

HYDROSTATIC PROCESSING OF UHMWPE COMPOSITES USING DISTRIBUTED ELASTOMER NETWORKS

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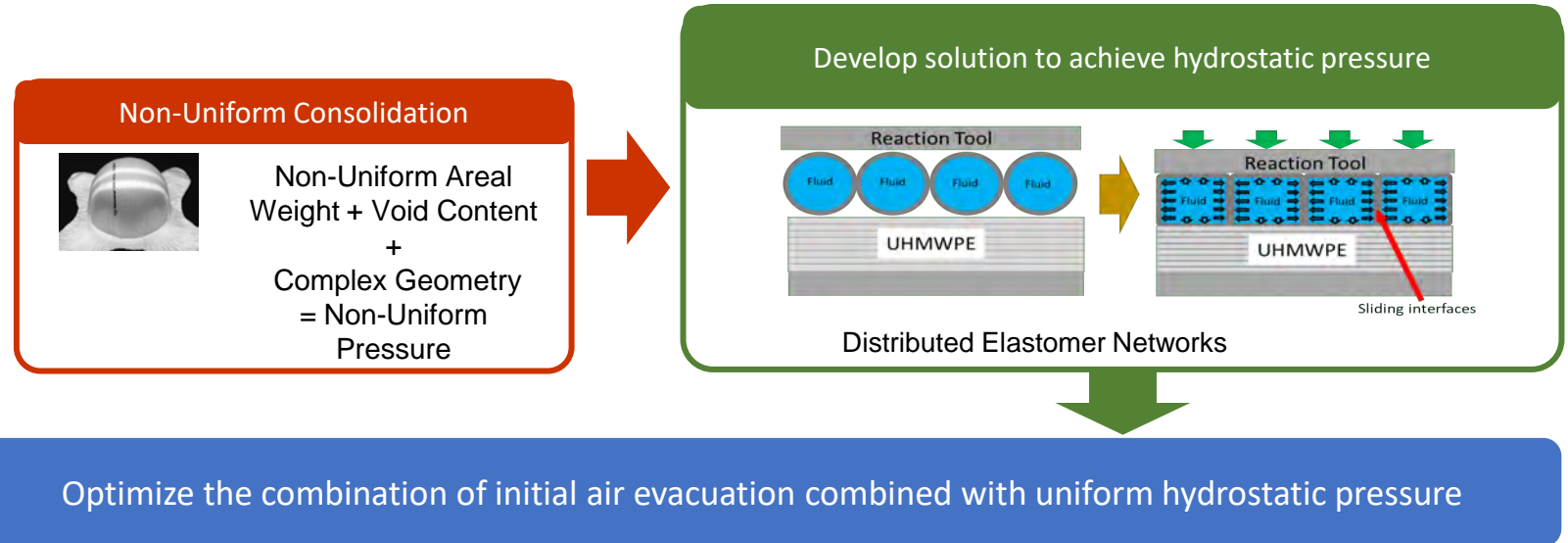
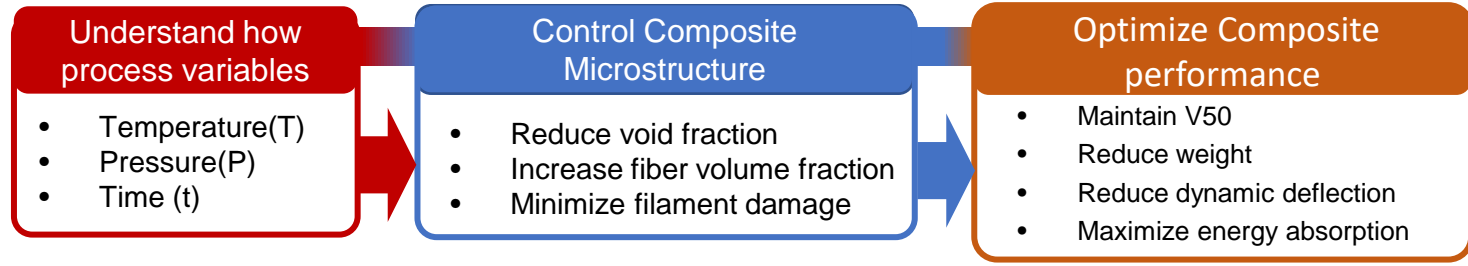
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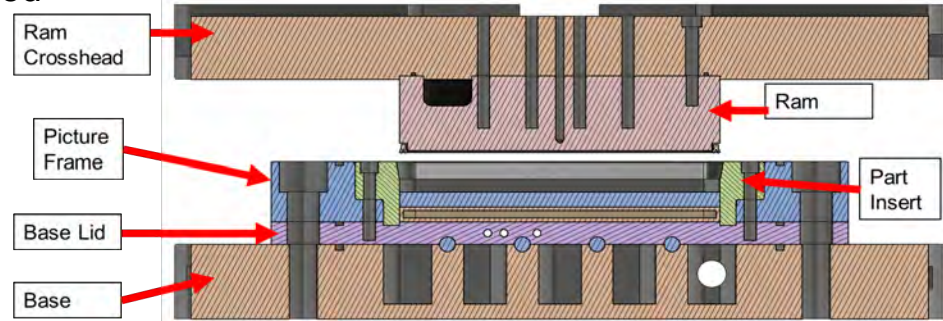
Celebrating 50 Years



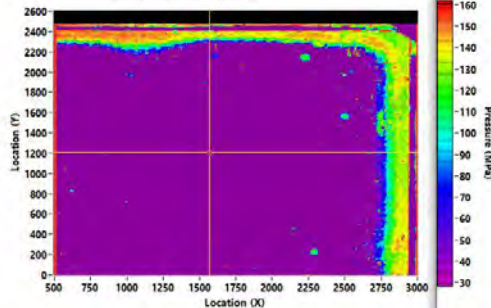
Why Hydrostatic Pressure?: Tooling Rigidity & Tolerances



UD-CCM Press: 1000ton rated

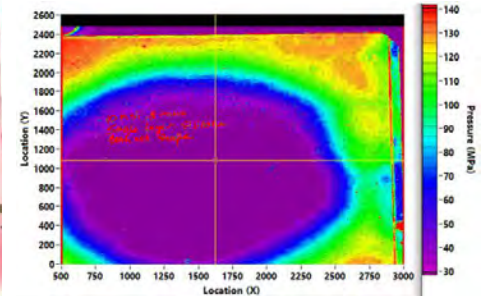
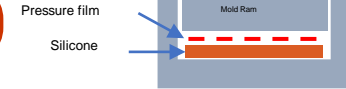


Tool Compliance



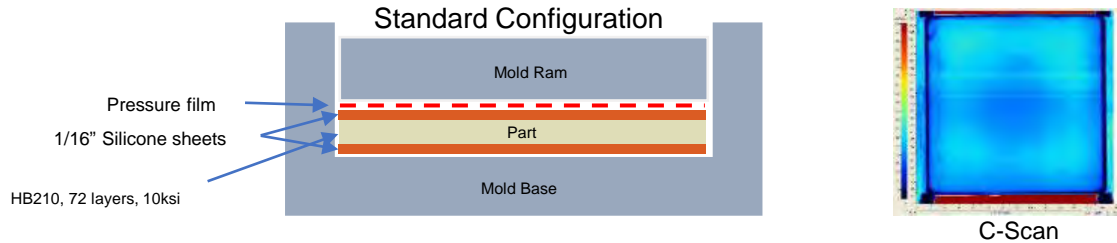
10ksi : Pressure Film Only, No Part

Non-uniform Pressure

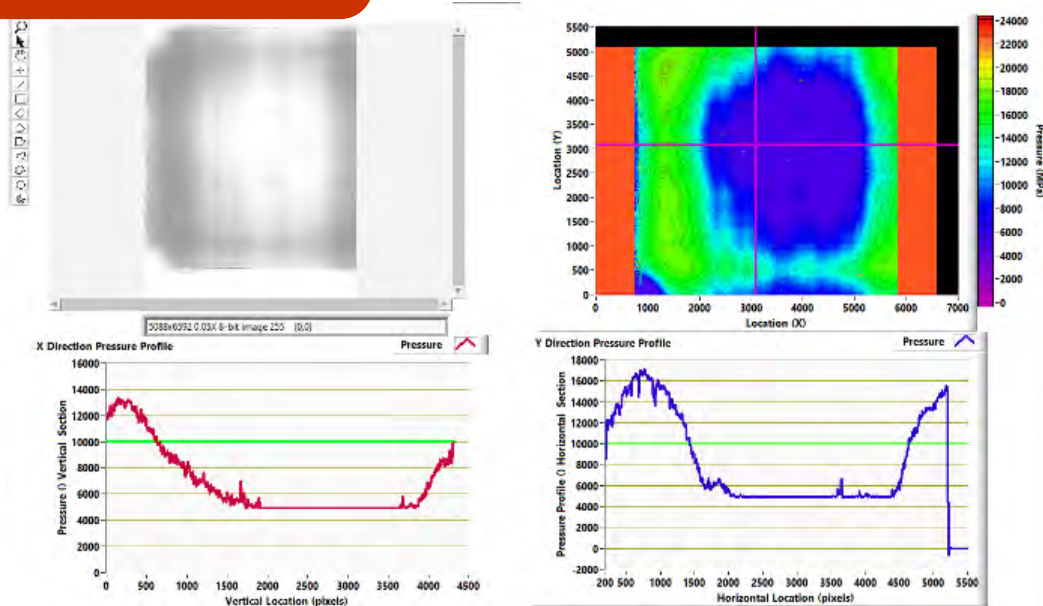


10ksi : Pressure Film, 1/16" Silicone Sheet

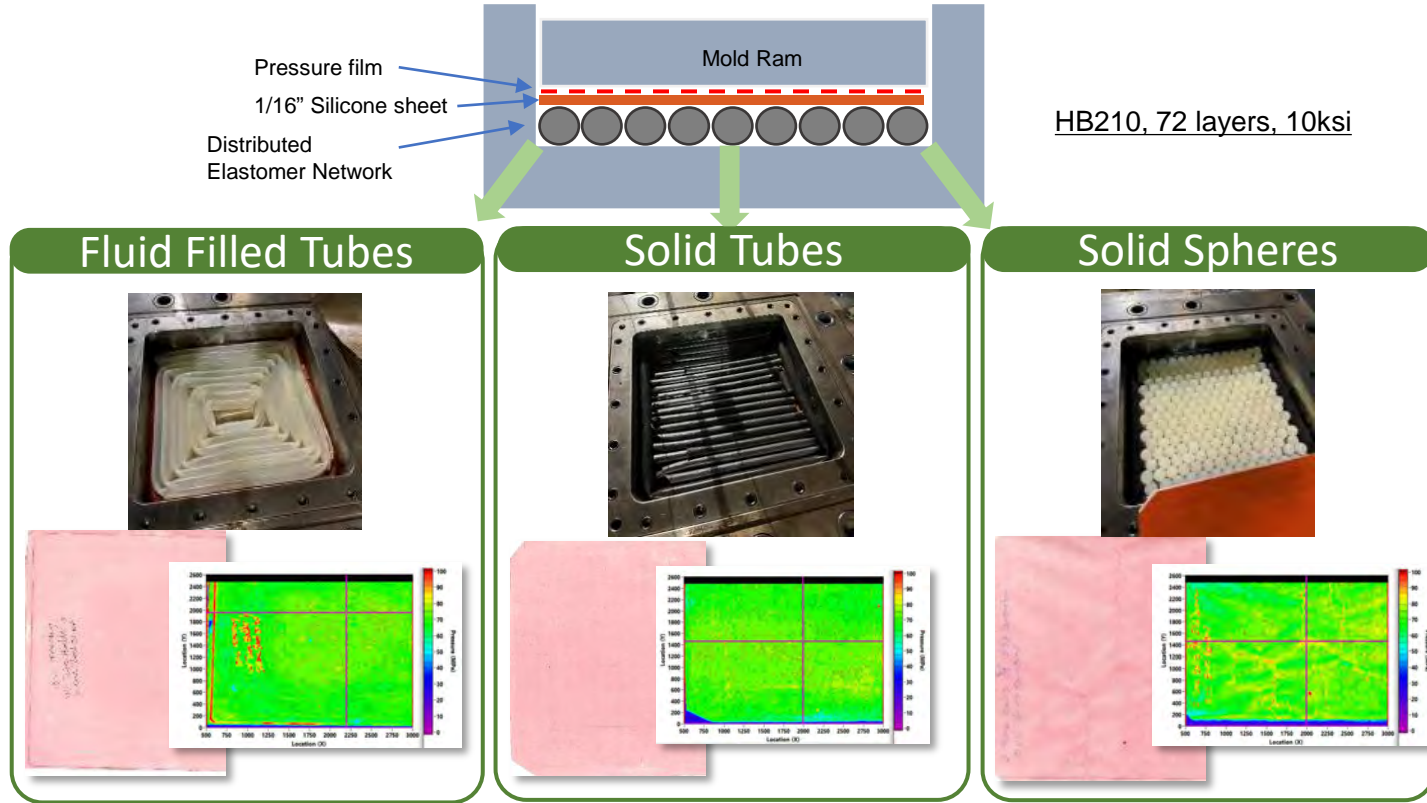
Pressing Challenges: Achieving Hydrostatic Conditions



Pressure Gradient in Panel



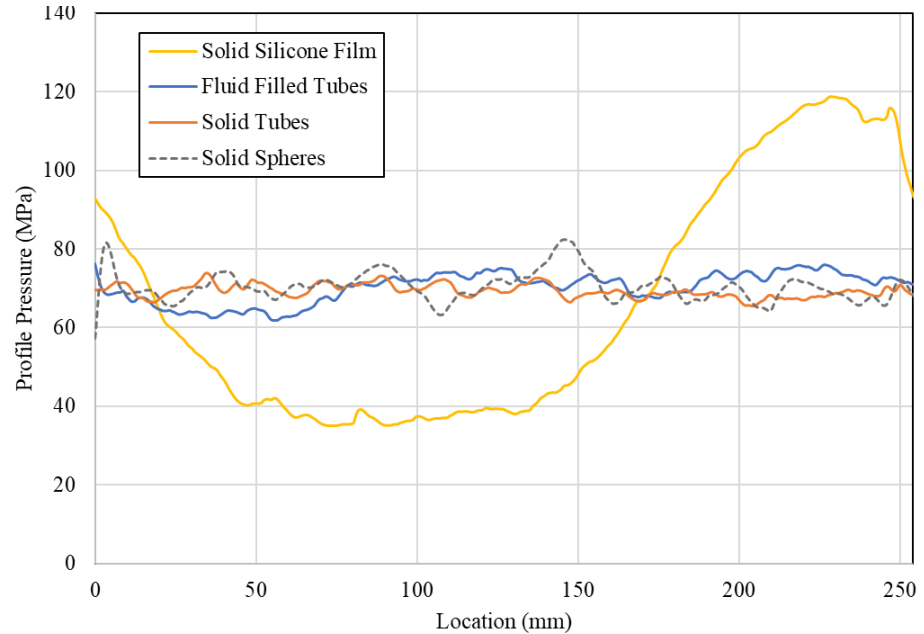
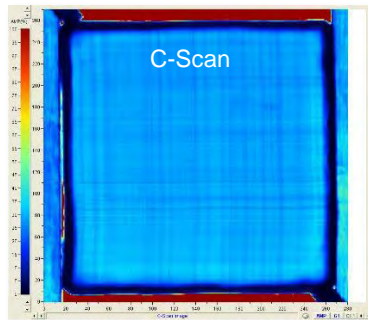
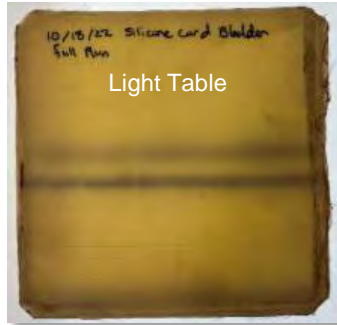
Distributed Elastomer Networks Provide Hydrostatic Pressure



The individual segments minimize buildup in shear within the elastomer volume during mold closure ensuring uniform normal force is applied to the composite structure upon pressurization

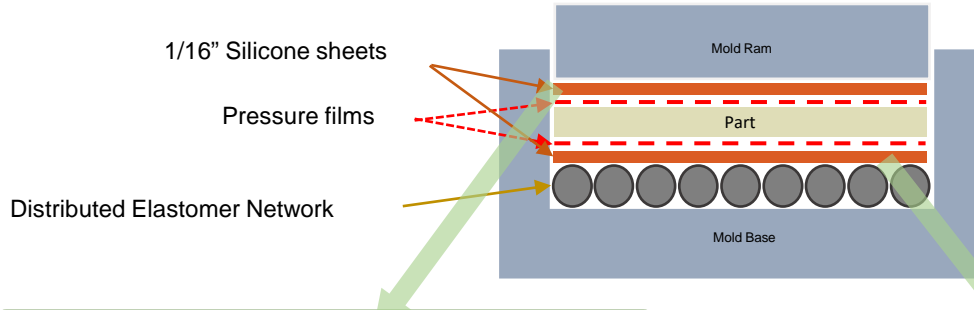
72-layer HB210 panel 69MPa (10ksi)

Uniform Quality

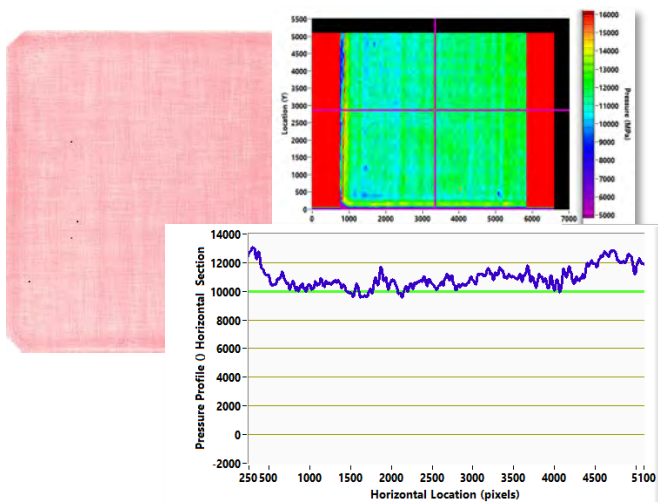


Standard deviation 3.7MPa (0.54ksi) (coefficient of variation of 5.29%)

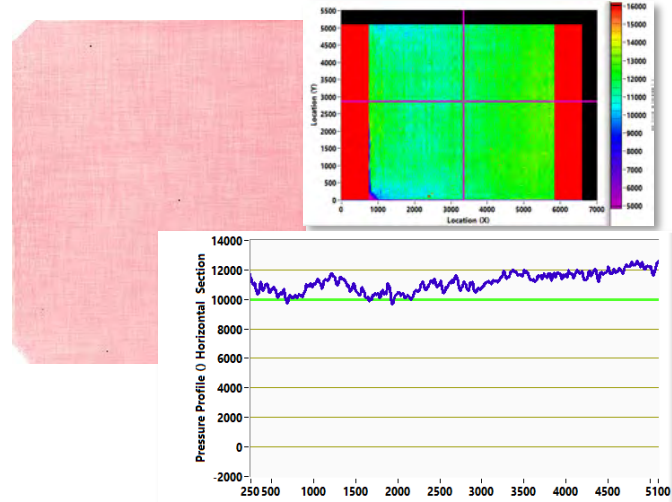
Hydrostatic Conditions Through Part



Pressure Distribution Above Part



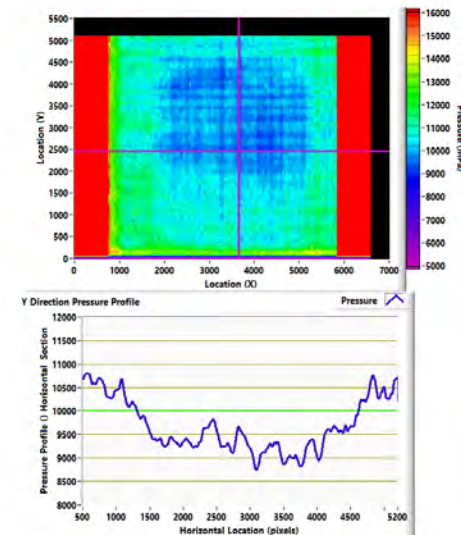
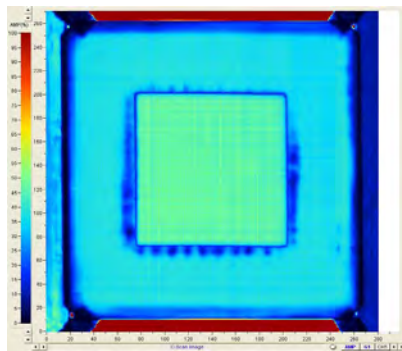
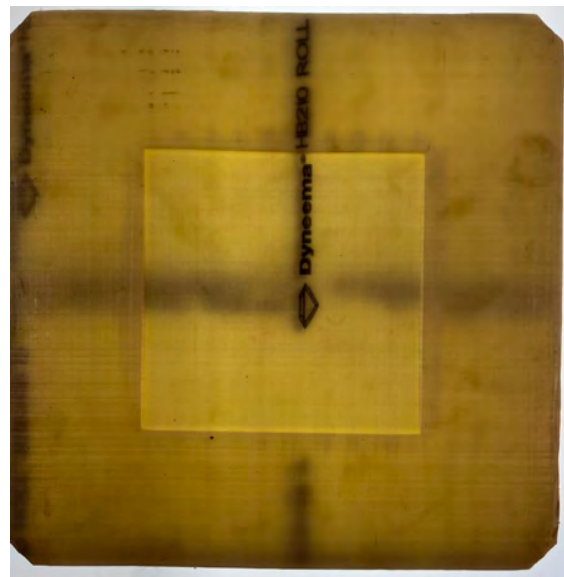
Pressure Distribution Below Part





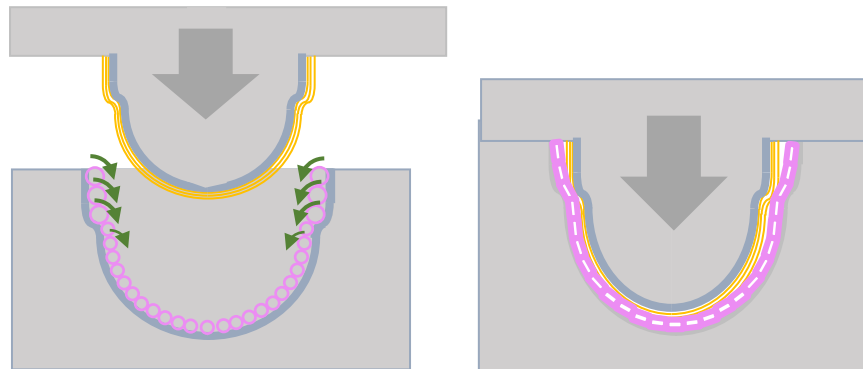
Panels with 15% thinner Center using Distributed Elastomer Array

- 15% thinner center section cutout
- Represents worst case layup for processing
- Pressure only dropped 1ksi from setpoint at center
- Sized elastomers would reduce this difference further
- Test demonstrates the versatility of distributed elastomers to achieve hydrostatic conditions



Concentric Cylinder Elastomer Array

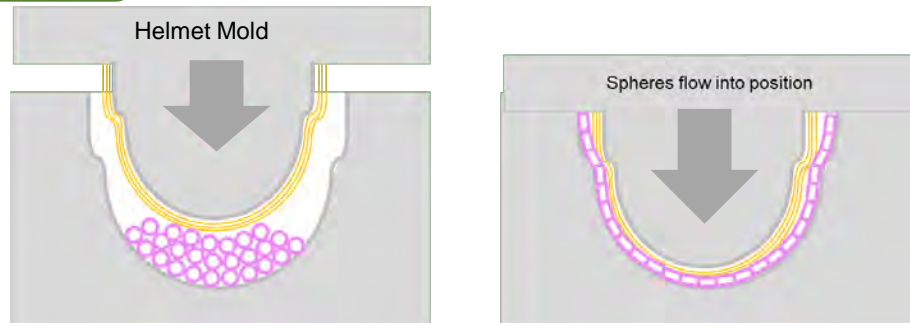
- Fluid filled or solid tubes arranged in concentric rings within female tool
- Each tube can rotate about center axis to minimize shear during mold closure
- Tube size and durometer distribution optimized to ensure hydrostatic conditions



Concentric Cylinders

“Flowing” Spherical Arrays

- Solid or fluid filled spheres placed in female mold chamber.
- Spheres “flow” to fill cavity with self arrangement driven by sphere-sphere friction and tool part interactions.
- Can be combined with concentric cylinders optimally arranged in mold cavity.

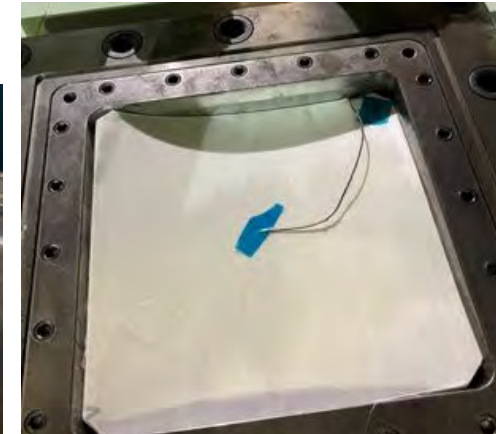
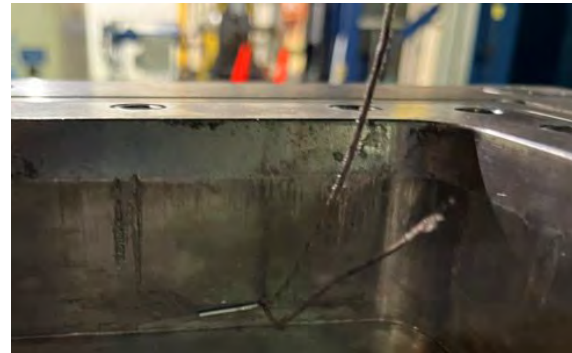
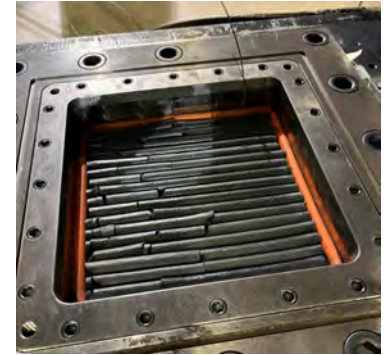
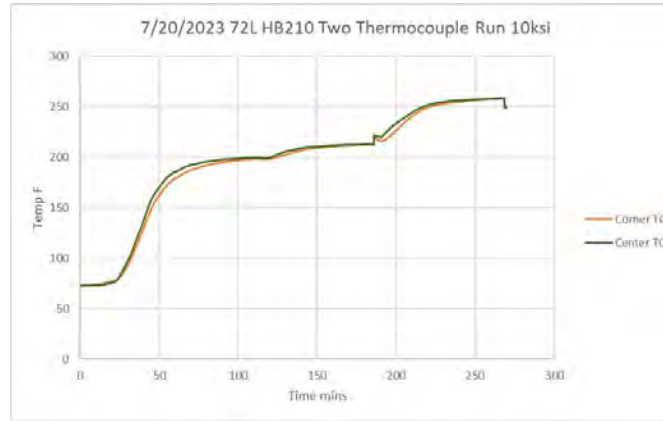


Lubricated Spheres

Temp verification run with two thermocouple

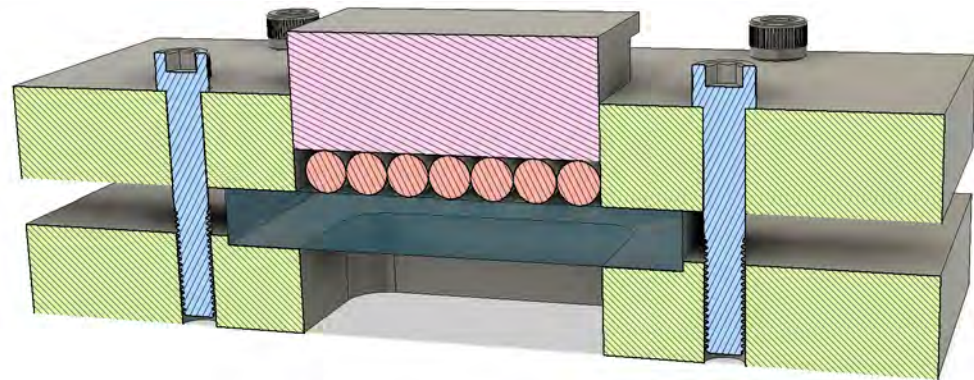
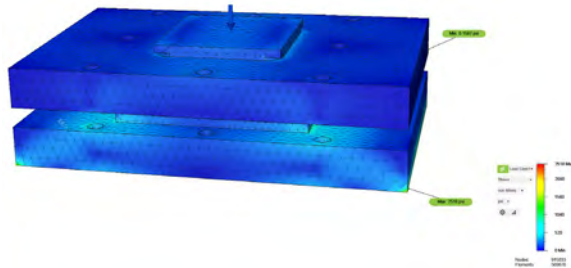
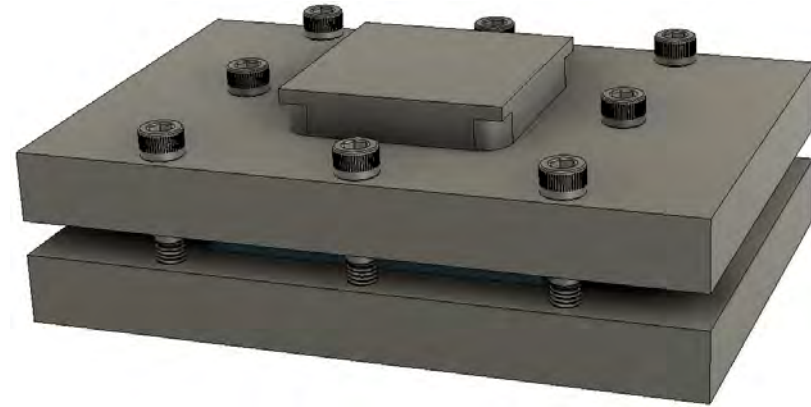
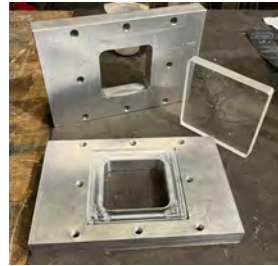


- › Two thermocouples same run
 - One thermocouple in corner center thickness
 - One in center of panel center thickness
- › Minimal differences in temperature for the duration of the run
- › 72 layer HB210 panel



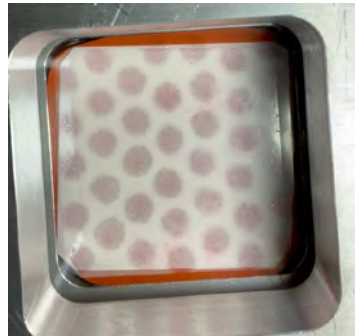
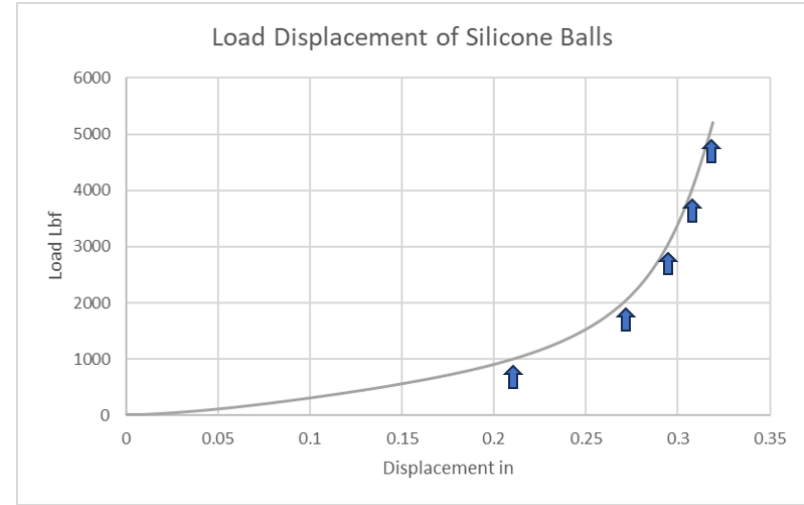
Subscale bladder testing in Instron

- › Built a subscale test cell for visualizing pressure evolution
- › 4" square window
- › Used pressure film good to 350psi (5600lbs)
- › Its predicted to be at yield stress at 16,000lbs load or 1ksi pressure

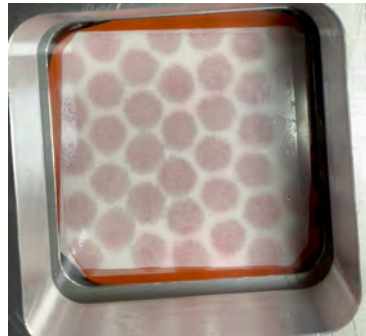


Silicone ball test

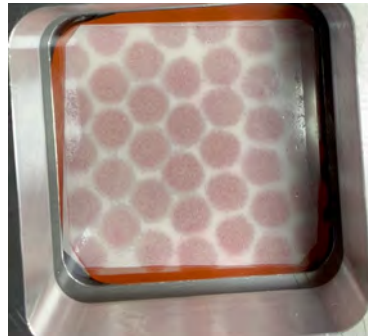
- › Can test to higher loads and different bladder configurations
- › Load is likely evenly distributed well before 10ksi
- › Setup can fit in the environmental chamber



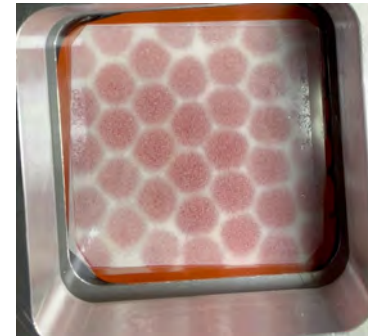
1klbs



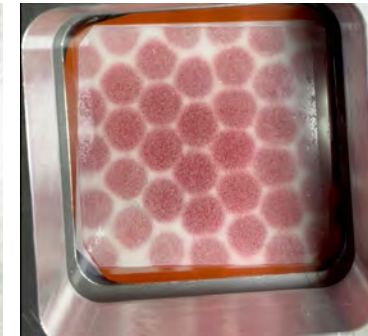
2klbs



3klbs



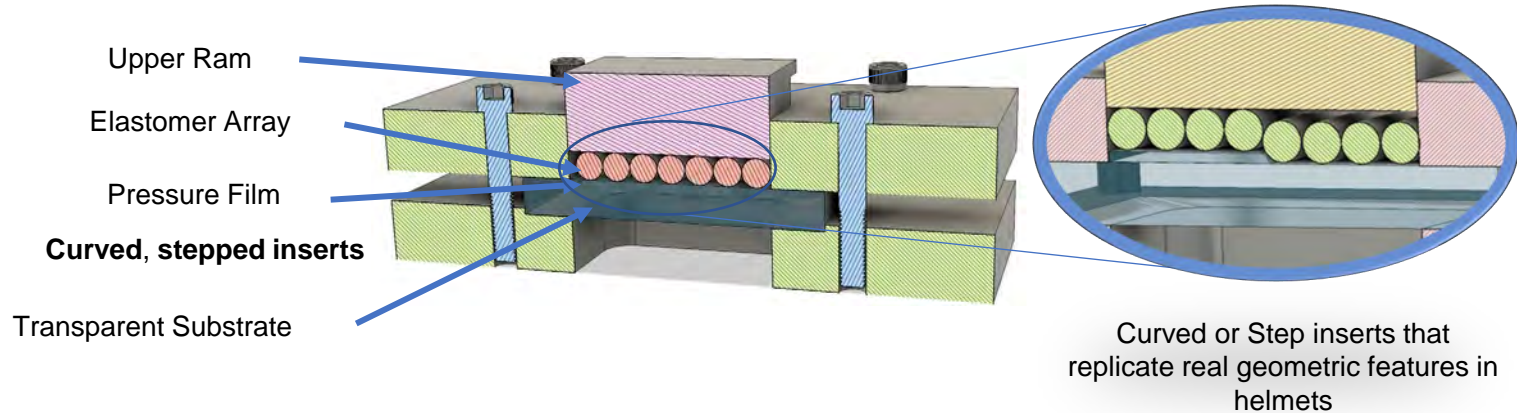
4klbs



5klbs

Hydrostatic Process Optimization

- Optimize distributed elastomer designs using transparent test cell that ensures hydrostatics conditions with areal weight variation over curved and feature geometrics.
- New test cell will establish these conditions measuring transient pressure distribution as a function of feature and panel temperature
- Through thickness temp uniformity





Acknowledgements

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