



DILLIMAX 965

HIGH STRENGTH FINE GRAINED STRUCTURAL STEEL
QUENCHED AND TEMPERED

Material data sheet, edition May 2011

DILLIMAX 965 is a high strength quenched and tempered, fine grained structural steel with a minimum yield strength of 960 MPa (140 ksi)¹⁾ in its delivery condition ex works (referring to the lowest thickness range). Its mechanical properties are achieved by water quenching followed by tempering.

DILLIMAX 965 is preferentially used by the customers for welded steel structures within mechanical constructions, plant constructions and structural steel works, such as machines for structural engineering, conveying plants, hoists, cranes, flood gates and frameworks.

Product description

Designation and range of application

DILLIMAX 965 can be delivered in three qualities:

- **Basic (B)** with minimum impact values down to -20 °C (-4 °F)¹⁾: **DILLIMAX 965 B**
Steel number 1.8941 - S960Q according to EN 10025-6
- **Tough (T)** with minimum impact values down to -40 °C (-40 °F)¹⁾: **DILLIMAX 965 T**
Steel number 1.8933 - S960QL according to EN 10025-6
- **Extra tough (E)** with minimum impact values down to -60 °C (-76 °F)¹⁾: **DILLIMAX 965 E**
Steel number 1.8934 - S960QL1

DILLIMAX 965 can be delivered in thicknesses from 6 to 100 mm (¼ to 4 in.)¹⁾, according to the dimensional program. Dimensions, which deviate from the usual dimensional program, may be possible on request.

Chemical composition

For the ladle analysis the following limiting values in % are applicable:

DILLIMAX 965	C	Si	Mn	P	S	Cr	Ni	Mo	V+Nb	B
B, T, E	≤ 0.20	≤ 0.50	≤ 1.40	≤ 0.020	≤ 0.010	≤ 0.90	≤ 2.0	≤ 0.70	≤ 0.10	≤ 0.004

The steel is fine grained through sufficient aluminium content.

The limiting CEV²⁾ values are partially below the values indicated by EN 10025-6 (where t is the nominal plate thickness):

Plate thickness t [mm] (in) ^{a)}	max. CEV [%]
t ≤ 50 (2)	0.77
50 (2) < t ≤ 100 (4)	May be agreed

^{a)} The values in brackets are for information only.

Lower carbon equivalent values may be agreed on request.

Delivery condition

Water quenched and tempered according to EN 10025-6.

¹⁾ The values in brackets are for information only.

²⁾ CEV = C + Mn/6 + (Cr+Mo+V)/5 + (Cu+Ni)/15



Mechanical and technological properties in the delivery condition

Tensile test at ambient temperature - transverse test specimens -

Plate thickness t [mm] (in.) ^{a)}	Tensile strength R _m [MPa] (ksi) ^{a)}	Minimum yield strength R _{eH} ^{b)} [MPa] (ksi) ^{a)}	Minimum elongation	
			A ₅ [%]	A _{zin} ^{c)} [%]
≤ 50 (2)	980 - 1150 (142 - 167)	960 (140)	12	13
> 50 (2) ≤ 60 (2.4)	950 - 1120 (138 - 162)	930 (135)	12	13
> 60 (2.4) ≤ 100 (4)	900 - 1100 (130 - 160)	850 (123)	12	13

^{a)} The values in brackets are for information only.

^{b)} If not apparent, the yield strength R_{p0.2} is measured instead.

^{c)} These values apply if tested according to ASTM A370.

Higher minimum values may be agreed on request.

Impact test on Charpy-V-specimens

DILLIMAX 965	Specimen direction	Impact energy A _V [J] (ft.-lb.) ^{a)} at test temperature			
		0 °C (32 °F) ^{a)}	-20 °C (-4 °F) ^{a)}	-40 °C (-40 °F) ^{a)}	-60 °C (-76 °F) ^{a)}
Basic (B)	longitudinal / transverse	40/30 (30/22)	30/27 (22/20)	—	—
High toughness (T)	longitudinal / transverse	50/35 (37/26)	40/30 (30/22)	30/27 (22/20)	—
Extra tough (E)	longitudinal / transverse	60/40 (44/30)	50/35 (37/26)	40/30 (30/22)	30/27 (22/20)

^{a)} The values in brackets are for information only.

The specified minimum value is the average of 3 tests. One individual value may be below the minimum average value specified, provided that it is not less than 70 % of that value. For plate thicknesses below 12 mm (0.5 in)¹⁾, the test can be carried out on Charpy-V test specimens with reduced width; the minimum width must be 5 mm (0.2 in)¹⁾. The minimum impact value will be decreased proportionally.

Testing

Tensile and impact tests will be performed according to EN 10025-6 once per heat and 40 t. Tests on every heat treatment unit may be possible on request.

The specimens for the tensile test are prepared according to EN 10025-6. Testing is carried out on specimens of gauge length L₀ = 5.65·√S₀ or L₀ = 5·d₀, in accordance with EN ISO 6892-1.

Tensile tests according to ASTM A370 may be agreed.

The impact test will be carried out on Charpy-V-specimens in accordance with EN ISO 148-1. Unless otherwise agreed, the test will be performed at the lowest temperature of the corresponding quality on transverse test specimens taken as follows:

- for plate thicknesses < 40 mm (1.6 in)³⁾: the test specimen shall be taken in such a way that one side is not further away than 2 mm (0.08 in)³⁾ from a rolled surface.
- for plate thicknesses ≥ 40 mm (1.6 in)³⁾: ¼ of the plate thickness.

Unless otherwise agreed, the test results are documented in a certificate 3.1 in accordance with EN 10204.

Marking

Unless otherwise agreed, the marking is carried out via low stress steel stamps with at least the following information:

- steel grade (e.g. DILLIMAX 965 B, T or E)
- heat number
- number of mother plate and individual plate
- the manufacturer's symbol
- authorized inspection representative's sign

³⁾ The values in brackets are for information only.



Processing

The entire processing and application techniques are of fundamental importance to the reliability of the products made from this steel. The user should ensure that his design, construction and processing methods are aligned with the material, correspond to the state-of-the-art that the fabricator has to comply with and are suitable for the intended use. The customer is responsible for the selection of the material. The recommendations of the EN 1011 (Welding) and CEN/TR 10347 (Forming) as well as recommendations regarding job safety in accordance with national rules should be observed.

Cold forming

Cold forming means forming below the maximum allowable stress relief temperature (560 °C/1040 °F)⁴⁾. DILLIMAX 965 can be cold formed with regard to its high yield strength. Flame cut or sheared edges in the bending area should be ground before cold forming. Cold forming is related to a hardening of the steel and to a decrease in toughness. Depending on the relevant design code this can result in the need of larger bending radii than indicated in the chart. For larger cold forming amounts we recommend you to consult the steel producer prior to ordering.

During the processing, the necessary safety measures have to be taken, so that nobody will be exposed to a danger by a possible fracture of the work piece during the forming process.

The following geometries can usually be achieved by cold forming without the formation of surface defects (where t is the plate thickness):

	Minimum bending radius	Minimum die width
Transverse direction	3 t	9 t
Longitudinal direction	4 t	12 t

Hot forming

If the temperature of 560 °C (1040 °F)⁴⁾ is exceeded, the initial tempering will be altered so that the mechanical properties are affected. To regain the initial properties new quenching and tempering become necessary. However, water quenching of a formed work piece or component will often be less effective than the original quenching in the plate mill so that the fabricator may not be able to re-establish the properties required and therefore hot forming is not suitable.

Finally, it is the fabricator's responsibility to obtain the required values of the steel through an appropriate heat treatment.

Welding and flame cutting

Due to its high yield strength, DILLIMAX 965 requires special care during plate processing.

For flame cutting, the following minimum preheating temperatures are recommended: 50 °C (122 °F)⁴⁾ for plate thickness up to 20 mm (0.8 in)⁴⁾, 100 °C (212 °F)⁴⁾ for plates thickness up to 50 mm (2 in)⁴⁾ and 150 °C (302 °F)⁴⁾ for thicker plates.

For general welding instructions, please consult the EN 1011-2. In order to ensure that the tensile strength of the weld metal fulfils the requirements of the base metal, the heat input and interpass temperature must be limited during welding. Experience has shown that the welding conditions should be chosen so that the cooling time $t_{8/5}$ does not exceed 8 seconds. This is applicable when using suitable filler materials of a corresponding yield strength class.

The high yield strength of the base material must be taken into account when choosing the filler materials. It should be considered that increased heat input leads to lower tensile properties in the weld metal. If a stress relieving heat treatment is planned during or after plate processing, this must also be considered when selecting the filler materials.

To avoid hydrogen-induced cold cracking, only filler materials, which add very little hydrogen to the base metal, may be used. Therefore, shielded arc welding should be preferred. For manual arc welding, electrodes with basic coating (type HD<5 ml/100g in accordance with ISO 3690), and dried according to the manufacturer's instructions, should be used.

⁴⁾ The values in brackets are for information only.



Heat treatment

If a stress relieving has to be considered because of constructional regulations, constructive reasons or because it is necessary for the fabrication, please consult us. The properties of structural components can be altered by a stress relief heat treatment.

Detailed instructions for flame cutting, welding, machining and about the structural properties of the DILLIMAX are provided in the technical information *"MAKE SAVINGS WITH HIGH STRENGTH STEELS - DILLIMAX"*.

General technical delivery requirements

Unless otherwise agreed, the general technical delivery requirements in accordance with EN 10021 apply.

Tolerances

Unless otherwise agreed, the tolerances will be in accordance with EN 10029, with class A for thickness and table 4, steel group H, for the maximum flatness deviation. Smaller flatness deviations may be possible on request prior to order.

Surface quality

Unless otherwise agreed, the specifications will be in accordance with EN 10163-2, class A2.

General note

If particular requirements are demanded and not covered in this data sheet, please contact us with the specifications for our review and agreement prior to ordering. The information in this data sheet is a product description. This data sheet is updated at occasion demands.

The latest version is available from the mill or as download at www.dillinger.de.

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