



DI-RACK

HIGH STRENGTH FINE GRAINED STRUCTURAL STEEL FOR RACKS AND CHORDS OF JACK-UP RIG LEGS

Material data sheet Edition January 2014¹⁾

DI-RACK is a high strength quenched and tempered, fine grained structural steel, with special requirements for racks and chords of jack-up rig legs.

Product description

Designation and range of application

DI-RACK plates can be delivered in three types:

- Type B: Basic grade
- Type M: Medium grade with higher yield and tensile strength
- Type S: Special grade with higher tensile strength compared to Type M

DI-RACK can be delivered in thicknesses from 6 up to 210 mm. Other thicknesses may be possible by agreement.

Tensile and impact properties of DI-RACK Type B (+ Option 2) correspond to those of the following ABS and DNV steel grades²⁾:

DI-RACK	ABS	DNV
DI-RACK Type B	AB EQ70	NV E690
DI-RACK Type B + Option 2	AB FQ70	NV F690

Chemical composition

For the ladle analysis, the following limiting values in % are applicable.

For plate thicknesses 6 mm ≤ t ≤ 100 mm:

C	Si	Mn	P	S	Cu	Cr	Ni	Mo	V	Nb	Ti	B
≤ 0.18	≤ 0.50	≤ 1.50	≤ 0.015	≤ 0.003	≤ 0.30	≤ 1.50	≤ 1.80	≤ 0.60	≤ 0.08	≤ 0.05	≤ 0.05	≤ 0.004
P_{cm} ^{a)}												
≤ 0.35												

For plate thicknesses 100 mm < t ≤ 210 mm:

C	Si	Mn	P	S	Cu	Cr	Ni	Mo	V	Nb	Ti	B
≤ 0.18	≤ 0.50	≤ 1.50	≤ 0.015	≤ 0.003	≤ 0.30	≤ 1.80	≤ 3.50	≤ 0.70	≤ 0.08	≤ 0.05	≤ 0.05	≤ 0.004
P_{cm} ^{a)}												
≤ 0.37												

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

The steel is fine grained through sufficient aluminium content.

For each type of DI-RACK the chemical composition is specially adjusted. A more specific chemical composition can be agreed upon customer's request.

Delivery condition

Unless otherwise agreed, the delivery condition is quenched and tempered. If otherwise agreed, test pieces in the simulated quenched and tempered condition will be tested.

Order example

DI-RACK Type B + option 1 (quality class Z35) + option 2 + option 3

¹⁾ The current version of the material data sheet can be also found on <http://www.dillinger.de>.

²⁾ For explanation of Option 2 please see page number 2/4.



Mechanical properties in the quenched and tempered condition

Tensile test at room temperature – transverse test specimens –

	DI-RACK Type B	DI-RACK Type M	DI-RACK Type S
Minimum yield strength R_{eH}^a [MPa]	690	723	723
Tensile strength R_m [MPa]	770 - 940	793 - 960	830 ^{b)} - 990
Minimum elongation A_5 [%]	15	14	14

^{a)} If R_{eH} is not apparent, $R_{p0.2}$ will be measured instead.

^{b)} For plate thicknesses $180 \text{ mm} < t \leq 210 \text{ mm}$, the minimum tensile strength R_m is 800 MPa.

Hardness

	DI-RACK Type B	DI-RACK Type M	DI-RACK Type S
Hardness at room temperature in $1/4$ plate thickness [HBW]	240 - 290	260 - 300	260 - 310

Option 1

For plate thicknesses $t \geq 15 \text{ mm}$, improved deformation properties perpendicular to the surface of the product according to EN 10164 can be ordered. The quality class Z15, Z25 or Z35 (corresponding to the minimum values for the reduction of area) must be specified in the order.

Impact test on Charpy-V-test specimens

Test temperature [°C]	Location of test pieces ^{a)}	Specimen direction	Minimum average impact values A_V [Joule]
-40	$1/4$ plate thickness	longitudinal	69
		transverse	48

^{a)} In accordance with EN 10025-6 resp. EN 10025-1, for plate thicknesses $12 \text{ mm} < t < 40 \text{ mm}$ test pieces are taken from sub-surface position with one face of a specimen located within 2 mm from a rolled surface. For plate thicknesses $t \leq 12 \text{ mm}$ the test can be carried out on Charpy-V test specimens with reduced width; the minimum width must be 5 mm. The minimum impact value will be decreased proportionally.

Options for impact test on Charpy-V-test specimens

Additionally, the following options can be ordered:

Option	Test temperature [°C]	Location of test pieces ^{a)}	Specimen direction	Minimum average impact values A_V [Joule]
Option 2	-60	$1/4$ plate thickness	longitudinal	69
			transverse	48
Option 3	-27	$1/2$ plate thickness	longitudinal	69
			transverse	48
Option 4	-37	$1/2$ plate thickness	longitudinal	69
			transverse	48

^{a)} In accordance with EN 10025-6 resp. EN 10025-1, for plate thicknesses $12 \text{ mm} < t < 40 \text{ mm}$ test pieces are taken from sub-surface position with one face of a specimen located within 2 mm from a rolled surface. For plate thicknesses $t \leq 12 \text{ mm}$ the test can be carried out on Charpy-V test specimens with reduced width; the minimum width must be 5 mm. The minimum impact value will be decreased proportionally.

The specified values for the impact test are the minimum values for the average of 3 tests. One individual value may be below the minimum average values specified, provided that it is not less than 70 % of these values. Other impact values or other test temperatures can be agreed.

Testing

Tensile and impact tests are performed according to EN 10025-6 resp. EN 10025-1, hardness tests according to EN ISO 6506-1. Mechanical tests are performed at one end of every plate as heat treated. If test pieces in the simulated quenched and tempered condition have to be tested, mechanical tests will be performed at one end of every plate as rolled.

If option 1 is ordered, through-thickness tensile testing will be performed according to EN 10164.

Unless otherwise agreed, the impact tests are carried out on Charpy-V transverse test specimens. If no options are ordered, the test will be carried out at -40 °C in $1/4$ plate thickness. If Option 2 is ordered, the impact test will be carried out at -60 °C in $1/4$ plate thickness. If Option 3 is ordered, the impact test will be carried out in addition at -27 °C in $1/2$ plate thickness. If Option 4 is ordered, the impact test will be carried out in addition at -37 °C in $1/2$ plate thickness.



Unless otherwise agreed, ultrasonic testing is carried out in accordance with ASTM A 578 Level B with supplementary requirement S1.

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

Identification of plates

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

- Steel grade (DI-RACK)
- Heat number
- Number of mother plate and individual plate
- The manufacturer's symbol
- Authorized inspection representative's sign

Processing

Due to its high yield strength and elevated hardenability, DI-RACK requires special care during plate processing. The following hints and recommendations are based on best knowledge and experience of Dillinger Hütte GTS. They shall help the fabricator to develop his own fabrication procedures, appropriate for the material and adapted to his particular conditions. The responsibility for the final choice of the processing conditions therefore remains with the fabricator. The recommendations of CEN/TR 10347 and EN 1011 (=ISO/TR 17671) should be considered.

Cold forming

Cold forming means forming below the maximum stress relief temperature of 560 °C. DI-RACK can be cold formed with regard to its high yield strength. Flame cut or sheared edges should be ground before cold forming. Cold forming is always related to a hardening of the steel and to a decrease in toughness. This change in the mechanical properties can, as a rule, be partially recovered through a subsequent stress relief heat treatment. For larger cold forming amounts or if prescribed by regulations, a new quenching and tempering treatment may be necessary to restore the initial mechanical properties. In this case we recommend to consult us prior to ordering.

Hot forming

Hot forming means forming at temperatures above the maximum allowable stress relief temperature of 560 °C. Hot forming can alter the initial properties of the material and therefore requires a subsequent quenching and tempering. If hot forming is required, please contact us prior to ordering.

Flame cutting and welding

Prior to cutting the surface of the plate must be free of scale and impurities that might disturb the cutting process and cause heavy drag lines and blow wholes. For flame cutting, a minimum preheating temperature of 150 °C - 200 °C is recommended. It is beneficial to preheat the complete plate and not only the area to be cut. The temperature shall not fall below 150 °C and not exceed 400 °C during the entire cutting process.

For general welding instructions, please consult EN 1011. Preliminary tests under actual shop conditions are recommended to prove the suitability of the intended processing conditions and consumables.

In order to avoid hydrogen-induced cold cracking, only welding conditions and filler materials which add very low hydrogen to the base material shall be used. Shielded arc welding introduces very low hydrogen provided that the gas protection is correct. For manual arc welding, electrodes with basic coating (type HD < 5 in accordance with ISO 3690) which are dried according to the manufacturer's instructions should be used.

If the tensile strength of the weld metal has to fulfil the requirements of the base material, this also 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. Experience has shown that the welding conditions should be chosen so that $t_{8/5}$ does not exceed 15 s. Heat input and interpass temperatures have to be restricted to approximately 2 kJ/mm and 200 °C to keep $t_{8/5}$ below this limit. If materials with undermatching strength properties should be joined (e.g. for welded joints between racks and chords of lower strength), welding consumables corresponding to the softer steel may be applied and higher heat input can be tolerated.



Minimum preheat and interpass temperature shall be 120 °C for GSAW and 150 °C for SMAW. For SAW the higher deposition rates will usually result in somewhat higher residual hydrogen content after welding.

To avoid cracks a hydrogen effusion treatment shall be carried out immediately after weld completion and for weld interruptions before the weld area has cooled below 80 °C. Hydrogen removal shall be performed at 250 - 300 °C for 3 - 6 h (increasing time and temperature with increasing weld thickness). Under well controlled and beneficial conditions (low hydrogen clearly below 5 ml, moderate restraint, shallow weld layers) a retarded cooling by insulating the weld may be good enough to reach a sufficiently low residual hydrogen level.

For more comprehensive information about flame cutting and welding, please consult us.

Heat treatment

If a thermal stress relieving has to be considered because of constructional regulations, constructive reasons or because it is necessary for plate processing, please consult us. The properties of the material may be altered by a stress relief heat treatment.

General technical delivery requirements

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

Tolerances

Unless otherwise agreed, the thickness tolerances are in accordance with EN 10029, class B. The maximum flatness deviation for 1000 mm measuring length is 5 mm in any plate direction.

Surface condition

Unless otherwise agreed, the provisions in accordance with class A2 of EN 10163-2 are applicable.

General Note

If special requirements, which are not covered in this material data sheet, are to be met by the steel due to its intended use or processing, these requirements are to be agreed before placing the order. The information in this data sheet is a product description. This data sheet is updated if necessary. The latest version is available from the mill or as download at <http://www.dillinger.de>.

Contact

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