



Boiler plates and pressure vessel steels
Resistance and reliability at high pressures and temperatures

ThyssenKrupp Steel Europe
Thinking the future of steel



ThyssenKrupp

Resistance and reliability at high pressures and temperatures

ThyssenKrupp
high pressure

X-COR®

For the manufacturers of boilers and pressure vessels, high chemical process efficiency is of great importance for cost reasons. Improving efficiency normally requires larger equipment operating at higher temperatures and/or higher pressures. To build equipment such as steam boilers, either simple or high-temperature pressure vessels, through to high-pressure hydrogen reactors like hydro-crackers, materials withstanding higher stresses and temperatures with simultaneously unchanged wall thicknesses, are available. One particular challenge for plant engineers is the increasing importance of storing hydrogen sulfide-containing gases, where the release of hydrogen atoms can cause dangerous corrosive damage to the vessel materials. To meet this challenge, special sour gas-resistant steels have been developed.

ThyssenKrupp Steel Europe has been producing heavy plate for boiler and pressure vessel construction for over 50 years. In addition to unalloyed boiler plate and alloyed pressure vessel steels, produced in accordance with all common European (EN) and American (ASTM) standards, the company's portfolio also includes sour gas-resistant boiler plate.



Steel production

Heat-treated grades for highest requirements



Steel production

The basis for steel production at ThyssenKrupp Steel Europe is a modern basic oxygen furnace (BOF) melt shop, which also has equipment for secondary steelmaking operations such as vacuum degassing and Ca treatment. The steel produced has extremely low sulfur and phosphorus contents and tight compositional tolerances. It is cast by continuous casting with the option of soft reduction to ensure minimum segregation.

The slabs produced in the melt shops are generally rolled on a four-high rolling mill, but can also be rolled on a hot strip mill and then cut to plates with high surface quality and close thickness tolerances. Temperature-controlled rolling methods such as normalized rolling and thermo-mechanical rolling are also used. For heat treatment of the alloyed boiler plates, various furnaces are available to produce normalized and air-hardened steels as

well as quench units to produce water quenched steels meeting extreme strength and toughness requirements. Heavy plates made from boiler and pressure vessel steels normally undergo ultrasonic testing during production, which is performed automatically in-line for small and medium thicknesses and manually for thicker plate. The ASTM standards A 578 and A 435 and the EN standard 10160 are generally applied. All equipment required for steel production at ThyssenKrupp Steel Europe has been certified by RWTÜV to ISO 9001.

Product range

From unalloyed to alloyed and high-strength

Boiler plates and pressure vessel steels – available grades and sizes						
	Grade as per EN 10028	Equivalent ASTM grade	Delivery condition	Alloy	max. thickness [mm]	max. width [mm]
Unalloyed/ low-alloy	P235GH–P355GH	ASTM A 299	N/NR	CuNiNb	125/80**	3,600
	P275N–P355N (NH/NL1/NL2)	ASTM A 516 Gr. 60/65/70	N/NR	CuNiNb	100/80**	3,600
Alloyed	16Mo3	–	N	0.3Mo	100/80**	3,600
	15NiCuMoNb5 (WB36)	–	NT	NiCuMoNb	100/80**	3,600
	13CrMo4-5/-4	ASTM A 387 Gr. 12 Cl. 2	NT	1Cr1/2Mo	100/80**	3,600
	10CrMo9-10	ASTM A 387 Gr. 22 Cl. 2	NT	2Cr1Mo	100/80**	3,600
High-strength Q&T	–	ASTM A 537 Cl. 2	Q&T	CrMo	100/80**	3,300
	P690Q/QH/QL1/QL2* (N-A-XTRA® M 700)	ASTM A 517	Q&T	CrMo(Ni)	100/80**	3,300

* only up to 50 mm thickness

** ASTM grade

NR: norm. rolled

N: normalized

NT: air-hardened

Q&T: quenched and tempered

Unalloyed and alloyed boiler and pressure vessel steels

In Europe, the steel grades commonly used for boiler and pressure vessel construction are standardized in parts 2 to 7 of EN 10028. In America the approved steel grades are listed in the ASME code. The above table provides an overview of the boiler and pressure vessel steels available from ThyssenKrupp Steel Europe in accordance with EN 10028 and the relevant ASTM standards along with sizes and maximum weights.

On request, boiler plates are also delivered to other international standards, as are so-called multi-grades which are certified to conform with several standards, such as P275NL2/NH/P265GH/ASTM A 516 Gr. 60/65 or P355NL2/NH/P355GH/ASTM A 516 Gr. 70. Boiler and pressure vessel steels are also available from stock via our service partners.

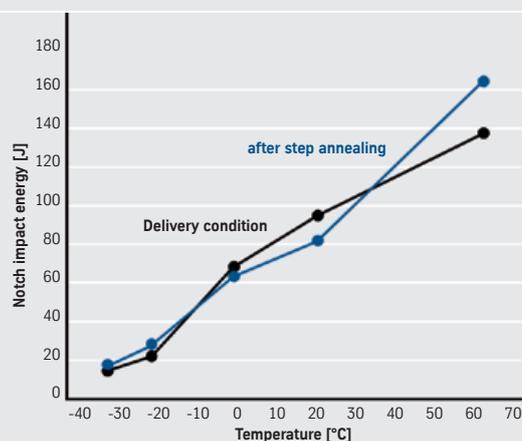
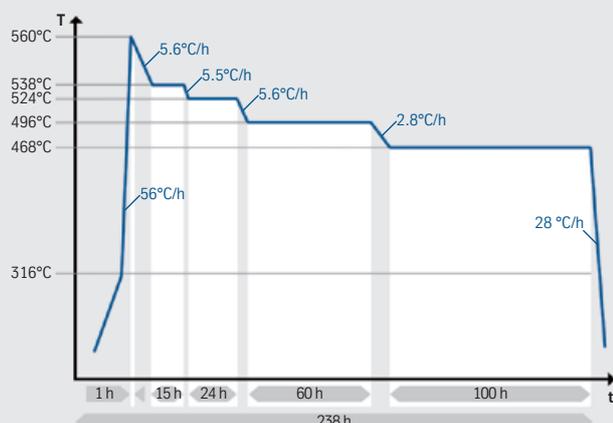
Processed plate

For the various applications of these steels, ThyssenKrupp Steel Europe also offers processed plate (edge preparation and bending). Close cooperation with first-class steel service centers ensures the best possible solutions for customers.

Composition and properties

High toughness even in long-term service

Determining the embrittlement susceptibility of 16Mo3 after step annealing to EN 10028



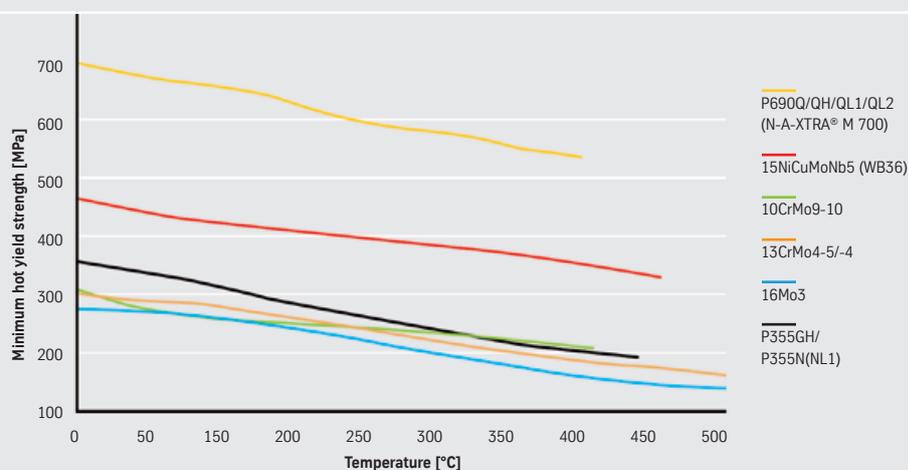
Chemical composition and mechanical properties

The chemical composition of the steels and their mechanical properties correspond to the respective European and American standards. Applications for unalloyed and low-alloy boiler plates are restricted to max. operating temperatures of 400°C, whereas the CrMo-alloyed pressure vessel steels continue to display favorable scaling and creep resistance properties at high operating temperatures of 500°C. The graphic on the right shows a comparison of the minimum hot yield strengths of various steels used in pressure vessel construction in the temperature range up to 500°C.

Material properties are affected by heat treatment during production and processing of the plates (e.g. stress relieving) and also by cold forming operations. ThyssenKrupp Steel Europe can provide its customers with corresponding empirical values on this. Although CrMo-alloyed steels are preferred for high-temperature applications, they are susceptible to embrittlement when exposed to these temperatures over longer periods. This embrittlement can be simulated in the laboratory by long-term step annealing, which can shift the notch impact energy-temperature curve towards higher temperatures. The high toughness of pressure vessel steels from ThyssenKrupp

Hot yield strengths of pressure vessel steels

as per standard or material data sheet (Thicknesses ≤ 16 mm)



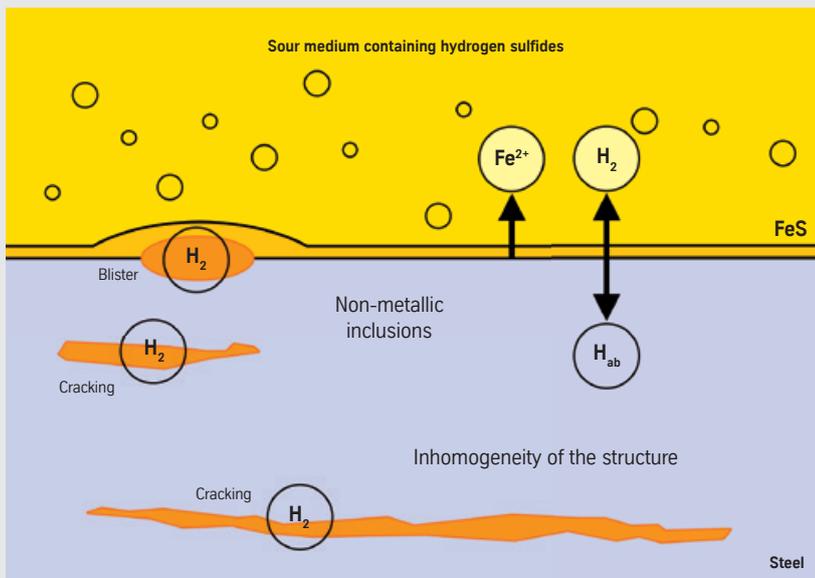
Steel Europe has been confirmed in corresponding long-term step annealing tests.

The embrittlement susceptibility is caused by trace elements in the steel such as P, Sb, As and Sn. Empirical correlations of embrittlement susceptibility to trace element content are reflected in the J or Watanabe factor or in the X or Bruscato factor. The high quality of the iron ore used by ThyssenKrupp Steel Europe and of steel production in the BOF melt shop allow the J and X factor values to be kept extremely low.

Sour gas-resistant steels

Extremely corrosion-resistant

Sour gas-resistant special structural steel X-COR®



ASTM A 516 Gr. 60/65/70 or equivalent EN 10028 grades

- Normalized, max. plate thickness 50 mm
- High cleanliness (S<0.0010%, P<0.015%)
- CE_{IIW} : 0.36%–0.43%
- Hardness < 22 HRC

Determination of sour gas resistance (HIC test)

- Guaranteed after stress relieving (600°C +/- 10°C, 60 min)
- Test to NACE standard TM0284-2003, solution A (pH3)
- Crack length ratios CLR <5%, CTR <1.5%, CSR <0.5% (mean values)

Sour gas-resistant steels

In petrochemical plants, the processing of sour gases containing hydrogen sulfides represents a particular challenge for the pressure vessel steels used. An electro-chemical corrosion reaction between the material surface and the sour gas-containing environment can cause hydrogen induced cracking (HIC) in the steel. To counter this dangerous cracking, ThyssenKrupp Steel Europe has developed a special sour gas- (HIC-) resistant steel grade, characterized in particular by an extremely high degree of cleanliness and low susceptibility to

segregation. This normalized, low-alloy steel is supplied in plate thicknesses up to max. 50 mm as a multi-grade with a chemical composition and mechanical properties in accordance with both ASTM A 516 Gr. 60/65/70 and EN 10028 part 3. Sour gas resistance (HIC resistance) is guaranteed in the stress relieved condition in accordance with NACE standard TM0284-2003 solution A (pH value of 3).

The tests are carried out in the company's own certified test lab which is recognized by external companies such as the Saudi oil company ARAMCO. As well as testing

for HIC resistance, this lab can also carry out tests to determine resistance to stress corrosion cracking. Like the unalloyed and alloyed pressure vessel steels, sour gas-resistant plates are also available from stock.

The ThyssenKrupp Steel Europe world of “Special Structural Steels” on CD

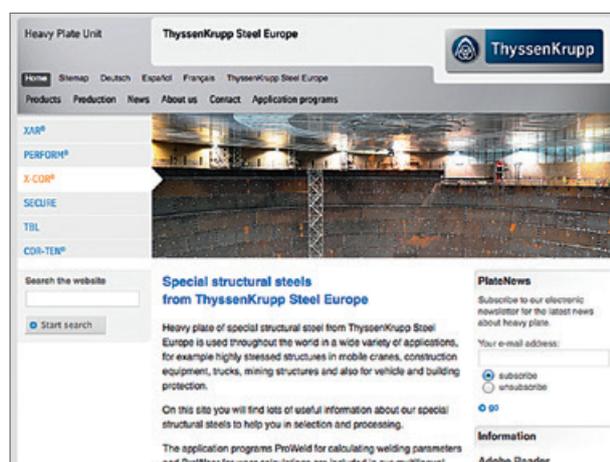
Optimum processing and use of boiler plates and pressure vessel steels require close collaboration between supplier and user. For this reason, an extensive technical support service has been set up which can provide assistance in all questions relating to design and processing. A wide range of useful information about our special structural steels,



including material data sheets, processing recommendations and ProWeld, a program for welding calculations developed by ThyssenKrupp Steel Europe, is available on a multi-language CD-ROM which can be requested from ThyssenKrupp Steel Europe free of charge. All the information is naturally also available in printed form in brochures. Customers can find out about the very latest developments on the internet website – only a click away.

ThyssenKrupp Steel Europe – more than just a material supplier

ThyssenKrupp Steel Europe is more than just a reliable material supplier. An expanded worldwide distribution network ensures fast supplies and just-in-time delivery to end users. This makes ThyssenKrupp Steel Europe even more responsive to customers' continuously rising demands.



General note

All statements as to the properties or utilization of the materials and products mentioned in this brochure are for the purpose of description only. Guarantees in respect of the existence of certain properties or utilization of the material mentioned are only valid if agreed upon in writing.

Subject to technical changes without notice. Reprints, even extracts, only with permission of ThyssenKrupp Steel Europe AG, Heavy Plate Unit.

Please contact:

Heavy Plate Unit

Sales

Domestic Market

Mario Klatt

Phone: +49 (0)203 52-75617

Fax: +49 (0)203 52-75653

E-mail: mario.klatt@thyssenkrupp.com

Export

Lukas Korves

Phone: +49 (0)203 52-40159

Fax: +49 (0)203 52-75653

E-mail: lukas.korves@thyssenkrupp.com

Technical Customer Service

Dr. Hans-Jürgen Kaiser

Phone: +49 (0)203 52-75114

Fax: +49 (0)203 52-75653

E-mail: juergen.kaiser@thyssenkrupp.com

The latest information can be found on the internet
www.thyssenkrupp-steel-europe.com/plate

ThyssenKrupp Steel Europe AG

Kaiser-Wilhelm-Strasse 100 · 47166 Duisburg · Germany

Postal address: 47161 Duisburg · Germany

Phone +49 (0)203 52-0 · Fax +49 (0)203 52-25102

www.thyssenkrupp-steel-europe.com · info.steel-europe@thyssenkrupp.com