Designation: E 1253 – 99

Standard Guide for Reconstitution of Irradiated Charpy-Sized Specimens[1]

This standard is issued under the fixed designation E 1253; 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.

1. Scope

1.1 This guide covers procedures for the reconstitution of Test Methods E 23, Type A Charpy specimens and specimens suitable for testing in three point bending in accordance with Test Method E 1921. Materials from irradiation programs (principally broken specimens) are reconstituted by welding end tabs of similar material onto remachined specimen sections that were unaffected by the initial test. Guidelines are given for the selection of suitable specimen halves and end tab materials, for dimensional control, and for avoidance of overheating the notch area.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 23 Test Methods for Notched Bar Impact Testing of Metallic Materials[2]

E 185 Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels, E 706 (1 F)[3]

E 220 Test Method for Calibration of Thermocouples by Comparison Techniques[4]

E 1921 Test Method for the Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range[2]

3. Significance and Use

3.1 Practice E 185 defines the minimum requirements for light-water reactor surveillance program Charpy V-notch specimens. It may be desirable to extend the original surveillance program beyond available specimens for plant lifetime extension, to better define existing data, or to determine fracture toughness of a material when no standard fracture toughness test specimens are available. The ability to reconstitute the broken halves of existing specimens can provide such material.

3.2 Charpy-sized specimens are typically machined from virgin material, that is, material not previously mechanically tested. There are occasions that exist when either (*1*) no full size specimen blanks are available or (*2*) the material available with the desired history (such as having been subjected to irradiation) is not sufficient for the machining of full-size specimens, or both.

3.3 An approach to this problem, that is addressed in this guide, is to fabricate new specimens using the broken halves of previously irradiated and tested specimens. In this guide, the central segment of each new specimen utilizes a broken half of a previously tested specimen and end tabs that are welded to the central segment, or the central section may simply be a piece of virgin material shorter than a Charpy-sized specimen. While specifically addressing reconstitution of irradiated pressure vessel steel, this guide can also provide guidance for reconstitution of Charpy-sized specimens for other situations involving material availability.

4. Reconstitution Technique

4.1 *Welding Process*:

4.1.1 Any welding process may be chosen, provided that the heat input and dimensional constraints, as given in this guide, can be achieved. Work to date has indicated successful results with stud welding **(1)**,[5] electron beam welding **(2, 3),** and projection welding **(4)**.

4.2 *Specimen Preparation*:

4.2.1 The specimen insert used for reconstitution and its orientation shall be identified such that it can be traced to the original specimen.

4.2.2 Each end face of the specimen insert and the selected extension tabs shall be prepared as required by the particular welding method selected.

4.2.3 If comparable data between the original and reconstituted tests are required, then the orientation of the reconstituted specimen and the original specimen must be identical.

4.2.4 The yield strength and the material type of the end tabs shall be similar to the specimen insert. The use of oversized tabs and subsequent machining is permitted.

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[1] This guide is under the jurisdiction of ASTM Committee E-10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.02 on Behavior and Use of Nuclear Structural Materials.

Current edition approved June 10, 1999. Published August 1999.

[2] *Annual Book of ASTM Standards*, Vol 03.01.

[3] *Annual Book of ASTM Standards*, Vol 12.02.

[4] *Annual Book of ASTM Standards*, Vol 14.03.

[5] The boldface numbers in parentheses refer to the list of references at the end of this standard.

4.2.5 It is important to ensure that the plastic deformation beneath the notch, produced when the reconstituted specimen is tested, will occur entirely within previously undeformed material in the central test section. The following guidelines are provided to meet this objective:

4.2.5.1 Sufficient material shall be removed from either side of the notch root of the original tested specimen to ensure that the specimen insert is free of prior plastic deformation.

4.2.5.2 The minimum length of the specimen insert shall be 18.0 mm (0.56 in.).

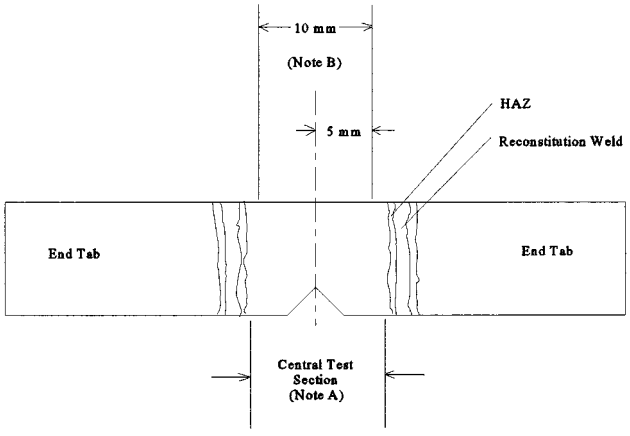
4.2.5.3 This dimensional requirement is based on Charpy impact specimens tested on the upper shelf (where the plastic zone is maximum) and the stud welding reconstitution technique (where heat input and HAZ sizes are maximum). Reconstituted specimens tested in the lower transition range or on the lower shelf in accordance with Test Methods E 23 and reconstituted precracked specimens tested in accordance with Test Method E 1921 will have much smaller plastic zones. Other reconstitution techniques, such as electron beam welding, produce HAZs smaller than stud welding. Therefore, this dimensional requirement may be relaxed, if it can be experimentally or analytically shown that the plastic deformation zone in subsequent testing will not extend into the heat affected zones produced by reconstitution and the requirement of 4.4.1 is met (see Fig. 1).

4.2.6 Many weld specimens contain base and HAZ material. Therefore, care shall be taken such that the heat-affected zone of an original weld is not contained in the central test section of the reconstituted specimen (see Fig. 1). HAZ specimens can be used as an additional source of weld or base material for inserts.

4.3 *Fixturing*—The fixture design will depend upon the type of welding process chosen for the welding operation. A successful design will maintain dimensional control, minimize heat input to the central test section, and satisfy design constraints associated with remote handling.

4.4 *Heat Input*:

4.4.1 To preclude irradiation damage annealing, heat input during welding shall be controlled such that no part of the volume of the central 10-mm (0.40-in.) portion of the reconstituted Charpy-sized specimen exceeds the prior metal irradiation temperature at any time during welding (see Fig. 1). This requirement can be relaxed if it can be shown that the plastic deformation zone in subsequent testing will not extend past the zone where irradiation temperature is exceeded.



NOTE A—No plastic deformation from previous testing is permitted in the region between the HAZs caused by the reconstitution welds (the central test section).

NOTE B—Temperature during welding shall not exceed the irradiation temperature.

FIG. 1 Schematic of a Reconstituted Charpy Specimen

4.4.2 To demonstrate that the temperature requirement of 4.4.1 is met for a given selection of welding parameters, temperature records shall be made daily, using thermocouples, during welding a set of Charpy-sized specimens. If surface thermocouples are used, then a surface-to-center temperature correction must be made. This correction shall be determined experimentally.

4.4.3 Thermocouples used in maximum temperature determination shall be calibrated in accordance with Test Method E 220.

4.5 *Dimensional Requirements*:

4.5.1 Dimensional control of reconstituted Charpy specimens shall be in accordance with Test Methods E 23 for subsequent testing.

4.5.2 If reconstituted specimens are to be tested in accordance with Test Method E 1921, then the notch geometry and fatigue precracking should be in accordance with Test Method E 1921. If reconstituted specimens have been notched for testing in accordance with Test Methods E 23, the specimens may be fatigue precracked from the root of the notch or modified by machining to approach the configuration of Fig. 3 of Test Method E 1921.

4.6 *Safety Precautions*—The reconstitution procedures generally involve handling irradiated specimen materials, and the user of this guide is responsible for establishing appropriate safety practices.

5. Qualification of Reconstitution Technique

5.1 The welding process and fixture design shall be qualified prior to reconstituting specimens of interest, using materials of known impact properties. It shall be demonstrated during qualification that the following acceptance criteria have been achieved:

5.1.1 The temperature of the central 10-mm (0.40-in.) portion of the specimen shall not exceed, at any time during the welding process, a temperature that affects its metallurgical condition unless it can be shown that the plastic deformation zone in subsequent testing will not extend past the zone where the metallurgical condition has been affected. In the case of irradiated specimens, the prior irradiation temperature must not be exceeded in the central 10-mm portion of the specimen.

5.1.2 The reconstitution process shall produce specimens conforming to the dimensional requirements of Test Methods E 23, except for the notch if subsequent testing is to be performed in accordance with Test Method E 1921.

5.1.3 The welding procedure shall routinely produce weld quality such that fracture is at the notch of the reconstituted specimen and not in the reconstitution weldment.

5.1.4 The reconstitution technique shall yield properties (41-J transition temperature and upper shelf energy or reference temperature, T_o, as appropriate) equivalent to those of original testing. It is recommended that the reconstituted specimens for technique qualification be tested at temperatures

identical to the original test temperatures so that data can be directly compared.

5.1.5 The material used for reconstitution qualification shall be selected such that the properties of this material encompass the properties of the material of interest.

6. Documentation

6.1 *Specimen Reconstitution Record*:

6.1.1 Test material, origin, location, and orientation.

6.1.2 Reconstituted specimen identity.

6.1.3 Irradiation temperature and fast neutron fluence (E > 1.0 MeV).

6.1.4 Welding process parameters.

6.1.5 Extension tab material.

6.1.6 Statement of conformance with dimensional control.

6.2 *Additional Documentation*—The following information should be available by reference to a suitable document.

6.2.1 *Process Qualification Information*:

6.2.1.1 Identities and nominal impact energies or K_{jc} of the qualification specimens.

6.2.1.2 Test temperature of the qualification specimens.

6.2.1.3 Impact energy, lateral expansion, and fracture appearance, or K_{jc}, of the qualification specimens as appropriate.

6.2.1.4 Comparison of original and reconstituted Charpy curves or comparison of the reference temperatures of the original and reconstituted specimens.

6.2.2 *Heat Input Monitoring*:

6.2.2.1 Type of temperature measurement equipment.

6.2.2.2 Number of temperature measurements and locations.

6.2.2.3 Details of temperature recording during the welding cycles.

6.2.2.4 Precision and bias of the temperature measuring system.

6.2.2.5 Fixturing details.

6.2.3 *Welding Procedure*.

REFERENCES

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(**5**) Onizawa, K., Van Walle, E., Nanstad, R. K., Sokolov, M., and Pavinich, W., "Critical Analysis of the ASTM Round Robin on Reconstitution," *ASTM STP 1329*, eds. W. R. Corwin, S. T. Rosinski, and E. Van Walle, ASTM, 1997.