HEAVY PLATES

USIMINAS

USIMINAS

INDEX

7 Complete Solutions in Steel

9 **HEAVY PLATES**

11 Production Processes

15 Steels for General Use

17 Steels for Shipbuilding and Offshore Platforms

21 Atmospheric Corrosion Resistant Steels

23 Steels for Pressure Vessel and Boiler

29 Structural Steels

39 Structural Steels - High-Strength and Weldable

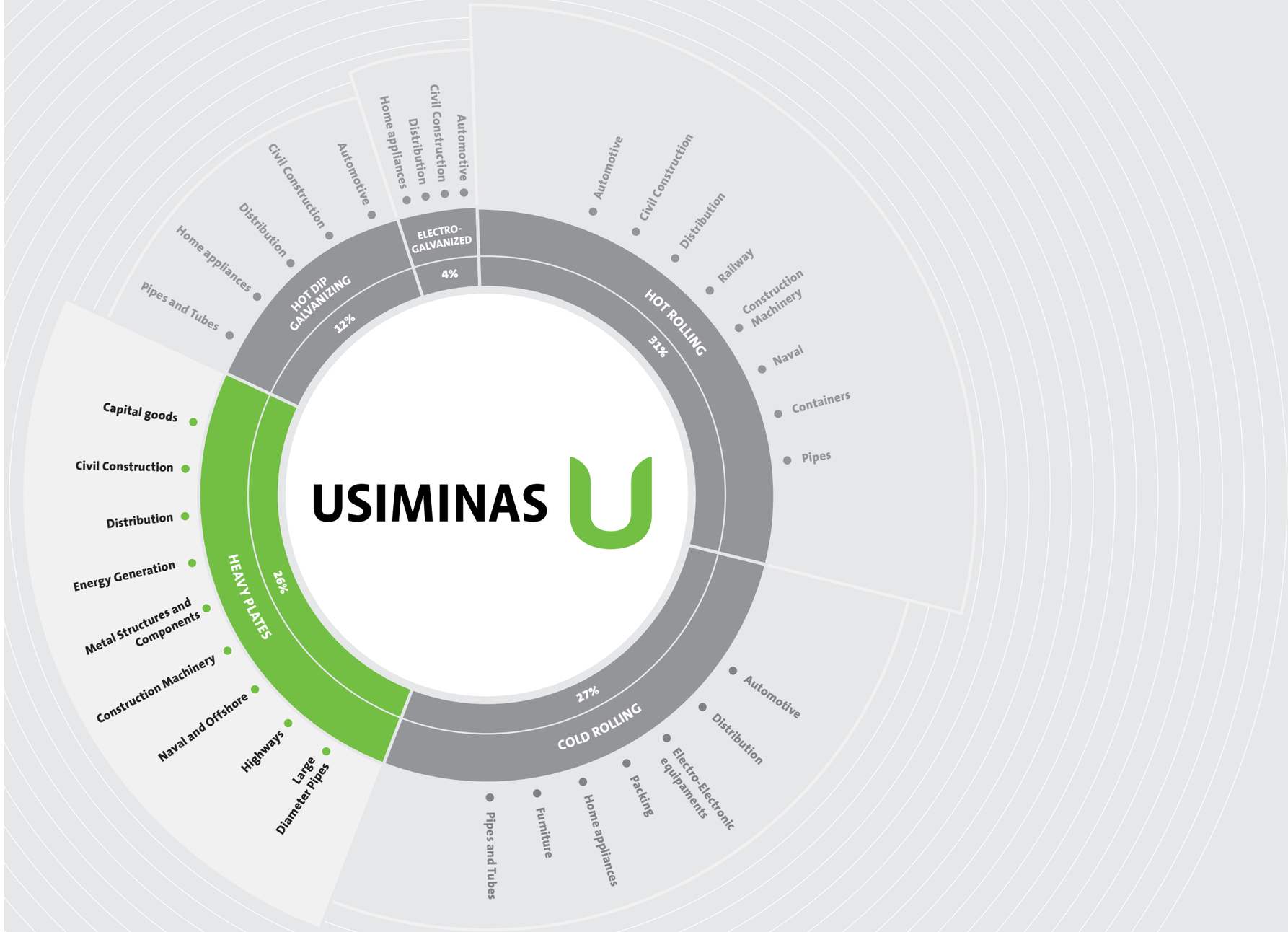
41 Steels for Agricultural and Construction Machinery

43 Wear Resistant Steels

45 Steels for Large Diameter Pipes

46 Finishing and Supply Conditions

CUIDADO
ATENÇÃO
ANTES DE EXECUTAR A TAREFA FAÇA ANÁLISE DE RISCO
CUIDADO
PERIGO



COMPLETE **SOLUTIONS IN STEEL**

WHEN THE STEEL IS FROM USIMINAS, QUALITY COMES FIRST.

Usiminas is a leading producer of flat steel in the Americas. There are units in six states of the country working on an integrated basis to deliver differentiated products and services.

A broad portfolio – from plates to coated cold rolling sheets - adds value to various strategic sectors of the economy, such as automotive, marine, oil and gas, civil construction, machinery and equipment, home appliances, distribution, among others.

Usiminas offers innovative steels resulting a historical vocation to technological research and developed in accordance with market needs and trends.

In the segment of **Heavy Plates**, Usiminas has production lines with the use of controlled rolling and thermal treatment, and of controlled rolling and accelerated cooling. These combinations produce quality steel at different levels of mechanical strength. Technology, quality and innovation mark Usiminas's commitment to excellence and to supporting the development of Brazil.

HEAVY PLATE

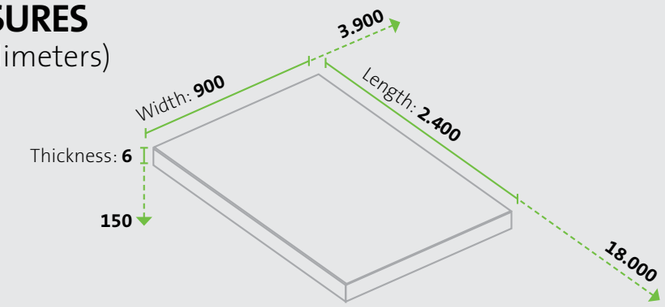
Heavy plates are high quality flat products available in thickness ranging from 6.00 to 150.00 mm, and widths ranging from 900 to 3,900 mm, and lengths from 2,400 to up to 18,000 mm. Thickness limitations may exist due to the desired mechanical characteristics or standard requirements, the application, or even the manufacturer operating conditions.

This type of product is intended to civil construction, shipbuilding, offshore platform, wind towers, industrial equipment, large-diameter pipes, highway machinery, agricultural machinery, boilers and pressure vessels, as well as in applications where excellent wear resistance is needed.

These steels can be produced by means of Conventional Rolling, Controlled Rolling or Controlled Rolling + Accelerated Cooling (TMCP – Thermomechanical Control Process). Heat treatments for Normalizing, Quenching, and Quenching & Tempering may also be utilized.

The TMCP process adopted by Usiminas uses CLC technology (Continuous Online Control) developed and patented by Nippon Steel & Sumitomo Metal Corporation, which consists of the combined use of secondary refining process, controlled rolling and accelerated cooling. This process allows the reduction of carbon equivalent and obtainment of refined microstructures, promoting excellent toughness of the steel at low temperatures and excellent weldability. By means of this process, premium quality heavy plates of the Sincron Steels series are produced which are widely used in shipbuilding, offshore platforms, civil construction and in machinery.

AVAILABLE MEASURES
(in millimeters)



STANDARDS AND SPECIFICATIONS

Usiminas supplies steels under many specifications. Below are given the most used.

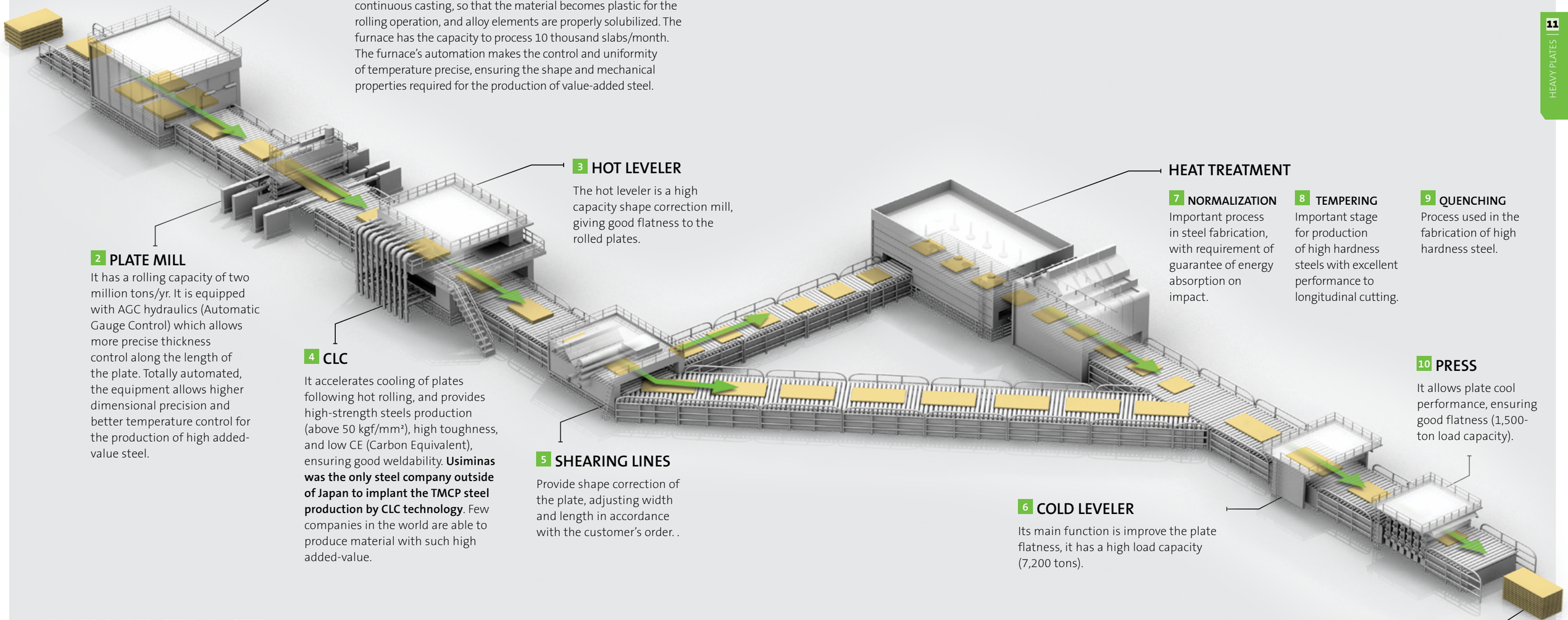
Usiminas	USI
American Society for Testing and Materials	ASTM
European Standard	EN
Japanese Industrial Standard	JIS
Brazilian Standard	NBR
Society of Automotive Engineers	SAE

This catalogue mentions heavy plate steel with chemical composition and mechanical characteristics produced by Usiminas, through their specifications or according to the beside-mentioned standards. It is important to highlight that this catalogue indicates basic information about these standards.

HEAVY PLATE PRODUCTION

1 WALKING BEAM FURNACE

Its function is to reheat the slabs produced in the steel shop, via continuous casting, so that the material becomes plastic for the rolling operation, and alloy elements are properly solubilized. The furnace has the capacity to process 10 thousand slabs/month. The furnace's automation makes the control and uniformity of temperature precise, ensuring the shape and mechanical properties required for the production of value-added steel.



2 PLATE MILL

It has a rolling capacity of two million tons/yr. It is equipped with AGC hydraulics (Automatic Gauge Control) which allows more precise thickness control along the length of the plate. Totally automated, the equipment allows higher dimensional precision and better temperature control for the production of high added-value steel.

3 HOT LEVELER

The hot leveler is a high capacity shape correction mill, giving good flatness to the rolled plates.

4 CLC

It accelerates cooling of plates following hot rolling, and provides high-strength steels production (above 50 kgf/mm²), high toughness, and low CE (Carbon Equivalent), ensuring good weldability. **Usiminas was the only steel company outside of Japan to implant the TMCP steel production by CLC technology**. Few companies in the world are able to produce material with such high added-value.

5 SHEARING LINES

Provide shape correction of the plate, adjusting width and length in accordance with the customer's order. .

6 COLD LEVELER

Its main function is improve the plate flatness, it has a high load capacity (7,200 tons).

HEAT TREATMENT

7 NORMALIZATION

Important process in steel fabrication, with requirement of guarantee of energy absorption on impact.

8 TEMPERING

Important stage for production of high hardness steels with excellent performance to longitudinal cutting.

9 QUENCHING

Process used in the fabrication of high hardness steel.

10 PRESS

It allows plate cool performance, ensuring good flatness (1,500-ton load capacity).

THE PROCESS, STEP-BY-STEP

1 The furnace reheats the slabs to the proper temperature (between 1050ºC and 1250ºC) for the rolling process and causes the dissolution of impurities formed during previous solidification process.

2 Rolling of slabs into plates performed with the dimensions required in the customer's order. An important stage to achieve the mechanical properties required, such as grain refinement.

3 Flatness correction of the rolled plate.

4 Accelerated cooling of the plates (with water) which has the objective of obtaining mechanical properties required in the final product by means of microstructure control. It allows the obtainment of steel that is tougher and more resistant while using low carbon equivalent alloy project. .

5 The tip is cut at the width and length requested by the customer. Then, the material is inspected for dimensions, flatness and superficial aspect.

6 Correct any flaws regarding shape, allowing compliance to strict flatness requirement.

7 Heat treatment consisting of steel austenitization on temperatures around 910ºC. The purpose is to obtain greater uniformity of the material structure, allowing greater toughness of the material.

8 Basically consists of heating the plate at a temperature of 910ºC and cooling it using water spray. This process aims to increase the steel hardness.

9 This is a continuation of the quenching process which aims to relieve residual tension and reduce a little the hardness of the quenched plate, avoiding cracking.

10 Fine correction of flatness.

FINAL PRODUCT:

HEAVY PLATE

STEELS **FOR GENERAL USE**

These steels are employed in structural components and parts of mobile or fixed equipment, with guarantee only of their chemical composition.

These materials are produced through conventional rolling. In this category, in addition to steel described by specification SAE J 403, are included steels for construction of galvanizing vats (USI-GV).

Designation*	Steel Grade	Thickness Range (mm)	Chemical Composition (% in bulk)				
			C	Mn	P	S	Other
USI-GV	-	6.00 ≤ E ≤ 101.60	0.08 máx.	0.45 máx.	0.035 máx.		
SAE-J403	1006	6.00 ≤ E ≤ 101.60	0.08 máx	0.45 máx.	0.030 máx.	0.035 máx.	(1)
	1008		0.10 máx.	0.50 máx.			
	1010		0.08 ~ 0.13	0.30 ~ 0.60			
	1012		0.10 ~ 0.15				
	1015		0.13 ~ 0.18				
	1020		0.18 ~ 0.23				
	1021		0.18 ~ 0.23	0.60 ~ 0.90			
	1023		0.20 ~ 0.25	0.30 ~ 0.60			
	1025		0.22 ~ 0.28				
	1030		0.28 ~ 0.34				
	1035		0.32 ~ 0.38				
	1040		0.37 ~ 0.44				
	1045		0.43 ~ 0.50				
	1050		0.48 ~ 0.55	0.60 ~ 0.90			
	1055		0.50 ~ 0.60				
	1060		0.55 ~ 0.65				
	1065		0.60 ~ 0.70				
	1070		0.65 ~ 0.75				
	1524		0.19 ~ 0.25	1.35 ~ 1.65			

* Standards quoted for reference only. Please contact Usiminas for other specifications.
(1) Other chemical elements acording to standard and customer specifications.

STEELS **FOR SHIPBUILDING** AND **OFFSHORE PLATFORMS**

This class of steel is destined to ship hulls and vessels in general as well as for several types of marine structures especially offshore fixed, semi-submersed, TLPs (tension leg platform), FPSOs (floating production, storage and offloading), self-elevating, and drilling ships platforms, in which the requirement of mechanical properties guarantee of welded joints is required. Shipbuilding steel is generally regulated by the ASTM Standard, or by international classification entities, like: American Bureau of Shipping (ABS), Bureau Veritas (BV), Det Norske Veritas (DNV), Germanischer Lloyd (GL), Lloyd's Register of Shipping (LR) and Nippon Kaiji Kyokai (NK), among others. Usiminas is certified by the main naval classifying entities.

For this application, Usiminas produces steel of medium and high mechanical strength with limitation of carbon equivalent. They are produced under several conditions: conventional rolling, controlled rolling, controlled rolling + accelerated cooling, or normalizing heat treatment. The steels for the shipbuilding sector have excellent cleanliness, good toughness at low temperatures, adequate tensile properties in the direction of thickness – "Z" test, good internal quality by ultrasonic testing, and be approved by special tests, when required, such as DWTT (Drop Weight Tear Test) and CTOD (Crack Tip Opening Displacement). These materials should also present excellent weldability, considering the wide variety of welding processes used in shipbuilding.

A highlight for this type of application is the Sincron Shipbuilding and Offshore line (*), which, due to lower carbon equivalent and refined microstructure, provides excellent toughness in the HAZ (Heat Affected Zone) even with the use of high heat input rates.

Specifically for offshore applications, Usiminas offers the API 2W standard steels in its portfolio, which have special characteristics of low carbon equivalent, refined microstructure, high toughness at low temperatures, excellent resistance in the direction of thickness – "Z" test – and higher weldability compared to equivalent steel of the API 2H or 2Y standard. This class of steel is produced by TMCP (Thermomechanical Control Process), through controlled rolling + accelerated cooling, in complement to the Sincron Shipbuilding and Offshore line (*).

The following table illustrates the main steels grade produced by Usiminas destined for shipbuilding and offshore platforms.

(*) For further information on the Sincron Shipbuilding and Offshore line and API 2W, see the Sincron catalogue.

Steel Grade	Thickness Range (mm) (1)	Chemical Composition (% mass)						Mechanical Properties						Charpy	
		C	Si	Mn	P	S	Other	Ceq %	YS (MPa)	TS (Mpa)	Tensile			T (ºC)	Minimum Energy (J)
											Thickness (mm)	Gauge Length (mm)	%		
A	6.00 ≤ E ≤ 80.00	0.21 máx.	0.50 máx.	2.5 x C mín.	0.035 máx.	0.035 máx.	(2)	0.40 máx.	235 mín.	400 ~ 520	(3)	200	16	-	-
B				0.60 mín.										0	27
D			0.35 máx.	0.60 mín.										-20	
E				0.70 mín.										-40	
AH-32		0.18 máx.	0.50 máx.	0.70 ~ 1.60	0.035 máx.	0.035 máx.		0.36 máx.	315mín.	440 ~ 585		200	16	0	31
DH-32				0.90 ~ 1.60										-20	
EH-32				0.70 ~ 1.60										-40	
AH-36				0.90 ~ 1.60										0	
DH-36				0.70 ~ 1.60	0.035 máx.	0.035 máx.		0,38 máx.	355 mín.	490 ~ 620		200	15	-20	34
EH-36				0.90 ~ 1.60										-40	
AH-40				0.70 ~ 1.60	0.035 máx.	0.035 máx.		0.40 máx.	390 mín.	510 ~ 660		200	14	0	39
DH-40				0.90 ~ 1.60										-20	
EH-40				0.70 ~ 1.60										-40	
				0.90 ~ 1.60											
BS 4360/86 43 EE	6.00 ≤ E ≤ 76.20	Upon request													
BS 4360/87 50 D															
API 2H 50	9.50 ≤ E ≤ 50.80														
API 2W 50															
SINCRON AH32~EH40	12.00 ≤ E ≤ 50.00	See Sincron Shipbuilding and Offshore Steels brochure													

(1) BV, DNV, NK: Max. thickness = 51.00 mm. Upon permission, greater thicknesses can be used.
(2) Other chemical elements (such as Ni, Cu, Cr, Mo, V, Ti, and Nb) acording to standard specification.
(3) The elongation values may vary depending on the gauge length and the product thickness.
Notes:
(i) Tensile test direction: transverse for all grades and classification entities.
(ii) Charpy test direction: longitudinal for all grades and classification entities.
(iii) For ABS and NK: TS= 440~590 MPa (AH32, DH32, EH32).
(iv) For BV, TS, KR, and GL: TS= 440~570 MPa (AH32, DH32, EH32); TS= 490~630 MPa (AH36, DH36, EH36).
(v) For NK, consider Mn= 0.90~1.60 for any thickness range.
(vi) For NV, consider Mn ≥ 0.80% (6.00 ≤ AND ≤ 25.00); Mn ≥ 0.60% (25.01 ≤ AND ≤ 50.80); TS= 440~570 MPa (A32, D32, E32); TS= 490~630 MPa (A36, D36, E36).
(vii) Ceq: C+Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15.
(viii) Supply conditions for naval grade: As Rolled, Normalized, Controlled Rolling, Controlled Rolling + Accelerated Cooling (Sincron Line).
(ix) Narrowing Test Z25, Z35: AH32 to EH40.

ATMOSPHERIC CORROSION RESISTANT STEELS

This class is usually named weathering steels due to present highly resistant to atmospheric corrosion. Its application is very diversified such as in building, bridges, agricultural machinery, mining and rail cars, among others. These steels have good welding characteristics and has excellent adherence to paint application. In this class is highlighted the steel series developed by Usiminas, called USI SAC.

Designation	Steel Grade	Thickness Range (mm)	Chemical Composition (% mass)								Mechanical Properties						
			C	Si	Mn	P	S	Cu	Cr	Other	YS (MPa) (3)	TS (MPa) (3)	Tensile			Bending	
													Thickness (mm)	Gauge Length (mm)	Elongation (%)	Direction	Opening
USI SAC	300	6.00 ≤ E ≤ 101.60	0.20 máx.	0.50 ~ 1.50	1.50 máx.	0.010 ~ 0.060	0.020 máx.	0.05 ~ 0.40	≤ 0.60	(1)	300 mín.	400 ~ 550	(2)	200	16	T	1.5E
	350	6.00 ≤ E ≤ 101.60	0.25 máx.								350 mín.	500 ~ 650					
ASTM-A242	Tipo 1	6.00 ≤ E ≤ 19.50	0.15 máx.	-	1.00 máx.	0.15 máx.	0.05 máx.	≥ 0.20	-		345 mín.	480 mín.				-	-
		19.51 ≤ E ≤ 38.10									315 mín.	460 mín.					
		38.11 ≤ E ≤ 101.60									290 mín.	435 mín.					
ASTM-A588	B	6.00 ≤ E ≤ 50.80	0.20 máx.	0.15 ~ 0.50	0.75 ~ 1.35	0.040 máx.	0.05 máx.	0.20 ~ 0.40	0.40 ~ 0.70		345 mín.	485 mín.					

* Standards quoted for reference only. Please contact Usiminas for other specifications.
(1) Other chemical elements acording to standard specification.
(2) The elongation values may vary depending on the gauge length and the product thickness.
(3) Tensile test direction: transverse for all standards and quality grades.

STEELS FOR **PRESSURE VESSEL AND BOILER**

These steels are specially destined to fabrication of pressure vessels and boiler and they are classified by the ASTM standard and its respective corresponding ASME and EN 10028 standards by range of mechanical strength, and temperature and work pressures conditions. The main characteristic of this steel is its versatile performance regarding usage temperature from -60°C up to 500°C. Many supplementary requirement may requested for a pressure vessel and boiler steel as impact test at low temperatures (-40°C or lower), high temperature tensile test (300°C or higher), bending test, SPWHT (Simulated Post-Welding Treatment) and other more specific tests.

The steel grade chosen should take into account the decrease in the yield strength values due to operating temperatures.

Another important characteristic of this class of products is its good weldability, considering the processes employed in the manufacture of pressure vessels and boilers (Shielded Metal Arc, Submerged Arc and Flux Cored Arc Welding).

Depending on steel grade and on supplementary requirements, the materials of this class may be produced by means of conventional rolling and subsequent thermal treatments: normalizing or Q&T (quenching and tempering).

Main Applications for Boilers and Pressure Tanks

Use	**Low Pressure Requirement**	**Medium Pressure Requirement**	**Medium and high pressure requirement, where savings in weight are not important**	High pressure requirement, where savings in weight are important (supply as hardened and tempered)
Classe (LE)	Mín. 165 MPa	Mín. 220 MPa	Mín. 260 MPa	Mín. 690 MPa
Graus Típicos	ASTM A285 A	ASTM A516 60	ASTM A516 70	ASTM A517
Similares	ASTM A285 B e ASTM A516 55	ASTM A516 65, ASTM A285 C, ASTM A515 60/65 ASTM A455 e EN10028-2 16 Mo3	ASTM A299, ASTM A515-70, ASTM A537 CL1 e ASTM A621	USI-SAR-80T

Designation	Steel Grade	Thickness Range (mm)	Chemical Composition (% in bulk)						Mechanical Properties (Tensile)				
			C	Mn	Si	P	S	Other	YS (MPa)	TS (Mpa)	Elongation		
											Thickness (mm)	Gauge Length (mm)	(%) min
ASTM-A285 (2003)	A	6.00 ≤ E ≤ 50.80	0.17 máx.	0.90 máx.	-	0.035 máx.	0.035 máx.	(1)	165 mín.	310 ~ 450	(2)	200	27
	B	6.00 ≤ E ≤ 50.80	0.22 máx.						185 mín.	345 ~ 485			25
	C	6.00 ≤ E ≤ 50.80	0.28máx.						205 mín.	380 ~ 515			23
ASTM-A299 (2004)	A	6.00 ≤ E ≤ 25.40	0.26 máx.	0.90 ~ 1.40	0.15 ~ 0.40				290 mín.	515 ~ 655			16
		25.40 < E ≤ 50.80	0.28 máx.	0.90 ~ 1.50					275 mín.				
	B	6.00 ≤ E ≤ 25.40	0.28 máx.	0.90 ~ 1.40					325 mín.	550 ~ 690			
		25.40 < E ≤ 50.80	0.30 máx.	0.90 ~ 1.50					310 mín.				
ASTM-A455 (2003)	-	6.00 ≤ E ≤ 9.53	0.33 máx.	0.85 ~ 1.20	0.10 máx.				260 mín.	515 ~ 655			15
		9.53 < E ≤ 14.70							255 mín.	505 ~ 640			
		14.70 <E ≤ 19.05							240 mín.	485 ~ 620			
ASTM-A515 (2003)	60	6.00 ≤ E ≤ 25.40	0.24 máx.	0.90 máx.	0.15 ~ 0.40				220 mín.	415 ~ 550			21
		25.40 < E ≤ 50.80	0.27 máx.										
		50.80 < E ≤ 76.20	0.29 máx.										
	65	6.00 ≤ E ≤ 25.40	0.28 máx.						240 mín.	450 ~ 585			19
		25.40 < E ≤ 50.80	0.31máx.										
		50.80 < E ≤ 76.20	0.33 máx.										
	70	6.00 ≤ E ≤ 25.40	0.31máx.	1.20 máx.					260 mín.	485 ~ 620			17
		25.40 < E ≤ 50.80	0.33 máx.										
		50.80 < E ≤ 76.20	0.35 máx.										
ASTM-A516 (2006)	55	6.00 ≤ E ≤ 12.70	0.18máx.	0.60 ~ 0.90					205 mín.	380 ~ 515			23
		12.70 < E ≤ 50.80	0.20 máx.	0.60 ~ 1.20									
		50.80 < E ≤ 76.20	0.22 máx.										
	60	6.00 ≤ E ≤ 12.70	0.21máx.	0.60 ~ 0.90					220 mín.	415 ~ 550			21
		12.70 < E ≤ 50.80	0.23 máx.										
		50.80 < E ≤ 76.20	0.25 máx.										
	65	6.00 ≤ E ≤ 12.70	0.24 máx.	0.85 ~ 1.20					240 mín.	450 ~ 585			19
		12.70 < E ≤ 50.80	0.26 máx.										
		50.80 < E ≤ 76.20	0.28 máx.										
	70 (4)	6.00 ≤ E ≤ 12.70	0.27 máx.						260 mín.	485 ~ 620			17
		12.70 < E ≤ 50.80	0.28 máx.										
		50.80 < E ≤ 76.20	0.30 máx.										
ASTM-A537 (2006)	CL1	6.00 ≤ E ≤ 38.10	0.24 máx.	0.70 ~ 1.35	0.15 ~ 0.50				345 mín.	485 ~ 620			18
		38.70 < E ≤ 63.50		1.00 ~ 1.60					310 mín.	450 ~ 585			
		63.50 < E ≤ 101.60											
EN-10028-5 P355 (2003)	M / ML1 / ML2	12.00 ≤ E ≤ 40.00	0.16 máx.	1.70 máx.	0.55 máx.	0.025 máx.	0.015 máx.		355 mín.	450 ~ 610		$5.65\sqrt{S_o}$	22
		40.01 < E ≤ 65.00							345 mín.				
EN-10028-2-16Mo3 (2009)	-	6.00 ≤ E ≤ 16.00	0.12 ~ 0.20	0.40 ~ 0.90	0.35 máx.	0.025 máx.	0.010 máx.		275 mín.	440 ~ 590		$5.65\sqrt{S_o}$	22
		16.00 < E ≤ 40.00							270 mín.				
		40.00 < E ≤ 60.00							260 mín.				
		60.00 < E ≤ 76.20							240 mín.	430 ~ 580			

(1) Standards quoted for reference only. The corresponding ASME specification and other possible grades and tolerances supplied upon request.
(2) The elongation values may vary depending on the measure base and the product thickness.
(3) Tensile test direction: transverse for all standards and quality grades.
(4) Optional condition (upon request): accelerated cooling followed by tempering in offline fournace.

CONSUMABLES

Below, some examples are listed of consumables that may be employed for steel welding of grades ASTM A285-A/B/C, ASTM-A299, EN10028-2-16Mo3, ASTM-A515-60/65/70 and ASTM A516- 55/60/65/70. In most applications, this steel is weldable in the field, employing the coated electrode welding process. Consultation to consumables manufacturers is recommended, mainly when wire/gas combinations (MIG/MAG and tubular wire processes) and wire/flux (submersed arc process) are employed.

Welding Process	Consumables (AWS class)	ASTM A 285 A, B and C, ASTM A 299	DIN 17155-15Mo3	ASTM A515-60, 65 and 70	ASTM A516-55, 60, 65 and 70
Shielded metal arc welding	Welding electrode	E7016, E7018	E7018-A1, E70018-G	E7018-A1, E7018-G	E7018-M, E8018-D3 and E8018-C1
MIG/MAG	Welding wire	ER 70S-3 and ER 70S-6	ER70S-G and ER80S-D2	ER70S-3 and ER70S-6	ER 70S-G , ER80S-Ni1 and ER80S-G
	Welding gas (a)	CO_2 or mixtures $Ar+CO_2$ or $Ar+O_2$	CO_2	CO2 or mixtures $Ar+CO_2$ or $Ar+O_2$	Ar +1 ~ 5%O_2
Flux cored metal arc welding	Welding wire	E71T-1, E71T-4 and E71T-5	E70T5-A1,E71T1-G and E81T1-B1	E71T1-G and E81T1-B1	E80T5-Ni1 and E80T5-N
	Welding (a) (b)	CO_2	CO_2 or mixtures $Ar+CO_2$	CO_2 or mixtures $Ar+CO_2$	CO_2 or mixtures $Ar + CO_2$
Submerged arc welding	Wire/flux	F7xxEL12 F7xx-EM12k	F7x0-EA1-A1 F7x0-EG-G	F7xx-EA1-A1 F7xx-EG-G	F7P6-EA3-A3 F7P6-ENi1-Ni1 F7P6-EG-G

(a) For group G wires, the shielding gas used and the deposited metal toughness requirement shall be agreed upon between buyer and supplier.
(b) Flux cored type wires that not require shielding gas.

WELDING PROCEDURES

Preheating temperature for welding depends on several factors, especially chemical composition, plate thickness, heat input and consumables employed. This temperature can be estimated without the need of conducting tests through the procedure described in standard BS 5135:1984 – Process of arc welding of carbon and carbon manganese steels.

As an illustration, the chart at the side and above supply the preheating temperature for welding of boiler and pressure vessel steels in function of their thickness and carbon equivalent (CE), considering a heat input of 1.4kJ/mm and the employment of consumables with a diffusible hydrogen of approximately 5 to 10 ml/100g of metal deposited (the higher heat input used and/or lower the diffusible hydrogen, the lower the preheat temperature needed).

Plate Thickness (mm)	Preheat temperature (ºc) (B)										
	CE (a)	0.35	0.38	0.41	0.43	0.45	0.47	0.50	0.53	0.55	0.57
10.0	-	-	-	-	-	-	-	-	-	-	-
12.5	-	-	-	-	-	-	-	-	-	50	75
15.0	-	-	-	-	-	-	-	40	70	90	100
20.0	-	-	-	-	-	-	-	100	120	130	140
25.0	-	-	-	-	-	70	90	120	140	150	160
30.0	-	-	-	-	50	90	110	140	160	165	175
37.5	-	-	-	50	90	110	130	160	175	180	185
50.0 ~ 100.0	-	50	75	90	115	125	140	170	190	200	200

(a) Ceq (carbon equivalent)= C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15.
(b) Intermediate Ceq and/or thickness values may be interpolated.

Table application conditions (according to the BS 5135:1984 standard).

(1) Heat input (HI) equal to 1.4 kJ/mm.

HI (kJ/mm) = V.A.60/v.1000

Where:
V = welding voltage in volts.
A = welding current in amperes.
v = welding speed in mm/min.

(2) Diffusible hydrogen content from 5 to 10 mL/100 g of deposited metal - typical range of shielded arc welding processes with basic coated electrodes, recently taken from the packaging or subjected to redrying treatment, submerged arc welding with dry fluxes, and welding with hollow wire. Gas shielding welding processes provide diffusible hydrogen contents lower than 5 mL/100 g of deposited metal.

Steels for boilers and pressure vessels normally require the use of post-welding heat treatment. The most efficient method is stress relief treatment in the temperature range of 590°C to 680°C, with soaking time of 60 minutes for each 25 mm of plate thickness with a minimum soaking time of 60 minutes. An alternative, subject to customer approval, is the use of post-heating. Due to the large dimensions of the structures, this treatment is generally non-applicable; in this case, the use of post-treatment in the range of 150°C to 200°C with soaking time of 30 minutes for each 25 mm of plate thickness is suggested (minimum soaking time of 30 minutes).

The support in the specification of welding procedures may be made by inquiring Usiminas and/or the welding consumables suppliers.

Coated electrodes and submerged arc fluxes		
Storage	**Redrying**	**Maintenance**
In the original packaging, not violated, to a minimum temperature of 18° C and relative humidity 50% maximum.	Must be made in the case of damage to the packaging or the exposure of consumables to the environment for long periods. Employ the following procedures (or as recommended by the manufacturer): • Coated electrodes: 350ºc for 2 hours. • Fluxs: 250ºc for 2 hours. Note: cellulosic electrodes should not be dry.	i) after opening the package, keep the consumables between 100 and 120°C. ii) for use on open areas, the electrodes should be placed in portable ovens and removed only at the usage time. iii) electrodes and flus contaminated (oil, ink or grease) should be discarded.

Wires for submerged arc, MIG, MAG, and flux cored welding.
Wires shall be stored in a dry place and protected against contaminants such as dust, oil, and grease.

STRUCTURAL STEELS

These are low, medium and high strength microalloyed steels, produced by conventional rolling, controlled rolling or controlled rolling + accelerated cooling (TMCP). They are applied in structural components such as bridges, buildings, warehouses, wind towers, agricultural machinery, industrial and highway equipment.

The products of the civil construction line (USI series) are available in medium to high mechanical strength classes that show good weldability and better toughness.

Designation	Steel Grade	Thickness Range (mm)	Chemical Composition (% in bulk)						Mechanical Properties (Tensile)				
			C	Si	Mn	P	S	Other	YS (MPa)	TS (Mpa)	Thickness (mm)	Gauge Length (mm)	Elongation (%)
USI CIVIL	300	6.00 ≤ E ≤ 75.00	0.25 máx.	1.50 máx.	0.60 ~ 1.60	0.060 máx.	0.020 máx.	(1)	300 mín.	400 ~ 550	(2)	200	18
	350		0.20 máx.		0.60 ~ 1.80				350 mín.	500 ~ 650			16
SINCRON BHS	450M	12.00 ≤ E ≤ 60.00	See Sincron Structural Steels brochure										
SINCRON BHS	900T	12.00 ≤ E ≤ 50.00	See Sincron Structural Steels brochure										
ASTM-A36 (2008)	-	6.00 ≤ E ≤ 38.10	0.25 máx.	0.40 máx.	-	0.040 máx.	0.050 máx.	(1)	250 mín.	400 ~ 550	(2)	200	18
		38.11 ≤ E ≤ 63.50	0.26 máx.	0.15 ~ 0.40	0.80 ~ 1.20								
		63.51 ≤ E ≤ 101.60	0.27 máx.										
		101.61 ≤ E ≤ 150.00	0.29 máx.		0.85 ~ 1.20								

CONTINUA

Designation	Steel Grade	Thickness Range (mm)	Chemical Composition (% in bulk)						Mechanical Properties (Tensile)				
			C	Si	Mn	P	S	Other	YS (MPa)	TS (Mpa)	Thickness (mm)	Gauge Length (mm)	Elongation (%)
ASTM-A283 (2003)	A	6.00 ≤ E ≤ 38.10	0.14 máx.	0.40 máx.	0.90 máx.	0.035 máx.	0.040 máx.		165 mín.	310 ~ 415		200	25
		38.11≤ E ≤ 101.60		0.15 ~ 0.40									
	B	6.00 ≤ E ≤ 38.10	0.17 máx.	0.40 máx.					185 mín.	345 ~ 450			23
		38.11≤ E ≤ 101.60		0.15 ~ 0.40									
	C	6.00 ≤ E ≤ 38.10	0.24 máx.	0.40 máx.					205 mín.	380 ~ 515			20
		38.11≤ E ≤ 101.60		0.15 ~ 0.40									
	D	6.00 ≤ E ≤ 38.10	0.27 máx.	0.40 máx.					230 mín.	415 ~ 550			18
		38.11≤ E ≤ 101.60		0.15 ~ 0.40									
ASTM-A-284-90	C	6.00 ≤ E ≤ 25.4	0.24 máx.	0.15 ~ 0.40					205 mín.	415 mín.			19
		25.5 ≤ E ≤ 50.8	0.27 máx.										
		50.9 ≤ E ≤ 101.60	0.29 máx.										
	D	6.00 ≤ E ≤ 25.4	0.27 máx.						230 mín.				
		25.5 ≤ E ≤ 50.8	0.29 máx.										
		50.9 ≤ E ≤ 101.60	0.31 máx.										
ASTM-A514 (2005) (3)	B	6.00 ≤ E ≤ 31.75	0.12 ~ 0.21	0.20 ~ 0.35	0.70 ~ 1.00		0.035 máx.		690 mín.	760 ~ 895		50	16
	H	6.00 ≤ E ≤ 50.80			0.95 ~ 1.30								
ASTM-A572 (2007)	42	6.00 ≤ E ≤ 9.52	0.21 máx.	0.40 máx.	0.50 ~ 1.35	0.040 máx.	0.050 máx.	(1)	290 mín.	415 mín.	(2)	200	18
		9.53 ≤ E ≤ 38.10			0.80 ~ 1.35								
		38.11≤ E ≤ 101.60		0.15 ~ 0.40									
	50	6.00 ≤ E ≤ 9.52	0.23 máx.	0.40 máx.	0.50 ~ 1 .35				345 mín.	450 mín.			16
		9.53 ≤ E ≤ 38.10			0.80 ~ 1.35								
		38.11≤ E ≤ 101.60		0.15 ~ 0.40									
	60	6.00 ≤ E ≤ 9.52	0.26 máx.	-	0.50 ~ 1.35				415 mín.	520 mín.			13
		9.53 ≤ E ≤ 25.40			0.80 ~ 1.65								
ASTM-A573 (2005)	58	6.00 ≤ E ≤ 12.70	0.23 máx.	0.10 ~ 0.35	0.60 ~ 0.90	0.035 máx.	0.040 máx.		220 mín.	400 ~ 490			19
		12.71≤ E ≤ 38.10											
	65	6.00 ≤ E ≤ 12.70	0.24 máx.	0.15 ~ 0.40	0.85 ~ 1.20				240 mín.	450 ~ 530			16
		12.71≤ E ≤ 38.10	0.26 máx.										
	70	6.00 ≤ E ≤ 12.70	0.27 máx.						290 mín.	485 ~ 620			
		12.71≤ E ≤ 38.10	0.28 máx.										
CSA-G40-21-04	44W	6.00 ≤ E ≤ 38.10	0.22 max.	0.040 máx.	0.50 ~ 1.50 máx.	0.040 máx.	0.050 máx.		304 mín.	448 ~ 620 mín.			18
		38.11 ≤ E ≤ 50.80	0.23 max.	0.15 ~ 0.40					276 mín.				
EN-10025-2-S235 (4)	JR	6.00 ≤ E ≤ 16.00	0.17 máx.	-	1.40 máx.	0.035 máx.	0.035 máx.		235 mín.	360 ~ 510		5.65√S_o	22
		16.01≤ E ≤ 40.00							225 mín.				
		40.01≤ E ≤ 100.00	0.20 máx.						215 mín.				
		100.01≤ E ≤ 150.00							195 mín.	350 ~ 500			
	J0	6.00 ≤ E ≤ 16.00	0.17 máx.			0.030 máx.	0.030 máx.		235 mín.	360 ~ 510			
		16.01≤ E ≤ 40.00							225 mín.				
		40.01 ≤ E ≤ 100.00							215 mín.				
		100.01 ≤ E ≤ 150.00							195 mín.	350 ~ 500			
	J2	6.00 ≤ E ≤ 16.00	0.17 máx.			0.025 máx.	0.025 máx.		235 mín.	360 ~ 510			
		16.01≤ E ≤ 40.00							225 mín.				
		40.01≤ E ≤ 100.00							215 mín.				
		100.01≤ E ≤ 150.00							195 mín.	350 ~ 500			

CONTINUED

Designation	Steel Grade	Thickness Range (mm)	Chemical Composition (% in bulk)						Mechanical Properties (Tensile)				
			C	Si	Mn	P	S	Other	YS (MPa)	TS (Mpa)	Thickness (mm)	Gauge Length (mm)	Elongation (%)
EN-10025-2-S275 (4)	JR	6.00 ≤ E ≤ 16.00	0.21 máx.	-	1.50 máx.	0.035 máx.	0.035 máx.		275 mín.	410 ~ 560		$5.65\sqrt{S_o}$	20
		16.01≤ E ≤ 40.00							265 mín.				
		40.01≤ E ≤ 63.00	0.22 máx.						255 mín.				
		63.01≤ E ≤ 80.00							245 mín.				
		80.01≤ E ≤ 100.00							235 mín.				
	J0	6.00 ≤ E ≤ 16.00	0.18 máx.			0.030 máx.	0.030 máx.		275 mín.				
		16.01≤ E ≤ 40.00							265 mín.				
		40.01≤ E ≤ 63.00							255 mín.				
		63.01≤ E ≤ 76.20							245 mín.				
	J2	6.00 ≤ E ≤ 16.00				0.025 máx.	0.025 máx.		275 mín.				
		16.01≤ E ≤ 40.00							265 mín.				
		40.01≤ E ≤ 63.00							255 mín.				
		63.01≤ E ≤ 76.20							245 mín.				
EN-10025-2-S355 (4)	JR	6.00 ≤ E ≤ 16.00	0.24 máx.		1.60 máx.	0.035 máx.	0.035 máx.	(1)	355 mín.	490 ~ 610	(2)		18
		16.01≤ E ≤ 40.00							345 mín.				
		40.01≤ E ≤ 63.00							335 mín.				
		63.01≤ E ≤ 76.20							325 mín.				
	J0	6.00 ≤ E ≤ 16.00	0.20 máx.			0.030 máx.	0.030 máx.		355 mín.	470 ~ 630			
		16.01≤ E ≤ 40.00							345 mín.				
		40.01≤ E ≤ 63.00	0.22 máx.						335 mín.				
		63.01≤ E ≤ 76.20							325 mín.				
	J2	6.00 ≤ E ≤ 16.00	0.20 máx.			0.025 máx.	0.025 máx.		355 mín.				
		16.01≤ E ≤ 40.00							345 mín.				
		40,01≤ E ≤ 63.00	0.22 máx.						335 mín.				
		63.01≤ E ≤ 76.20							325 mín.				
	K2	6.00 ≤ E ≤ 16.00	0.20 máx.	0.55 máx.					355 mín.				
		16.01≤ E ≤ 40.00							345 mín.				
		40.01≤ E ≤ 63.00	0.22 máx.						335 mín.				
		63.01≤ E ≤ 76,20							325 mín.				
EN-10025-4-S355 (4) (8)	M	12.00≤ E ≤ 16.00	0.16 máx.		1.70 máx.	0.035 máx.	0.030 máx.		355 mín.	470 ~ 630		$5.65\sqrt{S_o}$	22
		16.01 ≤ E ≤ 40.00							345 mín.				
		40.01 ≤ E ≤ 80.00							335 mín.	450 ~ 610			
	ML	12.00≤ E ≤ 16.00				0.030 máx.	0.025 máx.		355 mín.	470 ~ 630			
		16.01 ≤ E ≤ 40.00							345 mín.				
		40.01 ≤ E ≤ 80.00							335 mín.	450 ~ 610			
EN-10025-4-S420 (8)	M	12.00≤ E ≤ 16.00	0.18 máx.		1.80 máx.	0.035 máx.	0.030 máx.		420 mín.	520 ~ 680			19
		16.01 ≤ E ≤ 40.00							400 mín.				
		40.01≤ E ≤ 60.00							390 mín.	500 ~ 660			
	ML	12.00≤ E ≤ 16.00				0.030 máx.	0.025 máx.		420 mín.	520 ~ 680			
		16.01 ≤ E ≤ 40.00							400 mín.				
		40.01≤ E ≤ 60.00							390 mín.	500 ~ 660			

CONTINUED

Designation	Steel Grade	Thickness Range (mm)	Chemical Composition (% in bulk)						Mechanical Properties (Tensile)				
			C	Si	Mn	P	S	Other	YS (MPa)	TS (Mpa)	Thickness (mm)	Gauge Length (mm)	Elongation (%)
EN-10025-4-S460 (8)	M	12.0 ≤ E ≤ 16.00	0.18máx.	0.65 máx.	1.80máx.	0.035 máx.	0.030 máx.	(1)	460 mín.	540 ~ 720	(2)	5.65√S_o	17
		16.01 ≤ E ≤ 40.00							440 mín.				
		40.01 ≤ E ≤ 60.00							430 mín.	530 ~ 710			
	ML	12.0 ≤ E ≤ 16.00				0.030 máx.	0.025 máx.		460 mín.	540 ~ 720			
		16.01 ≤ E ≤ 40.00							440 mín.				
		40.01 ≤ E ≤ 60.00							430 mín.	530 ~ 710			
IRAM IAS 500 - 42 (2003)	F-24	6.00 ≤ E ≤ 12.70	0.21máx.	0.35 máx.	-	0.030 máx.	0.035 máx.		235 mín. (E ≤ 16.00) 225 mín. (16.00 < E ≤ 63.00) 215 mín. (65.00< E ≤ 100.00)	360 ~ 510			16
		12.71 ≤ E ≤ 25.00	0.22 máx.										
		25.01 ≤ E ≤ 101.60	0.24 máx.										
	F-26	6.00 ≤ E ≤ 12.70	0.21máx.	0.35 máx.					250 mín. (E ≤ 16.00) 245 mín. (16.00 < E ≤ 63.00) 235 mín. (65.00 < E ≤ 100.00)	400 ~ 550			15
		12.71 ≤ E ≤ 25.00	0.22 máx.										
		25.01 ≤ E ≤ 101.60	0.25 máx.										
	F-30	6.00 ≤ E ≤ 12.70	0.21máx.	0.35 máx.					295 mín. (E ≤ 16.00) 285 mín. (16.00 < E ≤ 40.00) 275 mín. (40.00 < E ≤ 63.00) 265 mín. (63.00 < E ≤ 75.00)	450 ~ 600			
		12.71 ≤ E ≤ 25.00	0.23 máx.										
		25.01 ≤ E ≤ 76.20	0.25 máx.										
	F-36	6.00 ≤ E ≤ 12.70	0.22 máx.	0.55 máx.					355 mín. (E ≤ 16.00) 345 mín. (16.00 < E ≤ 40.00) 335 mín. (40.00 < E ≤ 63.00) 325 mín. (63.00 < E ≤ 75.00)	490 ~ 640		200	14
		12.71 ≤ E ≤ 25.00	0.24 máx.										
		25.01 ≤ E ≤ 76.20	0.25 máx.										
JIS-G-3101 (2004)	SS-330	6.00 ≤ E ≤ 16.00	-	-	-	0.050 máx.	0.050 máx.		205 mín.	330 ~ 430			21
		16.01 ≤ E ≤ 40.00							195 mín.				
		40.01 ≤ E ≤ 100.00							175 mín.				
	SS-400	6.00 ≤ E ≤ 16.00							245 mín.	400 ~ 510			17
		16.01 ≤ E ≤ 40.00							235 mín.				
		40.01 ≤ E ≤ 100.00							215 mín.				
	SS-490	6.00 ≤ E ≤ 16.00							285 mín.	490 ~ 610			15
		16.01 ≤ E ≤ 40.00							275 mín.				
		40.01 ≤ E ≤ 100.00							255 mín.				
	SS-540	6.00 ≤ E ≤ 16.00	0.30 máx.	-	1.60máx.	0.040 máx.	0.040 máx.		400 mín.	540 mín.			17
		16.01 ≤ E ≤ 100.00							390 mín.				

CONTINUED

* Standards quoted for reference only. ASME, JIS 3106, JIS 3136, NBR 6648, NBR 5000 specification and other possible grades and tolerances supplied upon request.
(1) Other chemical elements acording standard specification. For ASTM A514 quality, Grade A (H: 0.30~0.70; Mo: 0.15~0.25; Ti: 0.01~0.04; V: 0.03~0.08; B: 0.0005~0.0050).
(2) The elongation values may vary depending on the gauge length and the product thickness.
(3) Hardness guarantee for ASTM A514, Grade A and B, for thickness ≤19.05mm: 235-293 HRB.
(4) Guarantees and special requirements for EN 10025.
(5) Products in industrial development phase. Thickness range: 50.01 to 76.20 mm.

Designation	Charpy	Temperature (°C)	Minimum Energy (J)
10025 - 2	JR	No requirement	No requirement
	J0	0	27 J
	J2	-20	27 J
	K2	-20	40 J
10025 - 4	M	-20	40 J
	ML	-20	47 J

Designation	Grade	Thickness Range (mm)	Ceq
10025 - 2	S235	E ≤ 40.00	0.35%
		E > 40.00	0.38%
	S275	E ≤ 40.00	0.40%
		E > 40.00	0.42%
	S355	E ≤ 40.00	0.45%
		E > 40.00	0.47%
10025 - 4	S355M/ML	E ≤ 40.00	0.39%
		E > 40.00	0.40%
	S420 M/ML	E ≤ 40.00	0.43%
		E > 40.00	0.45%
	S460 M/ML	E ≤ 40.00	0.45%
		E > 40.00	0.46%

Grade	Thickness Range (mm)	Ceq
F24	16.01≤ E ≤ 12.70	0.44%
	12.71≤ E ≤ 25.00	0.45%
	E ≥ 76.20	0.48%
F26	16.01≤ E ≤ 12.70	0.45%
	12.71≤ E ≤ 25.00	0.50%
	E ≥ 76.20	0.52%
F30	16.01≤ E ≤ 12.70	0.52%
	12.71≤ E≤ 25.00	0.55%
	E ≥ 76.20	0.55%
F36	16.01≤ E ≤ 12.70	0.55%
	12.71≤ E ≤ 25.00	0.58%
	E ≥ 76.20	0.58%

NOTES:
(i) For EN 10025-2 S355 and EN 10025-2 S275 JR: Cmax. (Spec.> 30.00 mm)= 0.22% - Ceq: C+Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15
(ii) For IRAM IAS 500-42 (2003) - Bending requirement as specified.
(iii) For JIS G 3101 and USI CIVIL -
Longitudinal bending test requirement as specified.
(iv) Tensile test direction: transverse for all standards and quality grades, except for JIS3101: longitudinal.

STRUCTURAL STEELS HIGH-STRENGTH AND WELDABLE

This class of structural steel involves ultra high strength materials with guarantee of toughness at low temperatures and superior welding performance. They are produced by conventional rolling, controlled rolling (CR), controlled rolling + accelerated cooling (TMCP), normalizing or Q&T.

They are characterized by lower carbon equivalent which results in excellent weldability. Due to their characteristics, high-strength weldable structural steels are indicated for applications where strict safety and lighter structures are recommended. They are applied to bridges, viaduct, tractors, cranes, railcars, off-road trucks, wind towers and industrial equipment, among others.

Sincron Structural line products are particularly suited for this application because of their low level of carbon equivalent provide excellent toughness in the HAZ (Heat Affected Zone) even with the use of high deposition rates welding processes (high heat input).

Designation	Steel Grade	Thickness Range (mm)	Chemical Composition (% mass)							Mechanical Properties							
												Tensile			Charpy		Bending	
			C	Si	Mn	P	S	Other	Ceq (%)	YS (MPa)	TS (Mpa)	Thickness (mm)	GL (mm)	Elongation (%)	T (ºC)	Energy (J)	Direction	Opening
USI-SAR	50 (3)	6.00 ≤ E ≤ 30.00	0.18 máx.	0.55 máx.	1.80 máx.	0.030	0.030	(1)	0.45 máx.	330 mín.	500 ~ 620	(2)	200	20 mín.	0	35	T	2,0E to 4,0E (depending on the thickness)
		30.01 ≤ E ≤ 76.20	0.20 máx.															
	60 (4)	6.00 ≤ E ≤ 25.00	0.18 máx.		0.90 a 1.60				0.47 máx.	460 mín.	600 ~ 720			12 mín.			L	3.0E
	60T (5)	6.00 ≤ E ≤ 50.80	0.16 máx.		0.90 a 1.50				0.47 máx.		600 ~ 700			13 mín.	-10	45 (12<E<50.80mm)		1.5E (≤ 32mm)
	80T (6)	6.00 ≤ E ≤ 50.80	0.16 máx		0.60 a 1.20				0.44 máx.	700 mín.	800 ~ 950			10 mín.	-15	45 (≤32mm)		
	120T	6.00 ≤ E ≤ 50.80	upon request															
SINCRON WHS	500M	See Sincron Structural Steels brochure																
	600T																	
	700T																	
	800T																	
	1000T																	

(1) Other chemicals as per the reference specification.
(2) The elongation values may vary depending on the product thickness range.
(3) Nb + V: max. 0.12%. The Charpy test temperature for normalized material is -10°C. For thickness above 39.99mm, the material will be provided normalized.
(4) Nb + V: max. 0.15%. It may be supplied with a Charpy impact requirement.
(5): USISAR60T: Nb + V: max. 0.18%. - Cr max.: 0,35% - B: 0.0010 to 0.0030%. In the 12.00 - 50.80 mm range, it may be provided as direct hardening + drawing back.
(6) USISAR80T: V max.: 0,10% - B max.: 0,0060% - Cr: 0.40 to 1.00% - Mo: 0.25 to 0.60%. In the 12.00 - 50.80 mm range, it may be provided as direct hardening + drawing back. The Charpy test is performed to above 12,00 mm thickness . For lower thicknesses on request.
(7) Tensile test direction: transverse for all standards and quality grades.
(8) Ceq: C+Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15

STEELS FOR **AGRICULTURAL** AND **CONSTRUCTION MACHINERY**

This class is composed by medium to high strength structural steels that are characterized by better performance in terms of conformability and strength to cyclical stress (fatigue).

Special fabricating conditions give these steels high performance in forming processes, meeting bending requirements in the transversal direction at 180° in curvature radius of up to “0T” (T= plate thickness). These steels are specified under several standards with the most common ones being NBR 6656 and USI LN (Usiminas’ specification).

They are mainly applied in girders, beams, chassis and axles of agricultural machinery, tractors and highway implements.

Designation	Steel Grade	Thickness (mm)	Chemical Composition (% mass)						Mechanical Properties						
			C	Si	Mn	P	S	Other	YS (MPa	TS (Mpa)	Tensile (2)			Bending	
											Elongation (%)	Gauge Length (mm)	Elongation (%)	Direction	Opening
USI LN	380 500 600 700 900	6.30 ≤ E ≤ 15.00 8.00 ≤ E < 12.00	-	-	-	-	-	upon request							
NBR 6656-LNE	200	6.30 ≤ E ≤ 16.00	0.12 máx.	0.35 máx.	0.60 máx.	0.025 máx.	0.025 máx.	(1)	200 ~ 330	280 ~ 410	(2)	$5.65\sqrt{S_o}$	35	T	0E
	230		0.15 máx.		0.80 máx.				230 ~ 360	330 ~ 460			30		
	260				1.00 máx.				260 ~ 390	370 ~ 500					
	380				1.10 máx.				380 ~ 530	460 ~ 600					
	500	6.30 ≤ E ≤ 10.00 10.01 ≤ E ≤ 15.00	0.12 máx.		1.50 máx.		0.015 máx.		500 ~ 620	560 ~ 630			23		0.5E 1.5E

* Please contact Usiminas for other standart specifications.
(1) Others chemical elements can be cited in the original standard.
(2) Transverse direction.

WEAR RESISTANT STEELS

These materials are quenched steels with alloy element additions. Their main characteristic is high hardness that make them suitable for service with high mechanical wear.

In this class it can find materials presenting Brinell hardness in the range of 360 to 550 HB (Brinnel hardnes). These steels also have good weldability and can be supplied with guarantee of Charpy impact of –20°C (or lower in special cases).

They are applied in tractors, excavators, off-road truckbeds, shovels, channel linings, ore rail car, blast furnace components and industrial ventilators.

Steel Grade	Thickness Range (mm)	Ceq
400	E ≤ 19.05	0.38%
	E > 19.05	0.47%
450	E ≤ 19.05	0.46%
	E > 19.05	0.54%
500	E ≤ 19.05	0.63%
	E > 19.05	

Ceq: C+Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15

Designation*	Steel Grade	Thickness Range (mm)	Chemical Composition (% mass)								Hardness Brinell (HB)	Heat Treatment
			C	Mn	P	S	Ni	Cr	Mo	Other		
USI AR	400	6.00 - 50.80 (1)	≤ 0.19	1.40	0.025	0.010	-	0.40	-	(2)	360 ~ 440	(3)
	450		≤ 0.25	1.50			0.20	0.40	-		410 ~ 490	
	500		≤ 0.29	1.20			0.70	0.70	0.40		450 ~ 550	

(1) Other dimensions upon request.
(2) Other elements as B, Nb, and Ti, acording to USI AR standard specification. Please contact us for more details.
(3) In the thickness range: 8.00 - 50.80 mm, the grade 400 is hardening by direct quenching (CLC accelerated cooling), supllied under commercial surface condition.

For grade 450 in the 8.00 - 32.00 mm thickness range, hardening by accelerated cooling, under commercial surface condition.
Other thicknesses (grades 400 and 450) and for grade 500: stress relief + offline quenching.

STEELS **FOR LARGE DIAMETER PIPES**

These materials are medium and high mechanical strength steels produced by controlled rolling (CR – Controlled Rolling) or controlled rolling + accelerated cooling (TMCP – Thermomechanical Controlled Process).

The TMCP process adopted by Usiminas is the CLC technology – Continuous Online Control developed by Nippon Steel which consists of the combined use of processes of secondary refining, controlled rolling and accelerated cooling. This line also has the Sincron product that ensures better steel weldability.

These steels are destined for fabrication of large-diameter pipes, produced by UOE forming processes, and longitudinally welded by submersed arc for applications in pipes for oil & gas, ore and derivatives transportation.

In this class, the API standard (American Petroleum Institute) 5L series is highlighted. The main steel grades produced by Usiminas are: 5L- A, B, X42, X46, X52, X56, X60, X65, X70 and X80. They are steels with excellent forming, weldability and toughness at low temperatures.

Due to the construction and/or field operation conditions, additional characteristics of chemical composition, carbon equivalent, Charpy and DWTT testing are required, in addition to special guarantees, such as hydrogen-induced crack resistance (HIC) for “Sour Service” applications and CTOD (Crack Tip Opening Displacement). These steels are usually supplied with prior request.

Designation*	Steel Grade	Thickness Range (mm)	Chemical Composition (% mass)							Mechanical Properties (Tensile)				
			C	Si	Mn (mín.)	P	S	Other	Ceq %	YS (MPa)	TS (Mpa)	Elongation		
												Espessura (mm)	Gauge Length (mm)	(%)
API 5L*	B	6.30 ≤ E ≤ 38.10	≤ 0.22	≤ 0.45	≤ 1.20	≤ 0.025	≤ 0.015	(1)	(2)	245 ~ 450	415 ~ 760	(3)	50.80	25
	X 42 M	6.30 ≤ E ≤ 38.10			≤ 1.30					290 ~ 495				25
	X 46 M	6.30 ≤ E ≤ 38.10								320 ~ 525	435 ~ 760			24
	X 52 M	6.30 ≤ E ≤ 38.10			≤ 1.40					360 ~ 530	460 ~ 760			23
	X 56 M	6.30 ≤ E ≤ 38.10								390 ~ 545	490 ~ 760			22
	X 60 M	6.30 ≤ E ≤ 38.10	≤ 0.12		≤ 1.60					415 ~ 565	520 ~ 760			21
	X 65 M	6.30 ≤ E ≤ 38.10								450 ~ 600	535 ~ 760			20
	X 70 M	6.30 ≤ E ≤ 38.10			≤ 1.70					485 ~ 635	570 ~ 760			19
	X 80 M	12.00 ≤ E ≤ 50.00			≤ 1.85					555 ~ 705	625 ~ 825			18

* Standard quoted for reference only. Please contact us about other possible tolerances and requirements.
(1) Other chemicals (such as Ni, Cu, Cr, Mo, V, Ti, and Nb) as per the standard specification.
(2) Ceq: C+Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15. References to values vary according to the project. Please contact us.

FINISHING AND SURFACE QUALITY SUPPLY CONDITIONS

SURFACE QUALITY
Heavy plates are supplied with first quality surface, commercial quality or special quality, according to application requirements.

EDGE TYPES
Heavy plates may be supplied with natural rolling edges (non-trimmed) or trimmed edges.

DIMENSIONAL AND SHAPE TOLERANCES
Dimensional and flatness tolerances are met according to several standards qualified by Usiminas. Please contact us.

SUPPLY TYPES
Supply types may be by weight or exact number of pieces with bulk shipment.

HEAT TREATMENT
Heavy plate can be normalized, quenched, or quenched and tempered (Q&T) with the purpose of meeting certain properties required by the users. Initially, all qualities can be normalized but there are some ones that normalization is a mandatory condition by its specifiocation.

ULTRASONIC TESTING
When requested we can guarantee ultrasonic testing according to specifications indicated by applicable standards (API, ASTM, EN, SEL and others).

IMPACT AND BEND TESTING
These are performed when prescribed by a standard or upon request.

MARKING
Usiminas has several types of marking for heavy plates. Please consult us for evaluation of the most appropriate type for your product.

USIMINAS

PLEASE CONTACT US

SALES OFFICE

Belo Horizonte – MG
3011 Professor José Vieira de Mendonça Street
Engenho Nogueira - Zip Code 31310-260
Phone: (31) 3499-8232 / (31) 3499-8500

São Paulo - SP
277 Do Café Avenue, tower A and 9º floor
Ed. Centro Empresarial do Aço
Vila Guarani - Zip Code 04311-900
Phone: (11) 5591-5200

Porto Alegre - RS
2350 Dos Estados Avenue
Humaitá - Zip Code 90200-001
Phone: (51) 2125-5801

Cabo de Santo Agostinho - PE
Tronco Distribuidor Rodoviário Norte Avenue, ZI3
Complexo Industrial Suape - Zip Code 54590-000
Phone: (81) 3527-5400

USIMINAS

Always do the best.

www.usiminas.com

Updated in 2015.