



Designation: E 1271 – 94

Standard Practice for Qualifying Charpy Verification Specimens of Heat-Treated Steel¹

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INTRODUCTION

The suitability of a pendulum-type impact machine for material acceptance testing has usually been based on a calibration of its scale and compliance with specified dimensions, such as the form and spacing of the anvils supporting the specimen. The scale calibration is commonly made by measuring the mass of the pendulum and its elevation at various scale readings. This procedure for evaluation of machines had the distinct advantage of requiring only measurements of quantities which can be traced to national standards. The objective nature of these traceable measurements minimized the necessity for arbitration regarding the suitability of the machines for material acceptance tests.

While using the procedure described above, it was found that sometimes two machines, both of which met all dimensional requirements, gave significantly different values when testing specimens from the same material. This difference was commercially important when values from one machine met the material specification, and values from the other machine did not.

To avoid such disagreements, some purchasers of large quantities of material added the requirement that all machines used for acceptance tests on material sold to them shall be verified by testing verification specimens supplied by them. Machines were considered verified only if the values indicated by them agreed, within specified limits, with the value furnished with the verification specimens. Successful experience in the use of verification specimens by large volume purchasers led to their use being required by some specifications and codes. For example, Test Method E 23 requires annual verification of Charpy impact machines using verification specimens. The purpose of this practice is to define the requirements for producing and selling these verification specimens.

1. Scope

1.1 This practice covers the allowable range of mechanical properties at each of three different energy levels of verification specimens of heat-treated steel.

1.2 This practice does not specify the composition or heat treatment for these verification specimens, but Appendix X1 gives examples of composition and heat treatments that have been used successfully in the past.

1.3 This practice describes the procedure that shall be used to establish the value of impact energy that is furnished with the specimens.

1.4 This practice lists information which the supplier of verification specimens shall make available to the purchaser.

1.5 Values stated in inch-pound units are to be regarded as the standard. SI units are provided for information only.

1.6 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 8 Test Methods for Tension Testing of Metallic Materials²

E 23 Test Methods for Notched Bar Impact Testing of Metallic Materials²

E 112 Test Methods for Determining Average Grain Size²

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process³

E 1236 Practice for Qualifying Charpy Impact Machines as Reference Machines²

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

³ *Annual Book of ASTM Standards*, Vol 14.02.

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *coordination program*—a program to compare the results from all reference machines in accordance with Practice E 1236.

3.1.2 *lot*—several hundred or more Charpy impact specimens manufactured under similar conditions of production from a single ingot or melt.

3.1.3 *reference machines*—impact machines used to determine the reference values.

3.1.4 *reference value*—energy value furnished with the verification specimens.

3.1.5 *set*—a group of specimens chosen at random from a lot.

3.1.6 *verification specimens*—impact specimens to be used to evaluate the suitability of a machine for material acceptance testing by comparing the energy values indicated by that machine to the reference energy value furnished with the verification specimens.

4. Significance and Use

4.1 Specimens with the mechanical properties required by this practice have been found to be suitable for evaluating the condition of general purpose impact machines used for testing a wide variety of materials.

4.2 It is desirable to develop or discover steels more suitable for verification specimens than those used in the past. Especially desirable are those that would permit verification tests at room temperature or give test results with less scatter.

5. Apparatus

5.1 The impact machines used to determine the reference value of verification specimens shall be registered as reference machines meeting the requirements of Practice E 1236.

5.2 The apparatus for determining the tensile yield strength shall meet the requirements of Test Methods E 8.

6. Materials

6.1 All the specimen blanks for a lot shall come from a single billet or melt.

6.2 All specimens shall be made of steel. The composition is not specified. Lots at different energy levels may have different compositions.

6.3 All specimen blanks for a lot shall receive the same heat treatment.

6.4 For each lot, the reference value shall fall within one of the following ranges.

Energy Level	Low	Medium	High
Reference value, ft-lb	10 to 15	65 to 100	130 to 180
Joules	(13 to 20)	(88 to 122)	(176 to 244)

6.5 Tension specimens heat treated with each lot shall show yield strength (offset = 0.2 %) equal to or greater than the values listed below when tested at the temperature at which the Charpy specimens are to be broken.

Energy Level	Low	Medium	High
Minimum yield strength (offset = 0.2 %), ksi	195	125	85
MPa	(1344)	(862)	(586)

NOTE 1—When using a single impact machine, the same amount of impact energy may be indicated by materials having different yield strengths. These same materials tested in another machine may indicate different values of impact energy. The difference is usually greater for the stronger materials. To accentuate these differences, materials of high yield strength are specified for the verification specimens at each energy level.

6.6 The tension and impact tests on a particular lot shall be made at the same temperature, that temperature being $-40^{\circ} \pm 2^{\circ}\text{F}$ ($-40^{\circ} \pm 1^{\circ}\text{C}$), $75^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($24^{\circ} \pm 3^{\circ}\text{C}$) or $200^{\circ} \pm 3^{\circ}\text{F}$ ($93^{\circ} \pm 2^{\circ}\text{C}$). At 200°F (93°C), the heating media shall be gaseous or oils with a boiling point above 250°F (121°C). Conditioning in heated water between 122° and 212°F (50° to 100°C) results in significant evaporative cooling of the specimen at 5 s after removal from the bath.⁴

NOTE 2—Test temperatures near the transition temperature of the materials should be avoided in order to reduce variability of values within a set. A secondary consideration is to select a material that will have the specified properties when tested at room temperature and, thus, avoid the added variability due to the complexity of testing heated or cooled specimens.

6.7 The low-energy-level specimens shall fracture in such a manner that each broken half will exit the anvil area in a direction approximately perpendicular to the direction of motion of the pendulum and strike the anvil leaving a visible mark between the notch and the mark made by the anvil on the specimen immediately before separation of the two halves.

NOTE 3—This fracture mode is made mandatory to ensure that the machines being verified have adequate provision for end clearance. Appendix X1 gives one combination of composition, heat treatment, and test temperature, which has been used successfully to fulfill this requirement.

7. Sampling and Test Specimens

7.1 Any group of specimens meeting the requirements of Sections 6 and 7 may be used as the lot from which verification specimens are randomly selected.

7.2 The verification specimens shall meet the dimensional requirements given in Test Methods E 23 for Charpy Impact Test Specimens, Type A.

7.3 All specimens from a lot shall be permanently marked with coded letters that uniquely identify the lot. In addition, each specimen shall be marked with a number to distinguish that specimen from all others within the lot.

7.4 Unless the same lot has been previously used as a source of specimens for a coordination program for reference machines, 3 or more sets of 25 specimens shall be drawn at random from the lot and each set tested by a different reference machine in accordance with 8.2 (that is, a minimum of three reference machines shall be used).

7.5 After the sets to be tested by reference machines have been drawn from the lot, the remaining specimens shall be drawn at random in sets of five or the next integer, rounded up, from the number calculated in accordance with 10.1. These sets are to be used for verification specimens.

7.5.1 Each set of verification specimens shall be retained henceforth in the sets, as originally drawn.

⁴ Nanstad et al, *Charpy Impact Factors and Variables*, ASTM STP 1072, January 1991.

7.5.2 No partial sets shall be sold or offered in exchange. If a purchaser can demonstrate to the supplier's satisfaction that one or more specimens of a set are defective, the whole set shall be returned and replaced without charge.

8. Procedure

8.1 Tension tests and impact tests of all specimens from one lot shall be made at the same temperature.

8.2 The reference value for every set of verification specimens from one lot shall be equal to the average value from the specimens from the same lot tested in three or more reference machines. These test results shall conform to 8.2.1 through 8.2.3.4.

8.2.1 If 5 % or more of all the results of tests made by the reference machines are found to be outliers in accordance with 8.2.3.2, that lot shall not be used for verification specimens.

8.2.2 If the lot was previously used as a source of specimens for a coordination program, the reference value shall be the grand average. This value is given in the report of the coordination program.

8.2.3 If the lot was not previously used for coordination specimens, the supplier of the verification specimens shall have the tests made by any three reference machines selected from the list available from Subcommittee E28.07.

8.2.3.1 The report of the tests by the selected reference machines shall show the identification number and the energy value for each specimen. The reported energy value shall have been corrected for friction and windage. The broken specimens shall be returned to the supplier of verification specimens.

8.2.3.2 The supplier of verification specimens shall identify erroneous values, in accordance with Practice E 1236 (Calculation of Results Section). The average value from each reference machine shall be calculated with the erroneous values deleted. The grand average of all values with erroneous values deleted shall also be calculated. If the difference between the average from any one machine and the grand average is greater than the larger of 1 ft-lbf (1.4 J) or 5 % of the grand average, the results from that one machine shall not be used to determine the reference value. The supplier shall have the option of substituting another set of 25 specimens tested by the same machine or of using a machine different from the first three machines chosen. If repeated trials fail to meet the requirements above, that lot of specimens shall not be used for verification specimens.

8.2.3.3 The same test results used to calculate the reference value shall be used for the calculations required by 8.2.3.4 and Section 10.

8.2.3.4 The supplier of verification specimens shall test for excessive variability in accordance with Practice E 1236 (Calculation of Results Section). If the results from one of the three machines shows excessive variability, the supplier of verification specimens has the option of testing another set of 25 specimens using the same machine or using a machine different from the three first chosen. If a retest is made, the procedure described in 8.2.3.2 shall be repeated with the additional results substituted for those rejected. Alternatively, the supplier has the option of using the results with excess variability and compensating by increasing the number of specimens in a verification set in accordance to 10.1.1.

8.3 The procedure for determining static tensile properties shall be as follows:

8.3.1 The tension specimens of circular cross section shall be fabricated from fully heat-treated but unmachined Charpy blanks. The Charpy blanks to be used for tension specimens shall be drawn at random from the heat-treated batches.

8.3.1.1 If the whole lot used for verification specimens is heat treated in one batch, three blanks shall be drawn for the tension specimens. If the lot is heat treated in two approximately equal batches, two blanks shall be drawn from each batch. If three or more heat-treated batches are required to heat treat the lot, a blank for a tensile specimen shall be drawn from each batch.

8.3.2 The specimen dimensions and testing procedure shall be in accordance with Test Methods E 8.

8.3.2.1 The tension tests shall be performed at the same temperature as that at which the impact tests are to be performed.

8.3.3 The following properties shall be reported:

8.3.3.1 Tensile strength,

8.3.3.2 Yield strength (offset = 0.2 %),

8.3.3.3 Elongation, and

8.3.3.4 Reduction in area.

8.4 The procedure for making verification tests consists of testing a set of verification specimens at the temperature specified by the supplier of the specimens and comparing the average of the results to the reference value supplied with the specimens.

8.4.1 The test procedure shall conform to the practice requiring the use of verification specimens.

8.4.2 The number of specimens in a verification set is fixed by the supplier. All specimens of each set shall be tested in random order and included in the average. Substitution or replacement of single specimens from another set is not permitted. At the option of the person making the verification tests, one or more additional complete set may be tested immediately after the first set. All the results shall be included in the average which is compared to the reference value. Tests of successive sets, averaged separately, are not permitted.

8.4.3 Unless otherwise stated in the practice that requires the verification tests, a machine shall be classified as unacceptable if the difference between the average of the results from the machine being verified and the reference value is greater than the larger of 1 ft-lbf (1.4 J) or 5 % of the reference value.

8.4.4 The supplier of verification specimens shall, on request, arrange an appointment for the purchaser to see the reference machines used to establish the reference value and to compare the broken verification specimens to the broken specimens from the same lot which were tested by the reference machines.

NOTE 4—Although not required by this practice, some suppliers of verification specimens will inspect the broken specimens and attempt to identify worn parts or other causes of excess difference between the results from the machine being verified and the results from reference machines. An additional charge is usually made for this service.