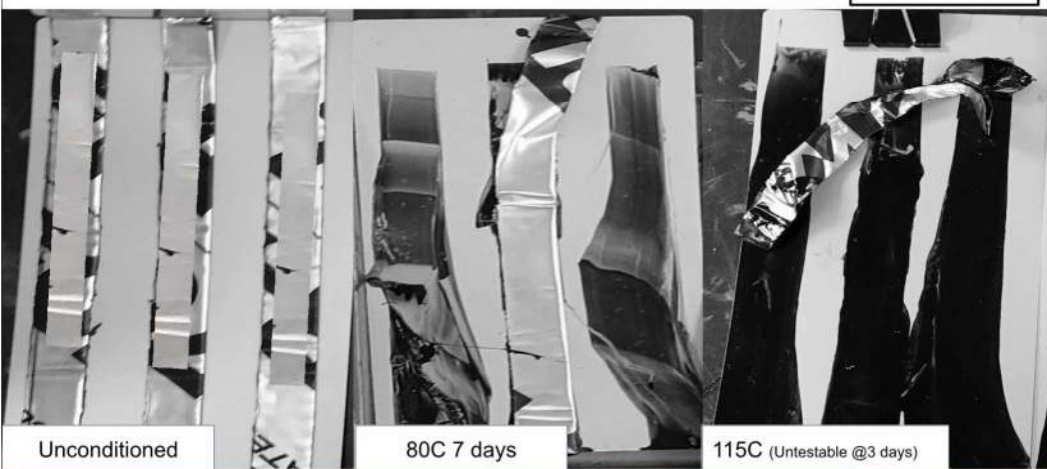
(176F)

(240F)



Analysis Part 3: Combined High Temp Elements

Material B



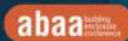
Unconditioned

80C 7 days

115C (Unstable @ 3 days)

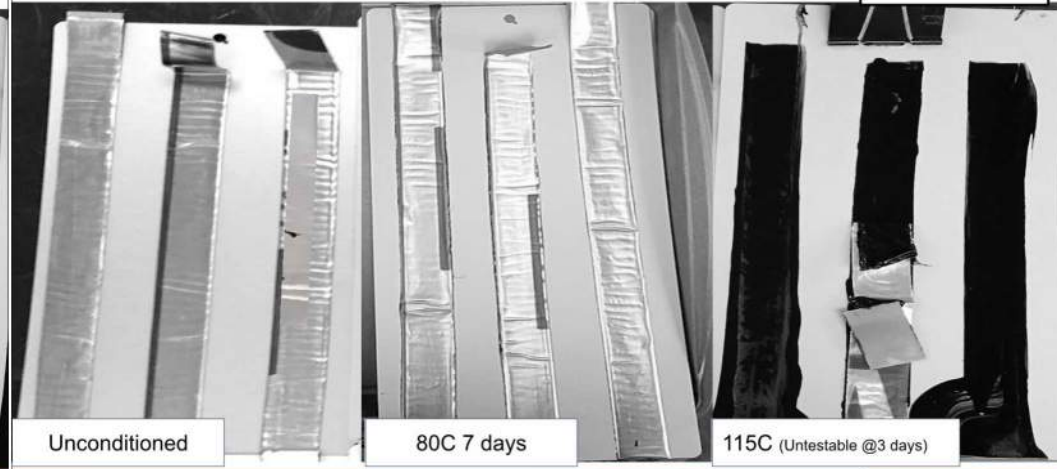
(176F)

(240F)



Analysis Part 3: Combined High Temp Elements

Material C



Unconditioned

80C 7 days

115C (Unstable @ 3 days)

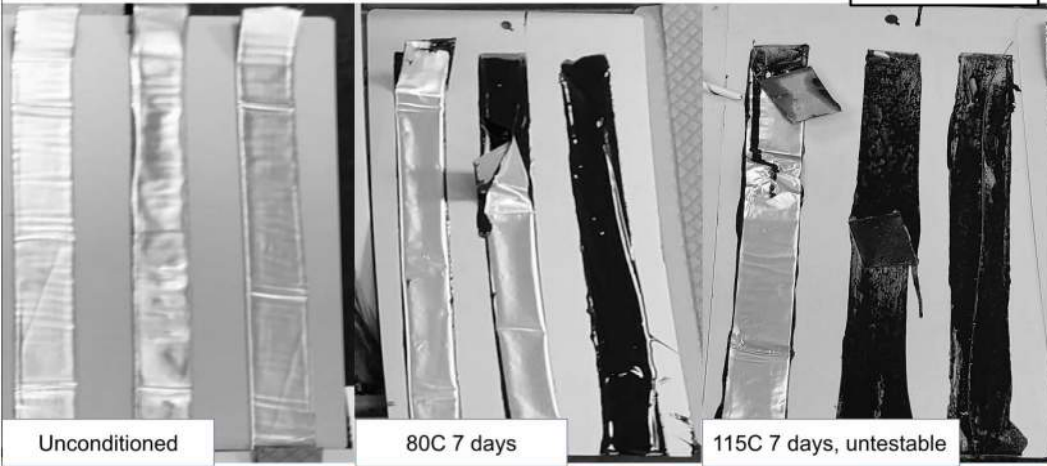
(176F)

(240F)



Analysis Part 3: Combined High Temp Elements

Material D



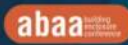
Unconditioned

80C 7 days

115C 7 days, untestable

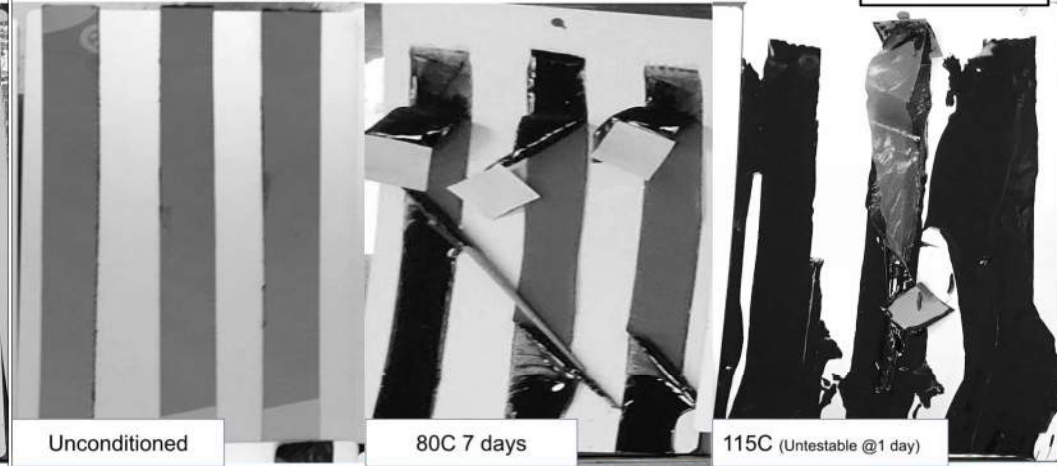
(176F)

(240F)



Analysis Part 3: Combined High Temp Elements

Material E



Unconditioned

80C 7 days

115C (Unstable @1 day)

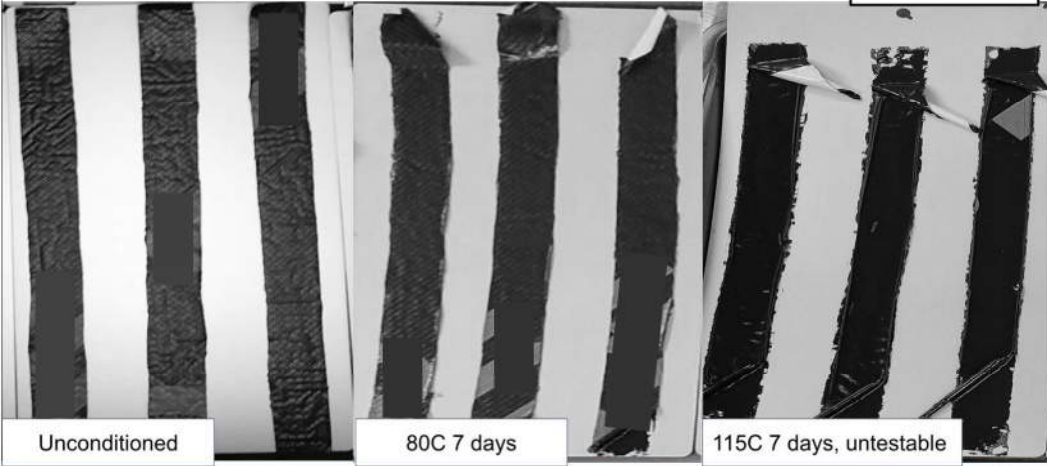
(176F)

(240F)



Analysis Part 3: Combined High Temp Elements

Material F



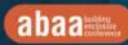
Unconditioned

80C 7 days

115C 7 days, untestable

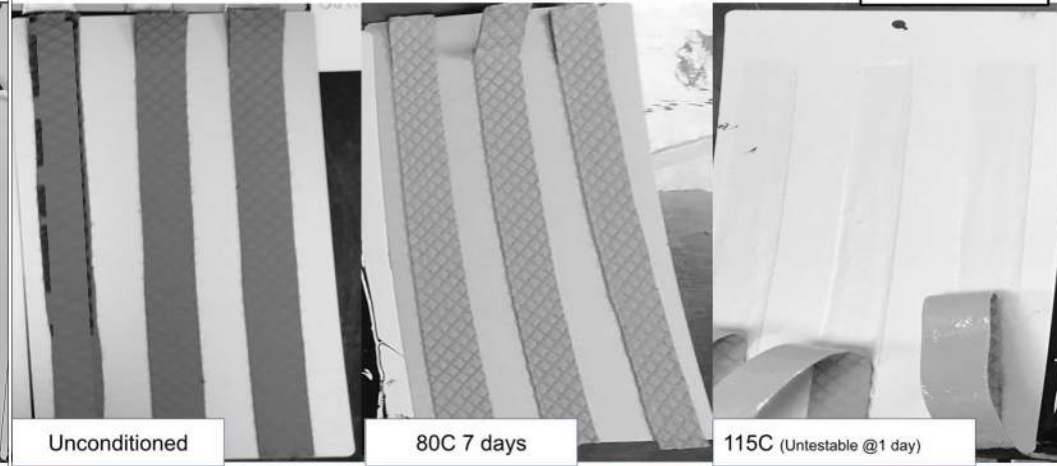
(176F)

(240F)



Analysis Part 3: Combined High Temp Elements

Material G



Unconditioned

80C 7 days

115C (Unstable @1 day)

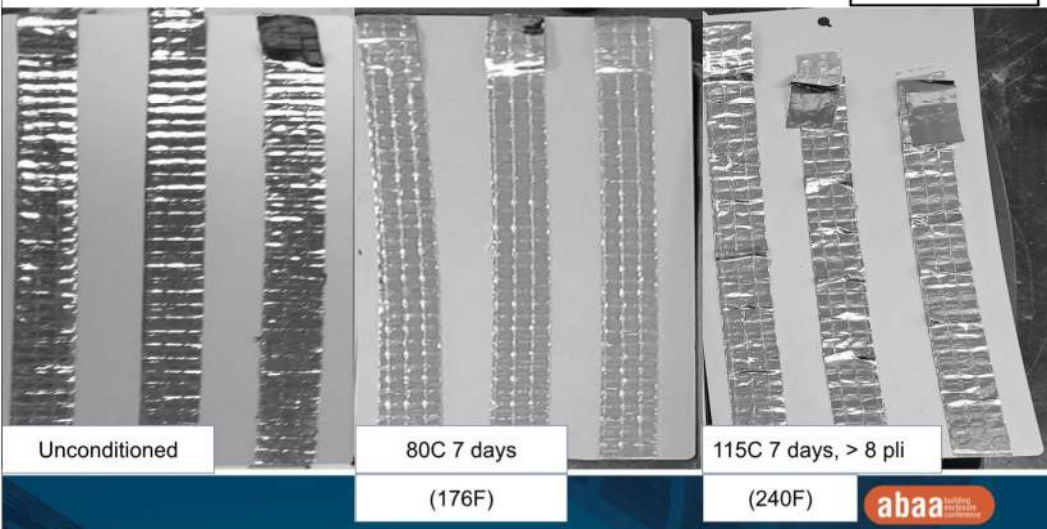
(176F)

(240F)



Analysis Part 3: Combined High Temp Elements

Material H



Summary of Analysis Part 3: Combined High Temp Elements

- Short periods of high temperatures (240F) can have irreversible effects and permanently decrease performance
- Long-term aging impacts of heat resistance can be quantitatively and qualitatively tested with vertical non-porous substrates
- Existing test standards are not structured to support performance temperature claims for all applications.
- Project specifications may need additional clarifications and manufacturer submittals for high temp critical applications.

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Analysis Overview

Part 1: Materials with current standards (ASTM D1970 & AAMA 711, level 3)

Part 2: Impact of substrate - Orientation and materials (ASTM D1970)

Part 3: Combined Learning Analysis - High Temp Stability Elements

- Substrate Conditions
- Adhesive Performance
- Adhesive Flow
- Topsheet Stability
- Substrate Orientation

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Project Specifications for High Temperature applications

- ABAA Evaluated Materials and Assemblies
- Self-Adhered Performance per AAMA 711: Pass all test criteria as Type A (without primer), and Level 3 (Exposure to 176F (80C)).
 - If the project needs more, list the requirements! *Example:*
 - Self-Adhered Performance per AAMA 711: Pass all test criteria as Type A (without primer), and Level **X (Exposure to 240F (115C))**.
- **Don't just list a "service temperature"!**
- **Don't rely on ASTM D1970:** test orientation and substrate don't indicate vertical application performance

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