



Consumer Solutions

LOW TEMPERATURE CURE LSR TECHNOLOGY ENABLES PROCESSING IMPROVEMENTS

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**Rubber
Division**
American Chemical Society

- Standard liquid silicone rubber (LSR) technology
- Standard condensation cure (hydrosilylation reaction)
- Low temperature cure (LTC) LSR
- LTC LSR advantages



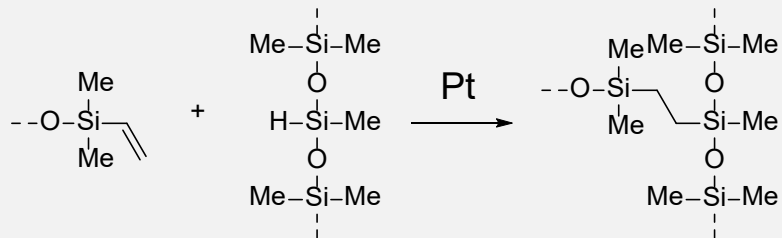
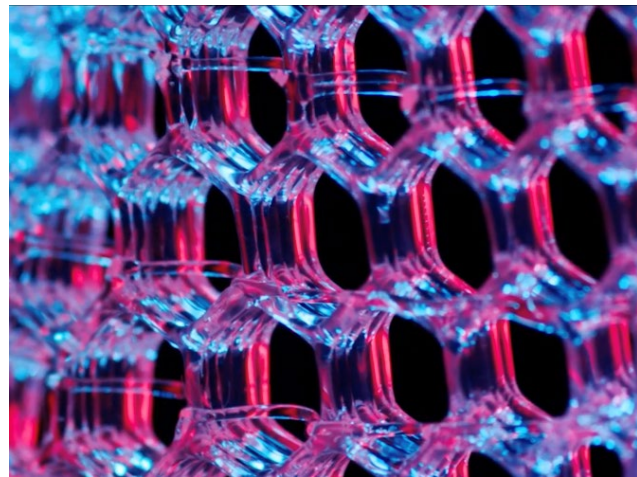
LIQUID SILICONE RUBBER

- Two-part, dispensable, heat-cured silicone elastomers
- Good mechanical properties
- Excellent resistance to weathering, extreme temperatures, and aging
- LSR market growth at CAGR >8%
- Wide range of applications
 - Transportation
 - Food/hygiene/medical
 - Electrical/electronics
- Overall trend for optimum quality, processing and efficiency



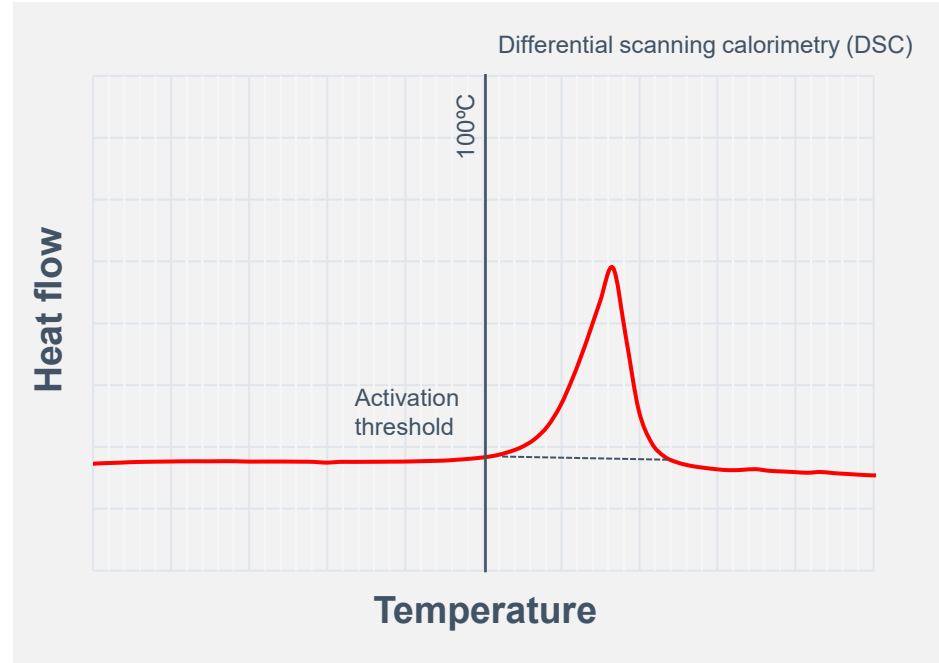
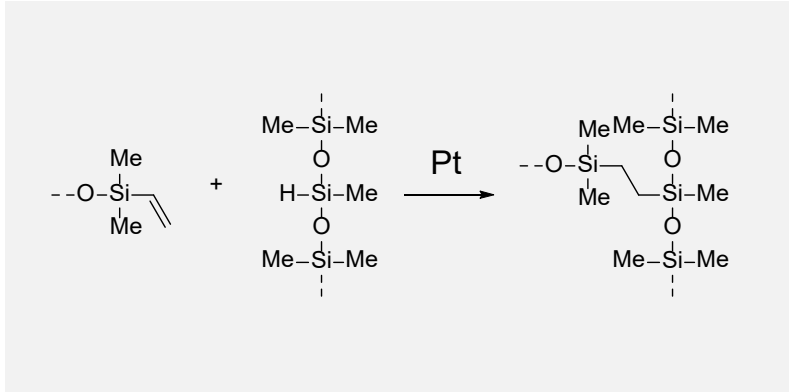
CONDENSATION CURE

- Pt-catalyzed hydrosilylation
- Addition of silicon hydrides (SiH) to unsaturated groups
- Reaction readily proceeds at 23°C
- Additives often included to provide handling time by inhibiting cure at room temperature
- Typically cure is **heat activated**

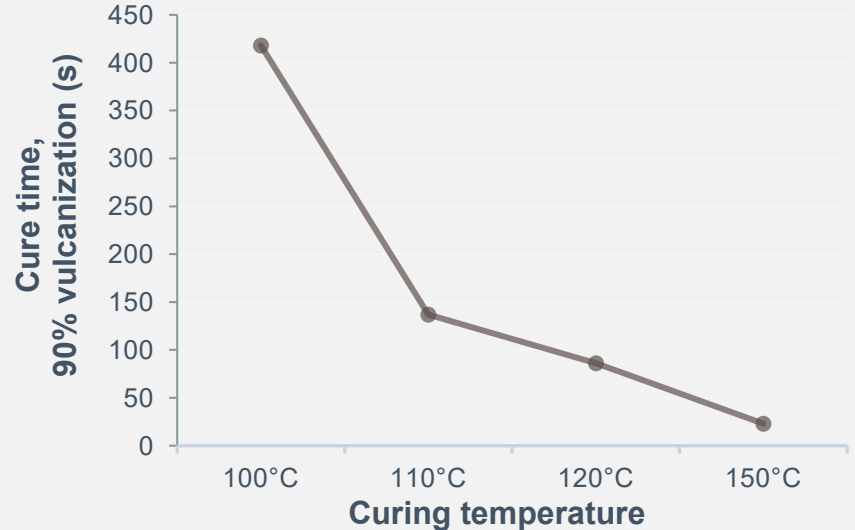


STANDARD CURE

- LSRs generally have a high activation threshold
- Standard cure temperature range from 160-220°C



- Reaction rate is temperature dependent
- Cure time increases as temperatures decrease



LOW TEMPERATURE CURE (LTC)

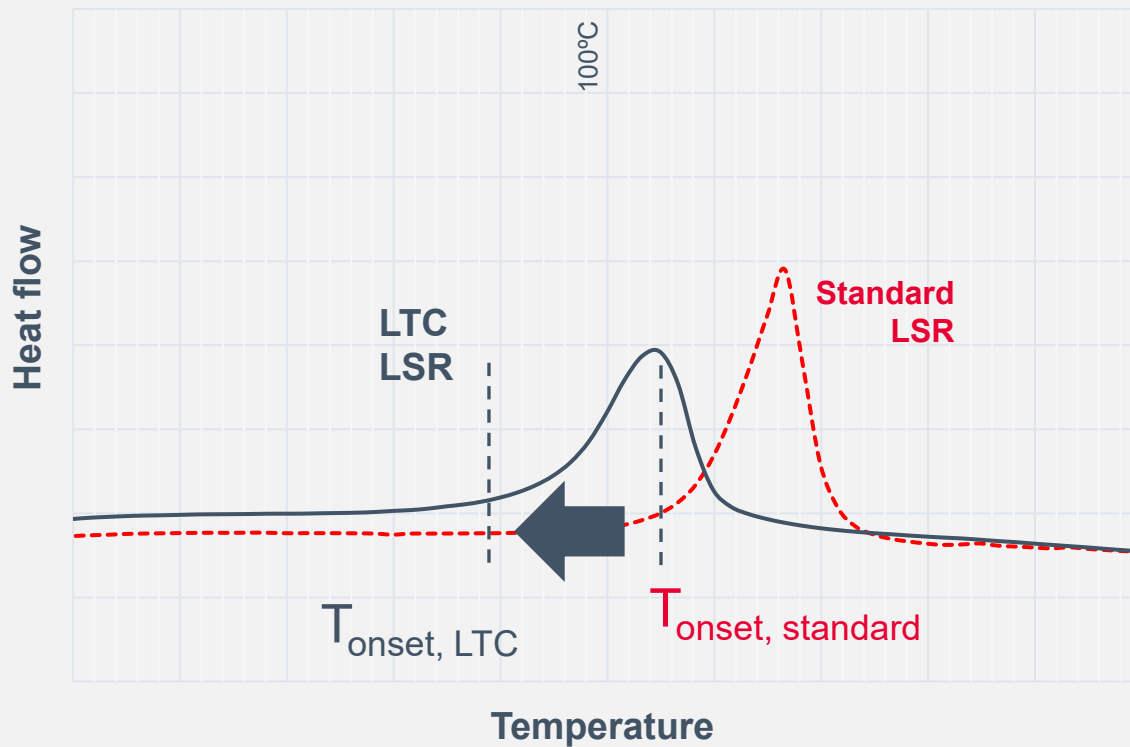
Low Temperature Cure (LTC) LSR:

- New LSR with **lower cure activation temperature**
- Can be used with conventional injection molding equipment and tooling
- Fast deep section cure at elevated temperatures
- Fast curing at **temperatures as low as 90°C**



LOW TEMPERATURE CURE (LTC)

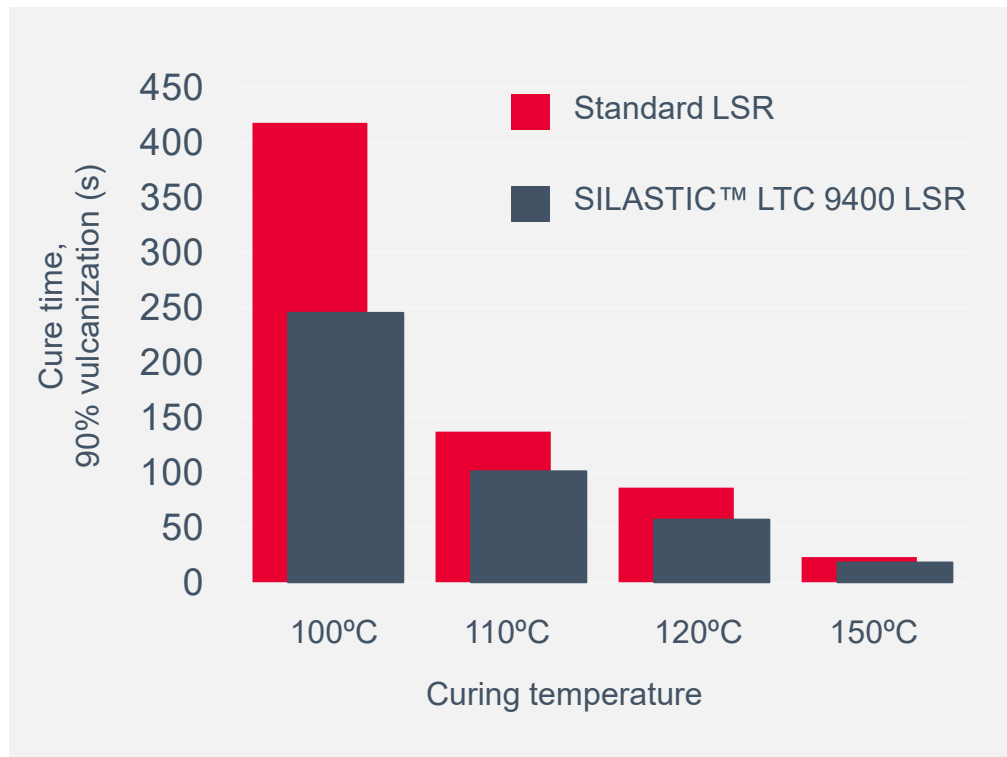
Activation threshold shifted to temperatures $<100^{\circ}\text{C}$



LOW TEMPERATURE CURE (LTC)

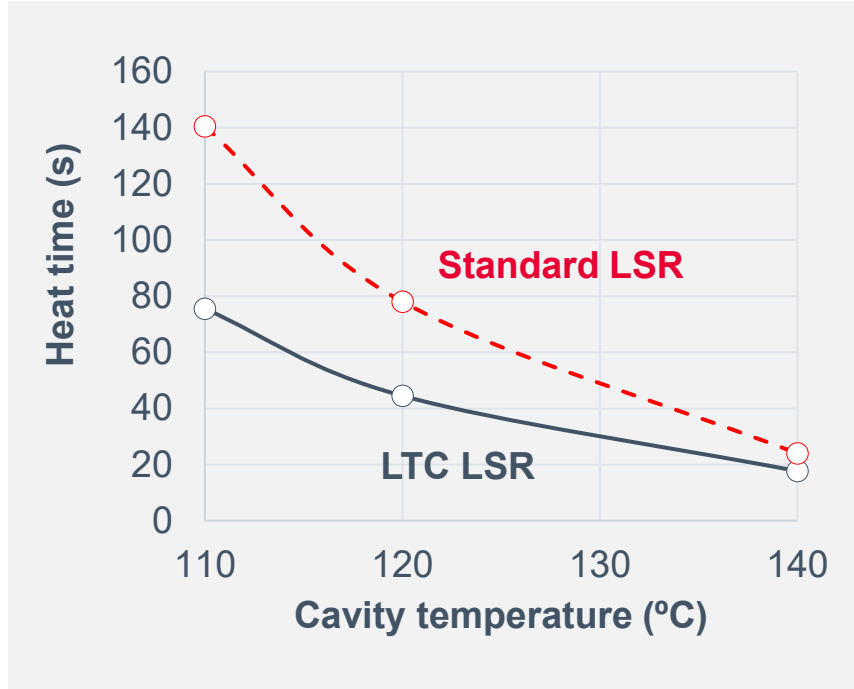
Low Temperature Cure (LTC) LSR:

- Significant reduction of curing time at low temperatures ($<120^{\circ}\text{C}$)
- 72 h pot life still maintained



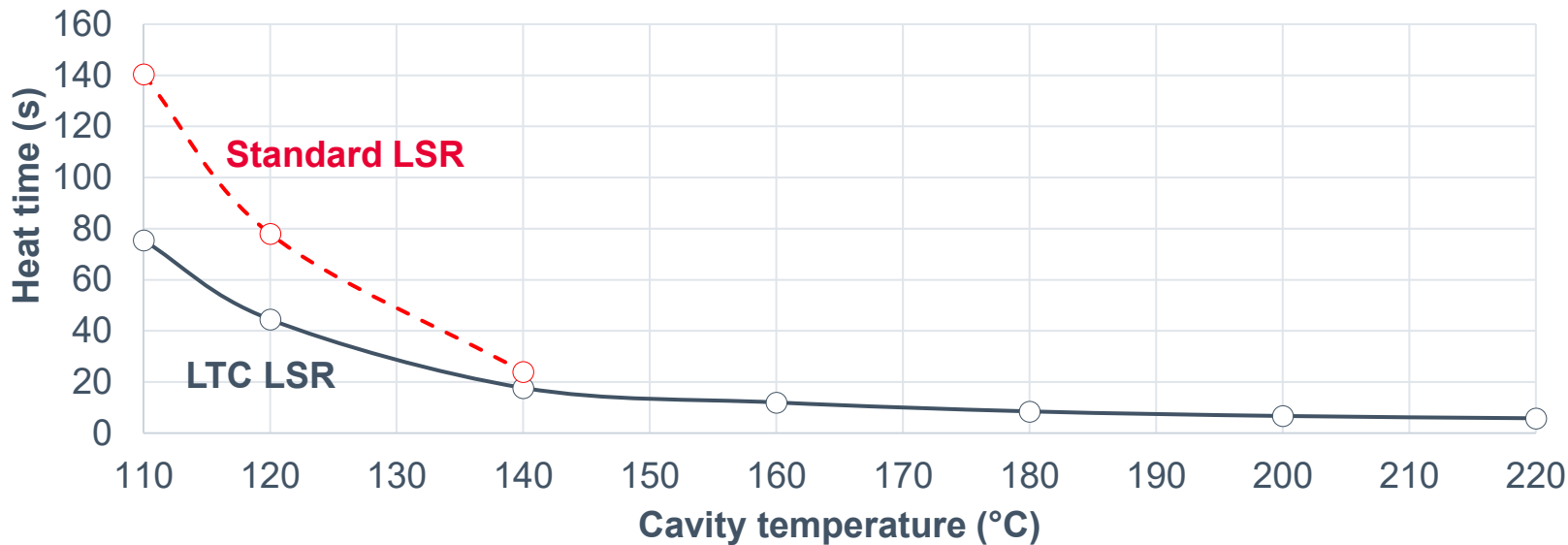
LTC LSR INJECTION MOLDING

Heating time at lower temperature **reduced by up to 46%**



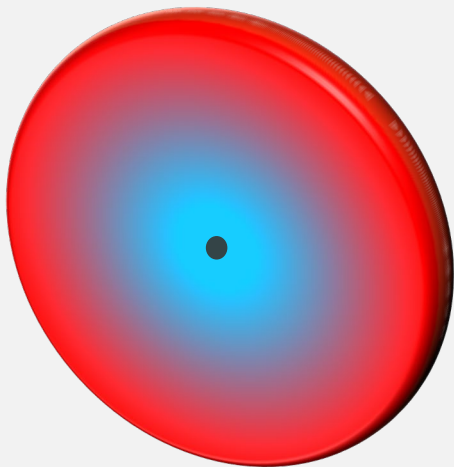
LTC LSR INJECTION MOLDING

- Heating time at lower temperature **reduced by up to 46%**
- Low temperature cure at high temperatures possible

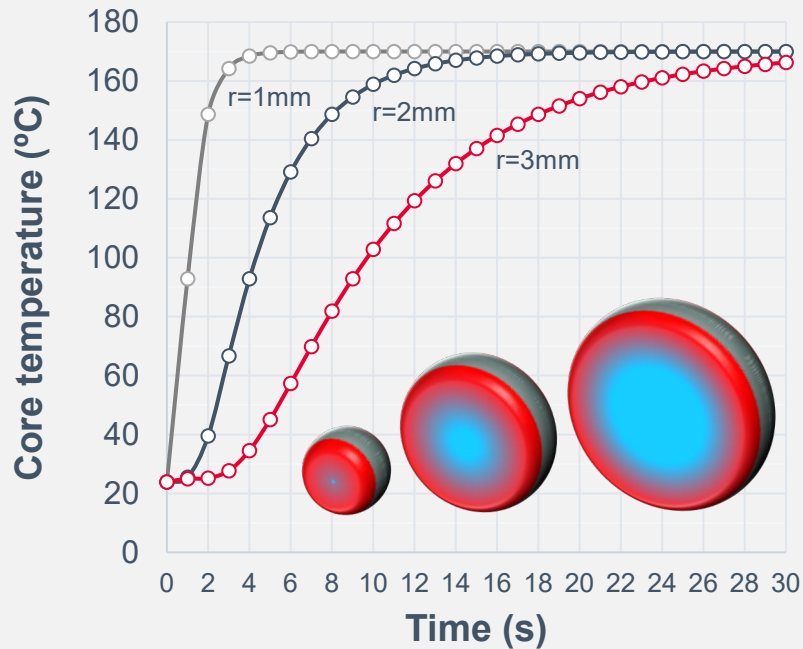


BENEFITS OF LTC LSR

LSRs, and silicones in general, have low thermal conductivity

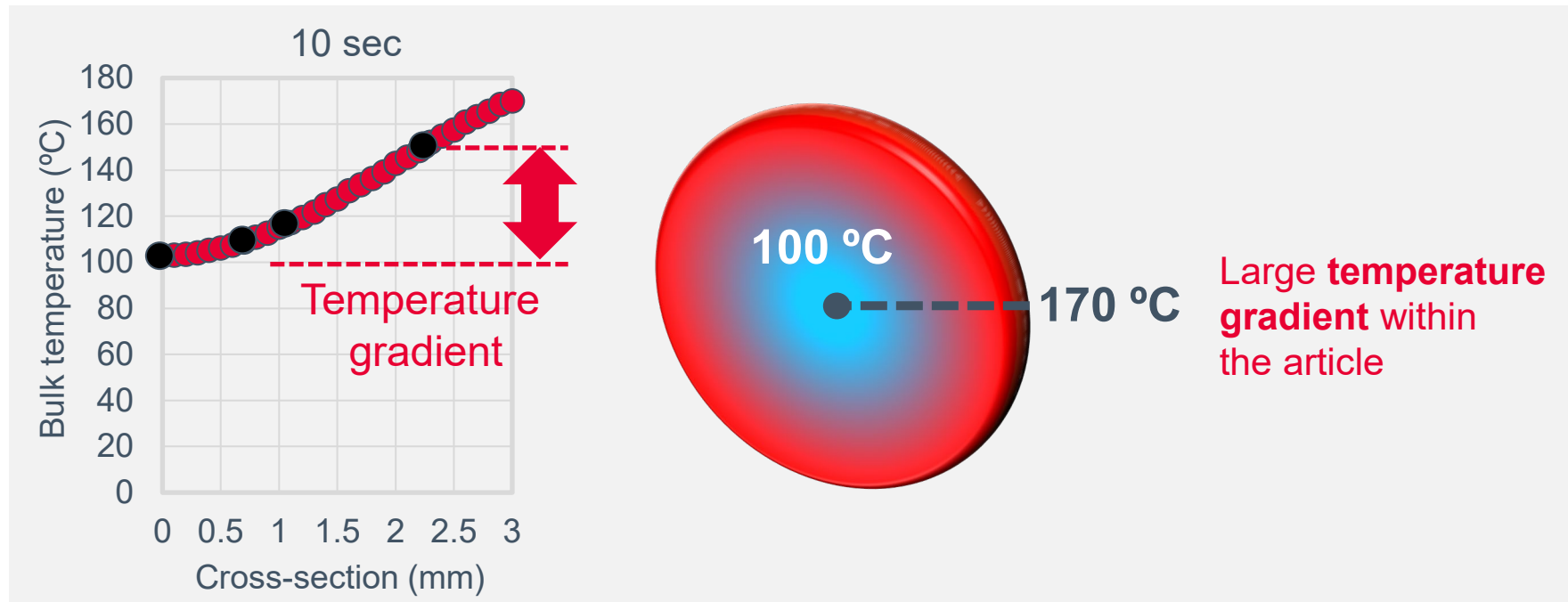


*Model: Cured LSR sphere of $r=x$ mm. Temperatures at $t_0=0$ sec:
 $T_{\text{bulk}}(t_0)=25^\circ\text{C}$, $T_{\text{surface}}(t_0)=170^\circ\text{C}$.



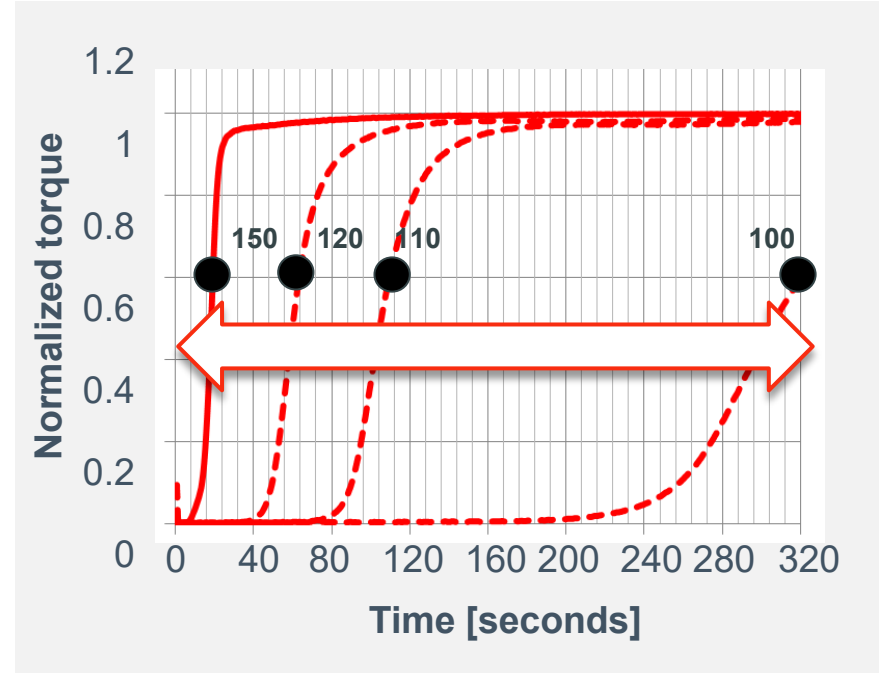
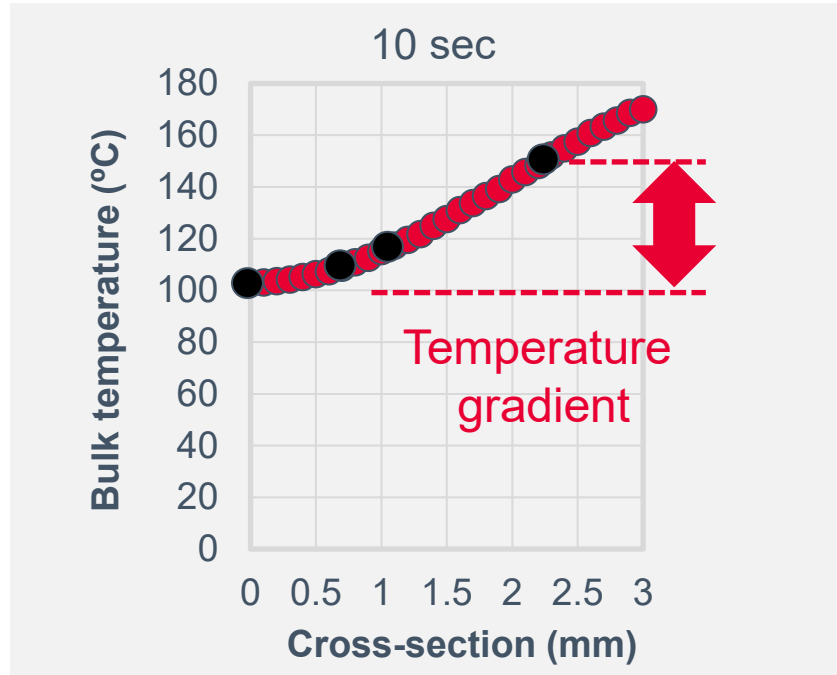
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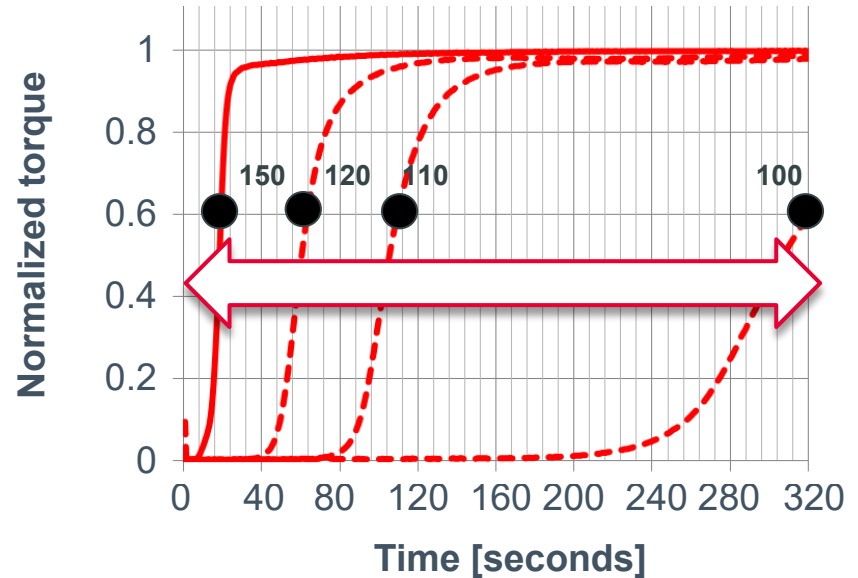
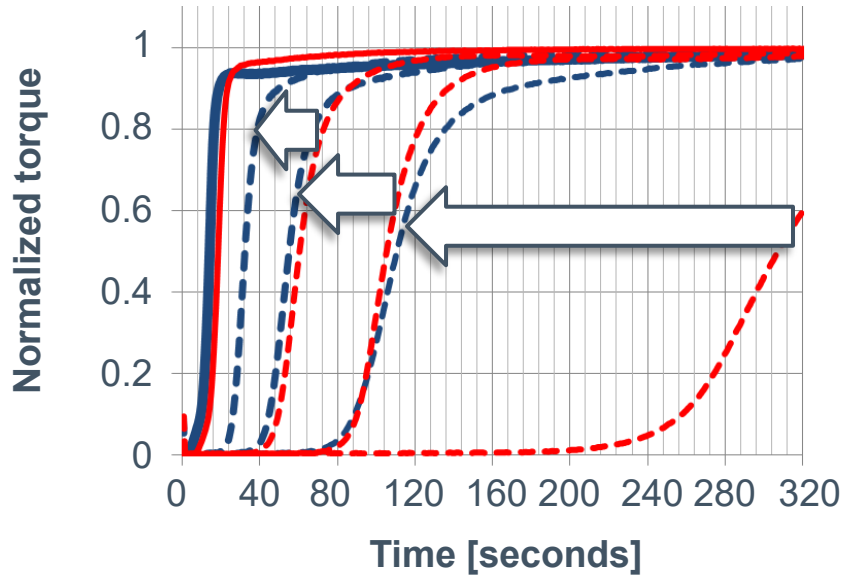
BENEFITS OF LTC LSR

- LSRs, and silicones in general, have low thermal conductivity
- Large temperature gradient within the article = **long cycle times**



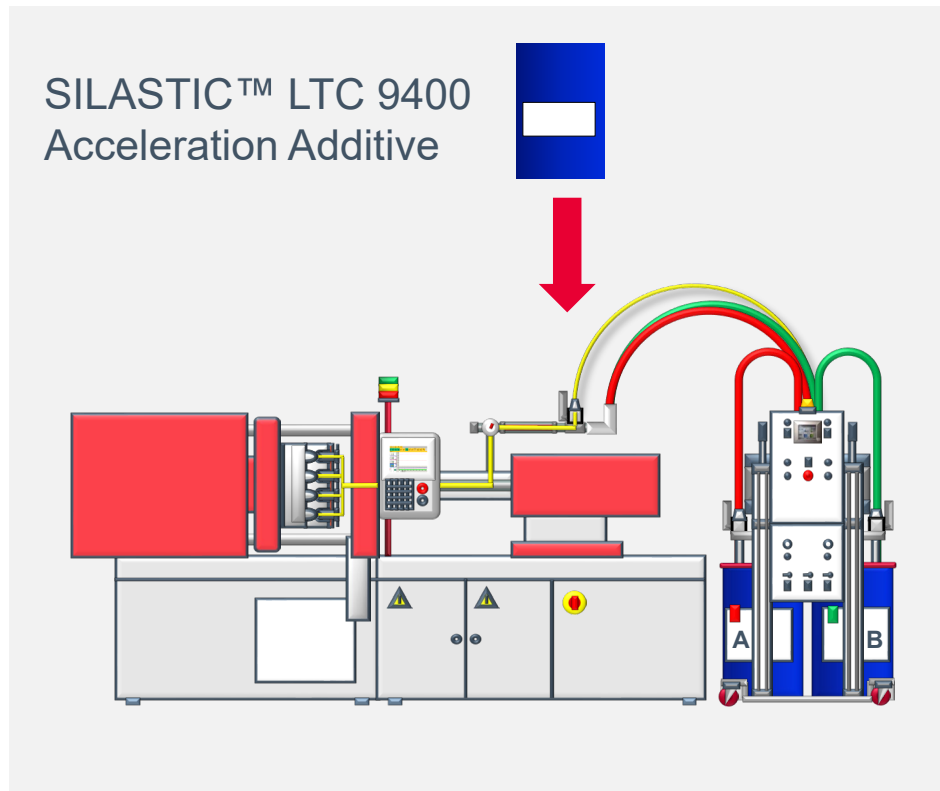
BENEFITS OF LTC LSR

- LSRs, and silicones in general, have low thermal conductivity
- Large temperature gradient within the article = **long cycle times**
- LTC LSR shows significantly reduced sensitivity to temperature gradients



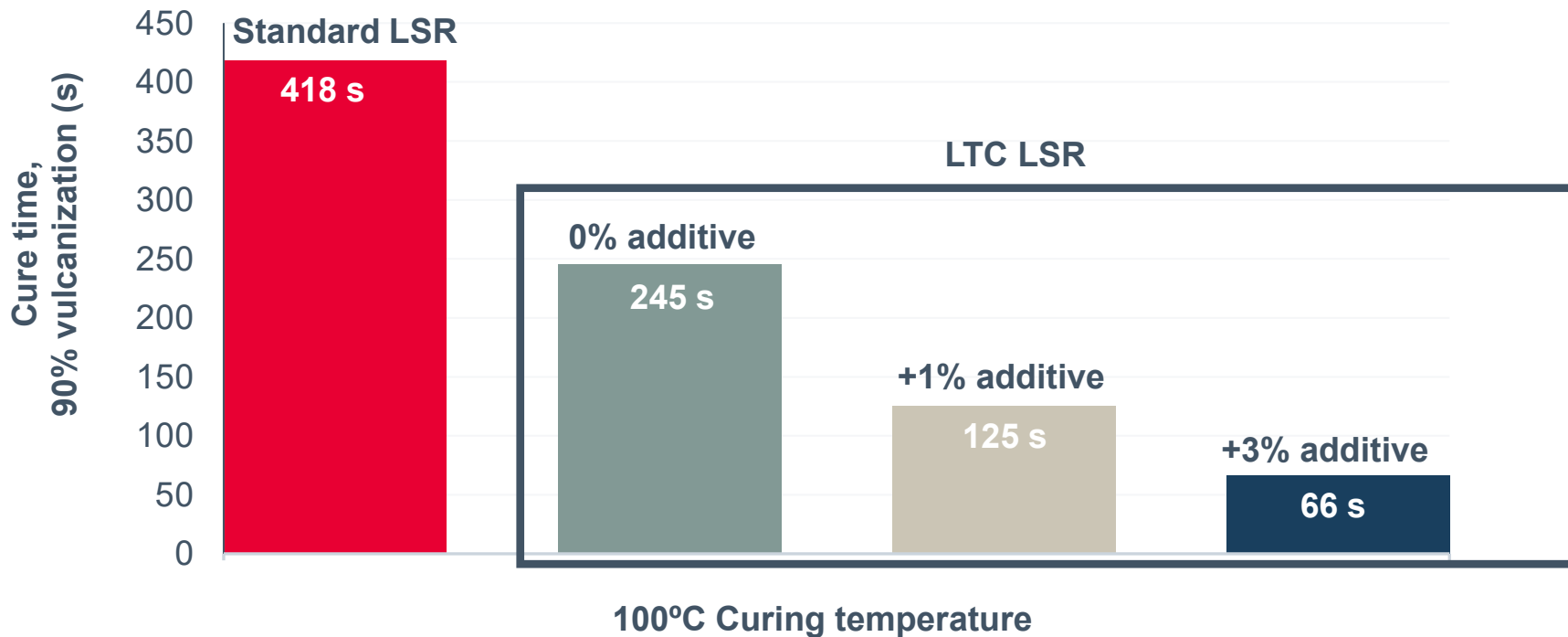
LTC ACCELERATION ADDITIVE

- **Lower** temperature cure achievable with additive
- Acceleration additive can be introduced via 3rd stream color dosing
- Tailored to match activation profile of SILASTIC™ LTC 9400 Series LSRs
- Allows on/off operation for robust processing and pot life control
- Large effect at low dosage levels (1-3%)



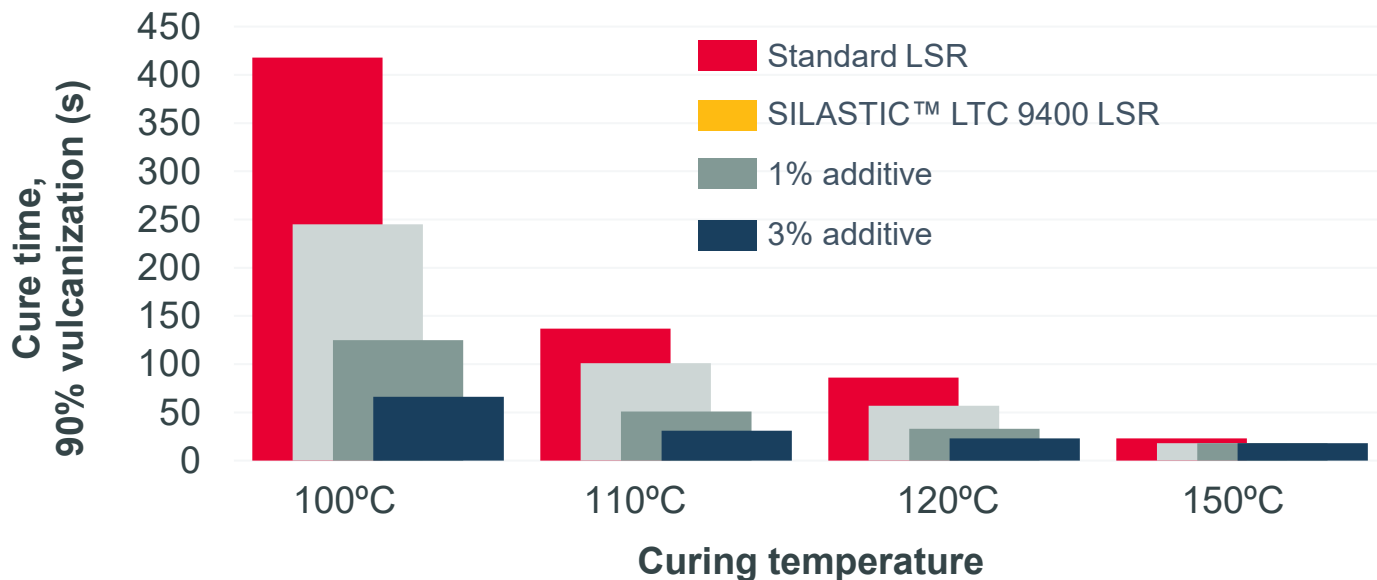
LTC ACCELERATION ADDITIVE

Significant impact on cure time, even at low dosage levels (1-3%)



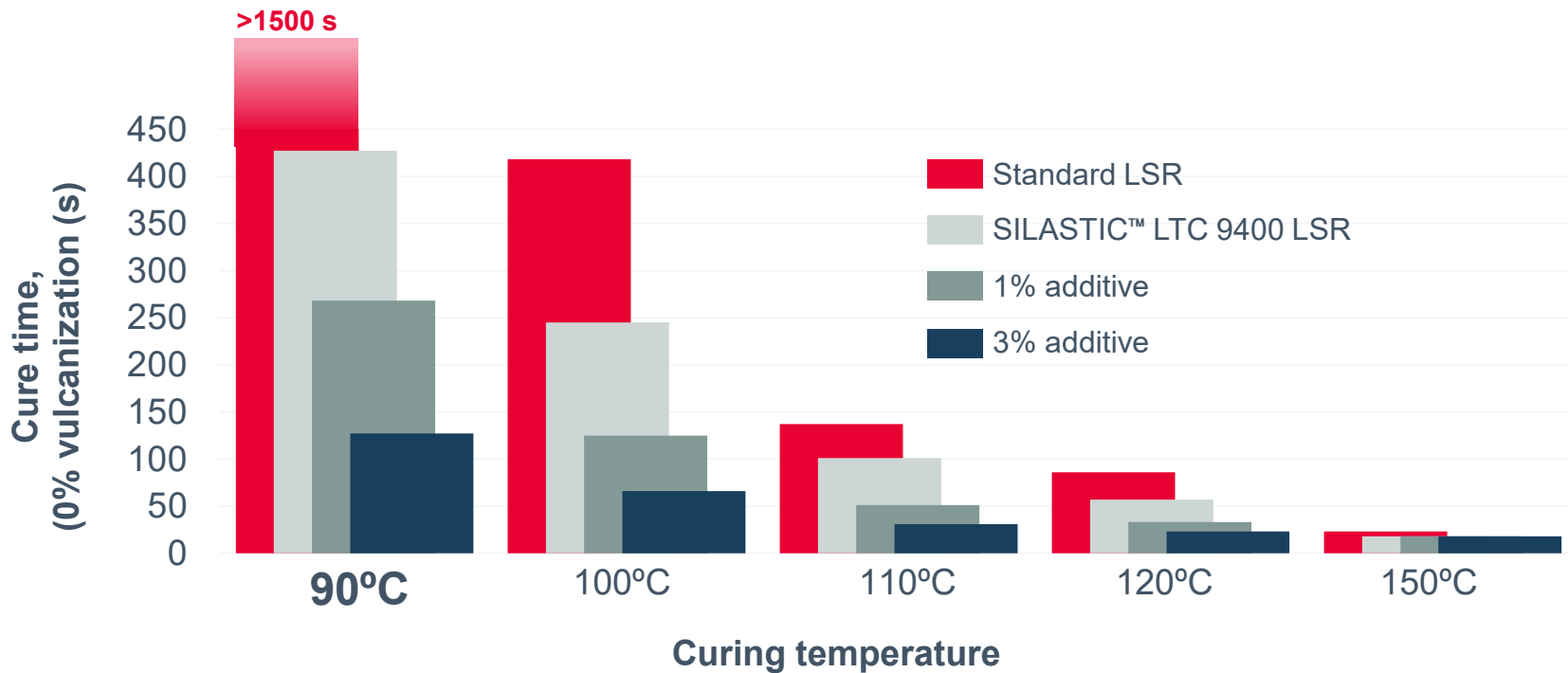
LTC ACCELERATION ADDITIVE

- Significant impact on cure time, even at low dosage levels (1-3%)
- Decreases temperature sensitivity at lower temperatures



LTC ACCELERATION ADDITIVE

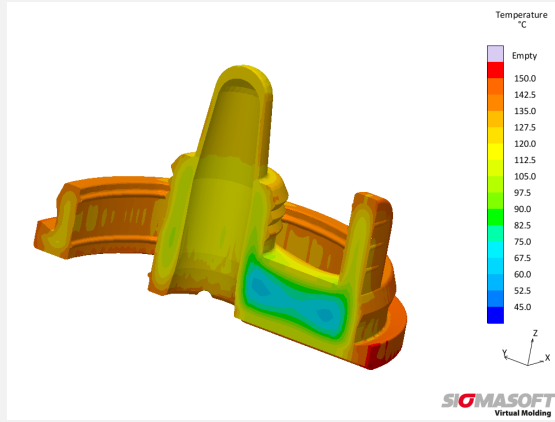
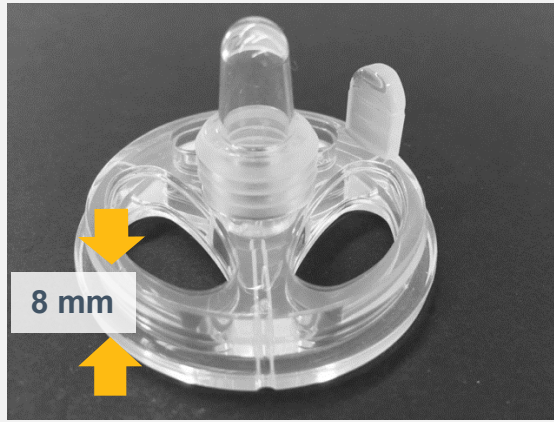
Impact of LTC and acceleration additive more significant at cure temperatures $\leq 100^{\circ}\text{C}$



DEEP-SECTION CURE MODELING AND VALIDATION

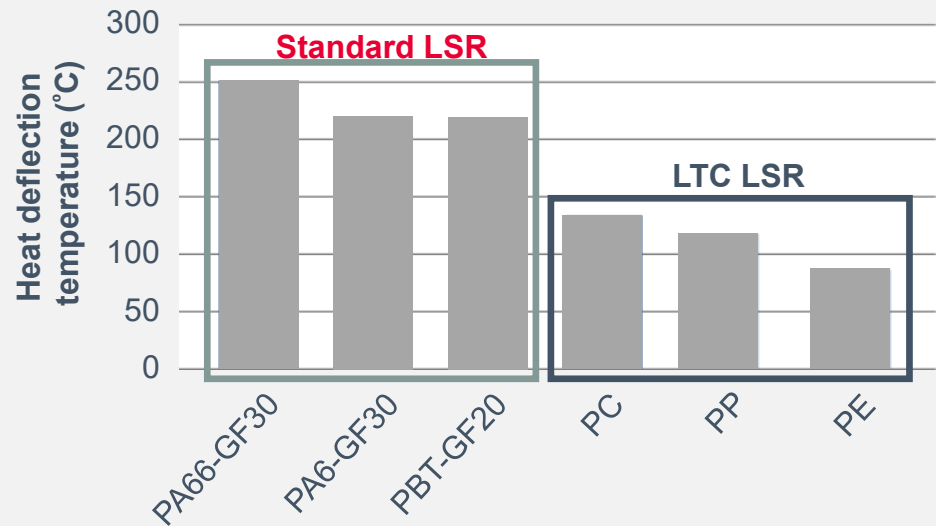
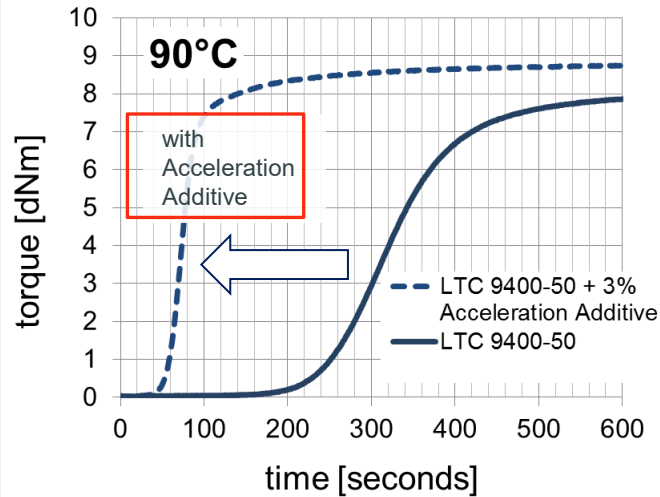
- Low Temperature Cure acceleration demonstrated with SILASTIC™ LTC 9400-50 LSR
- Further reduce sensitivity to temperature gradients
- SILASTIC™ LTC 9400 Acceleration Additive **introduced at 0.5%**
- 30 s total cycle time achieved at 160°C

Simulated by *SIGMASOFT*: Temperature distribution after 20 s



CO-MOLDING WITH PLASTICS

- LTC LSR allows fast curing at low temperatures
- Avoids plastic deformation
- Fast cycle time



CONCLUSIONS

- Low temperature cure is a novel technology platform for LSRs
- Step-change reduction in curing temperatures, $<120^{\circ}\text{C}$
- Acceleration additive allows reasonable cure times at temperatures $<100^{\circ}\text{C}$
- Can provide several benefits compared to traditional LSRs:
 - Lower operating temperatures
 - Shorter process cycle times
 - Faster bulk activation
 - Better deep-section cure
 - Ability to co-mold with wider range of substrates





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THANK YOU

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