EARLE M. JORGENSEN COMPANY

REFERENCE BOOK

ALLOY • ALUMINUM • BRASS • BRONZE
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STAINLESS • SUPER ALLOY • TITANIUM
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F

SECTION F

HIGH STRENGTH LOW ALLOY STEELS
HEAT TREATED CONSTRUCTIONAL ALLOY STEELS
ABRASION RESISTING STEELS

HIGH STRENGTH LOW ALLOY STEELS

SHEETS—PLATES

High strength low alloy (HSLA) steels are essentially low carbon steels to which have been added small amounts of such alloying elements as chromium, nickel, molybdenum, vanadium, zirconium, copper, and columbium. The effect of the alloy addition is to raise the yield point of the steel in the as-rolled condition to a level substantially higher than that of the structural carbon grades, and at the same time provide weldability and formability. Thus, they offer the advantages of higher strength-to-weight ratios, increased resistance to wear and abrasion, and in some cases improved resistance to atmospheric corrosion.

These steels are produced under dozens of different trade names and are covered by a number to ASTM, SAE, and military specifications. General characteristics are similar, but the various grades may be categorized in a general way according to their resistance to atmospheric corrosion.

Resistance to Atmospheric Corrosion
Equivalent to that of Carbon Steels

Color Marking: Brown and Orange

Specifications: ASTM A 572 Grade 50 (Plates)
SAE J410 Grade 950X (Sheets, Plates)

Resistance to Atmospheric Corrosion
Two times that of Carbon Steels

Color Marking: Red and White

Specifications: ASTM A 606 Type 2 (Sheets)
SAE J410 Grade 950B (Sheets, Plates)

Resistance to Atmospheric Corrosion
Four Times that of Carbon Steels

Color Marking: Gold and Red

Specifications: ASTM A 242 Type 1 (Plates)
A588 (Plates)
A606 Type 4 (Sheets)
SAE J410 Grade 950D (Sheets, Plates)

MECHANICAL PROPERTIES — The following minimums generally apply depending upon applicable thickness and specification:

Tensile Strength, min, psi	70,000
Yield Strength, min, psi	50,000
Elongation, min, % in 2" (Sheet)	22
% in 8" (Plate)	18

WELDABILITY — High Strength Low Alloy grades are weldable with welding techniques suitable for the grade and intended service.

HIGH STRENGTH SHEETS

Thickness	Width and Length	Est. Wt. Lbs. Per Sheet
Cold Rolled		
20 Ga. 1.50 Lbs. Sq. Ft. .0359"		
	36 x 120	45.00
18 Ga. 2.0 Lbs. Sq. Ft. .0478"		
	48x120	80.00
	144	96.00
16 Ga. 2.5 Lbs. Sq. Ft. .0598"		
	36x120	75.00
	48x120	100.00
	144	120.00
14 Ga. 3.125 Lbs. Sq. Ft. .0747"		
	60x120	156.25
	144	187.50
Hot Rolled		
14 Ga. 3.125 Lbs. Sq. Ft. .0747"		
	36x120	93.75
	120	175.00
	144	112.50
	48x96	100.00
	120	125.00
	144	150.00
	240	250.00
13 Ga. 3.75 Lbs. Sq. Ft. .0897"		
	60x240	375.00
12 Ga. 4.375 Lbs. Sq. Ft. .1046"		
	36x120	131.25
	48x96	140.00
	120	175.0
	144	210.00
	192	280.00
	240	350.00
	60x96	175.00
	120	218.75
	144	262.50
	192	350.00
	240	437.50

Thickness	Width and Length	Est.Wt. Lbs. Per Sheet
Hot Rolled		
12 Ga. (Cont.)		
	72x120	262.50
	144	315.00
	192	420.00
	240	525.00
11 Ga. 5.0 Lbs. Sq. Ft. .1196"		
	48x120	200.00
	144	240.00
	192	320.00
	240	400.00
	60x144	300.00
	192	400.00
	240	500.00
	72x120	300.00
	144	360.00
	192	480.00
	240	600.00
10 Ga. 5.625 Lbs. Sq. Ft. .1345"		
	36x96	135.00
	120	168.75
	48x96	180.00
	120	225.00
	144	270.00
	240	450.00
	60x96	225.00
	120	281.25
	144	337.50
	192	450.00
	240	562.00
	72x96	270.05
	120	337.50
	144	405.07
	192	540.00
	240	675.00
7 Ga. 7.5 Lbs. Sq. Ft. .1793"		
	48x120	300.00
	144	360.00
	192	480.00
	240	600.00

HIGH STRENGTH PLATES

High Strength

Low Alloy

Plates

are stocked in

thicknesses

from $3/16$" to 3 $1/2$",

widths up to 96",

and

lengths up to 360".

For

weights

refer to

Section D,

Pages 6 and 7.

HEAT TREATED CONSTRUCTIONAL ALLOY STEELS

PLATES — ASTM A 514

Color Marking: Blue and Brown

Heat Treated Constructional Alloy Steels are low carbon alloy steels that have been heat treated by conventional liquid quenching and tempering to a strength level substantially higher than that of the high strength low alloy grades. The alloying elements and amount of alloy content vary among the grades depending upon the section thickness and desired properties. The low carbon content improves their general weldability.

ASTM Specification A 514 covers this material in "Structural" Quality. The specification provides for a number of grades, which correspond to trade names of various steel producers.

ANALYSIS

ASTM Grade	"F"	"B"	"H"	"Q"	"C"
C	.10/.20	12./.21	.12/.21	.14/.21	.10/.20
Mn	.60/1.00	.70/1.00	.95/1.30	.95/1.30	1.10/1.50
P Max.	.035	.035	.035	.035	.035
S Max.	.040	.040	.040	.040	.040
Si	.15/.35	.20/.35	.20/.35	.15/.35	.15/.30
Cr	.40/.65	.40/.65	.40/.65	1.00/1.50	—
Ni	.70/1.00	—	.30/.70	1.20/1.50	—
Mo	.40/.60	.15/.25	.20/.30	.40/.60	.20/.30
V	.03/.08	.03/.08	.03/.08	.03/.08	—
Ti	—	.01/.03	—	—	—
Cu	.15/.50	—	—	—	—
B	.0005/.006	.0005/.005	.0005/.005	—	.001/.005

APPLICATIONS — "Structural" Quality is used in general structural applications where its greater strength permits reduction in weight by using smaller cross-sectional areas. It is intended for welded construction where welding procedures are suitable to maintain the properties of the plate. Such applications include bridge and building members, body and frame members for earth-moving and transportation equipment, and components for heavy machinery.

MECHANICAL PROPERTIES — Applicable to "Structural" Quality.

ASTM A 514 Grade	Thickness	Yield Strength (psi) Minimum	Tensile Strength (psi)	Elongation in 2" Min.	Reduction of Area Min. 3/4" & Under	Reduction of Area Min. Over 3/4" Thick
B & C	Up to 1 1/4" incl.	100,000	110/130,000	18%	40%	50%
H	Up to 2" incl.	100,000	110/130,000	18%	40%	50%
F	Up to 2 1/2" incl.	100,000	110/130,000	18%	40%	50%
Q	Up to 2 1/2" 6" incl.	90,000	100/130,000	16%	—	50%

FORMING — "Structural" Quality material is readily cold formed, provided sufficient power is available and allowance is made for greater spring back than with mild steel.

Thickness of Material	Minimum Radius
Up to 1" incl.	2 x thickness
Over 1" to 2" incl.	3 x thickness

Warm forming may be done at temperatures below 1100ºF without destroying the mechanical properties or toughness. Hot forming may be done at 1600º - 1800ºF, but the formed part must be heat treated to restore its original properties.

MACHINABILITY — Cutting speed of "Structural" Quality is approximately 40% of that of 1212, or 65 surface feet per minute.

WELDABILITY — Techniques similar to those used in structural carbon steels apply, but precautions must be exercised. Hydrogen must be kept out of the welding operation. Large sections or those under high restraint should be preheated to temperatures not exceeding 400ºF.

HEAT TREATING — Stress relieving may be performed, if necessary, by heating at temperatures up to 1100ºF. If "Structural" Quality material is heated over 1100ºF, it must be re-heat treated to restore the original strength.

Austenitize — 1650º - 1700ºF

Quench — Agitated Water

Temper — 1150º - 1250ºF

HEAT TREATED CONSTRUCTIONAL ALLOY PLATES

STOCK SIZES

Stocked in thicknesses from 3/16" to 6" and lengths up to 30'.
Stock widths are 72", 84", or 96", depending on thickness.

For weights, refer to Page 7 of Section D.

AR 235 ABRASION RESISTING STEEL

Plates — Sheets

Color Marking: Gray and Orange

Abrasion Resisting Steel AR 235 is a medium-carbon, high-manganese, product. It is a hard, tough, wear-resistant steel which is ductile enough to permit certain machining.The chemical composition of this grade provides a Brinell hardness of approximately 235 in the as-rolled condition, along with a tensile strength of approximately 115,000 psi.

ANALYSIS (Typical)

Carbon	Manganese	Phosphorus	Sulphur	Silicon
.40	1.50	.021	.028	.20

APPLICATIONS — Abrasion Resisting Steel will give two to ten times the life of Mild Steel when used in mixers, loaders, conveyors, scraper blades, dirt-moving equipment, dipper teeth, drag conveyor bottoms, mine screens, troughs, spouts, shovels, hoppers, dump truck bodies, concrete buckets, fan blades, ore skips, tail sluices, bucket lips, rock screens, loading chutes, agitator paddles, dredge pump liners, grinding pans, liner plates, tipple sluices, etc.

MECHANICAL PROPERTIES — Typical properties for ½" plate in the as-rolled conditions are:

Tensile Strength (psi)	Yield Strength (psi)	Elongation in 8"	Reduction of Area	Brinell Hardness
115,000	70,000	16%	35%	235

SHEARING and FLAME CUTTING — In shear cutting, the capacity rating of the shear should be discounted about 40%. Abrasion Resisting Steel can be readily cut with a gas torch but the extreme heat of the torch coming in contact with this hard metal has a tendency to harden the steel at point of contact, leaving an edge which is more difficult to machine. If flame cutting is necessary, it is recommended that an allowance of about ⅜" be made on all burned edges, followed by machine cutting inside the burned edges. Another method is to burn full to the size required and then grind off the oxidized edge. Either of these methods should eliminate the necessity of machine cutting through the burned edge. Some users prefer to preheat the edge that is to be flame cut to about 650ºF and normalize afterward. This eliminates grinding or machining the burned edge.

PUNCHING — Holes may be punched in thicknesses up to about ⅜". The capacity of the punch should be discounted about 40%. Holes in plates ⅜" and thicker should be drilled.

BENDING and FORMING — This steel, if not extremely cold, will take a 90º bend to a reasonable radius in thicknesses up to about ⅜" without fracture, providing it is bent slowly (by degree) until the forming has been completed. For more difficult forming and for all forming of heavier gauges, it should be heated and formed while hot. Hot forming should be done at about 1500ºF. If steel is allowed to cool slowly it will not lose its abrasive resisting qualities, nor should there be any cracking or distortion. High carbon steel such as this grade should not be worked by any method while extremely cold.

MACHINABILITY — This grade, due to its high hardness and toughness, is rather difficult to machine. However, the usual high-speed tools are more than capable of doing machine cutting when necessary.

AR 360 ABRASION RESISTING STEEL PLATES

Color Marking: Brown

Abrasion Resisting Steel is a medium-carbon, low-alloy steel that has been heat treated by quenching and tempering to develop high abrasion and impact resistance and high yield strength. Resistance to wear and abrasion is to a large degree a function of carbon content and hardness. This grade has a composition that is balanced to combine the desired properties with good welding and fabrication characteristics.

ANALYSIS (Typical Range)

C	Mn	P	S	Si	Cr	Mo
.25/.32	.40/.65	.035 Max.	.04 Max.	.20/.35	.80/1.15	.15/.25

APPLICATIONS — AR 360 is designed to provide the best in abrasion and impact resistance. Toughness is maintained while the high hardness contributes to excellent abrasion resistance.

MECHANICAL PROPERTIES — The following are typical properties that may be considered as representative:

Tensile Strength (psi)	Brinell Hardness
177,000	360

FORMING — Cold forming of AR 360 may be performed with the bending done at right angles to the direction of rolling. A generous forming radius should be used, preferably 10 times the plate thickness or greater. Allowance should be made for more springback. The edges should be ground to remove notches and the effects of burning.

Warm forming of this grade is not satisfactory because of the low temperature at which the tempering has been performed. Hot forming is easily accomplished in the 1600º - 1800ºF temperature range, but the formed part must be re-heat treated to restore its original properties.

WELDABILITY — This material may be welded with the usual production welding techniques. Hydrogen must be kept out of the welding operation. Low hydrogen electrodes such as E-100XX, E-110XX, or E-120XX are recommended. Preheating between 200ºF and 400ºF may be considered if a unique stress distribution pattern exists.

HEAT TREATING — This grade is water quenched from 1600º - 1650ºF. Tempering is usually performed between 700ºF and 1000ºF to obtain the required hardness.

AR 360 ABRASION RESISTING HEAT TREATED PLATES

Stocked in thicknesses from 1/4" to 1 1/2", widths up to 84", and lengths to 20'. For weights, refer to Pages 6 and 7 of Section D.

AR 400 ABRASION RESISTING STEEL PLATES

Abrasion Resisting Steel is a low-carbon, low-alloy steel that has been heat treated by quench and tempering to develop high abrasion resistance and high yield strength. Resistance to wear and abrasion is to a large degree a function of alloy content and hardness.

This grade has a composition balanced to combine the desired properties with good welding and fabrication characteristics.

ANALYSIS (Maximum % of Elements)

C	Mn	Si	Cr	Ni	B
.17	1.55	.55	.55	1.00	.0005/.005

MECHANICAL PROPERTIES — The following properties may be considered typical:

Tensile Strength (psi)	Brinell Hardness
200,000	400

FORMING — Cold forming of AR 400 may be performed with the bending radius done at right angles to the direction of rolling. A generous forming radius should be used, preferably 10 times the plate thickness or greater. Allowance should be made for more spring back. The edges should be ground to remove notches and the effects of burning.

Warm forming is not recommended due to the low tempering temperature used at heat treat. Hot forming at 1600º - 1800ºF is easily accomplished, however, material must be re-heat treated to restore properties.

WELDABILITY — This material is relatively weldable using standard welding techniques. Pre and post heating are recommended.

HEAT TREATING — This material is furnished in the water quench and tempered condition. Generally, this material is austenitized at 1600º - 1650ºF and water quenched followed by tempering between 700º and 1000ºF to obtain the desired hardness.

Other Hardness levels available upon request.

WELDABILITY — Abrasion Resisting Steel may be welded with proper precautions. Preheating is recommended, and after welding it is good practice to stress relieve or normalize. To normalize, heat to 1650°F and allow to cool slowly in air. Normalizing is sometimes omitted when the welded part is not subject to severe vibration and stress. However, normalizing will prevent cracks, give uniform structure, and will not reduce the abrasive-resisting qualities. The grade of welding rod to be used depends upon the thickness of section, design, service requirements, etc.

ABRASION RESISTING PLATES

Abrasion Resisting Plates are stocked in thicknesses from 3/16" to 1 1/2", widths up to 96", and lengths up to 360".

For weights refer to Section D, Pages 6 and 7.

ABRASION RESISTING SHEETS

Thickness	Width and Length	Est. Weight, Lbs. Per Sheet	Per Sq. Ft.
14 Ga.			
.0747"	36 x 144	112.50	3.125
	48 x 144	150.00	"
12 Ga.			
.1046"	48 x 144	210.00	4.375
11 Ga.			
.1196"	48 x 144	240.00	5.000
10 Ga.			
.1345"	48 x 120	225.00	5.625
	144	270.00	"

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