Modern AHSS Grades: Improved formability by advanced microstructure control

GALM 2018, Munich

Dr. Enno Arenholz
Head R&D – Technology and Innovation

voestalpine Stahl GmbH
www.voestalpine.com/stahl

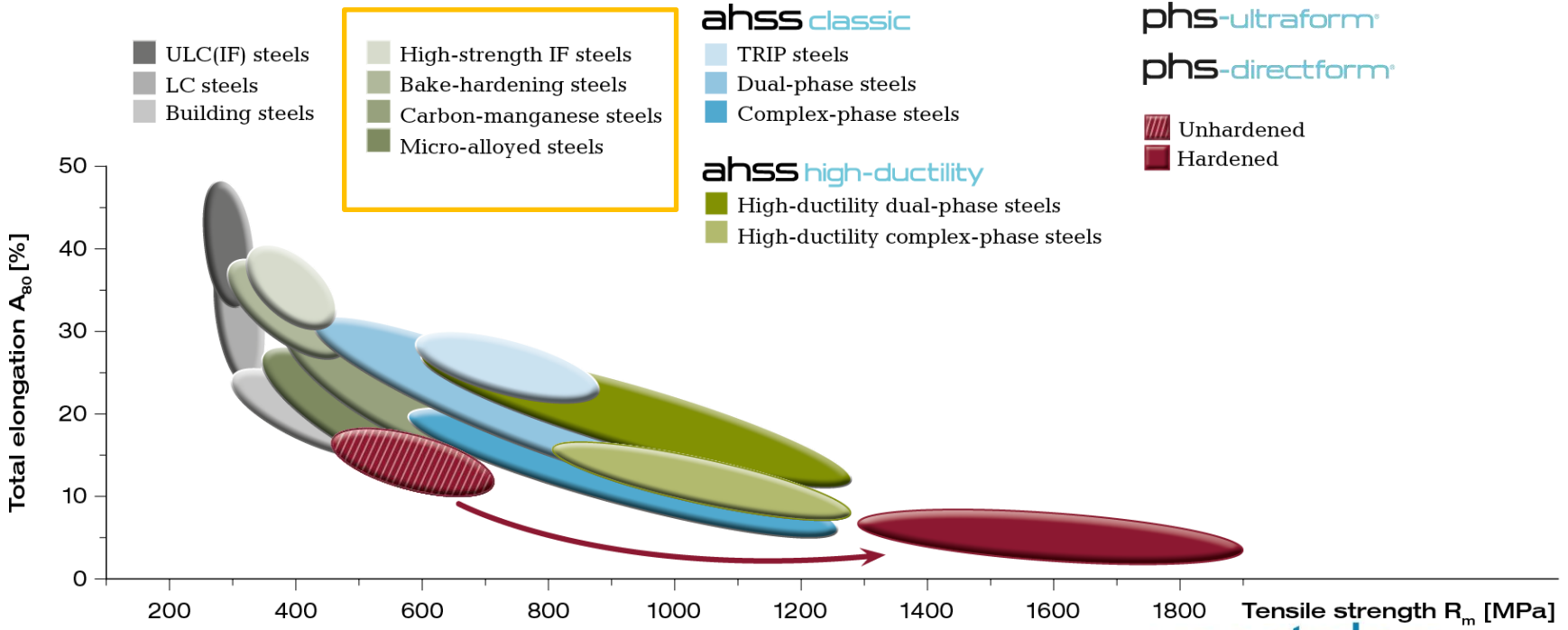
voestalpine
ONE STEP AHEAD.

Outlook

- ahss high-ductility
- Medium Mn steels
- phs-ultraform®

voestalpine
ONE STEP AHEAD.

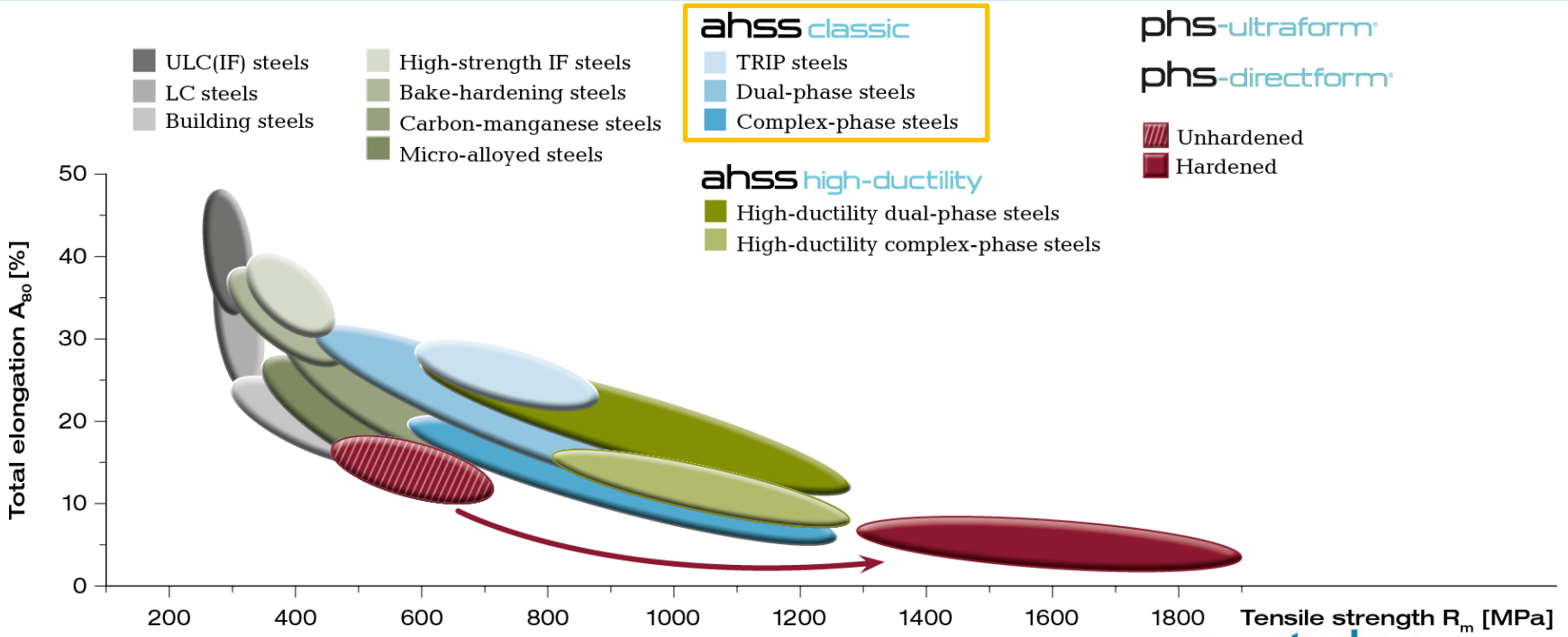
Overview of steel grades



voestalpine

ONE STEP AHEAD.

Overview of steel grades



voestalpine

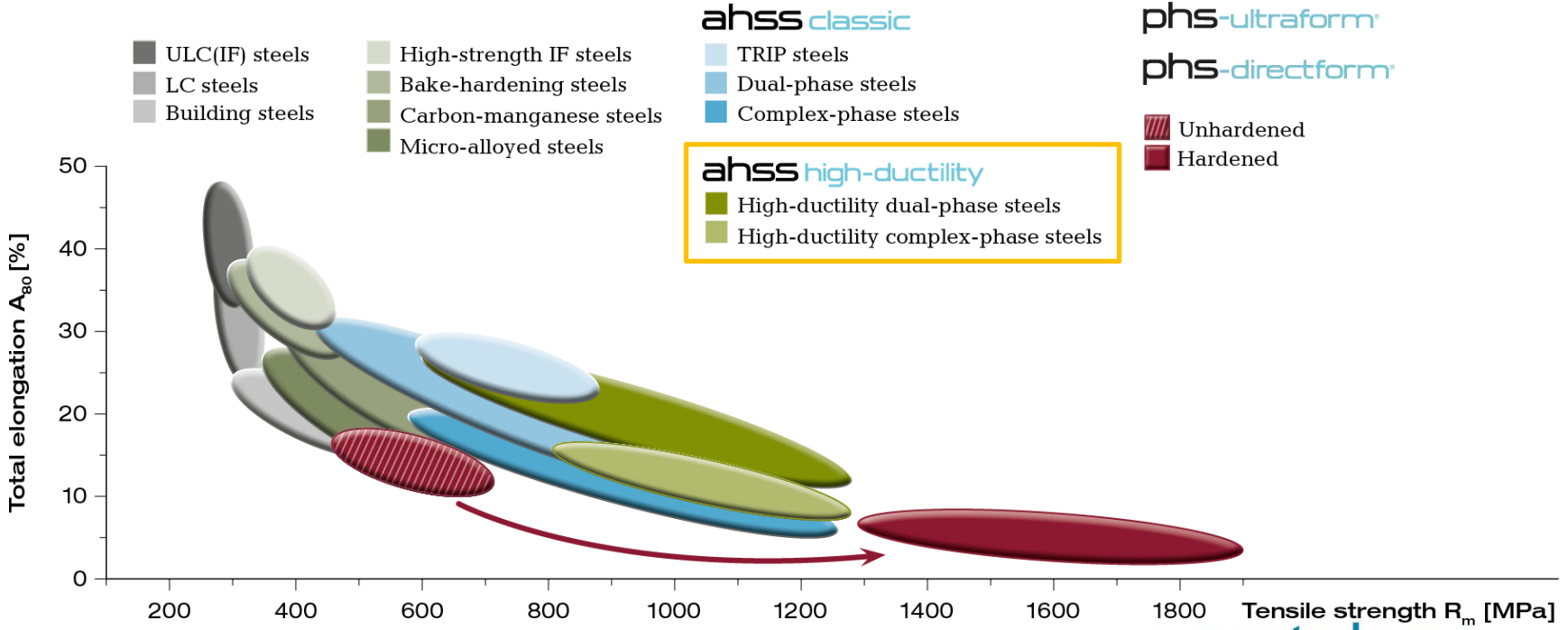
ONE STEP AHEAD.

Outlook

- ahss high-ductility
- Medium Mn steels
- phs-ultraform®

voestalpine
ONE STEP AHEAD.

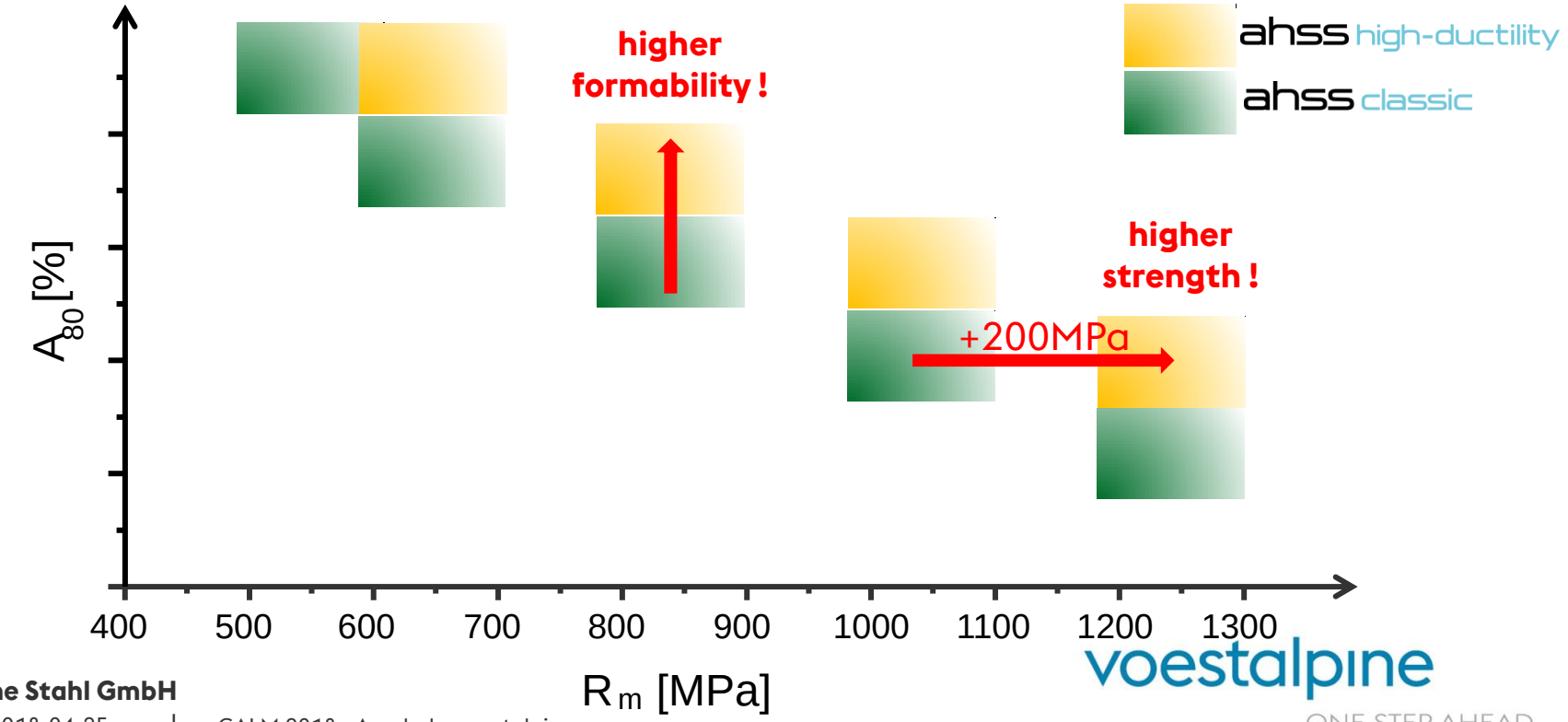
Overview of steel grades



voestalpine

ONE STEP AHEAD.

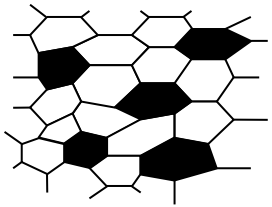
AHSS vs. AHSS high-ductility



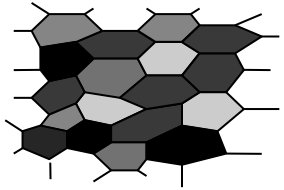
Microstructure: AHSS classic vs. high ductility

ahss high-ductility

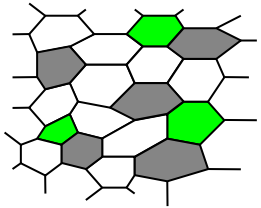
DP



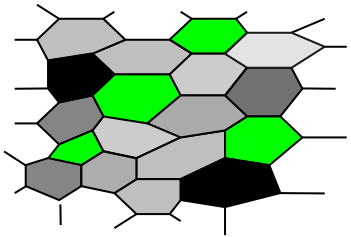
CP



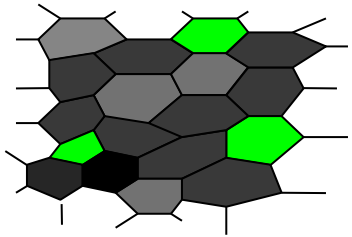
TRIP



DP-HD



CP-HD



voestalpine
ONE STEP AHEAD.

ahss high-ductility

Dual-phase high-ductility steels: The benchmark for high-strength steels with exceptional drawing properties

- Available with minimum tensile strengths of 590, 780, 980 and 1180 MPa
- **Extraordinary cold formability**
- Good weldability comparable to that of classical dual-phase steels
- Very low susceptibility to edge cracking
- Excellent crash behavior
- Corrosion resistance based on EG, GI or GA coatings

voestalpine
ONE STEP AHEAD.

Mechanical properties of dual-phase high-ductility steels

Steel grade	Test direction	0.2% Yield strength $R_{p0,2}$ [MPa]	Tensile strength R_m [MPa]	Total elongation A_{80} min. [%]	n-value $n_{10\text{-}UE}$ min.	BH_2-value BH_2 min. [MPa]
CR330Y590T-DH	Longitudinal	330 - 430	590 - 700	26	0.16	30
CR440Y780T-DH	Longitudinal	440 - 550	780 - 900	18	0.13	30
CR700Y980T-DH	Longitudinal	700 - 850	980 - 1130	13	-	30
CR850Y1180T-DH	Longitudinal	850 - 1050	1180 - 1350	10/13[1)]	-	30

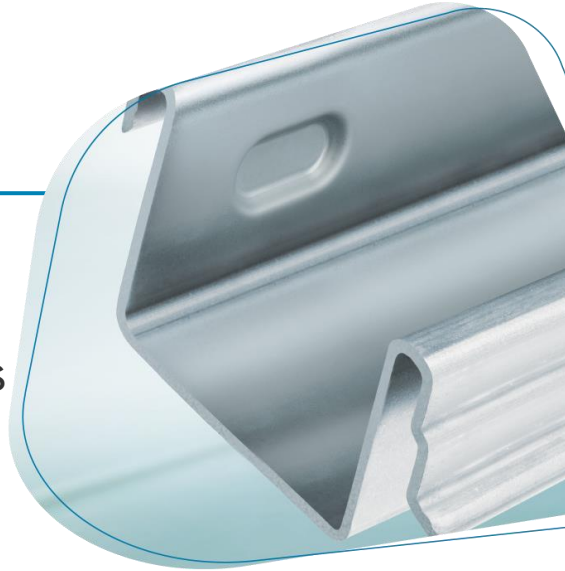
1) Higher grade with improved elongation possible upon customer request

Availability of dual-phase high-ductility steels

			UC	EG	GI	GA	ZM
Dual-phase high-ductility steels	CR330Y590T-DH	voestalpine					
	CR440Y780T-DH	voestalpine					
	CR700Y980T-DH	voestalpine					
	CR850Y1180T-DH	voestalpine					

In series	Pre-series and prototypes	Under development	Currently not available

ahss high-ductility



Complex-phase high-ductility steels: The benchmark for high-strength steels with exceptional bending properties

- Available with minimum tensile strenghts of 980 and 1180 MPa
- **Unique bending properties at high yield strengths**
- **Best forming properties of punches edges** based on high resistance to edge cracking
- Good weldability comparable to that of classical complex-phase steels
- **High crash energy absoption**
- Corrosion resistance based on EG, GI or GA coatings

Mechanical properties of complex-phase high-ductility steels

Steel grade	Test direction	0.2% Yield strength $R_{p0,2}$ [MPa]	Tensile strength R_m [MPa]	Total elongation A_{80} min. [%]	n-value $n_{10\text{-}UE}$ min.	BH_2-value BH_2 min. [MPa]
CR780Y980T-CH	Longitudinal	780 - 950	980 - 1140	10		30
CR900Y-1180T-CH	Longitudinal	900 - 1150	1180 - 1350	7		30

Availability of complex-phase high-ductility steels

			UC	EG	GI	GA	ZM
Complex-phase high-ductility steels	CR780Y980T-CH	voestalpine					
	CR900Y-1180T-CH	voestalpine					

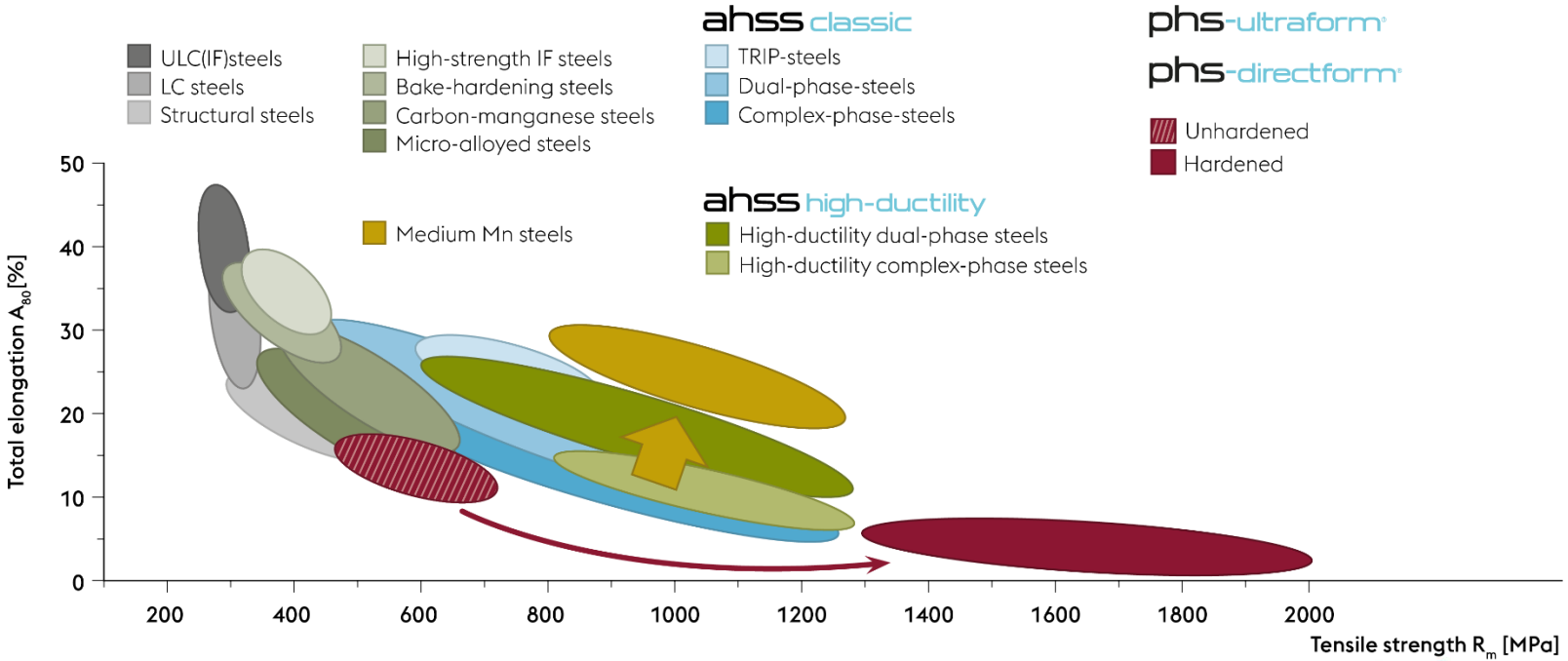
In series	Pre-series and prototypes	Under development	Currently not available

Outlook

- ahss high-ductility
- Medium Mn steels
- phs-ultraform®

voestalpine
ONE STEP AHEAD.

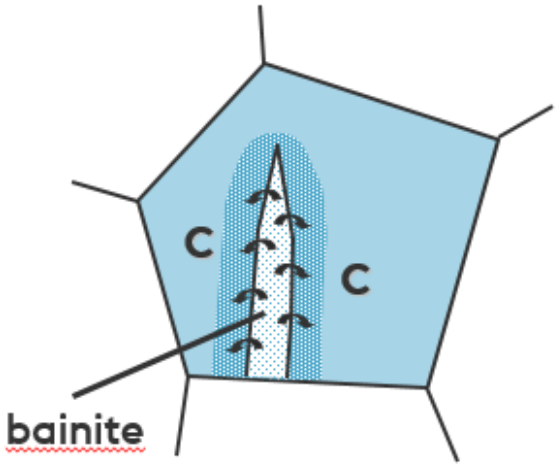
Overview of steel grades: medium Mn steels



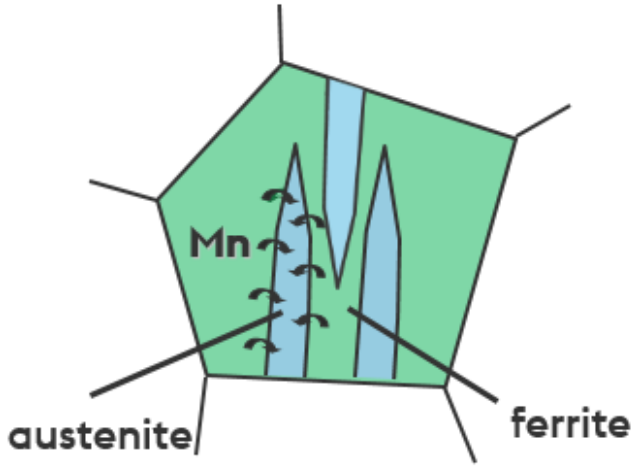
voestalpine
ONE STEP AHEAD.

Ongoing development: medium Mn steel

TRIP steels:
stabilization of the austenite due to carbon enrichment during holding in the bainitic region



Medium Mn steels:
stabilization of the austenite due to the Mn enrichment during intercritical annealing

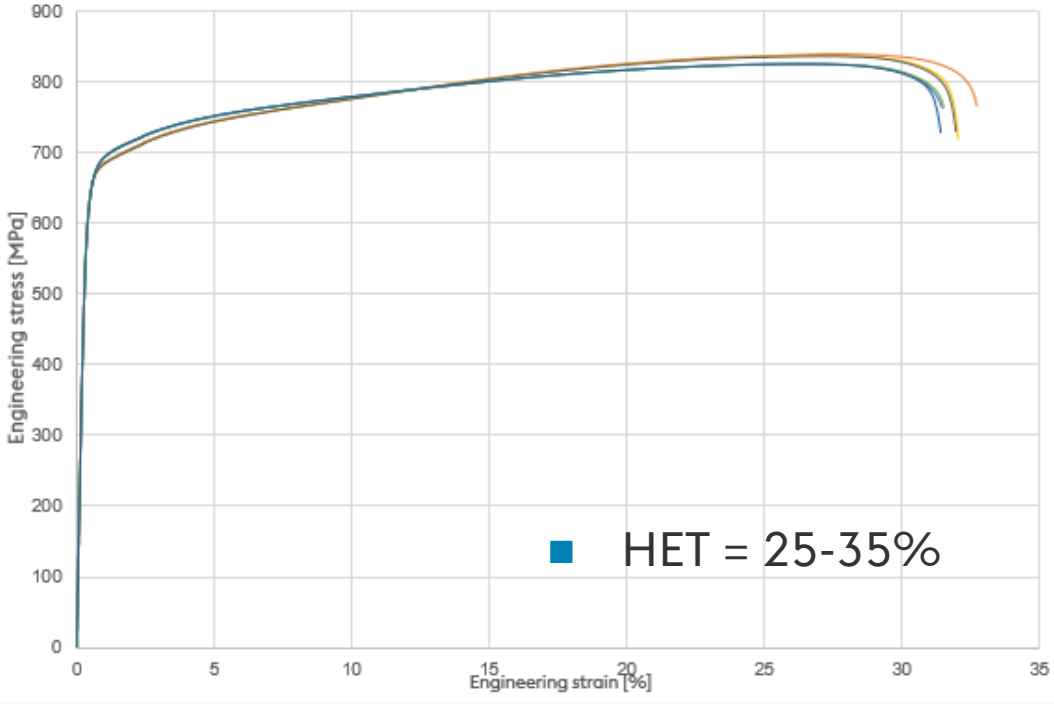


voestalpine
ONE STEP AHEAD.

Ongoing development: medium Mn steel

- Improved formability: TRIP-effect
  - meta-stable retained austenite
  - austenite stabilization due to manganese
- Medium Manganese vs. TRIP-steels
  - lower Carbon content in the retained austenite
  - full utilization of transformation plasticity
- Cost-performance ratio
  should be balanced
- Ongoing industrial trials with 0.1C6Mn: status - first industrially annealed coils
  - Evaluation of formability, weldability, hydrogen embrittlement, galvanizability…

Ongoing development: medium Mn steel



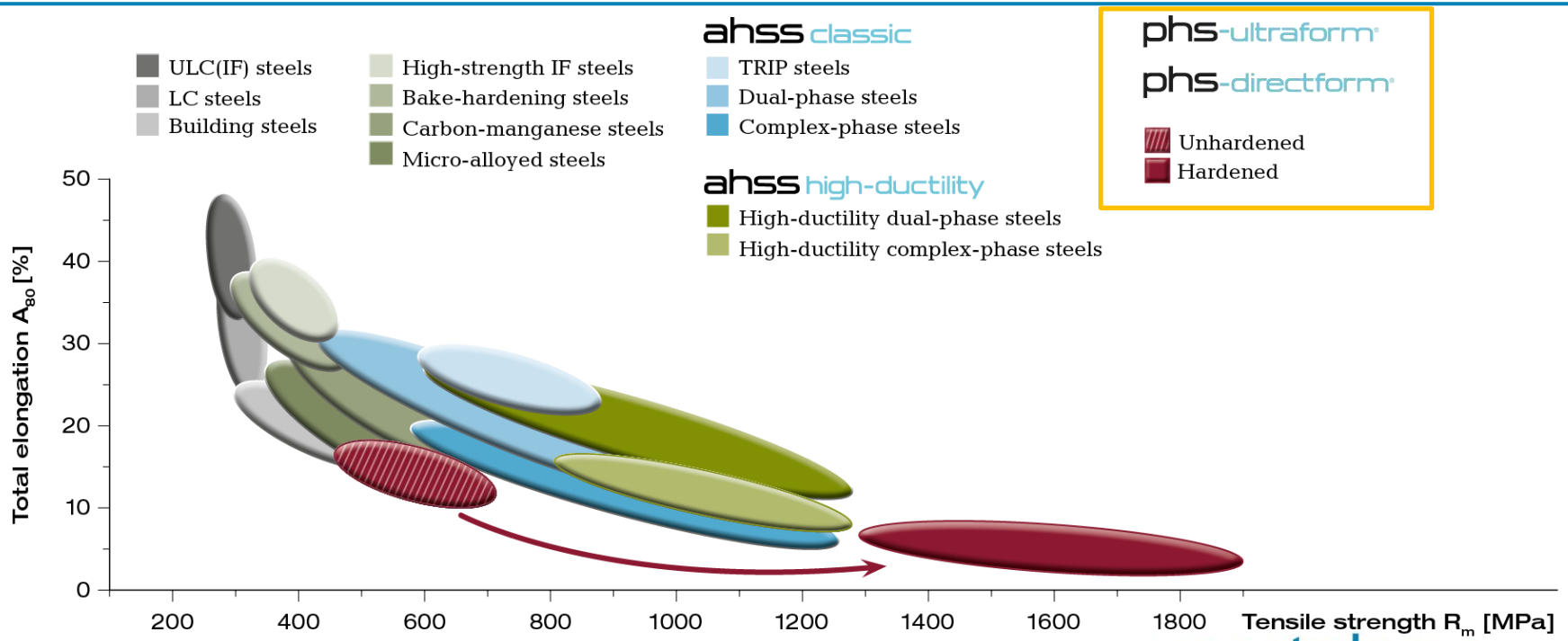
voestalpine
ONE STEP AHEAD.

Outlook

- ahss high-ductility
- Medium Mn steels
- phs-ultraform®

voestalpine
ONE STEP AHEAD.

Overview of steel grades

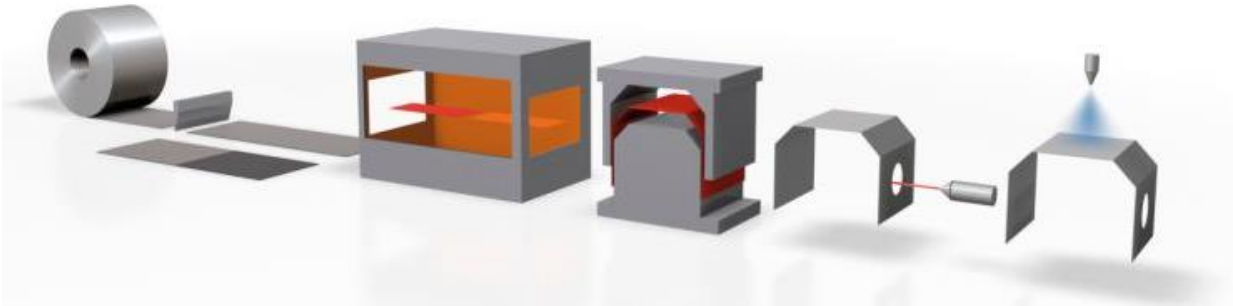


voestalpine

ONE STEP AHEAD.

Direct Press-hardening Process

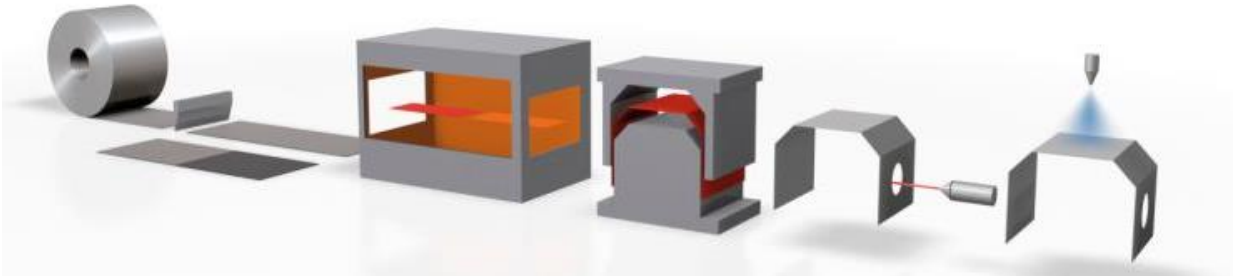
- Direct Process



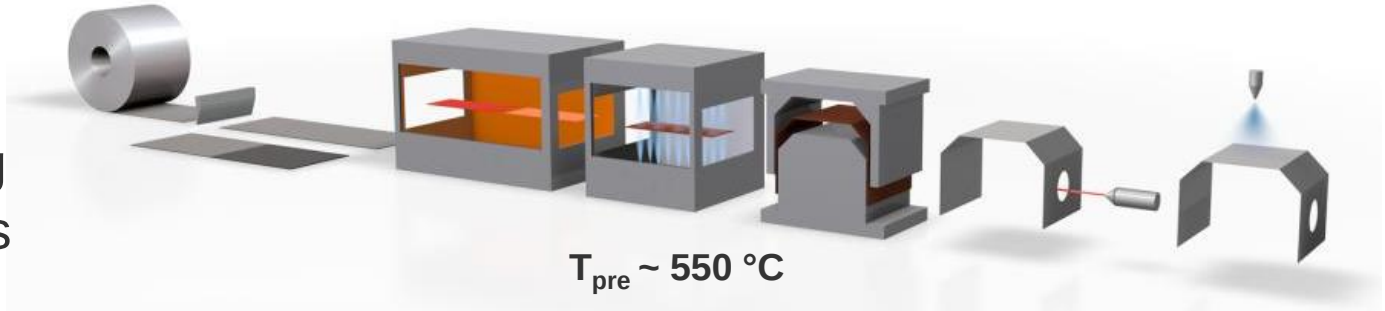
Direct Press-hardening Processes

Pre-cooling for zinc-coatings

- Direct Process

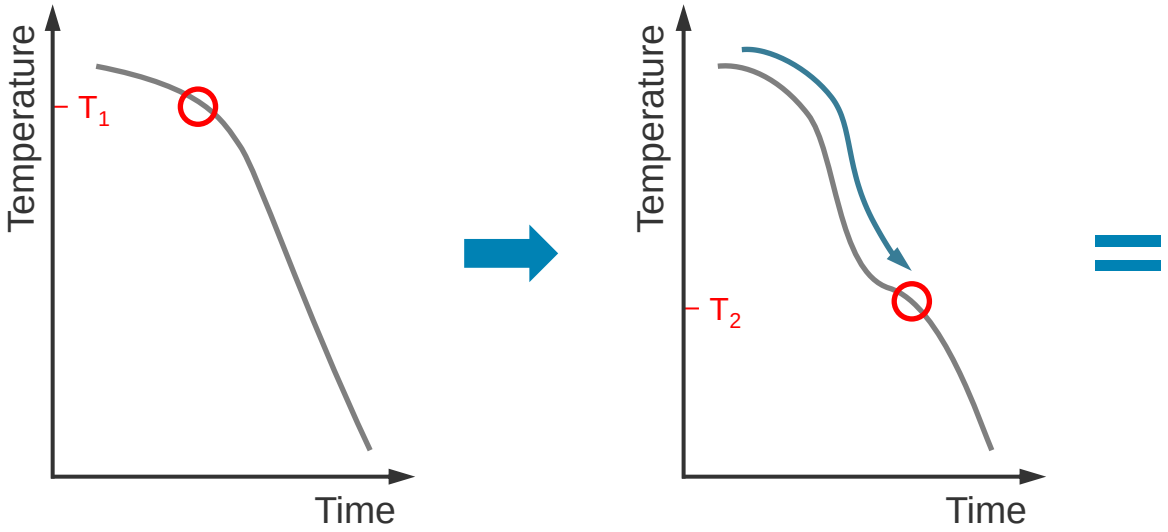


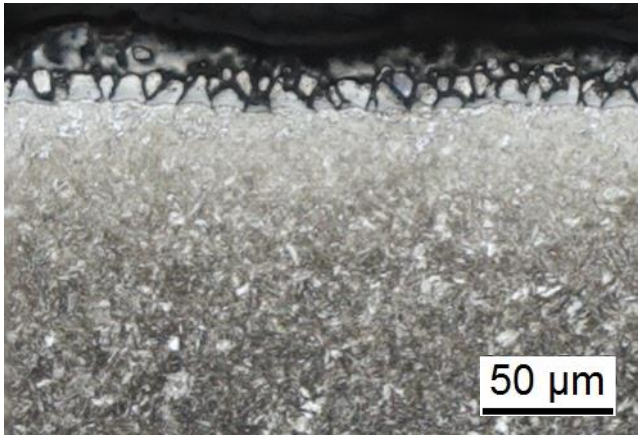
- Direct Process with Pre-cooling for zinc coatings



Direct Press-hardening Process with Pre-cooling

No liquid zinc-.phases → No liquid Metal Embrittlement





Adapted Material for Pre-cooling – 20MnB8

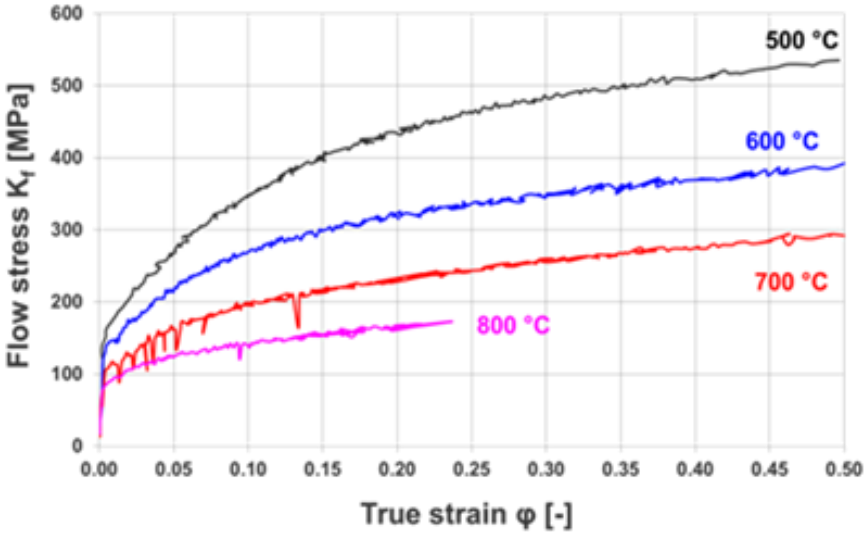
Typical Chemical Composition

Steel Grade	C wt %	Si wt %	Mn wt %	Cr wt %	Ti wt %	B wt %	N wt %
22MnB5	0.22	0.20	1.25	0.20	0.030	0.0030	0.0060
20MnB8	**0.19**	0.20	**2.00**	0.03	0.030	0.0030	0.0060

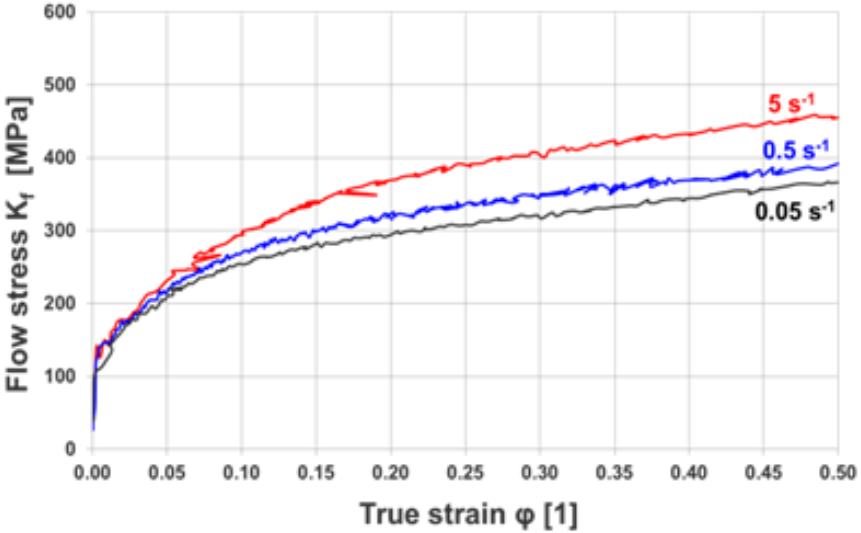
20MnB8 – phs-directform 1500

Hot Flow Curves

Temperature dependancy at 0.05 s^{-1}



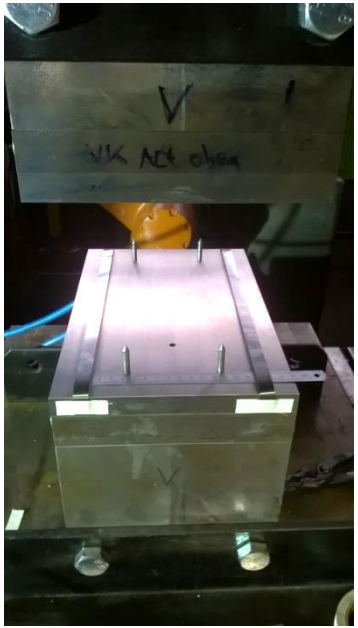
Strain rate dependancy at 600 °C



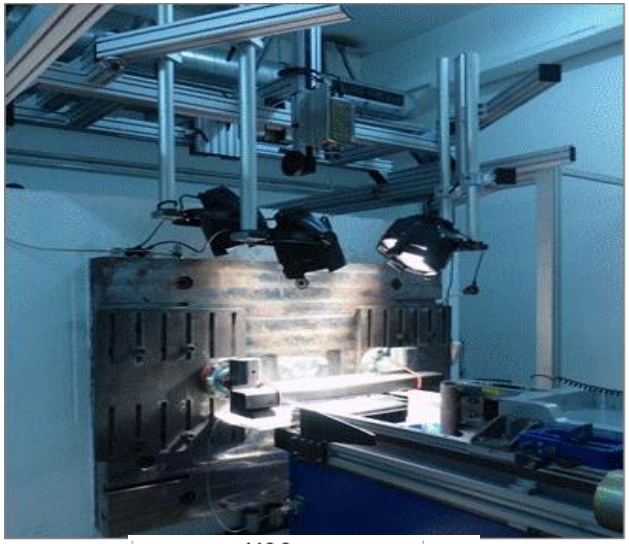
Variation of Heat Transfer

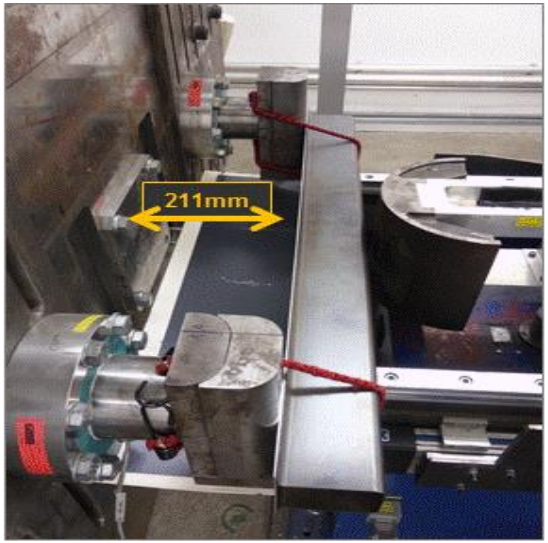
Cooling Tool with Defined Gap

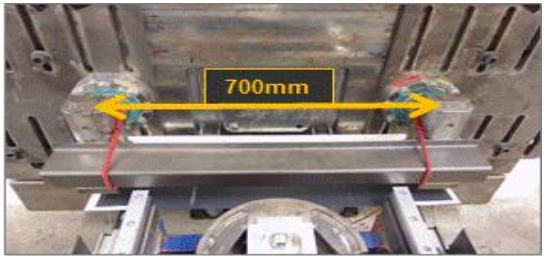
- Defined contact conditions
  - No gap → full contact
  - Defined gap → reduced heat transfer

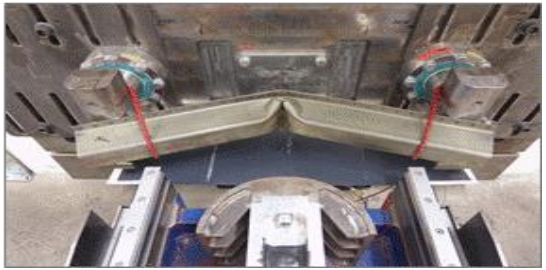


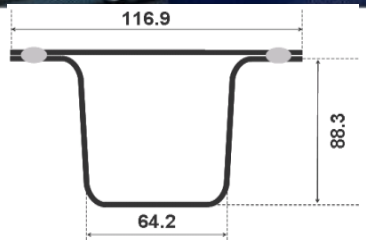
Side Impact Testing Set-up & Test Parameters







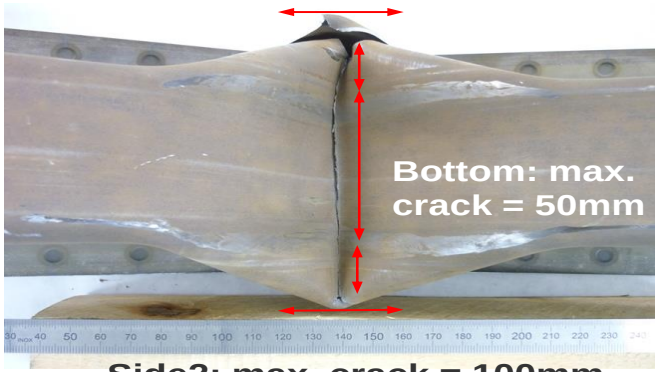




Sample length: 900 mm, Span: 700 mm
Load mass: 86 kg
Testing speed: 20 – 30 km/h
Impactor radius: 127 mm

Side Impact Crash Index Definition

Side1: max. crack = 100mm



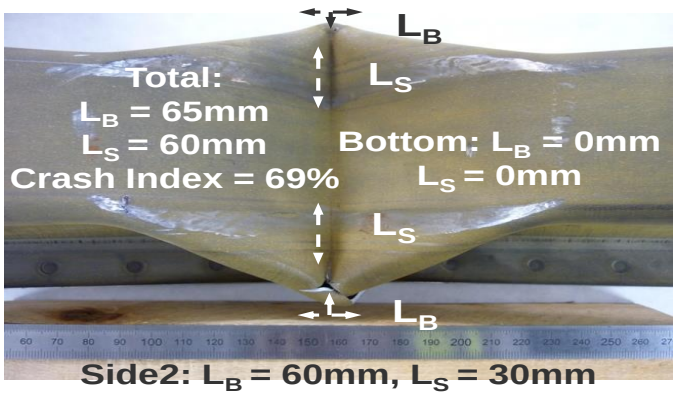
Side2: max. crack = 100mm

Best case: no crack ⇒ CI = 100%

Worst case: crack length L_B= 250mm, L_S=0

⇒ CI = 0%

Side1: L_B = 5mm, L_S = 30mm



Side2: L_B = 60mm, L_S = 30mm

Crash index: calculation example

$$\text{Crash index}_{\text{sideimpact}} = \left(0.2 \times \left(1 - \frac{L_S}{250}\right) + 1.0 \times \left(1 - \frac{L_B}{250}\right) - 0.2\right) \times 100$$

L_B: big crack length

L_S: small superficial crack length

Conclusions

- Direct press-hardening process with pre-cooling
  - Using an adapted steel composition of phs-directform® (20MnB8) results in a robust process for zinc coated steel
  - Hot forming at lower temperatures reduces critical thinning
  - Resulting mechanical properties are in the same range as 22MnB5
  - Crash behavior of different steel compositions is comparable via bending angle

Thank you

Dr. Enno Arenholz

enno.arenholz@voestalpine.com