

GREAT DESIGNS IN  
**STEEL**

**ULTRALUME® STEELS FOR HOT  
STAMPING OF AUTOMOTIVE  
STRUCTURAL COMPONENTS**

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Cleveland-Cliffs Inc.  
Product Research Engineer



**CLIFFS**

# Hot Processing Research and Operations

Fully Integrated Product and Process Development

Laboratory Simulations

Mill Trials

Part Design

Hot-Processing Trials

Part Validation

Mass Production



Tooling and Stamping  
CCTS

Research and Innovation Center  
RIC

Tubular Components  
CCTC

Our Brands

ULTRALUME®

FORMTUBE®



## Hot-Stamping Process Overview



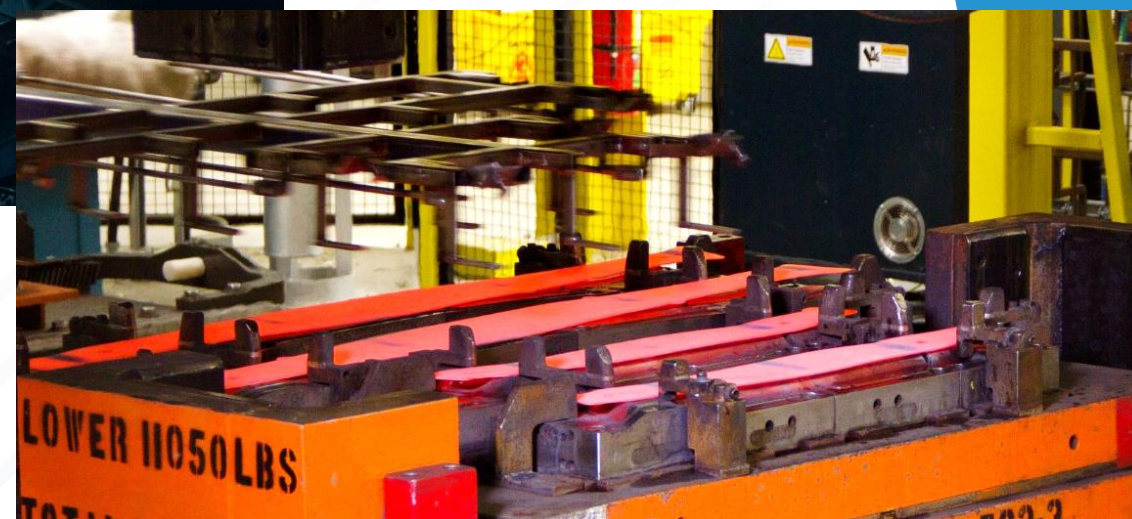
Heat Treating



Transferring

Typical heat-treatment  
parameters:  
910 to 950 °C / 3 to 6 minutes

Cleveland-Cliffs  
Tooling and Stamping



Hot Stamping

# Al-Si Coating: Aluminized Hot-Processed Steels

Uncoated and Stamped

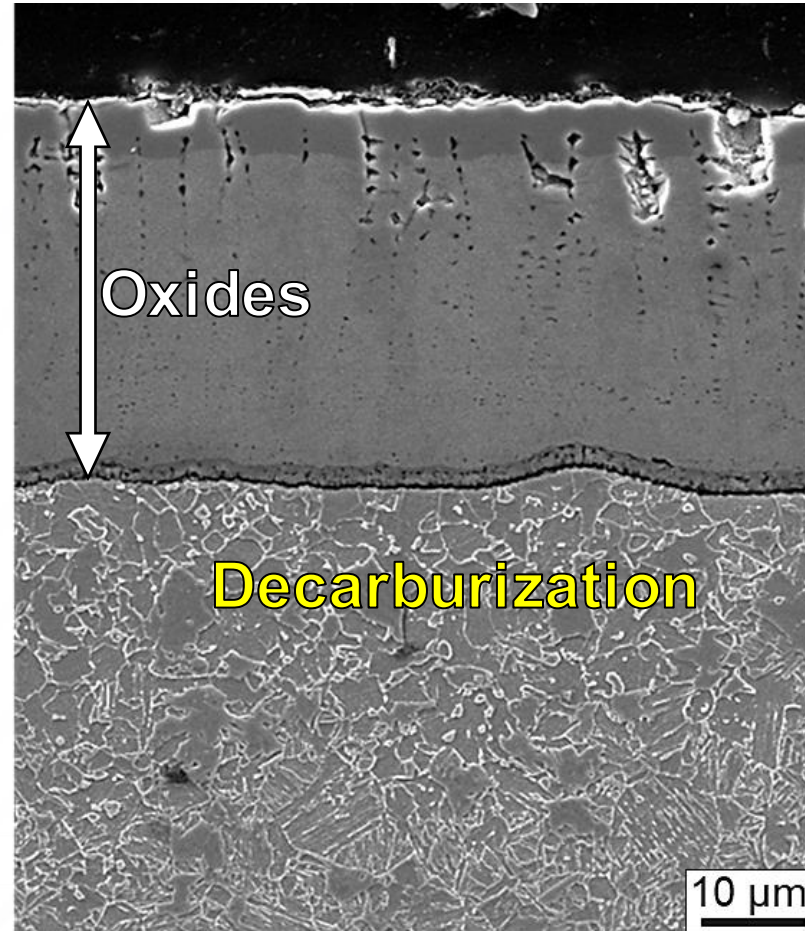


Al-Si Coated and Stamped

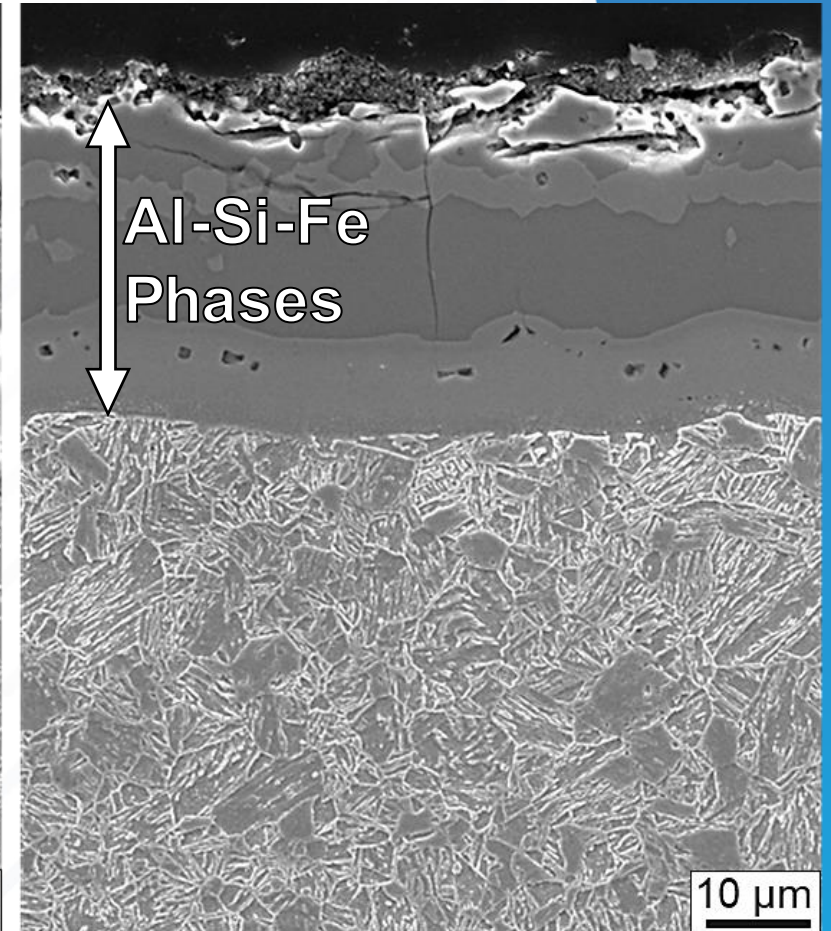


Treated at 930 °C, 5 minutes

Uncoated and Stamped



Al-Si Coated and Stamped



*Al-Si coating offers protection against scale formation and surface decarburization during heat-treatment*

# Cleveland-Cliffs ULTRALUME® Steels

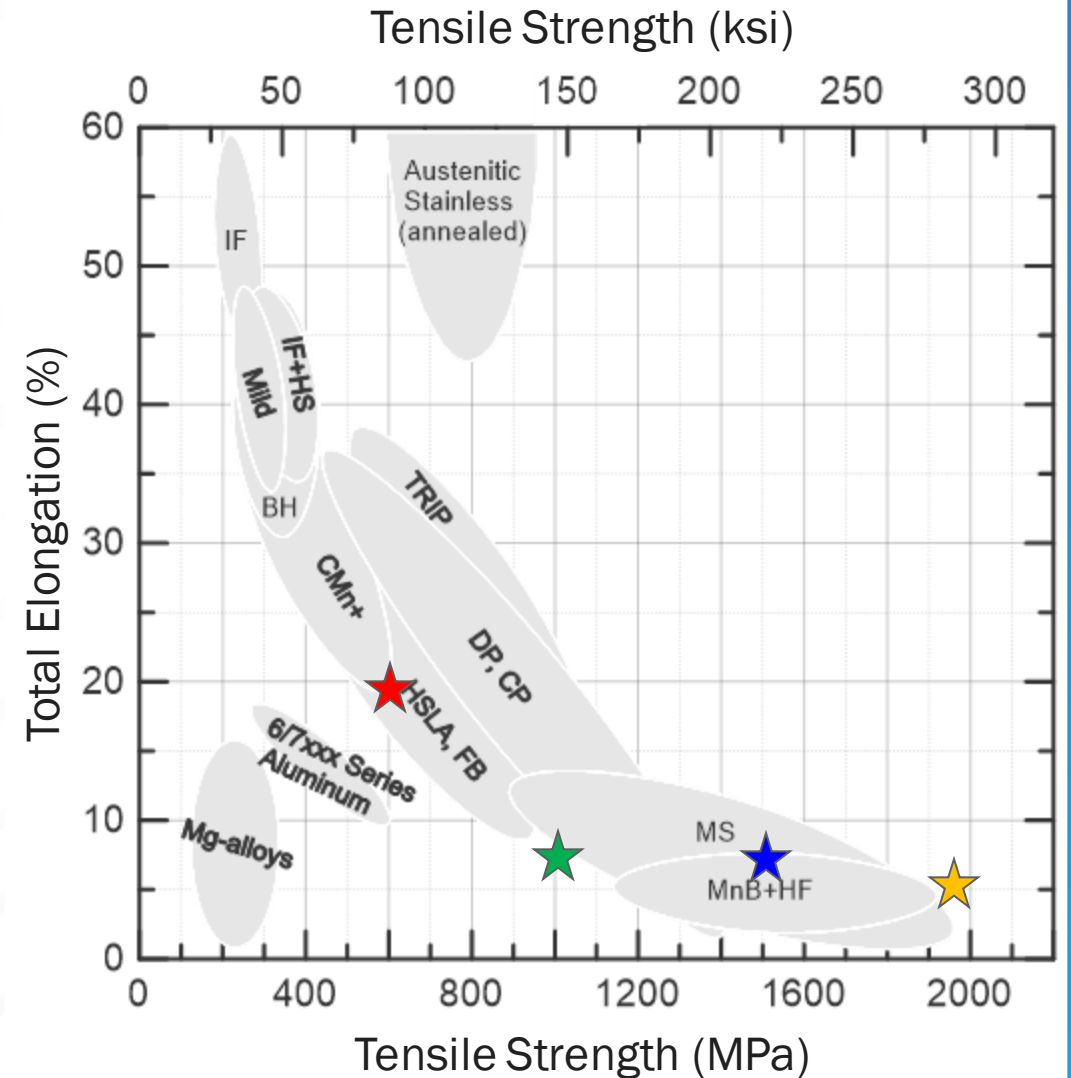
Grade	Yield Strength, MPa (typical)	Tensile Strength, MPa (typical)	Total Elongation, % (typical)	VDA 238-100 Bending Angle (°)‡	Stage
ULTRALUME® 500 As-Stamped	380	590	18 min.	110 min.	<b>Commercially Available</b>
ULTRALUME® 1000 As-Stamped	820	1030	6% min.	70 min.	Product Validation ( <i>Demonstration Material Available</i> )
ULTRALUME® 1500* As-Stamped	1000	1470	6% min.	45 min.	<b>Commercially Available</b>
ULTRALUME® 2000 As-Stamped and Baked	1450	1900	5% min.	40 min.	Mill Trials ( <i>Demonstration Samples Available 2025</i> )

*\*Uncoated version available*

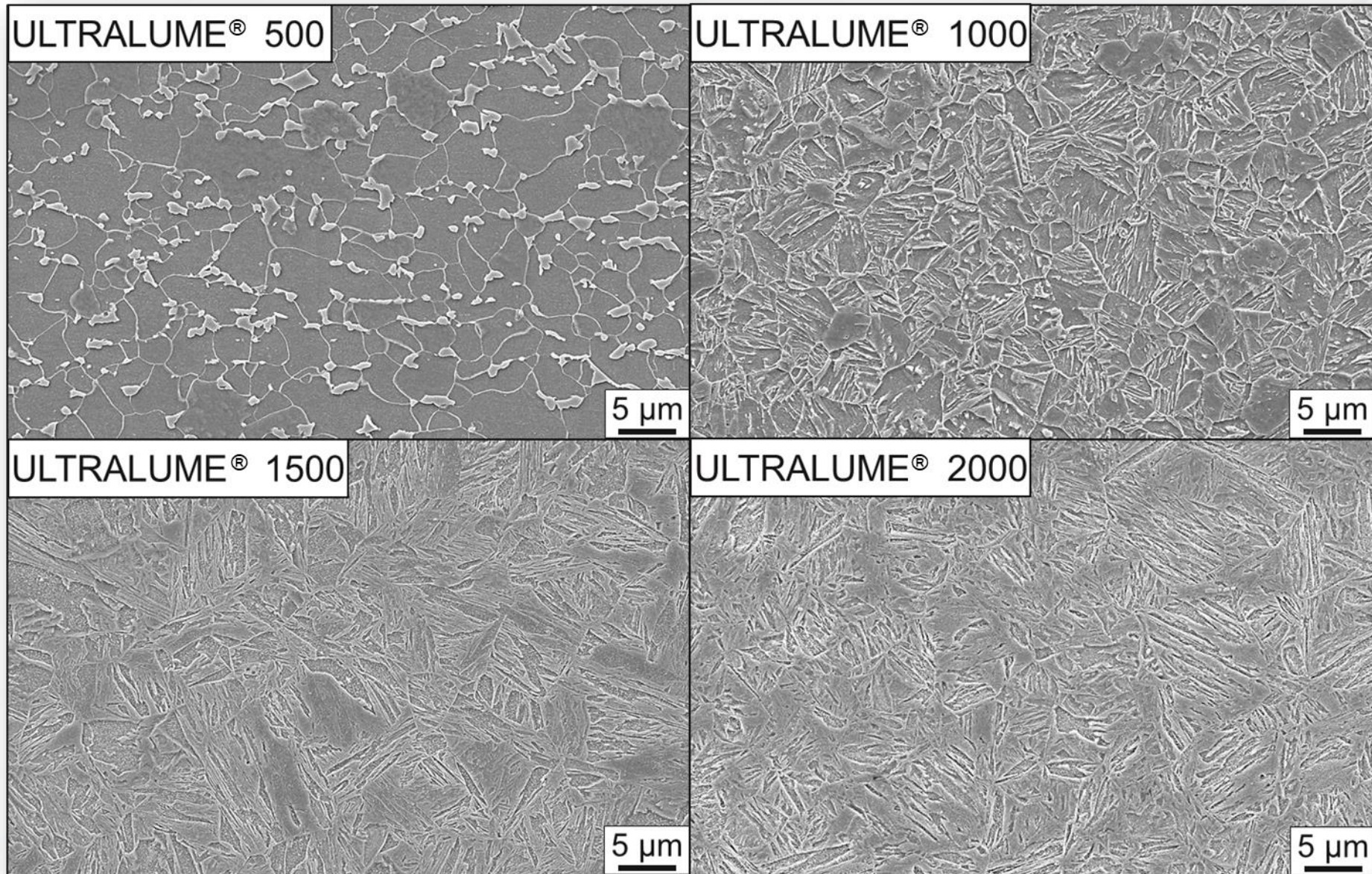
*‡Gauge dependent value*

# Cleveland-Cliffs ULTRALUME® Steels

Grade	C	Mn	Si	B	Ti	Other
ULTRALUME® 500 ★	0.065	1.45	0.25	-	0.070	Nb
ULTRALUME® 1000 ★	0.07- 0.10	<i>Product in validation stage (Demonstration material available)</i>				
ULTRALUME® 1500 ★	0.22	1.20	0.25	0.003	0.035	-
ULTRALUME® 2000 ★	0.30- 0.40	<i>Product in development stage</i>				

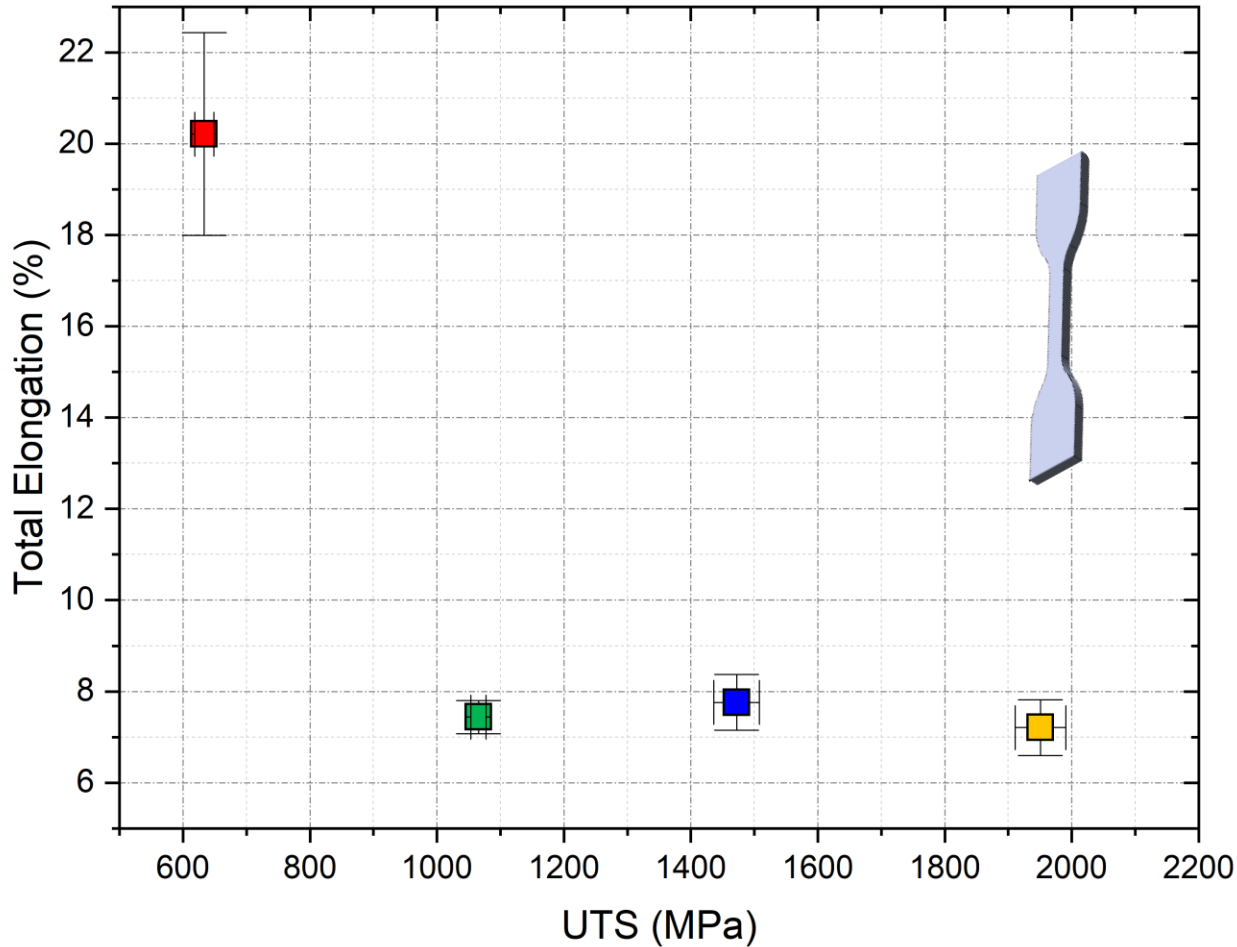


# Cleveland-Cliffs ULTRALUME<sup>®</sup> Steels



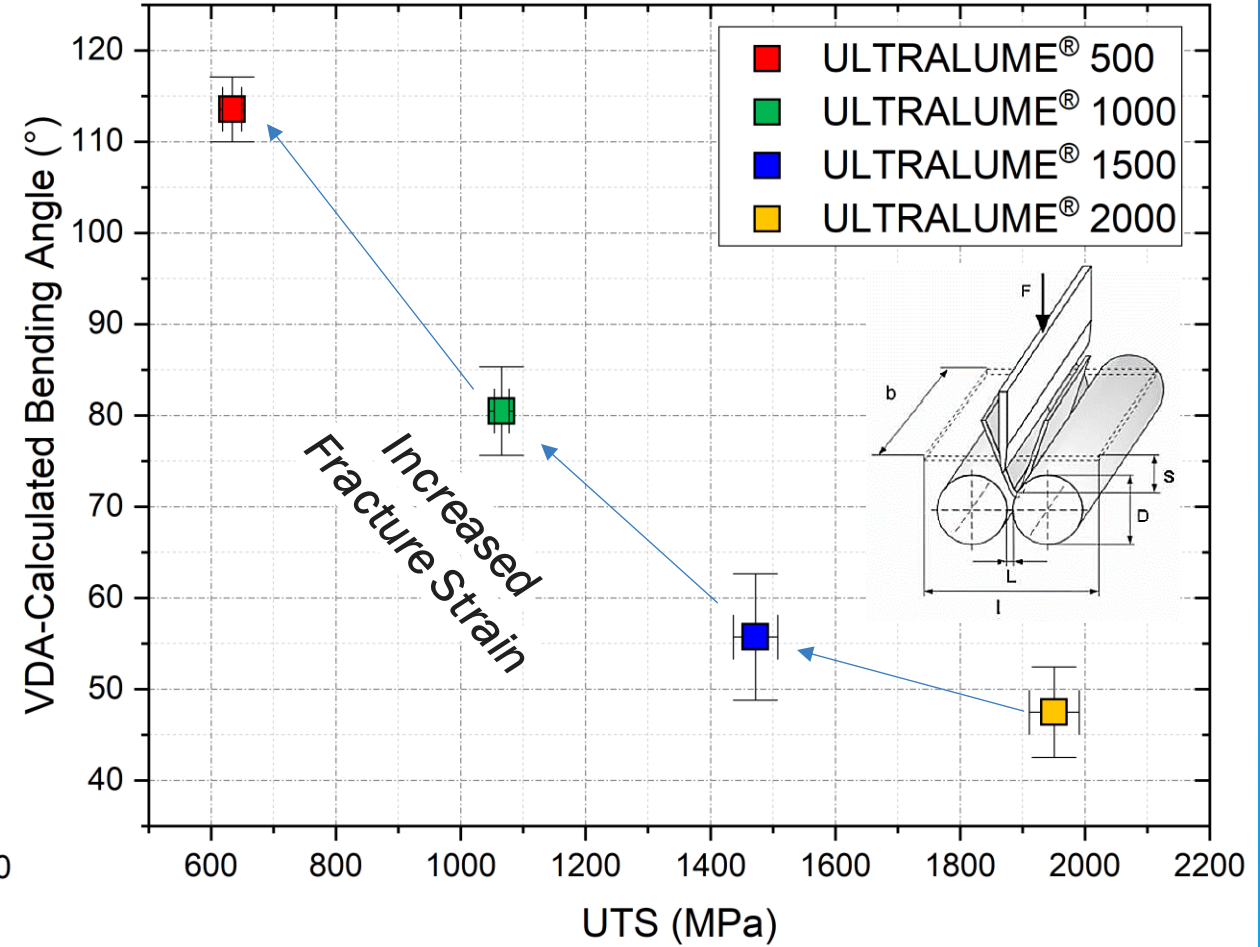
# Cleveland-Cliffs ULTRALUME<sup>®</sup> Steels

Uniaxial Tensile: ASTM E8



Note: Tensile axis parallel to rolling direction

Bendability: VDA 238-100



Note: Calculated bending angle at max. test force (Average LD-TD)

# Optimized Energy Absorption: Tailor Components



B-Pillar  
before  
crash

B-Pillar  
after  
crash



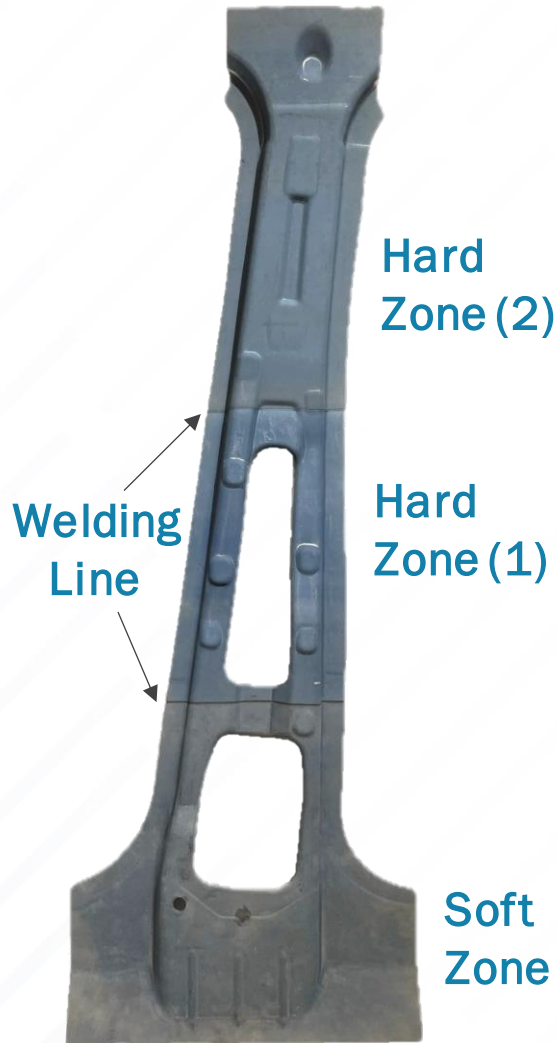
Distance from center of driver seat (cm)



Source: [iihs.org](http://iihs.org)

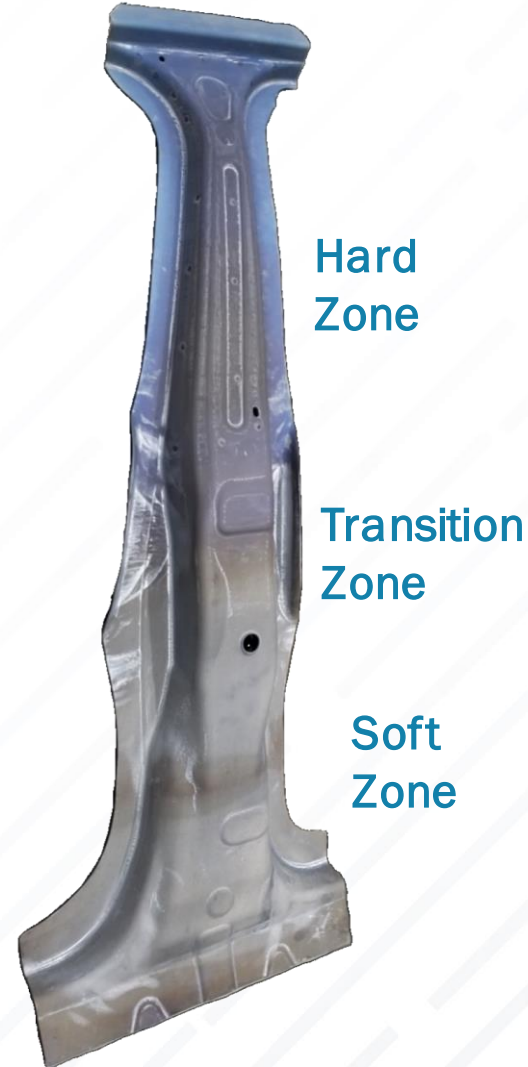
# Optimized Energy Absorption: Tailor B-Pillar

Tailor Welded



- Precise microstructural control and engineered crash behavior
- No special treating considerations
- Mitigation of thermal gradients prior to and during forming

Tailor Treated

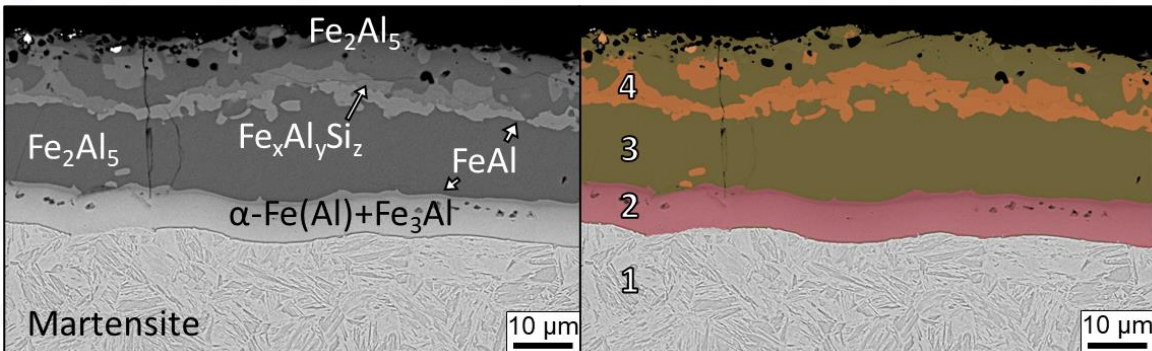
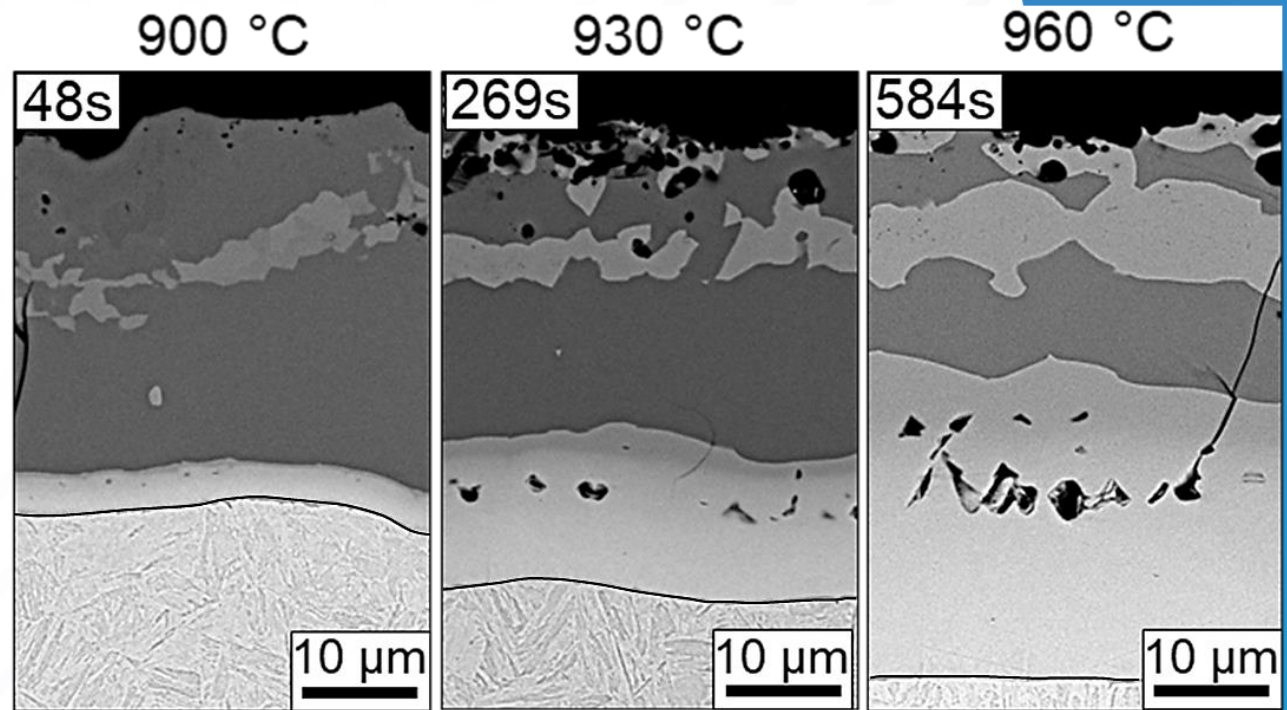
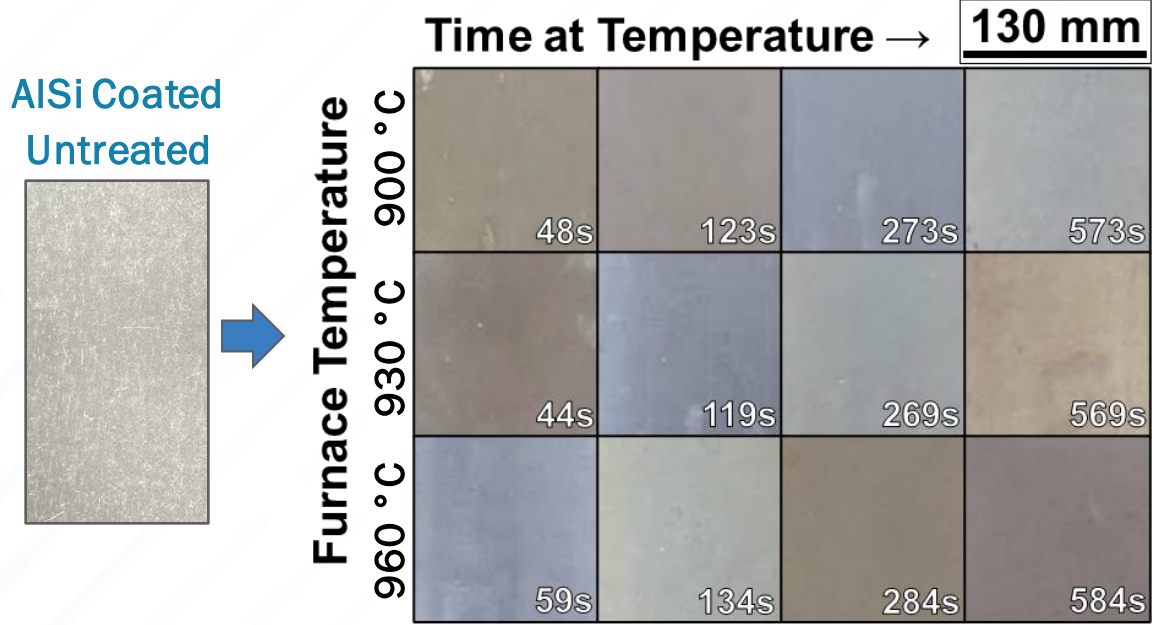


- Tailor welding is not required
- Transition zone manipulation
- No special tooling considerations

# Heat Treating Design

Evolution of Al-Si-Fe phases in the coating layer during austenitizing

## Austenitizing

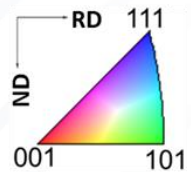
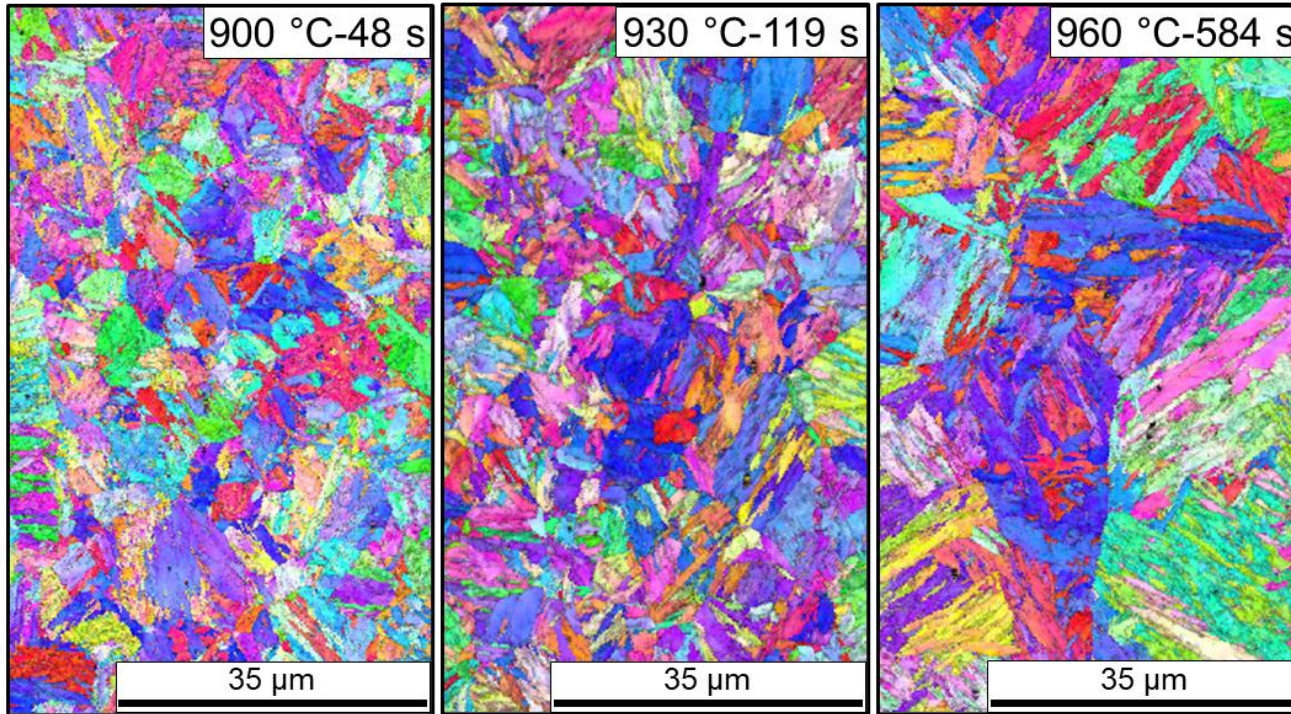


- Process design window
- Weldability
- Corrosion resistance
- Coating adherence

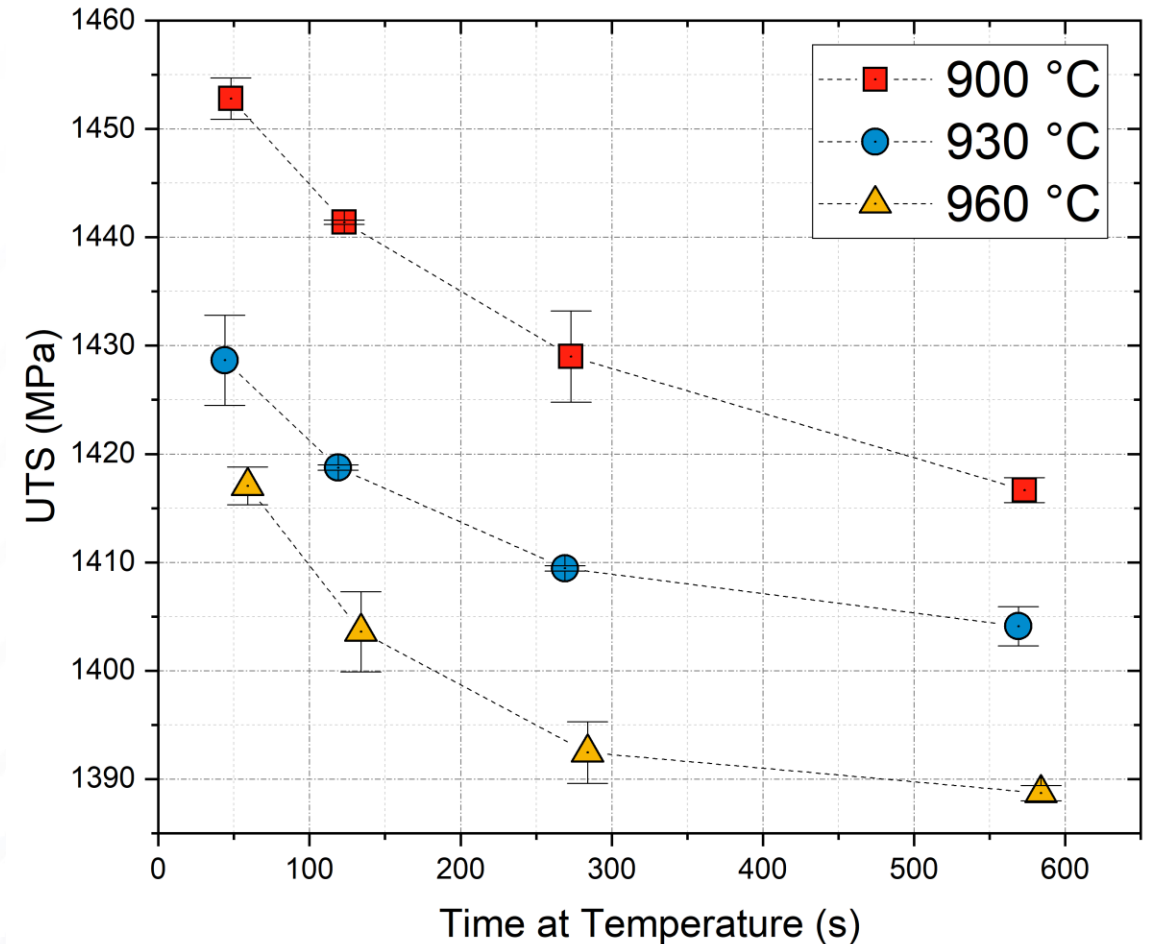
# Heat Treating Design

*Influence of the austenitizing parameters on the microstructure and strength*

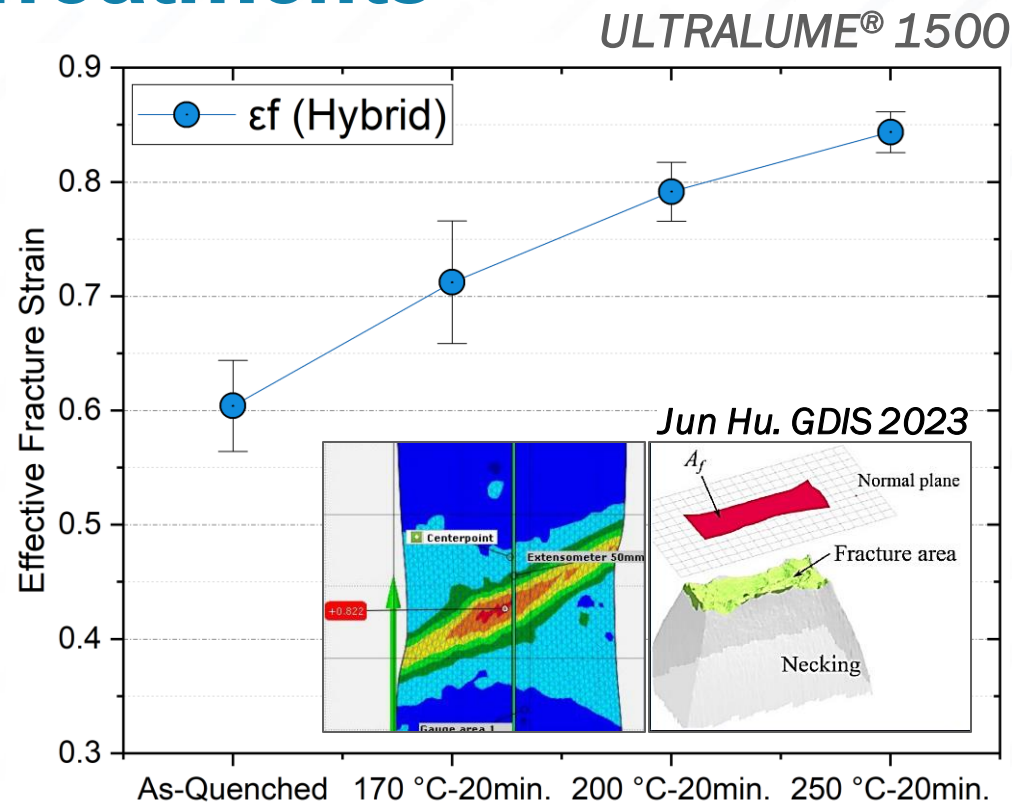
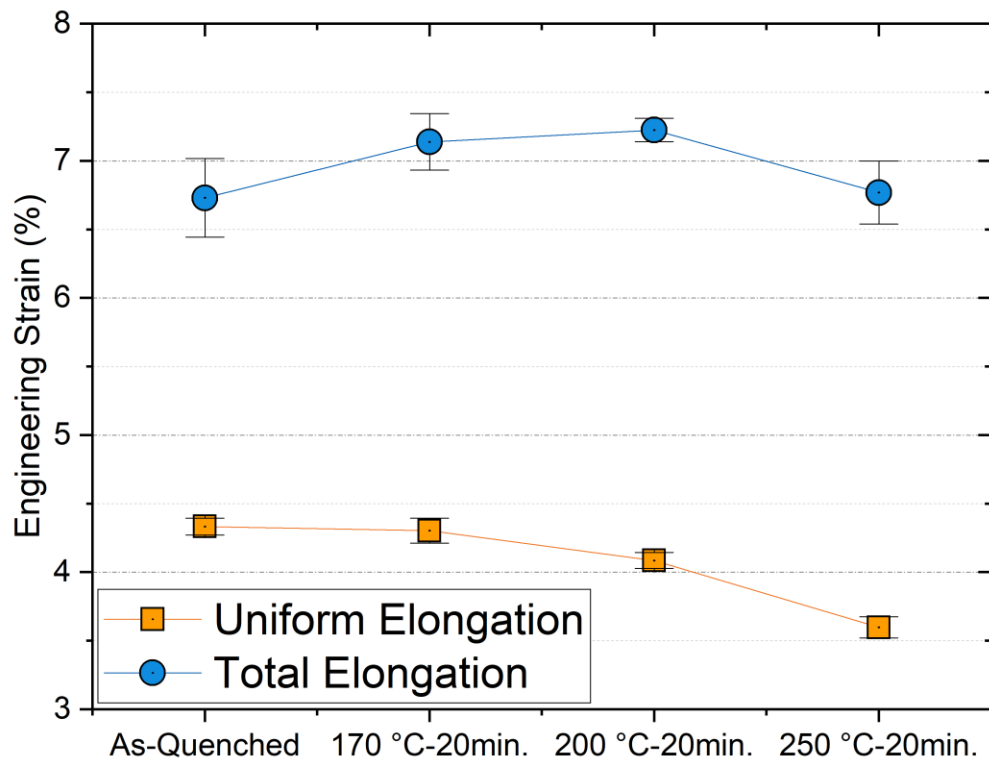
ULTRALUME® 1500



- *Hardening mechanisms*
- *Property-Treatment optimization*
- *Processing control*



## Low Temperature Post-Treatments

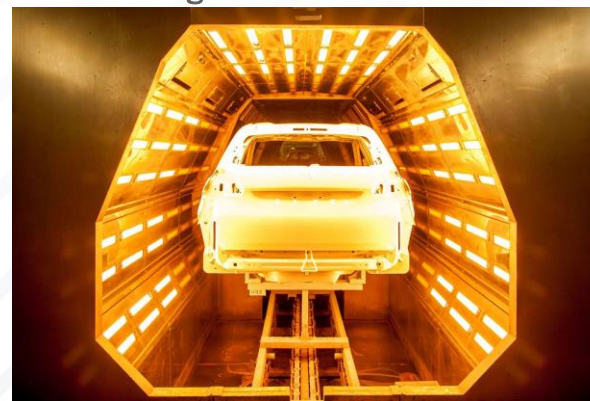


Baking and stress relief annealing are useful for improving the fracture strain of ultra-high strength ULTRALUME® Steels

Source: BMW



Source: Peugeot



# Processing of Tubular Components

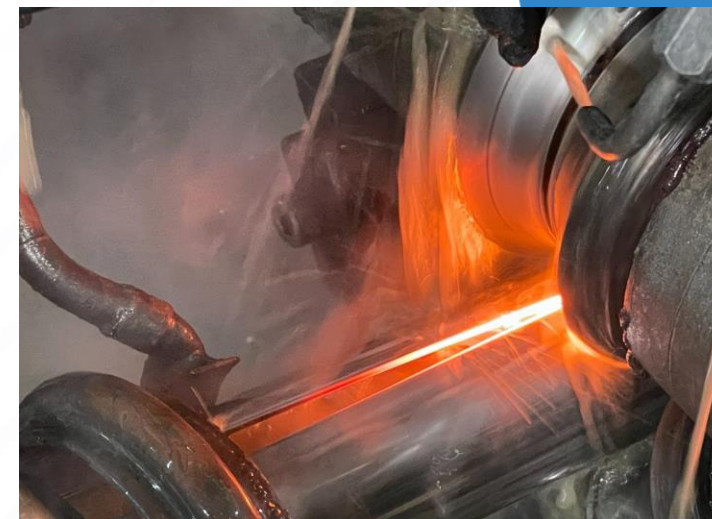
ULTRALUME® Steel Coil



Roll Forming



Welding



Weld Bead Removal



Final Sizing



Heat Treating



# Ultra-High Strength Tubes → FORMTUBE® QHS

## Cleveland-Cliffs Tubular Components

### FORMTUBE® Quench Hardenable Steel

#### Grades

FORMTUBE® QHS 1500

FORMTUBE® QHS 2000‡

‡ *Product under development*

- Bare or Al-Si coated products
- Round or complex custom shapes
- Available in D/t ratios up to 100:1
- Suitable for heat treating or hot forming and quenching

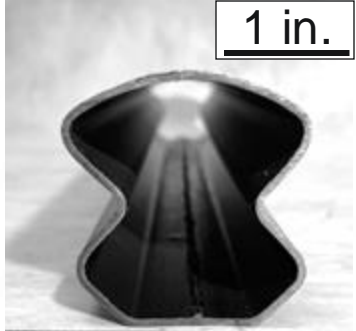
#### Sizes

- 19 – 168 mm diameter
- 1.0 – 3.5 mm thickness

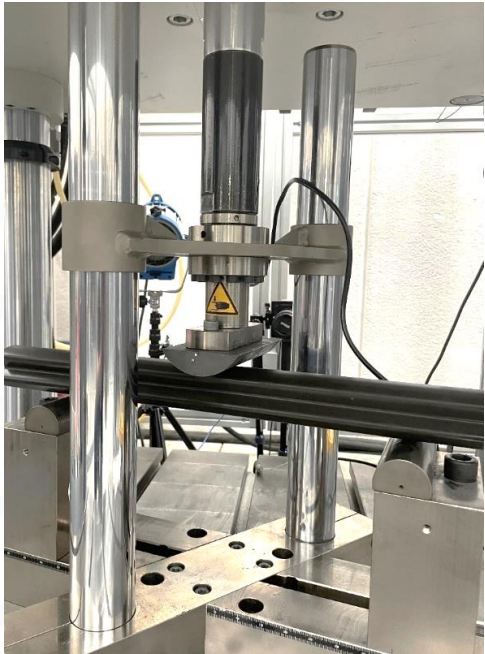
### Hot-Processed Tubular Components



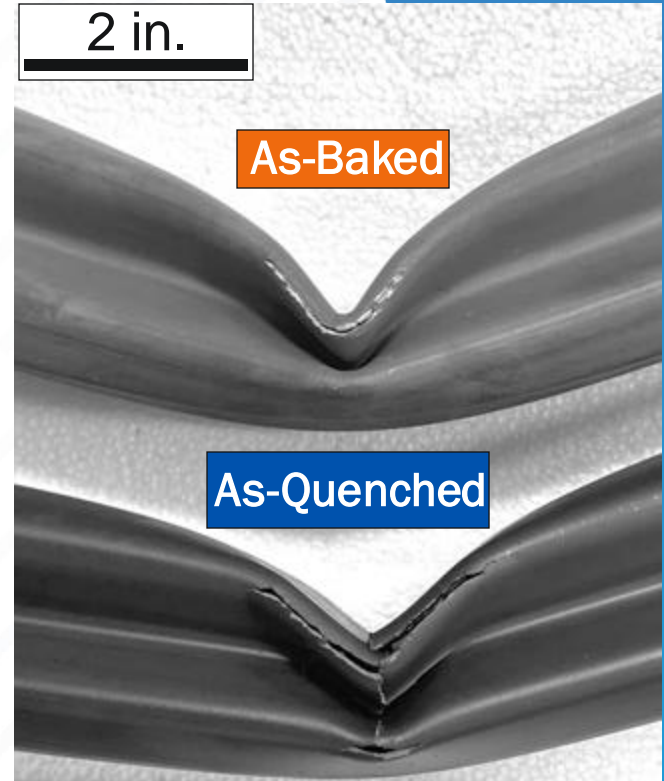
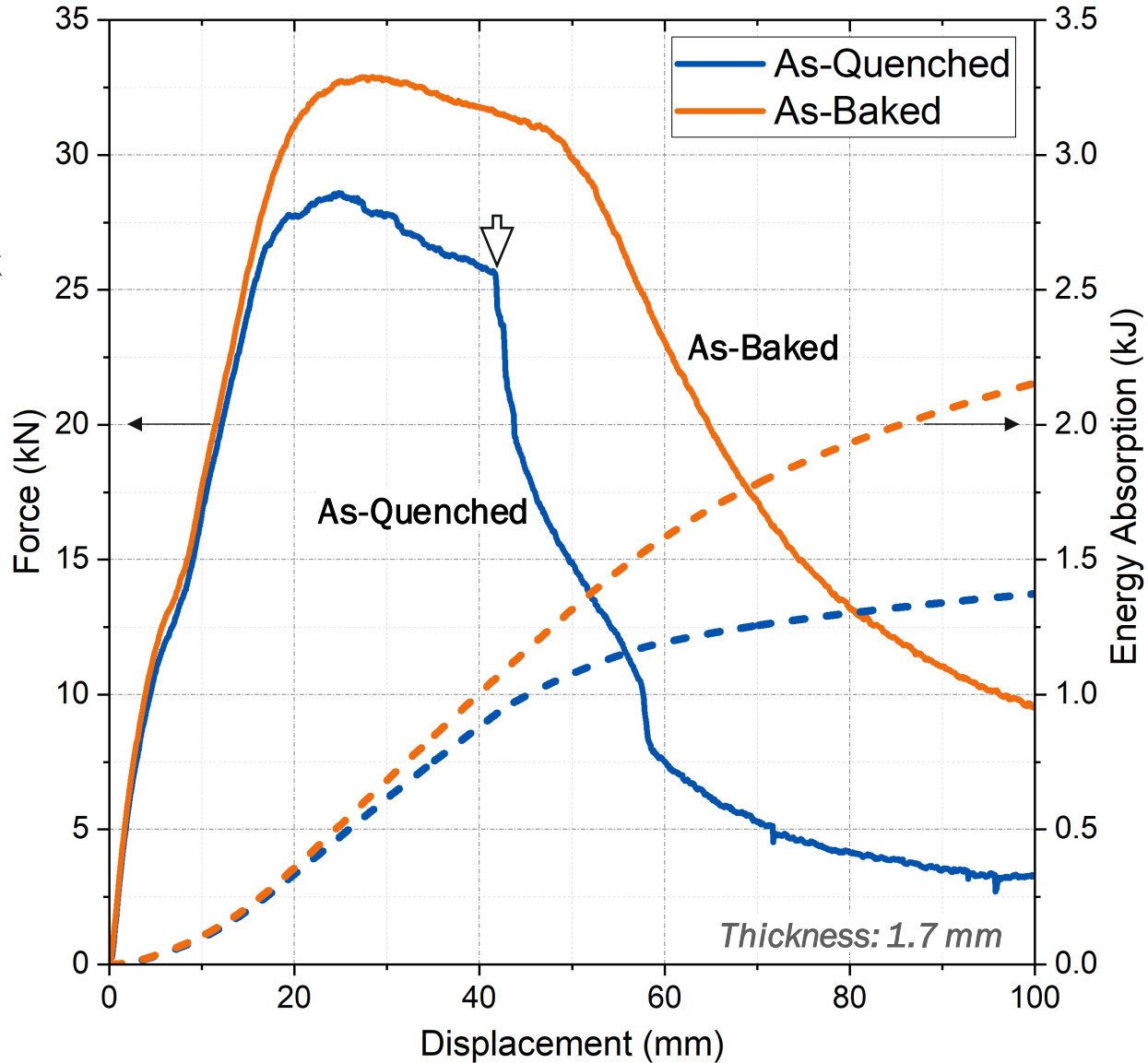
# 3-Point Bend Testing on FORMTUBE® QHS 1500



Complex Shape



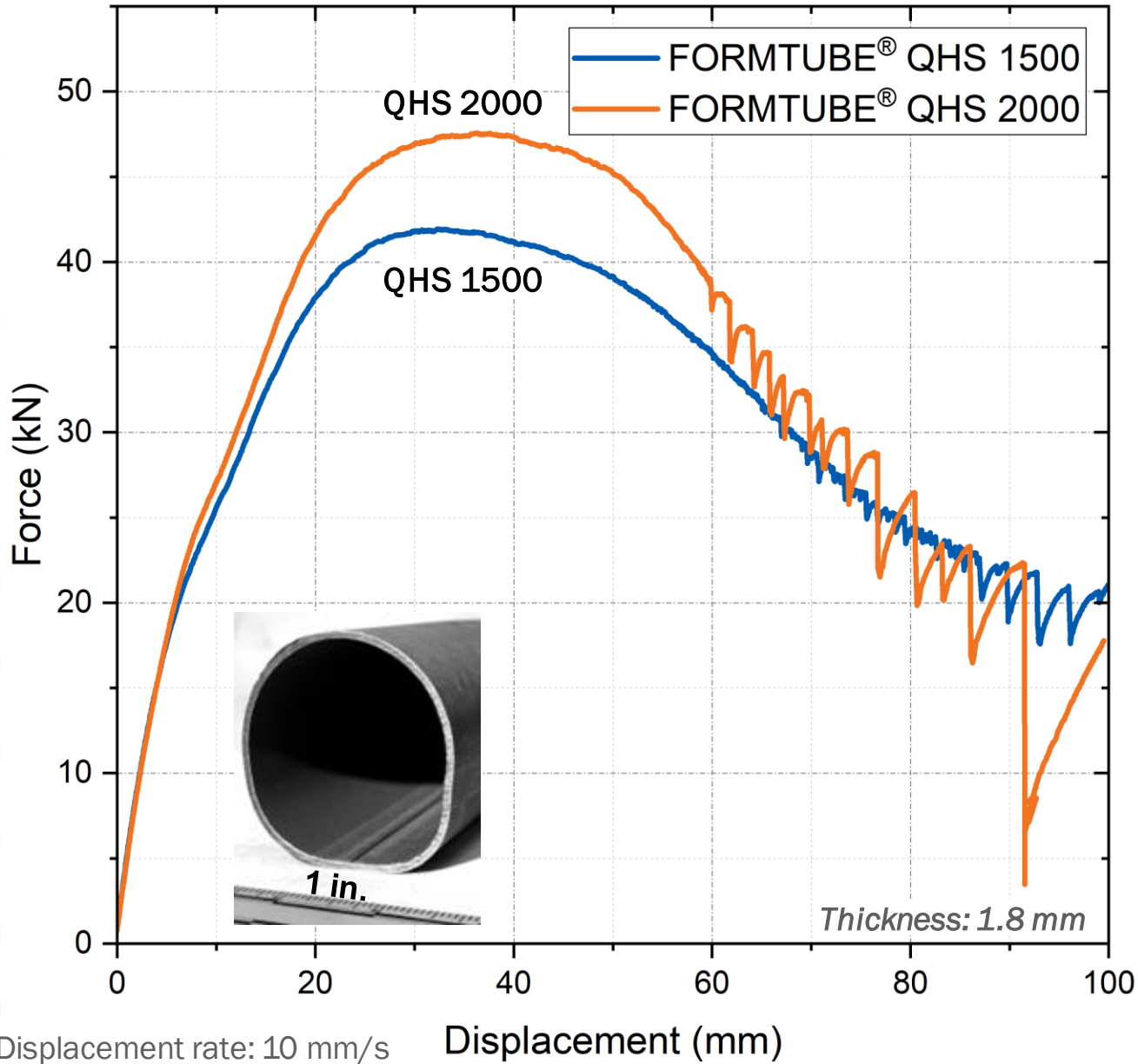
Displacement rate: 10 mm/s



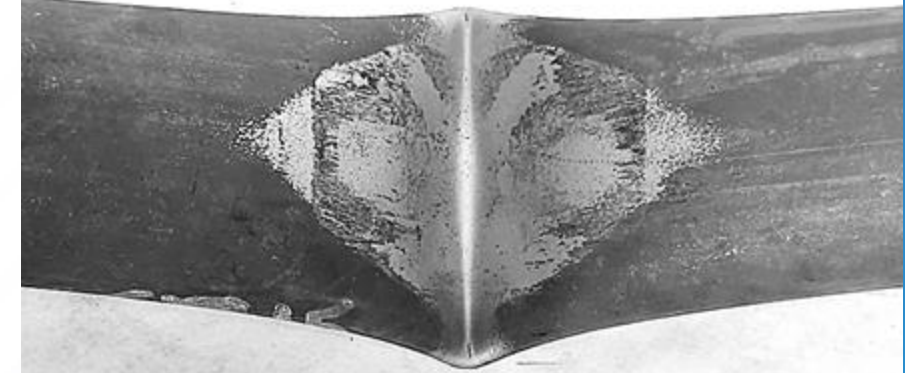
Benefits of baking:

- ↑ Peak Load
- ↑ Energy Absorption
- ↑ Fracture Strain

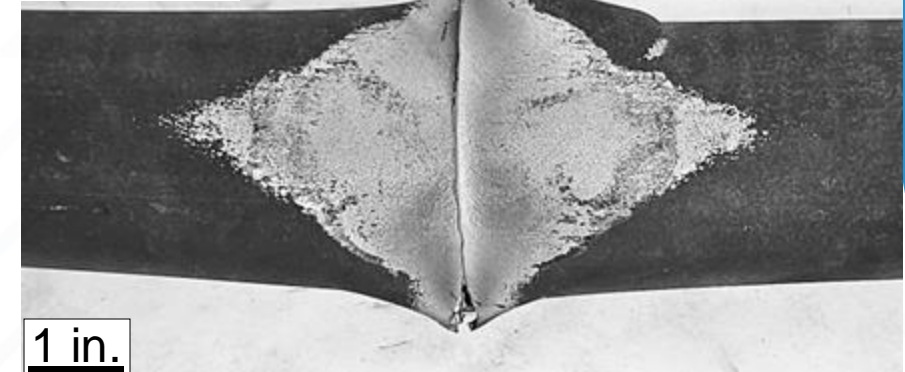
# FORMTUBE® QHS 1500 vs. QHS 2000



QHS 1500

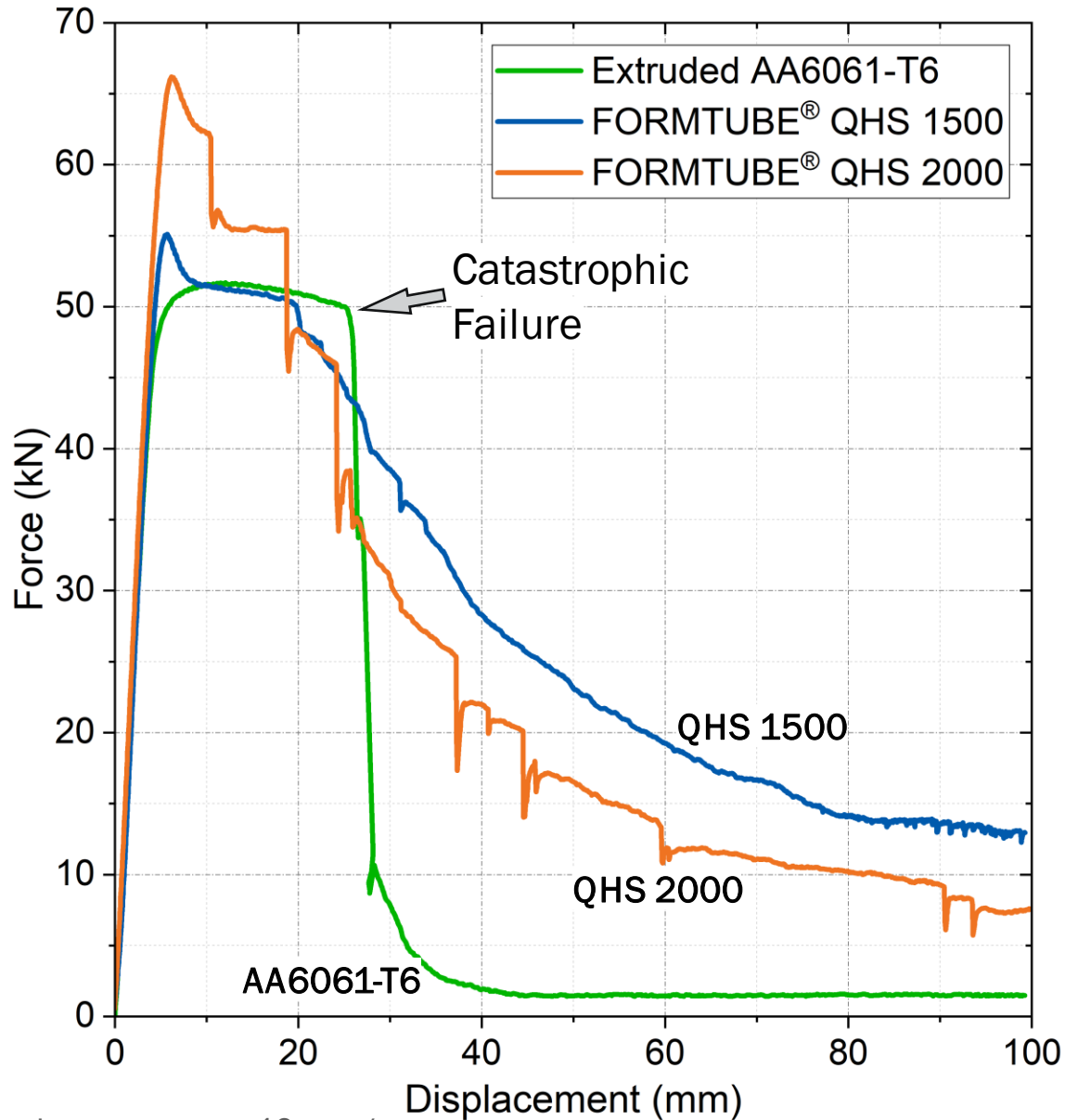


QHS 2000



Grade	FORMTUBE® QHS 1500	FORMTUBE® QHS 2000
Peak Force (kN)	42.0	47.6 (+13%)
Specific Energy Absorption 0-100 mm (J/kg)	1846.6	1952.1 (+6%)

# FORMTUBE® QHS vs. Al Alloy 6061-T6



Square tubes Nominal size 2"x2"	AA6061-T6	FORMTUBE® QHS 1500	FORMTUBE® QHS 2000
Nominal Thickness (mm)	4.8	1.8 (-63%)	1.8 (-63%)
Weight (kg)	1.4	1.7 (+21%)	1.7 (+21%)
Peak Force (kN)	51.7	55.1 (+7%)	66.2 (+28%)
Specific Energy Absorption 0-100 mm (J/kg)	986.9	1653.7 (+68%)	1450.9 (+47%)

AA6061-T6



FORMTUBE® QHS 1500



# C-STAR™ Protection

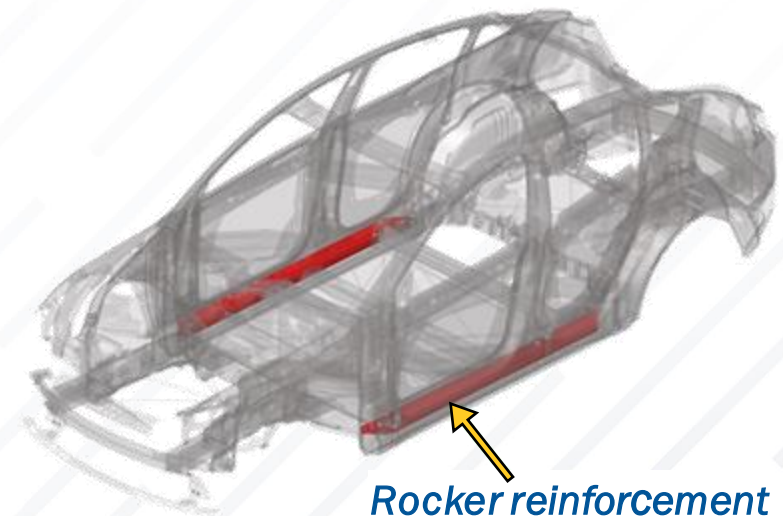
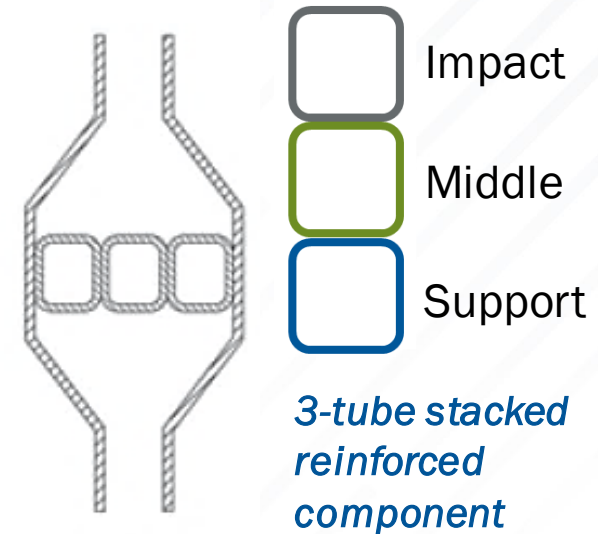
C-STAR™ is a configurable and scalable AHSS tube system used for occupant and components protection in any type of vehicle.

Integration of ULTRALUME® Steels into the C-STAR™ configuration:

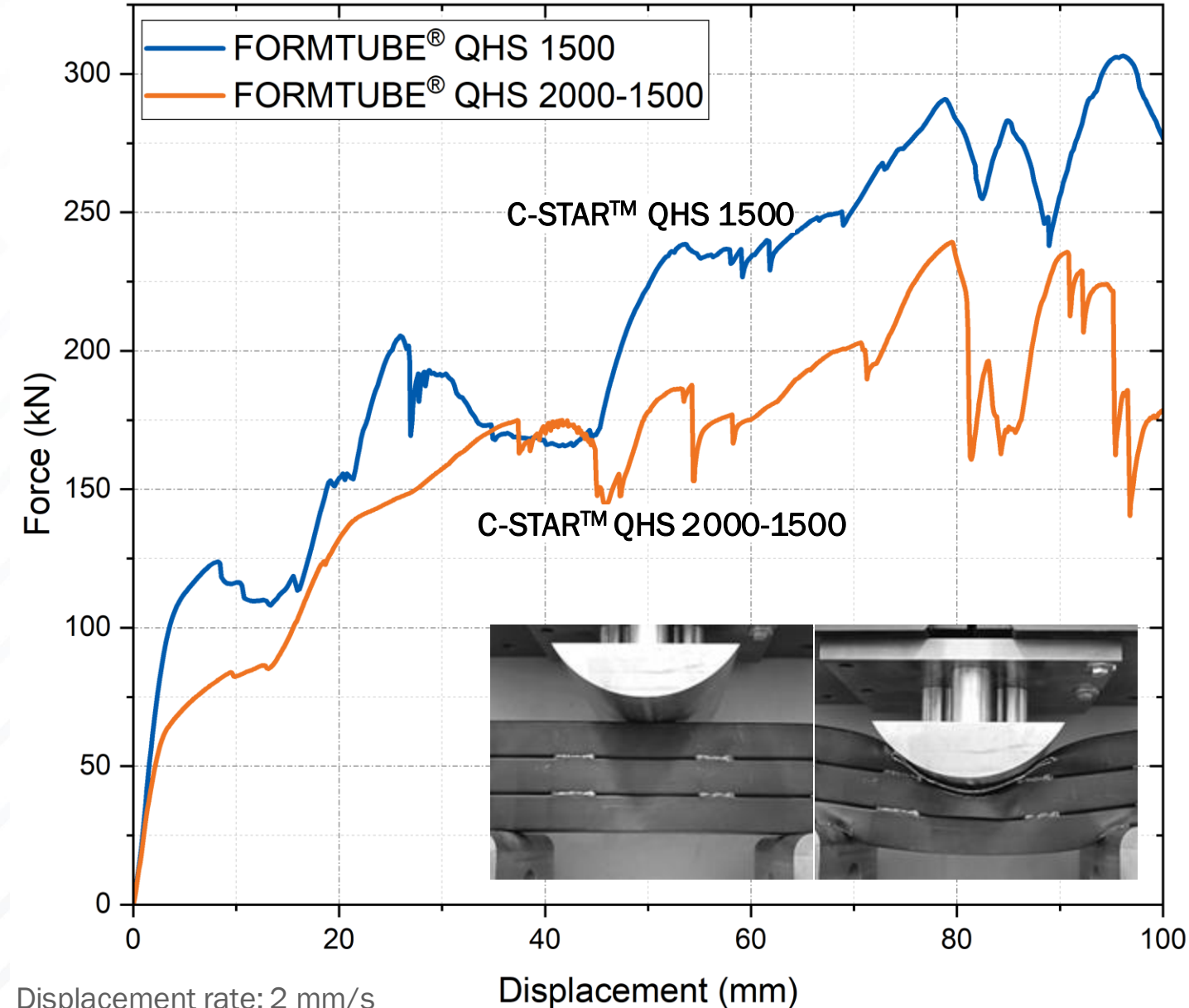
- Multigrade/gauge/geometry configuration
- Engineered deformation upon crash events
- Ultra-High Strength Tubes: FORMTUBE® 1500 - 2000 MPa
- Lightweighting







Three-point bending examples:

- C-STAR™ - FORMTUBE® QHS 1500 vs. QHS 2000/1500
- C-STAR™ - FORMTUBE® QHS 1500 vs. OEM Extruded HSAA

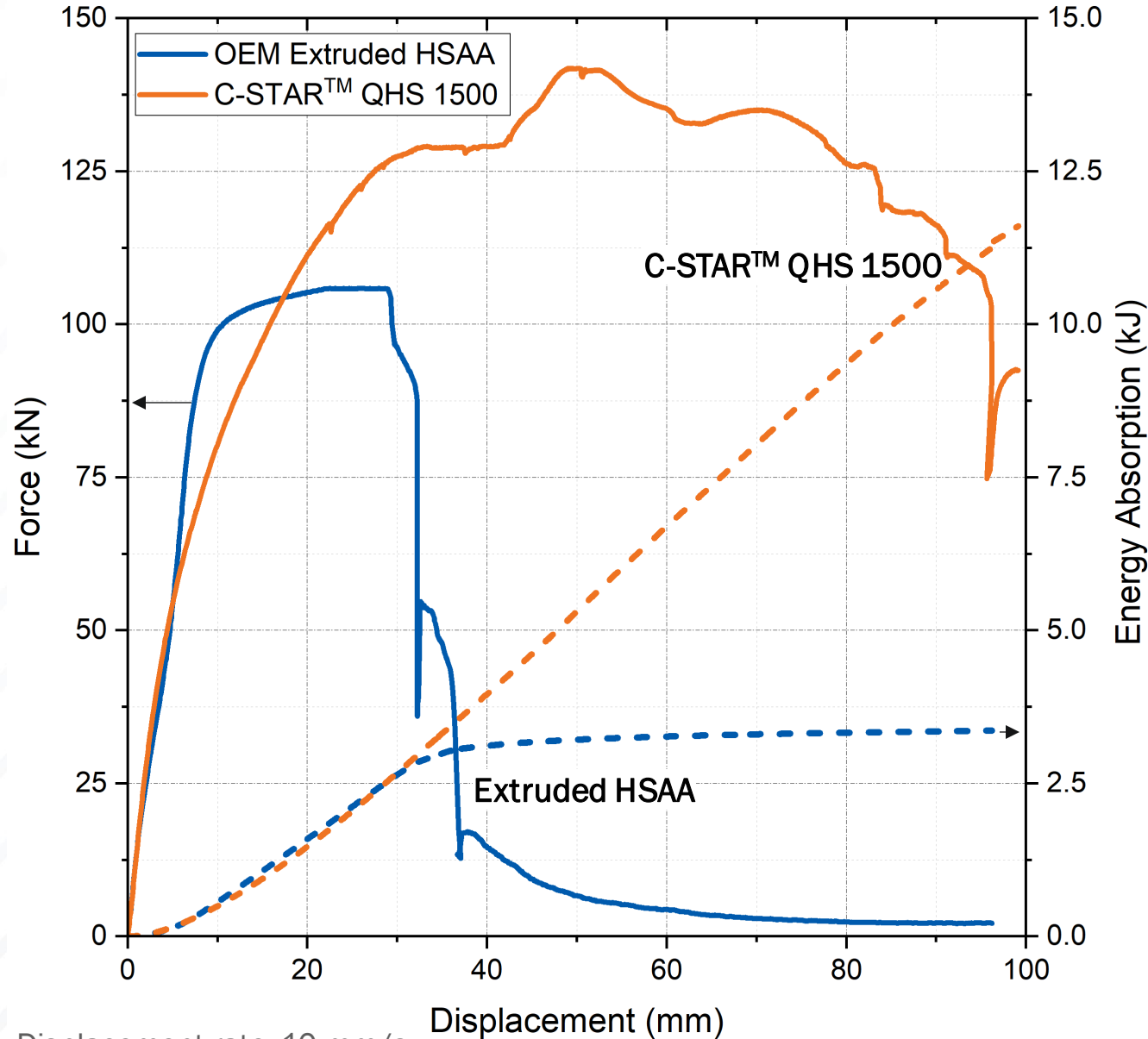


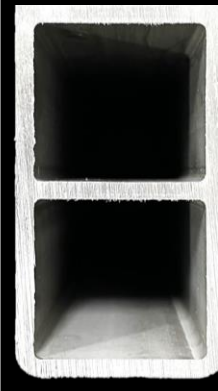

# FORMTUBE® QHS 1500/2000 C-STAR™ Configuration



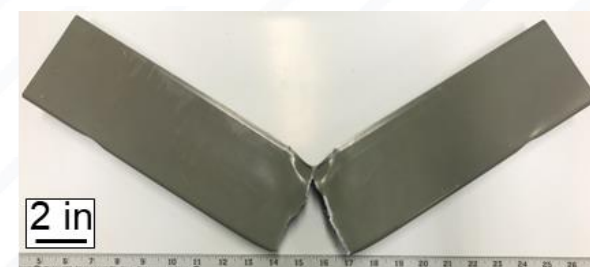
Grade	FORMTUBE® QHS 1500	FORMTUBE® QHS 2000-1500
C-STAR™ Configuration	 1500 2.2 mm	 1500 1.6 mm
Square tubes Nominal size 2"x2"	 1500 2.2 mm	 1500 1.8 mm
	 1500 2.2 mm	 2000 1.8 mm
Weight (kg)	6.6	4.8 (-28%)
Peak Force (kN)	306.5	239.1 (-21%)
Specific Energy Absorption 0-100 mm (J/kg)	3130.9	3375.7 (+8%)

# FORMTUBE® QHS 1500 C-STAR™ vs. Extruded HSAA



Grade	OEM Extruded High-Strength Al Alloy	FORMTUBE® QHS 1500 C-STAR™
Configuration	 H: 90 mm W: 50 mm T: 4.0 to 4.5 mm	 H: 90 mm W: 27 mm T: 1.8 mm
Weight (kg)	2.0	2.2 (+10%)
Peak Force (kN)	105.9	141.8 (+33%)
Specific Energy Absorption 0-100 mm (J/kg)	1827.1	5275.1 (+188%)

OEM HSAA



C-STAR™ QHS 1500



# Summary

- Cleveland-Cliffs has established a fully integrated production route for development of hot-processed steel grades.
  - ULTRALUME<sup>®</sup> 500 and 1500 are commercially available.
  - ULTRALUME<sup>®</sup> 1000 and 2000 are in development stage.
- ULTRALUME<sup>®</sup> Steels have been usefully utilized in the production of hot-stamped and tubular components → *FORMTUBE<sup>®</sup> QHS*.
- Ultra-High Strength Steel tubes made of ULTRALUME<sup>®</sup> Steels can be integrated in the C-STAR<sup>™</sup> configuration for improved impact absorption performance and lightweighting.

# For more information

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