GREAT DESIGNS IN STEEL

Coating Free Press Hardened Steel in Tubular Applications

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General Motors

Overview

- CFPHS: An Overview
- Tube Production
- Hot Blow Form Tube Manufacturing
- Mechanical Properties
- Microstructure
- Part Geometry and Stability
- Conclusions

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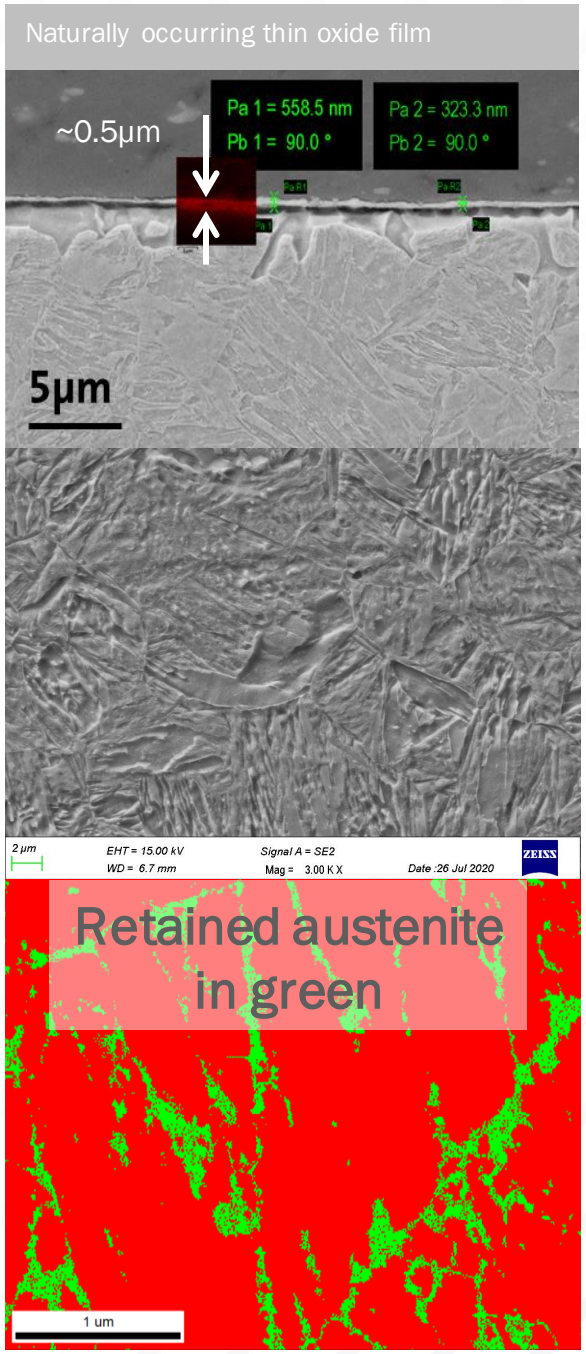
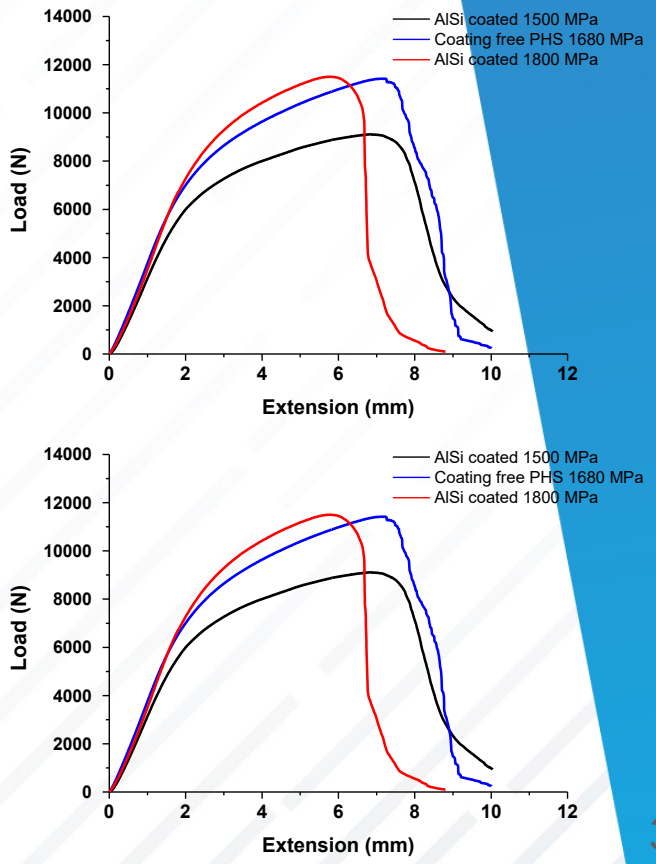
CFPHS: What It Is

- CFPHS: Coating Free Press Hardened Steel
- Forms a protective oxide barrier to prevent oxidation and decarburization in furnace
- Unique chemical composition utilizes Si and Cr to stabilize oxide layer and prevent formation of scale
- Cr and Si additions enable the formation of retained austenite in the quenched microstructure- increasing energy absorption in bending
- Cr and Si also allow the material to be air hardenable- which will be explored in this study.

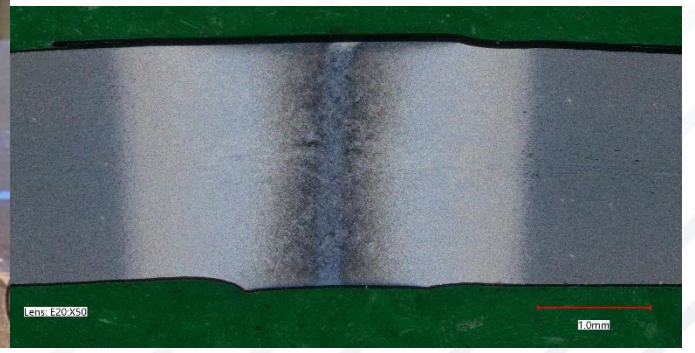




Tube Production

- Tube was produced from 1.9mm CFPHS
- Roll forming and resistance welding were used to manufacture tubing on a conventional tube mill
- Weld seams on the OD and ID were scarfed (scraped) to remove the burrs.
- Tube weld seams were tested via indentation on the weld seam and phalange expansion of the base (see picture). Weld soundness was determined to be satisfactory at the manufacturing site.

CFPHS tube sample. Left: Sample tube indented over the seam for quality check at manufacturing facility. Below: Weld seam post manufacture

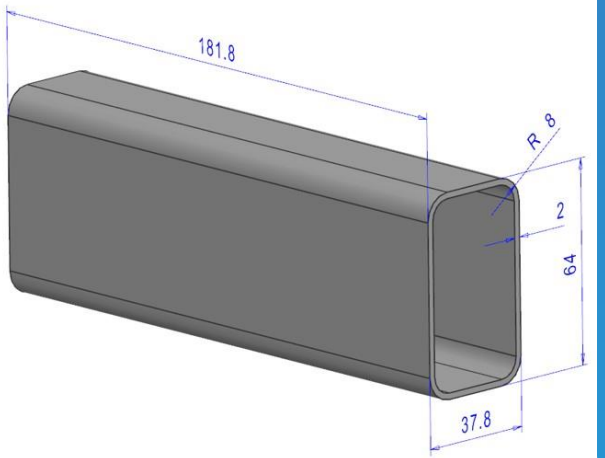


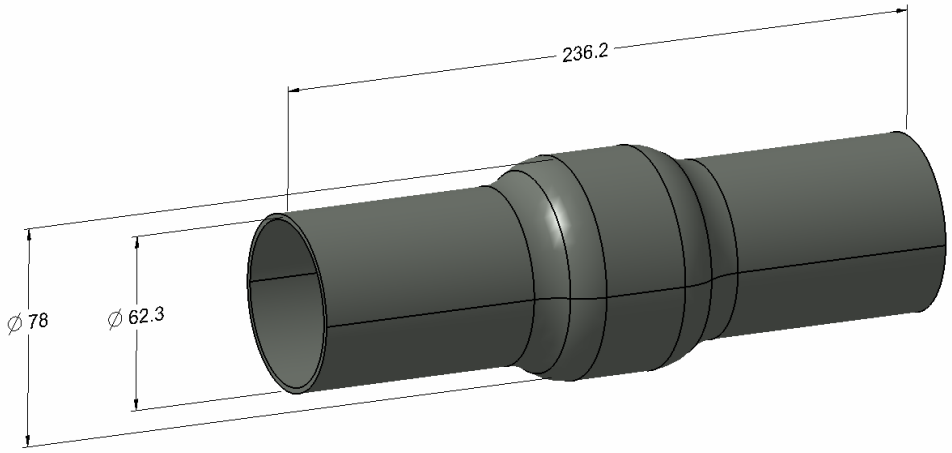
Hot Blow Form Tube Manufacturing

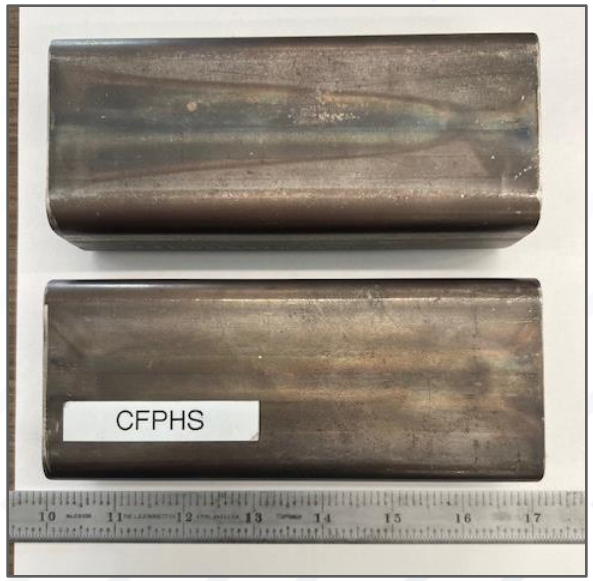
Tube was then sent to Multimatic Brompton ON for forming via the Accra® process.

Two tube geometries were used, rectangular and bulged. Tube geometry is shown below.

Tube was hot blow formed using forced air and either a water quench or no quench.

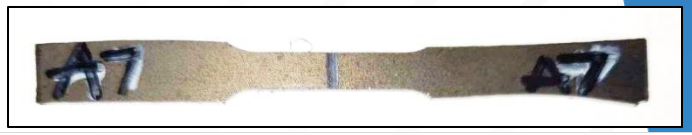


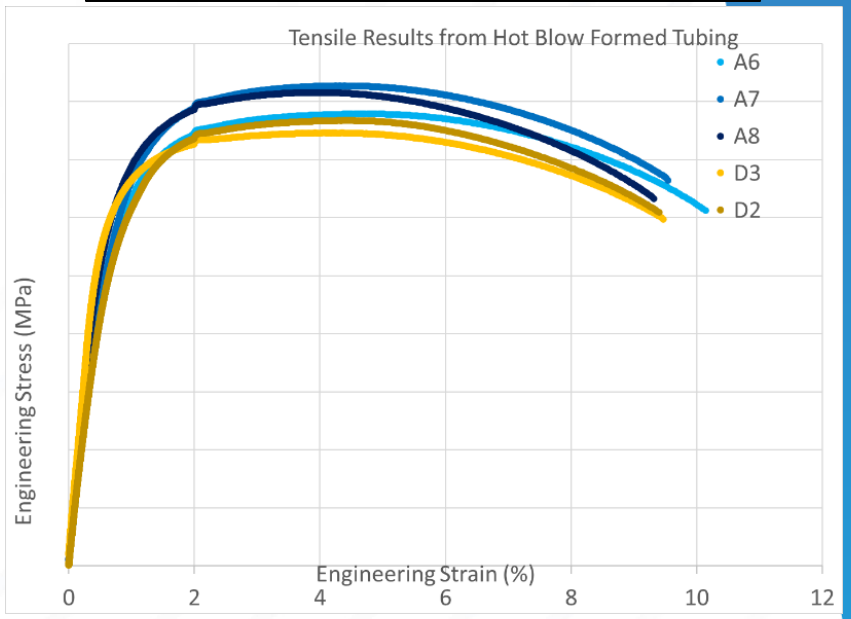




Mechanical Properties

- Mechanical properties in the finished rectangular tubes (without paint bake) were examined from various perspectives:
  - weld seam effects,
  - water quenched vs not water quenched
- Test results showed that weld seams did little to affect the tube's mechanical performance.
- Whether or not the tube was water quenched, the properties still met the expected range for the CFPHS material.





Tensile results: Weld vs No Weld

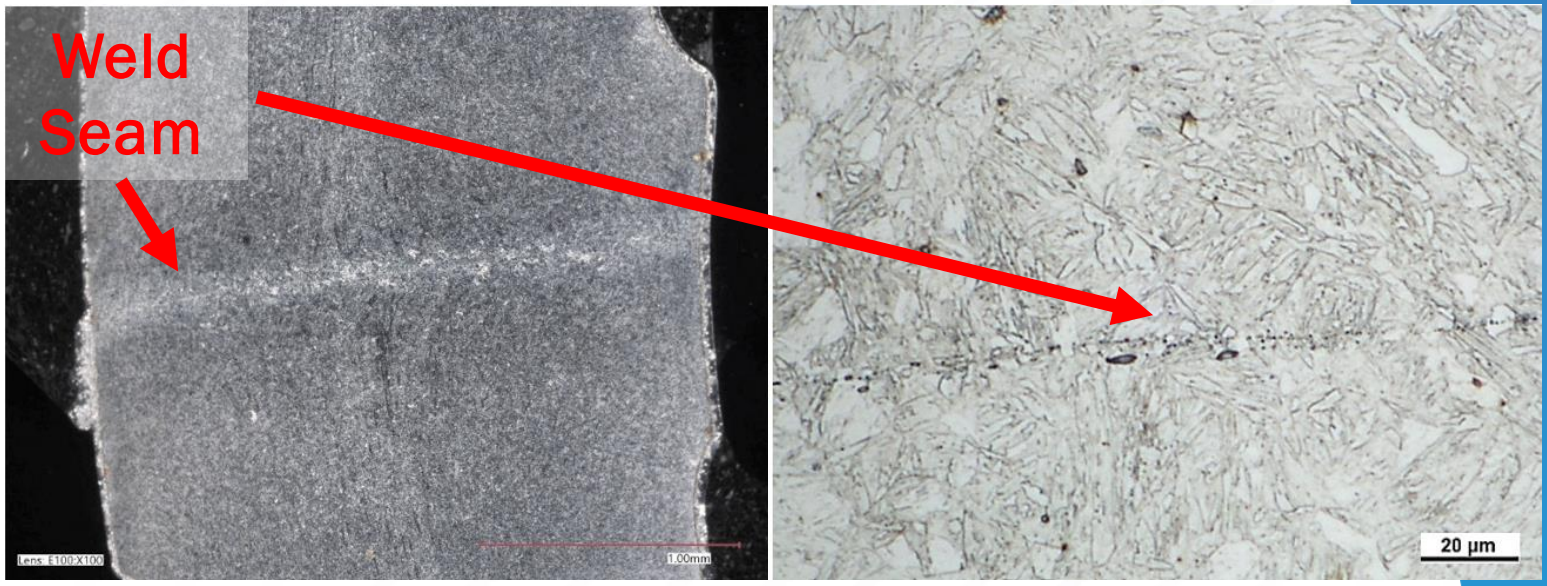
Average	0.2% YS (MPa)	UTS (MPa)	Uniform Elongation	Elongation at Fracture
Weld	1119	1549	4.9	10.5
No Weld	1184	1615	4.3	9.6
Difference	65	65	0.6	0.8

Tensile results: Water Quench vs. Non-Water Quench.

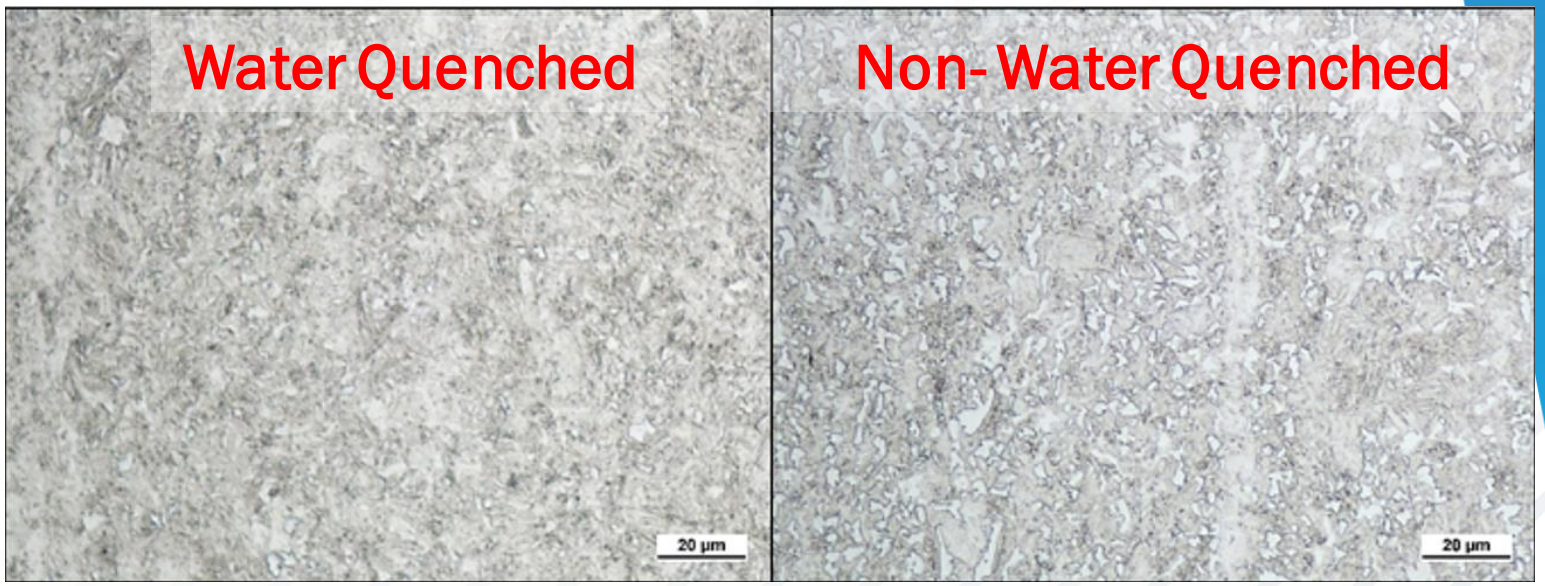
Average	0.2% YS (MPa)	UTS (MPa)	Uniform Elongation (%)	Elongation at Fracture (%)
Water Quench	1119	1549	4.9	10.5
No Water Quench	1133	1514	3.8	9.4
Difference	+24	-35	-1.1	-1.1

Microstructure Analysis

Microstructure of the weld seam, water quenched and non-water quenched tubes were examined. The tube weld seam post hot blow forming was martensitic, even at the weld seam (top images).

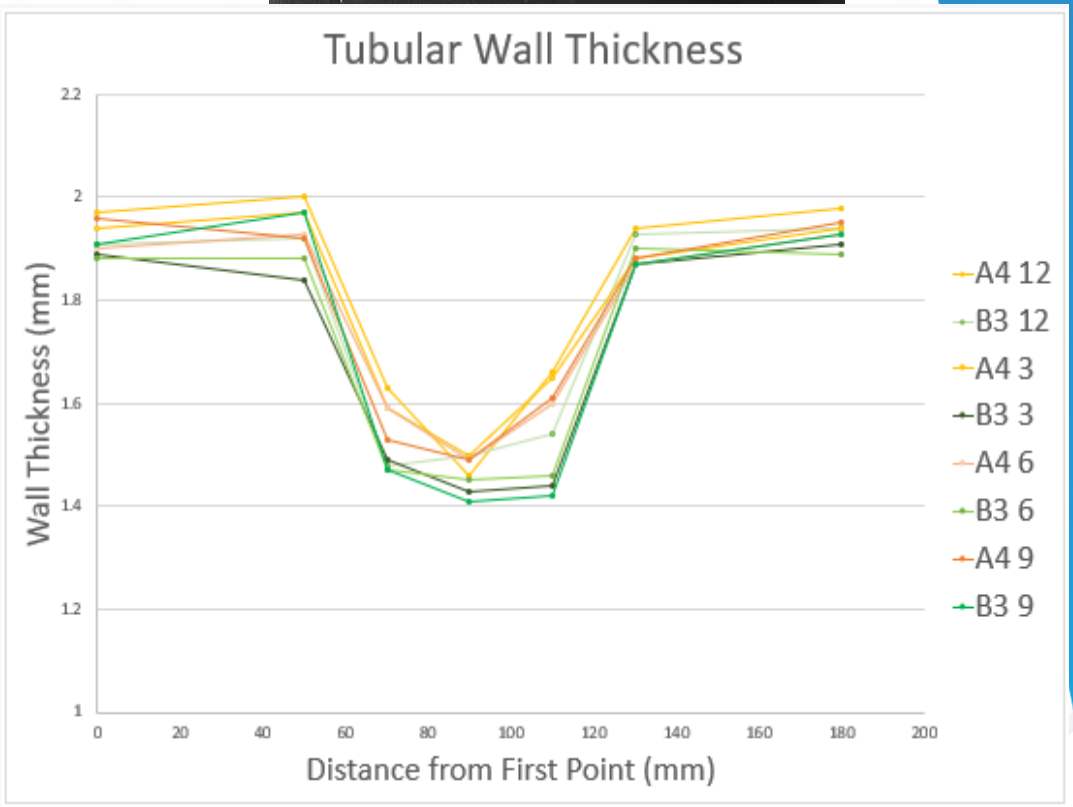


Both water quenched and non-water quenched samples were predominantly martensitic in the core (bottom images).



Part Geometry and Stability

- Wall thicknesses across both the water quenched and non-water quenched tube were investigated by sectioning the samples per the image at right.
- Sections were made for both water quenched and not water quenched samples.
- The samples were measured at 12, 3, 6 and 9 o'clock with 12 o'clock aligned with the weld seam for reference.
- The charted data showed a separation between the water quenched (A4, yellows) and non-water quenched (B3, greens) samples in the tubular wall thickness across the bulge.
- The bulge itself thinned as expected for both parts measured, with increased thinning at the greatest diameter of the bulge.



Conclusions

- Coating free PHS tubing can be manufactured on commercial tubing lines.
- Tubes can be hot blow formed into various shapes.
- Weld seams do not affect tensile performance of hot blow formed tubes.
- Whether the tube is water quenched or not water quenched, tensile properties fall within the expected range for this material.
- Microstructure of both water quenched and non-water quenched tubes were martensitic, even the weld seams displayed martensitic microstructures.
- Part dimensions displayed little variation between water quenched and non-water quenched samples.

Thank you for your attention!

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FOR MORE INFORMATION

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