ALGOMA STEEL INC.

YOUR PARTNER IN STEEL. SINCE 1901

Heat-Treated Steel Plate

The industry standard for high strength and abrasion resistance

Introduction

Algoma Steel Inc. (Algoma) is a fully integrated steel producer based in Sault Ste. Marie, Ontario. As a founding industry leader, we are proud of our legacy of producing top quality steel products for generations.

Our legacy is due to the quality of our people; reliable people who take pride in our community and our personal approach. We will meet you face-to-face. We'll talk to you on the phone. We'll be there when you need us. Most importantly, we're responsive. We know every customer is different. Through our full technical support team of Technical Service Representatives, Development Engineers, and Product Metallurgists, we aim to help our customers succeed in the markets they serve by delivering products that meet or exceed their quality, performance and delivery expectations.

With a manufacturing capacity of 4 million tons, Algoma manufactures hot and cold rolled sheet and plate products that meet international performance standards including ABS, Lloyds, CPR, PED, ISO 9001, ISO 17025, ISO 14001 and IATF 16949.

Algoma's size and diverse capabilities enable us to deliver responsive, customer-driven product solutions straight from the ladle to direct applications in the automotive, construction, energy, manufacturing, and transportation sectors. Situated at the hub of the Great Lakes, our strategic geographic location offers customers a logistical advantage with fast, direct shipping via rail, road and water throughout North America.

General Information

Algoma is one of the world's leading suppliers of heat-treated plate for high strength, abrasion resistant, ballistic and other specialty plate applications. Our end-to-end manufacturing process from steelmaking through to heat treatment enables complete control over product quality.

Algoma Steel's heat-treated plate is rapidly quenched by water sprayed under high pressure over the full top and bottom surface of the plate simultaneously at over 40,000 gallons per minute. This unique quench system is part of a process that enables Algoma to deliver heat-treated plate with user-friendly characteristics and longer life in abrasive applications. Rapid cooling ensures through-thickness hardness, and the virtually scale-free surface allows for easy flame cutting and welding without surface preparation.

Best Results

How to get the best results with Algoma's heat-treated plate

Welding

Algoma's heat-treat facility produces a low-alloy plate that is easy to weld using simple procedures and common, readily available consumables.

The carbon content and carbon equivalents of Algoma heat-treated plates are similar to those of many medium and high-strength alloy carbon steels. A high resistance to hydrogen-induced cold-cracking is inherent when proper welding procedures are employed as outlined in the next pages.

Consistently sound welds depend on good joint preparation, the temperature of the material, joint restraint and the use of the appropriate low-hydrogen consumables. Please consult your welding consumable supplier for the appropriate electrodes. High heat input processes – such as electrogas and electroslag should not be used, as they can adversely affect plate properties in, and adjacent to, the heat-affected zone.

Where a weld will be exposed to abrasives, most of the joint can be filled with lower-strength material, with a capping layer of abrasion-resistant weld material applied to complete the joint.

All heat-treated steels are sensitive to heat: in welding, stress relief, and elevated-temperature service. Holding the steel at or near stress-relieving temperatures for any length of time will result in lower mechanical properties. The length of time at temperature will determine the potential effects.

Gas Cutting

All grades of Algoma heat-treated plate are easy to cut using the proper shop and field procedures.

Algoma recommends the smallest possible torch tip combined with the fastest possible cutting speed to flame cut heat-treated plate. A small tip will minimize the heat effect and ensure minimal degradation of the steel's inherent properties.

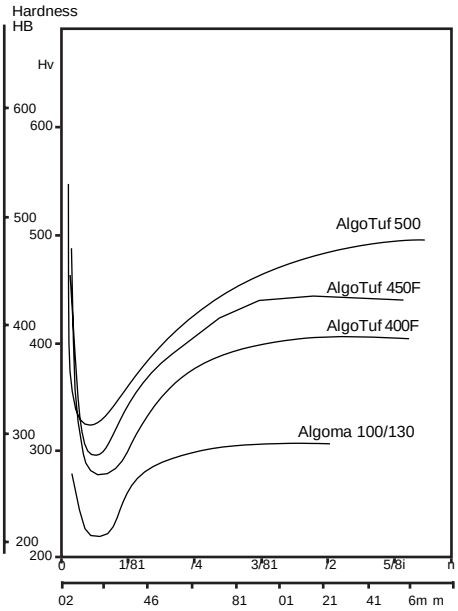
For flame-cut heat-treated plate that is going to be subjected to dynamic loading, forming, or restraint during welding, it is recommended that the plate edges be ground or machined to remove the hardened layer that results from the cutting operation.

The attached figure on the right shows the softening effect of oxy-acetylene cutting along the flame-cut edge.

Plasma-arc cutting is ideal for Algoma heat-treated plate: the cut will be smoother than with the oxy-fuel process and the depth of the heat-affected zone will be smaller.

To avoid cracking, Algoma heat-treated plate should be at least room temperature for flame cutting.

For AlgoTuf 400F plates 1.5" (38mm) and thicker, AlgoTuf 450F plates 0.63" (16mm) and thicker, and all thicknesses of AlgoTuf 500, a preheat temperature of 210°F (100°C) is recommended.



Distance from edge
Measured at midthickness, 3/8" (9.5mm) min thickness

The carbon equivalent on the data sheets for each grade is calculated using the Dearden-O'Neill formula:

$$C.E. = \%C + \frac{\%Mn}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Cu + \%Ni}{15}$$

ALGOMA STEEL INC.

Shearing and Punching

Both Algoma 100 and 130 grades, up to 0.5" (12.7mm), can be either sheared or punched using equipment of sufficient capacity. The punch diameter should be at least 1.25 times the plate thickness.

Tools must be kept in good working order and operator safety measures must be followed.

Algoma does not recommend that the AlgoTuf grades be either sheared or punched because of their high strength and hardness levels. Excessive tool wear, broken punches and/or damage to the shear or punch equipment could result.

Machining

Algoma heat-treated plate is easy to machine when using the proper cutting tools, speeds and feed rates. Cutting speeds greater than Algoma's recommendations can cause rapid tool deterioration. Liberal amounts of a good coolant are essential.

Due to its extreme hardness, AlgoTuf 500 is rarely machined.

Algoma recommends the following milling speeds, feed rates, etc., for its heat-treated plate grades, depending on the type cutting tool used.

Grade/Tool Type	Speed (fpm)	Depth in Cut (in.)	Feed/Tooth (in.)
Algoma 100/130 HSS (Cobalt) Carbide	50 250 to 450	0.250 0.020 to 0.200**	0.005 0.004 to 0.014
AlgoTuf 400F HSS (Cobalt) Carbide	30 250 to 450	0.250 0.020 to 0.200**	0.004 0.004 to 0.014
AlgoTuf 450F HSS (Cobalt) Carbide	15 250 to 450	0.250 0.020 to 0.200**	0.004 0.004 to 0.012
AlgoTuf 500F Carbide	130 to 150	0.020 to 0.125	0.004 to 0.010

** Feed and speed is dependent on cutter/insert selection and machine condition.

Drilling

Algoma heat-treated plate can be drilled easily, using the recommended drill speeds and the feed rates in the attached table. Higher cutting speeds may cause rapid deterioration of drill bits.

HSS (Cobalt) Drills									Solid carbide & carbide tipped drills grades GC1020 & P20		Drills with 2 indexable carbide inserts grade GC1020	
Drill Diameter (inches)	**ALGOMA 100** surface speed (40 ft./min.)		**ALGOMA 130** surface speed (30 ft./min.)		**AlgoTuf 400F** surface speed (25 ft./min.)		**AlgoTuf 450F** surface speed (15 ft./min.)		**AlgoTuf 500** surface speed (90* ft./min.)		**AlgoTuf 500** surface speed (120* ft./min.)	
	feed (in./rev.)	rpm	feed (in./rev.)	rpm	feed (in./rev.)	rpm	feed (in./rev.)	rpm	feed (in./rev.)	rpm	feed (in./rev.)	rpm
1/4	0.004	611	0.003	458	0.003	382	0.002	229	0.004	1375		
3/8	0.005	407	0.004	306	0.003	255	0.002	153	0.004	917		
1/2	0.007	306	0.005	229	0.004	191	0.003	115	0.004	687	0.003	907
5/8	0.007	244	0.006	183	0.004	153	0.003	92	0.005	550	0.003	733
3/4	0.008	204	0.007	153	0.004	127	0.004	76	0.005	458	0.004	611
7/8	0.009	175	0.008	131	0.004	109	0.004	66	0.005	393	0.004	524
1	0.010	153	0.009	115	0.004	96	0.004	57	0.005	344	0.004	458
1 1/8	0.010	136	0.009	102	0.004	85	0.004	51	0.005	306	0.004	407
1 1/4	0.011	122	0.009	92	0.004	76	0.004	46			0.005	367
1 3/8	0.011	111	0.010	83	0.004	70	0.004	42			0.005	333
1 1/2	0.012	102	0.010	76	0.004	64	0.004	38			0.005	306
1 5/8	0.012	94	0.010	71	0.004	59	0.004	35			0.005	282
1 3/4	0.013	87	0.010	66	0.004	55	0.004	33			0.005	262
1 7/8	0.013	82	0.011	61	0.004	51	0.004	31			0.005	244
2	0.014	76	0.011	57	0.004	48	0.004	29			0.005	229

** May be increased by at least 25% when using modern grades like GC3040 on modern CNC machines.

Notes to Table:

1. Centre punch the steel plate prior to drilling.
2. Ensure the work-piece is fully restrained.
3. Ensure liberal amounts of coolant are used.

Testing

All Algoma heat-treated plate is tested according to CSA G40.20/ G40.21 and/or ASTM A6 standards. Proprietary tests can be completed on request.

Consistent High-Quality

World Class Surface Quality

Algoma heat-treated plate is virtually scale-free, the result of high pressure water sprays used on both surfaces of the plate – simultaneously – as it enters the Drever roller quench unit.

The clean surface of Algoma plate is a key benefit for those applications where the surface is critical or exposed to view, and permits easy welding and flame cutting without surface preparation

Much Better Than A6 Flatness

Nearly all grades of Algoma heat-treated plate are supplied to 1/2 ASTM A6 flatness tolerances, an important characteristic where flatness is a critical requirement for end users.

Through-Thickness Hardness

Algoma produces several grades of abrasion-resistant plate that are through-hard over most of the thickness range. This attribute translates into longer service life and generates cost savings that result from a longer product life cycle.

Algoma heat-treated, abrasion-resistant plate grades achieve their final hardness without work hardening.

Some variation in core hardness may be encountered in the AlgoTuf 400F and 450F grades in thicknesses over 2.25" (57mm) and in the AlgoTuf 500 grade over 1.25" (31.8mm) thick.

Algoma's standard practice is to test hardness after the removal of 0.035"-0.075" (0.9mm-1.9mm) from the plate surface.

Excellent Abrasion Resistance

Abrasion resistance is an important quality of Algoma heat-treated plate, but abrasion resistance is just the starting point. Many different metallurgical factors must be balanced with the demands of many different applications to create the best product.

Different situations subject steel to different types of wear. For example, the rolling contact wear experienced in railroad rail is different than the high stress abrasive wear encountered by mining equipment. For this reason, it isn't possible to predict absolute wear rates for various steels. Instead, Algoma provides generalized relative performance data based on experience, published literature and standardized tests, performed on various steel grades under high-stress and low-stress test conditions.

The following chart shows the ability of Algoma heat-treated plate grades to resist high and low stress abrasion. The chart uses SAE 1016 as a reference for low-stress conditions and Algoma 100 (equivalent to ASTM A514 Grade S) as a reference for high-stress conditions.

For most plate applications, the dominant factor in determining abrasion resistance is the hardness difference between the steel and the material being handled. Increasing the steel hardness not only increases wear resistance, it may also change the wear mechanism from high-stress to low- stress. In those cases, the increase in wear resistance may greatly exceed the values shown on the chart.

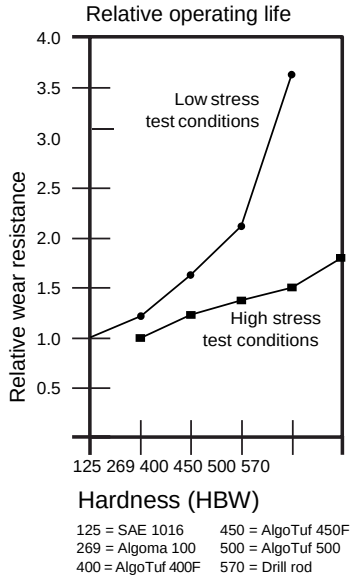
Cleanliness and Uniformity

Continuously-cast slabs, ladle metallurgy, sulphide shape control, and statistical process control, allow Algoma to produce heat-treated plate with internal cleanliness, uniform chemistry and consistent mechanical properties within the finished plate.

Up To 154" Wide, 960" Long

In thicknesses from 0.875" (22.2 mm) to 1.75" (44.5mm), Algoma can produce heat-treated plate up to a maximum width of 154" (3912mm). This unique capability can eliminate the cost of weld splices for applications wider than the standard 96" (2440mm).

Maximum plate length is 960" (24400mm); however the maximum cross-section area that can be heat-treated is 288 sq. inches (186,000 sq. mm). These capabilities provide Algoma customers with size options virtually unmatched in North America.



Algoma 100

Superior surface quality and notch toughness
High strength, structural quality heat-treated steel plate

Algoma 100 is the cost-effective choice for applications which require high strength with superior weldability, good formability, and improved notch toughness with good resistance to brittle fracture at low surface temperatures. Typical applications include highway trailers, forestry and mining equipment and other uses where weight is a critical factor. Algoma's improved surface capabilities make this product particularly suited for exposed, off-highway applications.

While Algoma 100 is available in the thickness range indicated below, specific thicknesses from 0.236" (6mm) to 2.75" (70mm) may be ordered to the following specifications:

- CSA G40.21-100Q (CSA G40.21-700Q)
- CSA G40.21-100QT (CSA G40.21- 700QT)
- ASTM A514 Grade S (ASTM A514M Grade S) 2.5" (63.5mm) max

Dimensions

Thickness range: 0.188" (5mm) – 2.75" (70mm)
Maximum width: 154" (3912mm)
Maximum length: 960" (24400mm)

The stock plate size most commonly available through Algoma's distributor network is 96" x 288" (2440mm x 7315mm).

Notch Toughness

Algoma 100 is produced to a minimum CVNL average value of 20 ft-lbs at -50°F (27 Joules at -45°C). Other testing temperatures and Charpy V-Notch values may be available on request.

Notch toughness (impact) testing may be conducted and reported if requested at the time the order is placed.

Hardness

Algoma 100 is heat-treated to develop yield strength. This results in a through-thickness hard product with a hardness range of 240-300 HBW, although there is no minimum hardness specified for this grade. Hardness values will be reported if requested at the time the order is placed.

Forming (Up to 90°)

Algoma 100's low alloy levels and consistent properties make it ideal for cold forming.

Plate up to 1" (25.4mm) thick can be cold bent to a minimum inside bend radius of 2t (where t is the plate thickness), with the bend axis transverse to the rolling direction (i.e. across the grain), and a radius of 3t when bending parallel to the rolling direction.

For plate over 1" to 2.5" (25.4mm to 65mm) thick, a radius of 3t should be used for cold forming with the bend axis transverse to the rolling direction, and a radius of 4t when bending parallel to the rolling direction.

Maximum Temperatures for Hot Forming and Stress-Relief

Algoma 100 can be heated to approximately 1000°F (535°C) for about 20 minutes, for hot forming or stress relief operations. Additional time at this temperature may result in some loss of mechanical properties.

Chemical Composition - Heat Analysis (% maximum)

Thickness	C	Mn	P	S	Si	Cr	Mo	B
0.188" (5mm) to 0.250" (6.35mm)	0.17	1.50	0.030	0.015	0.45	0.25	0.20	0.003
Over 0.250" (6.35mm) to 1.00" (25.4mm)	0.21*	1.50	0.030	0.015	0.45	0.20	0.20	0.003
Over 1.00" (25.4mm) to 2.75" (70mm)	0.21*	1.50	0.030	0.015	0.45	0.65	0.40	0.003

Notes:

1. *The molybdenum content will vary according to thickness.*
2. *To meet the required mechanical properties, Algoma may use additional alloy elements, which it will report to purchasers.*
3. **0.20% max C when CSA G40.21 is specified*

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Mechanical Properties (transverse)

Tensile Strength Mimimum	Tensile Strength Maximum	Yield Strength Minimum	Elongation (percent) Minimum In 2" (50mm)
110 ksi (760 MPa)	130 ksi (895 MPa)	100 ksi (700 MPa)	16*

**See elongation adjustment in ASTM A6 for thicknesses of 0.311" (8mm) or less.*

Welding

Algoma 100 exhibits excellent weldability. Because of its low alloy content, this grade can be welded using simple procedures and common, readily available consumables.

As Algoma 100 is a grade that can be specified as 700 QT under CSA W59-03 or grade 100 under AWS D1.1- 99, it is recommended that matching strength electrodes are used (E110XX or equivalent (E76XX)) conforming to CSA W59-03 clause 5.5.1.6 and CSA W48-01, for structural welds.

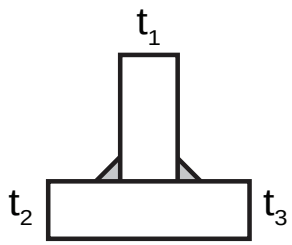
In the case of fillet welds, E4918 (E7018) electrodes may be used provided that the welds are appropriately sized and electrodes are categorized as low hydrogen H4 designation.

High heat inputs when using conventional arc welding processes should be used cautiously, particularly for thinner thicknesses, since the leaner chemistries of these gauges are more susceptible to a reduction of mechanical properties and hardness along the heat-affected zone.

Electrogas and electroslag processes are not suitable for the Algoma 100 grade because of their inherent high heat input.

Preheat and Interpass Temperatures

Algoma recommends the following preheat and interpass temperatures, which should be monitored with temperature crayons, thermocouples, etc. Higher preheat temperatures may be required when the weld metal hydrogen level is greater than 4ml/100g deposited weld metal, or when higher joint restraint is present.



Combined plate thickness (t1+t2+t3)	H4 Designation	
	Low restraint	High restraint
<=1.25" (32mm)	no preheat	no preheat
<=1.50" (38mm)	no preheat	no preheat
<=2.25" (57mm)	no preheat	120°F (50°C)
<=2.75" (70mm)	120°F (50°C)	210°F (100°C)
<=4.00" (100mm)	210°F (100°C)	300°F (150°C)
>4.00" (100mm)	255°F (125°C)	300°F (150°C)

**Ambient temperature is assumed as 68°F (20°C).*

The Dearden-O'Neill Carbon Equivalent (C.E.) of Algoma 100 is:

Thickness	Nominal Aim Carbon Equivalent	Maximum Carbon Equivalent
0.188" (5mm) to 0.25" (6.35mm)	0.38 0.41*	0.43 0.46*
Over 0.250" (6.35mm), to 1.00" (25.4mm)	0.44	0.49
Over 1.00" (25.4mm) to 2.75" (70mm)	0.56	0.62

The carbon equivalent calculated from the mill test report should be used for critical applications.

* When certified to CSA G40.21-100Q or 100QT and/or ASTM A514 grade S

Algoma 130

Superior surface quality and greater strength
Extra high strength, structural quality heat-treated steel plate

Algoma 130 is a higher strength version of Algoma 100, and may allow for weight savings due to its greater yield and tensile strengths. This product exhibits excellent weldability and formability characteristics, in addition to superior resistance to brittle fracture at low service temperatures.

Typical applications of Algoma 130 include highway trailers, crane booms, forestry and mining equipment, and any other uses where weight savings and high strength are critical factors.

Dimensions

Thickness range: 0.188" (5mm) – 2.5" (65mm)

Maximum width: 154" (3912mm)
Maximum length: 960" (24400mm)

Notch Toughness

Algoma 130 is produced to a minimum CVNT average value of 20 ft-lbs at -40°F (27 Joules at -40°C). Other testing temperatures and Charpy V-Notch values may be available on request.

Notch toughness (impact) testing is conducted and reported on a per-thickness per-heat basis.

Hardness

Algoma 130 is heat-treated to develop yield strength. This results in a through-thickness hard product with a hardness range of 280-340 HBW, although there is no minimum hardness specified for this grade. Hardness values will be reported if requested at the time the order is placed.

Forming (Up to 90°)

Algoma 130's low alloy levels and consistent properties make it ideal for cold forming.

Plate up to 1" (25.4mm) thick can be cold bent to a minimum inside bend radius of 3t (where t is the plate thickness), with the bend axis transverse to the rolling direction (i.e. across the grain), and a radius of 4t when bending parallel to the rolling direction.

For plate over 1" to 2.5" (25.4mm to 65mm) thick, a radius of 4t should be used for cold forming with a bend axis transverse to the rolling direction, and a radius of 5t when bending parallel to the rolling direction.

Maximum Temperatures for Hot Forming and Stress-Relief

Algoma 130 can be heated to approximately 900°F (475°C) for about 20 minutes for hot forming or stress relief operations. Additional time at these temperatures may result in some loss of mechanical properties.

Chemical Composition - Heat Analysis (% maximum)

Thickness	C	Mn	P	S	Si	Cr	Mo	B
0.188" (5mm) to 0.250" (6.35mm)	0.17	1.50	0.025	0.015	0.45	0.20	0.20	0.003
Over 0.25" (6.35mm) to 1.375" (35mm)	0.21	1.50	0.025	0.015	0.45	0.65	0.40	0.003
Over 1.375" (35mm) to 2.5" (65mm)	0.26	1.50	0.025	0.015	0.45	0.60	0.45	0.003

Notes:

1. *The molybdenum content will vary according to thickness.*
2. *To meet the required mechanical properties, Algoma may use additional alloy elements, which it will report to purchasers.*

Mechanical Properties (transverse)

Tensile Strength Mimimum	Yield Strength Minimum	Elongation (percent) Minimum In 2" (50mm)
136 ksi (940 MPa)	130 ksi (900 MPa)	12*

**See elongation adjustment in ASTM A6 for thicknesses of 0.311" (8mm) or less.*

Welding

Algoma 130 exhibits excellent weldability. Because of its low alloy content, this grade can be welded using simple procedures and common, readily available consumables.

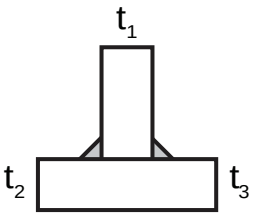
Algoma recommends low hydrogen (H4 designation) electrodes (E120X or higher) conforming to CSA W59-03 clause 5.5.1.6.

In the case of fillet welds, E4918 (E7018) electrodes may be used provided the welds are appropriately sized and the electrodes are categorized as low hydrogen H4 type.

High heat inputs when using conventional arc welding processes should be used cautiously, particularly for thinner thicknesses, since the leaner chemistries of these gauges are more susceptible to a reduction of mechanical properties and hardness along the heat-affected zone. Electrogas and electroslag processes are not suitable for the Algoma 130 grade because of their inherent high heat input.

Preheat and Interpass Temperatures

Algoma recommends the following preheat and interpass temperatures, which should be monitored with temperature crayons, thermocouples, etc. Higher preheat temperatures may be required when the weld metal hydrogen level is greater than 4ml/100g deposited weld metal, or when higher joint restraint is present.



Combined plate thickness (t1+t2+t3)	H4 Designation	
	Low restraint	High restraint
<=1.25" (32mm)	no preheat	170°F (75°C)
<=1.50" (38mm)	120°F (50°C)	210°F (100°C)
<=2.25" (57mm)	170°F (75°C)	255°F (125°C)
<=2.75" (70mm)	210°F (100°C)	255°F (125°C)
<=4.00" (100mm)	255°F (125°C)	300°F (150°C)
>4.00" (100mm)	255°F (125°C)	300°F (150°C)

**Ambient temperature is assumed as 68°F (20°C).*

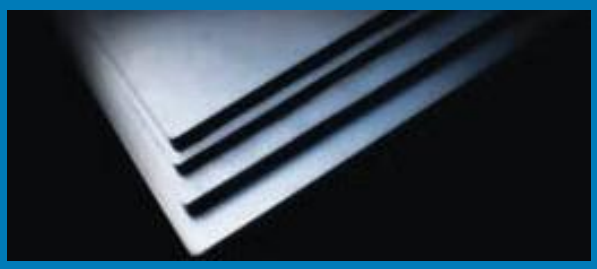
The Dearden-O'Neill Carbon Equivalent (C.E.) of Algoma 130 is:

Thickness	Nominal Aim Carbon Equivalent	Maximum Carbon Equivalent
0.188" (5mm) to 0.25" (6.35mm)	0.38	0.43
Over 0.25" (6.35mm), to 1.375" (35mm)	0.56	0.62
Over 1.375" (35mm) to 2.50" (65mm)	0.57	0.63

The carbon equivalent calculated from the mill test report should be used for critical applications.

AlgoTuf 400F

More formable, with less preheat
Abrasion-resistant heat-treated steel plate



AlgoTuf 400F is designed to provide a good level of abrasion resistance plus improved formability and weldability. Most of the thickness range of AlgoTuf 400F is through-hard, which translates into longer service life for the finished products. AlgoTuf 400F requires less preheat than the old Algoma 360, which it replaces.

AlgoTuf 400F is the cost-effective abrasion resistant material for mining, forestry and construction applications.

Dimensions

Thickness range: 0.188" (5mm) - 2.75" (70mm)
Maximum width: 154" (3912mm)
Maximum length: 960" (24400mm)

The stock plate size most commonly available through Algoma's distributor network is 96" x 288" (2440mm x 7315mm).

Notch Toughness

AlgoTuf 400F will typically have CVNL average values of 35 ft-lbs at -40°F (47 Joules at -40°C) for thicknesses up to 1.0" (25.4mm), and 15 ft-lbs at -40°F (20 Joules at -40°C) for thicknesses greater than 1.0" (25.4mm).

AlgoTuf 400F is not normally produced with certified notch toughness values. However, impact values may be reported, for information only, if requested at the time the order is placed.

Hardness

AlgoTuf 400F is heat-treated to produce a through-thickness hard product with a range of 360-440 HBW for thicknesses less than 2.25" (57mm). For thicknesses equal to or greater than 2.25" (57mm) there may be some softening in the core, below the 360 HBW minimum value. Hardness testing is conducted and reported on a basis of per heat, per 40 tons, per ± 0.591" (15mm) thickness deviation from the nominal thickness supplied.

Forming (Up to 90°)

AlgoTuf 400F is designed for improved formability, with low levels of carbon and sulphur, and is treated for inclusion shape control.

Plate up to and including 0.787" (20mm) can be cold bent to a minimum inside bend radius of 3t (where t is the plate thickness), with the bend axis transverse to the rolling direction (i.e. across the grain), and a radius of 4t when bending parallel to the rolling direction. For plate over 0.787" (20mm), a radius of 6t should be used for cold-forming with the bend axis transverse to the rolling direction.

Maximum Temperatures for Hot Forming and Stress-Relief

AlgoTuf 400F over 1" (25.4mm) thick can be heated to approximately 480°F (250°C) for about 10 minutes for hot forming or stress relief operations. Additional time at this temperature may result in some loss of mechanical properties.

Hot forming or stress relief operations are not recommended for thicknesses of 1" (25.4mm) and less.

Chemical Composition - Heat Analysis (% maximum)

Thickness	C	Mn	P	S	Si	Cr	Mo	B
0.188" (5mm) to less than 0.472" (12mm)	0.17	1.50	0.025	0.015	0.45	0.20	0.20	0.003
0.472" (12mm) to 0.787" (20mm)	0.17	1.50	0.025	0.015	0.45	0.25	0.20	0.003
Over 0.787" (20mm) to 1.00" (25.4mm)	0.20	1.50	0.025	0.015	0.45	0.60	0.35	0.003
Over 1.00" (25.4mm) to 2.75" (70mm)	0.26	1.50	0.025	0.015	0.45	0.60	0.45	0.003

Notes:

1. *The molybdenum content will vary according to thickness.*
2. *To meet the required mechanical properties, Algoma may use additional alloy elements, which it will report to purchasers.*

ALGOMA STEEL INC.

Mechanical Properties (transverse) for information only*

Tensile Strength Typical	Yield Strength Typical	Elongation (per cent) Typical 2" (50mm)
175 ksi (1206 MPa)	145 ksi (1000MPa)	15

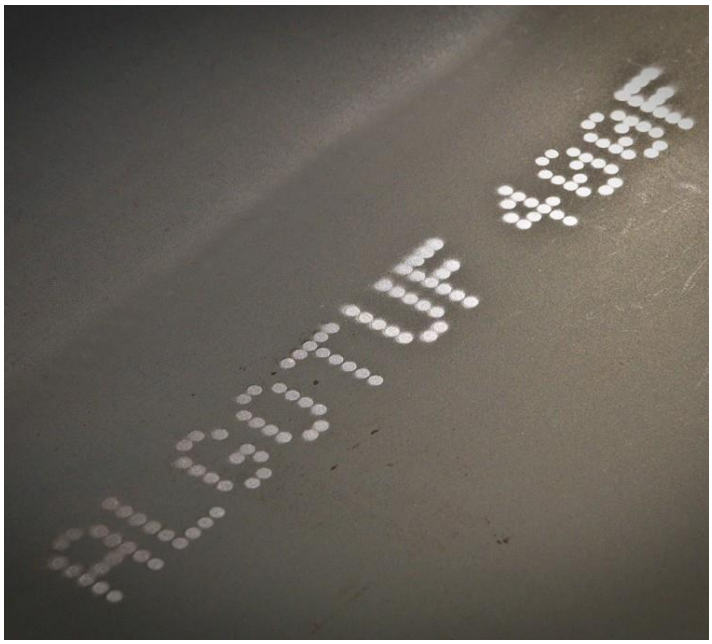
**These values are provided for reference only and no express or implied warranty is made that a specific plate will provide these properties, unless negotiated with Algoma prior to order acceptance*

Welding

AlgoTuf 400F exhibits excellent weldability. Because of its low alloy content, this grade can be welded using simple procedures and common, readily available consumables.

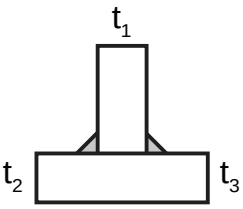
Algoma recommends H8 designation electrodes.

High heat input welding processes such as electroslag and electrogas are not suitable for AlgoTuf 400F, and will cause a reduction of mechanical properties and hardness along the heat-affected zone.



Preheat and Interpass Temperatures

Algoma recommends the following preheat and interpass temperatures, which should be monitored with temperature crayons, thermocouples, etc. Higher preheat temperatures may be required when the weld metal hydrogen level is greater than 8ml/100g deposited weld metal, or when higher joint restraint is present.



Combined plate thickness (t1+t2+t3)	H8 Designation	
	Low restraint	High restraint
<=2.25" (57mm)	no preheat	120°F (50°C)
<=3.00" (75mm)	255°F (125°C)	300°F (150°C)
<=4.00" (100mm)	255°F (125°C)	300°F (150°C)
>4.00" (100mm)	255°F (125°C)	300°F (150°C)

**Ambient temperature is assumed as 68°F (20°C).*

These temperatures are based on the SMAW process, using E7018 electrodes. Once the electrodes are removed from their sealed containers, they should be stored in an oven at 250°F (120°C).

Preheat temperatures can be reduced by 50°F (28°C) for the GMAW process.

The Dearden-O'Neill Carbon Equivalent (C.E.) of AlgoTuf 400F is:

Thickness	Nominal Aim Carbon Equivalent	Maximum Carbon Equivalent
0.188" (5mm) to less than 0.472" (12mm)	0.38	0.43
0.472" (12mm) to 0.787" (20mm)	0.41	0.46
Over 0.787" (20mm) to 1.00" (25.4mm)	0.49	0.55
Over 1.00" (25.4mm) to 2.75" (70mm)	0.57	0.63

The carbon equivalent calculated from the mill test report should be used for critical applications.

AlgoTuf 450F

Increased wear-resistance and toughness
Abrasion resistant heat-treated steel plate

AlgoTuf 450F is designed specifically for applications which require superior abrasion resistance. Most of the thickness range of AlgoTuf 450F is through-hard, which translates into longer service life for the finished products.

AlgoTuf 450F is the cost-effective material for truck and hopper liners, wear plates, chutes, buckets, crushers and similar heavy equipment.

Dimensions

Thickness range: 0.188" (5mm) – 2.5" (65mm)

Maximum width: 154" (3912mm)
Maximum length: 960" (24400mm)

The stock plate size most commonly available through Algoma's distributor network is 96" x 288" (2440mm x 7315mm).

Notch Toughness

AlgoTuf 450F will typically have CVNL average values of 30 ft-lbs at -40°F (40 Joules at -40°C) for thicknesses up to 0.787" (20mm), and 15 ft-lbs at -40°F (20 Joules at -40°C) for thicknesses greater than 0.787" (20mm).

AlgoTuf 450F is not normally produced with certified notch toughness values. However, impact values may be reported, for information only, if requested at the time the order is placed.

Hardness

AlgoTuf 450F is heat-treated to produce a through-thickness hard product with a range of 410-477 HBW for thicknesses up to 0.787" (20mm), and 420-477 HBW for thicknesses greater than 0.787" (20mm) to less than 2.25" (57mm). For greater thicknesses there may be some softening in the core below the 420 HBW minimum value. Hardness testing is conducted and reported on a basis of per heat, per 40 tons, per ± 0.591" (15mm) thickness deviation from the nominal thickness supplied.

Forming (Up to 90°)

AlgoTuf 450F is designed for improved formability, with low levels of carbon and sulphur, and is treated for inclusion shape control.

Plate up to and including 0.787" (20mm) thick can be cold bent to a minimum inside bend radius of 6t (where t is the plate thickness), with the bend axis transverse to the rolling direction (i.e. across the grain). For thicknesses greater than 0.787" (20mm), a radius of 8t should be used for cold-forming with the bend axis transverse to the rolling direction.

Maximum Temperatures for Hot Forming and Stress-Relief

AlgoTuf 450F over 0.787" (20mm) thick can be heated to approximately 480°F (250°C) for about 10 minutes, for hot forming or stress relief operations. Additional time at this temperature may result in some loss of mechanical properties.

Hot forming or stress relief operations are not recommended for thicknesses of 0.787" (20mm) and less.

Chemical Composition - Heat Analysis (% maximum)

Thickness	C	Mn	P	S	Si	Cr	Mo	B
0.188" (5mm) to 0.394" (10mm)	0.21	1.50	0.025	0.015	0.45	0.20	0.20	0.003
Over 0.394" (10mm) to 0.787" (20mm)	0.23	1.50	0.025	0.015	0.45	0.20	0.35	0.003
Over 0.787" (20mm) to 2.5" (65mm)	0.26	1.50	0.025	0.015	0.45	0.60	0.45	0.003

Notes:

1. *The molybdenum content will vary according to thickness.*
2. *To meet the required mechanical properties, Algoma may use additional alloy elements, which it will report to purchasers.*

Mechanical Properties (transverse) for information only*

Tensile Strength Typical	Yield Strength Typical	Elongation (per cent) Typical 2" (50mm)
200 ksi (1380 MPa)	NA	14

**These values are provided for reference only and no express or implied warranty is made that a specific plate will provide these properties, unless negotiated with Algoma prior to order acceptance*

Welding

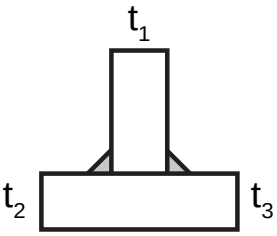
AlgoTuf 450F exhibits excellent weldability. Because of its low alloy content, this grade can be welded using simple procedures and common, readily available consumables.

Algoma recommends H8 designation electrodes.

High heat input welding processes such as electroslag and electrogas are not suitable for AlgoTuf 450F, and will cause a reduction of mechanical properties and hardness along the heat-affected zone.

Preheat and Interpass Temperatures

Algoma recommends the following preheat and interpass temperatures, which should be monitored with temperature crayons, thermocouples, etc. Higher preheat temperatures may be required when the weld metal hydrogen level is greater than 8ml/100g deposited weld metal, or when higher joint restraint is present.



Combined plate thickness (t1+t2+t3)	H8 Designation	
	Low restraint	High restraint
<=0.75" (20mm)	no preheat	no preheat
<=1.50" (38mm)	no preheat	210°F (100°C)
<=2.25" (57mm)	210°F (100°C)	255°F (125°C)
<=3.00" (75mm)	300°F (150°C)	350°F (175°C)
<=4.00" (100mm)	300°F (150°C)	350°F (175°C)
> 4.00" (100mm)	300°F (150°C)	350°F (175°C)

**Ambient temperature is assumed as 68°F (20°C).*

These temperatures are based on the SMAW process, using E7018 electrodes. Once the electrodes are removed from their sealed containers, they should be stored in an oven at 250°F (120°C).

Preheat temperatures can be reduced by 50°F (28°C) for the GMAW process.

The Dearden-O'Neill Carbon Equivalent (C.E.) of AlgoTuf 450F is:

Thickness	Nominal Aim Carbon Equivalent	Maximum Carbon Equivalent
0.188" (5mm) to 0.394" (10mm)	0.44	0.49
Over 0.394" (10mm) to 0.787" (20mm)	0.48	0.53
Over 0.787" (20mm) to 2.5" (65mm)	0.57	0.63

The carbon equivalent calculated from the mill test report should be used for critical applications.

AlgoTuf 500

Maximum wear-resistance
Abrasion resistant heat-treated steel plate

AlgoTuf 500 is designed specifically for applications which require extremely high abrasion resistance. This 500 HBW material has become the popular abrasion-resistant product for mining and other highly abrasive industrial applications.

Dimensions

Thickness range: 0.236" (6mm) - 1.25" (31.75mm)
Maximum width: 154" (3912mm)
Maximum length: 960" (24400mm)

The stock plate size most commonly available through Algoma's distributor network is 96" x 288" (2440mm x 7315mm).

Notch Toughness

AlgoTuf 500 will typically have CVNL average values of 20 ft-lbs at -40°F (27 Joules at -40°C).

AlgoTuf 500 is not normally produced with certified notch toughness values. However, impact values may be reported, for information only, if requested at the time the order is placed.

Hardness

AlgoTuf 500 is heat-treated to produce a through-thickness hard product with a range of 477-545 HBW for thicknesses up to 1.25" (31.75mm).

Forming (Up to 90°)

Because of its extreme strength and hardness, forming of AlgoTuf 500 is not recommended. If forming is absolutely essential, use an inside bend radius of at least 10t (where t is the plate thickness), with the bend axis transverse to the rolling direction (i.e. across the grain), for thicknesses up to 0.787" (20mm).

Maximum Temperatures for Hot Forming and Stress-Relief

AlgoTuf 500 can be heated to approximately 350°F (175°C) for about 20 minutes, for hot forming or stress relief operations. Additional time at this temperature may result in some loss of mechanical properties.

Chemical Composition - Heat Analysis (% maximum)

Thickness	C	Mn	P	S	Si	Cr	Mo	Ni	B
0.236" (6mm) to 1.25" (31.75mm)	0.33	1.50	0.025	0.015	0.50	0.70	0.35	0.70	0.003

Notes:

1. *The molybdenum content will vary according to thickness.*
2. *To meet the required mechanical properties, Algoma may use additional alloy elements, which it will report to purchasers.*

Mechanical Properties (transverse) for information only*

Tensile Strength Typical	Yield Strength Typical	Elongation (per cent) Typical 2" (50mm)
225 ksi (1551 MPa)	NA	14

**These values are provided for reference only and no express or implied warranty is made that a specific plate will provide these properties, unless negotiated with Algoma prior to order acceptance*

Welding

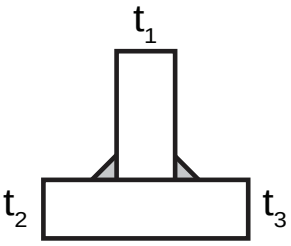
AlgoTuf 500 exhibits excellent weldability. Because of its low alloy content, this grade can be welded using simple procedures and common, readily available consumables.

Algoma recommends H8 designation electrodes.

High heat input welding processes such as electroslag and electrogas are not suitable for AlgoTuf 500, and will cause a reduction of mechanical properties and hardness along the heat-affected zone.

Preheat and Interpass Temperatures

Algoma recommends the following preheat and interpass temperatures, which should be monitored with temperature crayons, thermocouples, etc. Higher preheat temperatures may be required when the weld metal hydrogen level is greater than 8ml/100g deposited weld metal, or when higher joint restraint is present.



Combined plate thickness (t1+t2+t3)	H8 Designation	
	Low restraint	High restraint
<=0.75" (20mm)	120°F (50°C)	255°F (125°C)
<=1.50" (38mm)	210°F (100°C)	400°F (200°C)
<=2.25" (57mm)	255°F (125°C)	400°F (200°C)
<=3.00" (75mm)	300°F (150°C)	400°F (200°C)
>3.00" (75mm)	300°F (150°C)	400°F (200°C)

**Ambient temperature is assumed as 68°F (20°C).*

These temperatures are based on the SMAW process, using E7018 electrodes. Once the electrodes are removed from their sealed containers, they should be stored in an oven at 250°F (120°C).

Preheat temperatures can be reduced by 50°F (28°C) for the GMAW process.

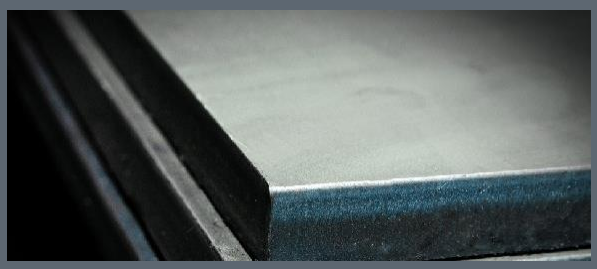
The Dearden-O'Neill Carbon Equivalent (C.E.) of AlgoTuf 500 is:

Thickness	Nominal Aim Carbon Equivalent	Maximum Carbon Equivalent
0.236" (6mm) to 1.25" (31.75mm)	0.61	0.66

The carbon equivalent calculated from the mill test report should be used for critical applications.

Armour

High hardness steel for ballistic applications



Algoma is one of North America's leading producers of Armour Plate which is used in ballistic and blast protection applications, such as tanks, trucks, personnel carriers, and other vehicles. Algoma's Armour Plate is used by the U.S. Armed Forces as well as the armed forces of other countries around the world.

Through control over the raw ingredients that are used to produce the Armour Plate grades, combined with tight control of our production process, including the rapid quench system, Algoma's Armour Plate is well known for both its excellent properties and surface characteristics.

Typical plate size is 96" x 288" (2440mm x 7315mm).

Algoma currently produces Armour Plate meeting the specification requirements of MIL-DTL-46100E(MR) Class 1.

For Armour Plate meeting other specifications, please inquire with your Algoma Sales Representative.

Military Specifications

		MIL-DTL-46100E (MR) Class 1
Thickness Range Available		0.236" (6mm) to 1.250" (31.75mm) inclusive
Chemical composition (%) unless a range is specified, individual values are maximums		
Carbon		0.22 - 0.32
Manganese		0.60 - 0.90
Phosphorus		0.020
Sulfur		0.010
Silicon		0.20 - 0.40
Chromium		0.40 - 0.70
Nickel		0.35 - 0.85
Molybdenum		0.20 - 0.35
Copper		0.25
Boron		0.003
Hardness (HBW) (average)		477 - 534
CVNL full size min. avg. impact (ft-lbs) @ -40°F		14
CVNT full size min. avg. impact (ft-lbs) @-40°F		12
Heat Treatment Requires		Q&T

ALGOMA STEEL INC.

Head Office & Steelworks

105 West Street
Sault Ste. Marie, ON
P6A 7B4
T: 705.945.2351
F: 705.945.2203

Corporate Sales Office

Suite 301
5515 North Service Road
Burlington, ON
L7L 6G4
T: 905.331.3400
F: 905.331.3408

Regional Sales

Calgary 403.620.2843
Montreal 514.694.9558
Vancouver 778.887.1560
Chicago 847.855.2766
Minneapolis 651.964.1577
Pittsburgh 724.941.8059