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

This standard is issued under the fixed designation E1253; 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 ferritic ~~pressure vessel steels used in nuclear power plant applications,~~ steel, Type A Charpy V-notch specimens (Test Methods E23) ~~specimens~~ and Charpy-sized fracture toughness specimens suitable for testing in three point bending in accordance with Test Methods E1921 or E1820. ~~Materials from irradiation programs (principally broken specimens)~~ Ferritic steels (principally broken specimens used in nuclear power plant irradiation programs) 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. A comprehensive overview of the reconstitution methodologies can be found in Ref (**1**).[2]

1.2 The values stated in SI units are to be regarded as ~~the~~ standard. The values given in parentheses ~~are for information only.~~ after SI units are provided for information only and are not considered standard.

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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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 Standards:*[3]

E23 Test Methods for Notched Bar Impact Testing of Metallic Materials
E185 Practice for Design of Surveillance Programs for Light-Water Moderated Nuclear Power Reactor Vessels
E220 Test Method for Calibration of Thermocouples By Comparison Techniques
E1820 Test Method for Measurement of Fracture Toughness
E1921 Test Method for Determination of Reference Temperature, T_o, for Ferritic Steels in the Transition Range
E2215 Practice for Evaluation of Surveillance Capsules from Light-Water Moderated Nuclear Power Reactor Vessels

3. Significance and Use

3.1 Practice E185 defines the minimum requirements for light-water reactor surveillance program Charpy V-notch specimens and

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

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Practice E2215 describes the evaluation of test specimens from surveillance capsules. It may be desirable to extend the original surveillance program ~~beyond available~~with additional specimens for plant aging management issues, such as plant license renewal, to better define existing data, or to determine fracture toughness of a material when no standard fracture toughness test specimens are available. The ~~ability~~possibility to reconstitute the broken halves of existing specimens can provide ~~such data.~~specimens which can be tested.

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~~A solution to this problem, which is addressed in this guide, is to fabricate new specimens using the broken halves of previously ~~irradiated and~~ tested Charpy-sized specimens or other ~~material irradiated for this purpose.~~ pieces of ferritic steel too small to fabricate a full Charpy-sized specimen. 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~~untested material shorter than a Charpy-sized specimen. While specifically addressing reconstitution of irradiated pressure vessel steels, this guide can also provide guidance for reconstitution of Charpy-sized specimens for other situations ~~involving material availability.~~where material availability is limited.

4. Reconstitution Technique

~~4.1 *Welding Process:*~~

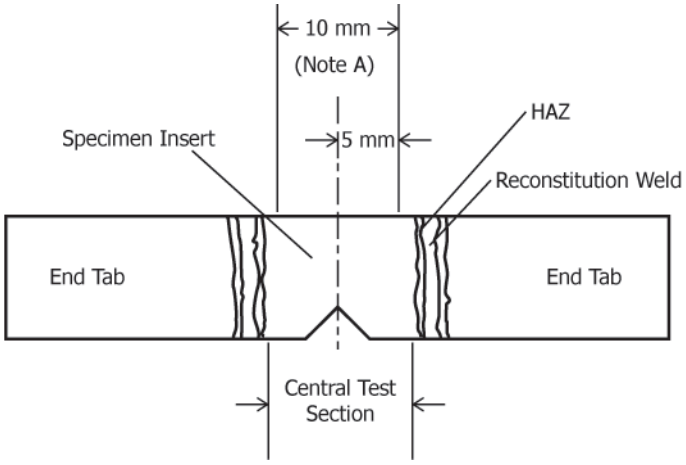
~~4.1.1 Any welding process may be chosen, provided that the heat input and dimensional constraints, as prescribed in this guide, can be achieved. Work to date has indicated successful results with stud welding (2), electron beam welding (3,4), projection welding (5), and laser welding (6).~~

4.1 ~~*Specimen Preparation:*~~ *Welding Process*—Any welding process may be chosen, provided that the heat input and dimensional constraints, as prescribed in this guide, can be achieved. Work to date has indicated successful results with stud welding (**2**), electron beam welding (**3, 4**), projection welding (**5**), and laser welding (**6**).

Specimen Preparation

4.1.1 The minimum length of the specimen insert shall be 18.0 mm (0.71 in.) unless the conditions stipulated in 4.1.6.2 are fulfilled (see Fig. 1).

4.1.2 The specimen insert used for reconstitution and its orientation shall be identified such that it can be traced to the original ~~specimen.~~ specimen, if applicable. Fig. 1 illustrates the components of the reconstituted specimen and defines several terms used in the following discussion. The *central test section* of the insert lies between the heat-affected zones (HAZ) created by the



NOTE A—No plastic deformation from previous testing is permitted in the central test ~~section.~~ section of the 18 mm specimen insert. Temperature during welding in the ~~10-mm (0.39-in.)~~ 10 mm (0.39 in.) central test section shall not exceed the irradiation temperature.

FIG. 1 Schematic of a Reconstituted Charpy Specimen

reconstitution welds. Within this central test section, the temperature during reconstitution welding shall not exceed the irradiation temperature in a ~~10-mm (0.39-in.)~~ 10 mm (0.39 in.) region centered about the notch.

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

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

4.1.5 The strength and the material type of the end tabs shall be similar to the specimen insert. This can be important, especially in the case of irradiated (highly hardened) materials. Strength or hardness and material type for the end tabs and central insert shall be documented. Differences within a defined range were shown not to influence the test results (**7**). The use of oversized tabs and subsequent machining is permitted.

4.1.6 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:

4.1.6.1 To ensure that the specimen insert volume, subjected to plastic deformation during the subsequent testing, is free of prior plastic ~~deformation,~~ deformation as indicated by dimensional change, sufficient material shall be removed from the fractured end of the broken specimen half. Some plastic deformation on either end of the original insert can be accepted if it is outside the central ~~10-mm (0.39-in.)~~ 10 mm (0.39 in.) portion.

~~4.2.5.2 The minimum length of the specimen insert shall be 18.0 mm (0.71 in.) unless the conditions stipulated in 4.2.5.3 are fulfilled.~~

4.1.6.2 The dimensional requirement of 18 mm (0.71 in.) is based on Charpy impact specimens tested on the upper shelf (where the plastic zone is largest) and fabricated with the stud welding reconstitution technique (where heat input and HAZ sizes are largest). Reconstituted specimens tested in the lower transition range or on the lower shelf in accordance with Test Methods E23 and reconstituted precracked specimens tested in accordance with Test Methods E1820 or E1921 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~~ HAZ produced by reconstitution and the requirement of ~~4.4.1~~4.3.1 is met (see Fig. 1). Test programs have shown acceptable Charpy results using shorter inserts (**8-10**).

4.1.7 Many weld specimens contain base material and HAZ. 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. In an inhomogeneous specimen insert, which contains base or weld material and HAZ, only the target test material shall be contained in the central ~~10-mm (0.39-in.)~~ 10 mm (0.39 in.) portion.

4.2 *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.

4.3 *Heat Input:*

4.3.1 ~~To~~ In the case of irradiated material, to preclude irradiation damage annealing, heat input during welding shall be controlled such that no part of the ~~volume of the central 10-mm (0.39-in.)~~ central 10 mm (0.39 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~~into the zone where irradiation temperature is exceeded.

4.3.2 To demonstrate that the temperature requirement of ~~4.4.1~~4.3.1 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.~~specimen. Such a demonstration is preferably made on dummy inserts with thermocouples that are welded or soldered in the mid-thickness of the dummy insert. If surface thermocouples are used, then a surface-to-center temperature correction must be made and the basis of the correction documented. A comprehensive overview of the important issues in temperature measurements can be found in Ref (**11**).

4.3.3 Thermocouples used in maximum temperature determination shall be calibrated in accordance with Test Method E220.

4.4 *Dimensional Requirements*—Dimensional control of reconstituted specimens shall be in accordance with the corresponding test method (Test Method E23, E1820, or E1921). If the user of this guide is unable to produce specimens that meet the applicable test method dimensional requirements, then the user shall justify using specimens with dimensions ~~exceeding~~ not meeting the corresponding test method requirements. All deviations from the test method shall be documented and reported with the data. Ref (**7**) describes a study on the effects of some dimensional deviations.

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

5. Qualification of Reconstitution Technique

5.1 The reconstitution process (for example, welding process and fixture ~~design~~design) shall be qualified prior to reconstituting specimens of interest, using materials of known impact ~~properties.~~ or toughness properties. The material used for reconstitution qualification shall be selected such that its strength and the material type are similar to the properties of the material of interest. It shall be demonstrated during qualification that the following acceptance criteria have been ~~achieved:~~met:

5.1.1 The temperature of the central ~~10-mm (0.39-in.)~~ 10 mm (0.39 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~~into 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 (0.39-in.)~~ 10 mm (0.39 in.) portion of the specimen.

5.1.2 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. Examples of a weld qualification methodology can be found in Ref (**12**).

5.1.3 The reconstitution technique shall yield ~~properties (41-J and 68-J transition temperatures~~impact or toughness properties which are not significantly different statistically from those obtained from an original test series. For test result comparison, a simple statistical method considering the test method repeatability can be used to assess the comparison. Using the same test type for which the reconstituted specimens will be tested (for example, 41-J and 68-J Charpy V-notch transition temperatures, ~~and~~ K_{Jc} ~~upper shelf energy or~~values for determining the reference temperature, T_{0}, ~~or fracture toughness, as appropriate) equivalent to those obtained from the original tests.~~ in the transition temperature region; upper shelf Charpy energy or upper shelf fracture toughness) is preferred, although any of the following tests may be used. It is recommended that the reconstituted specimens for technique qualification be tested at ~~temperatures~~temperature(s) identical to the original test ~~temperatures~~temperature(s) so that data can be directly compared.

5.1.3.1 For upper-shelf testing, a minimum of three tests (in accordance with either Test Method E23 or Test Method E1820) are required from both the original and reconstituted specimens for qualification.

5.1.3.2 For transition temperature testing, a minimum of six tests (in accordance with either Test Method E23 or Test Method E1921with valid T_0) are required from both the original and reconstituted specimens for qualification. Test Method E1921 provides calculation for T_0 and uncertainty that should be used for comparison.

~~5.1.4 The material used for reconstitution qualification shall be selected such that the properties of this material are similar to the properties of the material of interest.~~

6. Documentation

6.1 *Specimen Reconstitution Record:*

6.1.1 Test material, test material tensile strength or hardness, origin, location, and orientation.

6.1.2 Reconstituted specimen ~~identity.~~identification.

6.1.3 Irradiation temperature and fast neutron fluence (E > 1.0 ~~MeV).~~MeV), if applicable.