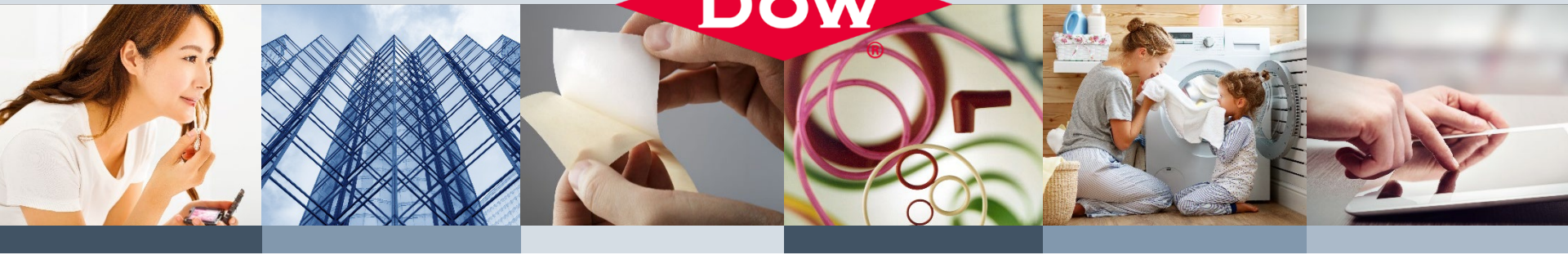

Consumer Solutions

LOW TEMPERATURE CURE LSR TECHNOLOGY ENABLES PROCESSING IMPROVEMENTS

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Rubber Division
American Chemical Society

OUTLINE

SiLASTIC™

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

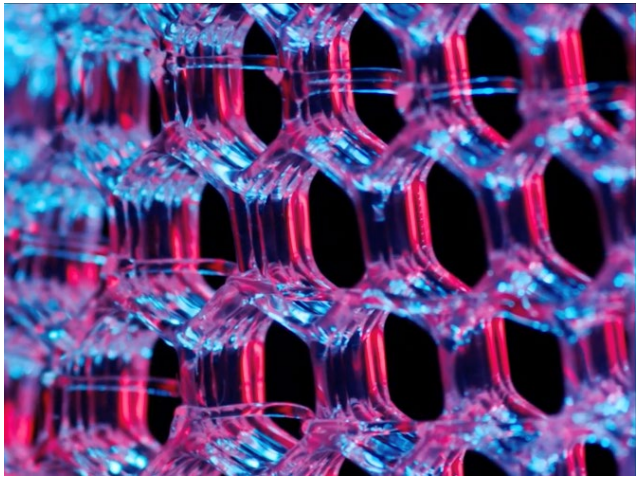
LIQUID SILICONE RUBBER

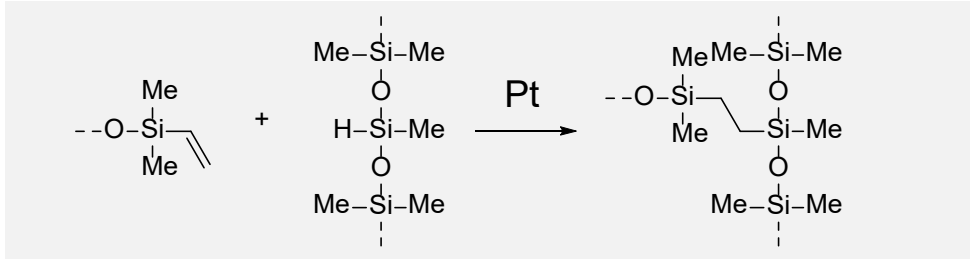
- Two-part, dispensible, heat-cured silicone elastomers
- Good mechanical properties
- Excellent resistance to weathering, extreme temperatures, and aging

- LSR market growth at CAGR >8%
- Wide range of applications
  - Transportation
  - Food/hygiene/medical
  - Electrical/electronics
- Overall trend for optimum quality, processing and efficieny

CONDENSATION CURE

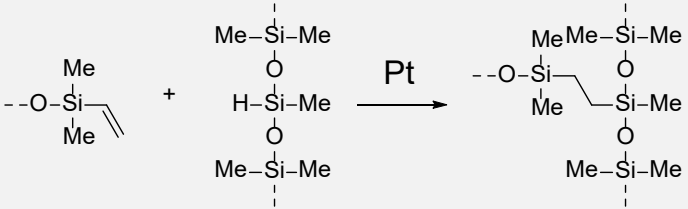
- Pt-catalyzed hydrosilylation
- Addition of silicon hydrides (SiH) to unsaturated groups
- Reaction readily proceeds at 23°C
- Additives often included to provide handling time by inhibiting cure at room temperature
- Typically cure is **heat activated**

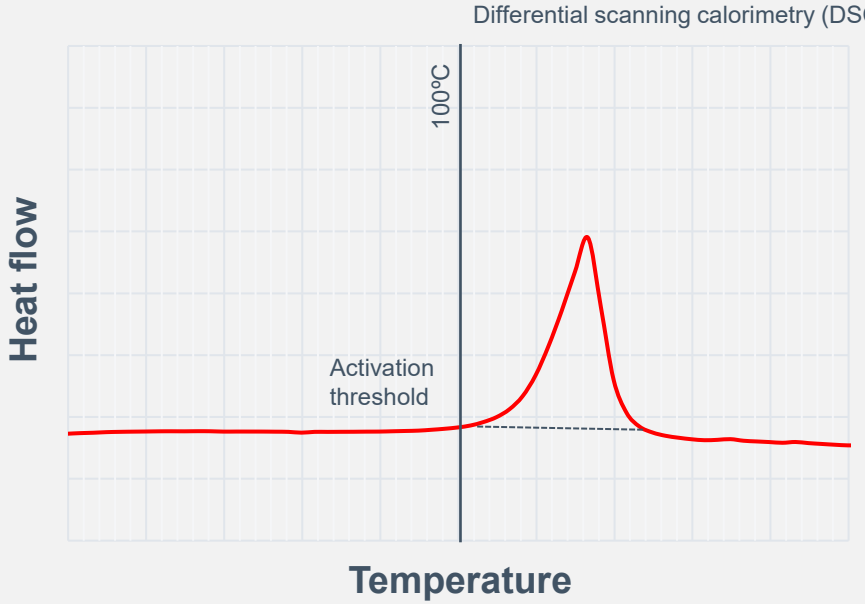




STANDARD CURE

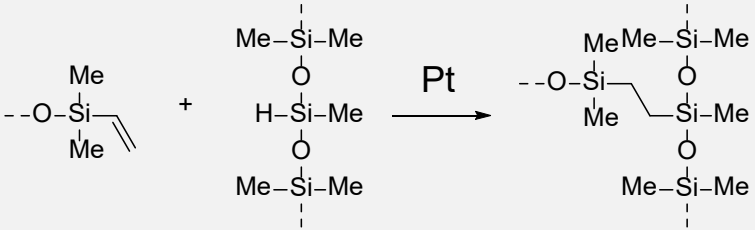
- LSRs generally have a high activation threshold
- Standard cure temperature range from 160-220°C

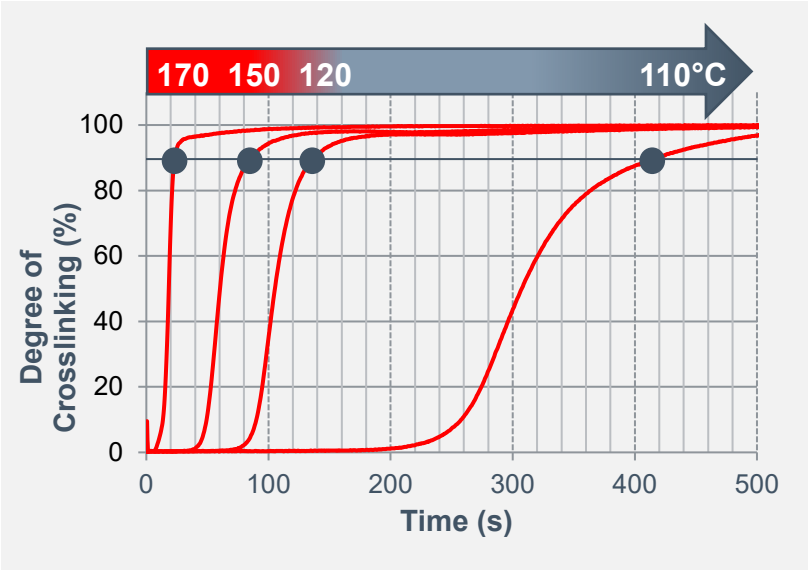


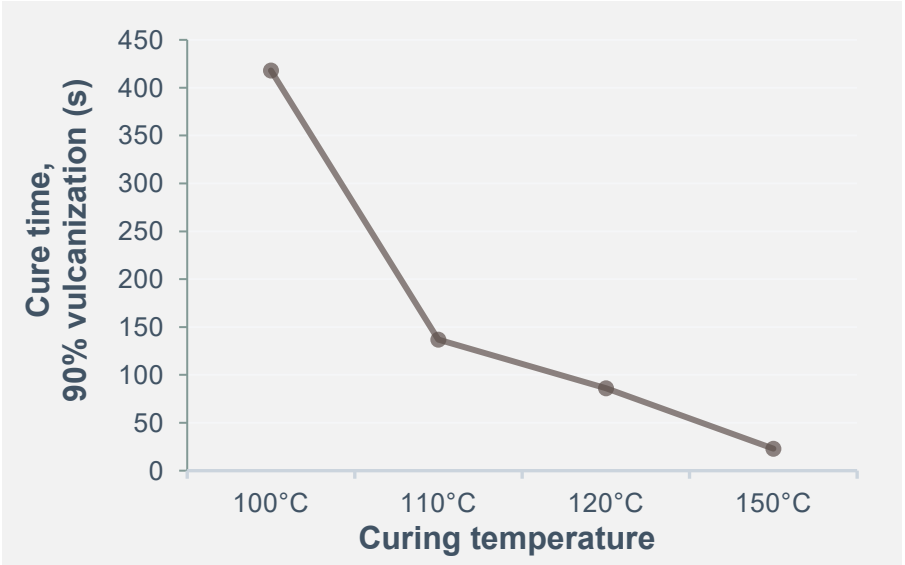


STANDARD CURE

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







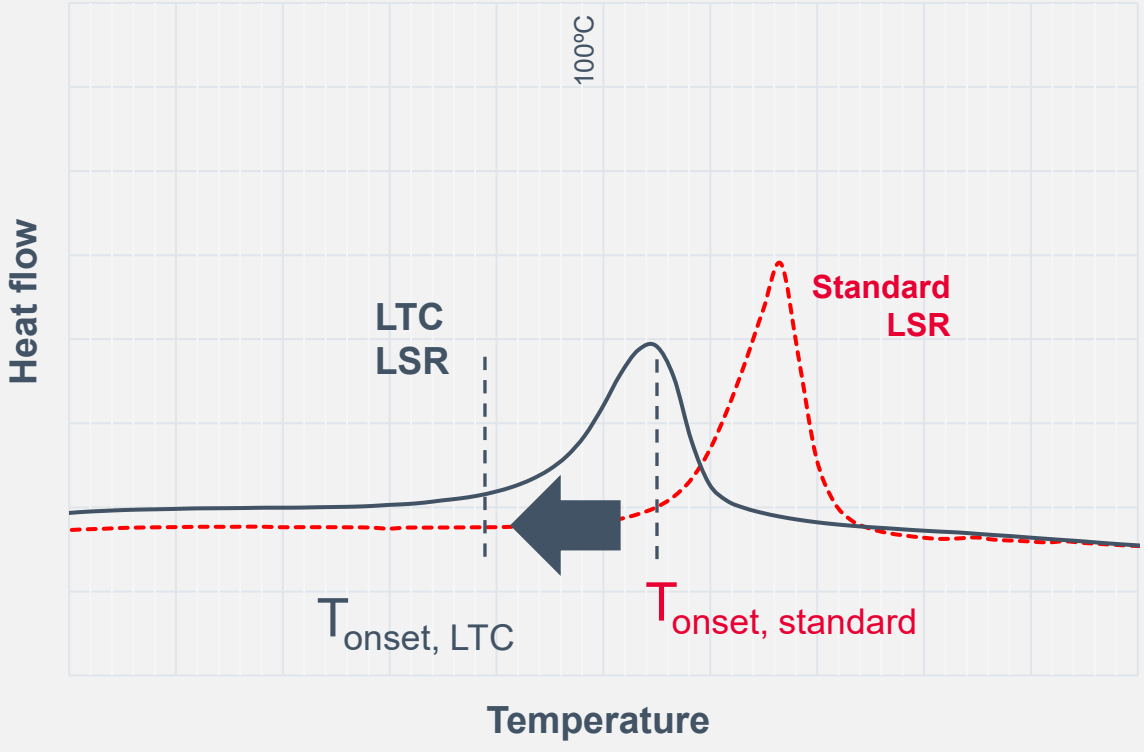
LOW TEMPERATURE CURE (LTC)

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)

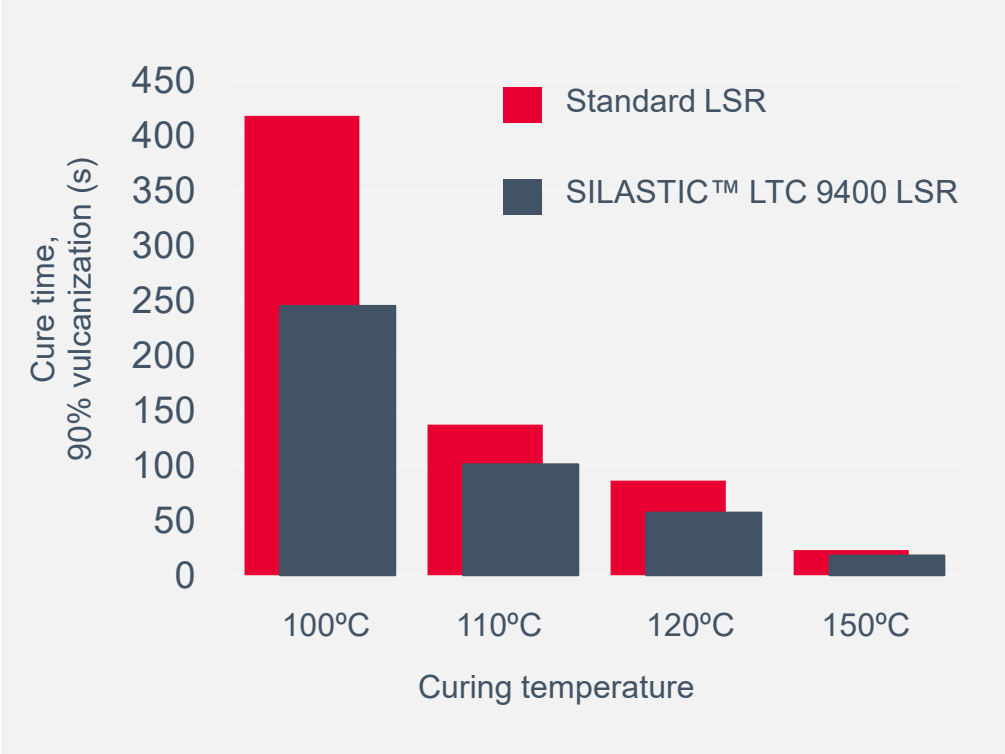
Activation threshold shifted to temperatures <100ºC



LOW TEMPERATURE CURE (LTC)

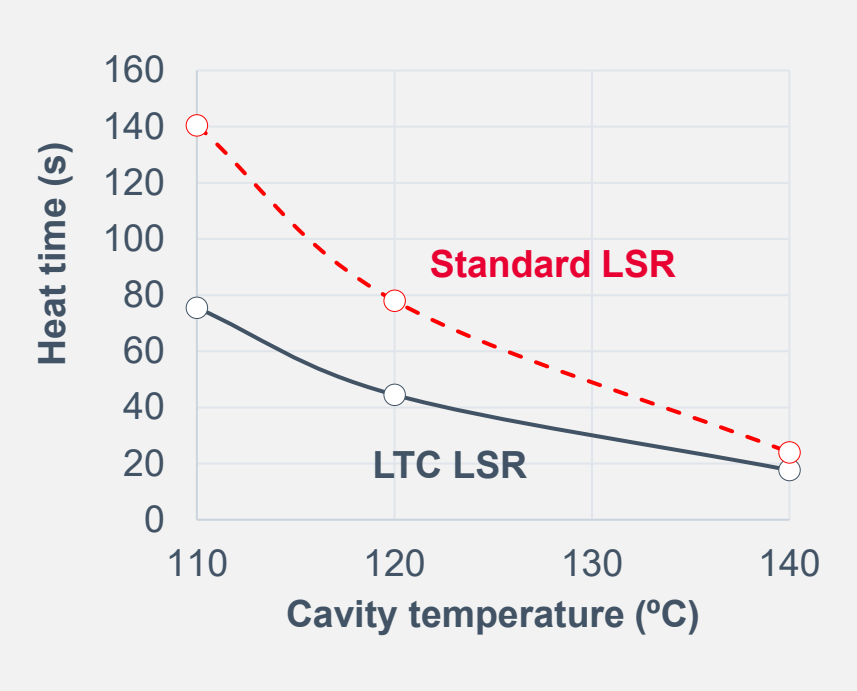
Low Temperature Cure (LTC) LSR:

- Significant reduction of curing time at low temperatures (<120°C)
- 72 h pot life still maintained



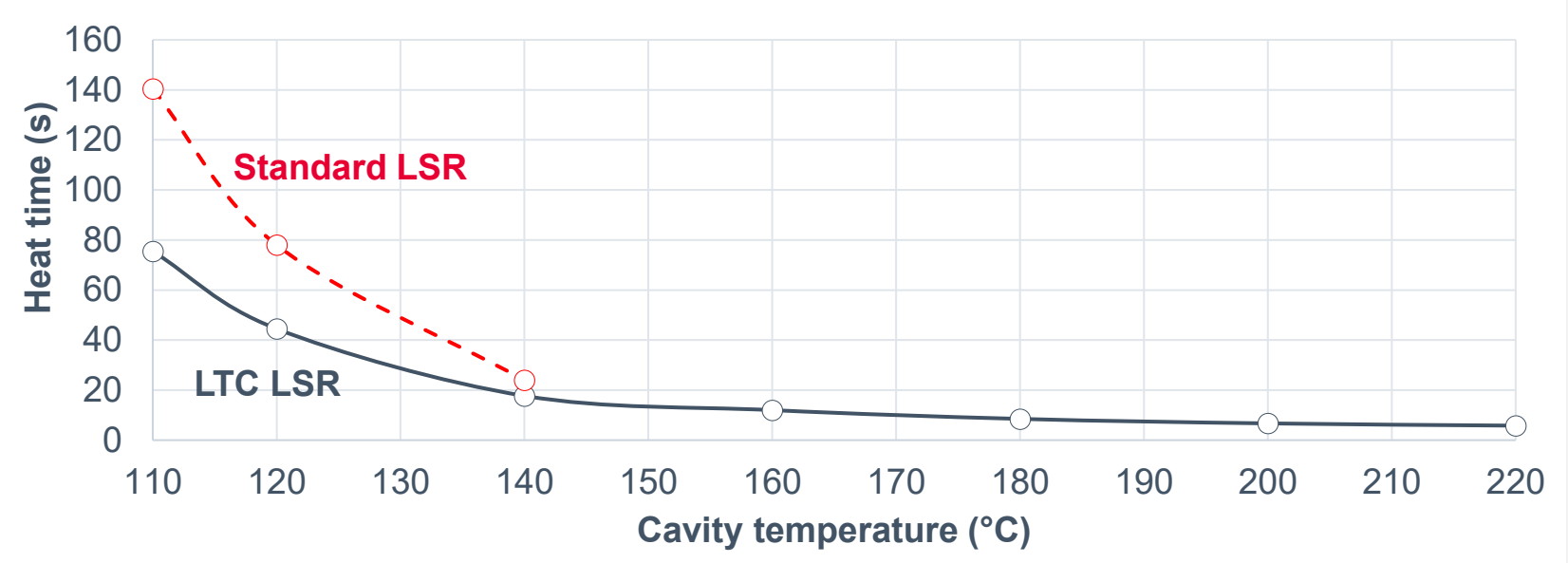
LTC LSR INJECTION MOLDING

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



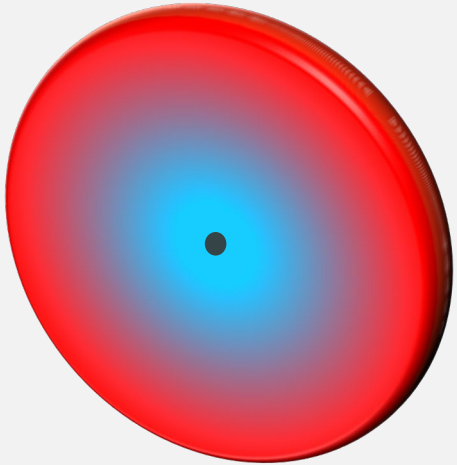
LTC LSR Injection Molding

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

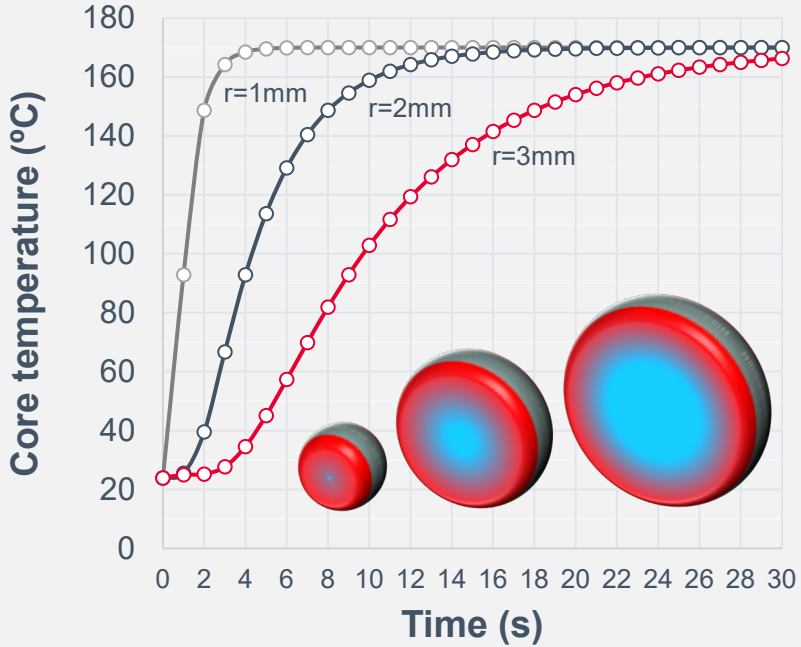


BENEFITS OF LTC LSR

LSRs, and silicones in general, have low thermal conductivity



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



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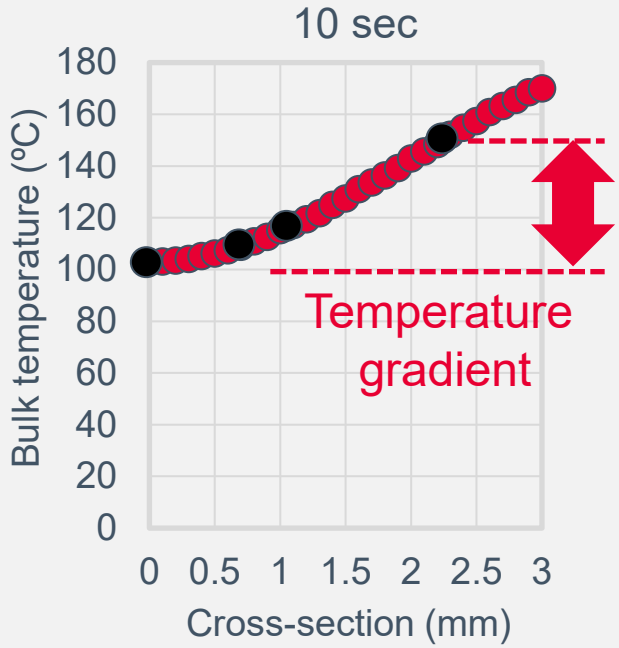
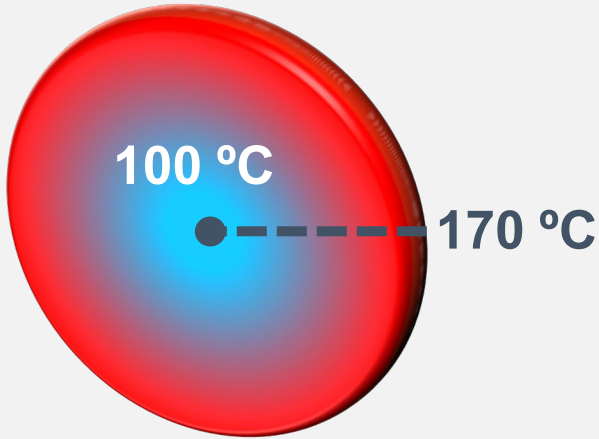
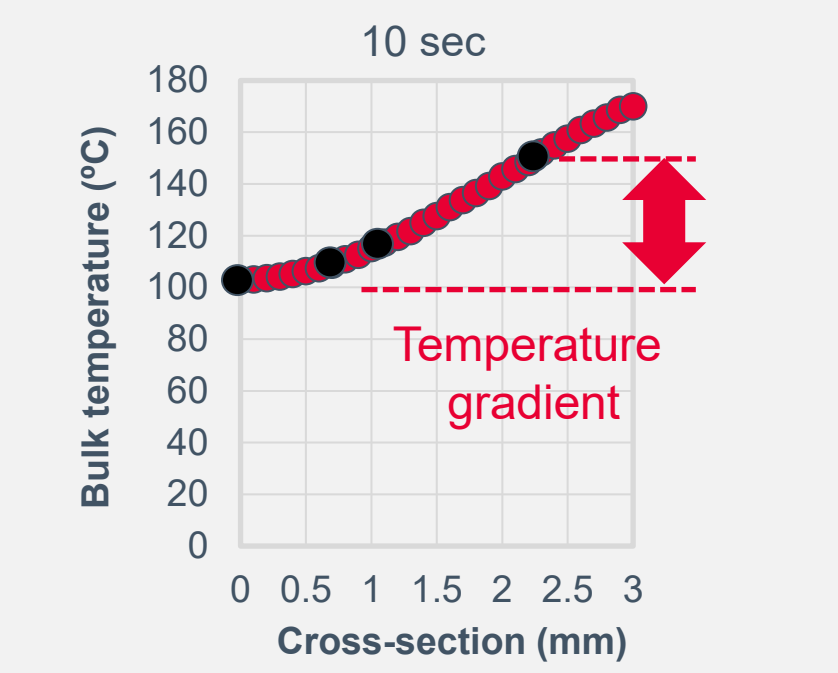


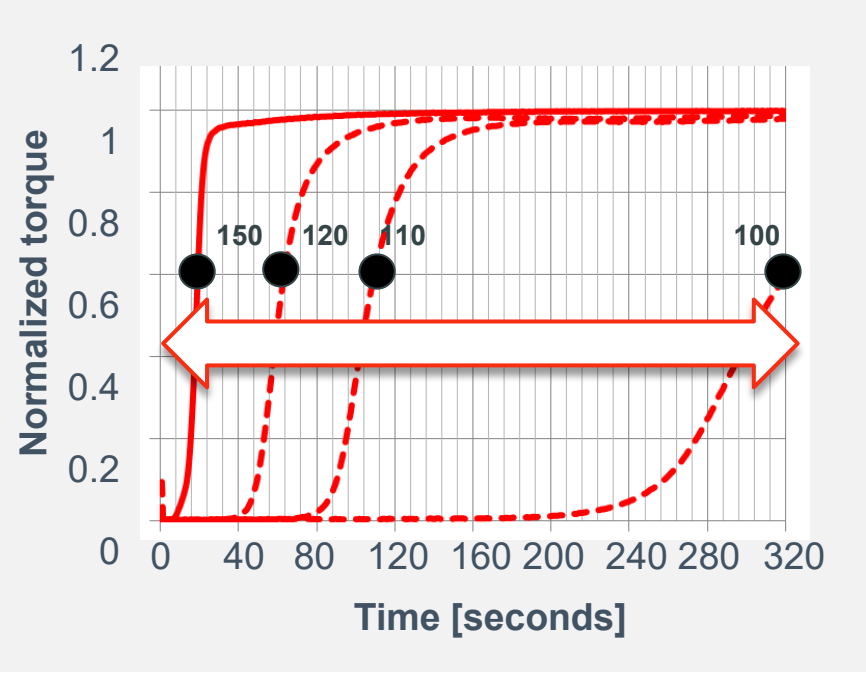


Large **temperature gradient** within the article

BENEFITS OF LTC LSR

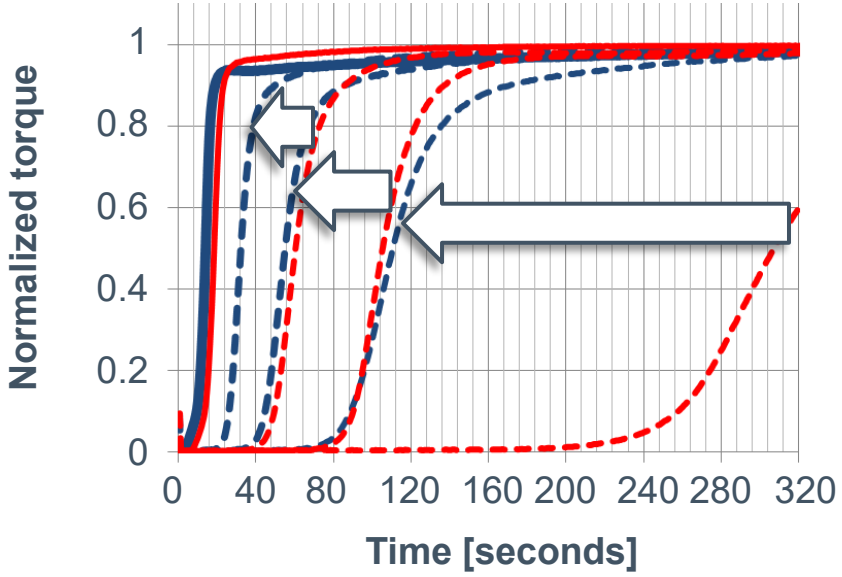
- LSRs, and silicones in general, have low thermal conductivity
- Large temperature gradient within the article = **long cycle times**

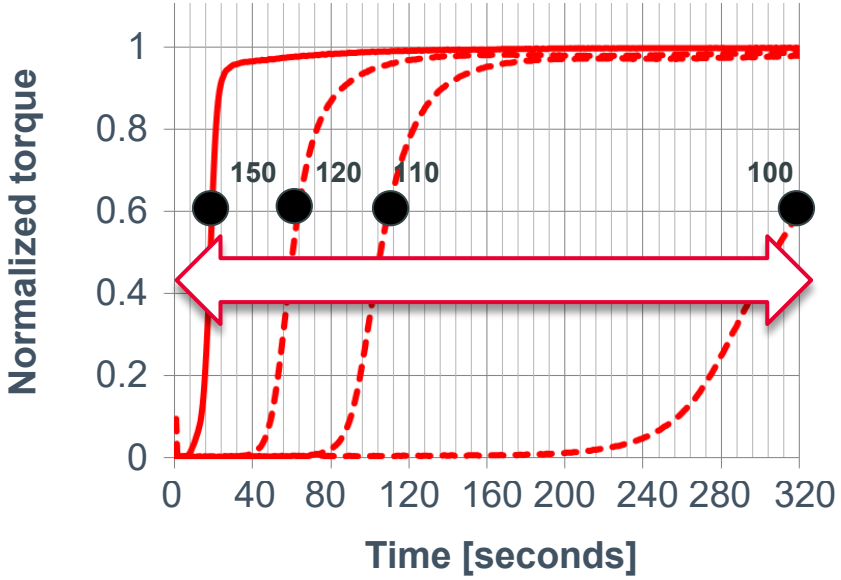




BENEFITS OF LTC LSR

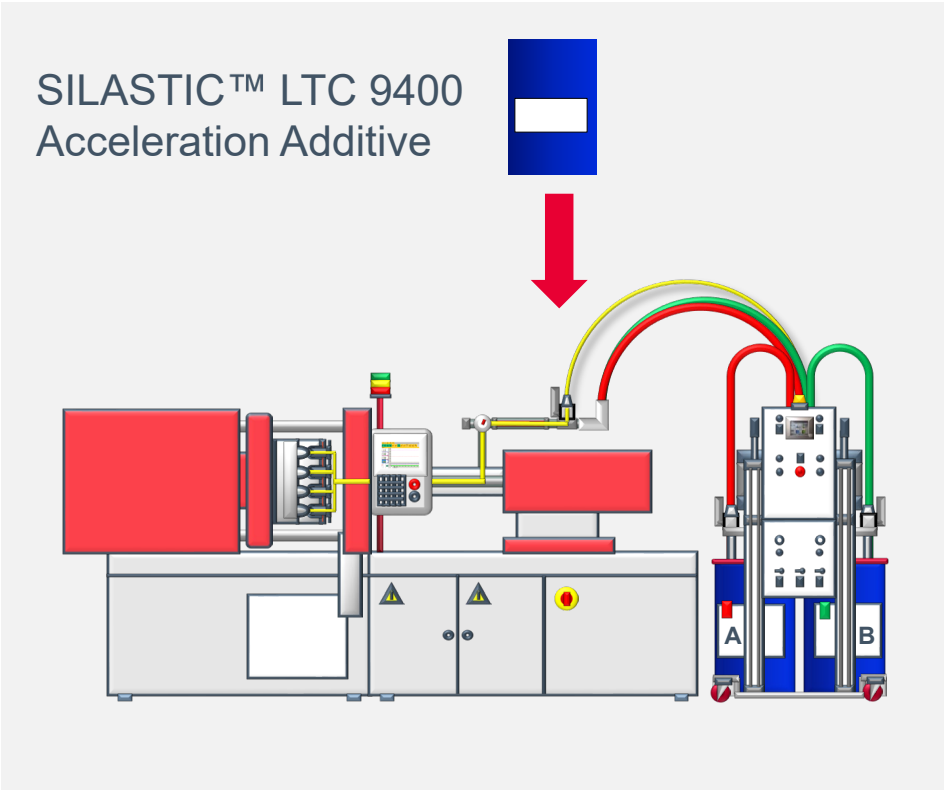
- LSRs, and silicones in general, have low thermal conductivity
- Large temperature gradient within the article = **long cycle times**
- LTC LSR shows significantly reduced sensitivity to temperature gradients





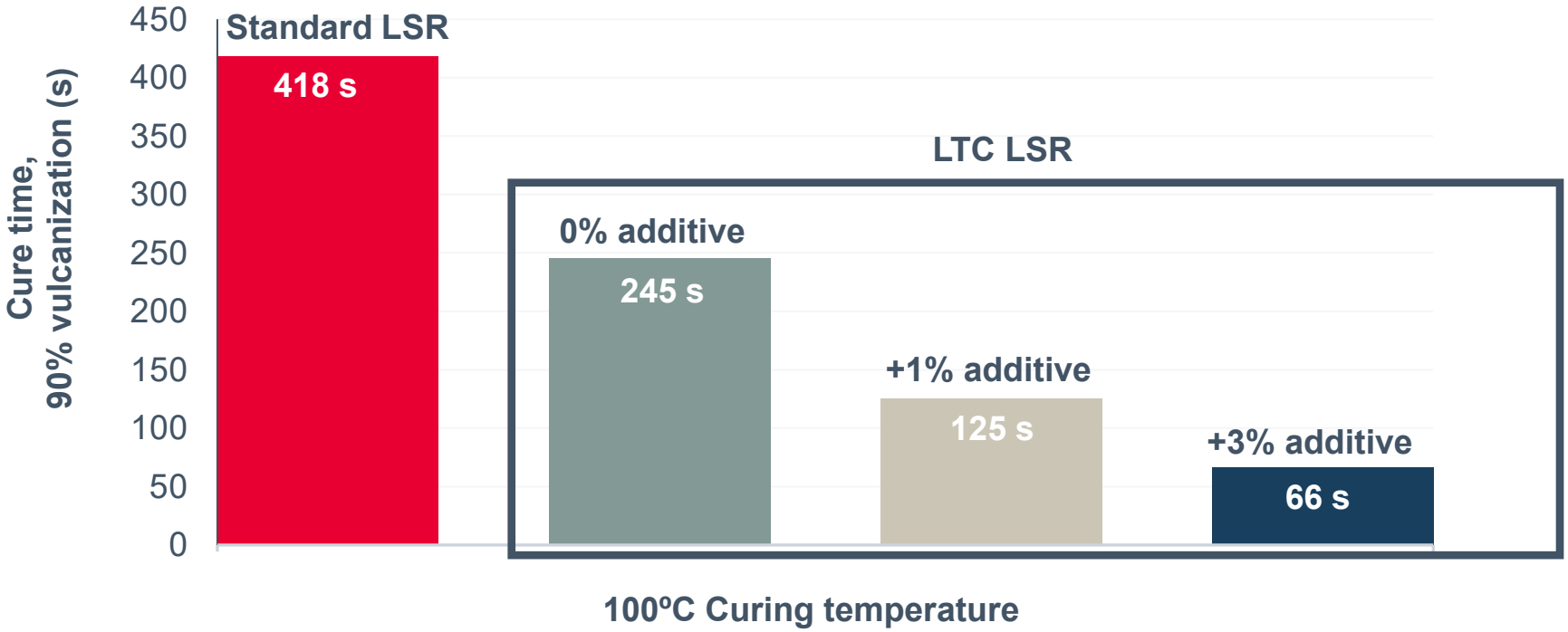
LTC ACCELERATION ADDITIVE

- **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%)



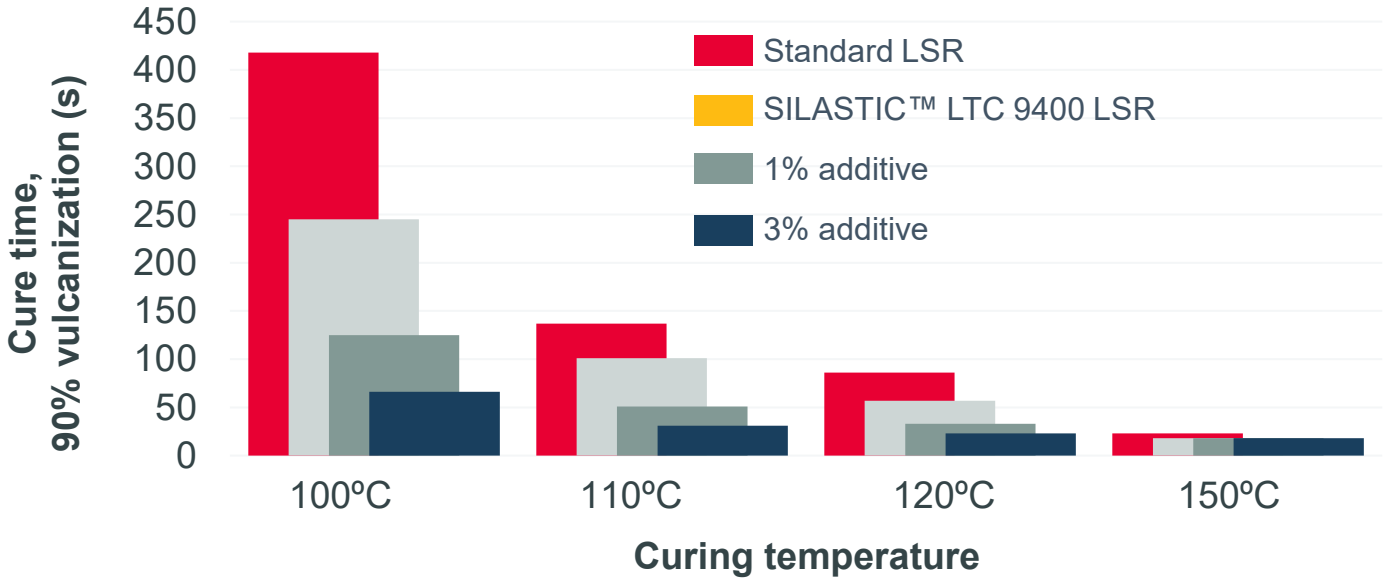
LTC ACCELERATION ADDITIVE

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



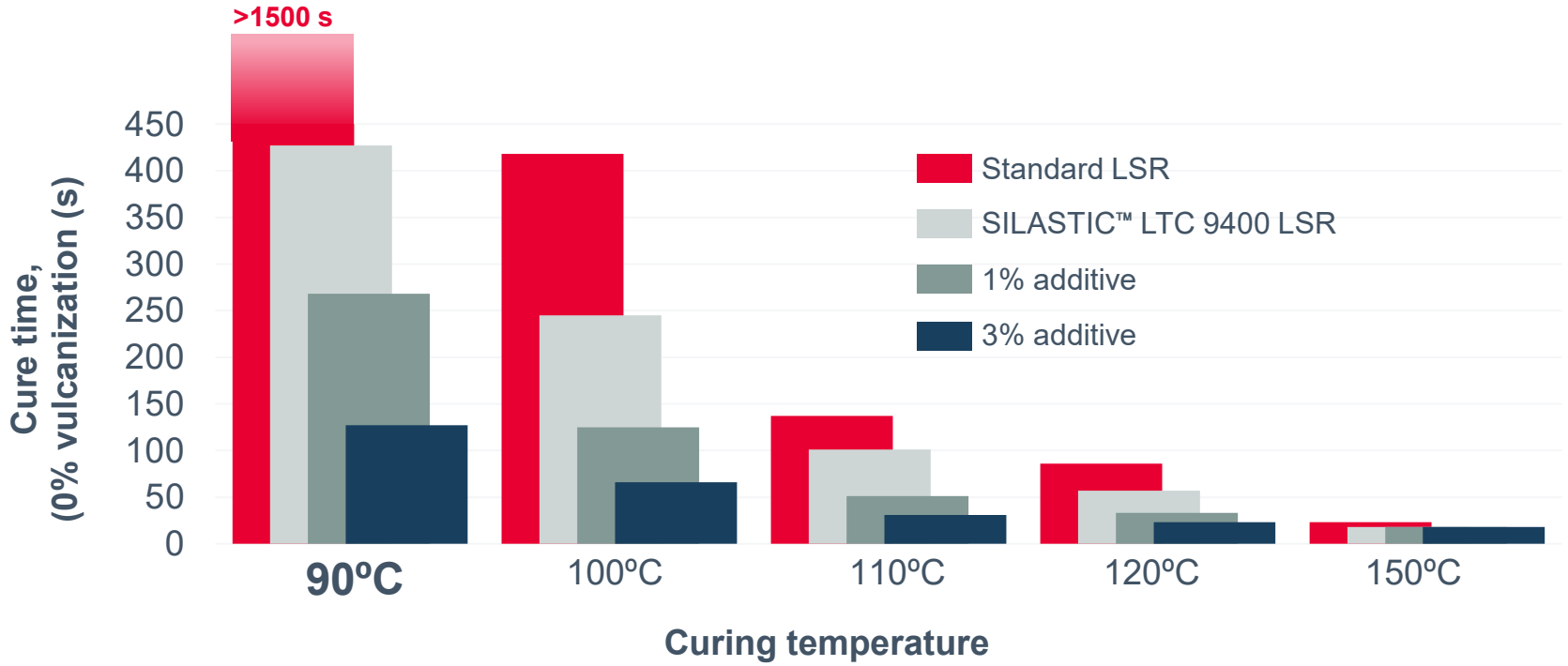
LTC ACCELERATION ADDITIVE

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



LTC Acceleration Additive

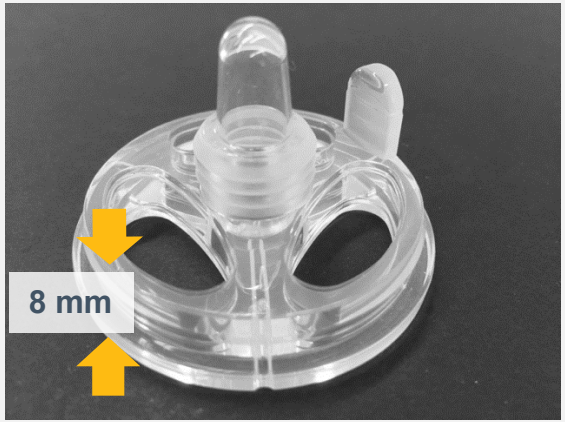
Impact of LTC and acceleration additive more significant at cure temperatures <100°C

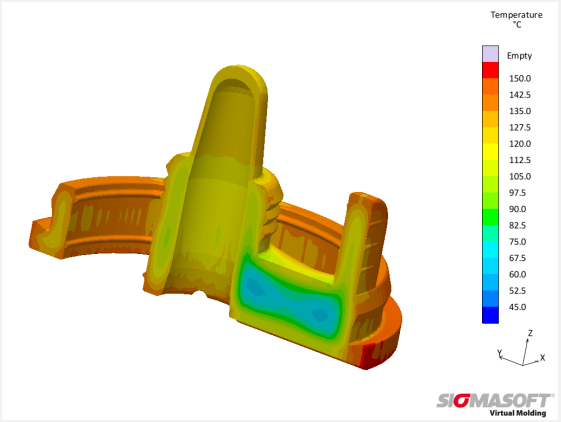


DEEP-SECTION CURE MODELING AND VALIDATION

- 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

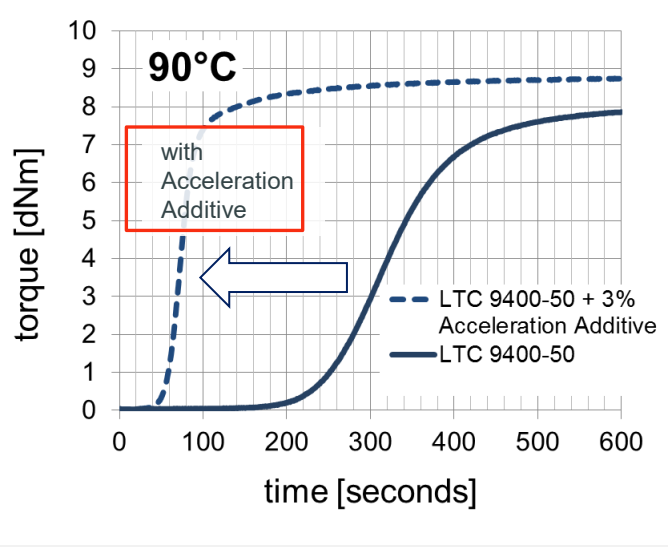
Simulated by *SIGMASOFT:* Temperature distribution after 20 s

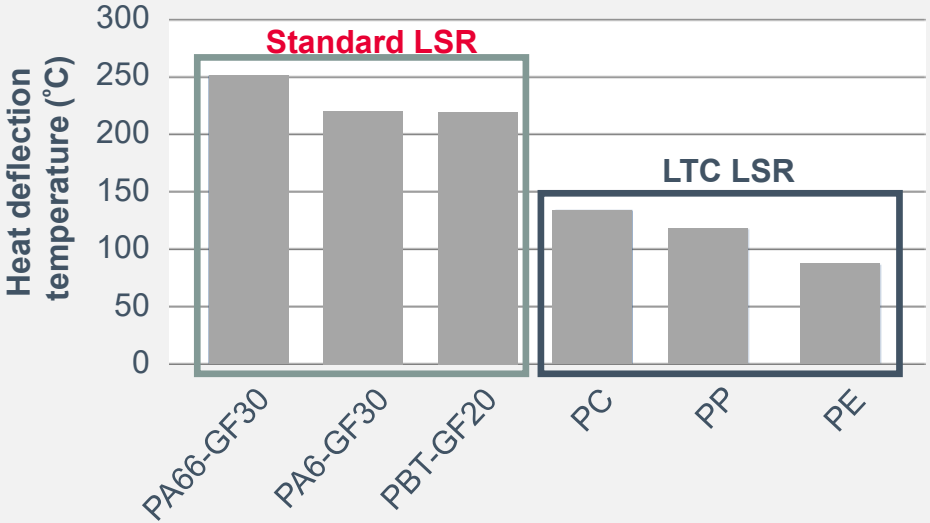




CO-MOLDING WITH PLASTICS

- 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°C
- Acceleration additive allows reasonable cure times at temperatures <100°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

Seek

Together™

THANK YOU

02.26.25

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International Elastomer Conference
Cleveland, OH, October 10, 2019

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