


# HOT-ROLLED STEELS



- Appliance Frames**
- Automotive**
- Construction**
- Shelving**
- Truck Frames**
- Floor Plate**



**HOT-ROLLED STEELS** meet strict chemistry and dimensional requirements in a wide variety of grades.

Consistency from coil to coil is maintained by applying ladle metallurgy and continuous casting to molten steel, plus rolling it on modernized hot strip mills.

This enables Cleveland-Cliffs to meet the most demanding customer specifications for hot bands, hot-rolled sheet coils, cut-and mill-edge coils, cut lengths and custom blanks. Pickling helps produce excellent strip surfaces.

# HOT-ROLLED STEELS

## Product Features

### FORMABILITY

Hot-rolled steels can be used to produce parts containing simple bends, as well as drawn parts.

### THICKNESS CONTROL

A computerized automatic gauge control system assures that Cleveland-Cliff's hot-rolled steels have excellent thickness control.

### WELDABILITY

Hot-rolled steels can be joined using accepted welding practices.

### WIDE VARIETY OF GRADES AND SIZES AVAILABLE

A wide variety of Hot-rolled steels are available in thicknesses of 0.071 – 0.75 in. (1.80 – 19.05 mm) and widths of 30 – 80 in. (1016 – 2032 mm), depending on thickness.

## Process

Cleveland-Cliffs is committed to producing top quality products by utilizing modern, well-maintained equipment. This begins with quality slabs produced by continuous casting producing a uniform chemistry for hot-rolled Steel. The hot strip mill is designed to produce consistent surface quality, uniform mechanical properties, and consistent thickness and crown. Walking beam furnaces minimize surface damage during slab reheating. Scale breakers remove heavy furnace scale and provide a uniform surface for rolling. Strip temperatures are controlled at critical points during rolling to produce the desired mechanical properties. The finishing mill produces excellent thickness and crown control on all Cleveland-Cliffs hot-rolled Steels. Finally, pickling can be used to remove the oxide that forms during hot rolling.

## Joining Systems

Most hot-rolled steels can be readily fabricated using a variety of welding and joining processes. This is largely due to the low carbon (C) and alloy content, strength levels and low impurity characteristics of these materials. Depending on gauge, surface conditions (pickled or unpickled) and joint design, suitable processes include arc welding, resistance welding, brazing, and soldering.

Resistance spot/seam/projection welding, soldering, and brazing normally are incompatible with unpickled hot-rolled steel. However, many arc welding processes which utilize consumable filler materials can be used successfully on unpickled (referred to as "black") hot-rolled steels.

Additional factors must be considered when welding medium carbon and high strength hot-rolled grades. Technical assistance is available to select appropriate welding techniques for these steels.

## HOT-ROLLED STEELS

### Formability and Mechanical Properties

The formability of all steel products is a result of the interaction of many variables. These variables include: the mechanical properties of the steel, the forming system (tooling) used to manufacture parts and the lubrication used during forming. Cleveland-Cliffs can directly affect the mechanical properties of the steel. Tight control over chemical composition and hot rolling parameters allows the production of high quality hot-rolled steel products to meet customer requirements.

#### **COMMERCIAL STEEL (CS)**

Commercial Steel (CS Type B) should be used for moderate forming or bending applications. Commercial Steel products are produced from continuously cast slabs and unless otherwise specified, have a carbon content of less than 0.15% C.

#### **DRAWING STEEL (DS)**

For more severe forming applications, Drawing Steel (DS Type B) can be ordered. DS has a controlled carbon content of less than 0.08% C. For more formability and minimization of coil breaks, DS with boron (B) can be ordered. Typical mechanical properties are shown in Table 1, page 3.

#### **HIGH STRENGTH ALLOY STEEL (HSLAS)**

For high strength or Structural Steel (SS) applications, hot-rolled steels are also available (shown in Table 2). HSLAS is intended for applications where greater strength or weight savings are important.

The increased strength of HSLAS is achieved from niobium (Nb) or vanadium (V) additions. Two classes are available, Class 1 and Class 2. Structural Steel is available for structural purposes where specific mechanical properties are required. Strength is achieved primarily by carbon and manganese (Mn) additions.

#### **PRESS HARDENABLE STEEL (PHS)**

Press Hardenable Steel, commonly referred to as Mn22B5 or 15B22, is available as hot-rolled black or pickled and oiled. This material is used in hot-stamping applications to achieve final ultimate tensile strength approaching 1500 MPa.

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## PAINTABILITY

Unpickled hot-rolled steels are normally unsuitable for painting. hot-rolled pickled steel provides a suitable surface for painting, provided proper care is taken in preparing the material. Prior to painting, the surface should be carefully cleaned with either a solvent or alkaline cleaner. Cleaning should be followed by a pretreatment prior to painting. Zinc (Zn) or iron phosphates give good results on hot-rolled steels. Mild abrasion prior to pre-treating may also be used to enhance mechanical bonding of the paint.

## APPLICATIONS

Hot-rolled steels are used where heavy thickness, strength levels, and formability are required. Many unexposed structural applications exist in automotive, appliance and manufacturing markets. These include frame components, brackets, brake components, wheels, clutch plates, tubing and compressor shells. Construction, industrial machinery, agricultural equipment, railroad and ship building are all areas where hot-rolled steels are used for panels, frames and component parts.

## ENGINEERING PROPERTIES

Young's Modulus of Elasticity	200 x 10 <sup>3</sup> MPa at 20 °C
Density	7.87 g/cm <sup>3</sup> at 20 °C
Coefficient of Thermal Expansion	Low-Carbon/HSLAS: 12.4 μm/m/°C in 20 – 100 °C range I-F Steel: 12.9 μm/m/°C in 20 – 100 °C range
Thermal Conductivity	Low-Carbon/HSLAS: 89 W/m°C at 20 °C I-F Steel: 93 W/m°C at 20 °C
Specific Heat	481 J/kg/°C in 50 – 100 °C range
Electrical Resistivity	0.142 μΩ·m at 20 °C

## SPECIFICATIONS

Hot-rolled steels are produced in conformance to the following specifications:

ASTM A568	General requirements
ASTM A1011	CS/DS/SS/HSLAS
ASTM A635	Heavy gauge HR General Requirements
ASTM A659	CS Carbon (0.16 – 0.25%)
SAE J1392	HSLAVSS
SAE J2340	HSLA
SAE J403	Carbon steels to 1080
SAE J404	Alloy steels (please inquire)
JIS G3113	Structural Uses
JIS G3134	High Strength Structural

*For any specifications not listed here, contact your Cleveland-Cliffs sales representative.*

# HOT-ROLLED STEELS

## OUTSIDE PROCESSING

Tailored blanks, tension leveling, re-squaring, slitting, cut-to-length and coil coating are just some of the services Cleveland-Cliffs can provide through arrangements with outside processors.

## TECHNICAL ASSISTANCE

Cleveland-Cliffs' technical representatives can provide you with more detailed information concerning this product. They also are available to assist you in reviewing any welding, forming, painting or other material selection issue.

## MILL LIMITS

Hot-rolled steels are available in thicknesses of 0.071 – 0.75 in. (1.80 – 19.05 mm) and widths of 30 – 80 in. (1016 – 2032 mm) depending on dimension and product quality. For sizes outside of these limits, please contact your Cleveland-Cliffs sales representative.

The standard inner diameter of hot-rolled pickled coils is 24 in. (610 mm), while hot bands have inside diameters of 30 in. (762 mm).

Thickness, width, and flatness tolerances are covered in ASTM A568 or A635.

## Tables

**TABLE 1 – TYPICAL MECHANICAL PROPERTIES – STANDARD GRADES**

Quality Designation	Description	YS		UTS		% Elong. in 2"	Rockwell Hardness
		ksi.	MPa	ksi.	MPa		
Commercial Steel (CS Type B)	May be moderately formed. A specimen out in any direction can be bent flat on itself without cracking.	36	248	51	351	37	B61
Drawing Steel DS (DS Type B)	Type B is made by adding aluminum to the molten steel and may be used in drawing applications.	33	220	49	338	39	B56
Drawing Steel with Boron (DS Type B with B)	DS is made by adding aluminum and boron to the molten steel and may be used in drawing applications.	30	210	45	310	40	B50

*Typical properties produced by Cleveland-Cliffs for these grades.*

*Commercial Steel and Drawing Steel are designations of the various steels described in A1011 and A1018. Each of these steel sheet designations is associated with unique requirements for chemical composition and with non-mandatory, typical mechanical properties. SS and HSLAS are required to meet mandatory mechanical property requirements and chemical requirements.*

# HOT-ROLLED STEELS

## Tables

TABLE 2 – ASTM PROPERTIES – HIGHER STRENGTH GRADES

Structural Steel (SS)	Min. YS		Min. UTS		A1011 Min. Elong. % 0.071 - < 0.097 in.	A1011 Min. Elong. % 0.097 - <0.230 in.	A1018 Min. Elong. %
	ksi.	MPa	ksi.	MPa			
Grade 30	30	205	49	340	24	25	22
Grade 33	33	230	52	360	22	23	22
Grade 36 (Type 1)	36	250	53	365	21	22	21
Grade 36 (Type 2) for conversion to A36	36	250	58 - 80	400 - 550	20	21	19
Grade 40	40	275	55	380	20	21	21
Grade 45 (Type 1)	45	310	60	410	18	19	18
Grade 50	50	340	65	450	16	17	—
Grade 55	55	380	70	480	14	15	—
High Strength Low Alloy Steel (HSLAS)	Min. YS		Min. UTS		A1011 Min. Elong. % 0.071 - < 0.097 in.	A1011 Min. Elong. % 0.097 - <0.230 in.	A1018 Min. Elong. %
	ksi.	MPa	ksi.	MPa			
CLASS 1							
Grade 45	45	310	60	410	23	25	22
Grade 50	50	340	65	450	20	22	20
Grade 55	55	380	70	480	18	20	18
Grade 60	60	420	75	520	16	18	16
Grade 65	65	450	80	550	14	16	—
CLASS 2							
Grade 45	45	310	55	380	23	25	22
Grade 50	50	340	60	410	20	22	20
Grade 55	55	380	65	450	18	20	18
Grade 60	60	410	70	480	16	18	16
Grade 65	65	450	75	520	14	16	—
High Strength Low Alloy Steel (HSLAS)	Min. YS		Min. UTS		A1011 Min. Elong. % 0.071 - < 0.097 in.	A1011 Min. Elong. % 0.097 - <0.230 in.	A1018 Min. Elong. %
	ksi.	MPa	ksi.	MPa			
Grade 50F	50	340	60	450	22	24	22
Grade 60F	60	410	70	520	20	22	16
Grade 70F	70	480	80	550	18	20	12
Grade 80F	80	550	90	620	16	18	12



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## Tables

TABLE 3 – JIS HIGH STRENGTH AND ADVANCED HIGH STRENGTH GRADES

Structural Steel (JIS G3113)	Min. YS						Min. UTS		Min. Elongation					
	t < 6.0 mm		6.0 mm ≥ t < 8.0 mm		8.0 mm ≥ t ≤ 14.0 mm				1.6 mm ≥ t < 2.0 mm	2.0 mm ≥ t < 2.5 mm	2.5 mm ≥ t < 3.15 mm	3.15 mm ≥ t < 4.0 mm	4.0 mm ≥ t < 6.3 mm	6.3 mm ≥ t ≤ 14.0 mm
	ksi	Mpa	ksi	Mpa	ksi	MPa	ksi	Mpa						
SAPH 310	—	—	—	—	—	—	45	310	33	34	36	38	40	41
SAPH 370	33	225	33	225	31	215	54	370	32	33	35	36	37	38
SAPH 400	37	255	34	235	34	235	58	400	31	32	34	35	36	37
SAPH 440	44	305	43	295	40	275	64	440	29	30	32	33	34	35

High Strength Steel (JIS G3134)	Min. YS		Min. UTS		Min. Elongation				Other
	ksi	Mpa	ksi	Mpa	1.6 mm ≥ t < 2.0 mm	2.0 mm ≥ t < 2.5 mm	2.5 mm ≥ t < 3.25 mm	3.25 mm ≥ t ≤ 6.0 mm	Min. Hole Expansion Ratio
SPFH 490	47	325	71	490	22	23	24	25	—
SPFH 540	52	355	78	540	21	22	23	24	—
SPFH 590	61	420	86	590	19	20	21	22	—
SPFH 590FB	61	420	86	590	19	20	21	22	65%



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## Tables

**TABLE 4 – LINE PIPE API**

X42	Inquire
X46	Inquire
X52	Inquire
X56	Inquire
X60	Inquire
X65	Inquire
X70	Inquire
X80	Inquire

### **About Cleveland-Cliffs Inc.**

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials and direct reduced iron 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 steel supplier to the automotive industry in North America. Headquartered in Cleveland, Ohio, Cleveland-Cliffs employs approximately 25,000 people across its mining, steel and downstream manufacturing operations in the United States and Canada.



#### **CLEVELAND-CLIFFS INC.**

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