CLIFFS

MULTI-PHASE & ULTRA FORM® COMPLEX PHASE STEELS

Automotive Safety Components

Suspension System Components

Greater Weight Reduction

Improved Local Formability

Cleveland-Cliffs **MULTI-PHASE STEELS** and **ULTRA FORM® 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 (MP) and ULTRA FORM Complex Phase (CP) 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. The forming characteristics inherent to products with these microstructures can lead to greater light-weighting potential than Dual Phase grades at the same tensile strength level. ULTRA FORM steels in particular can provide an alternative to NEXMET® Advanced High Strength Steels (AHSS), which have third Generation microstructure. If the cold forming demands of a given application do not require a NEXMET AHSS product, an ULTRA FORM grade may meet the requirements.

MULTI-PHASE & ULTRA FORM COMPLEX PHASE STEELS

Grade Availability

Cleveland-Cliffs' produces various Multi-Phase (MP) and ULTRA FORM Complex Phase (CP) steels as bare cold roll (CR), Electrogalvanized (EG) and Hot-Dip Galvanized (GI). Our available products include grades with 780MPa and 980MPa tensile strength and are shown in the table to the right.

Product	Product Details	Grade
GI	Multi-Phase	CR780T-440Y-MP
GI	ULTRA FORM® Complex Phase	CR780T-600Y-CP
CR, EG, GI	Multi-Phase	CR980T-700Y-MP
GI	ULTRA FORM® Complex Phase	CR980T-800Y-CP
CR, EG	Multi-Phase	CR1180T-875Y-MP

Product Characteristics

When discussing Multi-Phase and ULTRA FORM 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) ULTRA FORM 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 (it has limitations in global and local formability).
- 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.

Typical applications for multi-phase and ULTRA FORM complex phase steels.

CP980 door beam

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

MULTI-PHASE & ULTRA FORM COMPLEX PHASE STEELS

Chemistry

Product	Grade	Max. C	Max. Mn	Max. Si	Max. Cr+Mo	Max. Ti+Nb	Max. P	Max. S	Max. B
GI	CR780T/440Y-MP	0.12	2.4	0.5	0.6	0.06	0.025	0.008	0.003
GI	CR780T/600Y-CP	0.18	2.7	1.0	0.7	0.15	0.025	0.008	0.003
CR	CR980T/700Y-MP	0.12	2.4	1.0	0.08	0.05	0.025	0.008	0.001
EG	CR980T/700Y-MP	0.12	2.4	1.0	0.08	0.05	0.025	0.008	0.001
GI	CR980T/700Y-MP	0.12	2.4	0.5	1.0	1.2	0.025	0.008	0.003
GI	CR980T/800Y-CP	0.12	2.4	0.5	1.0	1.2	0.025	0.008	0.003
CR	CR1180T/875Y-MP	0.16	2.0	0.55	0.1	0.06	0.025	0.008	0.0005
EG	CR1180T/875Y- MP	0.16	2.0	0.55	0.1	0.06	0.025	0.008	0.0005

Mechanical Properties

TARGET LIMITS AS COMPARED TO DP GRADES AT SAME TENSILE STRENGTH

Grade	Yield strength min., MPa	Tensile strength min., MPa	Min. total elongation A_{50}, %	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/700Y-MP	700	980	8%	≤ 2.5	≈ 30%
CR980T/800Y-CP	800	980	7%	≤ 2.0	≥ 40%
CR1180T/875Y-MP	875	1180	6%	≤ 3.5	≈ 30%

Bend test, CP980

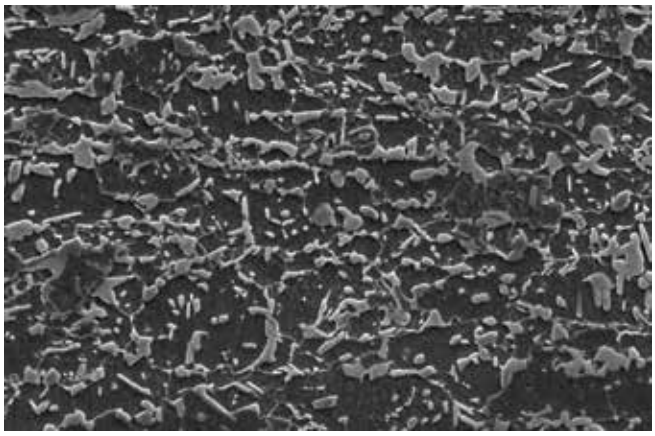
DP780 Hole expansion test

MP780 Hole expansion test

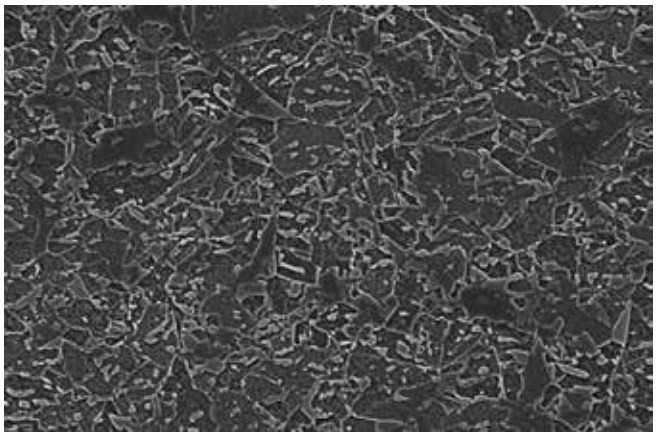
CP780 Hole expansion test

Metallography

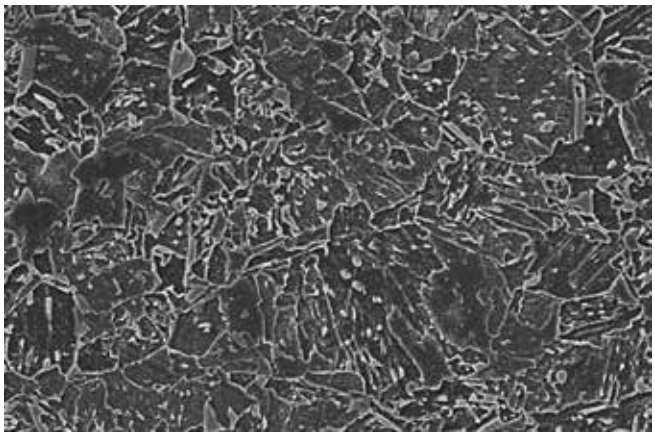
A comparative examination of 780MPa tensile strength products for the product types discussed in this brochure.



DP780: ferrite, bainite, martensite



MP780: ferrite, bainite, martensite (comparable to DP780 but with less martensite)

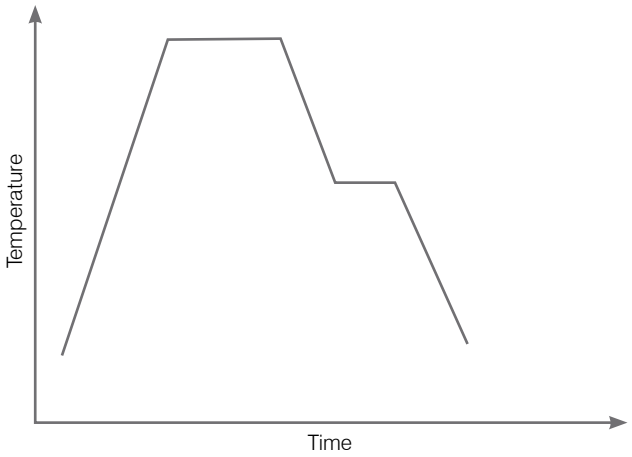


CP780: ferrite, bainite, martensite and tempered martensite

Mill Processing

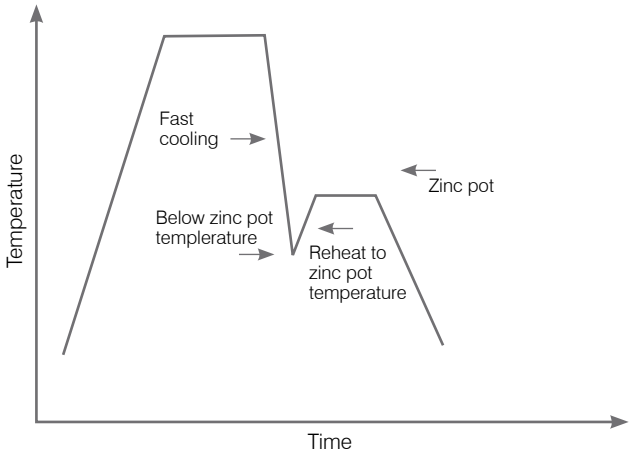
The uncoated and electrogalvanized versions of MP980 and MP1180 are produced on our unique water quench lines. These Multi-Phase products have been in production for several years. The mill processing necessary to achieve a Multi-Phase or an ULTRA FORM Complex Phase microstructure in a hot dip coating line is unique, requiring a process called low-end cooling. In general, a traditional or typical continuous anneal process cannot easily achieve the necessary steel temperatures that would result in the formation of either of these special microstructures. A unique anneal practice with specialized equipment is necessary.

TRADITIONAL HOT-DIP THERMAL PROFILE



Schematic of thermal profile used to produce Dual Phase steels.

MODIFIED HOT-DIP THERMAL PROFILE



Schematic of themal profile used to produce Multi-phase and ULTRA FORM Complex Phase steels.

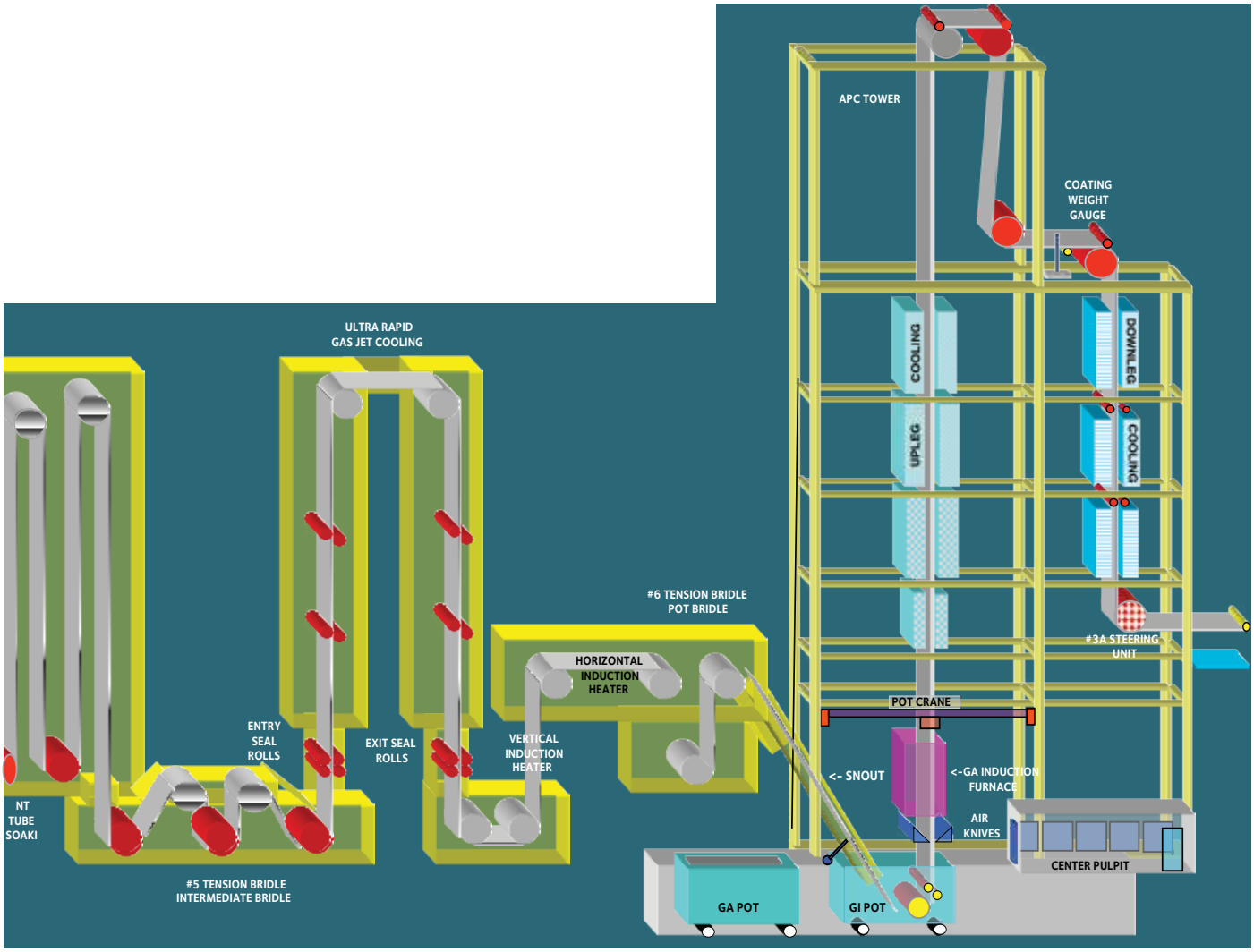
Operational Upgrades

The hot-dip line at our Dearborn Works facility was upgraded in 2017 to produce AHSS grades, including Multi-Phase and ULTRA FORM Complex Phase grades. In 2019, the hot-dip coating line at our Cleveland Works facility was upgraded to facilitate production of MP and ULTRA FORM 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 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.

MULTI-PHASE & ULTRA FORM COMPLEX PHASE STEELS

Size Availability

GI Only, 780 MPa Tensile Strength		
Thickness (mm)	Max. Width (mm)	
Nominal	MP780	ULTRA FORM® 780
0.76 - 0.83	Inquire	1195
0.84 - 0.99	Inquire	1195
0.97 - 1.16	1150	1448
1.17 - 1.37	1200	1448
1.38 - 1.96	1250	1345
1.97 - 2.05	1215	1270
2.06 - 2.29	1125	1125

GI Only, 980 MPa Tensile Strength		
Thickness (mm)	Max. Width (mm)	
Nominal	MP980	ULTRA FORM® 980
1.10 - 1.25	1524	Inquire
1.26 - 1.46	1524	1350
1.47 - 1.87	1524	1350
1.88 - 2.25	1524	1250
2.26 - 2.69	1320	Inquire

CR & EG Multi-Phase Grades		
Thickness, mm	Max. Width, mm	
Nominal	MP980	MP1180
0.70 - 0.80	1245	Inquire
0.81 - 0.94	1245	1320
0.95 - 1.16	1295	1320
1.17 - 1.46	1486	1375
1.47 - 1.66	1370	1375
1.67 - 1.74	1345	1375
1.75 - 2.08	1345	1375
2.08 - 2.32	1345	1375

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

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About Cleveland-Cliffs Inc.

Cleveland-Cliffs is a leading North America-based steel producer with focus on value-added sheet products, particularly for the automotive industry. 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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