



Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)¹

This standard is issued under the fixed designation G 14; 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 test method covers the determination of the energy required to rupture coatings applied to pipe under specified conditions of impact from a falling weight.

1.2 The values stated in SI units to three significant decimals 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:*²

G 12 Test Method for Nondestructive Measurement of Film Thickness of Pipeline Coatings on Steel

G 62 Test Methods for Holiday Detection in Pipeline Coatings

2.2 *SAE Standard:*
Grade 52100 Steel³

3. Summary of Test Method

3.1 This test method uses a falling fixed weight having a specified diameter impact surface, *tup*, which is restrained vertically and dropped from varying heights to produce impact energies over the required range. Electrical inspection is used to detect resultant breaks in the coating. Impact resistance is determined as the amount of energy required to cause penetration of the coating film.

¹ This test method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.48 on Durability of Pipeline Coating and Linings.

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² 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.

³ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

4. Significance and Use

4.1 The ability of a pipe coating to resist mechanical damage during shipping, handling, and installation will depend upon its impact resistance. This test method provides a systematic means for screening coating materials with regard to this property.

5. Apparatus

5.1 This test method can be successfully used with impact apparatus conforming to the following specifications:

5.1.1 *Tup*—The tup shall be made up from a tup body and a tup nose having a combined, fixed weight of 1.361 kg (3.00 lb) and shall be used over a drop range of 0.61 to 1.22 m (2 to 4 ft). With most coatings, a 1.361-kg (3.00-lb) tup dropped through a distance of 914 mm (3 ft) yields suitable results. The tup nose shall have a 15.875-mm (⁵/₈-in.) hemispherical head.

NOTE 1—Frequent replacement of the tup nose can be avoided if it is cut from steel capable of being hardened to a hardness of Rockwell C/45 while retaining an impact toughness of at least 15 ft-lb (20.34 J). Ball bearings conforming to SAE **Grade 52100** have also been found suitable for this purpose.

5.1.2 *Drop Tube*—A tube 1.52 m (5 ft) long shall be used to contain the tup and guide it during free fall. The drop tube shall be constructed of steel, aluminum, or any other suitably rigid material and internally sized to provide a minimum of friction to the falling tup. A scale shall be attached for measuring the height of drop to the nearest 2.54 mm (0.10 in.).

5.1.3 *Specimen Holder*—The base plate of the apparatus shall include a device for positioning and holding the pipe specimen on line with the axis of the vertical drop tube.

NOTE 2—An arrangement using a V-notch vise made of metal with spring clamp is recommended for this purpose. Glancing blows, caused by an out-of-plumb condition between drop tube and pipe sample, will cause erratic test results.

5.1.4 *Apparatus Support*—Both the apparatus and sample shall be firmly supported and secured to a rigid base to optimize energy transfer from the tup to the specimen.

5.2 A design for the test apparatus appears in **Figs. X1.1-X1.3** of **Appendix X1**.

5.3 *Thickness Gage*—Measurements of coating thickness will be required for this test, and shall be done in accordance with Test Method **G 12**.

5.4 *Holiday Detector*—A suitable detector as specified in Test Methods **G 62** shall be used to locate breaks in the coating film.

6. Test Specimen

6.1 The test specimen shall be a 406.4 mm (16 in.) long piece of Schedule 40, 60.325 mm (2.375 in.) outside diameter coated pipe prepared with its surface preparation and coating procedures equivalent to that of production coated pipe.

6.2 Seven specimens shall be required for the test.

7. Conditioning

7.1 The specimen shall be exposed to a room temperature of 21 to 25°C (70 to 77°F) for a period of 24 h before beginning the test.

8. Preliminary Measurements

8.1 Measure the applied coating thickness of each specimen in accordance with Test Method **G 12**.

8.2 Place test specimen in sample holder and lightly place tup on surface of the coating. Adjust either the drop tube or the attached scale so that the wing bolt (lifting pin) is at the zero mark of the scale.

8.3 Make a preliminary set of impact readings to determine the approximate starting point for the test. This shall be done by striking the first specimen from a height sufficient to cause failure of the coating film. Consider any penetration a failure if it is detectable with a suitable Holiday Detector as specified in Test Methods **G 62**.

8.3.1 Reduce the height by 50 % and make a second exploratory drop at a fresh area on the pipe surface. Continue testing in this manner, with the corresponding reduction in height between drops, until the coating fails to break.

NOTE 3—Choose test locations at the specimen surface in a random manner and keep at least a 76.2 mm (3 in.) distance between adjacent points of impact and within 38 mm (1½ in.) from the ends. Choosing test points in any regular pattern will bias the experiment and introduce error into the test results.

8.3.2 Repeat the test at the height immediately preceding the occurrence of the nonfailure to determine if an approximate level for the mean impact strength has been bracketed. Two successive reversals of coating performance between failure and nonfailure will give sufficient indication that the point has been reached.

9. Procedure

9.1 Perform the test at a room temperature of 21 to 25°C (70 to 77°F).

9.2 Begin testing from the approximate height determined in 8.2 and corresponding to the point at which the first nonfailure was registered. Maintain a fixed increment between adjacent testing heights.

9.3 Use a suitable detector, as specified in Test Method **G 6**, to determine penetration or lack thereof of the coating after each individual impact.

9.4 If the coating film is penetrated on the initial drop, make the next test at the next lower height increment. If the first specimen does not fail, make the second test at the next higher increment.

9.5 In a similar manner, determine the height of fall by the performance of the coating on each preceding drop. Maintain a constant height increment between readings. Continue to apply this “up-and-down” method⁴ until 20 successive impact readings have been made.

10. Calculation

10.1 Calculate the mean value of impact strength, m , in g/cm (or in./lb) as follows:

$$m = \left[h_0 + d \left(\frac{A}{N} \pm \frac{1}{2} \right) \right] \times W \quad (1)$$

where:

h_0 = minimum height at which the less frequent event occurs, cm (or in.),

d = increment in height of drop, cm (or in.),

A = sum of the frequency of occurrence at each height increment times the number of increments above the h_0 value for each observation in the N total,

N = total number of the less frequent event (coating failures or nonfailures), and

W = tup weight, g (or lb).

NOTE 4—The minus sign is used when the calculation of the mean is based on the total number of coating failures and the plus sign when it is based on the nonfailures.

10.2 Calculate the sample standard deviation, s , in gram-centimetres (or inch-pounds) as follows:

$$S = 1.620 dW \left(\frac{(NB - A^2)}{N^2} + C \right) \quad (2)$$

where:

C = 0.737 when d is in cm, or 0.029 when d is in in., d , N , A , and W are as defined in 10.1, and

B = sum of the frequency of occurrence at each height increment times the square of the number of increments above the h_0 value for each observation in the N total.

NOTE 5—Adequate definition of coating impact strength will result only if the height increment, d , has been properly chosen. When testing polymeric films in the range from 0.254 to 1.016 mm (0.010 to 0.040 in.), height increments of from 5.1 to 12.7 mm (0.2 to 0.5 in.) have been found suitable with the 1.361 kg (3.0 lb) tup. Larger increments may be necessary for thicker materials. If after making the calculations of 10.1 and 10.2, the ratio of the height increment to the standard deviation (d/s) is less than 0.20, the test should be repeated using a larger value for the increment d . This procedure will result in an improved estimate of the coating impact strength.

10.3 An illustration of the use of these equations appears in **Appendix X2**.

⁴ This system of testing, nomenclature, and calculation is described by Dixon, W. J. and Mood, A. M., “A Method for Obtaining and Analyzing Sensitivity Data,” *Journal Am. Statistical Assn.*, JSTNA, Vol 43, March, 1948, p. 109.

11. Report

11.1 The report shall include the following:

11.1.1 Complete identification of the specimen including:

11.1.1.1 Name and code number of the coating,

11.1.1.2 Size of pipe,

11.1.1.3 Source, production date, and production-run number,

11.1.1.4 Minimum, maximum, and average coating thickness,

11.1.1.5 Date of test, and

11.1.1.6 Other information that may be pertinent,

11.1.2 Average impact strength in g/cm (or in./lb),

11.1.3 Sample standard deviation in g/cm (or in./lb).

12. Precision and Bias

12.1 The reproducibility of the impact resistance determined by this method should not differ between one laboratory and another by more than $\pm 15\%$. When the same instrument is used by the same operator, repeatability on the same sample should not differ more than $\pm 15\%$. Bias cannot be determined since there is no acceptable standard material available for this test.

13. Keywords

13.1 falling weight test; impact resistance; pipeline coatings

APPENDIXES

(Nonmandatory Information)

X1. SUGGESTED DESIGN FOR TEST APPARATUS

X1.1 A design for the impact test apparatus is shown in **Figs. X1.1-X1.3.**

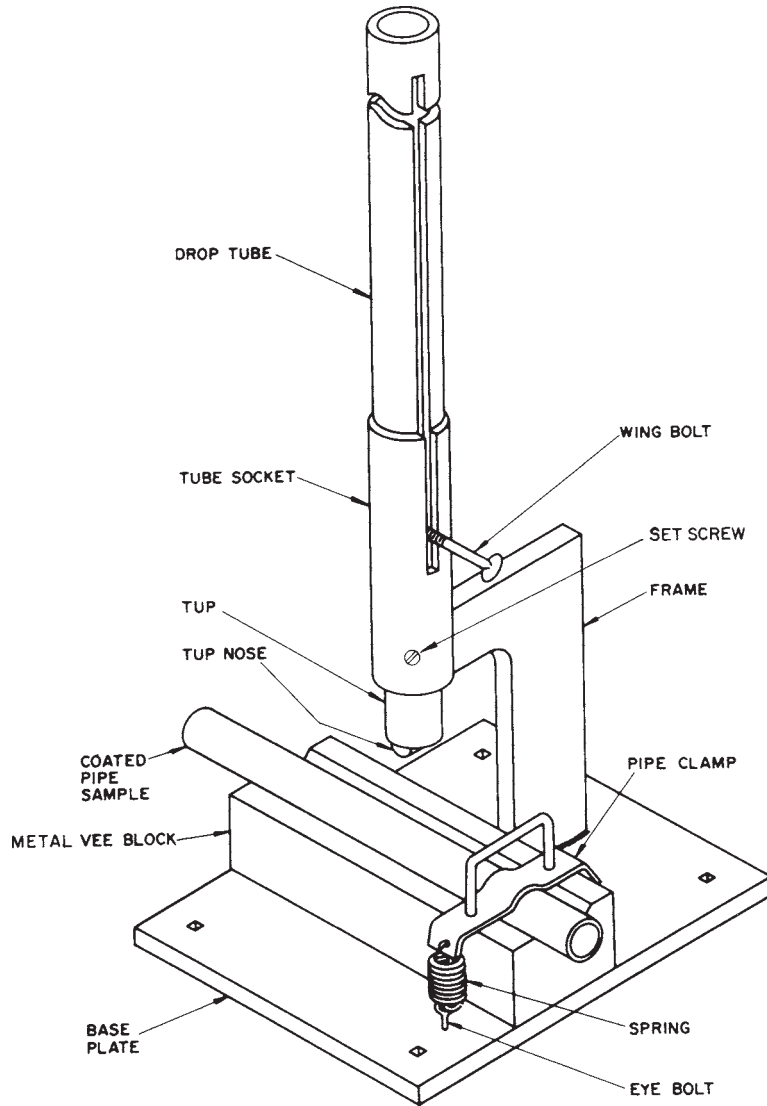


FIG. X1.1 Test Apparatus Assembly

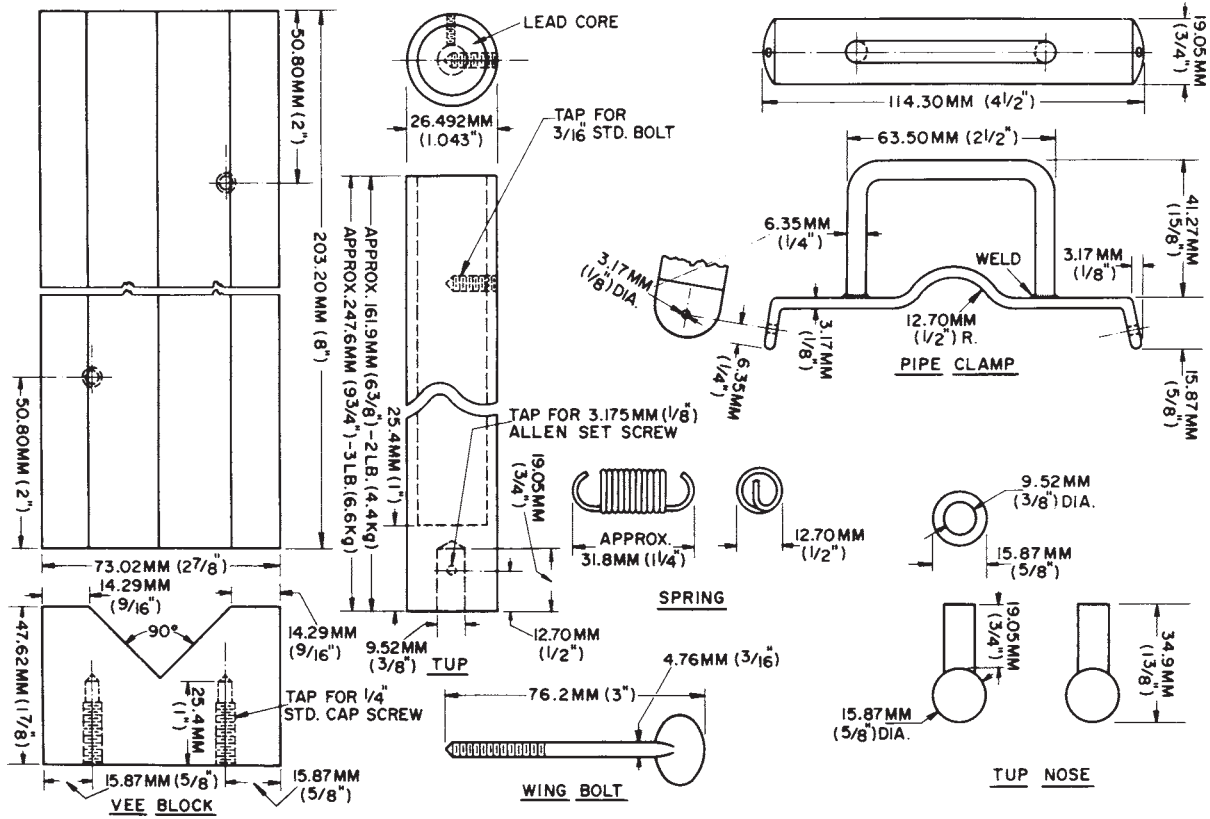


FIG. X1.2 Detailed Design of Test Apparatus

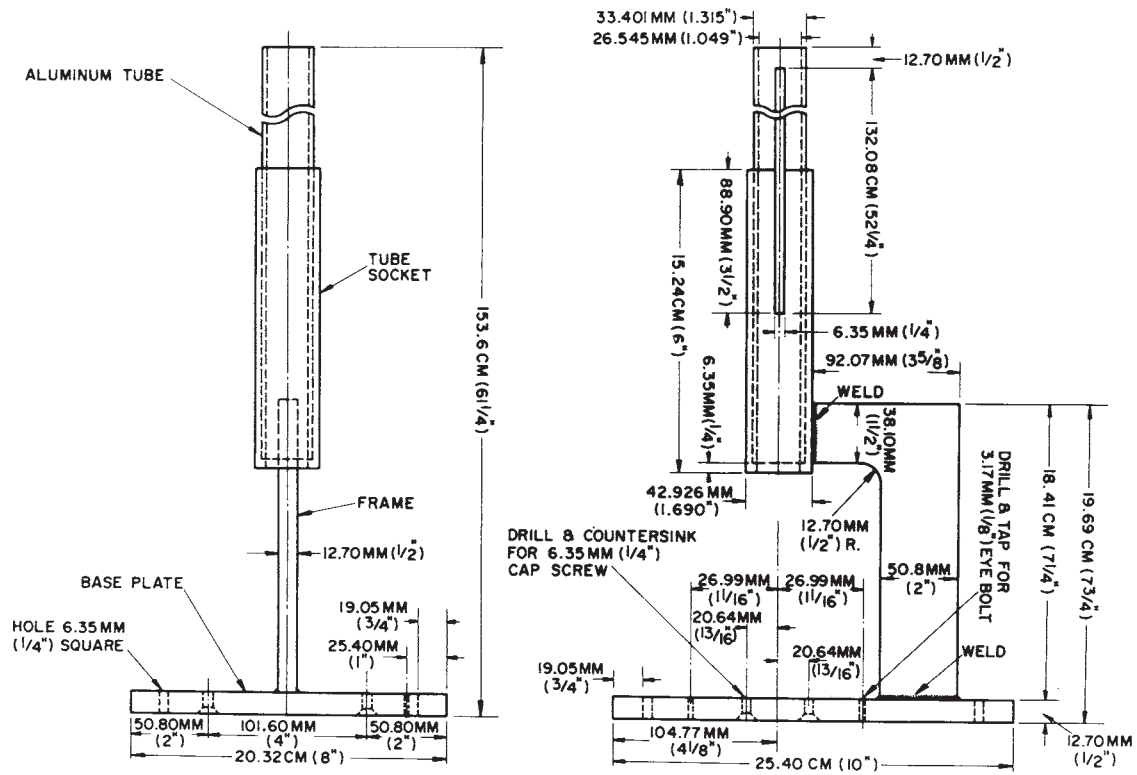


FIG. X1.3 Detailed Design of Test Apparatus

X2. SAMPLE CALCULATIONS

X2.1 Test results for 20 drops with a 1.361 kg (3 lb) tup are given in **Table X2.1**.

TABLE X2.1 Test Results

Test No.	Height of Drop, in.	Failed	Test No.	Height of Drop, in.	Failed
1	14.1	yes	11	13.5	no
2	13.8	no	12	13.8	no
3	14.1	no	13	14.1	yes
4	14.4	yes	14	13.8	yes
5	14.1	yes	15	13.5	no
6	13.8	no	16	13.8	yes
7	14.1	no	17	13.5	yes
8	14.4	yes	18	13.2	no
9	14.1	yes	19	13.5	no
10	13.8	yes	20	13.8	yes

Height increment = 0.3 in.

Failures = 11

Nonfailures = 9

Nonfailures at 13.2 in. (h_0) = 1; at 13.5 in. = 3; at 13.8 in. = 3; at 14.1 in. = 2

$$A = (0 \times 1) + (1 \times 3) + (2 \times 3) + (3 \times 2) = 15$$

$$B = ((0)^2 \times 1) + ((1)^2 \times 3) + ((2)^2 \times 3) + ((3)^2 \times 2) = 33$$

$$m = \left[13.2 + 0.3 \left(\frac{15}{9} + \frac{1}{2} \right) \right] 3.0 = 41.55 \text{ in.} \cdot \text{lb}$$

mean impact resistance = 41.55 in.·lb

$$S = 1.620 \times 0.29 \times 3.0 \left(\frac{9 \times 33 - (15)^2}{(9)^2} \right) = 1.338 \text{ in.} \cdot \text{lbs.}$$

Sample standard deviation = 1.383 in.·lb

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