

MARTENSITE

PRODUCED AT CLEVELAND-CLIFFS INDIANA HARBOR 3CAL



- Battery Box Members**
- Bumper Reinforcement**
- Door Intrusion Beams**
- Rocker Panel Inners and Reinforcements**
- Side Sill and Belt Line Reinforcements**
- Springs and Clips**

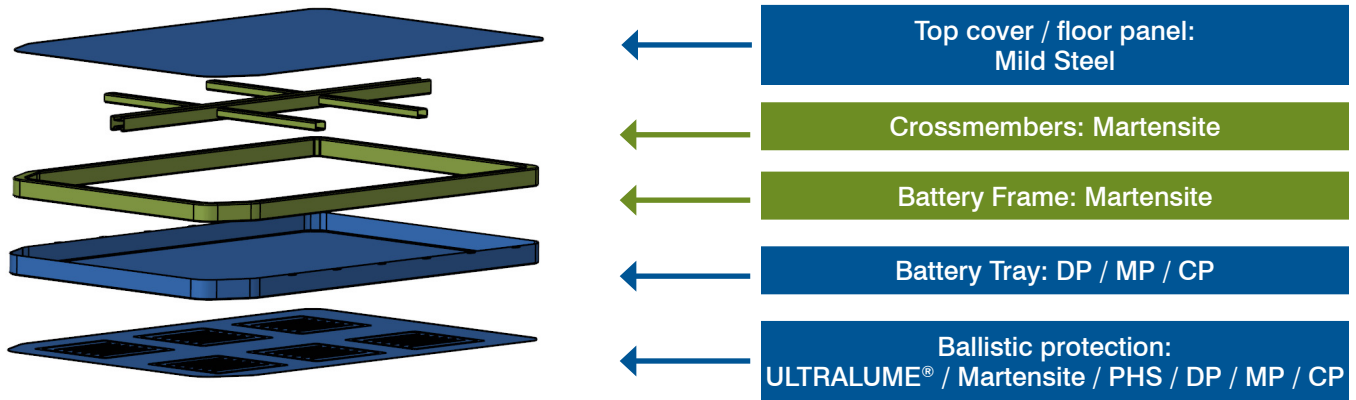
Cleveland-Cliffs' **MARTENSITIC ULTRA HIGH STRENGTH STEELS** boast some of the highest strength levels available. They offer higher strength-to-weight ratios than conventional cold-rolled steels and, like other advanced high-strength steels (AHSS), are more cost-effective than other metals or plastics.

Martensitic grades can be a key element of light-weighting strategy and are excellent for battery electric vehicles (BEV), including battery boxes. Unlike some competing materials, they have uniform tensile strengths in both longitudinal and transverse directions. This allows more flexibility in design and manufacturing, maximizing material utilization. Though limited in formability, readily-available manufacturing technologies, such as roll forming, allow for full utilization of these grades.

Cleveland-Cliffs offers martensitic grades as an uncoated cold roll product and an electrogalvanized coated product for superior corrosion protection.

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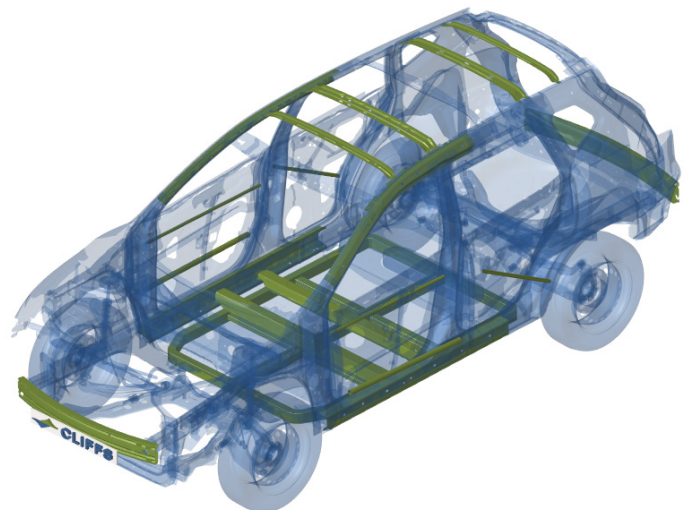
An Optimal Choice for Battery Electric Vehicles



Cleveland-Cliffs' martensitic steels, and AHSS grades in general, are excellent choices for designing battery boxes. As shown in detail on page five, our family of fully martensitic grades, in combination with other AHSS grades, help our customers achieve engineering and light-weighting objectives, especially with the design expertise of our Advanced Engineering Group. When considering the cost of weight savings, steel is unique in saving both weight and cost while increasing strength.

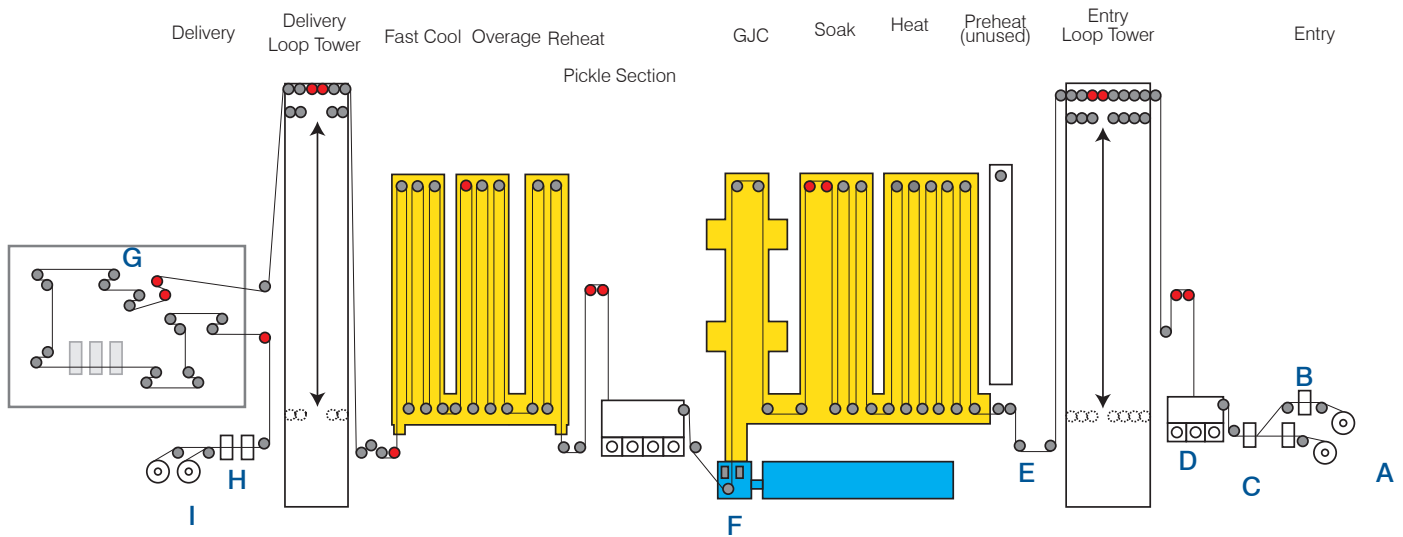
The engineering solution above utilizes martensite crossmembers and framing to protect the battery from damage. The lower tray is made from AHSS, although cold-stamped grades (Dual Phase, Multi-phase or Complex Phase) are also viable options. Ballistic protection can be made from Cliffs' press-hardened ULTRALUME products or any other cold-formed AHSS grade. Depending on the design, the mild steel top cover can be separate, or part of the floor pan itself.

The crossover body-in-white diagram shows the typical applications for martensitic grades: bumper reinforcements, rocker panel inners, side sills and door impact beams. Parts made from pure martensite do not absorb as much crash energy as parts made from other AHSS grades, so martensitic parts work in concert with these other steel grades to help prevent intrusions into the passenger compartment. While not depicted in this image, the seat structure can also be made using martensitic grades.



Car model design based on 2020 Nissan Rogue FE Model developed by Center for Collision Safety and Analysis at George Mason University.

3CAL Processing Line Schematic



This schematic shows the layout of the 3CAL Water Quench Line at Cleveland-Cliffs Indiana Harbor. Material enters from the right to begin the process.

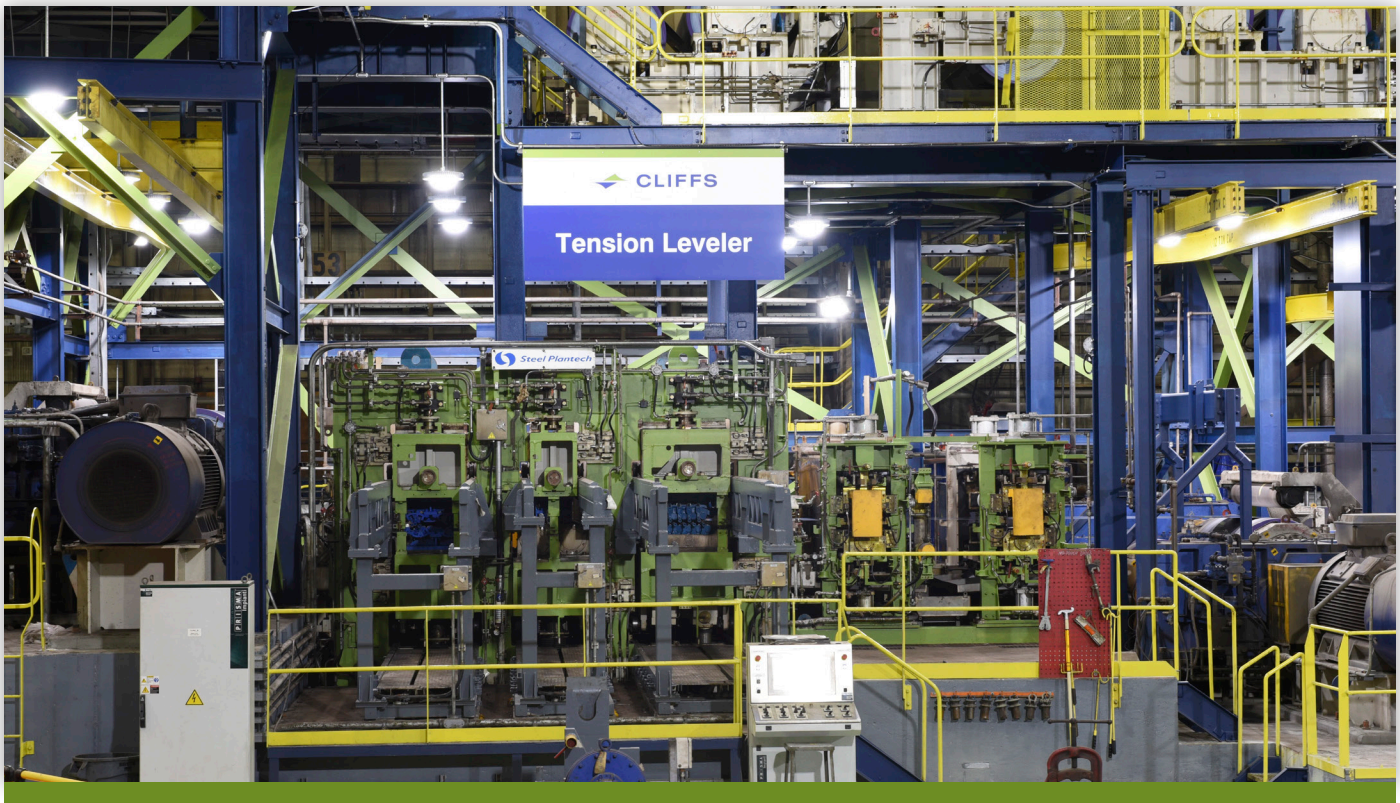
- | | |
|---|--|
| A. Payoff Reels | F. Quench (Commissioned 2018) |
| B. Shears | G. Tension Leveler (Commissioned 2018) |
| C. Welder (Commissioned 2017) | H. Oiler and Shear |
| D. Cleaning Section | I. Tension Reels |
| E. Steering Roll, Bridle Roll, and Dancer | |

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Produced on a State of the Art Modern Quench Line

Significant capital upgrades were recently completed on the 3CAL at Indiana Harbor. A new welder improved welder reliability, allowing for heavier gauge products and higher strength products to be produced. The quench tank was replaced with a new design, minimizing mechanical property variation across sheet width and improving product shape coming from the quench. But, most significantly a tension leveler was added, which allows for fine-tuning of product shape and production of AHSS grades with world-class flatness.

Metallurgically-speaking, the temperatures achieved in primary annealing and the quench tank are the 3CAL's key features. The facility's AHSS production includes fully martensitic grades. This uncommon metallurgical process produces AHSS with comparatively simple chemistries, giving Cleveland-Cliffs products advantages over competitive ones made with richer chemistries.



Grade Availability

Cleveland-Cliffs' cold-roll family of fully Martensitic Steels is offered with tensile strength grades ranging from 900 to 1700 MPa. These grades are also available in tensile strength grades from 900 to 1500 MPa with an electrogalvanized (EG) coating.

Tensile Strength	Uncoated	EG
900 MPa	yes	yes
1100 MPa	yes	yes
1300 MPa	yes	yes
1500 MPa	yes	yes
1700 MPa	yes	in development

Applications

The high strength-to-weight ratios open up many attractive weight reduction opportunities. They are designed especially for roll-formed and tubular applications where high strength is critically important.

Typical applications for Cleveland-Cliffs' family of martensitic grades are:

- battery box members,
- bumper reinforcement beams,
- door intrusion beams,
- rocker panel inners and reinforcements,
- side sill reinforcements, belt line reinforcements,
- springs and clips.



3CAL's world-class flatness. All products produced on the line have comparable shape to that shown in the photo above.

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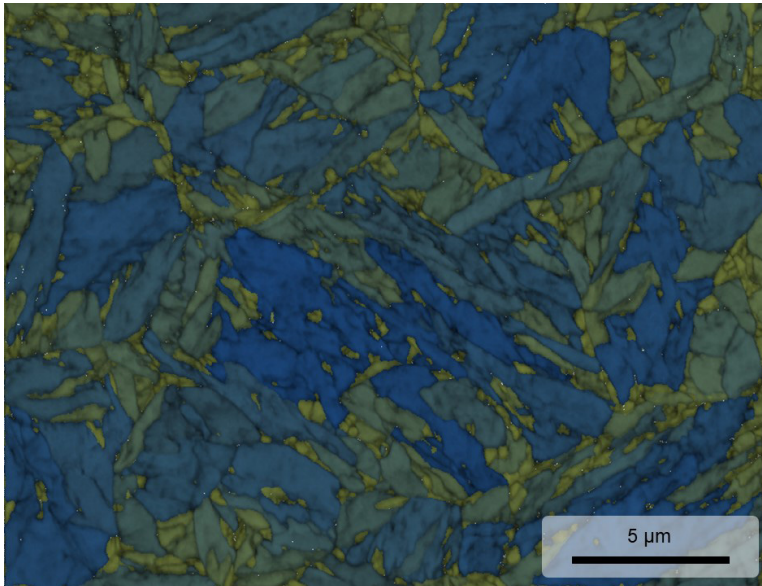
Chemistry

	C (wt. %)	Mn (wt. %)	P (wt. %)	S (wt. %)	Other	Form
M900	0.08	0.45	0.01	0.004	B, Ti	CR, EG
M1100	0.12	0.45	0.01	0.004	B, Ti	CR, EG
M1300	0.17	0.45	0.01	0.004	B, Ti	CR, EG
M1500	0.25	0.45	0.01	0.004	B, Ti	CR, EG
M1700	0.29	0.45	0.01	0.004	B, Ti	CR

Mechanical Properties – ASTM-L

		Yield strength (MPa)	Tensile Strength (MPa)	Total elongation (%)	Recommended bend radius
M900	Min	700	900	3	4T
	Typical	960	1070	5	
M1100	Min	860	1100	3	4T
	Typical	1070	1200	5	
M1300	Min	1030	1300	3	4T
	Typical	1230	1390	5	
M1500	Min	1200	1500	3	4T
	Typical	1420	1600	5	
M1700	Min	1350	1700	3	4T
	Typical	1560	1750	5	

Metallography - 100% Martensite



Magnification 1000X. M1700.
Contains 100% tempered Martensite.

Size Availability

nominal					
2.4					
2.2*					
2.0					
1.8					
1.6					
1.4					
1.2					
1.0					
0.8					
0.6					
0.4					
	900	1000	1100	1200	1300

■ Available dimensionally ■ Inquire for dimensional availability
 * enhanced capability



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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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