



## Plate

### A514 and "T-1"<sup>®</sup> : High Strength Steels

#### General Description

The A514 and "T-1"<sup>®</sup> family of ArcelorMittal USA plate steels is a group of quenched and tempered constructional alloy steels with an attractive combination of advantages and characteristics. The most important are high yield strength (90 or 100 ksi minimum yield strength), weldability and good toughness at low atmospheric temperatures. Designed for a wide range of structural uses, as well as for machinery and equipment, these constructional alloy steels offer customers help with selecting the optimum in strength, toughness, corrosion resistance, impact-abrasion resistance, and long-term economy. As a group, the high strength steels have a lower tolerance than lower-strength structural steels for zones of high stress concentration at design details and weld imperfections. Therefore, to obtain maximum advantage with A514 and "T-1" Steels, it is necessary that the higher yield strength be accompanied by refinements in application design, workmanship and inspection.

#### Available Grades

ArcelorMittal USA Plate facilities produce seven grades of steel in the ASTM A514 (structural applications) and ASTM A517 (pressure vessel applications) families. These are grades A, B, E, F, H, P and Q. They are chemically identical between A514 and A517 and also similar to the four "T-1" grades as follows:

A514/A517	B	E	F	H	P	Q	S
"T-1"	Type A	-	"T-1"	Type B	-	Type C	-
Max. Thickness, in.	1 ¼	6	2 ½	2	4	6	2 ½

"T-1" steels were originally developed by the U.S. Steel Corporation. The ArcelorMittal USA Plate facilities had been a licensee of "T-1" steels from USS since 1959. In 2003, the International Steel Group Inc. (now ArcelorMittal USA) purchased the plate assets of USS, which included a special license to the rights to the 'T-1' trademark.

Refer to the attached tables for particular chemical and mechanical properties.

#### Typical Applications

##### *Structural and Pressure Vessel Quality Plate*

For general use where the higher strength of these grades permits reduction in gross design weight because smaller cross sections can be specified, provided suitable design and fabrication practices are followed. Also used in fabricated bridges (A709 Grades 100/100W), tower and building members; components for earthmoving or transport equipment; booms, dipper sticks, and bucket parts for power shovels or cranes; penstocks, turbine scroll cases and unfired pressure vessels. The A514 and "T-1" Steels (with copper added where not specified) have been used for unpainted structures boldly exposed to the atmosphere. A514 and "T-1" Steels are not generally recommended for service at temperatures lower than -50°F (-46°C) since their toughness may not be sufficient to prevent brittle fracture at lower temperatures. A514 and "T-1" Steels are not recommended for service at temperatures higher than 800°F (425°C) because fracture could result from low stress-rupture ductility at higher temperatures.

##### *Abrasion-Resistant "T-1" Plate*

Heat-treated to 321, 340 or 360 minimum Brinell hardness (BHN) for impact-abrasion service, such as in truck and hopper body liners, chutes, wear plates and industrial fan blade liners. These steels are not intended for structural applications and should not be used for structural or main load-bearing members. Brittle fracture may occur at high stress levels encountered in such applications. Similarly, these steels should not be used for highly restrained weldments since high residual stresses develop during cooling after welding may also result in cracking. Therefore, abrasion-resistant "T-1" Steels should not be incorporated into a structure that is dependent upon the abrasion-resistant steels, except for its abrasion-resistant qualities. It should be noted that the abrasion-resistant "T-1" Steels do not comply with mechanical property requirements of ASTM A514 or A517. ArcelorMittal USA Plate facilities HARDWEAR<sup>®</sup> steels are considered to have better forming and welding performance than the Abrasion Resistant T-1 grades.

#### Fabrication Guidelines

Refer to section on [Fabrication Guidelines](#) for general information on A514 and "T-1" steels. For specific welding of "T-1" steels, refer to [How to Weld "T-1"](#).

SPECIFICATION	A514†† Grade B	A514† Grade E	A514†† Grade F	A514†† Grade H	A514† Grade P	A514†† Grade Q	A514 Grade S
<b>Type of Steel</b>	Alloy	Alloy	Alloy	Alloy	Alloy	Alloy	Alloy
<b>Requirements for Delivery</b>	A6	A6	A6	A6	A6	A6	A6
<b>Tensile Strength (ksi)</b>	110/130	110/130 to 2½" incl.; 100/130 over 2½-6" incl.	110/130	110/130	110/130 to 2½" incl.; 100/130 over 2½-6" incl.	110/130 to 2½" incl.; 100/130 over 2½-6" incl.	110/130 to 2-1/2" incl.; 100/130 over 2-1/2-6" incl.
<b>Yield Strength (Min. ksi) (Yield Point if designated YP)</b>	100	100 to 2½" incl.; 90 over 2½-6" incl.	100	100	100 to 2½" incl.; 90 over 2½-6" incl.	100 to 2½" incl.; 90 over 2½-6" incl.	100 to 2-1/2" incl.; 90 over 2-1/2-6" incl.
<b>Spec. Thickness (Max. in.)</b>	1¼	6	2½	2	6	6	2-1/2"
<b>ArcelorMittal USA Thickness (Max. in.)</b>	1¼	6	2½	2	4	8	2-1/2"
<b>Chemical Composition (%)</b>	Unless a range is specified, individual values are maximums						
<b>Carbon</b>	.12/.21	.12/.20	.10/.20	.12/.21	.12/.21	.14/.21	.11/.21
<b>Manganese</b>	.70/1.00	.40/.70	.60/1.00	.95/1.30	.45/.70	.95/1.30	1.10/1.50
<b>Phosphorus</b>	.035	.035	.035	.035	.035	.035	.035
<b>Sulfur</b>	.035	.035	.035	.035	.035	.035	.02
<b>Silicon</b>	.20/.35	.20/.40	.15/.35	.20/.35	.20/.35	.15/.35	.15/.45
<b>Chromium</b>	.40/.65	1.40/2.00	.40/.65	.40/.65	.85/1.20	1.00/1.50	-
<b>Nickel</b>	-	-	.70/1.00	.30/.70	1.20/1.50	1.20/1.50	-
<b>Molybdenum</b>	.15/.25	.40/.60	.40/.60	.20/.30	.45/.60	.40/.60	.10/.60
<b>Copper</b>	-	-	.15/.50	-	-	-	-
<b>Other Elements</b>	.03/.08 V .01/.03 Ti .0005/.005 B	.01/.10 Ti .001/.005 B	.03/.08 V .0005/.006 B	.03/.08 V .0005/.005 B	.001/.005 B	.03/.08 V	.06 V, .06 Ti, .001/.005 B, .06 Cb
<b>Heat Treatment Required</b>	Q&T	Q&T	Q&T	Q&T	Q&T	Q&T	Q&T
<b>Remarks</b>	235-293 HBW▲	235-293 HBW▲	235-293 HBW▲	235-293 HBW▲	235-293 HBW▲	235-293 HBW▲	235-293 HBW▲

- † Post-weld heat treatment may degrade heat-affected zone strength and toughness. Pretesting of specific welding and post-weld heat treating procedures is recommended to assure optimization of final property levels.
- †† 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). Therefore, ArcelorMittal USA recommends that careful consideration be given to this phenomenon by competent welding engineers before stress relieving is applied to weldments of this grade. Also, it is not recommended for service at temperatures lower than -50°F or higher than 800°F.
- ▲ Brinell hardness may be used in lieu of tensile test for plate ≤.375 inch thick.

SPECIFICATION	A517†† Grade B	A517† Grade E	A517†† Grade F	A517†† Grade H	A517† Grade P	A517†† Grade Q
<b>Type of Steel</b>	Alloy	Alloy	Alloy	Alloy	Alloy	Alloy
<b>Requirements for Delivery</b>	A20	A20	A20	A20	A20	A20
<b>Tensile Strength (ksi)</b>	115/135	115/135 to 2½" incl.; 105/135 over 2½-6" incl.	115/135	115/135	115/135 to 2½" incl.; 105/135 over 2½-3.33" incl.	115/135 to 2½" incl.; 105/135 over 2½-6" incl.
<b>Yield Strength (Min. ksi) (Yield Point if designated YP)</b>	100	100 to 2½" incl.; 90 over 2½-6" incl.	100	100	100 to 2½" incl.; 90 over 2½-3.33" incl.	100 to 2½" incl.; 90 over 2½-6" incl.
<b>Spec. Thickness (Max. in.)</b>	1¼	6	2½	2	4	6
<b>ArcelorMittal USA Thickness (Max. in.)</b>	1¼	6	2½	2	3.33	8
<b>Chemical Composition (%)</b>						
<b>Carbon</b>	.15/.21	.12/.20	.10/.20	.12/.21	.12/.21	.14/.21
<b>Manganese</b>	.70/1.00	.40/.70	.60/1.00	.95/1.30	.45/.70	.95/1.30
<b>Phosphorus</b>	.035	.035	.035	.035	.035	.035
<b>Sulfur</b>	.035	.035	.035	.035	.035	.035
<b>Silicon</b>	.15/.35	.10/.40	.15/.35	.15/.35	.20/.35	.15/.35
<b>Chromium</b>	.40/.65	1.40/2.00	.40/.65	.40/.65	.85/1.20	1.00/1.50
<b>Nickel</b>	■	■	.70/1.00	.30/.70	1.20/1.50	1.20/1.50
<b>Molybdenum</b>	.15/.25	.40/.60	.40/.60	.20/.30	.45/.60	.40/.60
<b>Copper</b>	■	■	.15/.50	■	■	■
<b>Other Elements</b>	.03/.08 V .0005/.005 B .01/.03 Ti	.01/.10 Ti .001/.005 B	.0005/.006 B .03/.08 V	.0005 Min. B .03/.08 V	.001/.005 B	.03/.08 V
<b>Heat Treatment Required</b>	Q&T TCVN	Q&T TCVN	Q&T TCVN	Q&T TCVN	Q&T TCVN	Q&T TCVN

- † Post-weld heat treatment may degrade heat-affected zone strength and toughness. Pretesting of specific welding and post-weld heat treating procedures is recommended to assure optimization of final property levels.
- † † 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). Therefore, ArcelorMittal USA recommends that careful consideration be given to this phenomenon by competent welding engineers before stress relieving is applied to weldments of this grade. Also, it is not recommended for service at temperatures lower than -50°F or higher than 800°F.
- Restricted to ASTM A20 limits for unspecified elements.

SPECIFICATION	T-1®††	T-1® Type A††	T-1® Type B††	T-1® Type C††
<b>Type of Steel</b>	Alloy	Alloy	Alloy	Alloy
<b>Requirements for Delivery</b>	A6, A20*	A6, A20*	A6, A20*	A6, A20*
<b>Tensile Strength (ksi)</b>	110/130	110/130	110/130	110/130 to 2½" incl.; 100/130 over 2½"
<b>Yield Strength (Min. ksi) (Yield Point if designated YP)</b>	100	100	100	100 to 2½" incl.; 90 over 2½"
<b>Spec. Thickness (Max. in.)</b>	2½	1¾	2	6
<b>ArcelorMittal USA Thickness (Max. in.)</b>	2½	1¾	2	6
<b>Chemical Composition (%)</b>				
<b>Carbon</b>	.10/.20	.12/.21	.12/.21	.14/.21
<b>Manganese</b>	.60/1.00	.70/1.00	.95/1.30	.95/1.30
<b>Phosphorus</b>	.035	.035	.035	.035
<b>Sulfur</b>	.040	.040	.040	.040
<b>Silicon</b>	.15/.35	.20/.35	.20/.35	.15/.35
<b>Chromium</b>	.40/.65 .80 if approved by customer	.40/.65	.40/.65	1.00/1.50
<b>Nickel</b>	.70/1.00	-	.30/.70	1.20/1.50
<b>Molybdenum</b>	.40/.60	.15/.25	.20/.30	.40/.60
<b>Copper</b>	.15/.50 if specified	.20/.40 if specified	.20/.40	■
<b>Other Elements</b>	.03/.08 V .0005/.006 B	.03/.08 V	.03/.08 V .01/.03 Ti	.03/.08 V .0005/.005 B
<b>Heat Treatment Required</b>	Q&T	Q&T	Q&T	Q&T
<b>Remarks</b>	-	-	-	-

\* A20: Raise tensile strength range by 5 ksi.

†† 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). Therefore, ArcelorMittal USA recommends that careful consideration be given to this phenomenon by competent welding engineers before stress relieving is applied to weldments of this grade. Also, it is not recommended for service at temperatures lower than -50°F or higher than 800°F.

■ Restricted to ASTM A20 limits for unspecified elements.

SPECIFICATION	T-1® Grade 321HB††	T-1® Grade 340 HB††	T-1® Grade 360 HB††	T-1® Type A Grade 321 HB††	T-1® Type A Grade 340 HB††	T-1® Type A Grade 360 HB††
<b>Type of Steel</b>	Alloy	Alloy	Alloy	Alloy	Alloy	Alloy
<b>ArcelorMittal USA Thickness (Max. in.)</b>	2½	2	1½	1¼	1	¾
<b>Chemical Composition (%)</b>	Unless a range is specified, individual values are maximums					
<b>Carbon</b>	.10/.20	.10/.20	.10/.20	.12/.21	.12/.21	.12/.21
<b>Manganese</b>	.60/1.00	.60/1.00	.60/1.00	.70/1.00	.70/1.00	.70/1.00
<b>Phosphorus</b>	.035	.035	.035	.035	.035	.035
<b>Sulfur</b>	.040	.040	.040	.040	.040	.040
<b>Silicon</b>	.15/.35	.15/.35	.15/.35	.20/.35	.20/.35	.20/.35
<b>Chromium</b>	.40/.65	.40/.65	.40/.65	.40/.65	.40/.65	.40/.65
<b>Molybdenum</b>	.40/.60	.40/.60	.40/.60	.15/.25	.15/.25	.15/.25
<b>Vanadium</b>	.03/.08	.03/.08	.03/.08	.03/.08	.03/.08	.03/.08
<b>Boron</b>	.0005/.006	.0005/.006	.0005/.006	.0005/.005	.0005/.005	.0005/.005
<b>Titanium</b>	-	-	-	.01/.03	.01/.03	.01/.03
<b>Copper</b>	.15/.50	.15/.50	.15/.50	-	-	-
<b>Nickel</b>	.70/1.00	.70/1.00	.70/1.00	-	-	-
<b>Heat Treatment Required</b>	Q&T	Q&T	Q&T	Q&T	Q&T	Q&T
<b>Surface Brinell Hardness (HB)</b>	321 Min.	340 Min.	360 Min.	321 Min.	340 Min.	360 Min.
<b>Melting Practice</b>	F/G/P	F/G/P	F/G/P	F/G/P	F/G/P	F/G/P
<b>Remarks</b>	-	-	-	-	-	-

†† 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). Therefore, ArcelorMittal USA recommends that careful consideration be given to this phenomenon by competent welding engineers before stress relieving is applied to weldments of this grade. Also, it is not recommended for service at temperatures lower than -50°F or higher than 800°F.

SPECIFICATION	T-1® Type B Grade 321 HB††	T-1® Type B Grade 340 HB††	T-1® Type B Grade 360 HB††	T-1® Type C Grade 321 HB††	T-1® Type C Grade 340 HB††	T-1® Type C Grade 360 HB††
<b>Type of Steel</b>	Alloy	Alloy	Alloy	Alloy	Alloy	Alloy
<b>ArcelorMittal USA Thickness (Max. in.)</b>	2	1½	1	6	2	1½
<b>Chemical Composition (%)</b>	Unless a range is specified, individual values are maximums					
<b>Carbon</b>	.12/.21	.12/.21	.12/.21	.14/.21	.14/.21	.14/.21
<b>Manganese</b>	.95/1.30	.95/1.30	.95/1.30	.95/1.30	.95/1.30	.95/1.30
<b>Phosphorus</b>	.035	.035	.035	.035	.035	.035
<b>Sulfur</b>	.040	.040	.040	.040	.040	.040
<b>Silicon</b>	.20/.35	.20/.35	.20/.35	.15/.35	.15/.35	.15/.35
<b>Chromium</b>	.40/.65	.40/.65	.40/.65	1.00/1.50	1.00/1.50	1.00/1.50
<b>Molybdenum</b>	.20/.30	.20/.30	.20/.30	.40/.60	.40/.60	.40/.60
<b>Vanadium</b>	.03/.08	.03/.08	.03/.08	.03/.08	.03/.08	.03/.08
<b>Boron</b>	.0005/.005	.0005/.005	.0005/.005	-	-	-
<b>Titanium</b>	-	-	-	-	-	-
<b>Copper</b>	-	-	-	-	-	-
<b>Nickel</b>	.30/.70	.30/.70	.30/.70	1.20/1.50	1.20/1.50	1.20/1.50
<b>Heat Treatment Required</b>	Q&T	Q&T	Q&T	Q&T	Q&T	Q&T
<b>Surface Brinell Hardness (HB)</b>	321 Min.	340 Min.	360 Min.	321 Min.	340 Min.	360 Min.
<b>Melting Practice</b>	F/G/P	F/G/P	F/G/P	F/G/P	F/G/P	F/G/P
<b>Remarks</b>	-	-	-	-	-	-

†† 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). Therefore, ArcelorMittal USA recommends that careful consideration be given to this phenomenon by competent welding engineers before stress relieving is applied to weldments of this grade. Also, it is not recommended for service at temperatures lower than -50°F or higher than 800°F.

### 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.

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