

DICREST

EN 10028 PART 3: P275, P355 (N, NH) DICREST 5/10/15

Fine grained pressure vessel steel adapted to sour service conditions

Specification DH-E18-I, edition April 2016¹

DICREST is the designation of Dillinger for a series of fine grained pressure vessel steels offering specific properties for sour gas service. DICREST steels are produced in a way to provide an improved resistance to hydrogen induced cracking (HIC) and are available with a minimum thickness of 10 mm. The special sour service properties of DICREST steels are an addition to the properties in accordance with the specified standard and do not influence these. This material specification describes the steel design for the DICREST series in accordance with EN 10028 Part 3: P275, P355 (N, NH).

Product description

The HIC resistance of DICREST steels is verified in the HIC test in accordance with NACE TM 0284. The test can be performed with test solution A or B (see "HIC test"). The following variants can be supplied:

Note: The values are only valid for the normalized + stress-relieved (PWHT) condition.

a) with test solution A (pH ≈ 3):

Acceptance criteria	CLR ^a %	CTR ^a %	CSR ^a %
DICREST 5	≤ 5	≤ 1.5	≤ 0.5
DICREST 10	≤ 10	≤ 3	≤ 1
DICREST 15	≤ 15	≤ 5	≤ 2

^a The CLR, CTR and CSR values (please refer to "HIC test") are calculated as mean values of all individual sections of one HIC test. Mean values per specimen (3 sections) or individual values per section can be offered upon agreement.

b) with test solution B (pH ≈ 5):

Acceptance criteria	CLR ^a %	CTR ^a %	CSR ^a %
DICREST 15	≤ 0.5	≤ 0.1	≤ 0.05

^a The CLR, CTR and CSR values (please refer to "HIC test") are calculated as mean values of all individual sections of one HIC test. Mean values per specimen (3 sections) or individual values per section can be offered upon agreement.

¹ The latest edition of this specification is available at <http://www.dillinger.de/>

Deliverable dimensions and unit weights

	Plate thickness ^a	Plate width and length	Unit weight ^a
DICREST 5	≥ 10 mm ≤ 80 mm	upon inquiry	≤ 22 t
DICREST 10	≥ 10 mm ≤ 120 mm	upon inquiry	≤ 25 t
DICREST 15	≥ 10 mm ≤ 150 mm	acc. delivery program	acc. delivery program

^a Other plate thicknesses and unit weights are possible upon agreement.

Production

In order to achieve the defined HIC resistance the following DICREST production process route is applied:

- hot metal desulfurization
- BOF converter treatment
- vacuum degassing on tank degassing unit
- desulfurization to very low S-contents
- clean steel treatment with stirring process
- inclusion shape control
- optimized casting conditions with minimization of segregation and special measures to assure high cleanliness
- high shape factor rolling (high thickness reduction)
- normalizing treatment
- stress relieving treatment on request (see "Delivery condition")

Only the combination of the above mentioned measures and the quality assurance adapted to DICREST assure that the specified HIC resistance is obtained homogeneously over the entire plate, respectively heat. This is also stated in the inspection certificate.

Chemical analysis (heat analysis)

The alloying concepts of the DICREST steels fulfill the requirements of EN 10028 Part 3; the limiting values for tramp elements phosphorus and sulfur are strongly restricted as against the standard. The following values are valid:

$$P \leq 0.010 \%$$

$$S \leq 0.0010 \%$$

Delivery condition

The plates are usually delivered in the **normalized condition**. To achieve the specified HIC resistance a stress relieving treatment (PWHT) after processing is mandatory. If no **stress relief of the entire part** after processing is scheduled (e.g. if there is no forming or welding) a stress relieving treatment of the plates, which is mandatory to obtain the specified HIC values has to be ordered.

If a hot forming of the plates is scheduled, delivery can be performed in the as rolled condition.

Mechanical properties in the normalized + stress-relieved condition

The properties of DICREST 5 to 15 steel grades fulfill the mechanical requirements of the respective steel grade of EN 10028-3. Hardness values ≤ 22 HRC are met for the base material. Hardness measurement is not performed.

Testing/Documentation

Testing of the mechanical properties is carried out on specimens in the normalized and stress-relieved condition. Unless otherwise agreed, the stress relieving treatment is carried out at a temperature between 580 °C and 600 °C, holding time 2 min/mm, but at least 60 min and not exceeding 150 min. For deliveries in the as rolled condition the testing is carried out on specimens on which the normalized plus stress-relieved condition was simulated.

Testing procedures and documentation are in accordance with the specified standard. The subsequently described HIC test is carried out per heat. Ultrasonic testing is performed on each plate in accordance with EN 10160 class S2 + E3. The test results are stated in an inspection certificate 3.1 in accordance with EN 10204, unless otherwise agreed.

HIC test

The HIC test is performed at the DILLINGER laboratory. Unless otherwise agreed, one test is carried out per heat on the thinnest plate.

Test procedure in accordance with NACE TM 0284: The inspection test is performed in accordance with NACE TM 0284: three specimens or more (depending on plate thickness) with defined dimensions are immersed for 96 h in a solution saturated with hydrogen sulfide. In general the test is performed with test solution A. DICREST 15 can be tested with solution A or B; unless otherwise indicated on the order, testing is performed with solution A.

Test solution A: Test solution A contains 5 % sodium chloride with 0.5 % acetic acid. It has a pH of 2.6 – 2.8 before saturation with hydrogen sulfide and a pH ≤ 4.0 at the end of the test.

Test solution B: Test solution B consists of artificial seawater. It has a pH of 8.1 – 8.3 before saturation with hydrogen sulfide and a pH of 4.8 – 5.4 at the end of the test.

Crack evaluation in accordance with NACE TM 0284: When the immersion is finished the specimens are cut to perform metallographic crack evaluation on 3 sections of each specimen. The crack dimensions are put in proportion to the sections' dimensions and are described by CLR (crack length ratio), CTR (crack thickness ratio) and CSR (crack sensitivity ratio) values. The final test result and acceptance criteria are the averages of CLR, CTR and CSR values of the sections of all specimens from one HIC test.

Identification of plates

The marking is carried out in accordance with EN 10028.

Processing recommendations (Welding, forming, heat treatment)

For processing the general technical rules in accordance with EN 1011 shall be observed.

The weldability of DICREST steels is in accordance with the specified standard. DICREST steels are weldable using the classical welding processes. Other more particular welding processes like electron beam welding, laser-beam welding, electro-slag welding, electro-gas welding would require more intense studies before being applied in fabrication.

The mechanical properties of heat affected zone and weld metal depend on the welding and heat treatment conditions. Welding parameters like heat input have to be limited according to the requirements. The hardness in the weld and in the HAZ will normally not exceed 22 HRC due to the mandatory post weld heat treatment (stress relieving conditions see "Testing/Documentation"). For P355, higher stress relieving temperatures respectively holding times than those indicated in the paragraph "Testing/Documentation" may be necessary if there are particular hardness requirements (e.g. max. 22 HRC in HAZ); this should be clarified on the inquiry.

Generally it is recommended to perform welding procedure qualification tests to prove the suitability of the intended processing conditions, especially if the fabricator is not sufficiently experienced in welding of the steel type.

If the plates are hot formed, the general conditions for hot forming concerning temperature and holding time apply. To obtain the specified HIC properties, a subsequent stress relief heat treatment is mandatory.

The work hardening caused by cold deformation reduces the HIC-resistance of steels. In order to avoid such a degradation a thermal treatment in the temperature range of stress relief shall be carried out after cold forming or as a final heat treatment of the equipment. Should the cold deformation exceed 5 % we recommend to normalize and stress relieve the cold formed structure to regain the HIC properties.

General technical delivery requirements

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

Tolerances

Unless otherwise agreed, tolerances are in accordance with EN 10029, with class B for the thickness.

Surface condition

Unless otherwise agreed, the indications in accordance with EN 10163 class B2 apply.

General note

If special requirements, which are not listed in this specification, 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 specification is updated as occasion demands.

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

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