CLIFFS

MULTI-PHASE AND COMPLEX PHASE
STEELS

Automotive Safety Components

Suspension System Components

MULTI-PHASE AND COMPLEX PHASE STEELS are cold formed to make lightweight structural elements. Given their high energy absorption capacity and fatigue strength, these grades are particularly well suited for automotive safety components requiring good impact strength, and for suspension system components. Multi-Phase and Complex Phase grades can meet forming requirements for applications where Dual Phase grades may not be adequate. This would most likely be related to hole expansion and/or bendability needs.

MULTI-PHASE AND COMPLEX PHASE STEELS

Grade Availability

Cleveland-Cliffs' Multi-Phase and Complex Phase Hot-Rolled (HR) and Hot-Dip Galvanized (GI) grade offerings currently include products with 780 MPa and 980 MPa tensile strength, as shown in the table to the right.

Product	Grade
GI	CR780T/440Y-MP
GI	CR780T/600Y-CP
GI	CR980T/800Y-CP

Product Characteristics

When discussing Multi-Phase and Complex Phase steels, it is appropriate to consider Dual Phase grades as the baseline for comparison. The progression of value added by the physical properties of these products is: 1) Dual Phase (DP), 2) Multi-Phase (MP), and 3) Complex Phase (CP).

At a given tensile strength level:

- Dual Phase steel provides a higher total elongation and lower yield strength. It has limitations of hole expansion and bendability.
- Complex Phase steel provides a much higher yield strength, a much better hole expansion ratio and superior bendability as compared to the DP steel. It has lower total elongation than a DP steel.
- Multi-Phase steel provides mechanical properties in between DP and CP steels.

930CP door beam

Chemistry – Typical (GI)

Grade	Max. C	Max. Mn	Max. Si	Max. Cr+Mo	Max. Ti+Nb	Max. P	Max. S	Max. B
CR780T/440Y-MP	0.18	2.7	1	1	0.15	0.05	0.01	0.005
CR780T/600Y-CP	0.18	2.7	1	1	0.15	0.05	0.01	0.005
CR980T/800Y-CP	0.18	2.7	1	1	0.15	0.05	0.01	0.005

Mechanical Properties

RANGES OR TARGET MINIMUMS AS COMPARED TO DP GRADES AT SAME TENSILE STRENGTH

Grade	Yield strength min., MPa	Tensile strength min., MPa	Min. total elongation A50, %	Bend ratio r/t	Hole expansion %
CR780T/420Y-DP	420	780	14%	≤ 3.0	≥ 20%
CR780T/440Y-MP	440	780	13%	≤ 2.0	≥ 30%
CR780T/600Y-CP	600	780	11%	≤ 1.0	≥ 45%
CR980T/550Y-DP	550	980	8%	≤ 3.0	≈ 20%
CR980T/800Y-CP	800	980	7%	≤ 2.0	≥ 40%

Bend test, 980CP

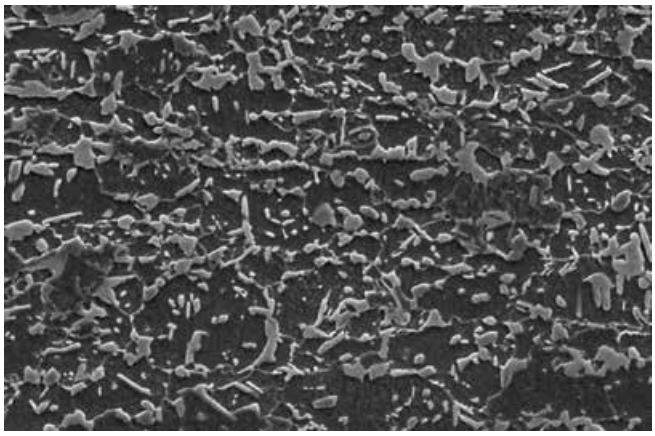
780DP Hole expansion test

780MP Hole expansion test

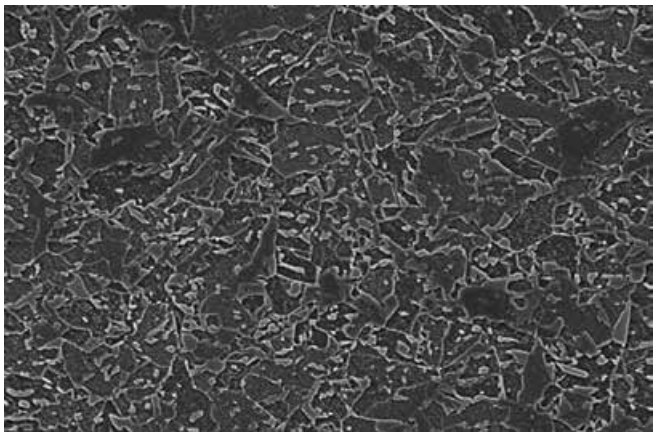
780CP Hole expansion test

Metallography

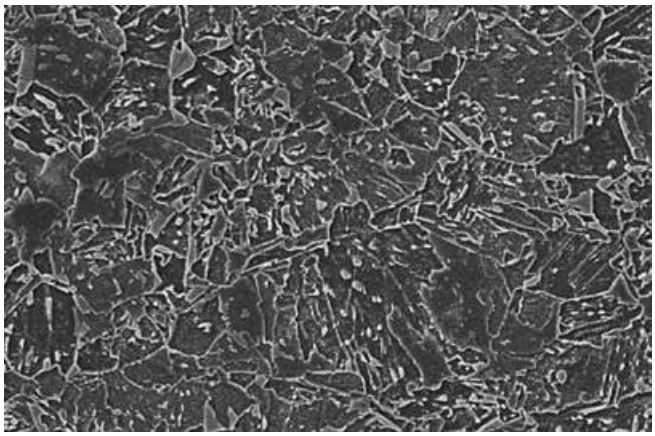
A comparative examination of products at the 780 MPa tensile strength level in order of increasing formability.



780DP: ferrite, bainite, fresh martensite



780MP: ferrite, bainite, fresh martensite (comparable to 780DP but with less fresh martensite)

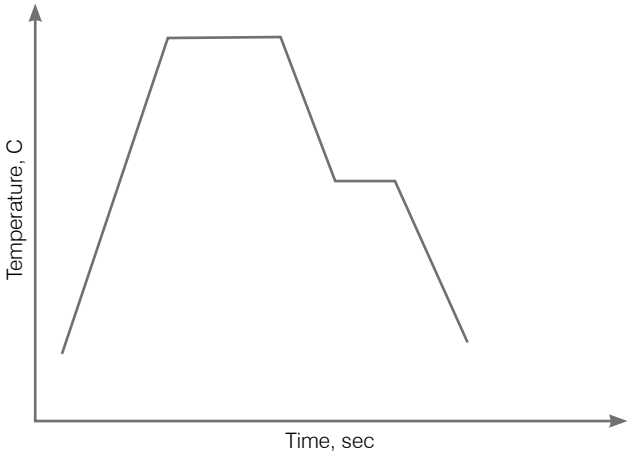


780CP: ferrite, bainite, martensite and fresh martensite

Mill Processing

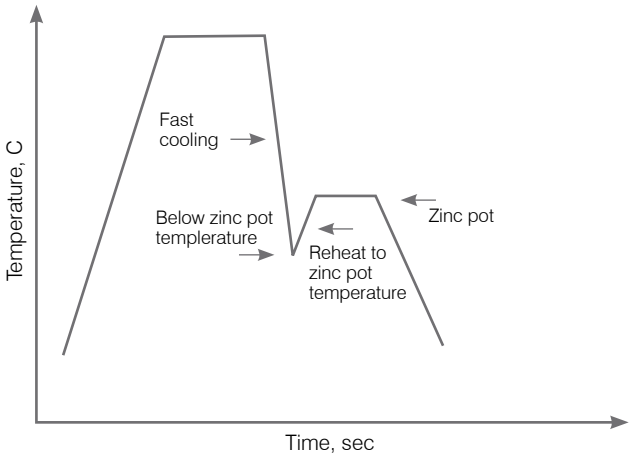
The mill processing necessary to achieve a Multi-Phase or Complex Phase microstructure is unique, requiring a process called low-end cooling. A traditional or typical continuous anneal process cannot achieve the necessary steel temperatures that would result in the formation of a Multi-Phase or Complex Phase microstructure. A unique anneal practice with specialized equipment is necessary.

TRADITIONAL HOT-DIP THERMAL PROFILE



This traditional anneal process would produce, for example, 780DP.

MODIFIED HOT-DIP THERMAL PROFILE



This anneal process produces MP and CP microstructures.

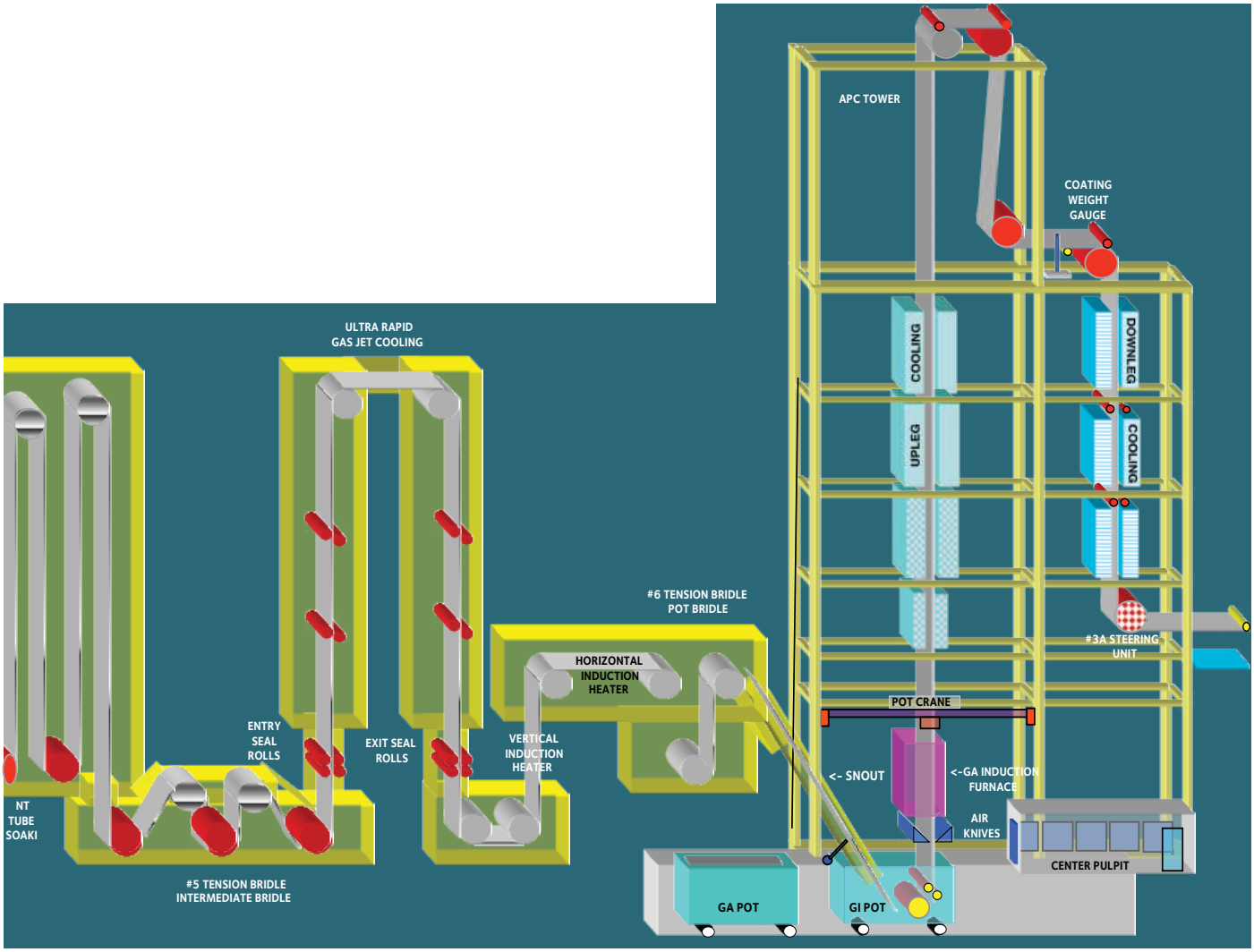
Operational Upgrades

The hot-dip line at our Dearborn Works facility was upgraded in 2017 to produce AHSS grades, including Multi-Phase and Complex Phase grades. In 2019, the hot-dip coating line at our Cleveland Works facility was upgraded to facilitate production of MP and CP steels. This added capability did not reduce or alter the prior product offerings of the lines.

Low-end cooling (LEC) is a heat-treating process in which the steel is fast cooled below zinc pot temperature and then heated up again before being coated with zinc.

In an LEC process, bainite and/or tempered martensite formation is promoted before the steel enters the zinc pot. This also minimizes the formation of fresh martensite. The resultant microstructure is beneficial for better local formability, namely superior hole expansion and bendability.

As a comparison, in the conventional production of a Dual Phase product, the steel is slowly cooled to zinc pot temperature and is then zinc coated. A large fraction of fresh martensite is formed in the cooling section after the zinc pot. It is this fresh martensite that is detrimental to hole expansion and bendability. The unique thermal processing achieved with a low-end cooling practice avoids most fresh martensite formation.



The additional gas jet cooling capacity added as part of the upgrades facilitates the production of Multi-Phase and Complex Phase steels.

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MULTI-PHASE AND COMPLEX PHASE STEELS

Size Availability

HOT-ROLLED

t(mm)	Max. Width
nom	HR780
<=2.5	Inquire
2.6 - 2.8	1086
2.9 - 3.1	1210
3.1 - 3.9	1200
4.0	1300
>= 4.1	Inquire

HOT-DIP GI

t(mm)	Max. Width
nom	980CP
0.90 - 1.0	Inquire
1.01 - 1.60	960
1.61 - 2.00	1040
2.01 - 2.10	1080
2.11 - 2.30	Inquire

HOT-DIP GI

t(mm)	Max. Width	
nom	780MP	780CP
0.76 - 0.96	Inquire	Inquire
0.97 - 1.16	1215	1080
1.17 - 1.37	1260	1120
1.38 - 1.96	1305	1160
1.97 - 2.05	1215	1080
2.06 - 2.29	1125	1000

Note: These are consolidated listings. We are capable of producing some cross sections not included in this table. Please inquire for availability.

About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, we are also the largest producer of iron ore pellets in North America. In 2020, we acquired two major steelmakers, AK Steel and ArcelorMittal USA, vertically integrating our legacy iron ore business with quality-focused steel production and emphasis on the automotive end market. Our fully integrated portfolio includes custom-made pellets and hot-briquetted iron (HBI); flat-rolled carbon steel, stainless, electrical, plate, tinplate and long steel products; as well as carbon and stainless steel tubing, hot and cold stamping and tooling. Headquartered in Cleveland, Ohio, we employ approximately 25,000 people across our mining, steel and downstream manufacturing operations in the United States and Canada.

CLIFFS

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