Critical Property Contrasts of Fluid Applied Air and Water Barrier Membranes used for Envelope: Chemistries, Performance and Durability

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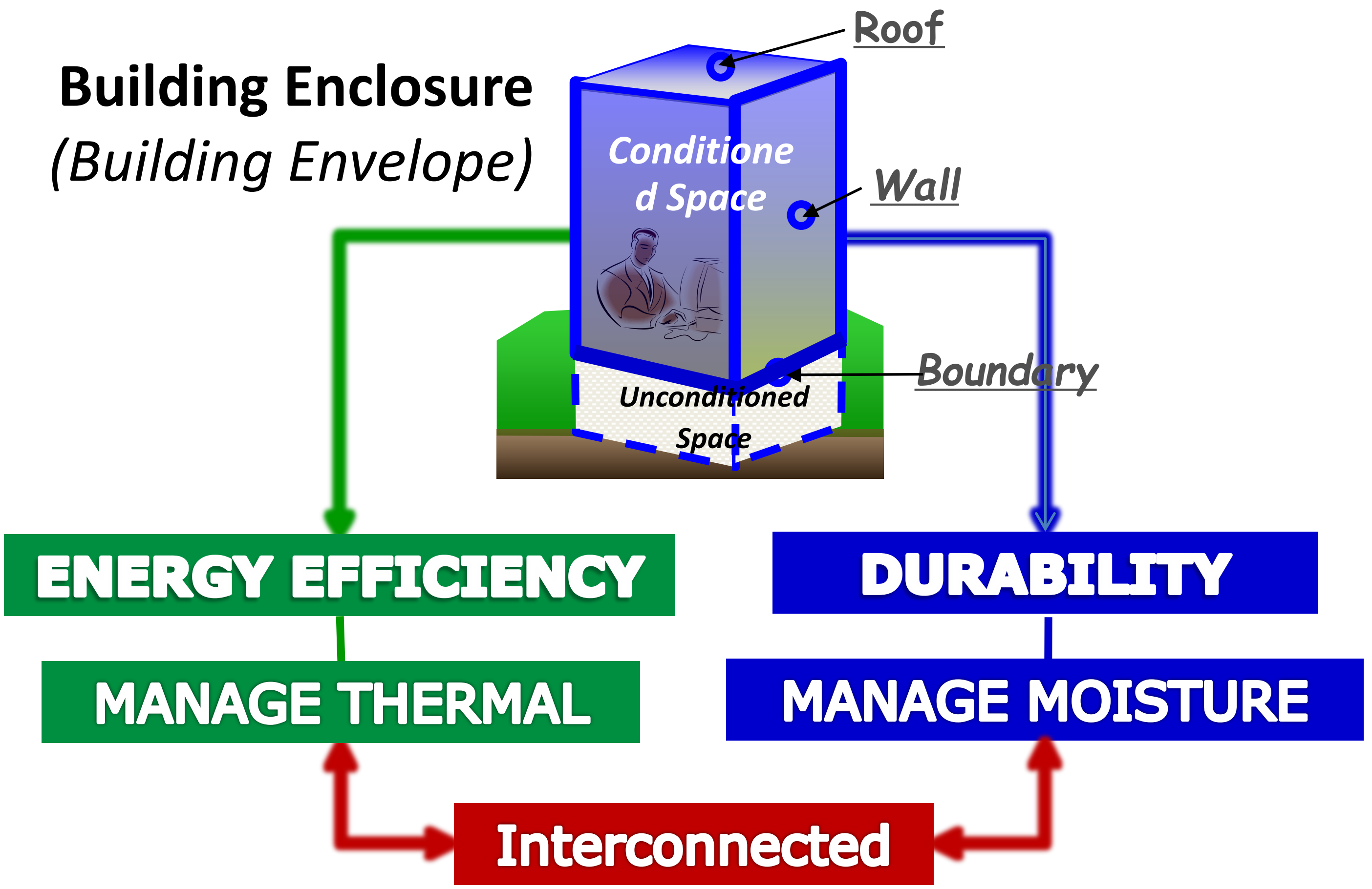
Agenda

- **Role of Fluid Applied Products**
- **Explanation of Properties**
- **Rationale and Experimentation**
- **Critical Property Contrasts**
- **Conclusions**

For complete data, citations and bibliography, please reference the publication in the Buildings XIII Conference prospectus, paper #46: "*Critical Property Contrasts of Fluid Applied Air and Water Barrier Membranes used for Envelope: Chemistries, Performance and Durability.*"

Role of Fluid Applied Membranes

- **Control air movement and prevent water infiltration**
- **Be durable by having elastomeric character, and retain the characteristics (e.g. ultimate elongation, dynamic recovery, Young's modulus) with various exposure and application conditions.**



Ultimate Elongation vs. Elastomeric Properties

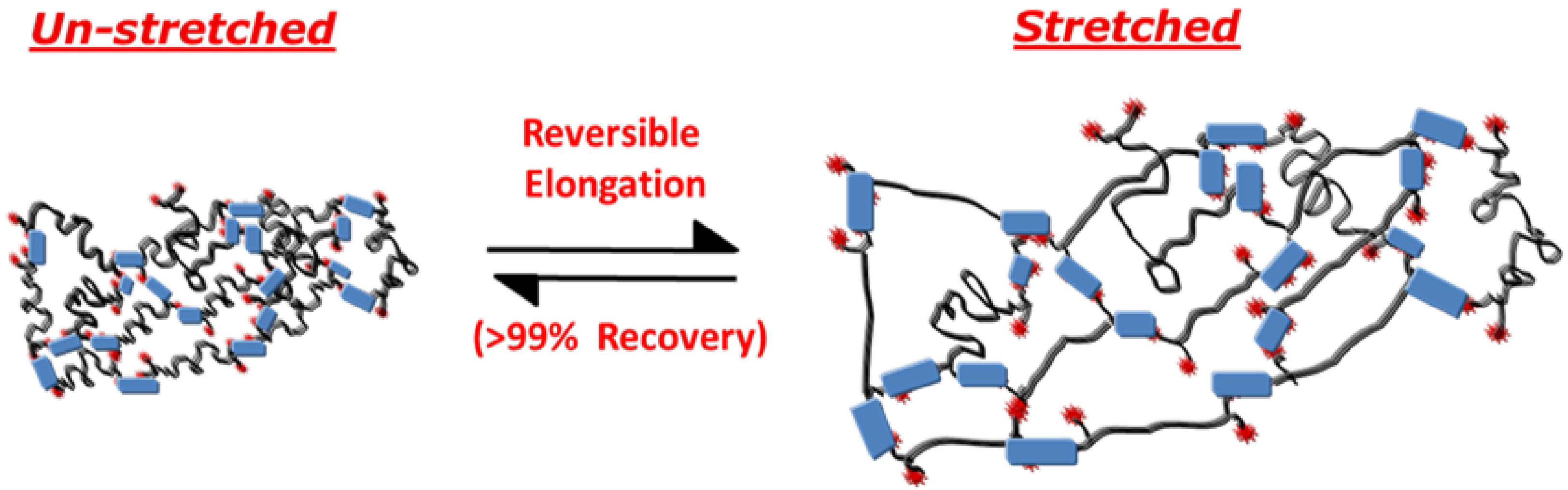
Product datasheets will frequently use ASTM D412 to associate ***Ultimate Elongation*** with ***Elastomeric Properties.***

But… Contrary to common practice:

- *Ultimate Elongation* alone **<u>does not</u>** accurately define the total *Elastomeric Properties* of the membrane since the number is obtained at catastrophic failure.
- Higher Ultimate Elongation **<u>will not</u>** necessarily translate to improved *Elastomeric Properties* over a wider dynamic range.
    - In fact, the opposite is frequently true.

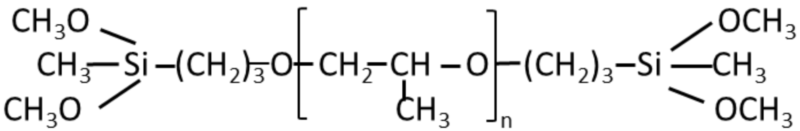
The ASTM 412 method does allow for reporting of a **<u>tensile set</u>** number which begins to address the recovery aspect of *Elastomeric Properties* but, there is little guidance on how to create a valid number for fluid applied membranes.

What is an Elastomer?

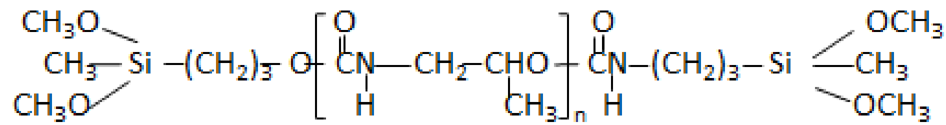


- A polymer that deforms under stress and returns to its original shape when stress is removed.
- For coatings, Elastomeric character is generally defined as 95–100% recovery at 100% elongation.
- Electrostatic Forces play a role in recovery characteristics of the elastomer.

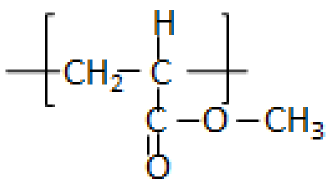
Example Chemistries



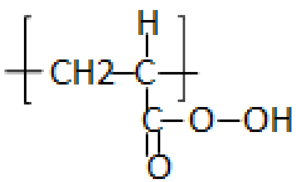
STPE



STPU

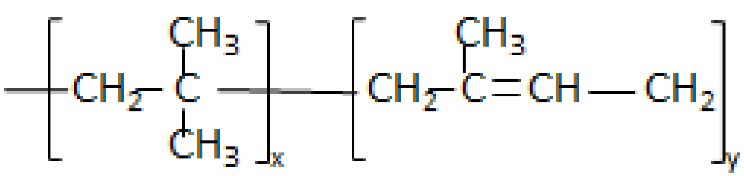


MA



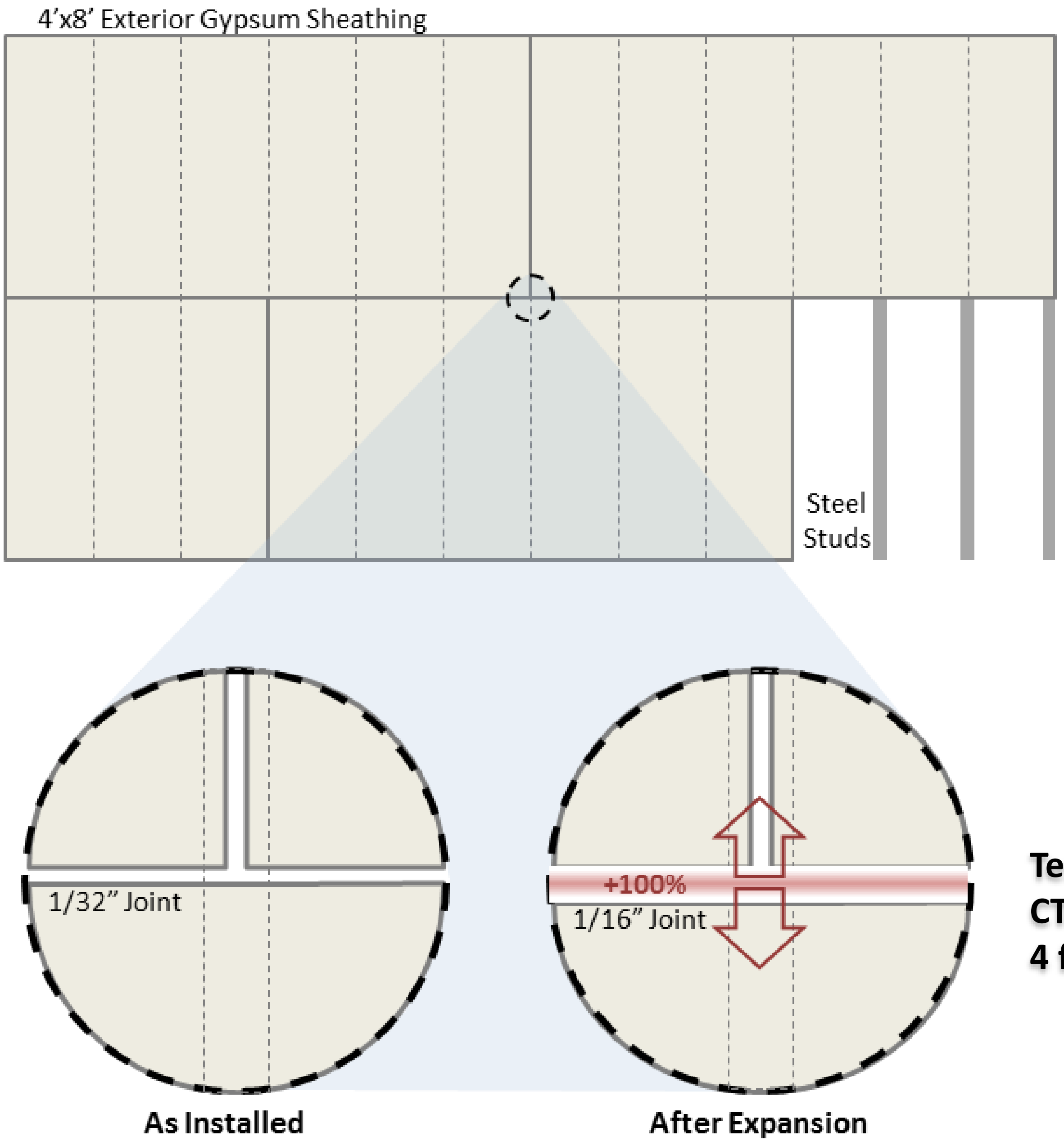
MAA

Acrylic



Butyl Rubber
Isobutylene and isoprene

Expansion / Contraction on a Building

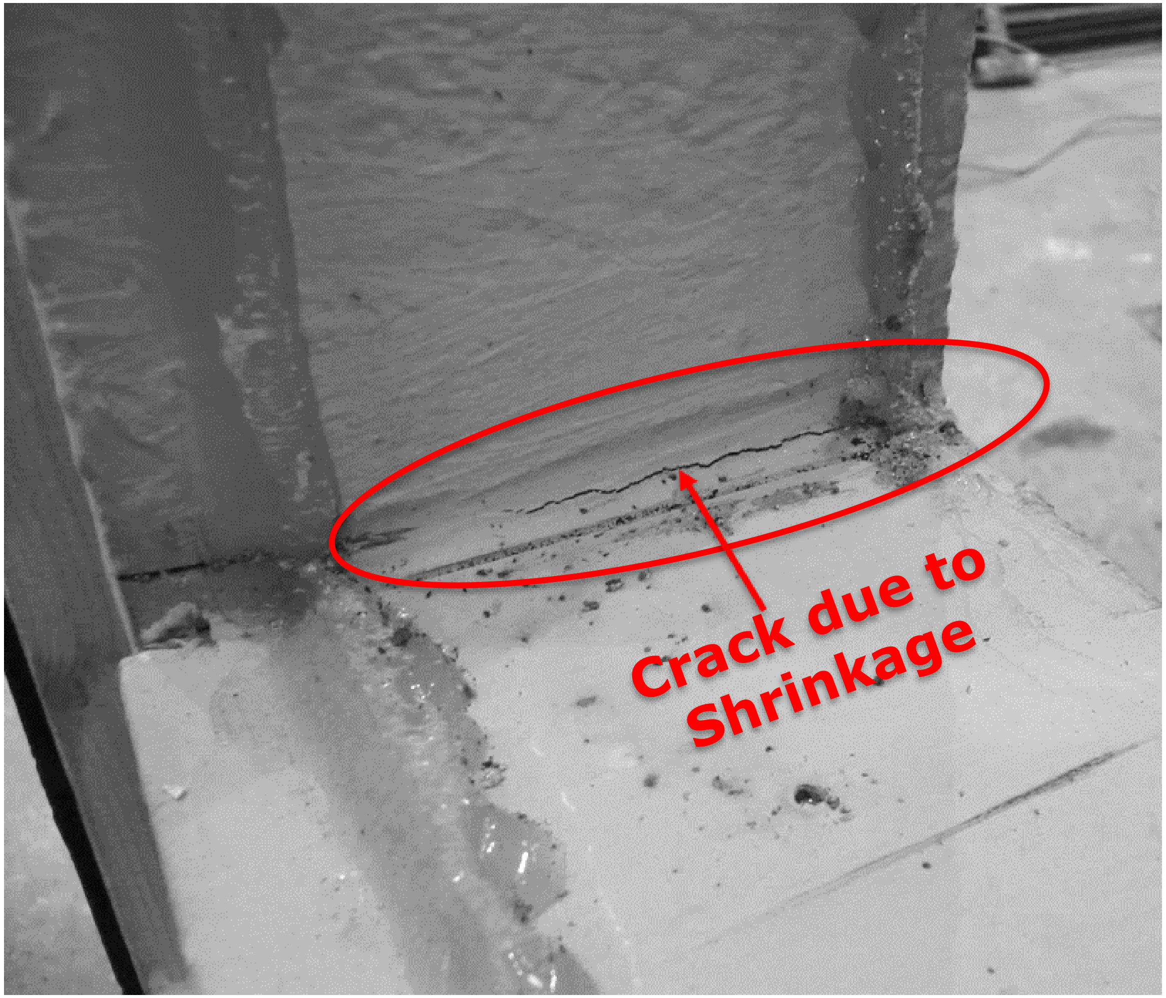


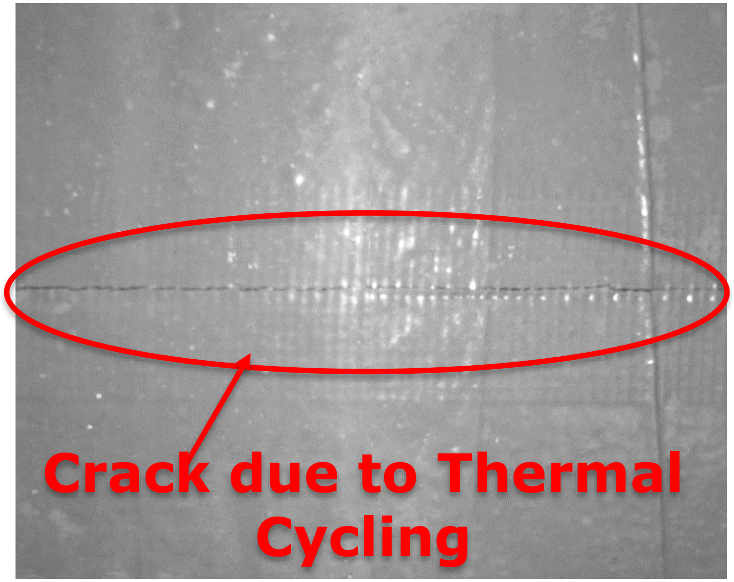
$$dL = L_o \, \alpha \, (t_1 - t_o)$$

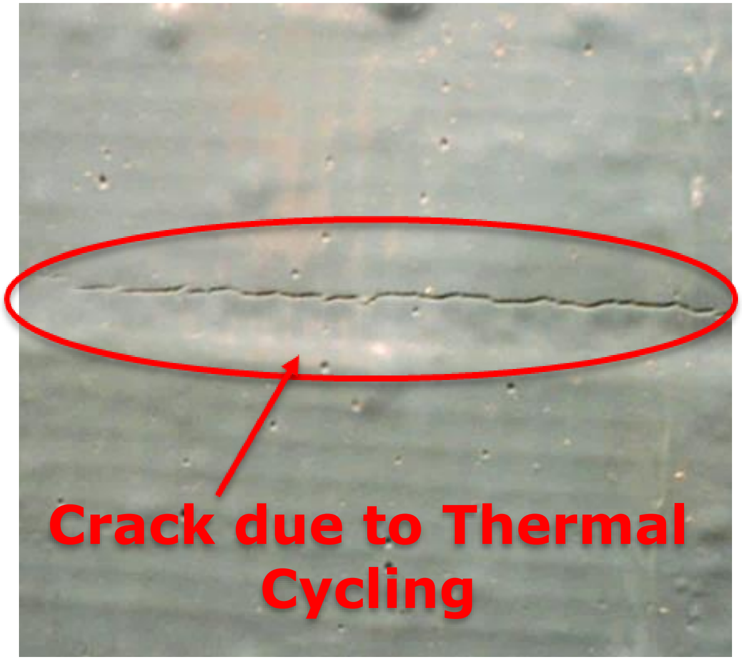
dL	=	change in length
L_o	=	initial length
α	=	coefficient of thermal expansion
t_1	=	initial temperature
t_o	=	final temperature

Temperature from 0 – 100 deg F.
CTE of Steel – 8.0 X 10-6 in/in-deg. F
4 foot Steel Stud

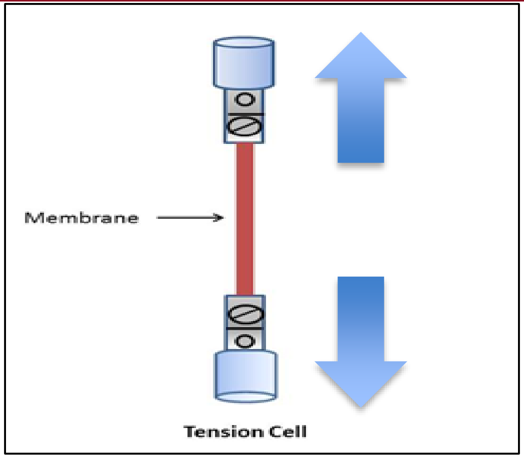
Cracking due to Dimensional Instability

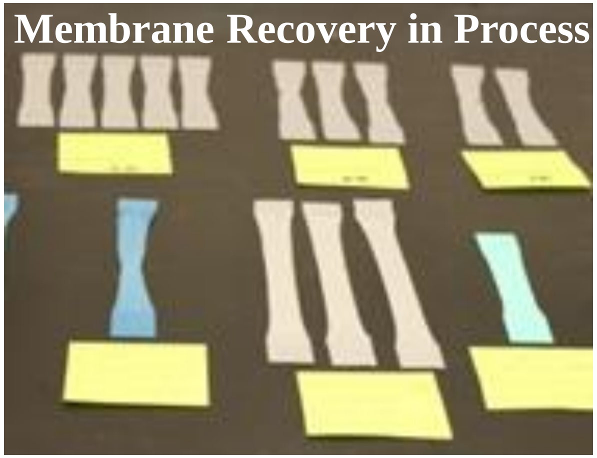






Experimental





Room Temp. Instron

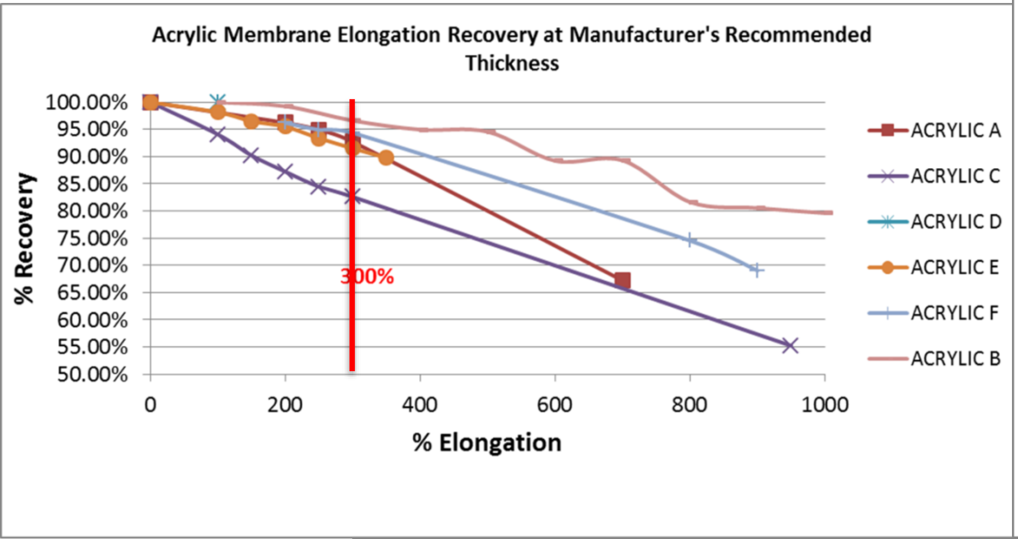
Elevated Temp. Instron

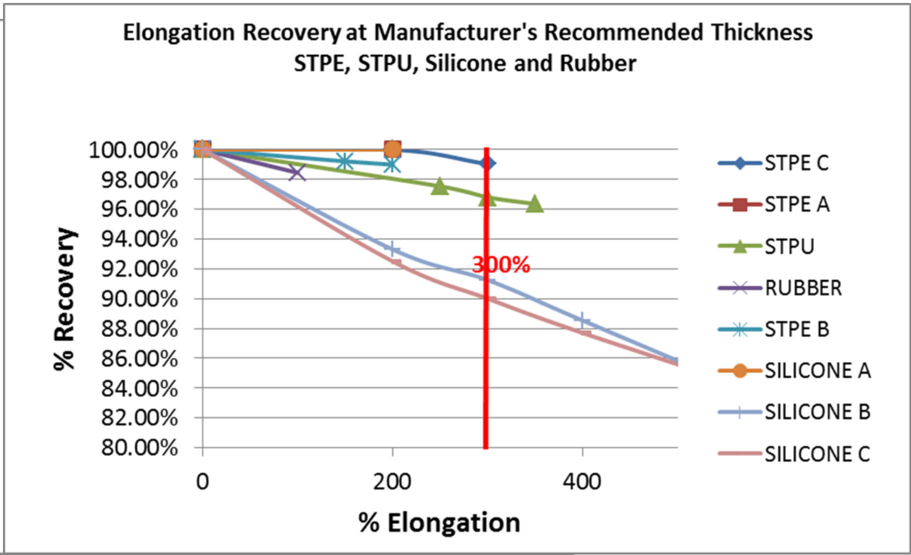
Thermal Mechanical Analysis (TMA)

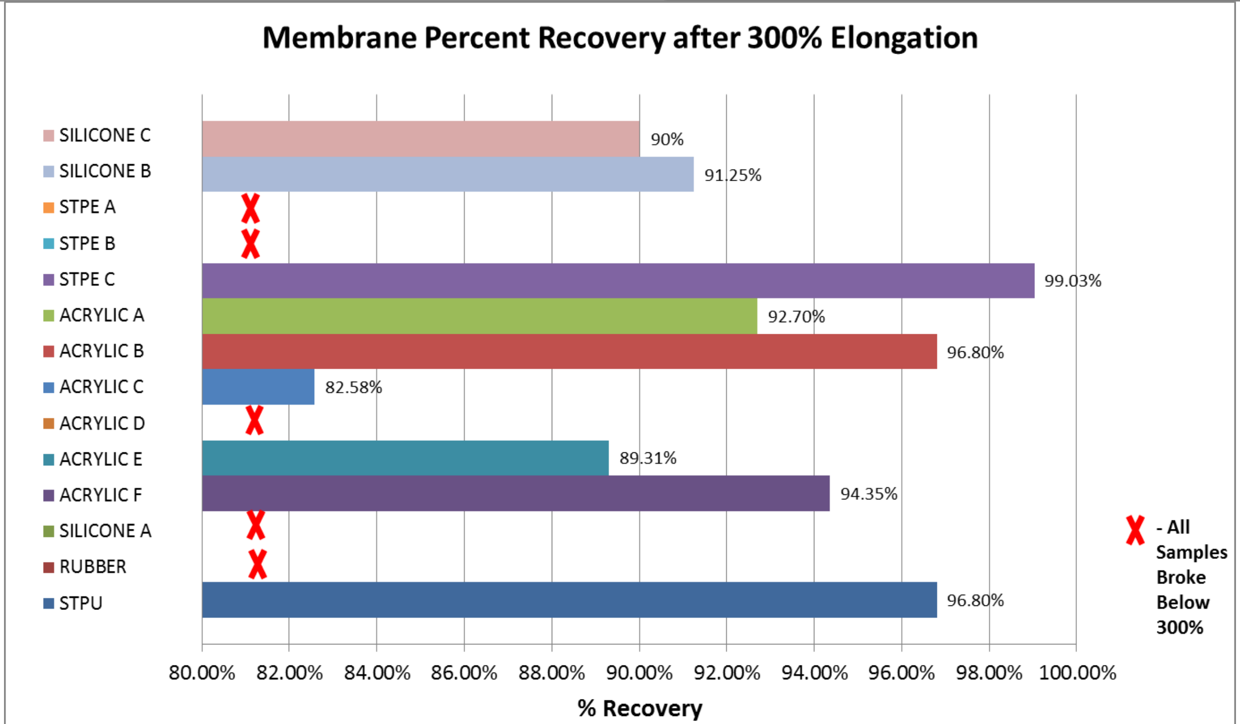
Products

Recommended Thickness and Chemistry for Each Competitive Sample		
Sample ID	**Wet Thickness Mils**	**Polymer Chemistry**
STPE A	26	Silyl Terminated Polyether
STPE B	12	Silyl Terminated Polyether
STPE C	25	Silyl Terminated Polyether
ACRYLIC A	60	Acrylic
ACRYLIC B	70	Acrylic
ACRYLIC C	60	Acrylic
ACRYLIC D	10	Acrylic
ACRYLIC E	68	Acrylic
ACRYLIC F	90	Acrylic
SILICONE	26	Silicone
RUBBER	10	Rubber
STPU	12	Silyl Terminated Polyurethane

Elongation and Recovery at Room Temperature





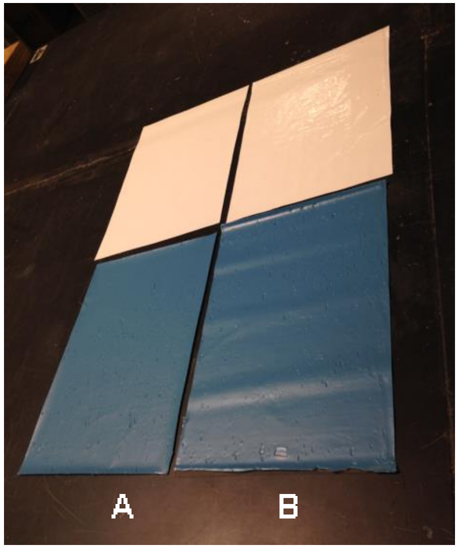


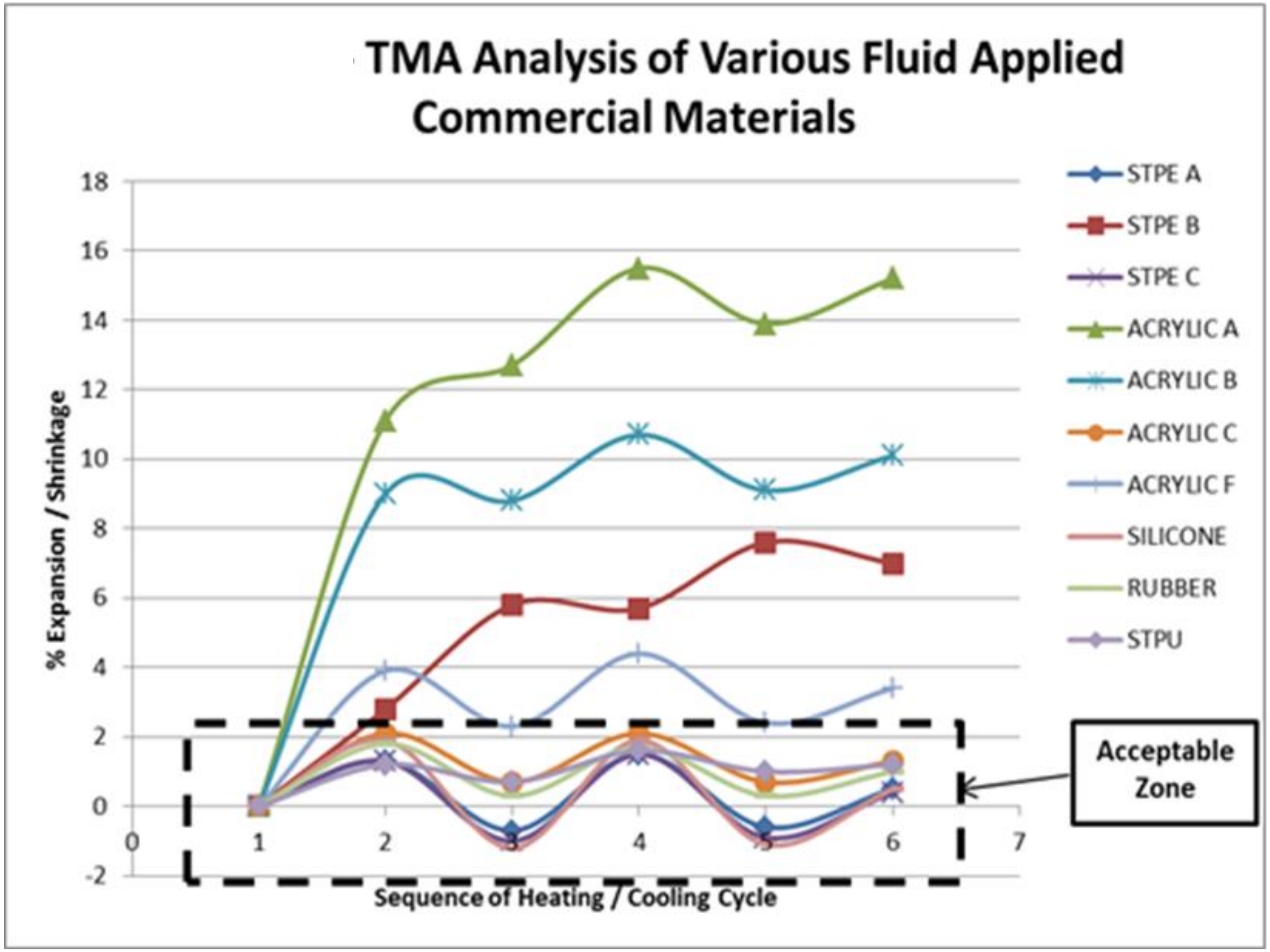
Measured Elongation to Break at Room Temperature and Heated in the Environmental Chamber				
Sample ID	Thickness (mils)	Elongation to Break* (70 F)	Elongation to Break* (180 F)	Percent Loss of Elongation at 180 F
STPE A	26	300%	150%	50%
STPE B	12	250%	135%	46%
STPE C	25	350%	230%	34%
ACRYLIC A	50	750%	40%	95%
ACRYLIC B	60	1000%	>300%	N/A**
ACRYLIC C	60	950%	210%	78%
ACRYLIC D	14	76%	N/A	N/A
ACRYLIC E	60	450%	250%	44%
ACRYLIC F	70	950%	250%	74%
SILICONE	24	250%	250%	0%
RUBBER	10	150%	30%	80%
STPU	12	400%	>300%	N/A**
* Method per discussed in the experimental section				
** Environmental Chamber only allows for a 300% elongation to break				

Elongation Recovery at Elevated and Room Temp.

Since heating causes elastomeric polymer chains to contract, stretching of fluid applied membranes under a heat load should result in a lower elongation to break. --> 200%

Thermal Mechanical Analysis Cycling of Competitive Fluid Applied Membranes.						
Sample ID	Initial Measurement	180 Deg F First Cycle	Neg. 20 deg. F First Cycle	180 Deg F Second Cycle	Neg. 20 deg. F Second Cycle	75 Degrees F Second Cycle
	Sequence 1	Sequence 2	Sequence 3	Sequence 4	Sequence 5	Sequence 6
	% Expansion / Shrinkage	% Expansion / Shrinkage	% Expansion / Shrinkage	% Expansion / Shrinkage	% Expansion / Shrinkage	% Expansion / Shrinkage
STPU	0	1.2	0.7	1.6	1	1.2
STPE C	0	1.3	-1	1.5	-0.9	0.4
STPE A	0	1.3	-0.7	1.5	-0.6	0.5
ACRYLIC A	0	11.1	12.7	15.5	13.9	15.2
SILICONE	0	1.9	-1.2	1.9	-1.1	0.5
ACRYLIC C	0	2.1	0.7	2.1	0.7	1.3
RUBBER	0	1.8	0.3	1.7	0.3	1
ACRYLIC F	0	3.9	2.3	4.4	2.4	3.4
ACRYLIC B	0	9.0	8.8	10.7	9.1	10.1
STPE B	0	2.8	5.8	5.7	7.6	7

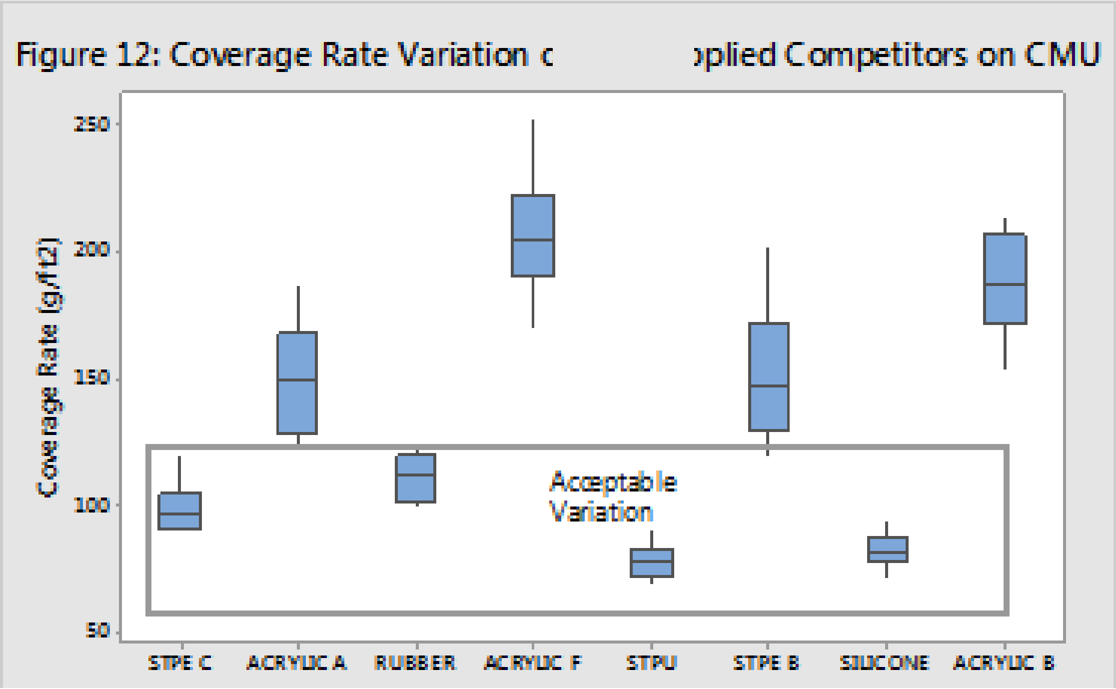


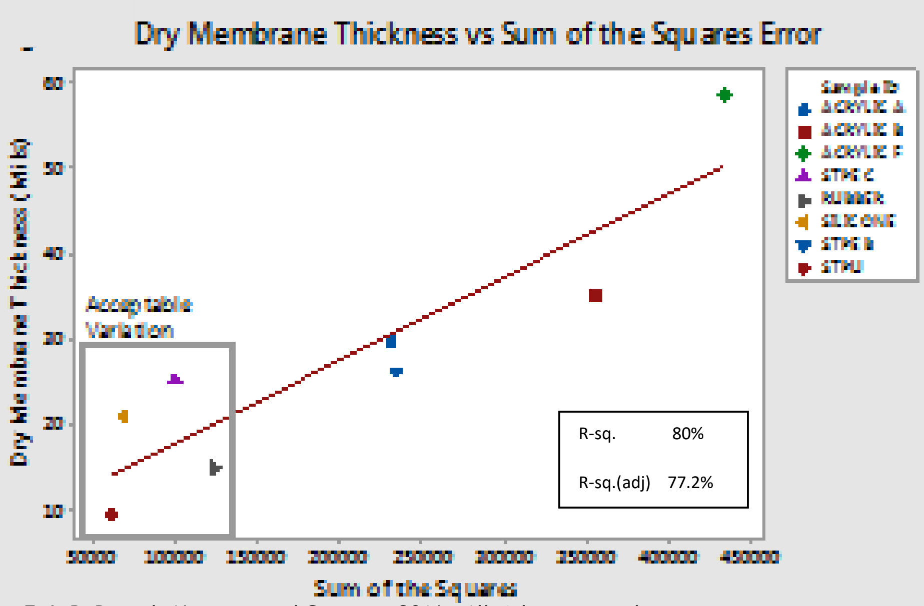


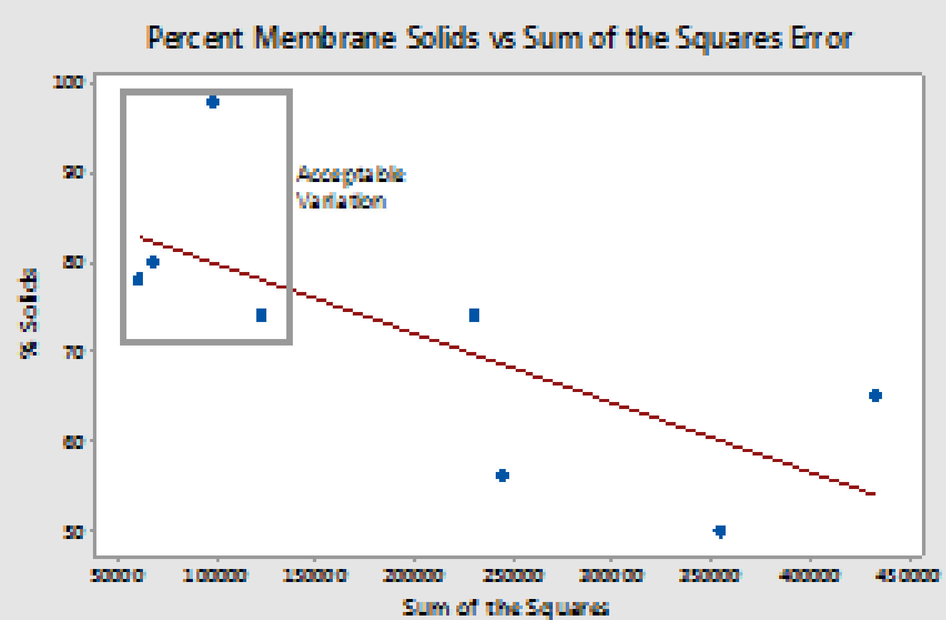
: Fluid Applied drawdowns at manufacturer's recommended thickness onto 75 gauge PET film. Blue is "Acrylic A" and White is "STPE C."
A – Room temperature. B – Heated to 180 degrees F for 10 minutes.

Coverage Rate Studies

Coverage Rate Comparisons







Conclusions

Summation of Property Contrasts When Comparing all Competitive Fluid Applied Products								
Sample ID	Wet Thickness Mils*	Perms E96 Method B*	Polymer Chemistry	TMA Analysis**	Sum of the Squares***	% Loss of Elongation to Break from RT to 180 F.	> 99% Recovery at 300% Elongation at RT	> 99% Recovery at 200% Elongation at 180 F
STPE A	26	32	Silyl Terminated Polyether	PASS	N/A	50%	FAIL	N/A
STPE B	12	18	Silyl Terminated Polyether	FAIL	FAIL	46%	FAIL	FAIL
STPE C	25	25	Silyl Terminated Polyether	PASS	PASS	34%	PASS	PASS
ACRYLIC A	60	14	Acrylic	FAIL	FAIL	95%	FAIL	FAIL
ACRYLIC B	70	12	Acrylic	FAIL	FAIL	N/A	FAIL	FAIL
ACRYLIC C	60	12	Acrylic	PASS	N/A	78%	FAIL	FAIL
ACRYLIC D	10	10	Acrylic	N/A	N/A	N/A	FAIL	FAIL
ACRYLIC E	68	15	Acrylic	N/A	N/A	44%	FAIL	FAIL
ACRYLIC F	90	21	Acrylic	FAIL	FAIL	74%	FAIL	FAIL
SILICONE	26	6	Silicone	PASS	PASS	0%	FAIL	PASS
RUBBER	10	18	Rubber	PASS	PASS	80%	FAIL	FAIL
STPU	12	13	Silyl Terminated Polyurethane	PASS	PASS	N/A	FAIL	FAIL

* From Manufacturer's Datasheet Accessed in November 2015

** A zone of acceptable dimensional stability was defined to range from +/- 2%.

*** Membrane groupings which had sum of the squares error variations of less than 150,000 were defined as acceptable.

Conclusions

The results confirm:

- Polymers with a high ultimate elongation will not necessarily translate to improved elastomeric character over a broader dynamic range.
- Materials displaying a high elongation with good elastic recovery will exhibit those same qualities over a broad dynamic range.
- Elongation to break is only one small fragment of the property puzzle when evaluating and comparing fluid applied membranes.
- Elastic recovery at a specific elongation is also a key component.

Questions?

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