Standard Method for the 1-Inch Dynamic Tear Test

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ABSTRACT

This report describes a standard method for conducting dynamic tear (DT) tests to determine the DT energy (fracture toughness) value for structural base metal and weld metal using the standard 1-in. DT test specimen. A description of the apparatus, the dimensions and preparation of specimens, and details of the testing procedures are given. Use of this standard method is recommended for specification purposes, and it provides for comparison of results between different laboratories on a common basis.

The DT test was evolved at the Naval Research Laboratory starting in 1960 and has been used extensively for characterization of fracture toughness properties of ferrous and nonferrous structural metals. DT test facilities have been established at the various research laboratories and production plants of the major steel companies in this country and abroad.

PROBLEM STATUS

This is a special interpretive report covering the standardization and use of 1-in. dynamic tear (DT) tests for characterization of fracture toughness properties of ferrous and nonferrous structural metals. The major portions of the studies are continuing under established problem and subtask categories.

AUTHORIZATION

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STANDARD METHOD FOR THE 1-INCH DYNAMIC TEAR TEST

INTRODUCTION

The dynamic tear (DT) test was evolved at the Naval Research Laboratory starting in 1960 and has been used extensively for the characterization of fracture toughness properties of ferrous and nonferrous structural metals. The initial version of the DT test featured a composite specimen utilizing a brittle cast bar welded to the test material. The composite specimens were fractured with a drop-weight machine, and the test was called the Drop-Weight Tear Test (DWTT). Several specimens were tested to establish the "fracture energy" of the test material, i.e., via bracketing techniques. An improved specimen design, featuring an integral brittle weld created by special electron-beam welding techniques and a 5000-ft-lb pendulum machine with direct energy readout capability, was evolved in about 1963. This simplified the test procedure and reduced the costs of testing by making it possible to determine the fracture energy of test materials using single specimens. To reflect these evolutionary improvements, the name was changed to *dynamic tear* test in 1967. DT test facilities have been established at various research laboratories and production plants of the major steel-producing companies in this country and abroad.

Structural metals can manifest a variety of fracture modes, from plane strain (square break) to elastic-plastic (mixed mode) to gross strain (full slant), depending on the intrinsic fracture toughness and the severity of the imposed mechanical conditions. The basic concept and intent of the DT test is to measure the energy of the fracture process (fracture toughness) for the characteristic fracture mode obtained under limit severity test conditions. Incorporating limiting mechanical conditions of crack sharpness, dynamic loading, and sufficient thickness to develop characteristic fracture modes results in a measured energy value that represents a definable lower limit of fracture toughness. For thickness greater than 1 in. (say 2 to 3 in.), an exact or close approximation of the limiting fracture mode energy value is obtained. For much larger thicknesses (>5 in.), tests of full-thickness dynamic tear are conducted to develop the correspondence of fracture modes. In effect, calibration is required for the very thick sections, and this is presently under way with 6- to 12-in.-thick steels

Since the characteristic limiting fracture mode represents the condition of least fracture energy that can be imposed on the metal, it may be defined as the *baseline* value. This baseline energy value is directly relatable to the plastic zone size generated in the fracture process. Thus, the DT energy value provides an index of the plastic zone size developed under limit-severity test conditions. Since less severe mechanical conditions (lower constraint) will result in a more ductile fracture mode, the evaluation of fracture toughness by the DT test represents a realistic estimate of the inherent fracture toughness properties of the metal; i.e., it cannot be less than that indicated for limit conditions. This feature of the DT test provides for the comparison of metal characteristics on a common basis.

Interpretations of DT energy to flaw-size, stress-level relations for instability fracture can readily be made for purposes of fracture-safe design. The transition from a gross-strain to an elastic-plastic or to a plane-strain fracture mode represents a transition from absolute to conditional (depends on flaw and stress) resistance to fracture. For structural steels that feature a fracture transition in the service temperature range, the DT energy curve can be indexed to the fracture analysis diagram (FAD). In the lower temperature region approaching nil-ductility transition (NDT) conditions, the nil-ductility analysis diagram (NAD) provides expanded definition of flaw-size and stress-level relations for fracture initiation. For high-strength ferrous and nonferrous metals and structural conditions providing for a plane strain fracture mode, the DT energy can be correlated to the K_{Ic} value and graphically indexed to the K_{Ic}/σ_{ys} ratio with the newly developed ratio analysis diagram (RAD), Fig. 1. By enhancing the interpretations of the critical temperature concept, and by additionally providing an engineering definition of the effective K_{Ic}/σ_{ys} ratio, the DT test permits indirect use of fracture-mechanics technology sufficient for most engineering purposes (Ref. 1-5).

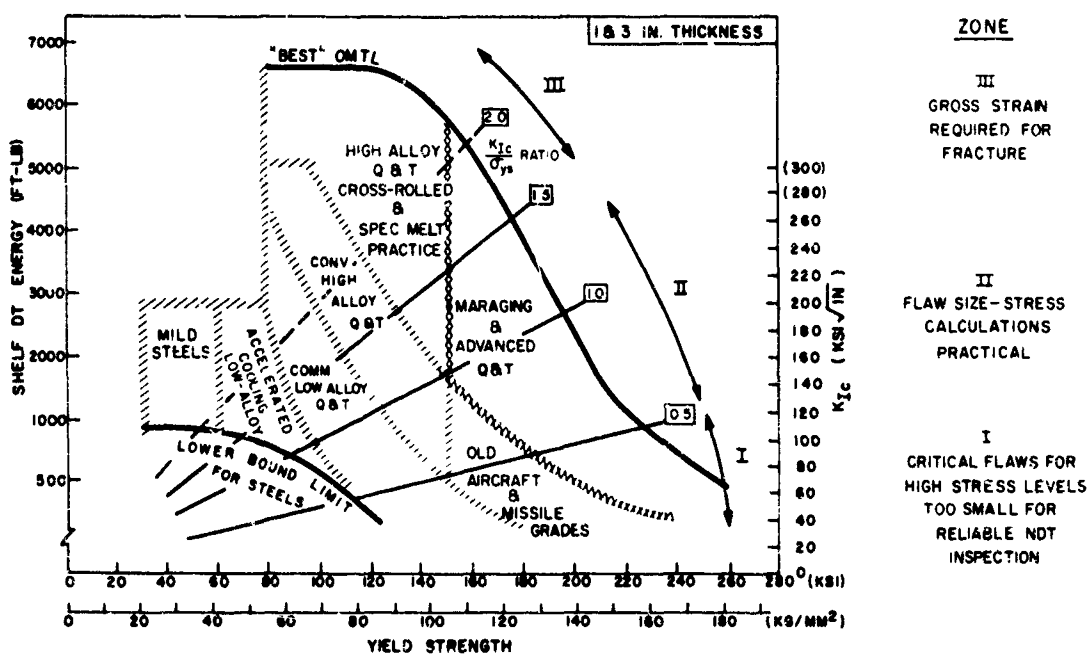


Fig. 1 - Compendium Ratio Analysis Diagram (RAD), illustrating zonal indexing for generic classes of steels. The K_{Ic}/σ_{ys} ratio lines provide ready reference to flaw-size, stress-level conditions for fracture initiation for engineering purposes, as described in Ref. 1.

1. SCOPE

1.1 This report describes the method of conducting DT tests to determine the DT energy value for structural base metal and for weld metal, using the standard 1-in. DT test specimen. It gives a description of the apparatus, the dimensions and preparation of specimens, and details of the testing procedures.

1.2 This method may be used whenever the inquiry, contract, order, or specification states that the structural base or weld-metal products are subject to fracture toughness requirements as determined by the DT test.

2. SUMMARY OF METHOD

2.1 The basic DT test procedure, Fig. 2, consists of impacting a simply supported specimen having a specially prepared, brittle crack-starter weld (a in Fig. 2) on the

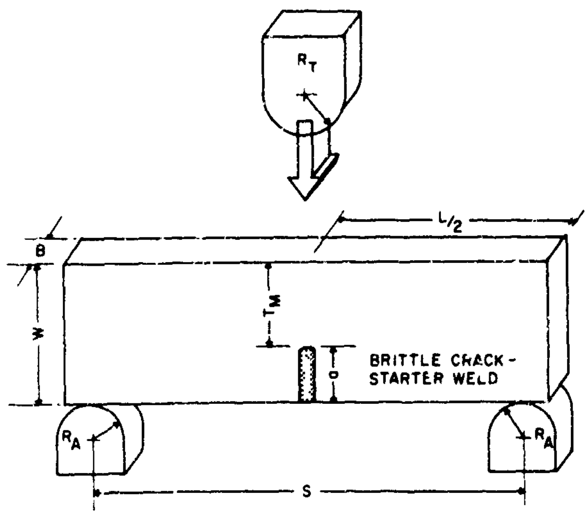


Fig. 2 - Diagram of basic dynamic tear test setup (parameters are defined in Tables 1 and 2)

tension side. The brittle crack-starter welds are prepared by diffusing a small amount of embrittling material in an electron-beam weld through the 1-in. plate thickness to form a highly brittle alloy. Very little energy need be applied to the brittle crack-starter weld to initiate and propagate a crack into the ligament of test material (T_M in Fig. 2). The 1-in. DT specimens are fractured using pendulum machines, and the total energy for fracture is recorded. Representative 1-in. DT energy versus temperature-transition curves for various steels are shown in Fig. 3.

3. SIGNIFICANCE OF TEST

The significance of the DT test derives from the limiting (worst-case) mechanical conditions imposed on the metal sample. The DT energy value is a measure of fracture energy under conditions of the most adverse, crack tip, mechanical constraint features. A significant material property is thus defined for the temperature of the test.*

4. PRECAUTIONS

4.1 Standard Specimen

This method establishes a standard 1-in.-thick specimen and conditions to determine the DT energy value of a given structural metal or weld metal for a specific temperature. The use of standard specimens with nonstandard test conditions or the use of nonstandard specimens shall not be allowed under this specification.

*The limiting mechanical conditions of the 1-in. DT test are necessarily severe and represent the worst case. Indexing procedures that provide close approximations to this baseline value are being established for certain structural metals using smaller DT test specimens, with essentially equivalent mechanical conditions produced with a deep-machined and pressed-tip notch where DPN is deep-pressed notch (5/8-in. DPN).

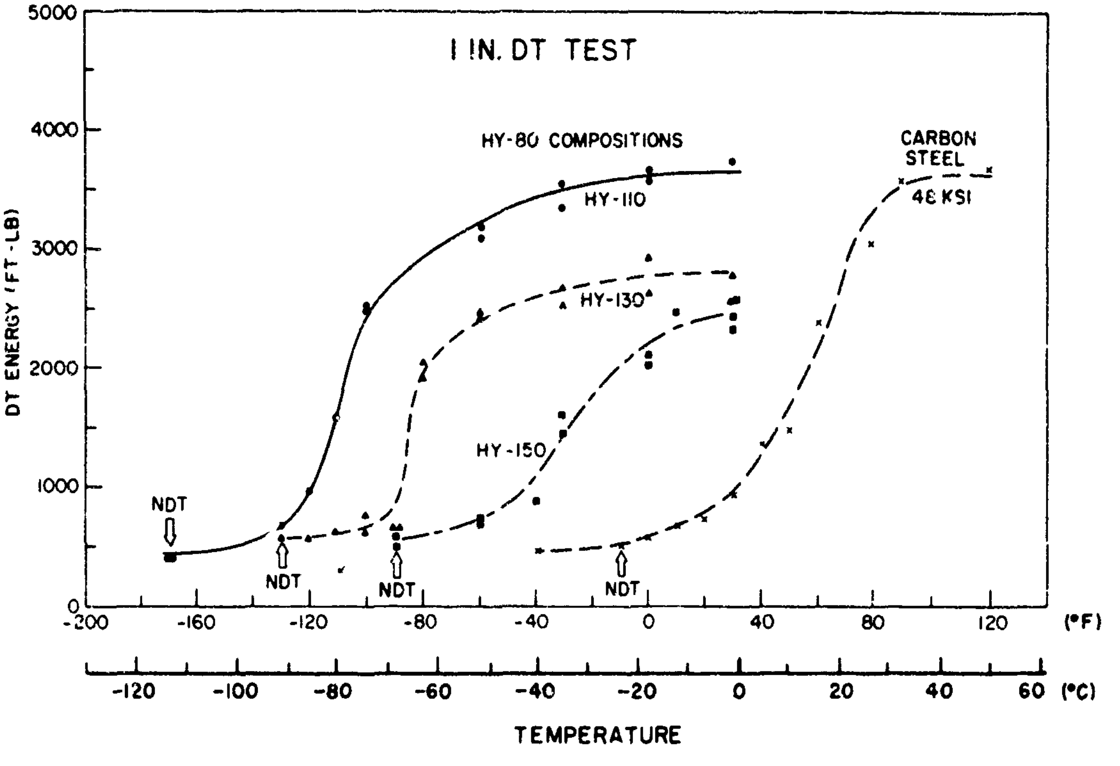


Fig. 3 - Representative 1-in. DT energy transition curves as a function of test temperature for various steels. Note that NDT temperatures determined by the drop-weight test are always located at the toe region of the respective DT curves, and the sharp rise (limiting baseline values) of low to high DT energies occurring above the NDT temperature in the transition temperature range for all steels.

4.2 Fracture Interruption

This method employs a brittle electron-beam (EB) weld to achieve conditions for fracture initiation with a minimum of energy. If the crack-starter action is interrupted at the interface of the brittle weld and the test material, the recorded DT energy value will be higher than that indicative of the true toughness level for the material. After the completion of each DT test, the specimen shall be examined and the test shall be considered not valid upon visual evidence that an interruption occurred. Figure 4 shows the fracture face of a 1-in., plate-metal DT specimen in which an interruption did occur due to the presence of a "hole" in the specimen caused by prolonged holding of the electron beam at the interface of the test material and the crack-starter weld. Figure 5 illustrates a case in which an interruption occurred due to a preexisting, transverse crack in a 1-in., weld-metal DT specimen. The DT fractures and the appearance of several crack-starter welds that provided valid tests are shown in Fig. 6.

5. DEFINITIONS

5.1 Dynamic Tear Energy

The DT energy is the total energy required to fracture a standard 1-in. DT specimen when tested according to the provisions of this method. The average DT energy

Fig. 4 - Fracture face of 1-in. DT plate metal specimen illustrating the interruption of crack-starter action caused by a defective EB weld

Fig. 5 - Weld metal DT specimen in which effective crack-starter action was interrupted by preexisting transverse crack in sample of weld metal

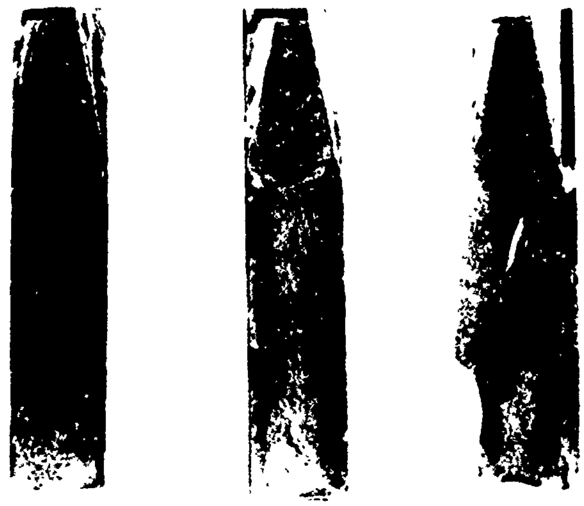


Fig. 6 - DT fractures and the crack-starter appearance in valid tests for three specimens showing, right, gross strain (full slant); center, elastic-plastic (mixed mode); and left, plane strain (flat-break) fracture modes as a function of test temperature

shall be based upon a minimum of two specimens, or more if required by the purchaser or if retest specimens are required.

5.1.1 With a single-pendulum machine, the DT energy value recorded is the difference between the initial and the final potential energies of the pendulum as in the Charpy-V test.

6. APPARATUS

6.1 General Requirements

Any pendulum-type machine with a capacity sufficient to fracture completely the standard 1-in. DT specimen with one blow and with an energy measuring system calibrated within an accuracy of ±10% shall be satisfactory equipment for conducting 1-in. DT tests. The principal components of the machine are a free-falling weight and a rigidly supported anvil, which provide for the loading of the rectangular plate specimen as a simple three-point loaded beam.

6.2 Single-Pendulum Machine

Figure 7 illustrates a 5000-ft-lb capacity, single-pendulum machine commonly used for DT testing. This machine can be equipped with exchangeable pendulums to provide a 10,000-ft-lb capacity for testing 1-in. DT specimens of metals that exhibit extremely high levels of fracture toughness. Blueprint drawings showing assembly and details for this single-pendulum machine are available upon request.*

*Address request to: Naval Research Laboratory, Metallurgy Division, Code 6380, Washington, D.C. 20390.

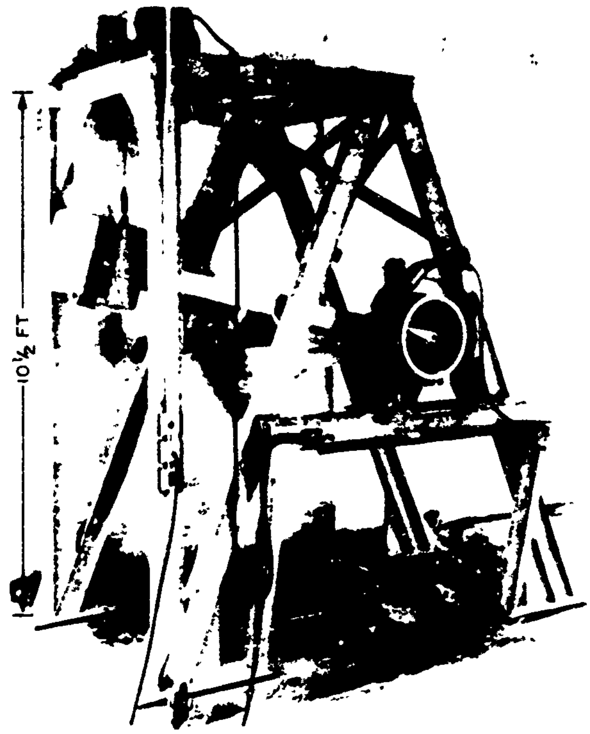


Fig. 7 - Single-pendulum (5000 and 10,000 ft-lb capacity) machine commonly used for DT testing

6.3 Anvil Supports and Striking Tup

The anvil supports and striking tup for 1-in DT tests are shown schematically in Fig. 2. These shall conform to the values given in Table 1.

Table 1
Requirements for Striking Tup and Anvil Supports

Parameter	Units	Dimension	Tolerance
Radius of Striking Tup, R_T	in. mm	1-1/2 38.0	±1/64 ±0.5
Radius of Anvil Supports, R_A	in. mm	1-3/8 35.0	±1/64 ±0.5
Support Span, S	in. mm	16.0 405.0	±1/16 ±1.5

The anvil supports and striking tup shall be steel, hardened to a minimum hardness value of Rockwell C 48. The dimensions of the test specimen shown schematically in Fig. 2 are specified in paragraph 7.1.

6.4 Construction of Pendulum and Anvil Weight

Construction of the pendulum and anvil shall be such as to allow rotation of the specimen halves around the anvil support without lateral interference with the sides of the pendulum. This is accomplished by design of the dumbbell-shaped pendulum as shown in Fig. 8.

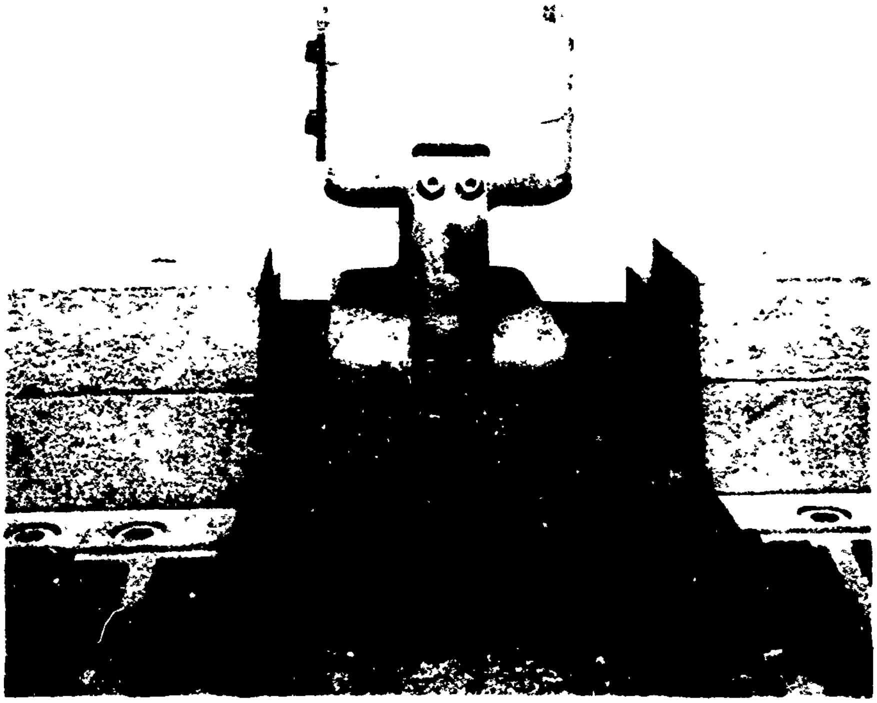


Fig. 8 - Design of pendulum machine hammer and striking tup to allow for rotation of DT specimen halves without lateral interference with the sides of pendulum or anvil supports

6.5 Drop Height and Size of Pendulum

The limits for the vertical drop heights of the pendulum are set to achieve the maximum effect of strain rate on the fracture toughness of the test material without introducing error due to the vibrational aspects of impact tests. The weight of the pendulum for a specific machine is dependent upon the desired capacity of the machine. The drop heights for the tup from the starting position to the specimen shall not be less than 4 feet (1.2 meters) nor more than 7 feet (2.1 meters). The weight of the pendulum corresponding to the suggested 5000 ft-lb capacity using the maximum specified drop height is: hammer weight = 5000/7 ≈ 715 lb (or 325 kg).

7. TEST SPECIMENS

7.1 Size of Specimen

A schematic drawing of the 1-in. DT specimen is shown in Fig. 2. The tolerances for the dimensions of the 1-in. DT specimen blank shall conform to the values given in Table 2.

Table 2
Dimensions of 1-in. DT Specimen Blank

Parameter	Units	Dimension	Tolerance
Test Material, T_M	in. mm	3.0 75	±0.04 ±1.0
Width, W	in. mm	4.75 120.0	±0.12 ±3.0
Length, L	in. mm	18.0 455.0	±1.0 ±25.0
Thickness, B	in. mm	1.0 25.0	±0.06 ±1.5
Brittle EB Weld, a	in. mm	1.75 nom. 44.5 nom.	

7.2 Length of Crack-Starter Weld

The crack-starter EB weld is positioned to provide a 3-in. fracture path in the test material. Thus, the crack-starter weld and surface notch constitute the remainder of the specimen width, or a nominal 1-3/4 in. In preparing the specimen for EB welding, the terminal end of the machined groove fixing the length of the EB weld is located within the tolerance specified in Table 2 for the 3-in. dimension for the test material (T_M).

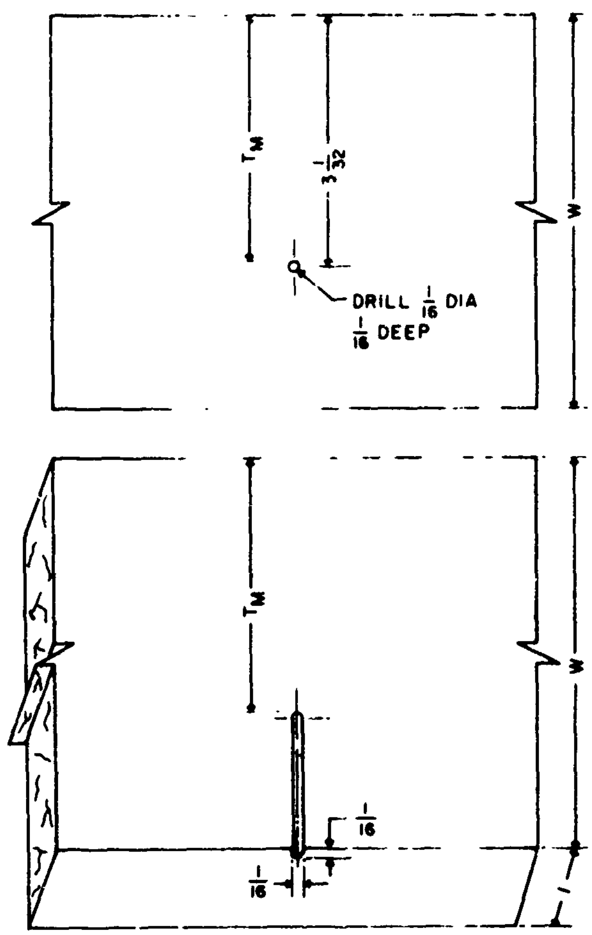
7.3 Procedure for EB Welding of Crack-Starter Weld

7.3.1 Preparation of the DT specimen for the EB crack-starter weld requires machining a shallow groove on the side of the DT specimen, as shown in Fig. 9. One method for machining the groove is as follows. The test-material (T_M) dimension is laid off and marked with a center punch (Fig. 9, top), and a 1/16-in.-deep hole is drilled at that location with a 1/16-in.-diameter drill. The groove is then cut from the tension edge of the specimen to the hole using a parting tool with 1/32-in. radius and a shaper (Fig. 9, bottom). A wire of an alloy known to embrittle the test material is placed in the machined groove.

7.3.2 For steel DT specimens, an unalloyed titanium wire (0.063-in. diam) is placed in the machined groove and upset by light hammering to hold it securely in place. This is done to ensure the uniform distribution of embrittling alloy along the length of the groove. If the wire does not make good contact with the base metal, there is a tendency for the electron beam to premelt the wire, which causes the embrittling material to ball up and be ejected from the weld zone. Complete penetration of the embrittled crack-starter weld in steel can be accomplished from one side.

7.3.3 Tin or phosphor bronze wire (0.063-in. diam) is used to embrittle aluminum alloy plates, and iron or stainless steel wire is employed with titanium alloys. The normal procedure for aluminum and titanium alloys is to machine a groove on both sides of the test specimen and use two EB passes to provide the embrittled crack-starter weld.

7.3.4 The penetration of the EB weld is primarily dependent upon the power level, the focus or diameter of the beam, and the traverse speed. Typical machine settings for a gun-to-work distance of 3-1/2 in., with sharp focus on the top surface of the work piece, are as follows:



DIMENSIONS IN INCHES

Fig. 9 - Preparation of DT specimens for EB welding of crack-starter weld

Metal	Applied Voltage (kv)	Traverse (in./min)
Steels	40-45	50-40
Titanium	30-35	50-40
Aluminum	30	60-45

The beam current is in the range of 325 to 400 ma. A trial run should be made on each alloy to obtain the correct settings that provide the desired penetration with a minimum of spatter. Higher voltage and slower traverse speeds increase the penetration.

7.3.5 Notching the Crack-Starter Weld. The bottom (tension) edge and sides of the crack-starter weld are notched in a trapezoidal pattern to assist initiation of the crack in the brittle weld. The dimensions of the trapezoidal notch are given in Fig. 10.

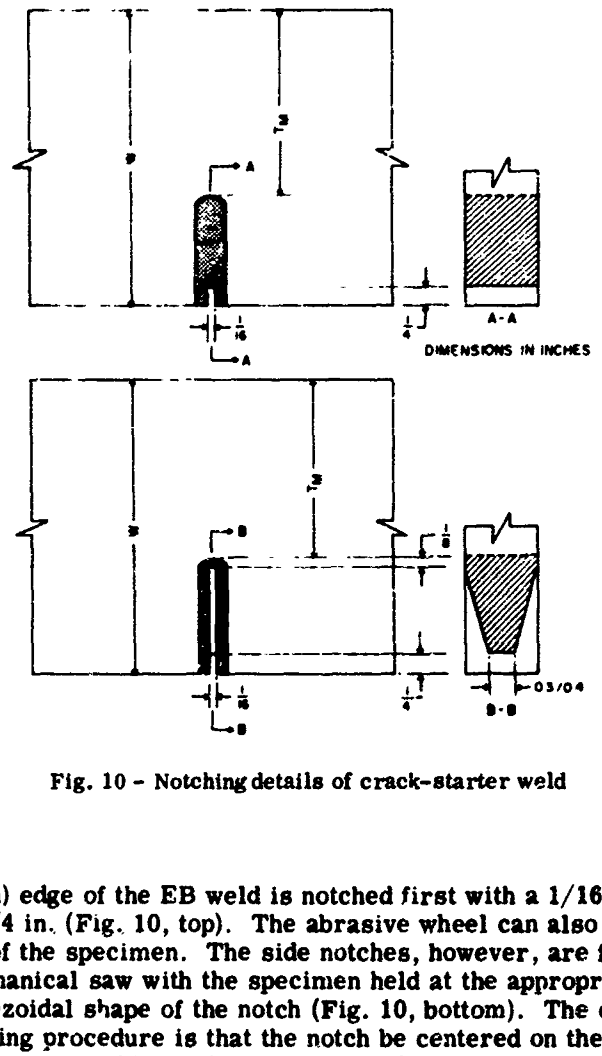


Fig. 10 - Notching details of crack-starter weld

The bottom (tension) edge of the EB weld is notched first with a 1/16-in.-thick abrasive saw to a depth of 1/4 in. (Fig. 10, top). The abrasive wheel can also be used to start the notch on the sides of the specimen. The side notches, however, are finished with a 1/16-in.-thick mechanical saw with the specimen held at the appropriate angle in a vise to provide the trapezoidal shape of the notch (Fig. 10, bottom). The only tolerance provided for this notching procedure is that the notch be centered on the EB weld and that the side notches do not extend beyond the end of the EB weld into the test material. A scribed line, marked 1/8 in. from the end of the EB weld, can be used as a guide to terminate the saw cutting of the side notches.

7.4 Preparation of Weld-Metal DT Test Specimens

7.4.1 The DT test procedure provides a method for assessing the fracture-toughness characteristics of weld metal. The weld-metal DT specimen shall be sawed from a given length of weldment fabricated with the specific welding procedures, welding process, electrodes, and plate alloys being qualified. The minimum width of the weldment shall be 17 inches. The weld joint geometry may be any of those illustrated in Fig. 11. Each of the illustrated weld joint geometries requires approximately the same quantity of weld metal. The weldment configurations shown in Fig. 11 are required for weld-metal DT tests because they provide a width of weld metal sufficient to contain all of the DT fracture surface in the weld deposit. With conventional double-V geometry weldments using narrow (1/16- to 1/8-in.) root openings, the DT fractures may involve weld-metal, heat-affected zone, and prime plate areas. An integrated DT energy is thus obtained which may not be indicative of the intrinsic fracture toughness of the weld metal.

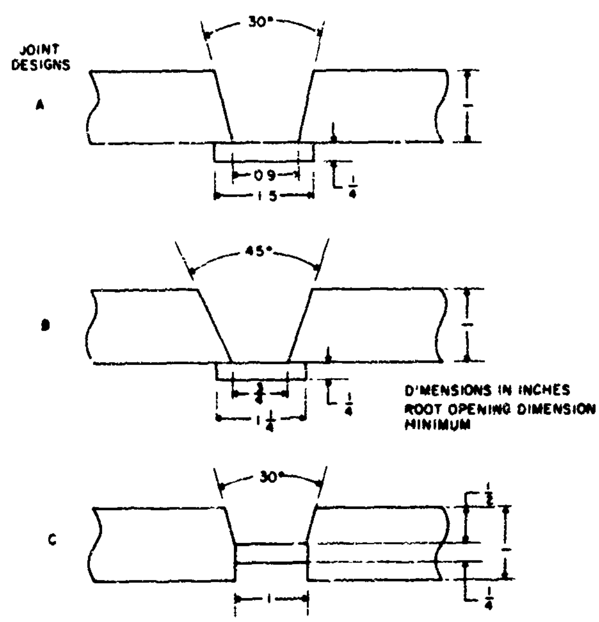


Fig. 11 - Suitable joint geometries for weld metal DT test specimens

7.4.2 Prior to welding the bottom side of the weld joints illustrated in Fig. 11, the backup bar is removed and a depth of approximately 1/8 in. above the illustrated top surface of the backup bar is also removed (by arc-air gouging, chipping, and/or grinding) to expose sound and clean weld metal. Prior to rewelding of the back, the ground area shall be magnetic-particle inspected; if flaws are present, they shall be removed before rewelding begins. The weld crown at the plate surfaces shall be ground "smooth and flush," which for purposes of this method is defined as 0 to 1/16-in. maximum weld crown.

7.4.3 The brittle crack-starter portion of a weld-metal DT specimen is located on the central axis of the test weld. Preparation and techniques for electron-beam welding of the crack-starter weld are the same as those described for plate-metal DT specimens. Figure 12 depicts a steel weld-metal DT specimen at various stages in its preparation.

7.5 Identification of DT Test Specimens

All sample material and specimens removed from a given plate shall be marked to identify their particular source (heat number, slab number, etc.). A simple identification system shall be used in conjunction with an itemized table to record all pertinent information.

7.5.1 Weld-metal DT test specimens shall be marked to identify the heat and lot number of the welding electrode, the welding process and procedures, the preheat and interpass temperatures employed, joint geometry, and prime plate metal used for the qualifying weldment.

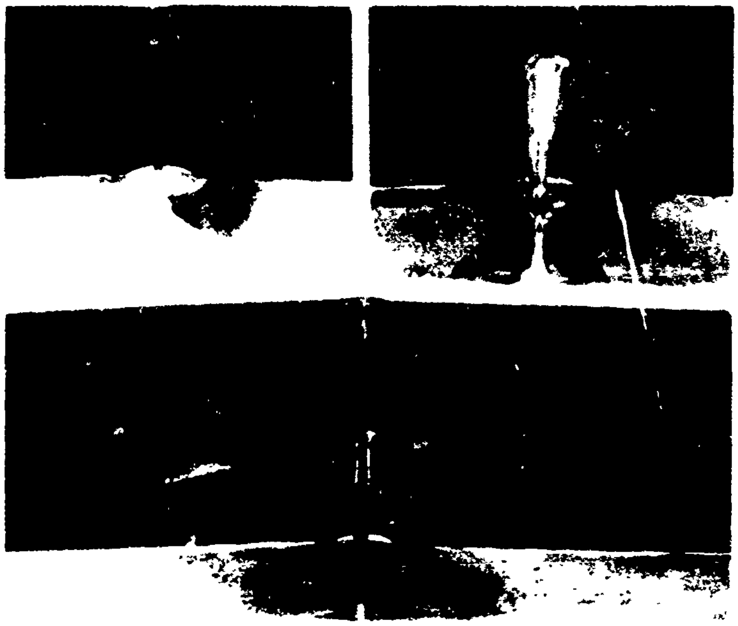


Fig. 12 - Electron-beam weld techniques for crack-starter weld preparation in a steel weld metal DT specimen: above left, titanium wire peened into 1/16-in. deep shaper groove; above right, completed electron-beam weld; bottom, completed DT specimen with notched EB weld

7.6 Orientation

For the low-temperature toe region (brittle) of the DT energy versus temperature transition curve, the DT test is insensitive to orientation with respect to rolling or forging direction. However, in the transition temperature range and at the upper shelf (gross plastic strain) temperatures, the DT test can be highly sensitive to orientation depending upon the anisotropy of the material being evaluated. Therefore, unless otherwise agreed to, all DT specimens specified for plate products by the purchaser shall be oriented so that the fracture propagates in the principal rolling direction of the plate (i.e., the ASTM WR orientation (6)).

7.7 Relation to Other Specimens

Unless otherwise specified by the purchaser, the DT specimens shall be removed from material at positions adjacent to the location of other required test specimens (for example, tensile test specimens). For products receiving a quenched and tempered heat treatment, the side of the DT specimen containing the EB weld shall be nearest to and a minimum of three plate thicknesses from the as-heat-treated end of the plate.

7.8 Specimen Cutting

The specimen sample material and the specimen ends may be flame cut. The specimen side containing the EB crack-starter weld may also be flame cut, providing semiautomatic equipment and fixturing is used to produce a smooth, flame-cut edge perpendicular to the plate surfaces. The test material (T_M) side shall be saw cut or machined, using adequate coolant to prevent specimen overheating, and shall be a minimum of 1 in. from any flame-cut surface.

8. PROCEDURE

8.1 General

Conduct the DT test by placing a specimen in a heating or cooling device until it is at the desired temperature. Then place it on the anvil and align so it will be struck squarely by the pendulum within the time specified in 8.3.2. Care must be taken to ensure the proper measurement of the specimen temperature and the alignment of the specimen on the anvil. Using adequate auxiliary equipment and following a definite procedure will aid in making a valid test.

8.2 Measurement of Specimen Temperatures

The entire test specimen shall be at a known and uniform temperature during the test. It can be assumed that if the specimen is fully immersed in a liquid medium in an agitated bath at a known constant temperature and separated from adjacent specimens by a minimum of 1 in. for a period of at least 45 min, the specimen temperature is the same as the bath temperature. If a gas heat-transfer medium is used, the required minimum holding time is increased to 60 min. If it can be shown by appropriate test techniques, such as using a thermocouple buried in the center of a dummy test specimen, that specimen equilibrium temperatures can be developed in a shorter period, the specimen-holding period can be reduced, provided prior approval is obtained from the purchaser. The constant-temperature baths or ovens may be of any type that will heat or cool the specimens to a known and uniform temperature.

8.2.1 Measure the bath temperature by a device with calibration known to ±2°F or ±1°C. One convenient method for bath-temperature measurement is to use a bare thermocouple connected to an automatic recorder.

8.2.2 A deep, well-insulated container, holding from 10 to 12 gallons (42 to 49 liters) of a suitable heat-transfer liquid, will maintain a given temperature for the required specimen-holding period with minor corrections. By immersing an open basket of cracked dry ice or an electrical heater in the bath, the bath temperature can be precisely adjusted. Standing the specimens on end in the bath with the upper ends leaning on the vessel wall is recommended. Specimens placed horizontally in the bath should be laid on a screen or perforated platform at least 1 in. (25 mm) from the bottom. If several specimens are placed in one bath, they should be spaced a minimum of 1 in. (25 mm) apart to ensure an adequate flow of heat-transfer liquid around each specimen.

8.2.3 For reasons of convenience, economy, and safety, several different heat-transfer liquid baths may be used to cover the spectrum of test temperatures. A liquid bath containing 68% ethylene-glycol and 32% water is suitable for test temperatures ranging from -60° to 220°F. A liquid bath of trichloromonofluoromethane (Refrigerant 11) can be used to cover test temperatures ranging from -120°F to -40°F. For test temperatures of -100°F and lower, liquid-nitrogen cooling of the heat-transfer liquid bath is required. With adequate ventilation, an isopentane liquid bath can be used for test temperatures ranging from -240°F to -100°F; however, caution is recommended because of the flammability of isopentane vapors.

8.3 Specimen Testing and Anvil Alignment

8.3.1 Any convenient procedure may be used to remove a specimen from the temperature bath and transfer it to the test machine, provided it does not affect the control of specimen temperature. Tongs, if used, shall be kept in the temperature bath to maintain a temperature equal to the specimen temperature. For conventional test temperatures, transfer and alignment of a specimen can be accomplished by hand, using heavy rubber gloves and grasping the specimen at the ends away from the fracture area.

8.3.2 The specimen shall be broken within 30 seconds after it has been removed from the constant-temperature medium or temperature control is presumed to be lost and the specimen shall be returned to the medium for a minimum additional holding time of 15 minutes.

8.3.3 To obtain a valid test, the specimen, anvil, and pendulum shall be properly aligned so the specimen is broken under the following conditions:

8.3.3.1 The specimen shall be centered on the anvil, and the ends shall contact or rest on the anvil supports.

8.3.3.2 The tup of the pendulum shall strike within ±0.1 in. (±2.5 mm) of a line drawn normal to the tension surface of the specimen and passing through the centerline of the crack-starter weld.

8.3.3.3 The specimen sides and ends shall be free from any interference during the test.

8.4 Alignment Tool

Any convenient alignment tool may be employed to achieve proper longitudinal alignment of the specimen with respect to the anvil and tup of the pendulum. Proper alignment of the specimen on pendulum machines is achieved in the manner shown in Fig. 13. The length of the alignment tool is exactly one-half the distance between the anvil supports. One edge of the alignment tool is held squarely against the side of one anvil support, and the center of the crack-starter notch is aligned with the other edge of the alignment tool.

9. REPORT

9.1 Contents

The report shall include the following information:

9.1.1 Type of material (steel, titanium, aluminum, etc.), nominal alloy content, and heat treatment condition;

9.1.2 Mill processing practices including melting and deoxidation practices, relative degree of cross-rolling for plate products, and processing information for welding electrodes;

9.1.3 For plate material, the size and heat number of the parent melt and subsequent special remelts, if any, and plate number, etc.;

9.1.4 For DT test of weld metal, the heat and lot number, the electrode type, the welding process, welding procedures, etc.;

Fig. 13 - Method recommended for alignment of DT specimen on anvil of pendulum machine

9.1.5 Identification, orientation, and location of DT test specimens;

9.1.6 Test conditions, including pendulum weight, drop height, and test temperatures;

9.1.7 Results of the test for each specimen (including retest specimens, if any) and the average DT energy for the product involved;

9.1.8 Deviations, if any, from this test method.

10. MATERIAL-QUALIFICATION TESTING

10.1 Use of DT Test

On the basis of refinement of structural design, fabrication quality, expected service conditions, and material characteristics, a DT energy value and test temperature can be selected as the performance criteria for a product specification.

10.2 Single-Temperature Tests

Specification tests conducted at a given test temperature, on a go, no-go basis, shall require that a minimum of two DT specimens be tested. Both DT specimens thus tested shall exhibit DT energy values in excess of the minimum specified DT energy value of the product specification.

10.2.1 If the DT energy value of one of the two DT specimens noted in paragraph 10.2 above falls below the minimum specified DT energy of the product specification, a retest of two additional DT specimens shall be required. Both retest DT specimens shall exhibit energy values in excess of the minimum DT energy value of the product specification in order to obtain an average DT energy of all four specimens. If one or both of the retest DT specimens should fall below the minimum energy value of the product specification, the heat shall be considered unsatisfactory.

10.2.2 If the DT energy values of both of the two DT specimens noted in paragraph 10.2 above fall below the minimum specified DT energy of the product specification, then retests shall not be allowed and the heat shall be considered unsatisfactory for the product application.

REFERENCES

1. Pellini, W.S., "Advances in Fracture Toughness Characterization Procedures and in Quantitative Interpretations to Fracture-Safe Design for Structural Steels," NRL Report 6713, Apr. 3, 1968; Welding Research Council Bulletin No. 130, May 1968

2. Goode, R.J., Judy, R.W., Jr., and Huber, R.W., "Procedures for Fracture Toughness Characterization and Interpretations to Failure-Safe Design for Structural Titanium Alloys," NRL Report 6779, Dec. 5, 1968; Welding Research Council Bulletin No. 134, Oct. 1968

3. Pellini, W.S., Goode, R.J., Puzak, P.P., Lange, E.A., and Huber, R.W., "Review of Concepts and Status of Procedures for Fracture-Safe Design of Complex Welded Structures Involving Metals of Low to Ultra-High Strength Levels," NRL Report 6300, June 1965

4. Pellini, W.S., and Puzak, P.P., "Practical Considerations in Applying Laboratory Fracture Test Criteria to the Fracture-Safe Design of Pressure Vessels," NRL Report 6030, Nov. 5, 1963; Trans. ASME, Vol. 86, Series A, Oct. (1964), pp. 429-443

5. Pellini, W.S., and Puzak, P.P., "Fracture Analysis Diagram Procedures for the Fracture-Safe Engineering Design of Steel Structures," NRL Report 5920, Mar. 15, 1963; Welding Research Council Bulletin Series No. 88, May 1963

6. Materials Research and Standards, Vol. 1, No. 5, May 1961

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13 ABSTRACT

This report describes a standard method for conducting dynamic tear (DT) tests to determine the DT energy (fracture toughness) value for structural base metal and weld metal using the standard 1-in. DT test specimen. A description of the apparatus, the dimensions and preparation of specimens, and details of the testing procedures are given. Use of this standard method is recommended for specification purposes, and it provides for comparison of results between different laboratories on a common basis.

The DT test was evolved at the Naval Research Laboratory starting in 1960 and has been used extensively for characterization of fracture toughness properties of ferrous and nonferrous structural metals. DT test facilities have been established at the various research laboratories and production plants of the major steel companies in this country and abroad.

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Nil-ductility transition (NDT)						
Ratio analysis diagram (RAD)						
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