more with metals

Hot rolled Steel Plates, Sheets and Coils

Structural steels

Optim 500 ML

Optim 500 ML is a high strength, durable structural steel, which allows lightening of massive steel structures. Steels make manufacture more efficient and feasible, because preheating during welding is often not needed, and work and filler material costs become lower thanks to smaller joint preparation.

Applications

- Tanks
- Framework structures
- Bridges
- Tubular bridges
- Vehicles
- Lifting and mobile equipment
- Marine construction

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- **Description of the steel grade and benefits to the customer**
  Optim 500 ML offers both strength and workshop-friendliness at the same time, table 1 and 2. Steel structures can be made lighter, which improves the performance of machinery and equipment. Despite its strength, the steel is easy to handle in workshops and handling costs will decrease. The capital letter "M" indicates the thermomechanical rolling of this steel grade. The capital letter "L" means that the steel has excellent low temperature toughness properties, in compliance with EN 10025-4. Optim 500 ML has no equivalence in any standard steel.

- **Product shapes**
  Plate products; thickness range 8 – 40 mm.
  Plate products are also delivered workshop prime coated. Priming and the proceeding shot-blasting provide steel with temporary protection against corrosion during transport and temporary storing. In addition, there is a large variety of prefabrication choices available.

- **Delivery condition**
  The delivery condition is thermomechanical (TM) rolled or thermomechanical rolled and accelerated cooled, depending on the thickness.

- **Dimensional and shape tolerances**
  The dimensional and shape tolerances meet, and in part exceed, EN 10029 requirements. Thickness tolerance is in accordance with EN 10029 Class A. Flatness guarantee for heavy plate is 6 mm/m.

- **Surface quality**
  EN 10163-2 Class A3.

- **Materials testing**
  Testing and sampling are carried out in accordance with EN 10025-4. Yield strength, tensile strength and elongation are tested transversally in relation to the rolling direction.

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

- **Welding**
  As a result of the use of thermomechanical processing, alloying and carbon equivalent can be kept low compared to the strength level, table 3. This becomes evident in the excellent weldability, both in the engineering workshop and on site. Preheating is seldom needed which saves on costs. Good welding results can be ensured by the use of low hydrogen welding consumables and welding methods.

Choice of welding consumables
The consumables for welding of structural steels are generally chosen such that the chemical composition of the weld material is the same as that of the base material. For the high strength steel Optim 500 ML, however, consumables of higher alloying than the base material should be used where the weld strength is required to be at the same level of that of the base material. If the root run is welded using alloyed consumables then it may be at advantageous to use preheating in order to avoid hardening. To avoid preheating it is recommended that low alloy consumables, which produce a soft weld, are used. An additional advantage of the low hardening is the good formability of the weld and resistance to weld stress. If the welded joints are situated in the parts of a structure which is to be only slightly stressed, then even the high strength steels Optim 500 ML may be welded using conventional consumables. These types of welds may be for example, fillet welds under low shear stress. It is vitally important to follow the instructions of the manufacturer with regard to storage and drying of consumables.

Working temperature and welding energy
In high strength, stiff steel structures the weld material forms the most critical area with regard to the prevention of cold cracking. The working temperature is determined on the base of the following factors: hardening and hydrogen content of the weld material, welding energy and combined plate thickness. The hydrogen content of the consumable is important, the lower it is the less is the need for preheating. Following are guideline examples for working temperature:

- When using a welding energy of a minimum of 2.0 kJ/mm and when the hydrogen content of the weld, HD < 10 ml/100 g (ISO 3690), the work needs to be preheated if the combined plate thickness is 100 mm or more, and then only to about 75°C.
- When the minimum energy level is lowered to 1.0 kJ/mm and with the same weld hydrogen content, HD < 10 ml/100 g (ISO 3690), the recommended working temperature is +50°C, for combined plate thickness greater than 40 mm.

Generally even the most rugged structures can be welded in the engineering shop, so that cooling rate of the weld seam is slow enough and no external heating is required. If low energy must be used e.g. for tack welding or small repair welding, light preheating is recommended. Preheating need is highlighted as the joint plate thickness increases.

Forming

As a result of the use of thermomechanical rolling the alloying of this steel is low and it can be easily formed in a workshop. As a result of this, components previously made by welding can now be made by bending, which shortens the throughput time and so reduces costs. Table 4 indicates the smallest bending radius depending on plate thickness.

Successful utilization of the excellent forming properties requires the use of good workshop techniques. Worn tools, insufficient lubrication, scratches on the surface of the steel as well as edge burrs will all reduce the quality of the forming. Plates taken from cold storage must be allowed to warm up to room temperature before being formed.

Heat treatment

The strong, thermomechanically rolled Optim 500 ML steel is used in structures for which heat treatment is generally not required after welding. If the structural requirements necessitate reduction of residual stresses then stress relieving may be carried out at 530 – 580°C as shown in Table 5. Heating the steel to temperatures higher than 580°C may reduce its strength, and for this reason hot working or normalising are prohibited.

Cutting

Optim 500 ML can be cut easily using thermal methods such as flame, plasma and laser cutting. When cutting mechanically, attention must be paid to the stiffness of the equipment, the blade condition and clearance, and the supporting of the workpiece. Plates taken from cold storage must be allowed to warm up to room temperature before being cut.

Flame straightening

Flame straightening is permitted at a temperature of max 550°C. Instead of heating the steel red hot, straightening may be made more efficient by employing sharper and more precisely applied flames. Straightening temperatures of max 600°C are permitted for short periods of time. The applicable recommendations for flame straightening are published in CEN/TR 10347:2006 (E) “Guidance for forming of structural steels in processing.”

Mechanical properties and thickness ranges

Table 1

	Yield strength R_{eH} N/mm² Minimum Thickness mm 8 – 16	(16) – 40	Tensile strength R_m N/mm²	Elongation A_5 % Minimum	Impact strength Longitudinal minimum t °C	KV J
Optim 500 ML	500	480	570 – 720	16	-50	27

Chemical composition

Table 2

Content, % (ladle analysis)

	C Maximum	Si Maximum	Mn Maximum	P Maximum	S Maximum	Al Minimum	Nb Maximum	V Maximum	Ni Maximum	N Maximum	Ti Maximum
Optim 500 ML	0.18	0.50	1.70	0.020	0.015	0.020	0.05	0.12	1.00	0.015	0.050

Carbon equivalent (CEV)

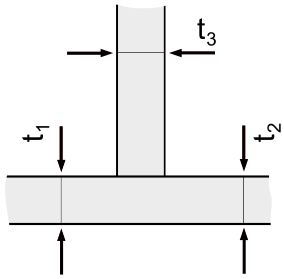
Table 3

	CEV maximum	P_{cm} maximum
Optim 500 ML	0.43	0.26

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

$P_{cm} = Si/30 + (Mn + Cu + Cr)/20 + Ni/60 + Mo/15 + V/10 + 5B$

Example of the determination of combined plate thickness



Combined plate thickness:

T-joint $t = t_1 + t_2 + t_3$

Butt joint: $t_3 = 0$

Minimum permissible bending radius for cold flanging, bending angle 90°

Table 4

	Thickness mm 8	(8) – 10	(10) – 12	(12) – 14	(14) – 16	(16) – 18	(18) – 20
	Minimum permissible inside bending radius mm						
Optim 500 ML	9.5	12.0	14.5	17.0	19.0	21.5	24.0

The bending test is not carried out at the Raahe Works, but the flangeability is guaranteed in accordance with the table.
No limitations on bending direction.

Heat treatment

Table 5

Heat treatment	Temperature °C	Treatment time and manner of cooling
Stress relieving	530 – 580 (target 560)	2 minutes / millimetre thickness, minimum 30 minutes. Slow cooling in the furnace.

Too high temperature and too long treatment time may weaken mechanical properties.

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