Quenched and tempered special structural steels	Steel grade		Material No.	Material Specification
	TKSE-Short name	EN-Short name		
	N-A-XTRA® M 550	**S550QL**	**1.8926**	215
	N-A-XTRA® M 620	**S620QL**	**1.8927**	
	N-A-XTRA® M 700	**S690QL**	**1.8928**	
	N-A-XTRA® 550	**S550QL1**	**1.8986**	
	N-A-XTRA® 620	**S620QL1**	**1.8987**	
Heavy plate	**N-A-XTRA® 700**	**S690QL1**	**1.8988**	November 2014

Scope

This Material Specification applies to quenched and tempered heavy plates made of the special structural steel N-A-XTRA® This steel can be supplied in 3 different grades with a minimum yield strength of 550, 620 and 700 MPa (79.8, 89.9 and 101.5 ksi) [1]. All steel grades can be delivered in two qualities with different toughness properties.

1. Quality for low service temperature with minimum impact energy at - 40 °C (- 40 °F) for grade N-A-XTRA® M in a thickness range from 3 to 120 mm (0.118 to 4.724 in.).
2. Special quality for low service temperature with minimum impact energy at - 60 °C (- 76 °F) for classic N-A-XTRA® in a thickness range from 3 to 100 mm (0.118 to 3.937 in.).

Ordering according to EN 10025-6 is also possible.

Application

The steels are used for welded constructions of all kinds, such as pressure vessels, penstocks, bridges and structures, as well as transport vehicles, mobile cranes, mining equipment, hoistings and earth moving equipment, which are utilized in different types of climatic conditions.

The entire processing technique is of fundamental importance for the good performance of the products made of these steels. The processor must assure himself, that his methods of calculation, designing and working conform with the material to be used, meet the latest requirements of technical progress, and are suited to the proposed application. Due consideration must be given to relevant construction specifications.

The selection of the material is up to the purchaser.

The classic N-A-XTRA® has been approved under the terms of the provisions in force in the Federal Republic of Germany for the construction of pressure vessels (see VdTÜV-Werkstoffblatt 257).

Chemical composition (heat analysis, mass. -%)

C	Si	Mn	P	S	Cr	Mo
≤ 0.20	≤ 0.8	≤ 1.6	≤ 0.020	≤ 0.010	≤ 1.5	≤ 0.6

To the discretion of the steel producer the steel N-A-XTRA® (M) may contain Ni, Nb, Ti, V and B up to the limits in EN 10025-6 (Plates made of high yield strength structural steels in the quenched and tempered condition). The steel has a fine-grained microstructure. Nitrogen is absorbed to form nitrides.

Delivery condition: quenched and tempered (see paragraph "Heat treatment").

[1] 1 MPa = 1 N/mm² (1 ksi = 10^3 lbf/in²)

Mechanical properties in the state of delivery condition at room temperature (transverse test specimens according to ISO 6892-1, method B).

Steel grade	Minimum yield strength R_{eH} *) MPa (ksi)			Tensile strength R_m MPa (ksi)			Minimum elongation at fracture A %
	≤ 65 mm (≤ 2.559 in.)	> 65 ≤ 100 mm (> 2.559 ≤ 3.937 in.)	> 100 mm (> 3.937 in.)	≤ 65 mm (≤ 2.559 in.)	> 65 ≤ 100 mm (> 2.559 ≤ 3.937 in.)	> 100 mm (> 3.937 in.)	
N-A-XTRA® (M) 550	550 (79.8)	530 (76.9)	490 (71.1)	640 - 820 (92.8 - 118.9)	640 - 820 (92.8 - 118.9)	590 - 770 (85.6 - 111.7)	16
N-A-XTRA® (M) 620	620 (89.9)	580 (84.1)	560 (81.2)	700 - 890 (101.5 - 129.1)	700 - 890 (101.5 - 129.1)	650 - 830 (94.3 - 120.4)	15
N-A-XTRA® (M) 700	700 (101.5)	650 (94.3)	630 (91.4)	770 - 940 (111.7 - 136.3)	760 - 930 (110.2 - 134.9)	710 - 900 (103.0 - 130.5)	14

*) If continuous yielding occurs, the yield strength is determined as $R_{p0,2}$

Preparation of the tensile test specimens according to EN 10025-1.

In cases where a bend test has been agreed upon in the order, the mandrel diameter is D = 4a for transverse specimens and D = 3a for longitudinal specimens (bending angle = 180 °; a = specimen thickness). The number of tests and the direction of the specimen are to be agreed upon when placing the order.

Impact energy in the state of delivery condition (Charpy V-specimens according to ISO 148-1).

Steel grade	Specimen direction	Impact energy KV in J (ft lbf) at a test temperature of			
		0 °C (32 °F)	- 20 °C (- 4 °F)	- 40 °C (- 40 °F)	- 60 °C (- 76 °F)
N-A-XTRA® M	longitudinal	50 (36.9)	40 (29.5)	30 (22.1)	-
	transverse	35 (25.8)	30 (22.1)	27 (19.9)	-
N-A-XTRA® (classic)	longitudinal	60 (44.3)	50 (36.9)	40 (29.5)	30 (22.1)
	transverse	40 (29.5)	35 (25.8)	30 (22.1)	27 (19.9)

The values stated for the impact energy are minimum values obtained as average of 3 specimens, no single value being less than 70 % of the values stated in the table. For plate thicknesses < 40 mm (< 1.575 in.) the specimens are taken near the surface and ≥ 40 mm (≥ 1.575 in.) they are taken at a distance of ¼ of the plate thickness. For thicknesses < 10 mm (< 0.394 in.) the impact energy value is reduced proportionally to the specimen width.

For thicknesses < 6 mm (0.236 in.) impact tests are feasible upon special agreement.

Yield strength $R_{p0,2}$ at higher temperatures in the state of delivery condition (transverse specimens)

Steel grade	Minimum yield strength $R_{p0,2}$ in MPa (ksi) at test temperature						
	100 °C (212 °F)	150 °C (302 °F)	200 °C (392 °F)	250 °C (482 °F)	300 °C (572 °F)	350 °C (662 °F)	400 °C (752 °F)
N-A-XTRA® 550	530 (76.9)	510 (74.0)	475 (68.9)	455 (66.0)	440 (63.8)	425 (61.6)	410 (59.5)
N-A-XTRA® 620	590 (85.6)	570 (82.7)	540 (78.3)	520 (75.4)	500 (72.5)	485 (70.3)	470 (68.2)
N-A-XTRA® 700	660 (95.7)	640 (92.8)	605 (87.7)	585 (84.8)	570 (82.7)	550 (79.8)	530 (76.9)

A test certificate of $R_{p0,2}$ at higher temperature shall be given only if this has been agreed upon at the time of ordering. In such cases mention must be made with regard to the number of tests and to the test temperature.

ThyssenKrupp high strength N-A-XTRA®

Number of tests

Unless otherwise agreed upon in the order, the tests listed below will be performed during inspection:

1 tensile test	1 test specimen per 40 t from each heat*
1 notched-bar impact test (3 specimens)	1 set specimens per 40 t from each heat* at a specified test temperature and specimen direction. If no mention is made in the order, the impact energy will be determined at the lowest temperature in the table above on longitudinal specimens respectively to the steel grade ordered.

* as referenced in EN 10025-1.

General processing information

For those who process these steels for the first time, it is recommended to consult the steel supplier to take advantage of the experiences gathered so far.

The general information stated below can only cover a few of the important points. The instructions outlined in STAHL-EISEN-Werkstoffblatt 088 (weldable fine-grain structural steels, processing directives, especially for welding) apply equally to these steels.

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

Cold forming

The steels are generally processed cold, i. e. at temperatures below the highest permissible stress relieving temperature.

After severe cold forming operations it is normally sufficient if a stress relieving treatment is carried out in order to reduce the effects of cold forming and to improve the toughness which has been impaired due to the cold forming. This only is done in cases, where the inspection specifications or other regulations do not stipulate a repeated heat treatment after cold forming corresponding to the heat treatment that has been carried out at the time of delivery. It is to be noted that a stress relieving heat treatment does not completely rectify the effects of cold forming.

Hot forming

Hot forming, i. e. processing at temperatures above the maximum allowed stress relieving temperature, basically is possible. Such an operation, however, will remove the original heat treatment effect. Therefore, after hot forming it is necessary to perform a heat treatment equivalent to that of the state of delivery condition.

Heat treatment

In general the steels obtain their mechanical properties through austenitization followed by conventional quenching and tempering. Direct quenching after hot rolling followed by tempering is considered equivalent to conventional quenching and tempering according to EN 10025 - 6. The heat treatment is governed by the chemical composition and the thickness of the material. Information on this can be obtained from the manufacturer.

Thermal cutting

Under suitable conditions flame cutting is possible without any difficulty. The processing conditions correspond to unalloyed or alloyed steels. The surface condition of the plates exerts a substantial influence on the flame cutting parameters and the attainable quality of the cut edge. In cases where a higher quality for the flame cut surface is required, then it is recommended to clean the upper and lower sides of the cutting edge. In that case rust, scale and other kinds of dirt must be removed. In order to avoid cold cracking, for workpiece temperatures below 5 °C (41 °F) and for plate thicknesses > 30 mm (1.181 in.) and also if the flame cut edges are to undergo cold forming it is recommended to preheat a zone of around 100 mm (3.937 in.) wide to about 150 °C (302 °F) before flame cutting.

Welding

If due consideration is given to the general rules for welding, these steels are weldable both manually and automatically. The manual arc welding and the gas shielded arc welding procedures are preferably used. Depending on plate thickness, hydrogen content of the weld metal and heat input the welding may be carried out under preheating. The recommendations of the STAHL-EISEN-Werkstoffblatt 088 should be followed. The working temperature should not go beyond 250 °C (482 °F).

A prerequisite to obtain the same mechanical properties in the weld compared to the base material is the application of suitable welding consumables and the choice of appropriate welding conditions. To prevent cold cracking in the welded joints only welding consumables giving welds of very low hydrogen content should be used. A high cooling rate in the weld region should be avoided.

To ensure, that the steel properties are not impaired to an inadmissible extent by thermal cycles during welding, an upper limit for the heat input has to be fixed. The heat input for welding is governed by the welding process, the plate thickness, the preheating temperature, the form of the welding seam and the requirements imposed on the construction. Normally the welding conditions should be chosen in a way, that the cooling time $t_{8/5}$ ranges from 5 to 25 s.

In consideration of the desired mechanical properties at the welded joints, post weld heat treatments are not required. If stress-relieving is prescribed in construction regulations or if it is required for reasons of design, it should be performed at a temperature ranging from 530 - 580 °C (986 - 1076 °F).

General information

Unless otherwise agreed upon in the order, the delivery will be governed by the conditions outlined in EN 10021.

The admissible tolerances are based on EN 10051 for plates cut from hot strip and EN 10029 for four-high mill plates, unless other terms have been agreed upon.

The plates will be supplied with a maximum flatness tolerance according to EN 10029, table 4, steel type H. Smaller flatness tolerances can be agreed upon at the time of ordering.

For surface quality requirements EN 10163 is applicable.

As per prior agreement at the time of ordering other testing conditions are also possible.

As per special agreement it is possible to supply plates descaled or descaled and primed.

Publisher´s addresses

EN-, ISO Standards	Beuth Verlag GmbH, Postfach, D-10772 Berlin
STAHL-EISEN-Werkstoffblätter	Verlag Stahleisen GmbH, Postfach 10 51 64, D-40042 Düsseldorf
VdTÜV-Werkstoffblätter	Verlag TÜV Rheinland, Postfach 90 30 60, D-51123 Köln
ThyssenKrupp Steel Europe brochures „Processing of Quenched and Tempered Special Structural Steels“	ThyssenKrupp Steel Europe AG , D-47161 Duisburg
“Recommendations for thermal cutting of N-A-XTRA®”	
“Recommendations for welding of N-A-XTRA®”	
“Quenched and tempered N-A-XTRA® and XABO® steels - for lighter living”	