



Plate

Armor: Steels for National Defense



Introduction

In 1825, the Brandywine Iron and Nail Factory (later to become Lukens Steel Company and now ArcelorMittal USA) rolled the plates for the Codus, America's first iron-hulled vessel. It was the start of a long and successful association between our company and the nation's shipbuilders. During the 19th Century, we furnished boiler plate for the great riverboats that served as the supply and transport line for the westward-moving frontier. With the arrival of the age of steel, we turned our attention to developments in heat treated armor plate for naval vessels and military ground vehicles. Early in the atomic era, we produced hull plate for the first nuclear-powered submarine, the Nautilus.

With significant facilities devoted to the production of plate steels and plate steel products, ArcelorMittal USA is well positioned to make a strong contribution to the national defense effort. ArcelorMittal USA is currently the largest supplier of armor plate to the U.S. armed forces. This brochure presents a brief overview of our capabilities.

Capabilities

ArcelorMittal USA ranks among the world's leading producers of plate steels, including carbon, alloy and clad plates and plate shapes. We can roll thicknesses from 0.12 in. (3 mm) to 28 in. (711 mm), widths to 196 in. (4978 mm) and lengths to 1500 in. (38.1 m), with weights up to 50 tons (45 Mt), depending upon size combinations.

Our melting facilities are among the most modern and efficient in North America, with the result that our finished plate products possess enhanced internal quality. Armor plate steel is melted in our electric furnace and further refined in a ladle furnace and by vacuum degassing to reduce impurities.

Heat treatment at ArcelorMittal USA is accomplished in both continuous heat treating lines and batch-type furnaces. Treatments include annealing, normalizing, stress relieving and quenching and tempering (Q&T). We can offer the heaviest Q&T plates made in North America. Lengths of 650 in. (16.5 m), and widths to 196 in. (4978 mm) are available. Q&T processing is critical to the performance of armor plate.



Specifications

ArcelorMittal USA is qualified to produce the following military specifications:

U.S. ARMY	U.S. NAVY	U. S. NAVY	FOREIGN
MIL-A-12560	MIL-S-24113	MIL-S-13281	IDF-603
MIL-A-46100	MIL-S-24238	MIL-S-13326	IDF-605
MIL-STD-46177	MIL-S-24371 *	MIL-S-16113	CMS-18
	MIL-S-18729	MIL-S-16216 *	CMS-19
	MIL-S-24645 *	MIL-S-22698	Def-Stan 95-13
			Def-Stan-95-24

* these specifications have been combined in a new NAVSEA Technical Publication T9074-BD-GIB-010/0300

ArcelorMittal USA also produces the full range of American Bureau of Shipping (ABS) specifications and armor plate meeting popular civilian standards. Contact ArcelorMittal USA Plate offices with your particular requirements. See details of some of these specifications at the end of this brochure.

Popular Grades

MIL-A-12560 – A very popular Q&T U.S. Army grade for “rolled-homogeneous armor”. This grade is produced to 12 in. (305 mm) thick with minimum hardness requirements up to 341 HB minimum depending on thickness. Charpy-VNotch (CVN) impact requirements at -40°F (-40°C) range from 16 to 65 ft.-lbs. (22-88J) depending on hardness. Ballistic test plates are required for thicknesses up to 6.0 in. (152 mm).

MIL-A-46100 – A popular Q&T U.S. Army high hardness armor grade. This grade is produced to 2 in. (51 mm) thick with hardness requirements of 477-534 HB and CVN impact minimum requirements of 10 ft.-lbs. (14 J) transverse and 12 ft.-lbs. (16 J) longitudinal. Ballistic testing requirements must also be met.

MIL-S-16216* – A U.S. Navy high strength steel, also known as HY-80 and HY-100. These Q&T Ni-Cr-Mo alloy grades must meet 80 ksi (552 MPa) and 100 ksi (690 MPa) yield strength levels with minimum transverse dynamic tear test requirements at -40°F (-40°C) of 450 ft.-lbs. (610 J) and 500 ft.-lbs. (678 J) respectively. HY-80 may be produced to 8 in. (203 mm) and HY-100 to 6 in. (152 mm) thickness.

MIL-S-24645* – A popular U.S. Navy high strength steel also referred to as HSLA-80 and HSLA-100, which was designed to be more weldable than MIL-S-16216. These Q&T low carbon, Cu-Ni-Cr-Mo alloy grades must meet 80 ksi (552 MPa) and 100 ksi (690 MPa) yield strength levels with minimum transverse CVN impact requirements at -120°F (-84°C) of 60 ft.-lbs. (81 J). HSLA-80 is produced to 1-1/4 in. (32 mm) and HSLA-100 to 6 in. (152 mm) thickness.

ASTM A945 Grade 65 – The U.S. Navy has established this new grade, also called HSLA-65, with 65 ksi (448 MPa) min. yield strength and CVN impact requirements of 70 ft.-lbs. (95 J) transverse at -40°F (-40°C). ArcelorMittal USA's Burns Harbor plate mill can produce this by Thermo-Mechanical-Controlled-Processing (TMCP) to make long plate lengths. TMCP produced HSLA-65 is available to 1.25 in. (32 mm) thick. Plates to 2.5 in. (64 mm) will be produced by Q&T.

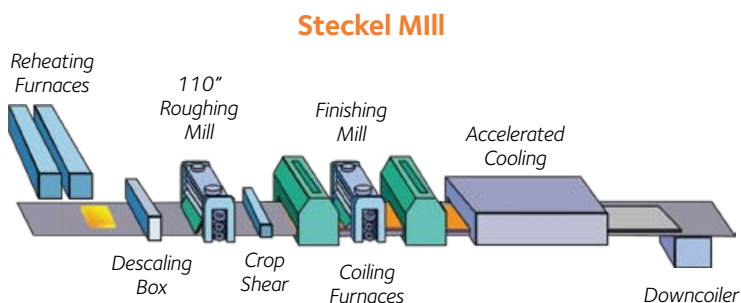
Facilities

A heat of steel from our electric furnace facilities in Coatesville, PA can produce individual plates weighing up to 50 tons (45 Mt), the largest and heaviest available in North America. Our refining capability makes it possible to achieve low impurity levels. We offer a low sulfur (as low as 0.001% maximum when specified) with calcium treatment for inclusion shape control processing capability, which produces a family of plate steels, called *Fineline*®, that have enhanced mechanical properties required in critical applications, such as armor plate. Our facilities also make it possible to meet very accurate alloy levels. Because the electric furnace produces heat lots of only 165 tons (149 Mt), ArcelorMittal USA is able to melt unique chemistries designed for specific applications.

* these specifications have been combined in a new NAVSEA Technical Publication T9074-BD-GIB-010/0300

Our melted product may be converted to slabs through a continuous caster. Molten steel is poured directly into the unit, where it gradually cools while being passed through a series of straightening rolls, emerging in slab form, ready for transport to the rolling mills. Larger plates are produced from our bottom-poured ingots. Bottom-pouring results in better internal and surface quality than top-pouring.

Conshohocken's SMART® Facility (Steckel Mill Advanced Rolling Technology)



The Conshohocken, PA rolling mill has a Steckel Mill to allow rolling thinner plate to 1/2 ASTM A6 thickness tolerances. A continuous heat treat line at this mill also produces all quenched and tempered (Q&T) product to 1/2 ASTM A6 flatness tolerances for 0.125 in. (3 mm) to 1 in. (25 mm) thick, to 100 in. (2540 mm) wide and to 600 in. (15.2 m) long. Tighter tolerances are available upon request.

The rolling mills in Coatesville, PA produce heavy, wide plate. The Q&T facilities in Coatesville include a continuous heat treating line which handles plates as long as 540 in. (13.7 m) (refer longer) and weighing up to 40 tons (36 Mt). Our batch-type furnaces in Coatesville are used to heat treat particularly thick and heavy plate. These units can accommodate plates up to 650 in. (16.5 m) long and up to 50 tons (45 Mt).

ArcelorMittal USA has facilities to flame cut all plate steels into various shapes in thicknesses up to 30 in. (762 mm). This sketch cutting capability includes furnaces for heat treating and presses for flattening, thereby permitting ArcelorMittal USA to deliver a component ready for fabrication. ArcelorMittal USA also has the capabilities to perform ultrasonic and magnetic particle testing, descaling, machining and painting.

The rolling mill at Burns Harbor, IN has controlled rolling and accelerated cooling capabilities to produce TMCP product. This allows for longer plates to be produced of certain grades, such as HSLA-65. The rolling accuracy of this mill allows “precise weight” plate to be produced.

ArcelorMittal USA Military Alloy Steels

ArcelorMittal USA PROPRIETARY GRADES SPECIFICATION HSLA 80▲ MIL-S-24645A†† HSLA 100▲ MIL-S-24645A†† HY 80▲ MIL-S-16216-K HY 100▲ MIL-S-16216-K MIL-STD-46177▲▲ MIL-A-12560▲▲ MIL-A-46100▲▲

Type of Steel	Alloy	Alloy	Alloy	Alloy	Alloy	Alloy	Alloy
Requirements for Delivery	A20	A20	A20	A20	A20	A20	A20
Tensile Strength (ksi)	Report info. only	Report info. only	Report info. only	Report info. only	362/400 HB	HB varies per thickness	477/534 HB
Yield Strength (Min. ksi) (Yield Point if designated YP)	80/110 to ¼" excl.; 80/100 ¼" and over	100/130 to ¾" incl.; 100/125 over ¾"	80/100 to ¾" incl.; 80/99.5 over ¾"	100/120	–	–	–
Spec. Thickness (Max. in.)	Cl. 1-½ Cl. 3-1¼	Cl. 3-4	8	6	.249	8	2
ArcelorMittal USA Thickness (Max. in.)	Cl. 1-^{5/16} Cl. 3-1¼	Cl. 3-4	8	6	.249	8	2
Chemical Composition (%)	Unless a range is specified, individual values are maximums						
Carbon	.06	.06	.10/.18 to 1¼" incl.; .13/.18 over 1¼"	.10/.18 to 1¼" incl.; .14/.20 over 1¼"	.18/.28	.18/.28 to 2.5" .20/.30 over 2.5"	.22/.32
Manganese	.40/.70	.75/1.15	.10/.40	.10/.40	1.10/1.60	1.10/1.60 to 2.5" .15/.45 over 2.5"	.70/1.00
Phosphorus	.020	.020	.015	.015	.025	.015	.010
Sulfur	.004	.004	.004	.004	.015	.015	.010
Silicon	.40	.40	.15/.38. May be .08 Min. when vacuum carbon deoxidized	.15/.38. May be .08 Min. when vacuum carbon deoxidized	.20/.40	.20/.40	.35/.50
Chromium	.60/.90	.45/.75	1.00/1.80 to 1¼" incl.; 1.40/1.80 over 1¼-3" incl.; 1.50/1.90 over 3"	1.00/1.80 to 1¼" incl.; 1.40/1.80 over 1¼-3" incl.; 1.50/1.90 over 3"	–	1.20/1.60 over 2.5"	.40/.70
Nickel	.70/1.00	1.50/2.00 to 1" incl.; 2.50/3.00 over 1"-1½/8" 3.35/3.65 over 1½/8"	2.00/3.25 to 1¼" incl.; 2.50/3.50 over 1¼-3" incl.; 3.00/3.50 over 3"	2.25/3.50 to 1¼" incl.; 2.75/3.50 over 1¼-3" incl.; 3.00/3.50 over 3"	–	2.00/3.40 over 2.5"	.80/1.30
Molybdenum	.15/.25	.30/.55 to 1" incl.; .45/.60 over 1"-1½/8" .55/.65 over 1½/8"	.20/.60 to 1¼"; .35/.60 over 1¼-3" incl.; .50/.65 over 3"	.20/.60 to 1¼"; .35/.60 over 1¼-3" incl.; .50/.65 over 3"	.40/.55	.40/.55 to 2.5" .21/.36 over 2.5"	.50/.65
Copper	1.00/1.30 to 1½/8" incl.	1.00/1.30 to 1½/8" incl.; 1.15/1.75 over 1½/8"	.25	.25	–	–	–
Other Elements	.02/.06 Cb CT Other residuals per specification	.02/.06 Cb CT Other residuals per specification	.02 Ti/.03 V Var. others	.02 Ti/.03 V Var. others	–	–	–
Heat Treatment Required	Cl. 1 as rolled&PHT Cl. 3 Q&PHT	Cl. 3 Q&PHT	Q&T	Q&T	Q&T	Q&T	Q&T

▲ Currently, the HY and HSLA Navy Alloy grades are specified by the NAVSEA Technical Publication T9074-BD-GIB-010/0300 replacing the MIL-S Specifications. The information given here is from this new document.

▲▲ ArcelorMittal USA declared chemistries

†† It is important to note that this grade of steel may be susceptible to cracking in the heat-affected zone of welds during post-weld heat treatment (stress relief) or elevated temperature service. Also, post-weld heat treatment or elevated temperature service may degrade heat affected zone toughness. Therefore, ArcelorMittal USA recommends that careful consideration be given to these phenomena by competent welding engineers before application.

Reference

1. "Recent Experience with New Plate Steels for Defense Applications", A. D. Wilson, [NWC Advanced Materials Conference](#), April, 2006, Baltimore.

Further Information

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All information in this brochure is for the purpose of information only. ArcelorMittal USA reserves the right to change its product range at any time without prior notice.

Facility Locations:

Burns Harbor & Gary, IN
Coatesville & Conshohocken, PA

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