Designation: ~~E208 – 19~~ E208 – 20

Standard Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels[1]

This standard is issued under the fixed designation E208; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

INTRODUCTION

This drop-weight test was developed at the Naval Research Laboratory in 1952 and has been used extensively to investigate the conditions required for initiation of brittle fractures in structural steels. Drop-weight test facilities have been established at several Naval activities, research institutions, and industrial organizations in this country and abroad. The method is used for specification purposes by industrial organizations and is referenced in several ASTM specifications and the ASME Boiler and Pressure Vessel Code. This procedure was prepared to ensure that tests conducted at all locations would have a common meaning. This test method was originally published as Department of the Navy document NAVSHIPS-250-634-3.

1. Scope*

1.1 This test method covers the determination of the nil-ductility transition (NDT) temperature of ferritic steels, ⅝ in. (15.9 mm) and thicker.

1.2 This test method may be used whenever the inquiry, contract, order, or specification states that the steels are subject to fracture toughness requirements as determined by the drop-weight test.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Adjuncts:*

~~Drop Weight~~Drop-Weight Test Machine[2]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *ferritic*—the word ferritic as used hereafter refers to all α-Fe steels, including martensitic, pearlitic, and all other nonaustenitic steels.

3.1.2 *nil-ductility transition (NDT) temperature*— the maximum temperature where a standard drop-weight specimen breaks when tested according to the provisions of this method.

[1] This test method is under the jurisdiction of the ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.07 on Impact Testing.

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[2] Detail drawings for the construction of this machine are available from ASTM Headquarters. Order ADJE0208. Original adjunct produced in 2002.

*A Summary of Changes section appears at the end of this standard

4. Summary of Test Method

4.1 The drop-weight test employs simple beam specimens specially prepared to create a material crack in their tensile surfaces at an early time interval of the test. The test is conducted by subjecting each of a series (generally four to eight) of specimens of a given material to a single impact load at a sequence of selected temperatures to determine the maximum temperature at which a specimen breaks. The impact load is provided by a guided, free-falling weight with an energy of 250 to 1400 ft·lbf (340 to 1900 J) depending on the yield strength of the steel to be tested. The specimens are prevented by a stop from deflecting more than a few tenths of an inch.

4.2 The usual test sequence is as follows: After the preparation and temperature conditioning of the specimen, the initial drop-weight test is conducted at a test temperature estimated to be near the NDT temperature. Depending upon the results of the first test, tests of the other specimens are conducted at suitable temperature intervals to establish the limits within 10 °F (5 °C) for break and no-break performance. A duplicate test at the lowest no-break temperature of the series is conducted to confirm no-break performance at this temperature.

NOTE 1—In 1984, the method of applying the crack-starter weld bead was changed from a two-pass technique to the current single-pass procedure, and the practice of repair-welding of the crack-starter weld bead was prohibited. For steels whose properties are influenced by tempering or are susceptible to temper embrittlement, the nil-ductility transition (NDT) temperature obtained using the single-pass crack-starter weld bead ~~may not agree with~~<u>is sometimes different from</u> that obtained using the previous two-pass crack-starter weld bead, or when the crack-starter <u>weld</u> bead was repaired.

5. Significance and Use

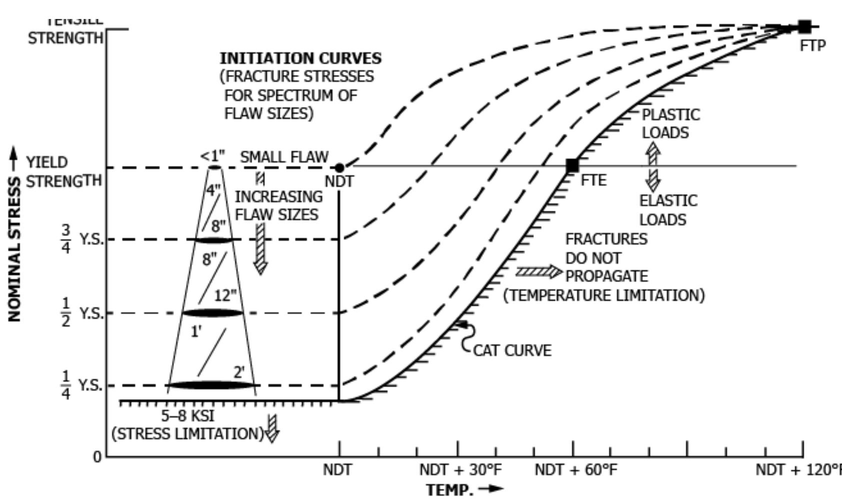
5.1 The fracture-strength transitions of ferritic steels used in the notched condition are markedly affected by temperature. For a given "low" temperature, the size and acuity of the flaw (notch) determines the stress level required for initiation of brittle fracture. The significance of this test method is related to establishing that temperature, defined herein as the NDT temperature, at which the "small flaw" initiation curve, Fig. 1, falls to nominal yield strength stress levels with decreasing temperature, that is, the point marked NDT in Fig. 1.

5.2 Interpretations to other conditions required for fracture initiation may be made by the use of the generalized flaw-size, stress-temperature diagram shown in Fig. 1. The diagram was derived from a wide variety of tests, both fracture-initiation and fracture-arrest tests, as correlated with the NDT temperature established by the drop-weight test. Validation of the NDT temperature has been documented by correlations with numerous service failures encountered in ship, pressure vessel, machinery component, forged, and cast steel applications.

5.3 Lists of Selected References Relating to Development of Drop-Weight Test. Selected References Relating to Correlation of NDT temperature to Service Failures, and Selected References Relating to Neutron Irradiation Embrittlement are presented following Section 17 on Precision and Bias.

6. Apparatus

6.1 The drop-weight test machine is of simple design based on the use of readily available structural steel products.[2] The principal components of a drop-weight machine are a vertically guided, free-falling weight, and a rigidly supported anvil which



CAT (crack arrest temperature)–the temperature of arrest of a propagating brittle fracture. CAT curve is thus a stress versus temperature curve as related to crack arrest.

FTE (fracture transition elastic) temperature–the crack arrest temperature for a stress level equal to the yield strength thus marks the highest temperature of fracture propagation for purely elastic loads.

FTP (fracture transition plastic) temperature–the temperature above which fractures are entirely shear, that is, show no center regions of cleavage fracture, and the stress required for fracture approximates the tensile strength of the steel.

FIG. 1 Generalized Fracture Analysis Diagram Indicating the Approximate Range of Flaw Sizes Required for Fracture Initiation at Various Levels of Nominal Stress, as Referenced by the NDT Temperature[3, 4]