

P460ML2

Weldable fine-grain structural steels for pressure vessels

Material no.	1.8831
analogic	DIN EN 10028-5
Tensile strength class	C

Usage

These fine-grain structural steel grades are characterised by a minimum yield strength of 275-460 N/mm², by good weldability and high resistance to brittle cracking. These grades are used above all for manufacturing vessels for pressurised gas (LPG, butane and propane tanks), pressure vessels, steam boiler parts, pressure piping, compressors ect.

The following special grades are available for extraordinary applications:

- P...NL1 and P...NL2 or P...ML1 and P...ML2 for application temperatures below -20 °C
- P...NH for operating temperatures of up to 400 °C.

The user of these steel grades must make sure that his calculation, design and processing methods are appropriate for the material. The welding technique used must be suitable for the intended application and comply with the state-of-the-art.

The fine-grain structural steel grades rolled under normalised conditions offer good cold-forming and hot-forming properties without negatively affecting the material properties. These steel grades are therefore also suitable for cold-bending and cold-flanging as well as for cold-bending and cold-folding, considering the bending radii according to DIN 6935 for a steel grade of corresponding strength.

With cold-forming above 5 % or hot-forming outside of the temperature range of 850–1.000 °C as well as after excess times, the steels rolled under normalised conditions should be subsequently normalised at 900–950 °C. The holding time after temperature equalisation should be approx. 1 minute per millimetre of plate thickness.

Notch Impact energy

Minimum value of notch impact energy¹⁾ [J] at a test temperature of [°C]

°C	longitudinal [J]	transverse [J]
+20°C	-	-
0°C	-	≥ 80 J
-20°C	-	≥ 60 J
-40°C	-	≥ 40 J
-50°C	-	≥ 27 J

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

Chemical composition (in percent by weight)

	min.	max.
C		0,16
Si		0,60
Mn		1,70
P		0,020
S		0,015
N		0,020
Ni		0,50
Ti		0,050
V		0,10
Nb		0,050 ¹⁾
Al	0,020 ^{2) 3)}	

1) Nb + V + Ti ≤ 0,15%

2) Cr ≤ 0,30%, Mo ≤ 0,80%, Cr + Cu + Mo ≤ 0,45%

3) Minimum value for Al does not apply, if there are enough nitrogen setting elements. CE = C + Mn/6 + (Cr + Mo + V)/5 + (Cu + Ni)/15

A carbon equivalent value $C_E = C + Mn/5 + (Cr + Mo + V)/5 + (Cu + Ni)/15$ may be agreed in the order, i.e. 0,40 % max. for grades P275, 0,43 % for grades P355N, 0,39 % for grades P355M, 0,43 % for grades P420 and 0,45 % for grades P460.

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Mechanical properties ¹⁾

Nom. thick. e	Yield strength $R_{eL}/R_{p0,2}$
≤ 16 mm	460 MPa
> 16 mm	440 MPa

Nom. thick. e	Tensile strength R_m
	530 – 720 MPa

Nom. thick. e	Min. total elongation
	17 %

The samples for the tensile test are taken at right angles to rolling direction unless the product width is opposed to this.

1) Transverse samples

Available dimensions

Hot-rolled coils unpickled, mill edge

Thickn. in mm	Width in mm
2,00 – 2,24	900 – 1300
2,25 – 2,99	900 – 1350
3,00 – 3,99	900 – 1550
4,00 – 6,00	900 – 1650

Hot-rolled slit strip

Thickn. in mm	Width in mm
2,50 – 2,99	100 – 640
3,00 – 4,50	100 – 690
4,51 – 6,00	140 – 740

≤ 100 mm on request

Welding

The fine-grain structural steel grades of this series can be perfectly welded both manually and using automatic equipment by means of all known welding processes. However, the quality of the weld joint depends on the welding process, the welding conditions and the selection of the correct filler metals.

The welding wires and electrodes approved in this strength category must be used as filler metals. Basic coated electrodes are recommended for manual welding.

In general, pre-heating prior to welding or torch-cutting is not necessary. At outside temperature below +5 °C, pre-heating to approx. 150 °C should be carried out.

Subsequent normalised or stress relief annealing with the grades rolled under normalised conditions is required only if called for in the regulations or if operating and manufacturing conditions make a reduction of the residual welding stresses appear useful. The thermo-mechanically rolled steels are not suitable for normalizing; stress relief annealing is possible.

With stress relief annealing at 530–580 °C, the holding time should be 2 minutes per millimetre of plate thickness, not fall short of 30 minutes and not significantly exceed 60 minutes.

Excessively high annealing temperatures or excessively long annealing times bear the risk of reducing the strength values to below the condition of delivery.

In addition to this, the guidelines for processing these steel grades according to „Stahl-Eisen-Werkstoffblatt“ (Iron and steel material sheet) 088 must be observed.

Condition of delivery, scope of testing and certificate

The steel grades P275NH-P355NL2 are delivered in a condition obtained by normalised rolling. The steels grades P355M-P460ML2 are delivered in a thermomechanically-rolled condition. The provisions of EN 10028-2 and -5 shall apply for delivery and inspection.