COR-TEN,CORTEN A,CORTEN STEEL,A242,A558 GR A,S355JOW,
DIFFERENT TYPE AND GRADES OF CORTEN STEEL.

CORTEN A STEEL / Weather resistant steel

Physical Properties

Weather resistant steel	Standard	Tensile Strength MPa	Yield Strength MPa	Elongation in 2 inches (min.) %
CORTENA	US steel	470-630	355	20
IRSM 41-97	Indian Railways	480 min	340 min	21
ASTM A 588	ASTM	485 MIN	345 min	21

Chemical Properties

Weather resistant steel	C	Mn	P	S	Si	Cr	Ni	Mo	Cu
Corten-A	0.12	0.20-0.50	0.070-0.150	0.030	0.25-0.75	0.50-1.25	0.65	-	0.25-0.55
IRS M-41	0.10	0.25-0.45	0.075-0.112	0.030	0.28-0.72	0.35-0.49	0.20-0.49	-	0.30-0.39
ASTM A 588	0.20	0.75-1.30	0.04 MAX	0.050	0.15-0.50	0.30-050	0.50 MAX	-	0.20-0.40

ASTM A242-04 High-Strength Low-alloy Structural Steel

Grade	Chemicals Composition%					Tensile Test				
	C	Mn	P	S	Cu	Thikness (t)mm	Yield Point Ksi(N/mm2)	Tensile Strength Ksi(N/mm2)	Elongation	
						t<19.05	50(345) Min	70(480) Min	Test Piece In (mm)	% Min
			0.15	0.05	0.20	19.05<t<38.10	46(315) Min	67(460) Min	GL=8(200)	18
Type1	0.15 Max	1.00 Max	Max	Max	Min	38.10<t<101.6	42(290) min	63(435) Min	GL=2(50)	21

Remarks:
1 For plates wider than24 in(600mm), the Elongatior requirment is reduce Two Percentage points.
2 For normal thickness 5/16in(8mm), the deduction from the specified percentage of elongation in 8 in(200mm). Shall be made for decereses of the nominal thickness below 5/16 in.(8mm). See elongation requirement adjustment under the tension tests section of specification A6 for deduction values.

Specifications for Corten Steel Strip & Coil according tp Jis 3125-87(SPA-H & SPA-C)JAPAN STANDA										
Type Symbol	C	Si	Mn	P	S	Cu	Cr	Ni	Yield N/mm2	TensileN/mm
SPA-H	0.12 max	0.25 to 0.75	0.20 to 0.50	0.07 to 0.15	0.4 max	0.25 to0.60	0.30 to 1.25	0.65 max	343 min	481 min
SPA-C									34 min	451 min

Standards

Europe	Material no.	D	F	GB	USA	J	Salzgitter Flachstahl	FK[1)]
S355J0WP	1.8945	-	E 36 WA 3	WR 50 A	-	-	Allwesta 510 P	B
S355J2WP	1.8946	-	E 36 WA 4	-	A 242 Type 1	-	Allwesta 510 FP	B
S355J0W	1.8959	-	E 36 WB 3	WR 50 B	A 588	SMA 50 AW	Allwesta 510	B
S355J2W	1.8965	WTSt 52-3	E 36 WB 4	WR 50 C	-	SMA 50 CP	Allwesta 510 F	B
S355K2G2W	1.8967	-	-	-	-	-	Allwesta 510 F 40	B

[1)]FK = Tensile strength class

Chemical composition in percent by weight[1)][%] (Heat analysis)

Grade	C	Si	Mn	P	S	N	Cu	Cr	Ni
	max.	max.			max.	max.			max.
S355JOWP	0,12	0,75	max. 1,00	0,06 - 0,15	0,035	0,009[3)]	0,25 - 0,55	0,30 - 1,25	0,65
S355J2WP	0,12	0,75	max. 1,00	0,06 - 0,15	0,030	–[4)]	0,25 - 0,55	0,30 - 1,25	0,65
S355JOW	0,16	0,50	0,50 - 1,50	max. 0,035	0,035	0,009[2)] [3)]	0,25 - 0,55	0,40 - 0,80	0,65
S355J2W	0,16	0,50	0,50 - 1,50	max. 0,030	0,030	–[4)]	0,25 - 0,55	0,40 - 0,80	0,65
S355K2W	0,16	0,50	0,50 - 1,50	max. 0,030	0,030	–[4)]	0,25 - 0,55	0,40 - 0,80	0,65

1) The steel may contain a maximum of 0,65 % Ni, 0,30 % Mo and 0,15 % Zr.
2) Exceeding the specified maximum value is permitted if the phosphorous content remains below the maximum value by 0,005 % for each 0,001 % of nitrogen; however, the nitrogen content must not exceed 0,012 % in the heat analysis.
3) The maximum nitrogen content shall not apply if the steel grades contain at least 0,020 % Altotal or sufficient quantities of other nitrogen-fixing elements.
4) The steel grades contain at least one of the following elements: Altotal : ≥ 0,020 %, Nb: 0,015 - 0,060 %, V: 0,02 - 0,12 %, Ti: 0,02 - 0,10 %. If a combination of these elements is present, at least one of them is contained with the specified minimum content.

Mechanical properties[1)]

Grade	Position of sample	Min. yield strength		Tensile strength		Min. total elongation [%]			
		MPa		MPa		L_0= 80 mm			L_0= 5,65 $\sqrt{S_0}$
		e[2)]≤ 16	e[2)]> 16	e[2)]< 3	e[2)]≥ 3	e[2)]≤ 2	2 < e[2)]≤ 2,5	2,5 < e[2)]≤ 3	e[2)]≥ 3
S355J0WP	l/t	355	-	510 - 680	470 - 630	16/14	17/15	18/16	22/20
S355J2WP	l/t	355	-	510 - 680	470 - 630	16/14	17/15	18/16	22/20
S355J0W	l/t	355	345	510 - 680	470 - 630	16/14	17/15	18/16	22/20
S355J2W	l/t	355[3)]	345	510 - 680	470 - 630	16/14	17/15	18/16	22/20
S355K2W	l/t	355[3)]	345	510 - 680	470 - 630	16/14	17/15	18/16	22/20

The tensile test values given in the table apply to longitudinal samples; in case of strip and sheet steel of widths of ≥ 600 mm, transverse samples should be taken.
2) Nominal thickness e [mm]
3) S355J0WP and S355J2WP: e ≤ 12 mm.

Notch impact energy in condition of delivery (minimum values obtained using Charpy-V samples)

Grade	Notch impact energy[1)]	Position
	J	^{0}C
S355J0WP	27	0
S355J2WP	27	-20
S355J0W	27	0
S355J2W	27	-20
S355K2W	40	-20

Average values of 3 samples; one individual value may fall short of the required minimum value by not
2)More than 30 %. The sample width shall equal the product thickness if the latter is between 5 - 10 mm,
3)The tests being performed using samples which are similar to Charpy-V samples. The valuesspecified
4)In the table above are to be reduced proportionally to the sample width.

COR-TEN, CORTEN, CORTEN A, CORTEN STEEL, A242, A558 GR A, S355JOW,

Scope

CORTEN A applies to plates up to 12.5mm in thickness, CORTEN B applies to plates up to 50mm in thickness.

Definition

Weathering means that due to their chemical compositions CORTEN A and CORTEN B steels, when utilised unprotected, exhibits increased resistance to atmospheric corrosion compared to unalloyed steels. This is because it forms a protective layer on its surface under the influence of the weather.

The corrosion retarding effect of the protective layer is produced by the nature of its structure components and the particular distribution and concentration of alloying elements in it. The layer protecting the surface develops and regenerates continuously when subjected to the influence of the weather.

Formation, duration of development and protective effect of the covering layer on weathering steels depend largely upon the corrosive character of the atmosphere. Its influence varies and depends mainly upon general weather condition (e.g. continental) macroclimate (e.g. industrial, urban, maritime or countryside climate) and the orientation of the structure components (e.g. exposed to or shaded from the weather, vertical or horizontal position). The amount of aggressive agents in the air has to be taken into account . In general the covering layer offers protection against atmospheric corrosion in industrial, urban and countryside climate.

When utilising this steel in unprotected condition it is up to the designer to take into account the expected loss of thickness due to corrosion and as far as necessary, compensate for it by increasing the thickness of the material.

In cases of particular air pollution by aggressive agents conventional surface protection is recommended. Coating is absolutely necessary in cases of contact with water for long periods, when permanently exposed to moisture, or if it is to be used in the vicinity of the sea. The susceptibility of paint coats to undercreepage by rust is less in the case of weathering steel than in the case of comparable non-weathering steel.

Applications

The corten steel is used for various types of welded, bolted and riveted constructions e.g. steel frame structures, bridges, tanks and containers, exhaust systems, vehicles and equipment constructions.

Basic guidles for the use of corten steel in the unprotected condition are described in EN 10025-5 and DASt rule 007.

The entire application technology is of fundamental importance for the performance of the products made from this steel. It must be taken into account that not only general climate conditions but also specific unfavourable local climate conditions in the broadcast sense as well as details of a construction may affect the corrosion behaviour of unprotected weathering steel. The dependency on these facts makes it understandable that no warranty can be given. It is recommended to control the corrosion progress of protected parts out of weathering steel exposed to the influence of weather in reasonable time intervals. A minimum thickness of 5mm is recommended when exposed to the

weather in the unprotected condition.

To use the benefits of the higher atmospheric corrosion resistance of CORTEN in comparison to unalloyed steel it is necessary that design and execution of structures as well as the performance of maintenance works allow an impeded formation and regeneration of the protective rust layer. The methods must meet the latest requirements of technical progress and must be suited for the proposed application. Due consideration must be given to relevant construction specifications.

The selection of the material is up to the purchaser.

Chemical Composition(heat analysis, %)

Grade	C	Si	Mn	P	S	Cr	Cu	V	Ni
COR-TEN A	0.12	0.25-0.75	0.20-0.50	0.07-0.15	0.030	0.50-1.25	0.25-0.55		0.65
COR-TEN B	0.16	0.30-0.50	0.80-1.25	0.030	0.030	0.40-0.65	0.25-0.40	0.02-0.10	0.40

In order to obtain fine grain structure a sufficient amount of nitrogen absorbing elements is added (e.g. ≥0.02% Al).

Mechanical Properties, in the state of delivery condition

At room temperature for plates ≥3mm in thickness (transverse test specimans, according to EN 10002). Requirements to hot rolled plates ≤3mm in thickness according to EN 10025-5.

Grade	Minimum yield point (ReH Mpa *)	Tensile strength Rm MPa	Minimum elongation A (Lo=5.65 √So) %
COR-TEN A	355	470-630	20

*) 1 Mpa = 1N/mm2

In case of cold rolled material the yield point is min. 310 Mpa and the tensile strength min. 445 MPa. Furthermore cold rolled sheets ≤3mm in thickness made of steel grade COR-TEN A-F for increased demand to the cold formability is available. Mechanical properties: Yield point min. 275 Mpa; Tensile strength min. 410 Mpa; elongation min. 25%. Tolerances on dimensions and shape according to EN 10131.

Mechanical Properties, in the state of delivery condition

At room temperature for plates ≥3mm in thickness (transverse test specimans, according to EN 10002). Requirements to hot rolled plates ≤3mm in thickness according to EN 10025-5.

Grade	Material thickness mm	Minimum yield point (ReH Mpa *)	Tensile strength Rm MPa	Minimum elongation A (Lo=5.65 √So) %
COR-TEN B	≤16	355	470-630	20
	> 16 ≤50	345		

*) 1 Mpa = 1N/mm2

The notched-bar impact energy is determined on ISO-V longitudinal test specimans at a temperature of - 20°C as an average of three tests. For product thicknesses ≥10mm the average value is at least 27 J. For thicknesses between 10mm and 6mm, the minimum impact value is reduced

proportionally to the speciman width (product thickness).

No impact test is performed on products below 6mm in thickness.

Number of Tests

1 tensile test	1 test specimen per 40 t from eachheat*)
1 notched bar impact test (3 specimens)	1 set specimens per 40 t from each heat *) (at test temperature -20°C)

*) as referenced in EN 10025-5

General Processing Information

The information given below can only deal with some important points.

Forming

The conditions for hot forming are in accordance with those stated in EN 10025-5. For cold forming the statements according to table 6 of EN 10025-5 are valid. If the mechanical properties have undergone changes due to cold forming, the properties indicated in the table can be substantially restores by stress relieving - at least 30 minutes at 530°C - 580°C. For higher degrees of cold forming subsequent normalising is recommended.

Flame Cutting

CORTEN is suitable for flame cutting provided proper operating methods are used. At temperatures below 5°C a sufficiently wide zone on either side of the intended cut should be preheated. If flame cut edges are to undergo cold forming, the hardening effect should be prevented by preheating - as in the case of S355J2 or the hardened zones must be worked off e.g. by appropriate grinding.

Welding

CORTEN can be welded both manually and mechanically, provided the general rules of welding practices are observed. A prerequisite for obtaining identical mechanical properties in the weld and in the base material is the application of suitable welding consumables and the choice of appropraite welding conditions. To consider are EN 10025-5 - Technical delivery conditions for structural steels with improved atmospheric corrosion resistance

Recommendations for welding are also given in EN 1011 part 1 and part 2 - Welding, Recommendations for welding of metallic materials-.

Lime basic electrodes, inert-gas welding wire, and wire/power combinations equivalent to the tensile strength of S355 are used as welding consumables

For unprotected use care must be taken that the welded joint is also weather resistant. This is possible by using welding consumables matching the base material.

If due to design or building specification stress relieving is required, it should be performed in the range temperature from about 530°C to 580°C.

Bolting and Riveting

Joining elements such as bolts, rivets and their accessories (nuts and washers) must be so selected that the formation of local electro-chemical cells are avoided. The joining elements should preferably consist of weathering steel.

At these joints capillary action can lead to permanent moisture resulting in increased corrosion. Critical zones should therefore be protected by painting, sealing or other protective measures.

In the case of high-strength connections (HV) the conditions for non-weathering structural steels as given in DIN 18800 part 1 apply.