

# DICREST-PLUS

Fine grained pressure vessel steel adapted to sour service conditions

Specification DH-E82-C, edition April 2023<sup>1</sup>

**DICREST-PLUS** is the designation of Dillinger for a series of fine-grained pressure vessel steels offering specific properties for sour gas service. DICREST-PLUS steels are produced in a way to provide an improved resistance to hydrogen induced cracking (HIC) and are available with a minimum thickness of 12 mm. The special sour service properties of DICREST-PLUS 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-PLUS series. DICREST-PLUS is an enhanced version of DICREST.

## Product description

The HIC resistance of DICREST-PLUS steels is verified in the HIC test in accordance with NACE TM0284. The tests are performed with test solution A (see "HIC test"). The following acceptance criteria can be supplied:

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

Acceptance criteria	CLR <sup>a</sup> %	CTR <sup>a</sup> %	CSR <sup>a</sup> %
DICREST-PLUS	≤ 7	≤ 2	≤ 0.7

## Deliverable dimensions and unit weights

	Plate thickness <sup>b</sup>	Plate width and length	Unit weight <sup>b</sup>
DICREST-PLUS	≥ 12 mm ≤ 100 mm	upon inquiry	≤ 28 t

<sup>1</sup> The latest edition of this material data sheet is available at [www.dillinger.de](http://www.dillinger.de).

<sup>a</sup> The CLR, CTR and CSR values (please refer to "HIC test") are single values of individual sections. Mean values can be offered upon agreement.

<sup>b</sup> Other plate thicknesses and unit weights are possible upon agreement.

## Production

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

- hot metal desulfurization
- BOF converter treatment or electric arc furnace (EAF)
- 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
- normalized or normalized and accelerated cooled and tempered condition (NACT for ASTM or ASME grades only)
- stress relieving treatment on request (see "Delivery condition")

Only the combination of the above-mentioned measures and the quality assurance adapted to DICREST-PLUS assure that the specified HIC resistance is obtained. This is also stated in the inspection certificate.

## Chemical analysis (heat analysis)

The alloying concepts of the DICREST-PLUS steels fulfil the requirements of the specified standards. Additionally, the following values are valid:

$$P \leq 0.010 \%$$

$$S \leq 0.0010 \%$$

## Delivery condition

The plates are usually delivered in the **normalized condition**. Other delivery conditions are possible on agreement as far as they are permitted by the standard, metallurgically necessary respectively reasonable. 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

Mechanical properties of the specified standards are met; hardness values are  $\leq 22$  HRC for the base material. Hardness measurement is not performed.

## Testing/Documentation

Testing of the mechanical properties is carried out on specimens in the agreed delivery condition and stress-relieved. The stress relieving conditions are to be agreed (e. g. according to customer specification). For deliveries in the as rolled condition the testing is carried out on specimens on which the agreed reference condition plus stress relieving 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 in accordance with the customer specification. 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 per heat is carried out.

Test procedure in accordance with NACE TM0284: The inspection test is performed in accordance with NACE TM0284: 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.

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  $\leq 4.0$  at the end of the test.

Crack evaluation in accordance with NACE TM0284: 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 test result and acceptance criteria are either single values of individual sections or average values of CLR, CTR and CSR from one HIC test.

## Identification of plates

The marking is carried out in accordance with the specified standard.

## Processing recommendations (welding, forming, heat treatment)

For processing the general technical rules in accordance with ASME VIII/1, ASME VIII/2 or EN 1011, CEN-TR 10347 shall be observed.

The weldability of DICREST-PLUS steels is in accordance with the specified standard. DICREST-PLUS 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"). 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.

For the fabrication of pressure vessels qualified welding consumables are recommended.

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 as per ASTM/ASME A/SA 20 apply for steels according to ASTM/ASME and general technical delivery requirements as per EN 10021 apply for steels according to EN; for other steel types technical delivery conditions have to be agreed.

## Tolerances

Unless otherwise agreed, tolerances as per ASTM/ASME A/SA 20 apply for steels according to ASTM/ASME and tolerances as per EN 10029, with class B for the thickness apply for steels according to EN; for other steel grades tolerances have to be agreed.

## Surface condition

Unless otherwise agreed, the indications as per ASTM/ASME A/SA 20 apply for steels according to ASTM/ASME and the indications in accordance with EN 10163-2 class B2 apply for steels according to EN; for other steel grades surface conditions have to be agreed.

## 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](http://www.dillinger.de).

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## Contact

AG der Dillinger Hüttenwerke  
Postfach 1580  
66748 Dillingen / Saar  
Germany

Phone: +49 6831 47 3455  
Fax: +49 6831 47 3089  
E-Mail: [info@dillinger.biz](mailto:info@dillinger.biz)

You can find your contact person on:

<https://www.dillinger.de/d/en/products/applications/boilers/index.shtml>