CLIFFS

AN INNOVATIVE FAMILY OF FORMABLE TUBE PRODUCTS

FORMTUBE®

FORMTUBE® AL

FORMTUBE® SS

FORMTUBE® PHS

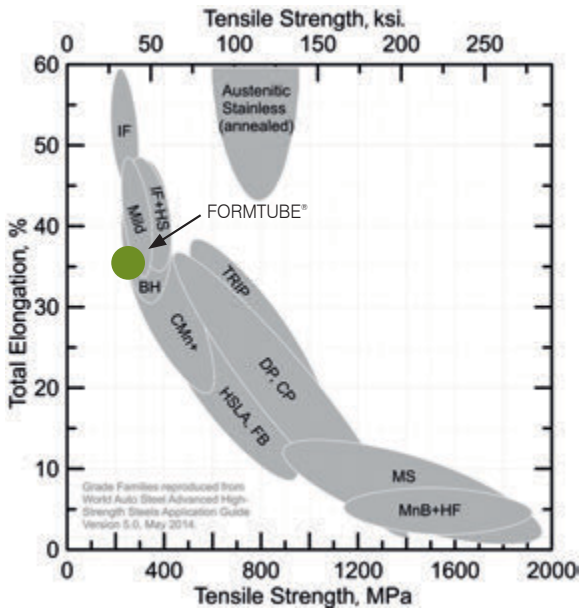
FORMTUBE® 800 / 1000 / 1200

FORMTUBE ®– Product Description

Designed for improved formability at a lower cost for Pressure Tube (PT) applications. Cost-effective alternative for J356 standards for low pressure applications.

TUBE MECHANICAL PROPERTIES (minimums)

Yield Strength	Tensile Strength	Elongation
172 MPa	276 MPa	35%



ADVANTAGES

- Typical elongation of 46%
- Available as cold-rolled or aluminum-coated product
- Available in diameter-to-thickness (D/t) ratios up to 100:1
- Lower-cost alternative to annealed tube

APPLICATIONS

- Fuel filler neck
- Radiator tubes
- Fluid line tubing
- Vent tubes
- Exhaust tubes

SIZES

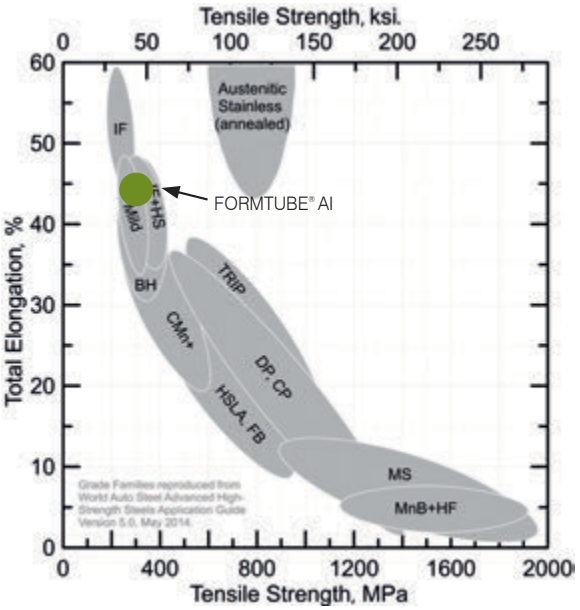
- 19 – 168 mm diameters
- 0.8 – 3.0 mm thickness

FORMTUBE® AL – Product Description

A highly-formable, aluminum-coated, carbon tubing available in extremely high D/t ratios, specifically designed for use in demanding exhaust applications that require tight 1XD bends. Proven to improve customer quality and reduce production costs. Meets ASTM A787.

TUBE MECHANICAL PROPERTIES (typical – 76 mm diameter)

Yield Strength	Tensile Strength	Elongation
220 MPa	296 MPa	44%



ADVANTAGES

- High corrosion resistance in carbon tube
- Excellent heat reflectivity at temps less than 430 °C
- Material effective up to 680 °C
- Available in Diameter/t ratios up to 100:1

APPLICATIONS

- Automotive aftermarket exhaust tubular components
- OEM and aftermarket truck exhaust tubular components
- Coolant fluid transfer tubular components
- Heat Exchanger and HVAC tubular components

SIZES

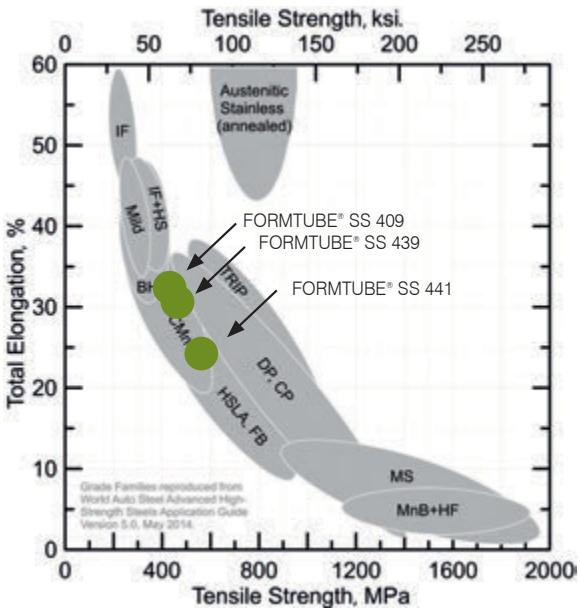
- 19 – 168 mm diameters
- 0.8 – 3.0 mm thickness

FORMTUBE® SS – Product Description

Stainless steel tubing developed with superior formability. Available in 304L, 316L, 409, 436, 439, 441, 15 Cr-Cb™ and 18 Cr-Cb™. The 409 and 439 grades are available in aluminum coated versions.

TUBE MECHANICAL PROPERTIES (typical – 127 mm diameter)

Stainless	Yield Strength	Tensile Strength	Elongation
409	340 MPa	420 MPa	31%
439	370 MPa	475 MPa	29%
441	470 MPa	520 MPa	24%



ADVANTAGES

- Equiaxed grain structure improves forming and reduces customer scrap
- Uniform mechanical properties for repeated forming
- Minimal tube cold work allows maximum customer forming
- Aluminum-coated product available in 409 and 439 grades for increased corrosion resistance
- Available in D/t ratios up to 100:1

APPLICATIONS

- Automotive, truck and ATV/UTV exhaust tubes
- OEM Hot and cold end exhaust system tubular components
- Coolant fluid transfer tubular components
- Heat Exchanger and HVAC tubular components

SIZES

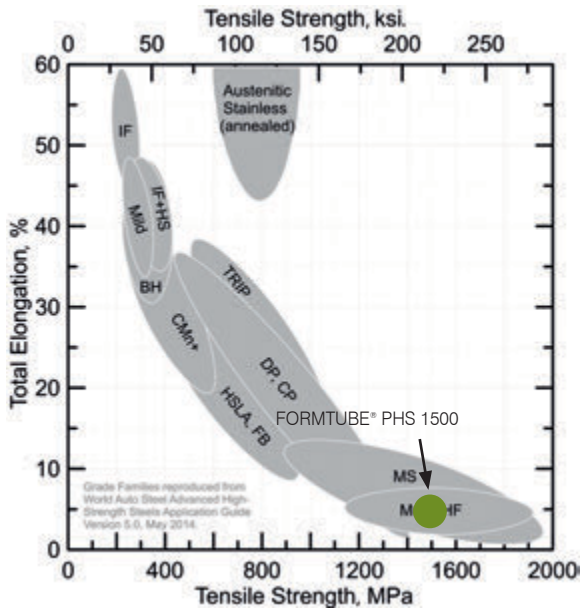
- 32 – 168 mm diameters
- 0.8 – 3.0 mm thickness

FORMTUBE® PHS – Product Description

Available in 1500 MPa Press Hardenable Steel (PHS) grades (after customer hot-forming). Designed specifically for tubular hot-forming applications.

TUBE MECHANICAL PROPERTIES (typical – 63.5 mm diameter, before hot-forming)

	Yield Strength	Tensile Strength	Elongation
PHS 1500	470 MPa	630 MPa	23%



* Note: Properties after hot-forming

ADVANTAGES

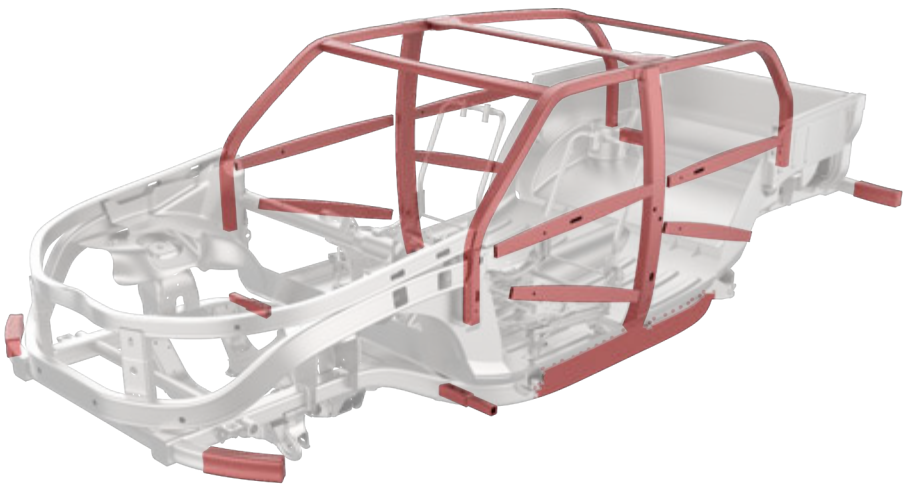
- Bare or Aluminum-coated product available
- Available in round or complex custom shapes
- Smooth cut ID and OD surface for precise mandrel bending
- Available in D/t ratios up to 100:1

APPLICATIONS

- Hot-formed structural components
- Impact beams, roof rails and pillars
- C-STAR™ (Cliffs Steel Tubes as Reinforcement) assemblies

SIZES

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



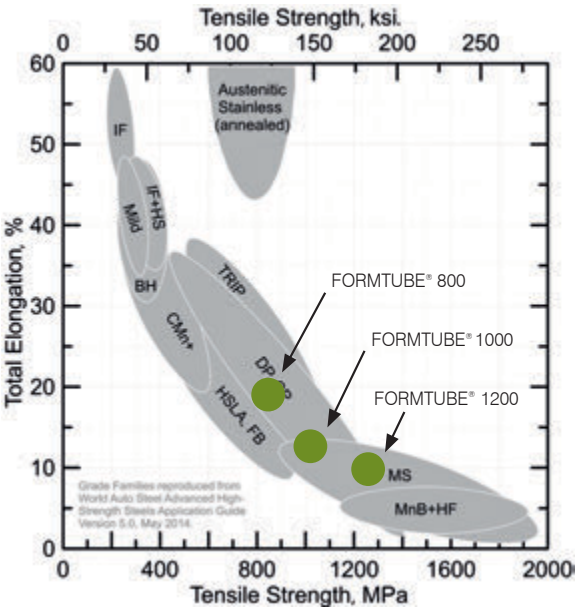
FORMTUBE® 800 / 1000 / 1200 – Product Description

Available in DP 600 / 800 / 1000 and DP 1200 grades, in both bare and galvanized coated versions. Offers highest D/t range in the market today. Excellent for lightweighting.

TUBE MECHANICAL PROPERTIES (typical)

	Yield Strength	Tensile Strength	Elongation
DP 800	620 MPa	841 MPa	17%
DP 1000	730 MPa	1020 MPa	12%
MP 1000	870 MPa	1030 MPa	8%
DP 1200	1000 MPa	1270 MPa	8%

Note: Typical bake hardening effect on Yield Strength – 7% increase.



ADVANTAGES

- Uniform tube properties for consistent forming
- High D/t ratios up to 100:1
- Consistently smooth cut ID and OD cutting for efficient bending and forming
- Lightweight alternative to current mild carbon or HSLA grades

APPLICATIONS

- Any automotive, truck or power sports structural application
- Excellent for lightweight and/or crash management applications
- C-STAR (Cliffs Steel Tubes as Reinforcement) assemblies

SIZES

- 19 – 168 mm diameters
- 0.9 – 2.5 mm thickness

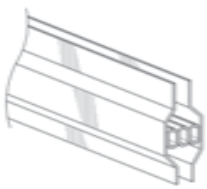
CLIFFS

C-STAR™ PROTECTION

CLIFFS STEEL TUBES AS REINFORCEMENT
C-STAR PROTECTION IS AN INNOVATIVE VEHICLE STRUCTURE STEEL SOLUTION

C-STAR PROTECTION FEATURES:

- Cost-efficiency and sustainability
- Scalability to meet different performance requirements
- Manufacturability
- Less product design space requirement



View of 3-tube stacked reinforced rocker panel

Front cross-section of 3-tube stacked reinforced panel

Front cross-section of 5-tube stacked reinforced panel

Front view of C-STAR steel design tested sample

Front view of comparative extruded aluminum design

WHAT DO YOU WANT PROTECTING YOUR FAMILY, VEHICLE AND VEHICLE BATTERY?

Modern vehicles use a variety of structural components to protect both passengers and internal mechanical and electrical systems. In the event of a collision, you want the structural components to absorb energy and/or deform in a controlled and predictable way. Cliffs' Steel Tubes As Reinforcement, C-STAR™ protection, used in combination with structural components, contributes to the ability for structural components to absorb energy and/or deform in a more controlled and predictable way.

A C-STAR structure may be used in electric, hybrid, or ICE vehicles as reinforcements in rocker panels to protect passengers and/or batteries from a side-impact collision. C-STAR protection may also be used to protect motors, engines, electrical components, passenger compartments, storage compartments, and any area in a vehicle where this design is implemented. The specifics of the design can be varied to meet your performance criteria, such as varying wall thickness, shape, configurations or orientation of the tubes. Suitable alternative applications may include reinforcement of, or functioning as, A-pillars, B-pillars, C-pillars, D-pillars, bumpers, roof bow, roof rails, cross members, window rails, and more.

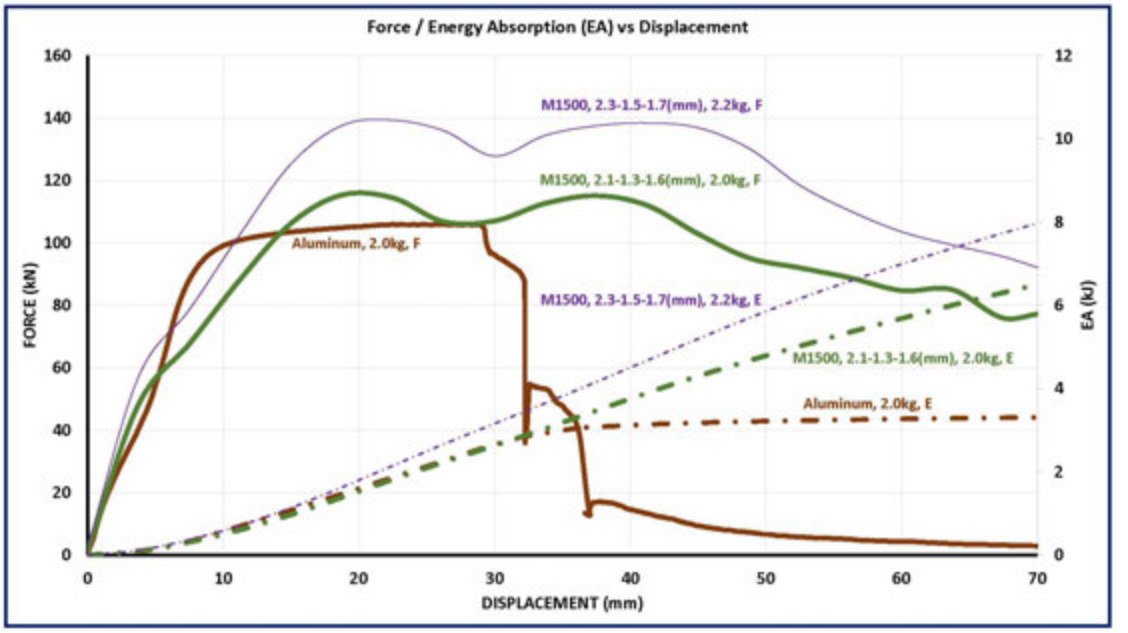
C-STAR protection is a configurable and scalable Advanced High-Strength Steel (AHSS) steel tube system used for occupant or battery protection, or protection in any other area in any type of vehicle.

The steel grade used for the steel material may correspond to desired performance criteria such as energy absorption and/or intrusion protection. You can find one example of steel superiority on the other side of this datasheet.

C-STAR™ PROTECTION

In the example, a validated CAE model was used to evaluate the performance of three stacked C-STAR™ designs of M1500 with different thicknesses under 3-point bending. The results were then compared against the 3-point bend test results of an extruded 6000 series aluminum reinforcement. As shown below, with mass parity, the optimized M1500 C-STAR™ shows similar performance to aluminum at the initial impact stages, then it starts to outperform aluminum both in peak force (by 6% at 20 mm displacement), and in energy absorption (by 50% at 50 mm displacement).

Offering superior performance and mass parity to aluminum, C-STAR™ protection is the only choice.



About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials, direct reduced iron, and ferrous scrap to primary steelmaking and downstream finishing, stamping, tooling, and tubing. The Company serves a diverse range of markets due to its comprehensive offering of flat-rolled steel products and is the largest supplier of steel to the automotive industry in North America. The Company is headquartered in Cleveland, Ohio with mining, steel and downstream manufacturing operations located across the United States and in Canada. For more information, visit www.clevelandcliffs.com.

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December 2023