Coatings Trends & Technologies SUMMIT

Silicone Resins
for Breathable, Long-Lasting Exterior Architectural Paint

Amanda (Dershem) Schmotzer

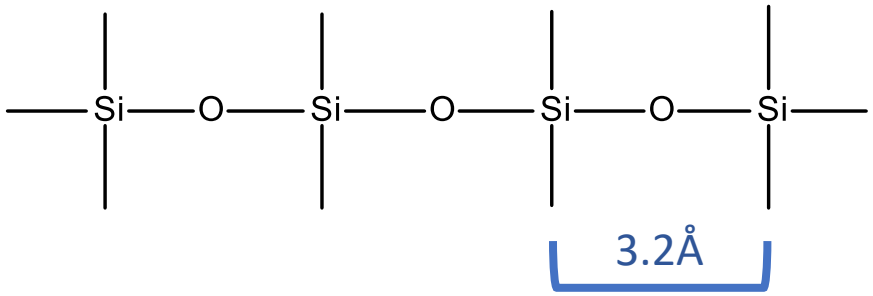
Chemist, Wacker Chemical Corporation

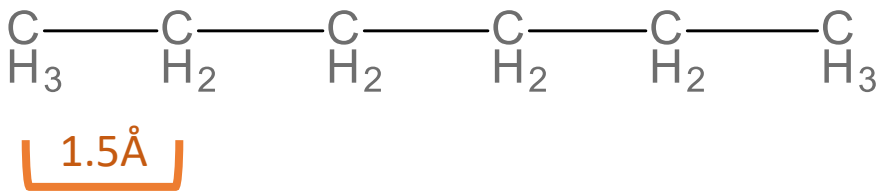
WACKER

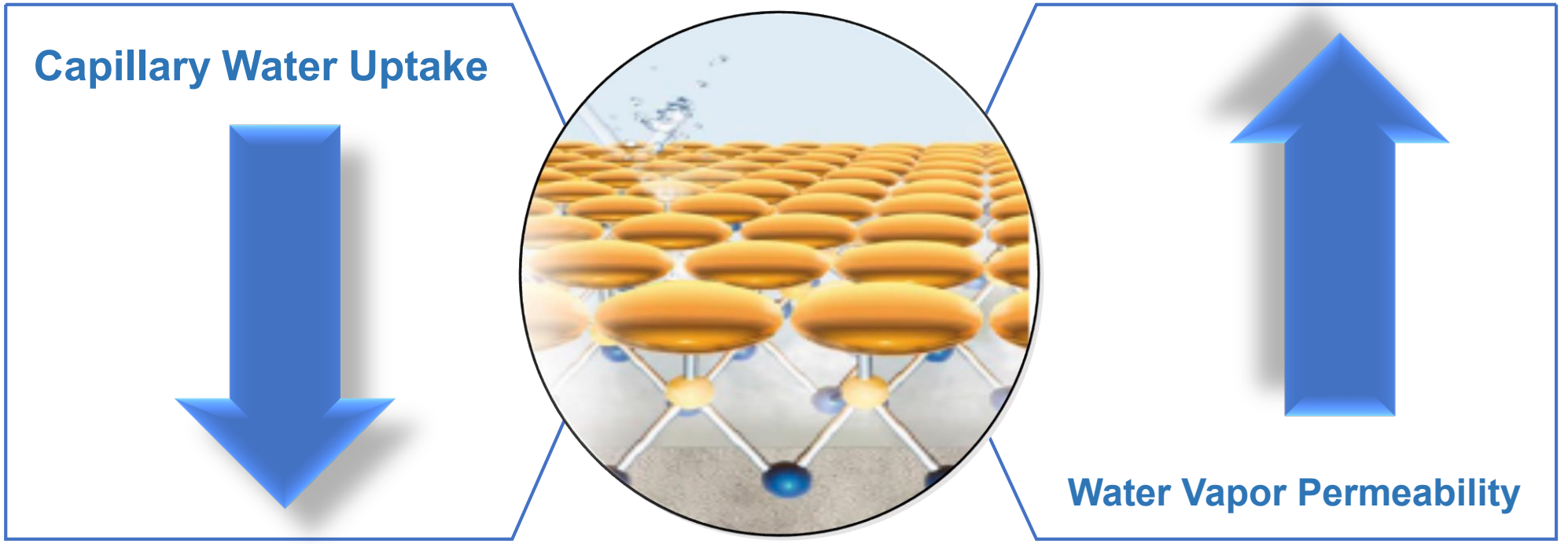
Agenda

1. **Background** – Mechanism for Silicone Breathability
2. **Study** – Silicone Resin in Architectural Coatings
3. **Conclusions** & Next Steps

Mechanism: Breathability & Hydrophobicity







Water-borne Architectural Paint

Water-borne Architectural Paint with silicone resin

Agenda

1. **Background** – Mechanism for Silicone Breathability
2. **Study** – Silicone Resin in Architectural Coatings
3. **Conclusions** & Next Steps

Testing

Tests/Methodology

Water Vapor Permeability
(ASTM D1653)

Water Absorbance

(Accelerated Weathering)

Contact Angle (water)

Objective

Investigate silicone resin performance against acrylic latex binders and silicone additives

Characteristics of Acrylics/Silicone

Label	Type	Intended use	Solids	MFFT
Acrylic A	acrylic	interior/exterior	50	15
Acrylic B	acrylic ester	exterior	50	14
Acrylic C	acrylic	premium grade	50	10
Acrylic D	styrene acrylic	masonry	50	20
S1	silicone	exterior	54	13
S2	silicone	exterior	60	19
S3	silicone additive	exterior	55	na

Commercial Paints		
Com1	Flat exterior	Premium
Com2	Flat exterior	Mid
Com3	Flat exterior	Value

Formulations

1: 30% PVC Formulation

DC010_015_P30	30% PVC ppw (g)
Water	29
Dispersant	0.2
Dispersant	0.2
Biocide	0.3
pH modifier	0.4
HMHEC thickener	0.1
Defoamer	0.3
Co-Solvent	1
TiO_2	12
$CaCO_3$	10.5
Talc	5
Total Grind:	59.0
Silicone Resin / Acrylic	34
Silicone additive or water	3
High Shear modifier	4
Total Let-Down	41.0
Total	**100.0**

2: 60% PVC Formulation

DC010_015_P60	60% PVC ppw (g)
Water	27.65
Dispersant	0.2
Dispersant	0.2
Biocide	0.3
pH modifier	0.1
HMHEC thickener	0.25
Defoamer	0.3
Co-Solvent	1
TiO_2	12
$CaCO_3$	21
Talc	10
Total Grind:	73.0
Silicone Resin / Acrylic	20
Silicone additive or water	3
High Shear modifier	4
Total Let-Down	27.0
Total	**100.0**

3: 30% PVC Formulation
with alternate filler

4: 60% PVC Formulation
with alternate filler

	Acrylic	Resin as Additive	Silicone/Acrylic	Silicone Resin	Silicone Additive
S1 or S2	0	3	10	20	0
Acrylic A, B, C or D	20	20	10	0	20
S3 additive	0	0	0	0	3
Water	3	0	3	3	0

Testing

Tests/Methodology

Water Vapor Permeability
(ASTM D1653)

Water Vapor Permeability
(wet cup)

1. 3mL initial coat on PE frit
2. 2mL second and third coats, all dried 24hrs between coats
3. Cure for 7days @RT, 55%RH
4. Secure frits in perm cups filled with 300g DI water
5. Weigh cups at same time each day until 4 consecutive linear points established (or 3 weeks)

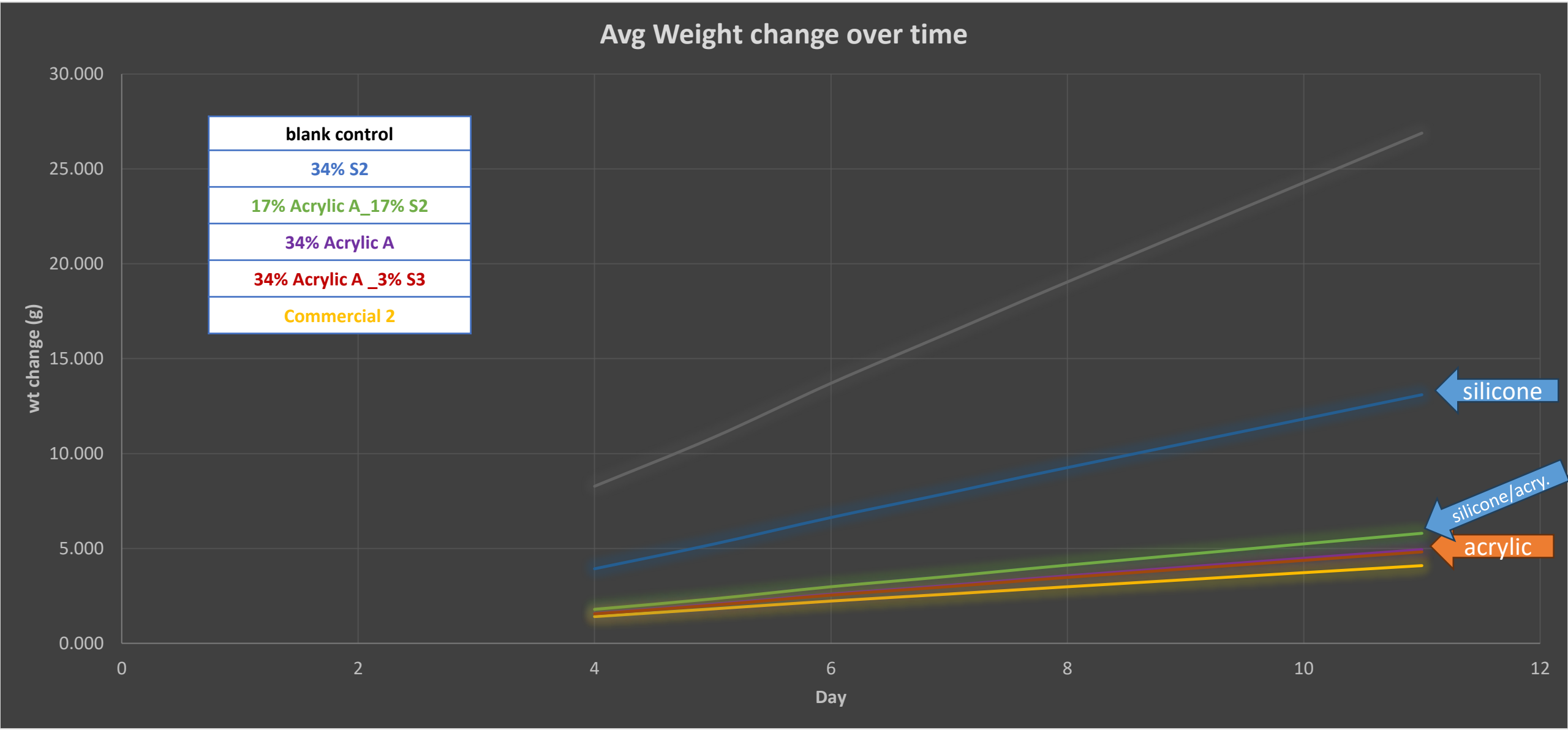
Water Vapor Transmission: Acrylic A

1: 30% PVC Formulation **2: 60% PVC Formulation** **3: 30% PVC Formulation** with alternate filler **4: 60% PVC Formulation** with alternate filler

Label	Type	Intended use	Solids	MFFT
Acrylic A	acrylic	interior/exterior	50	15
Acrylic B	acrylic ester	exterior	50	14
Acrylic C	acrylic	premium grade	50	10
Acrylic D	styrene acrylic	masonry	50	20
S1	silicone	exterior	60	19
S2	silicone	exterior	54	13
S3	silicone additive	exterior	55	na

Commercial Paints		
Com1	Flat exterior	Premium
Com2	Flat exterior	Mid
Com3	Flat exterior	Value

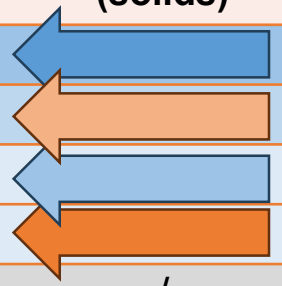
Water Vapor Transmission: Acrylic A



Applied 3 coats of 2.5mL (24hrs between coats) on PE chromatography frits. dried in humidity-controlled lab 7 days before test

Water Vapor Transmission

	WVT Rate		WVP		% Silicone (solids)
	grains/ft² per hr	g/m² per 24hr	Perms	Metric Perms	
34% S2	11.46	8.00	6.10	0.17	
17% Acrylic A_17% S2	5.08	3.54	2.70	0.07	
34% Acrylic A _3% S3	4.22	2.94	2.24	0.06	
34% Acrylic A	4.32	3.02	2.30	0.06	
Commercial 2	3.58	2.50	1.91	0.05	n/a
blank control	23.53	16.41	12.52	0.35	n/a



	Avg Wt Loss 11 Days	Standard Deviation 11 Days	Std as % of wt loss
34% S2	13.10	0.56	4.27
17% Acrylic A_17% S2	5.80	0.33	5.61
34% Acrylic A _3% S3	4.82	0.72	14.96
34% Acrylic A	4.94	0.23	4.58
Commercial 2	4.10	0.11	2.59
blank control	26.89	0.45	1.66

- Silicone resin outperforms standard acrylic
- Silicone additive has little effect on permeability, as expected
- 50/50 blend of silicone resin/acrylic performs better than acrylic alone

Water Vapor Transmission: Acrylic B

1: 30% PVC Formulation

2: 60% PVC Formulation

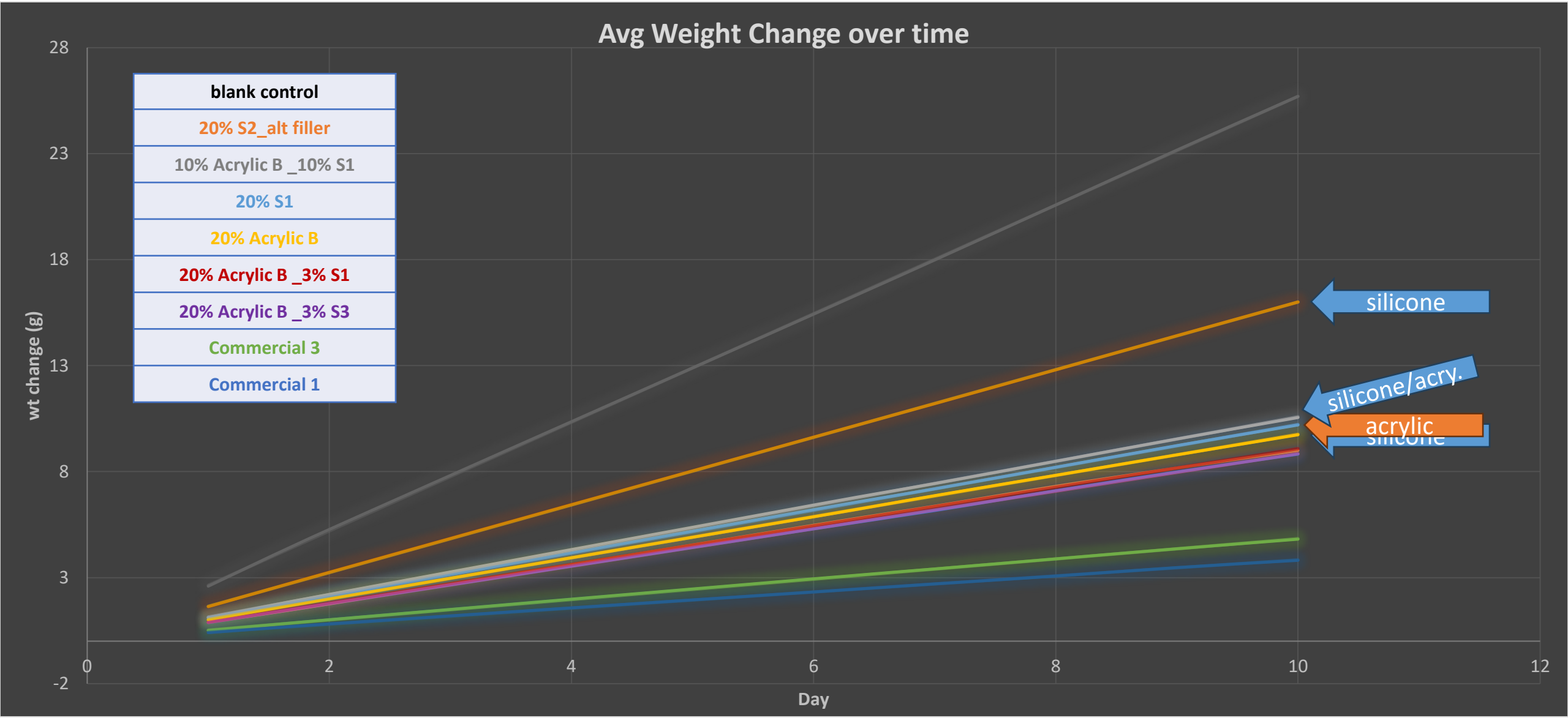
3: 30% PVC Formulation with alternate filler

4: 60% PVC Formulation with alternate filler

Label	Type	Intended use	Solids	MFFT
Acrylic A	all acrylic	interior/exterior	50	15
Acrylic B	acrylic ester	exterior	50	14
Acrylic C	all acrylic	premium grade	50	10
Acrylic D	styrene acrylic	masonry	50	20
S1	silicone	exterior	60	19
S2	silicone	exterior	54	13
S3	silicone additive	exterior	55	na

Commercial Paints		
Com1	Flat exterior	Premium
Com2	Flat exterior	Mid
Com3	Flat exterior	Value

Water Vapor Transmission: Acrylic B



Applied 3 coats of 2.5mL (24hrs between coats) on PE chromatography frits. dried in humidity-controlled lab 7 days before test

Water Vapor Transmission

	WVT Rate		WVP		% Silicone (solids)
	grains/ft² per hr	g/m² per 24hr	Perms	Metric Perms	
20% S2_alt filler	15.40	10.75	8.19	0.23	11
20% S1	9.38	6.54	4.99	0.14	12
10% Acrylic B_10% S1	10.16	7.09	5.40	0.15	6
20% Acrylic B_3% S1	8.66	6.04	4.61	0.13	2
20% Acrylic B_3% S3	8.50	5.93	4.52	0.12	2
20% Acrylic B	9.82	6.85	5.22	0.14	0
Commercial 3 (value)	4.63	3.23	2.46	0.07	n/a
Commercial 1 (premium)	3.67	2.56	1.95	0.05	n/a
blank control	24.75	17.26	13.16	0.36	n/a

	Avg Wt Loss 10 Days	Standard Deviation 10 Days	Std as % of wt loss
20% Acrylic B	10.20	2.21	21.71
20% S2_alt filler	16.00	0.51	3.18
20% S1	9.74	0.03	0.29
10% Acrylic B_10% S1	10.55	0.51	4.83
20% Acrylic B_3% S1	9.00	0.30	3.30
20% Acrylic B_3% S3	8.82	0.59	6.65
Commercial 3 (value)	4.81	0.85	17.64
Commercial 1 (premium)	3.82	1.27	33.18
blank control	25.71	0.56	2.17

- Linear additive should have little/no effect on permeability

- Std of Acrylic sample is 22% of total wt change

Water Vapor Transmission: remove cup

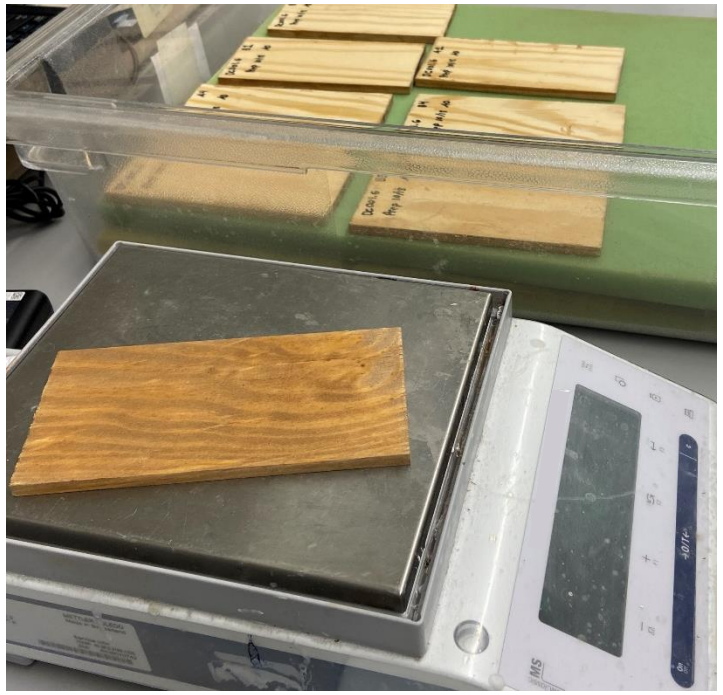
	WVT Rate		WVP		% Silicone (solids)
	grains/ft² per hr	g/m² per 24hr	Perms	Metric Perms	
20% S2_alt filler	15.40	10.75	8.19	0.23	11
20% S1	9.38	6.54	4.99	0.14	12
10% Acrylic B_10% S1	10.16	7.09	5.40	0.15	6
20% Acrylic B_3% S1	8.66	6.04	4.61	0.13	2
20% Acrylic B_3% S3	8.50	5.93	4.52	0.12	2
20% Acrylic B	8.31	5.80	4.42	0.12	0
Commercial 3 (value)	4.63	3.23	2.46	0.07	n/a
Commercial 1 (premium)	3.67	2.56	1.95	0.05	n/a
blank control	24.75	17.26	13.16	0.36	n/a

- Removal of suspected damaged perm cup
- Re-run perms to verify

Water Vapor Transmission: Acrylic C &D

Testing

Tests/Methodology



Water Absorbance

(Accelerated Weathering)

Water Uptake

1. 2 coats of paint on 3x6” southern yellow pine
2. Cure 7 days
3. Accelerated weathering for 500hrs (ASTM G154/D4587, UVA-340, 8hrs UV/4hrs Condensation)
4. Equilibrate to RT over 24hrs
5. Water baths filled (DI water) and equilibrated to RT (min. 1hr)
6. Weigh each panel, then place panels in random order face-down on sponge
7. After 24hrs sponge off excess water and reweigh
8. 24hr %Water Uptake calculated on total weight of substrate

Accelerated Weathering (QUV)

1: 30% PVC Formulation

2: 60% PVC Formulation

3: 30% PVC Formulation with alternate filler

4: 60% PVC Formulation with alternate filler

Label	Type	Intended use	Solids	MFFT
Acrylic A	acrylic	interior/exterior	50	15
Acrylic B	acrylic ester	exterior	50	14
Acrylic C	acrylic	premium grade	50	10
Acrylic D	styrene acrylic	masonry	50	20
S1	silicone	exterior	60	19
S2	silicone	exterior	54	13
S3	silicone additive	exterior	55	na

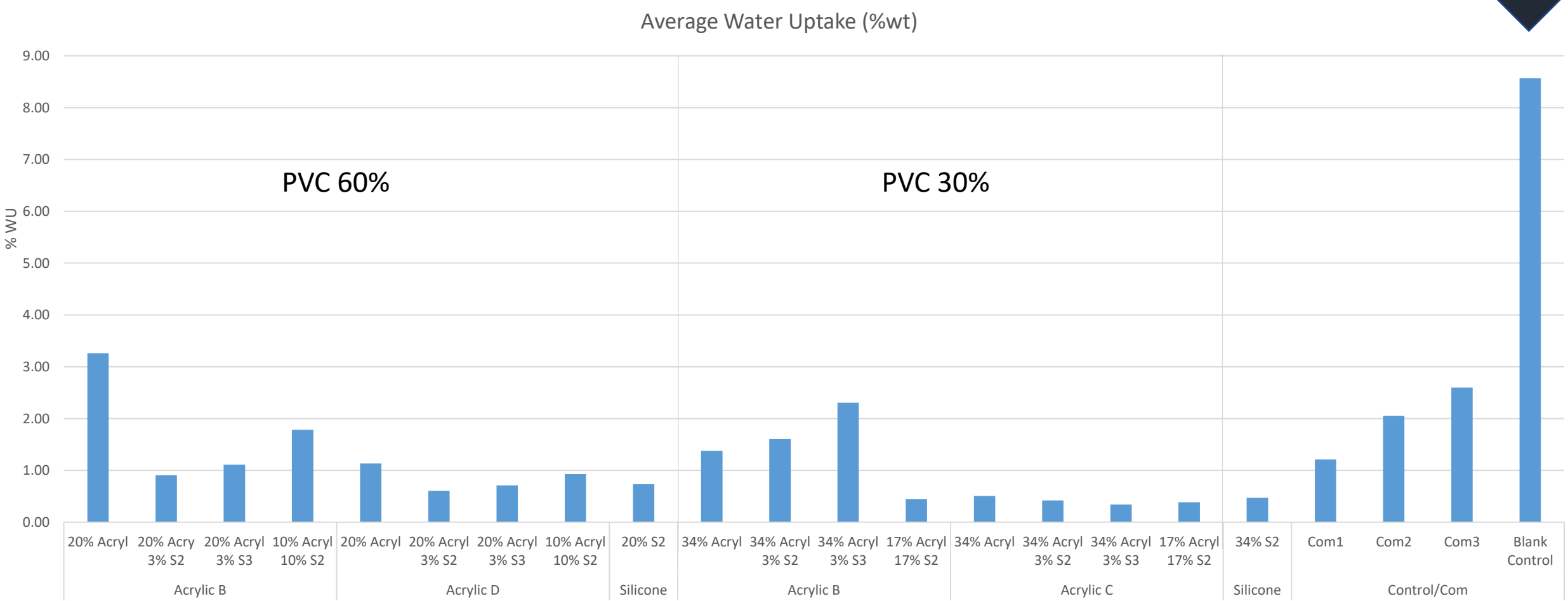
Commercial Paints		
Com1	Flat exterior	Premium
Com2	Flat exterior	Mid
Com3	Flat exterior	Value

Water Absorption (Water Uptake)

**% Water Uptake is the difference in weight aft 24hr soak divided by the initial weight of the substrate

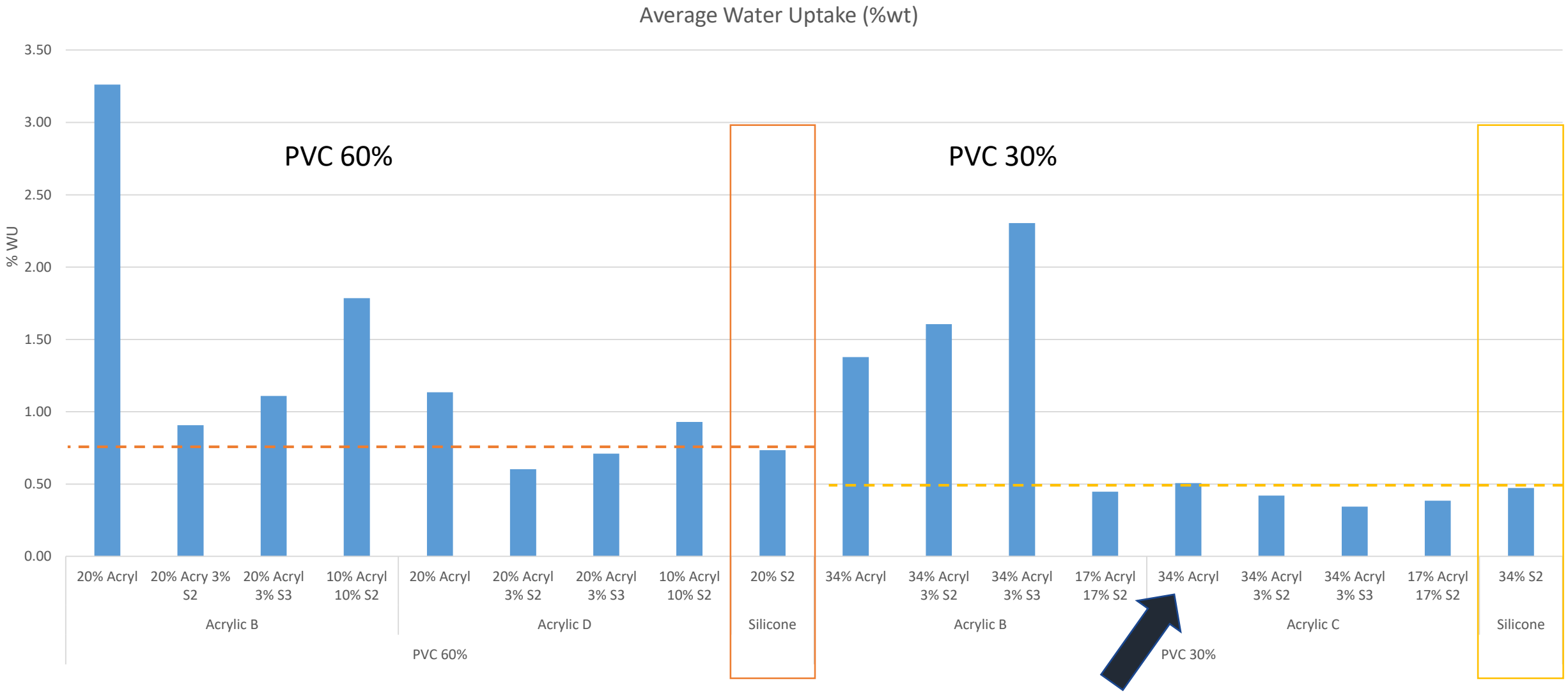
$$\%WU = \frac{wt_{24} - wt_i}{wt_i} \times 100$$

Lower is best!



Water Absorption (Water Uptake)

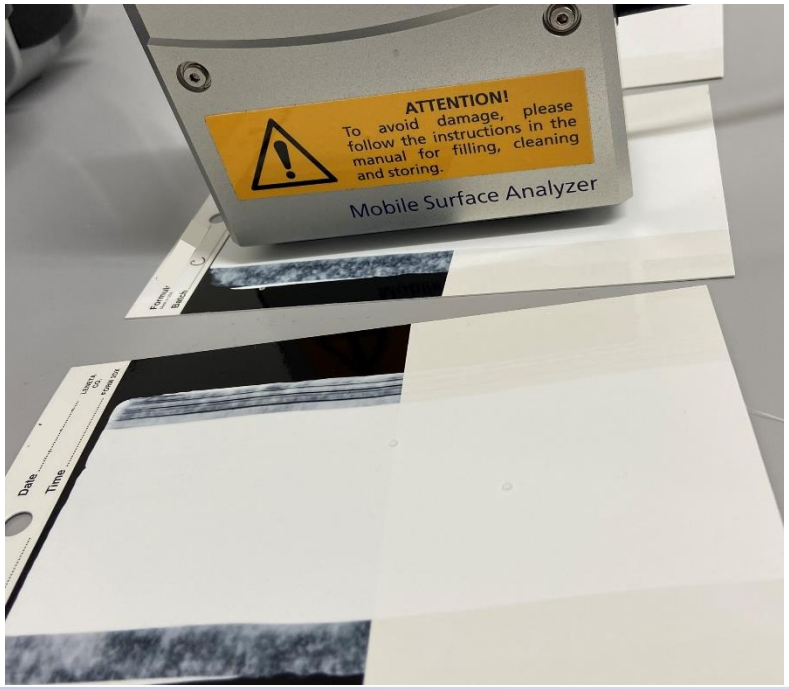
Lower is best!



Acrylic C (premium grade acrylic) is only acrylic that performed on par with silicone resin

Testing

Tests/Methodology



Contact Angle (water)

Contact Angle

1. 10mil (wet) drawdown on leneta cards in duplicate
2. Cure for 1 day
3. Measure contact angle of DI water using KRUSS Mobile Surface Analyzer on Sensile Double Drop method (OWRK)
4. Average three readings on each card, average both cards

Contact Angle

1: 30% PVC Formulation

2: 60% PVC Formulation

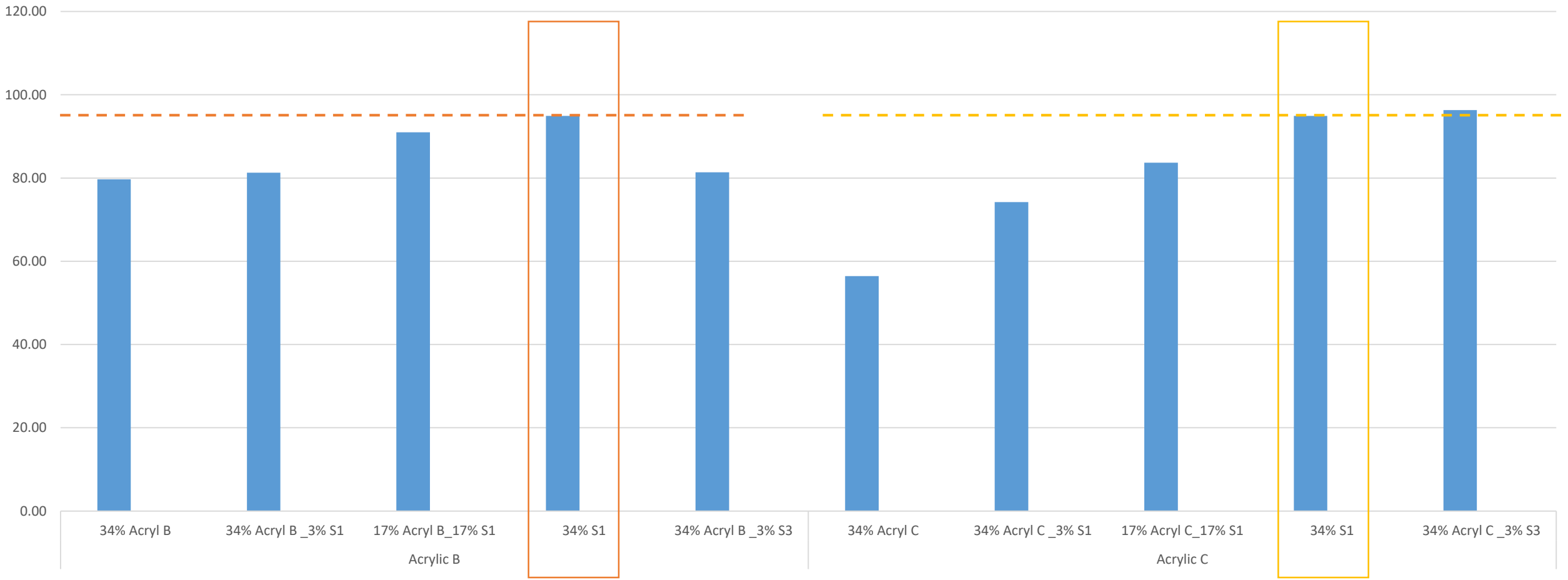
3: 30% PVC Formulation with alternate filler

4: 60% PVC Formulation with alternate filler

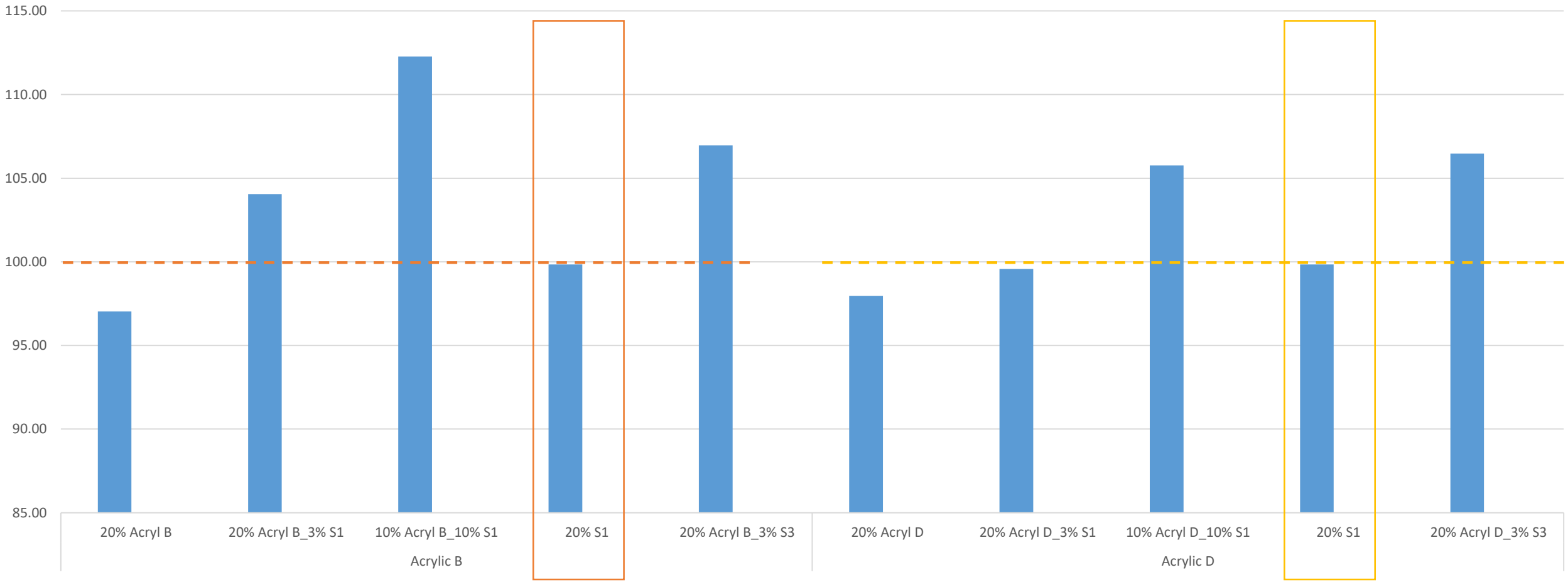
Label	Type	Intended use	Solids	MFFT
Acrylic A	acrylic	interior/exterior	50	15
Acrylic B	acrylic ester	exterior	50	14
Acrylic C	acrylic	premium grade	50	10
Acrylic D	styrene acrylic	masonry	50	20
S1	silicone	exterior	60	19
S2	silicone	exterior	54	13
S3	silicone additive	exterior	55	na

Commercial Paints		
Com1	Flat exterior	Premium
Com2	Flat exterior	Mid
Com3	Flat exterior	Value

Contact Angle – 30% PVC



Contact Angle – 60% PVC



Agenda

1. **Background** – Mechanism for Silicone Breathability
2. **Study** – Silicone Resin in Architectural Coatings
3. **Conclusions** & Next Steps

Conclusions & Next Steps

Conclusions

- Silicone resins outperformed Acrylic A & B:
  - water vapor perms
- Silicone resins outperformed Acrylic B & D:
  - lower water uptake
  - higher contact angle
- Silicone resins performed slightly better than Acrylic C:
  - lower water uptake
  - higher contact angle
- Silicone resin performed as expected vis a vis additives:
  - best in water vapor perms
  - better/similar in water uptake
  - mixed on contact angle (surface effects of additives)

Next Steps

- Water vapor permeability: silicone resin vs Acrylic C&D
- Additional testing: Acrylic A & S2
- Continued testing with aged/weathered coatings

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Thank you! Any Questions?

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and the **Wacker Analytical Team** for assistance with this project

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Silicone Resin Emulsion Paints: Tested on a "Living Object"

For us at WACKER, it's always exciting to see how our products actually perform in real life. Consider, for example, silicone resin emulsion paint, which was first patented in 1963. In 2003, our colleague Dr. Heinz Geich decided to paint the exterior walls of his house with it. What does that look like 20 years later? Let's have a look!

https://www.wacker.com/cms/en-us/insights/silicone-resin-paints-homestory.html

LUISENGYMNASIUM MUNICH APPLICATION IN 1990

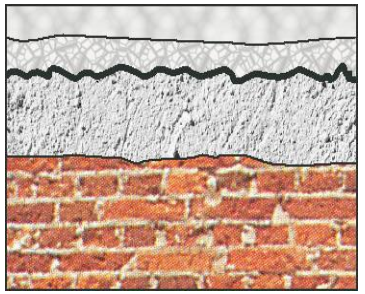
Age at Evaluation: 17 Years

Built:
1900

Location:
close to the central station on a dusty, dirty, heavily traveled street

Characteristic:
3-5mm thin lime slurry plaster, decorative gables were exposed to water

Evaluation 2007:
Excellent water proofing;
no frost damage



MUNICH-NEUPERLACH

APPLICATION IN 1988

Age at evaluation: 19 years

Built:

1960

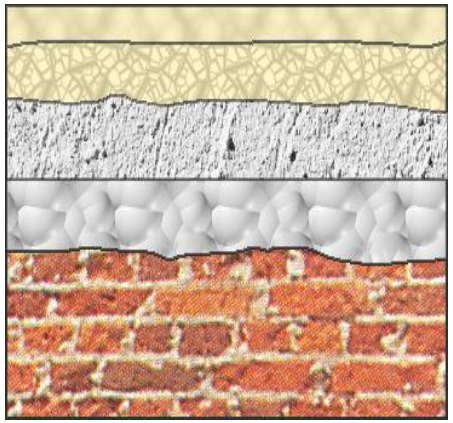
Location:
outskirts of the district,
very busy streets

Characteristic:

Concrete skeleton structure + brick infill, EIFS, mineral plaster

Evaluation 2007:

no microorganisms, good water repellency, no damage



Silicone Resin top coat
Silicone Resin first coat

Mineral plaster

Thermal Insulation System (EIFS)

Brickwork

MUNICH-FRÖTTMANING
APPLICATION IN 1975 / 1976

Age at Evaluation:
30 Years

Built:

1927

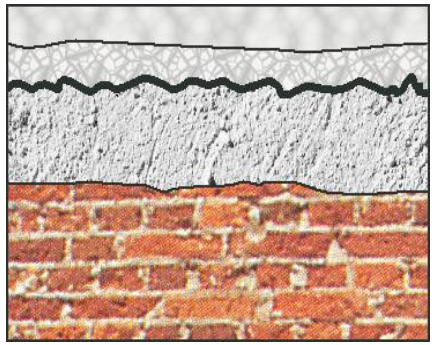
Location:
Close to the highway,
very dusty environment

Characteristic:

Brickwork with air lime mortar,
extremely rough plaster surface

Evaluation 2007:

Very good water repellency
excellent weather protection



Silicone Resin top coat
Silicone Resin first coat
Silicone primer

Hydrophobic slurry plaster

Brickwork

Label	Type	Intended use	Solids	Density	pH	Viscosity	MFFT	Particle Size
Acrylic A	all acrylic	interior/exterior	50	1.06	7.5-8.5	<500	15	120nm
Acrylic B	acrylic ester	exterior	50	1.06	7.5-9.5	600-1800	14	na
Acrylic C	all acrylic	premium grade	50	1.06	7.8-8.8	100-800	10	140 nm
Acrylic D	styrene acrylic	masonry	50	1.04	7.5-8.5	6000-8500	20	.1 um
S1	silicone	exterior	60	1.1	7	100		na
S2	silicone	exterior	54	1.04	5	1000	13	na
S3	silicone additive	exterior	55	1.0	6-7	~100	na	na

Accelerated Weathering (QUV)

Color & Gloss Readings

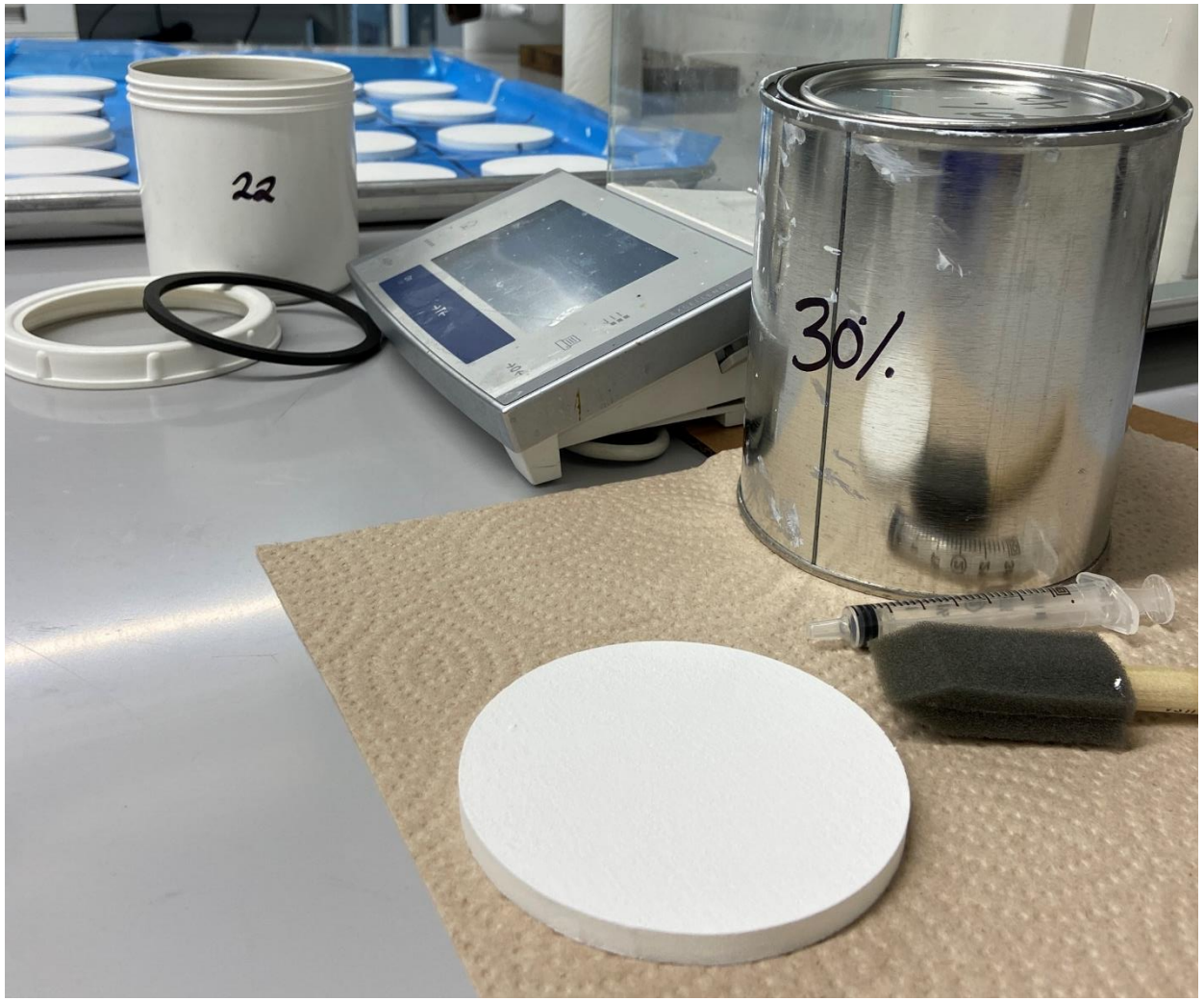
Color and Gloss readings taken before and after 500 hours of accelerated weathering (ASTM G154)

Test color gloss every 250hr interval after 500hrs

No significant change in color (ΔE) or gloss after 500 hours

	ΔE	ΔGloss (60°)
20% Acrylic B	0.17	0.45
20% Acrylic B_3% S1	0.25	1.08
10% Acrylic B_10% S1	0.19	0.28
20% Acrylic D	0.41	0.18
20% Acrylic D_3% S1	0.43	0.38
10% Acrylic D_10% S1	0.36	0.48
20% S1	0.12	0.02

Testing



Water Vapor Permeability
(wet cup)

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3. Cure for 7days @RT, 55%RH
4. Secure frits in perm cups filled with 300g DI water
5. Weigh cups at same time each day until 4 consecutive linear points established (or 3 weeks)

Water Vapor Transmission: remove cup

	WVT Rate		WVP		% Silicone (solids)
	grains/ft² per hr	g/m² per 24hr	Perms	Metric Perms	
20% S2_alt filler	15.40	10.75	8.19	0.23	11
20% S1	9.38	6.54	4.99	0.14	12
10% Acrylic B_10% S1	10.16	7.09	5.40	0.15	6
20% Acrylic B_3% S1	8.66	6.04	4.61	0.13	2
20% Acrylic B_3% S3	8.50	5.93	4.52	0.12	2
20% Acrylic B	11.32	7.90	6.02	0.17	0
Commercial 3 (mid)	4.63	3.23	2.46	0.07	n/a
Commercial 1 (premium)	3.67	2.56	1.95	0.05	n/a
blank control	24.75	17.26	13.16	0.36	n/a

- Performance of suspected damaged perm cup by its lonesome