



**ADVANCES IN SHELL ROOM
WITH ADBOND® QUIKSET™
FAST DRYING SHELL SYSTEM**

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YOUR CONCEPT TO CASTING PARTNER

INTRODUCTION

PRESENTATION OUTLINE

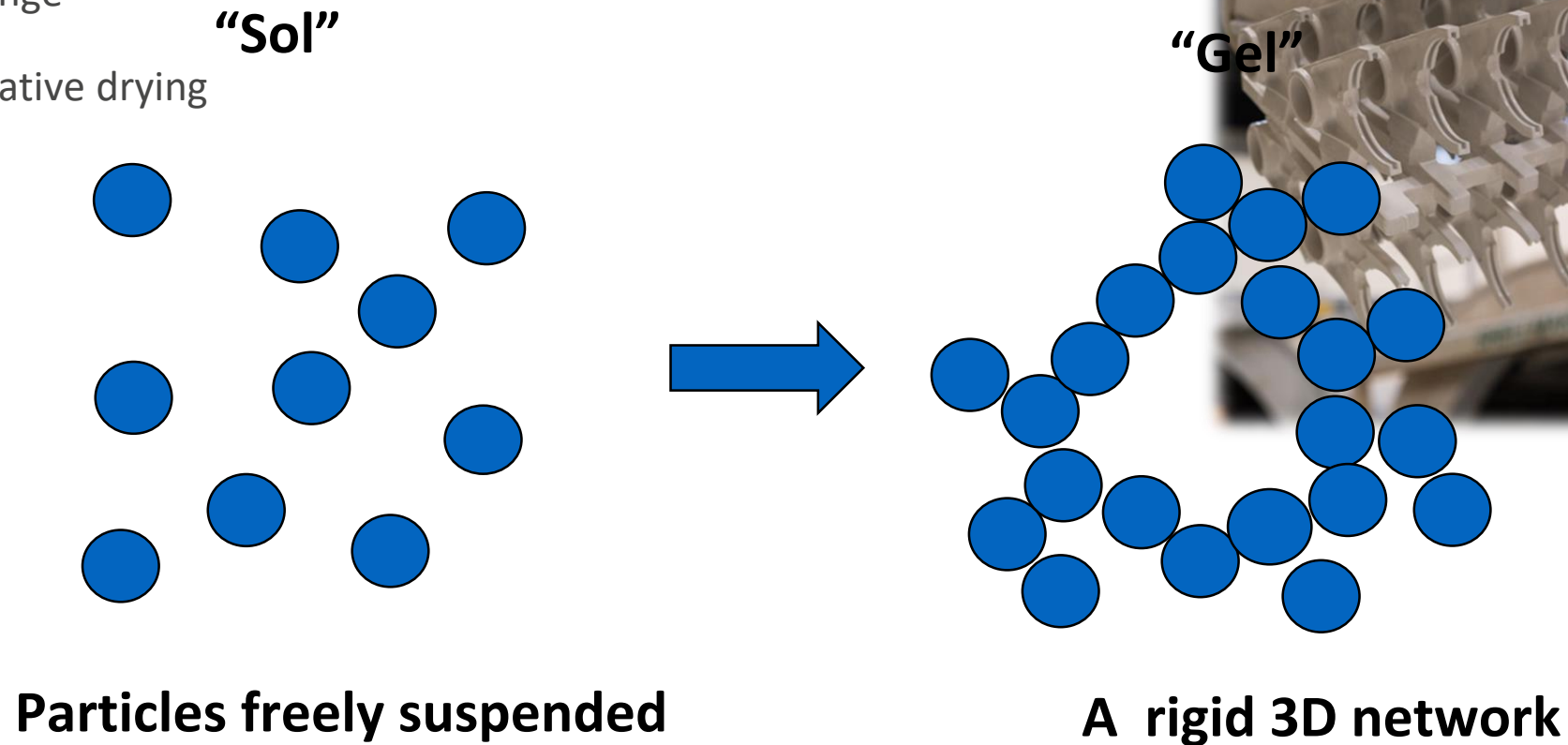
- Introduction
- Colloidal Chemistry - Drying
- Polymer improvements
- QuikSet
- Testing
- Trials
- Conclusion



COLLOIDAL CHEMISTRY

SHELL SYSTEM DRYING

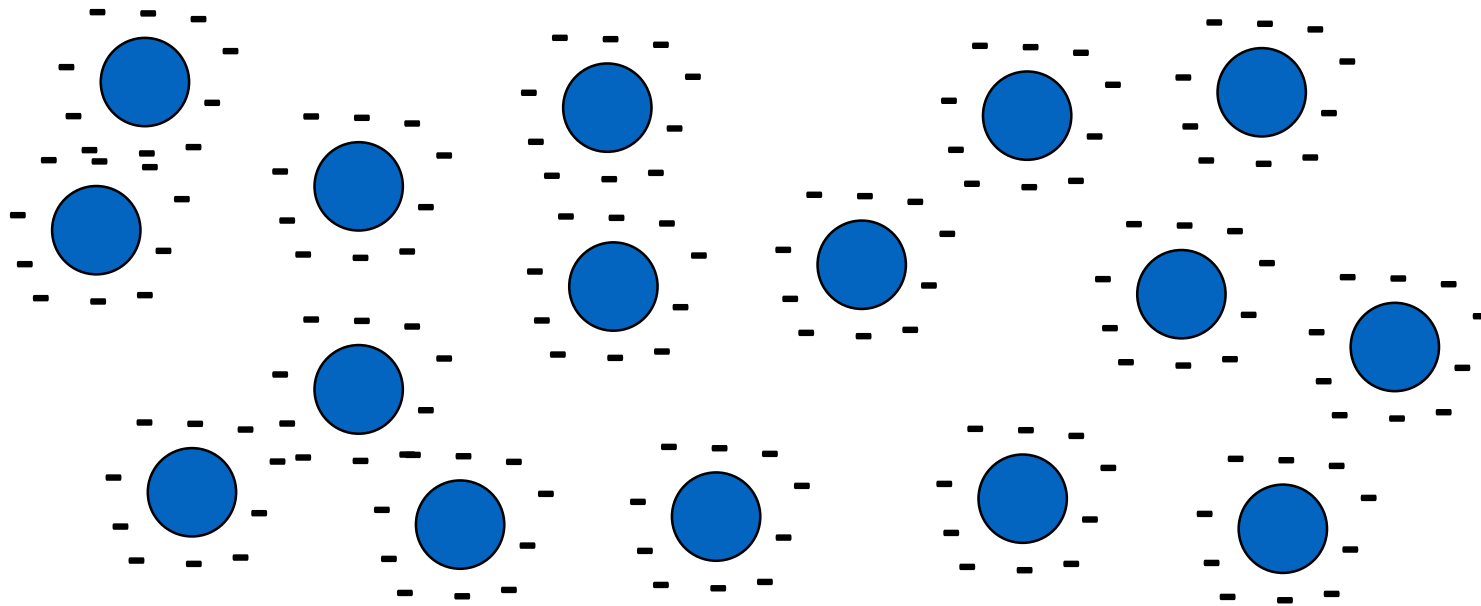
- The process of transforming a liquid of freely suspended particles to a 3D rigid network
 - pH change
 - Evaporative drying



COLLOIDAL CHEMISTRY

COLLOIDAL STABILITY

The silica particles repel each other

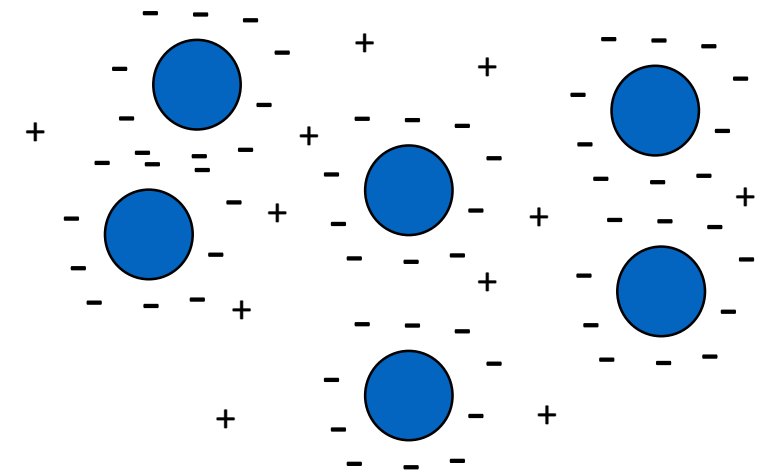


They all carry the same charge

COLLOIDAL CHEMISTRY

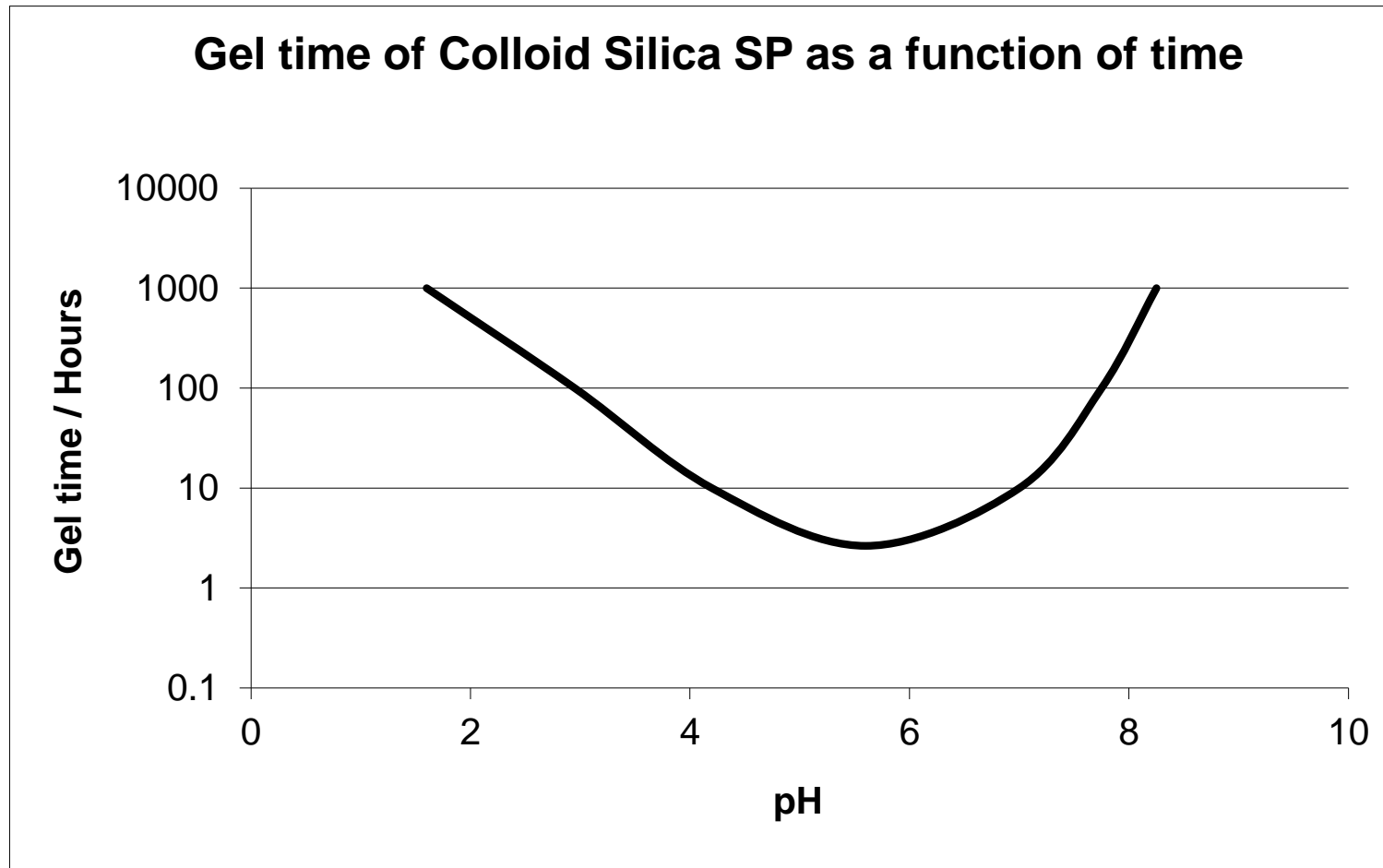
THE IMPORTANCE OF PH

- You can't have a sol full of -ve particles
- It is balanced by Na^+ (Typically 0.5% - added as NaOH)
- pH is measure of how many free H^+ ions are in a liquid
- pH is a measure of how electronically stable the sol is
- pH is the mechanism by which stability is maintained



COLLOIDAL CHEMISTRY

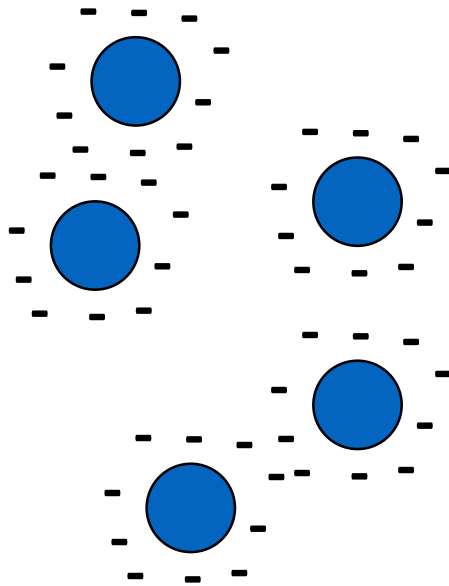
STABILITY: PH & TIME



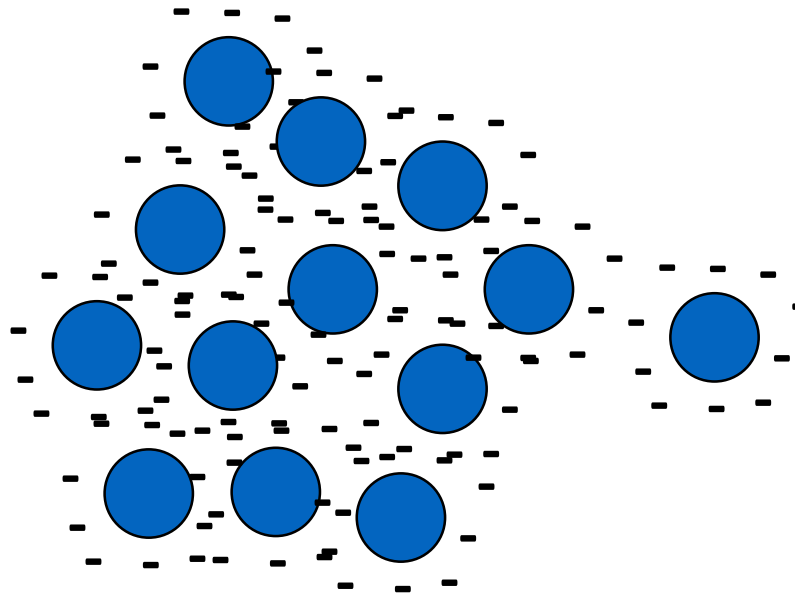
COLLOIDAL CHEMISTRY

EVAPORATION PROCESS

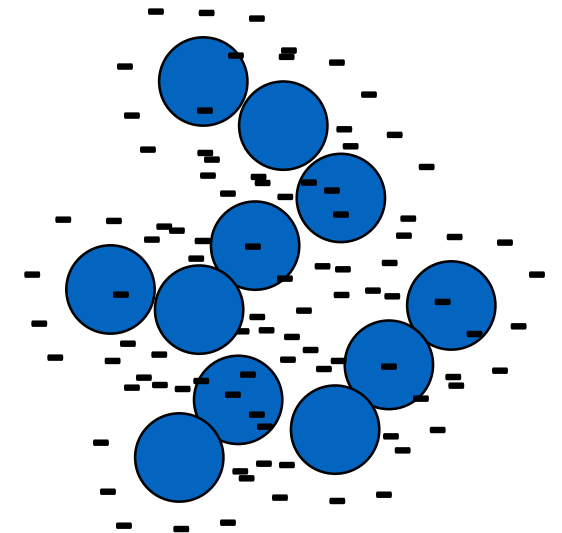
Sol



**Evaporation forces
particles closer together**



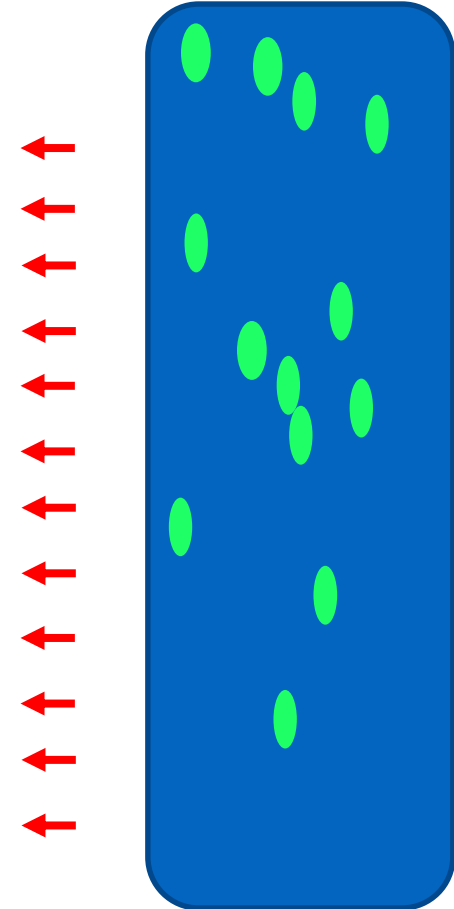
Gel



POLYMERS

INTRODUCTION

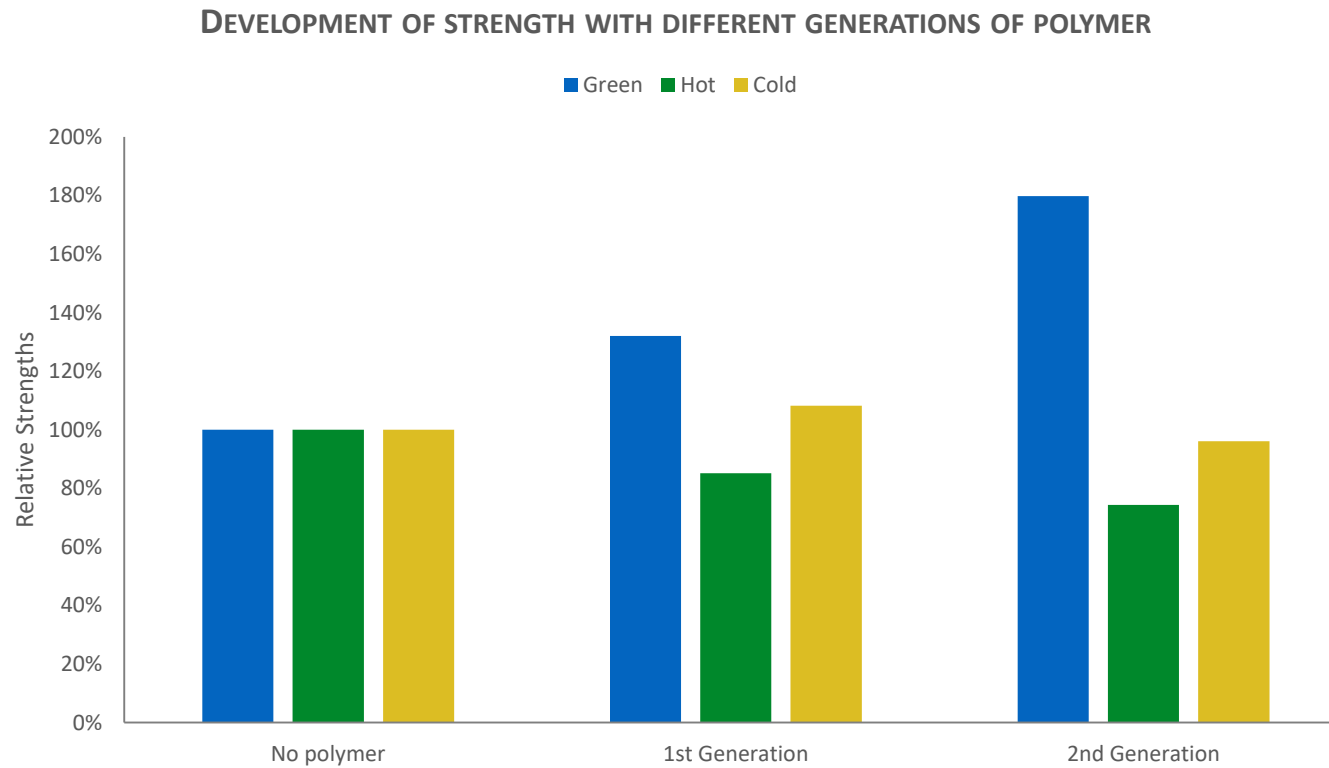
- The presence of polymers within shell systems have three beneficial effects:
 - Drying defects – The presence of the polymer reduces shell related cracking and defects
 - Drying effectiveness – Drying can be achieved quicker with the presence of polymers
 - BoilerClave Strength – The flexibility of the shell ensures the expansion of the wax will not crack the shell



POLYMERS

INTRODUCTION

- Generations of polymers have incrementally improved these green strengths to reduce scrap and improve drying



POLYMERS

QUIKSET

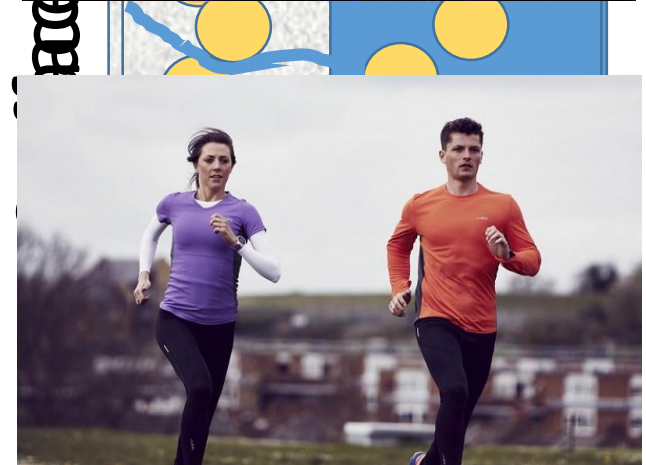
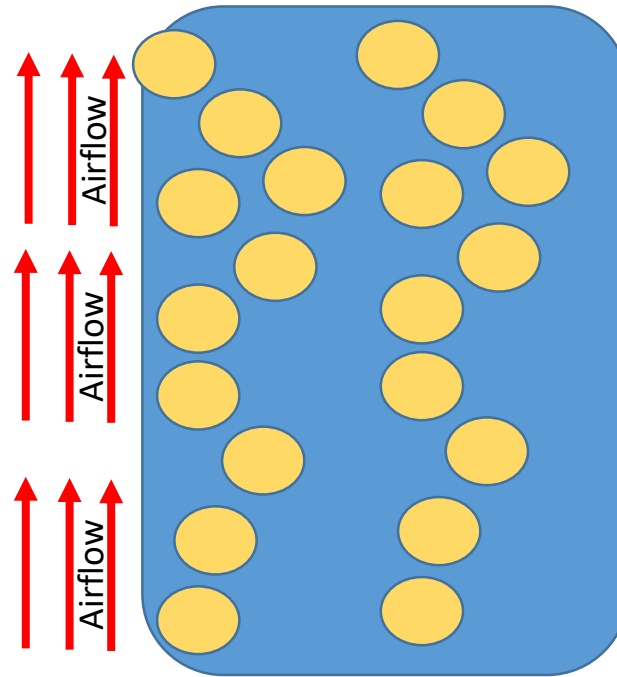
- However, the drying improvements have remained relatively static with no slurry consumable to improve drying
- A innovative QuikSet polymer has been introduced which improves the drying of shells dramatically!
- Shells can be dipped with as little as 30 minute drying time



POLYMERS

QUIKSET PRINCIPLE

- Water gets trapped within the shell matrix during drying. This inhibits evaporation and drying
- QuikSet's novel formulation can ensure the water can evaporate while the slurry has gelled
- This also has the ability to increase strength



TESTING PROCEDURE

SLURRY OUTLINE

- Water based slurry was compared to a traditional polymer system
- 9 coats were applied
- Temperature and humidity controlled conditions
- No prime layer used

SLURRY FORMULATION FOR MECHANICAL TESTING

Component:	Ultra	QuikSet
Fused Silica 200 Mesh	62.92%	60.87%
SP30	31.46%	30.43%
Polymer	4.5% Ultra	7.60% QuikSet
Wetin	0.90%	0.87%
Burst 100	0.22%	0.22%

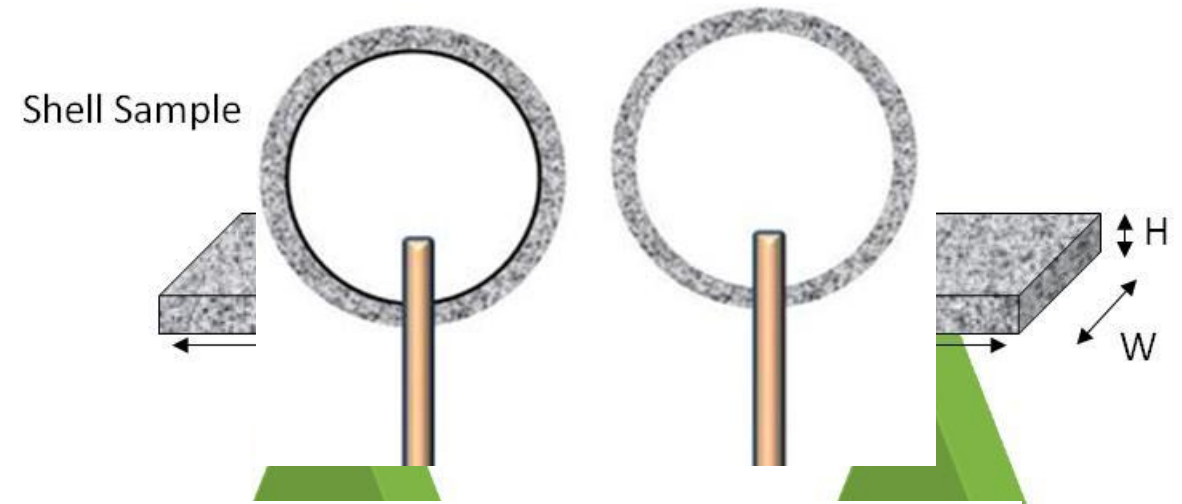
Slurry formulation for DMA and thermal analysis

Component:	AdBond Advantage	QuikSet
Zircon 200	62 %	62%
Binder	32.00%	30.40% SP 30
Polymer	6%	7.60%

TESTING

MECHANICAL ANALYSIS

- Water based slurry was compared to a traditional polymer system
- Testing conducted:
 - MOR - 3 Point Bend
 - Permeability

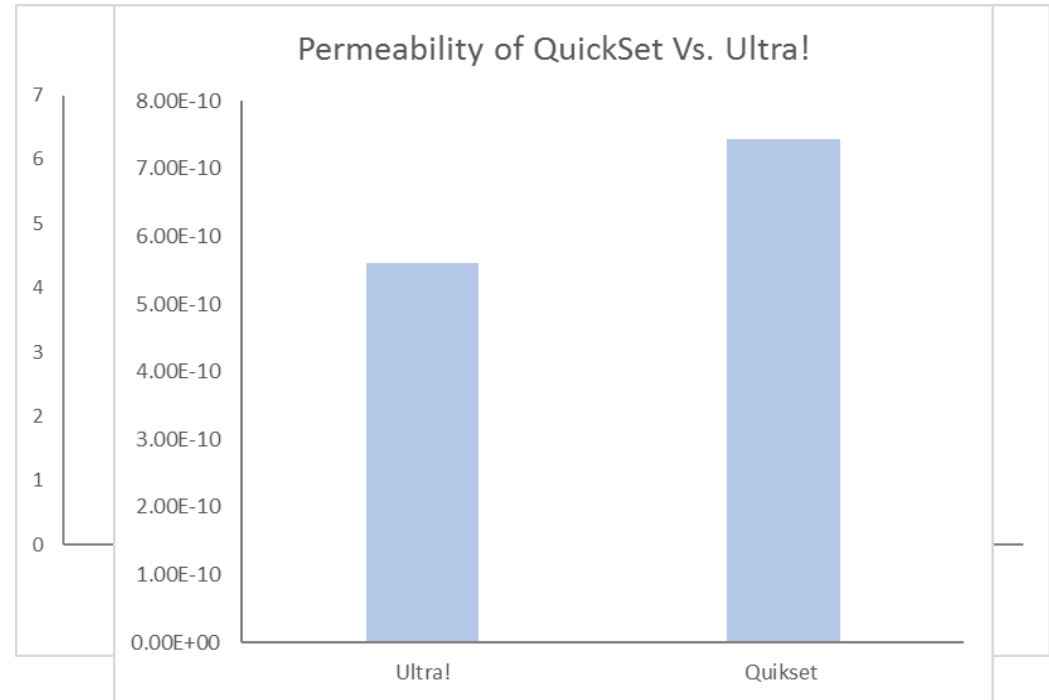


$$\mu = \frac{sV_c\eta}{a\Delta P} \quad \frac{xL}{I^2}$$

TESTING

MECAHNICAL ANALYSIS

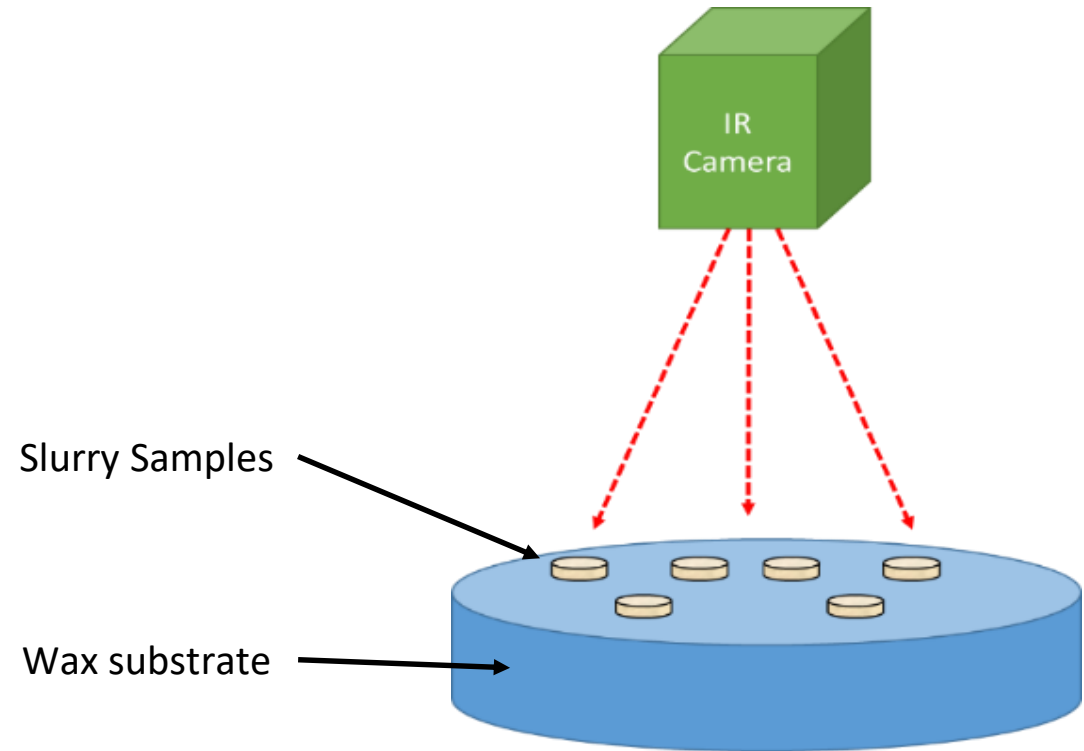
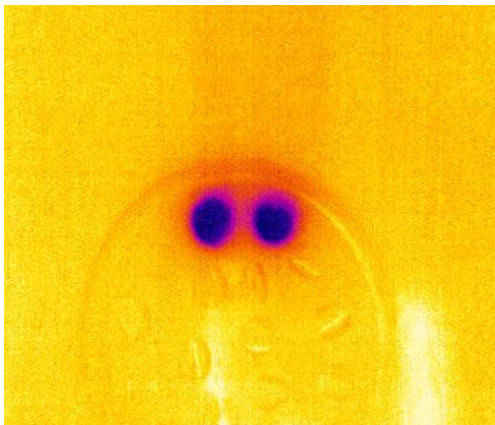
- MOR testing produced shells which were
 - 49 % stronger during green testing than traditional shell system.
 - Hot strength was also increased by 22%
- Permeability testing produced shells which were
 - 46 % higher permeability than a traditional system



TESTING

THERMAL IMAGING

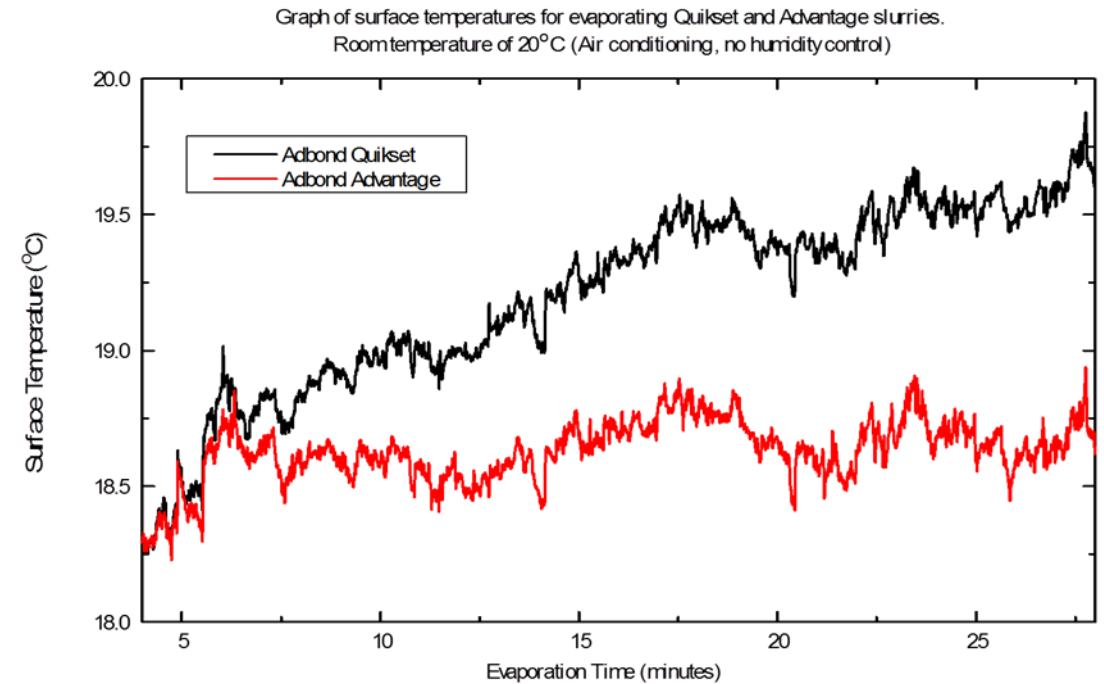
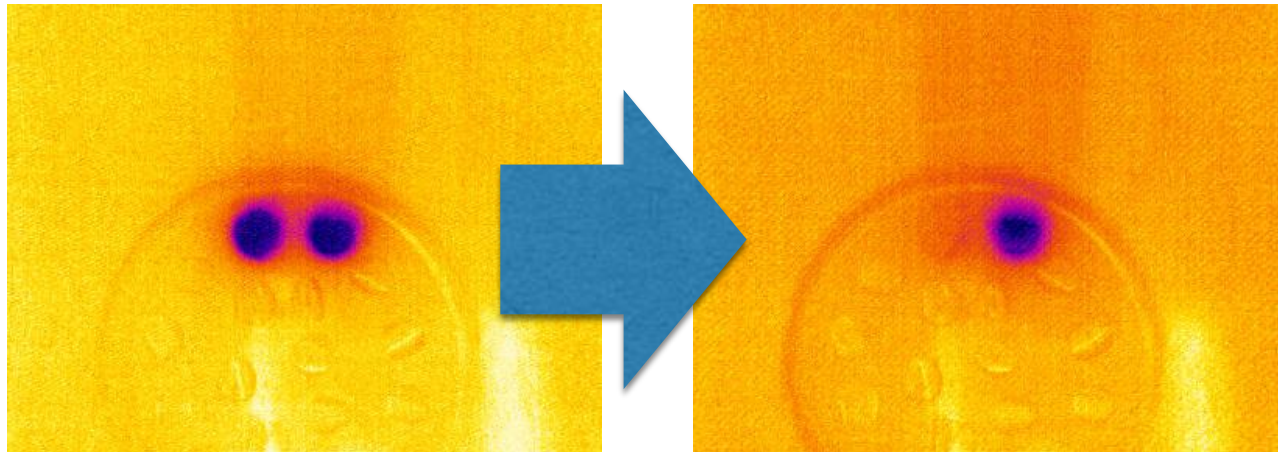
- Thermal imaging camera - micro epsilon thermo imager
- Samples of the same volume placed on a wax substrate
- Single point on slurry surface selected and tracked over time



TESTING

THERMAL IMAGING

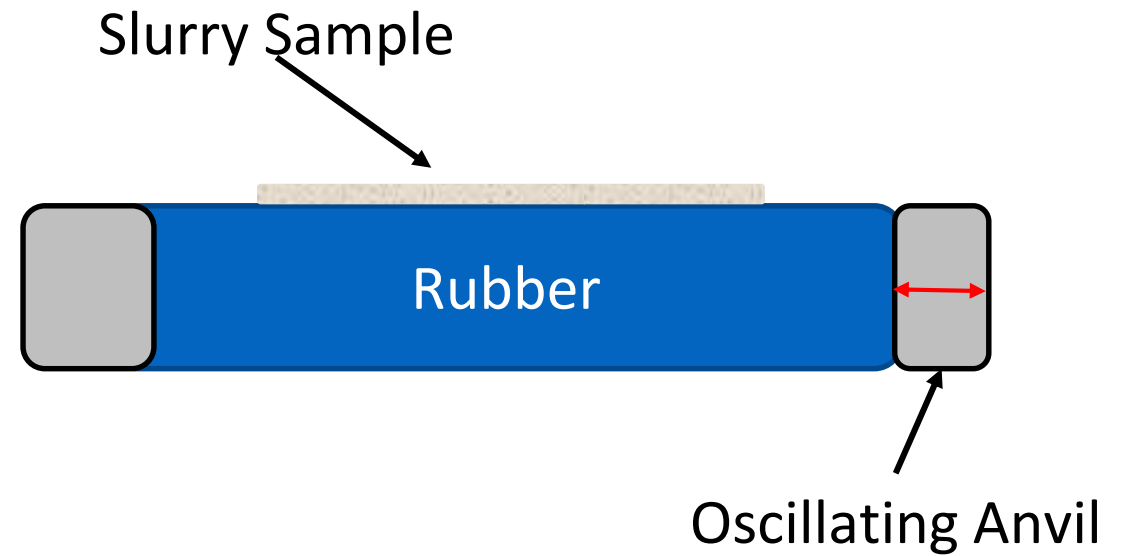
- Dipping traditionally results in a reduction in temperature as evaporative drying takes place
- The recovery of the shell to ambient temperature occurs much quicker than a traditional shell system with QS polymer addition



TESTING

DMA ANALYSIS

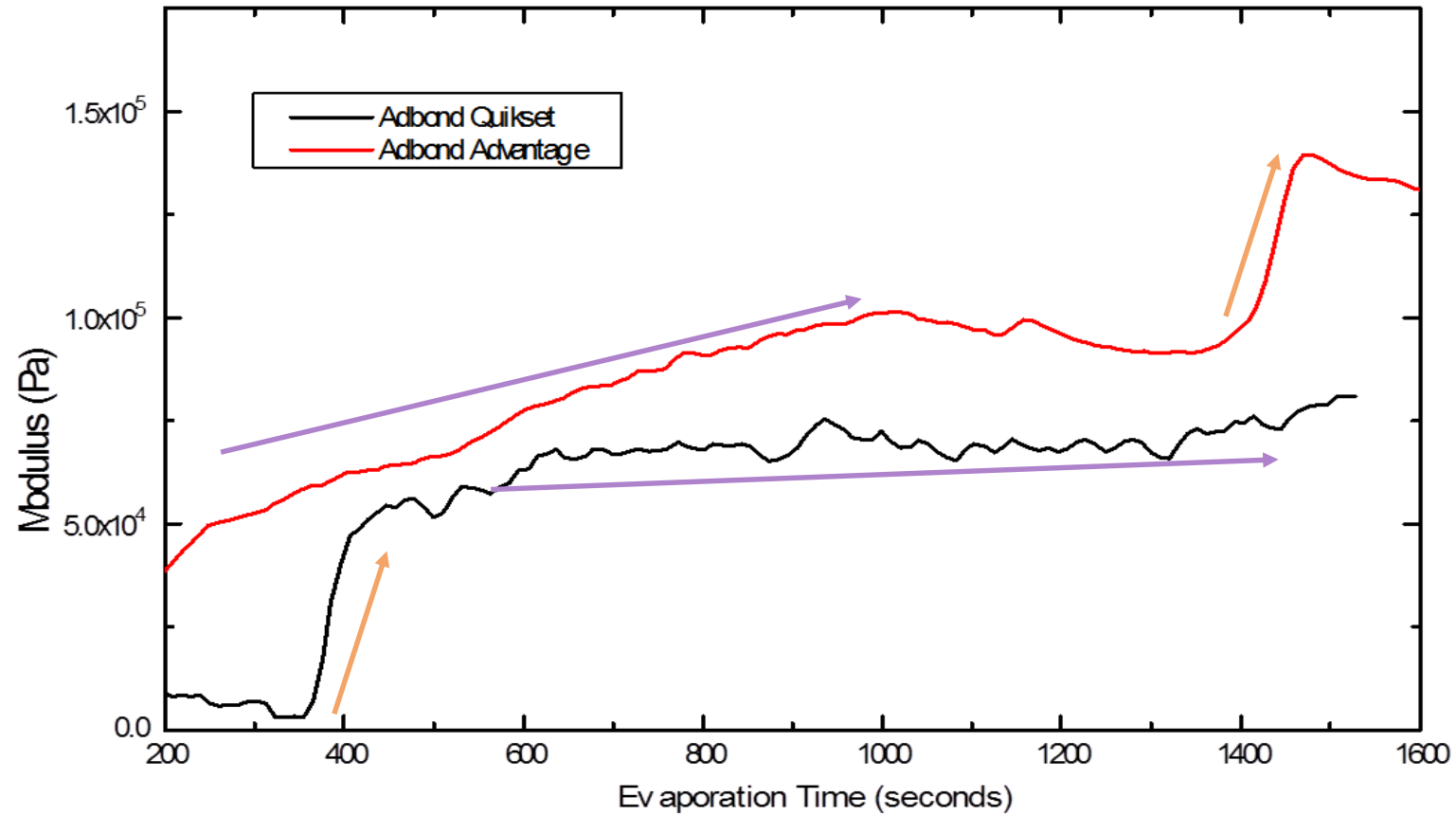
- Water based slurry was compared to a traditional polymer system
- Slurry sample of the same size was placed on rubber substrate
- This was then oscillated and the modulus was measured from the output



TESTING

DMA ANALYSIS

Plot of Modulus against evaporation time for Adbond Advantage and Adbond Quikset coated on rubber substrate





QUICKSETTING POLYMER TESTS AT OFALLON CASTING

Matt Cavins
10/23/18



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YOUR CONCEPT TO CASTING PARTNER

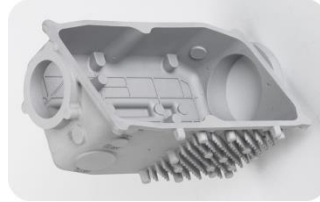
Who is O'Fallon Casting?

- Located Near St. Louis, Missouri
- Small Business – 175 Employees
- Founded In 1969
- AS 9100 / ISO 9001 Registered
- Special Processes Accredited By NADCAP

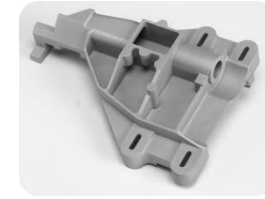
What we do?



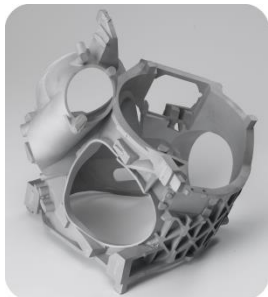
Brass &
Bronze
Castings



Aluminum Castings



SiC MMC
Castings



Prototype
Castings



Machined
Castings

Objectives

- Develop an intermediate slurry to replace the ethyl silicate slurry
- Maintain existing shell dry times
- Maintain existing knockout procedures and rates
- Minimal changes to part dimensions

Current Shell System

- Prime
 - Water-based binder
 - Zircon/fused silica flour
 - Aluminosilicate stucco
- Intermediates
 - Ethyl Silicate binder
 - Virginia Mullite flour
 - Aluminosilicate stucco
- Backups
 - Water-based binder
 - Fused Silica Flour
 - Aluminosilicate stucco

Shell Testing

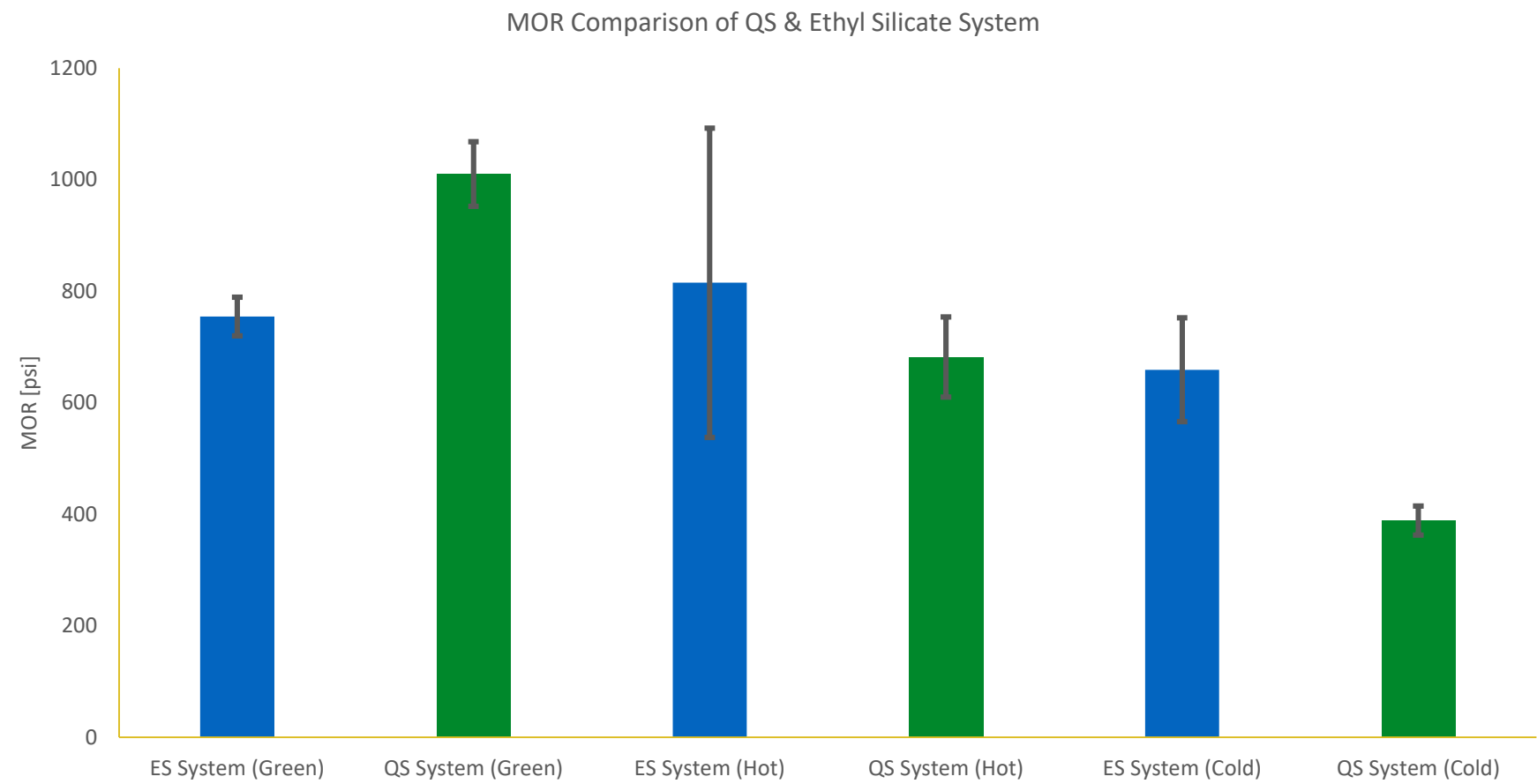
- Intermediates

- Colloidal silica binder with quick setting polymer
- Virginia Mullite flour
- Aluminosilicate stucco

- Drying and Environment

- Temp 68-72F
- Humidity 55-65%
- Current dry times (minimum 2 hr)

MOR and Permeability Results



Part Trial

- Multiple parts of varying complexity
- Hand dipping and robot dipping
- Autoclaved and fired
- Cast

Part Results

- Initially positive results
- Complexity led to issues
- Adjustments
 - Silica content
 - Drying environment



Dimensional Results

- 4 different part configurations
- All dimensions met drawing tolerances
- Mixed results when compared to ES

Part #	Drawing Dimension with tolerance (inch)	ES Dimension (inch)	QS Dimension (inch)	Change from ES to QS (inch)
1	0.720 ± 0.020	0.7220	0.7228	0.0007
2	1.50 ± 0.015	1.4995	1.5034	0.0039
2	3.78 ± 0.020	3.7841	3.7785	-0.0056
3	13.31 ± 0.075	13.3434	13.3503	0.0068
4	1.590 ± 0.010	1.5950	1.5955	0.0005
4	$0.630 \pm .010$	0.6279	0.6310	0.0031
4	$1.380 \pm .010$	1.3742	1.3785	0.0043

CONCLUSIONS

- QuikSet has been proven to improve the conversion from ES to Water based systems
- Good results in drying time
- Good mechanical results during testing
- Good knockout results
- More work needed to understand dimensional change

CONCLUSIONS

- Analysis of QuikSet™ polymer with traditional systems has shown:
 - 49 % stronger during green testing than traditional shell system.
 - Hot strength was also increased by 22%
 - 46 % higher permeability than a traditional system
 - Novel methods including IR thermal imaging and DMA were used to assess the physical gelation of the system also





QUESTIONS?



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