# Drop-Weight Tear Tests on Line Pipe

API RECOMMENDED PRACTICE 5L3
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## Foreword

This standard is under the jurisdiction of the API Subcommittee on Standardization of Tubular Goods and includes changes approved by letter ballot in 2013.

The need for a determination of the fracture toughness of line pipe was considered in 1964 and at the midyear meeting in 1965. Certain ground rules were submitted at the 1965 meeting for the development of a specification on fracture toughness.

As a result of the information obtained through the research efforts of the American Gas Association, methods for conducting drop-weight tear tests for line pipe were developed. The methods of conducting this test and evaluating the results are described in this recommended practice.

The verbal forms used to express the provisions in this recommended practice are as follows:

— the term “shall” denotes a minimum requirement in order to conform to the recommended practice;

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

# Contents

# Drop-Weight Tear Tests on Line Pipe

## 1 Scope

These procedures describe a recommended method for conducting Drop-Weight Tear Tests to measure the fracture appearance or fracture ductility of the pipe as referenced in API Specification 5L, *Specification for Line Pipe*.

## 2 Normative References

The following referenced document is indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5L, *Specification for Line Pipe*

## 3 Abbreviations

For the purposes of this document, the following abbreviations apply.

| | |
|---|---|
| $D/t$ | diameter-to-thickness ratio |
| DWTT | Drop-Weight Tear Test |
| $t$ | pipe wall thickness |
| T | neglected regions for shear area evaluation |
| $t_s$ | DWTT specimen thickness |

## 4 General Information

### 4.1 Apparatus

**4.1.1** The testing machine may be of any configuration that has sufficient energy to completely break the specimens in one impact.

**4.1.2** The velocity of the hammer at impact shall be in the range of 16 ft/sec to 30 ft/sec (5 m/sec to 9 m/sec).

**4.1.3** The specimen shall be inserted in the testing machine so that the notch is lined up with the centerline of the hammer tip within $^{1}/_{16}$ in. (1.59 mm). The notch should also be centered between the supports of the anvil.

**4.1.4** The radius of the anvil supports for the specimen should not be larger than $^{5}/_{8}$ in. (15.9 mm). Larger radii have been found to contribute to specimen jamming.

### 4.2 Metric Units

Metric conversions of US customary units are shown in parenthesis in the test, figures, and tables. See Annex A for metric conversion factors.

NOTE Drop-Weight Tear Testing pipe with upper shelf Charpy impact energies greater than 200 J (148 ft-lb) often results in invalid tests, making the test method ineffective.

# 5 Specimens

## 5.1 Orientation

**5.1.1** The specimens shall be removed from pipe such that the length of the specimen is in the circumferential direction of the pipe.

**5.1.2** The specimens shall be flattened unless the $D/t$ is less than 40. If the $D/t$ is less than 40, then the center 1 in. to 2 in. (25 mm to 51 mm) may be left unflattened. If buckling occurs, the test results are not valid and replacement tests shall be conducted.

Flattening has been observed to decrease the percent shear of the fracture. In the case of a difference between flattened and nonflattened specimen results, or in referee testing, the results from nonflattened specimens shall govern.

**5.1.3** The specimens may be removed from the pipe wall by sawing, shearing, or flame cutting with or without machining, provided the dimensions of the finished specimen are within the tolerances shown in Figure 1.

NOTE If the specimen is flame cut, it is usually difficult to press in the notch unless the heat-affected zone is removed by machining.

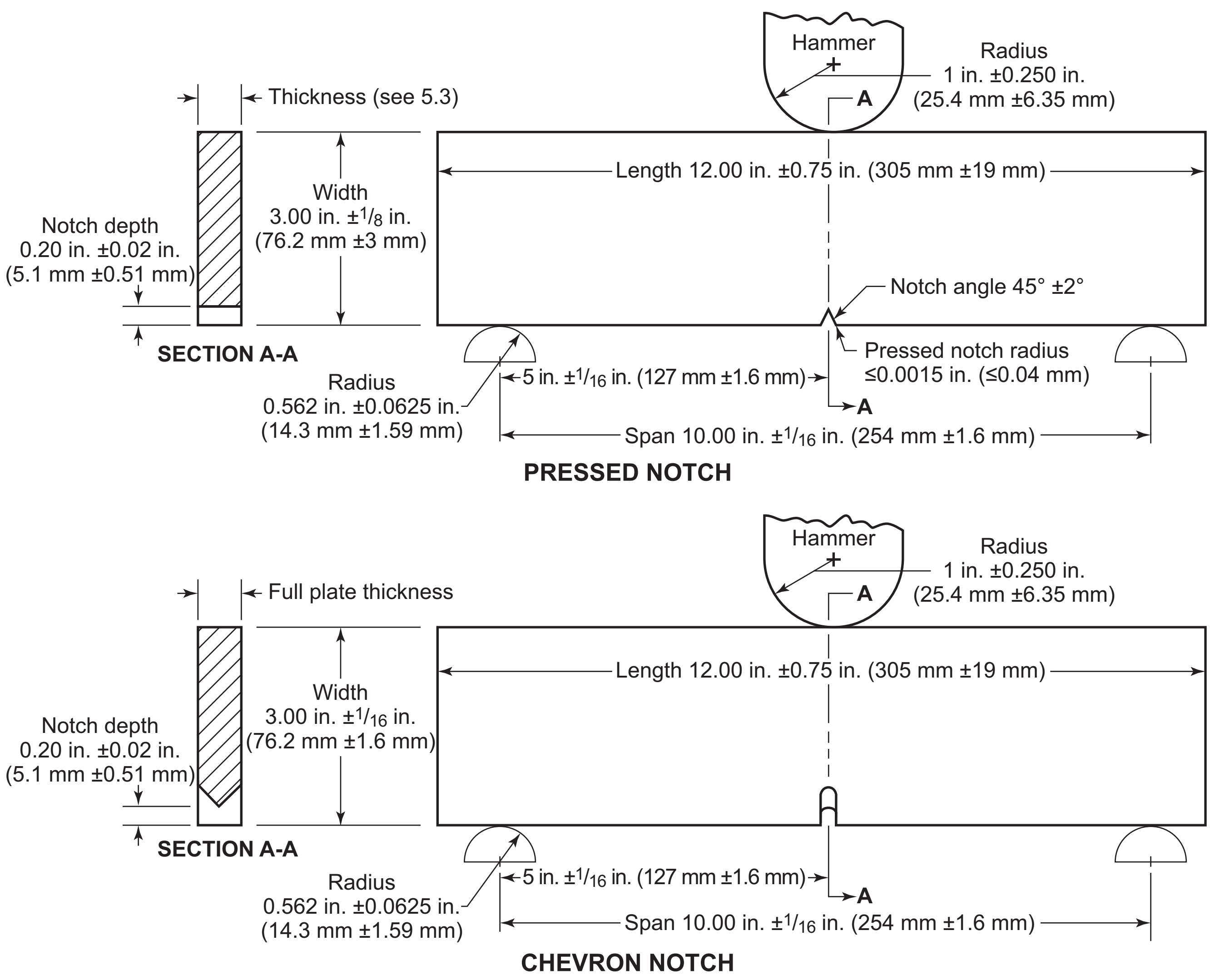



**Figure 1—Drop-Weight Tear Test Specimen and Support Dimensions**

## 5.2 Notch Geometry

The pressed notch is the preferred notch. The chevron notch may be considered an alternative to the pressed notch, particularly for higher Charpy V-notch energy steels where invalid results are more likely to occur with pressed notch. The chevron notch can eliminate excess initiation energy associated with some higher toughness line-pipe steels, which frequently result in invalid specimens as defined in 7.1.

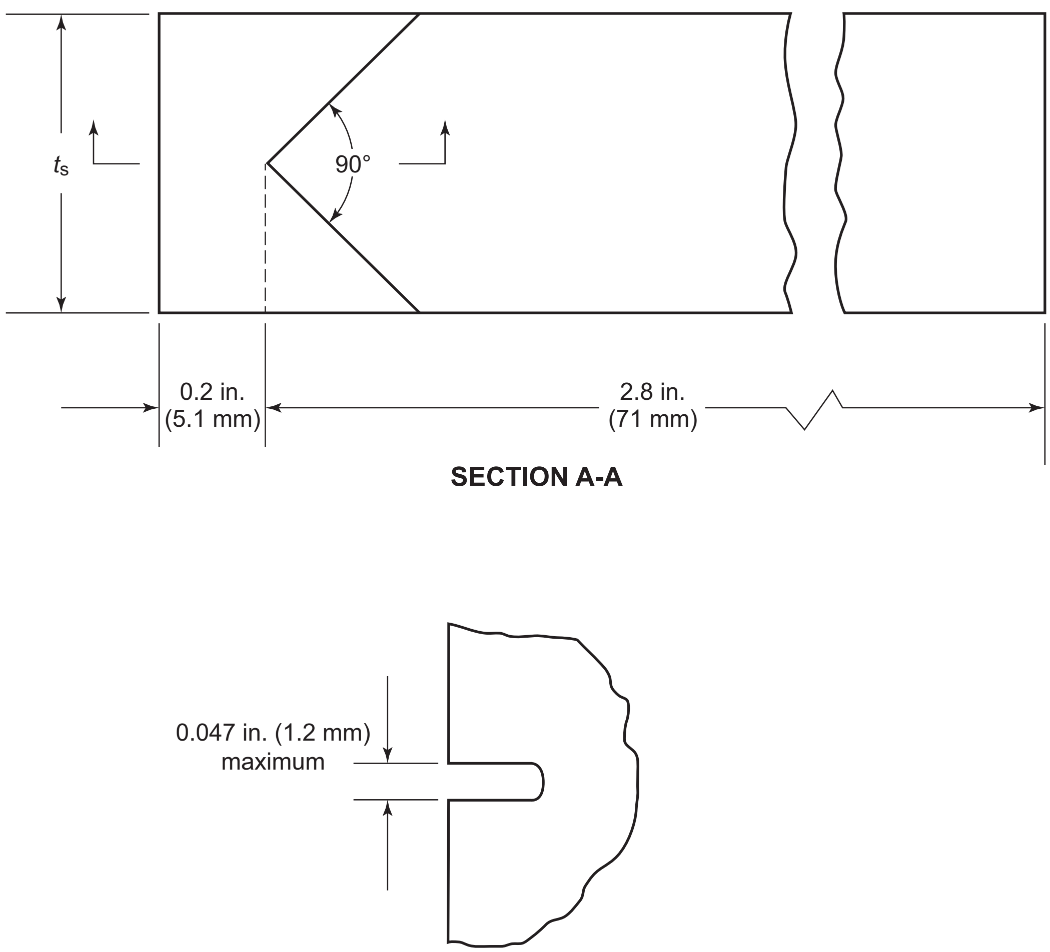
a) Pressed Notch.

The pressed notch shall be pressed to the depth shown in Figure 1 with a sharp (no radius) tool steel chisel with an included angle of 45° ±2°. Machined notches are prohibited.

When many specimens are to be tested, it is helpful to use a jig which will guide the chisel and stop it at the proper depth.

b) Chevron Notch.

The chevron notch shall be cut or machined to the 90° nominal configuration shown in Figure 2 with a width not to exceed 0.047 in. (1.2 mm). There is no notch radius requirement (i.e. the notch may be round or have a flat bottom).




NOTE SECTION A-A is the through-notch fracture plane shown in Figure 1.

**Figure 2—Drop-Weight Tear Test Chevron Notch Details**

### 5.3 Dimensions

Specimens from pipe with a wall thickness of 0.750 in. (19.0 mm) and less shall be the full-wall thickness of the pipe. Specimens from pipe with wall thickness greater than 0.750 in. (19.0 mm) shall be either: (1) the full wall thickness; or (2) reduced in thickness to 0.750 in. (19.0 mm) minimum by machining one or both surfaces. Specimens that are reduced to a thickness less than the pipe wall thickness shall be broken at a temperature that is reduced from the specified test temperature by the amount shown in Table 1.

NOTE Heavy wall pipe tested at a reduced temperature shall be marked with the specified temperature.

**Table 1—Test Temperature Reduction**

| **Specified Pipe Thickness,** in. (mm) | **Test Temperature Reduction,** °F (°C) |
|---|---|
| 3/4 to 7/8 (19.0 to 22.2) | 10 (6) |
| 7/8 to 1 1/8 (22.2 to 28.6) | 20 (11) |
| 1 1/8 through 1 9/16 (28.6 through 39.7) | 30 (17) |

## 6 Specimen Testing

**6.1** The specimens shall be completely immersed in a batch of a suitable liquid at a temperature within 2 °F (1 °C) of the desired test temperature for the minimum time requirement as given in Table 2.

**Table 2—Minimum Bath Time Requirements**

| **Thickness ($t_s$),** in. (mm) | **Time,** minutes |
|---|---|
| Less than 0.50 (12.7) | 15 |
| 0.50 to 1.00 (12.7 to 25.4) | 20 |
| 1.00 to 1.50 (25.4 to 38.1) | 45 |

The specimens shall be separated from each other and the bath sides and bottom by at least 1 in. (25 mm) or one wall thickness of the specimen, whichever is greater. Provision shall be made for circulation to ensure uniform bath temperature.

NOTE Alternate heating or cooling methods may be used provided they produce an equivalent temperature at the mid-thickness of the specimen.

**6.2** The specimens shall be removed from the bath and broken as described herein within a time period of 10 seconds. If this time is exceeded, the specimen shall be returned to the bath for a minimum of 10 minutes. The specimen shall not be handled in the center by devices whose temperature appreciably differs from the test temperature.

## 7 Specimen Evaluation

**7.1** Valid specimens exhibit cleavage fracture from the notch tip with the exception being those specimens that exhibit ductile fracture on the complete fracture surface. Specimens shall be invalid if the fracture under the notch is ductile and changes to a cleavage fracture, a phenomenon known as inverse fracture.

**7.2** The shear fracture appearance (dull, gray, and silky) is to be rated by differentiating the percent of shear fracture as opposed to cleavage fracture which is typically bright and crystalline in appearance. The fracture appearance of the specimen to be evaluated is the surface observed when looking parallel to the fracture specimen. Controlled-rolled steels may have splits parallel to the plate surface which exhibit cleavage fracture. The cleavage fracture in splits parallel to the plate surface should not be included in the shear area percent rating. Cleavage fracture on splits angled from the plate surface shall be included in the shear area percent rating by looking normal to the specimen surface. (See Figure 3)

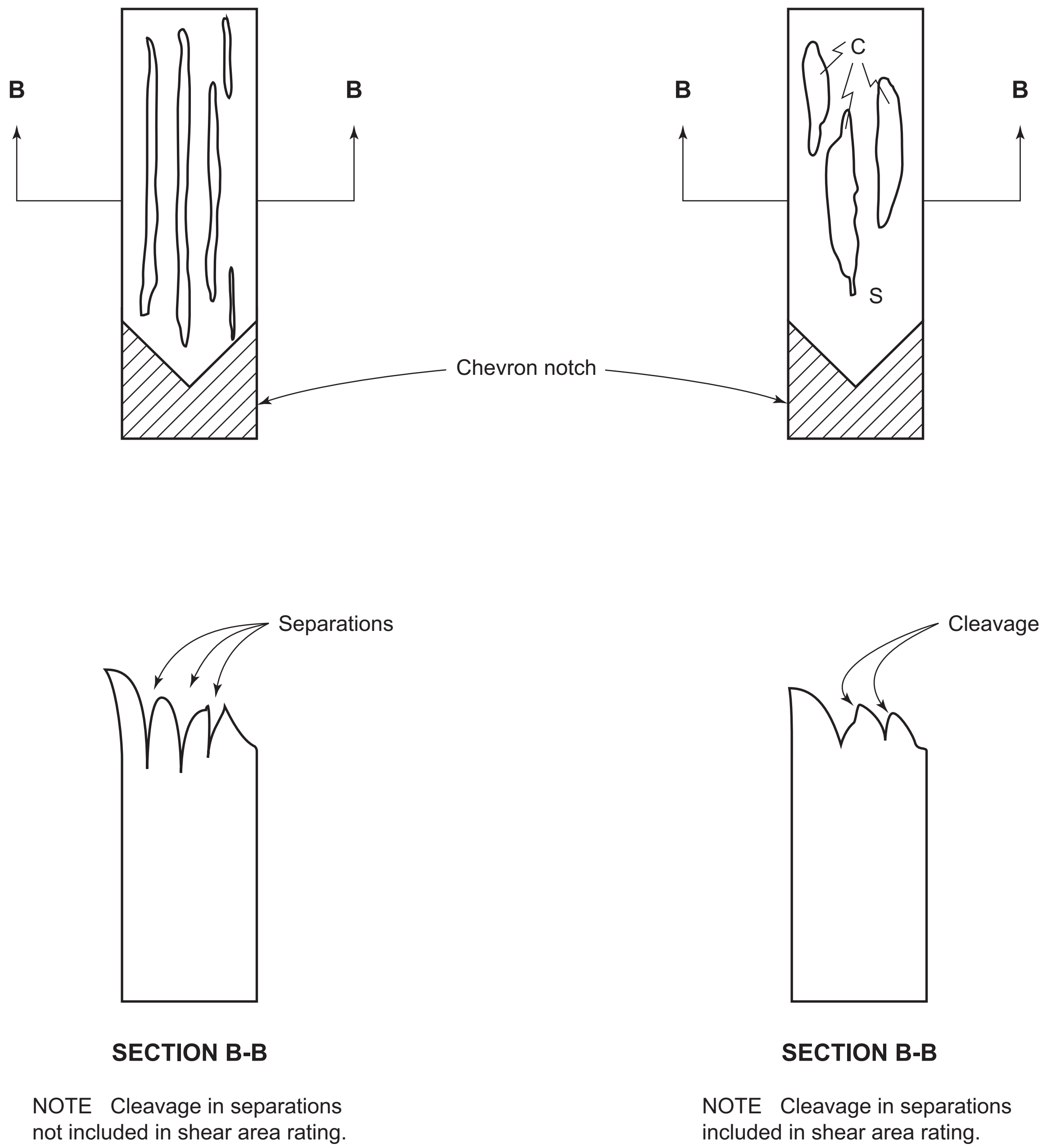
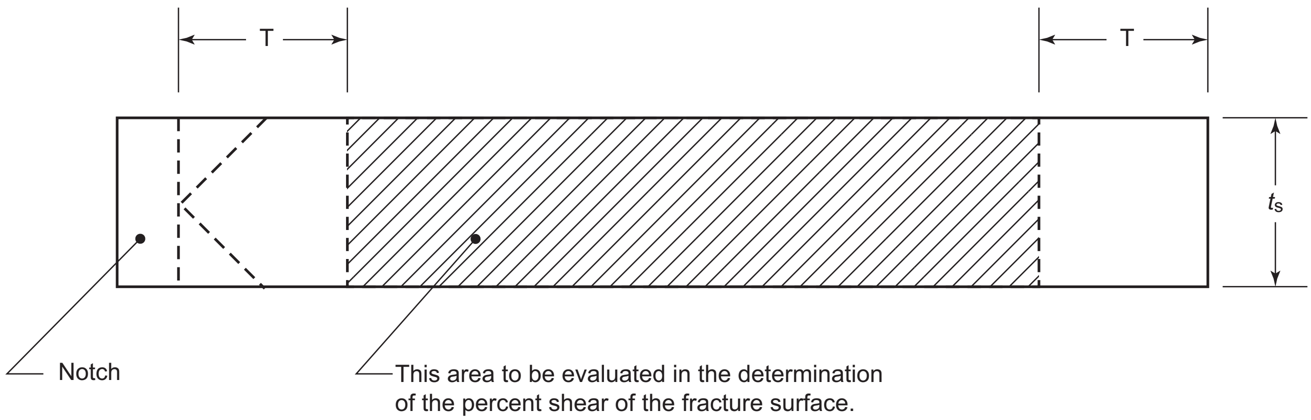



**Figure 3—Shear Area Rating of Separations in Controlled-rolled Steel Fracture Surfaces**

**7.3** For specimen thickness ($t_S$) of 0.750 in. (19.0 mm) or less, they shall be evaluated by determining the percent shear area of the fracture surface, neglecting the fracture surface for a distance of one specimen thickness from the root of the pressed notch or the tip of the chevron notch, and the fracture surface for a distance of one specimen thickness from the opposite side of the specimen.

For specimens with a thickness ($t_s$) greater than 0.750 in. (19.0 mm), the neglected regions (T) shall be 0.750 in. (19.0 mm). Figure 4 illustrates in the cross-hatched area that portion of the fracture surface to be considered in the evaluation of the percent shear area of the fracture surface. See Annex B for method of measuring shear area.

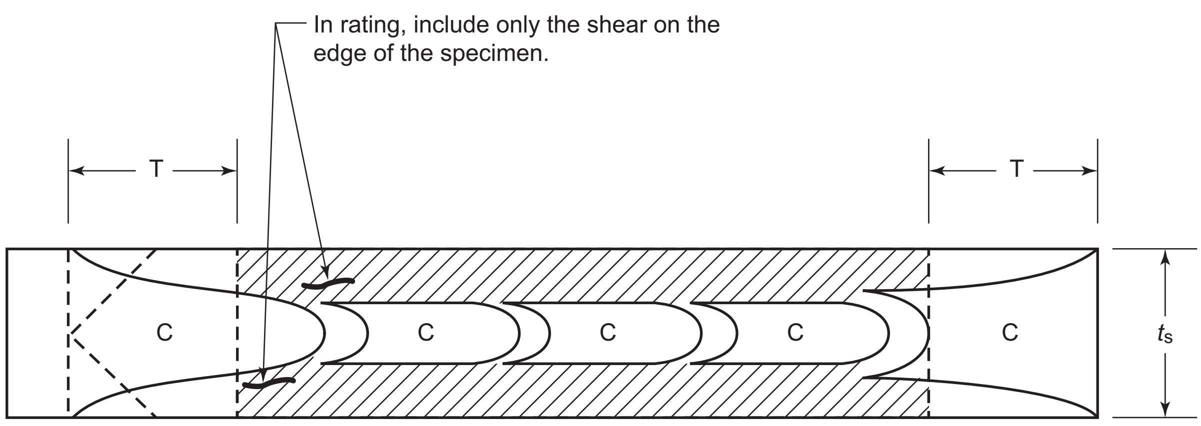



NOTE T = 0.750 in. (19.0 mm) for specimens with thickness greater than 0.750 in. (19.0 mm).

**Figure 4—Fracture Surface Included in Shear Area Determination**

**7.4** Occasionally specimens exhibiting the fracture appearance shown in Figure 5 will be encountered. On specimens of this type, the fracture appears to have stopped and started a number of times, exhibiting intermittent regions of shear and cleavage in the mid-thickness portion of the specimen.

The shear area included in the rating of specimens of this type shall be that shown in the cross-hatched area of Figure 5. The shear areas in the region of intermittent shear and cleavage fracture shall be neglected in rating the specimen.




NOTE 1 C denotes the cleavage appearing regions.

NOTE 2 T = 0.750 in. (19.0 mm) for specimens with thickness greater than 0.750 in. (19.0 mm).

**Figure 5—Alternate Shear-cleavage Fracture Appearance**

**7.5** The percent shear area of the fracture surface can be determined in several ways, as described below.

a) Measure the shear area of the fracture surface with a planimeter on a photograph or optical projection of the fracture surface.

b) Compare the fracture surface with a calibrated set of photographs of previously fractured specimens or with actual specimens of calibrated percent areas for a specific thickness.

c) Follow procedure as described in Annex B.

d) Use any other procedure which has been demonstrated to produce results equivalent to those obtained from 7.5 a, 7.5 b, or 7.5 c above.

## 8 Report

Inspection documentation shall conform to the requirement of API Specification 5L. A report of the test results shall be furnished to the purchaser and shall include:

— steel heat number;

— specimen number or identification;

— wall thickness within ±0.005 in. (±0.127 mm);

— test temperature;

— total shear area, percent; and

— notch type.

# Annex A
(normative)

## Metric Conversion Factors

The following equation is used to convert degrees Fahrenheit (°F) to degrees Celsius (°C):

$$°C = {}^{5}/_{9}\ (°F - 32)$$

| US Customary Unit | | Metric Unit |
|---|---|---|
| 1 inch (in.) | = | 25.4 millimeters (mm) exactly |
| 1 square inch (sq in.) | = | 645.16 square millimeters (sq mm) exactly |
| 1 foot (ft) | = | 0.3048 meters (m) exactly |
| 1 pound (lb) | = | 0.45359 kilograms (kg) |
| 1 pound per foot (ppf) | = | 1.4882 kilograms per meter (kg/m) |
| 1 pound per square inch (psi) | = | 6.895 kilopascals (kPa) for pressure |
| | = | 0.006895 megapascals (MPa) for stress |
| 1 foot-pound (ft-lb) | = | 1.3558 joules (J) for impact energy |

# Annex B
(normative)

## Measurement of Shear Area

**B.1** Many ways have been suggested and tried for measuring the percent shear of DWTT specimens. Some of the methods such as photographing and planimetering the fracture are accurate but slow. Other methods such as measuring the shear at the midpoint of the specimen are rapid but not accurate enough. The procedure outlines herein has been developed over a period of time as a reasonably accurate and rapid method of measuring the percent shear area.

**B.2** It has been found that the procedure to be used depends upon the configuration of the fracture surface. Figure B.1 shows three representative fracture surfaces. The specimens exhibiting fracture surfaces between Detail A and Detail B of Figure B.1, the shear area is calculated assuming the cleavage portion of the fracture is a third-degree curve—this approximates the cleavage fracture surface configuration with reasonable accuracy. This results in the following equation which is applicable between approximately 100 % and 45 % shear or to the point where the cleavage fracture extends to the “one T” line on the back end of the specimen.

For US Customary Units:

$$\%SA = \frac{(2.8 - 2\mathrm{T})t_s - \frac{3}{4}AB}{(2.8 - 2\mathrm{T})t_s} \times 100$$

where

$A$ is the width of the cleavage fracture at the “one T” line beneath the notch in inches; and

$B$ is the length of the cleavage fracture in between the “two T” lines in inches.

For SI Units:

$$\%SA = \frac{(71 - 2\mathrm{T})t_s - \frac{3}{4}AB}{(71 - 2\mathrm{T})t_s} \times 100$$

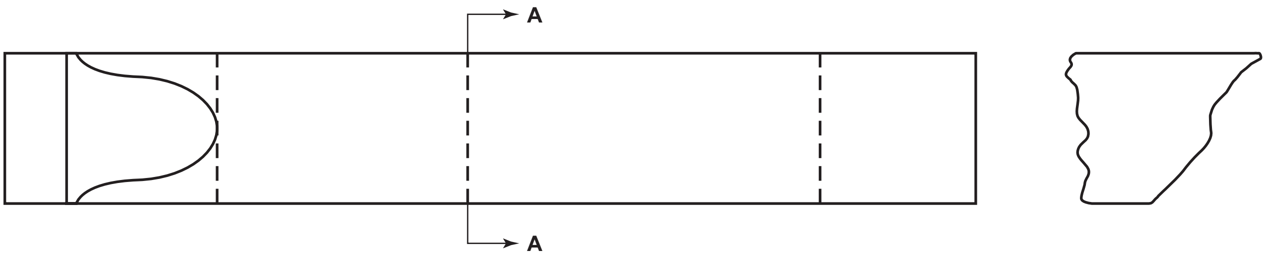
where

$A$ is the width of the cleavage fracture at the “one T” line beneath the notch in millimeters; and

$B$ is the length of the cleavage fracture in between the “two T” lines in millimeters.

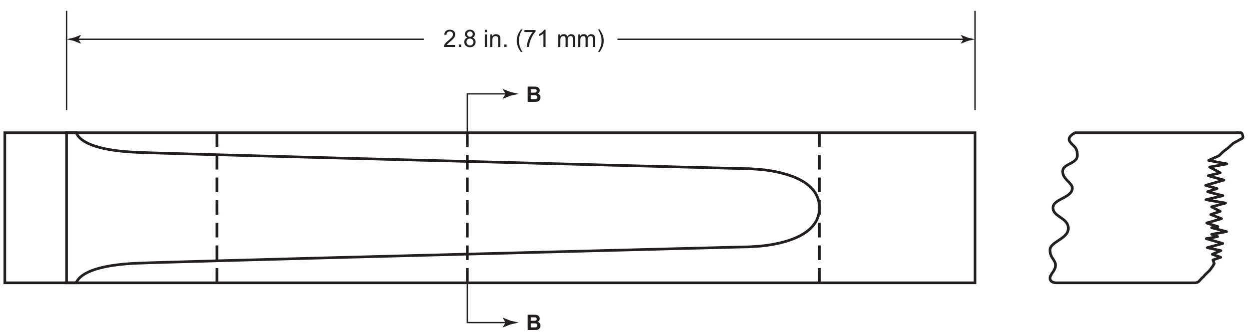
**B.3** Rather than make the calculation for each specimen it is quicker to compute the data for various thicknesses and plot it. Figure B.2 and Figure B.3 are examples of plots for determining percent shear of 0.312 in. and 0.344 in. (7.9 mm and 8.7 mm, respectively) thick material. With figures such as these it is possible to determine shear areas of specimens by measuring the A and B dimensions of the fracture surfaces for shear areas in the range of 45 % to 100 %.

In the shear range between 45 % and 0 %, represented by the fracture surface shown in Figure B.1, Detail C, the percent shear is obtained by making three or four measurements of the total shear lip thicknesses, averaging them, and dividing by the specimen thickness. This may also be tabulated for ease of determination.



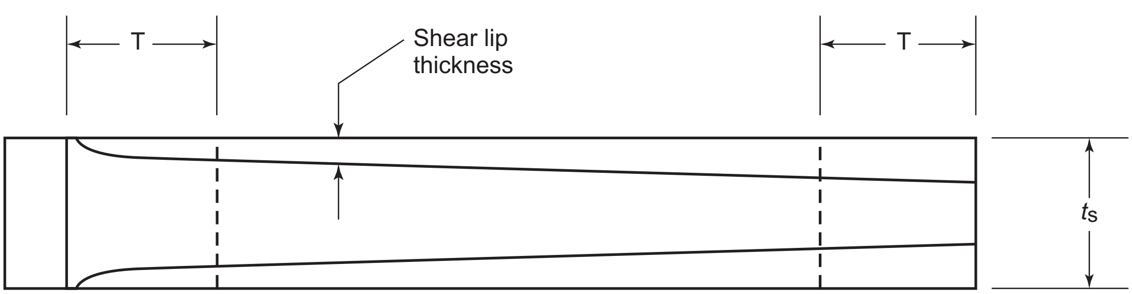

**Detail A**
100 % Shear

**SECTION A-A**




**Detail B**
Approximately 45 % shear

**SECTION B-B**




**Detail C**
Less than 45 % shear

**Figure B.1—Representative DWTT Fracture Surfaces**

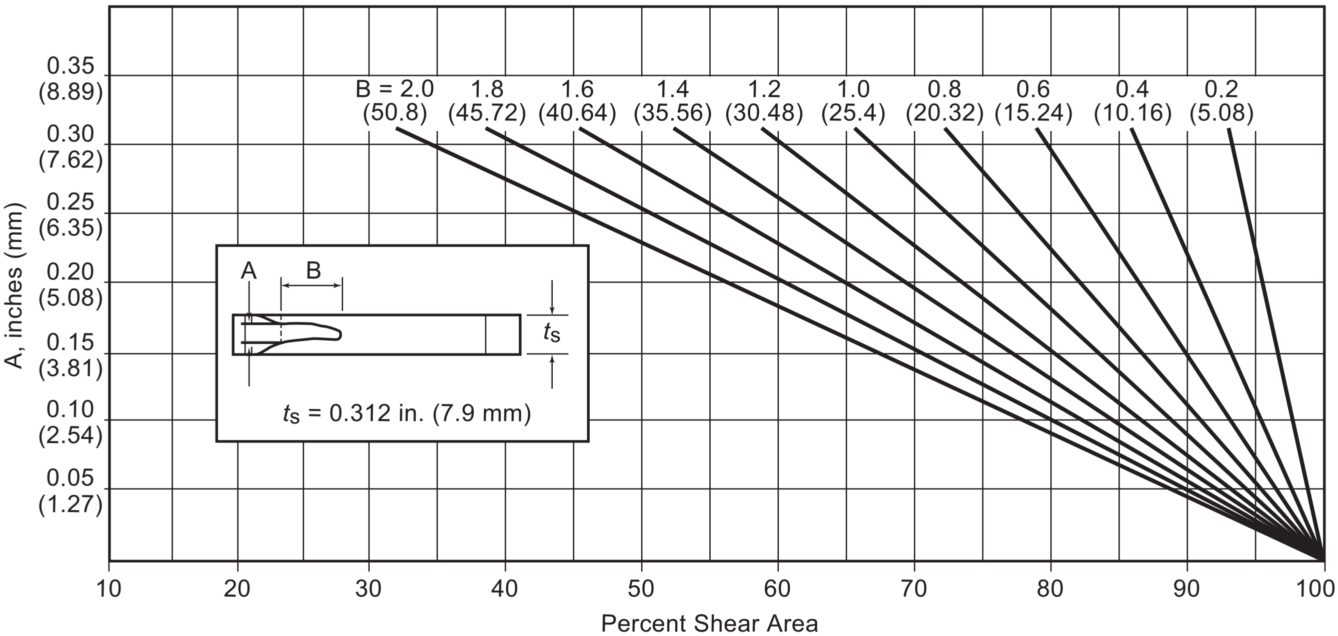



**Figure B.2—Chart for Determining Percent Shear for 0.312 in. (7.9 mm) Material**

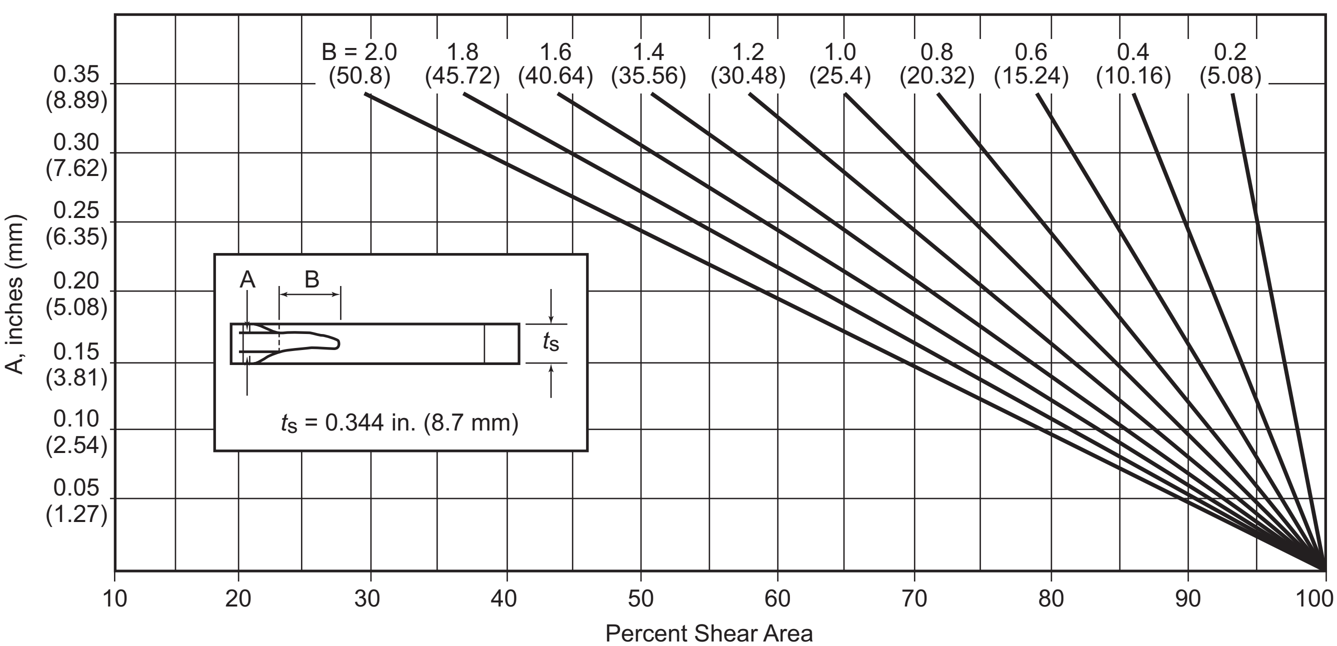



**Figure B.3—Chart for Determining Percent Shear for 0.344 in. (8.7 mm) Material**

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