Hot rolled Steel Plates, Sheets and Coils

Structural steels

Optim QC

Ultra high strength steel grade that can be used to maximise the service load, performance and efficacy of vehicles and lifting equipment. Ultra high strength, reasonable abrasion resistance, good surface quality, cold resistance and dimensional accuracy open new opportunities for designers. The steel grades make equipment manufacture more efficient thanks to their good weldability, reasonable flangeability and smaller unit weights.

Applications

- frame and surface structures of commercial vehicles
- booms of forestry vehicles
- crane arms and other lifting equipment
- load handling equipment
- load support and fastening equipment
- feeding and unloading hoppers

Ruukki is a metal expert you can rely on all the way, whenever you need metal based materials, components, systems or total solutions. We constantly develop our product range and operating models to match your needs.

- **Description of the steel**
  Optim QC steels are ultra-high-strength, formable and wear-resistant structural steels of high tensile strength. Thanks to the low level of alloying material, welding of the steel grades is easy (table 1 and 2). Their abrasion resistance is significantly better that that of common structural steels. The ultra high strength (table 3), good formability and weldability make possible the use of slender, light structures, which posses unique durability. These steels do not have any equivalent structural or other steel standard.

- **Product shapes and dimensions**
  Strip products: thickness range 2,5 – 6,4 mm.
  - Cut lengths and coils, maximum width 1560 mm.

  Cut lengths can be supplied over the length range of 2000 – 12000 mm. Strip products are also delivered pickled. Pickled products may be of smaller maximum width and thickness but this, and the delivery of slit strips, must be agreed on ordering.

- **Delivery condition**
  Specially heat treated. Special rolling and cooling technology developed for this steel grade is used in the manufacture of coils.

- **Dimensional and shape tolerances**
  Ruukki's production programme tolerances fulfil and partly exceed EN 10051.

- **Impact strength**
  Impact strength (KV) is established by the Charpy V impact test at -40°C using the longitudinal test pieces. The guaranteed impact energy value is 50 Joules tested with 10 mm thick standard test pieces. For smaller strip thickness, less than 10 mm, the width of the impact test piece is equal to the strip thickness. Correspondingly, the guaranteed values are lower in direct proportion such that for a 5 mm thick Optim QC steel a value of 2/3 of 50 J, that is 33 J, is guaranteed. For cut lengths and coils of less than 5 mm of thickness, the impact test is omitted, but the impact strength is guaranteed. Lower test temperatures can be used by separate agreement.

- **Abrasion resistance and hardness**
  Specially heat treated Optim QC steels have a bainite-martensite microstructure. Their hardness is on average a little over 300 HBW, which is a level of hardness approximately twice that of S355 structural steel. The high hardness and tensile strength indicate high resistance to abrasion.

- **Materials testing**
  Test pieces are taken and tested in accordance with EN 10149-1. Tensile and impact tests are carried out on test pieces taken longitudinally to the rolling direction, whereas the flanging test uses test pieces taken transversally. The flanging test is chosen as the test of formability as it very well reproduces bending under workshop conditions.

- **Inspection document**
  Test certificate is in accordance with EN 10204-3.1.

- **Welding**
  This steel is easy to weld using all the normal methods when the instructions for high strength steels are adhered to e.g. use, drying and storage of consumables. Preheating is not normally required, as the steel plates are thin and their CEV values are reasonable. The surfaces of the weld must be dry and clean to avoid the formation of hydrogen in the weld. When using high welding energy and/or low material thicknesses, a narrow zone of material softer than the parent metal may appear in the weld and this must be taken into account in the design of the structure. The location of welded joints in the most stressed parts of a structure must be avoided, as must also be the use of high welding energy.

  The welding consumables must be of the low hydrogen types (weld hydrogen content HD ≤ 5 ml/100 g), and must be stored and dried in accordance with the manufacturers instructions as they are to be used for the welding of ultra high-strength steel. The weld metal properties must be in the main close to those of the parent metal. In order to achieve this, high strength (matching) consumables, having a tensile strength class of minimum 89 (minimum 890 N/mm^2) according to standards are to be used.

  The following products are examples of this kind of matching consumables:
  - Welding rods: OK 75.78
  - MAG-welding: OK Autrod 13.31
  - MAG-flux cored welding: FILARC PZ6149.

  When weld joint is to have equal strength with the base material, it is important to limit the tempering effect of the welding in the heat affected zone (HAZ). Following measurements are recommended:
  - Limit the heat input to a rather low value. For thickness > 4 mm the max. value is 0,5 kJ/mm, for thickness ≤ 4 mm the value should not exceed 0,4 kJ/mm.
  - The cooling time from 800°C to 500°C ($t_{8/5}$) should not exceed 4 seconds.

- In welding edge preparation, the opening angle for a butt weld V and single bevel groove (HV) for thicknesses ≥ 4 mm should be ≤ 50°.
- Welding has to be performed with dry plates and with room temperature. We recommend no preheating.
- The inter-pass temperatures should be close to room temperature.
- In GMAW (MAG) welding a solid wire electrode acc. DIN EN 12534, strength class of min 89 (min 890 N/mm^2) with a diameter of 1 mm is recommended.

Consumables of a lower strength than the steel (undermatching) may be used if, for example, the location of welded joints or the effective throat thickness (a-dimension) allow this in the design stage. Examples of undermatched consumables of a tensile strength class 42 (minimum 420 N/mm^2) in accordance with standards are the following products:
- Welding rods: OK 48.00, P48 S or an equivalent electrode.
- MAG-welding: OK Autrod 12.51, DB-20, Elga-Matic 100, LNM 26 or EMK 6.
- MAG-flux cored welding: OK Tubrod 14.12, OK Tubrod 15.14, PZ 6102, PZ 6113, MXA 100 or DWA 50.
- Submerged arc welding: OK Autrod 12.22 + OK Flux 10.71; L-61 + FX860 or Union S 2 + UV 400.

The use of undermatched consumables produces a tough, flexible weld which stands up well to weld stress. The longitudinal seams on lifting jibs, for example, are often welded using undermatched consumables in order to achieve a tough durable construction.

The above mentioned consumables are only given as examples of commercial products. Other manufacturer's equivalent products are also recommended in the same way. Before the commencement of any welding work, however, the manufacturer to ensure that they are up-to-date. If needed, the compliance with the requirements of the welded joint should be verified by performing the appropriate welding procedure test.

Forming

The formability of Optim QC steels is good, in regard to their strength. They can be cold-formed in any chamfering direction and the bend can be located independently from the rolling direction. The smallest inside bending radius in accordance with thickness is shown in table 4.

To obtain full advantage of the formability good engineering workshop techniques must be used. Worn tools, poor lubrication, surface defects and burrs on cut edges may all impair forming quality. Plates taken from cold storage must be allowed to warm up to room temperature before being formed.

Cutting

Optim QC steels are very suitable for thermal cutting. The surface of the cut is smooth which makes good fatigue resistance possible. During flame, plasma or laser cutting a softened zone forms round the edge of the plate due to the heat, but by using suitable cutting method this heat-affected zone remains narrow. When cutting high strength steel by mechanical means special attention must be paid to the stiffness of the cutting equipment, blade condition and clearance, and supporting of the work piece. Plates taken from cold storage must be allowed to warm up to room temperature before being cut.

Hot-dip galvanizing

The good galvanizing characteristics of ultra high strength steel is the result of the optimisation of its chemical composition. Control of the galvanizing parameters produces a good surface and durable coating. The desired coating thickness is achieved by control of galvanizing time and temperature. A too long immersion time must be avoided in order to maintain reasonalbe thickness and good adherence of the coating. The mechanical properties of the steel remain in accordance with requirements if the hot-dip galvanising is carried out in the proper manner.

Heat treatment

Ultra high strength steel is not meant to be heat treated after welding or other workshop operations. If, however, stress relieving is required it should be carried out in the temperature range 400 – 450°C with a soaking time in the range of 60 – 120 min. After this, slow cooling within the oven is recommended. Annealing or working at a temperature above 450°C may considerably reduce the strength of the steel.

Chemical composition

Table 1

	Maximum content % (ladle analysis)						
	C	Si	Mn	P	S	P + S	Ti
Optim 900 QC	0.10	0.25	1.15	0.020	0.010	0.030	0.07
Optim 960 QC	0.11	0.25	1.20	0.020	0.010	0.030	0.07

In addition, aluminium (Al), niobium (Nb), vanadium (V), chromium (Cr), molybdenum (Mo) or boron (B) may be used either singly or in combination.

Carbon equivalent CEV

Table 2

	CEV typical	CEV maximum
Optim 900 QC	0.46	0.51
Optim 960 QC	0.47	0.52

CEV = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15

Mechanical properties

Table 3

Strength properties

	Yield strength R_{eH} N/mm² Minimum	Tensile strength R_m N/mm² Minimum	Elongation A_5 % Minimum
Optim 900 QC	900	950	8
Optim 960 QC	960	1000	7

The strength properties in this table are guaranteed values both in the longitudinal and transverse directions..

Typical strength properties according to tensile tests

	Yield strength R_{eH} N/mm² Typical	Tensile strength R_m N/mm² Typical	Elongation A_5 % Typical
Optim 900 QC	900 – 1000	1050 – 1150	12
Optim 960 QC	960 – 1060	1080 – 1180	10

The strength properties in this table are typical values in the longitudinal direction.

Minimum permissible bending radius, bending angle 90°

Table 4

	Plate thickness mm 3	(3) – 4	(4) – 5	(5) – 6
	Minimum inside bending radius mm			
Optim 900 QC	9.0	12.0	15.0	19.0
Optim 960 QC	10.5	14.0	17.5	22.0

No limitations on bending direction.

Our Customer Service is happy to give you further information

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