



Designation: D2509 – 20

# Standard Test Method for Measurement of Load-Carrying Capacity of Lubricating Grease (Timken Method)<sup>1</sup>

This standard is issued under the fixed designation D2509; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This test method covers the determination of the load-carrying capacity of lubricating greases by means of the Timken Extreme Pressure Tester.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific warning statements, see 7.1, 7.2, and 9.4.

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:*

**G40 Terminology Relating to Wear and Erosion**

2.2 *ASTM Adjuncts:*

Glossy Prints of Test Blocks Showing Various Types of Scar<sup>2</sup>

## 3. Terminology

3.1 *Definitions:*

3.1.1 *load-carrying capacity, of a lubricating grease, n*—the maximum load or pressure that can be sustained by a lubricat-

ing grease without failure of the sliding contact surfaces as evidenced by seizure or welding.

3.1.1.1 *Discussion*—The values of load carrying capacity of a lubricating grease vary according to test method.

3.1.2 *scoring, in tribology, n*—a severe form of wear characterized by the formation of extensive grooves and scratches in the direction of sliding.

3.1.2.1 *Discussion*—When the lubricant film is substantially maintained, a smooth scar is obtained on the test block, but when there is a breakdown of the lubricant film, scoring or surface failure of the test block takes place as shown in Fig. 1.<sup>2</sup> In its simplest and recognized form, scoring is characterized by a wide scar on the test block and by the transfer of metal from the test block to the contacting surface of the test cup. The form of surface failure more usually encountered, however, consists of a comparatively smooth scar, which shows local damage that usually extends beyond the width of the scar. Scratches or striations that occur in an otherwise smooth scar and that do not extend beyond the width of the scar are not considered scoring in this test method. The term scuffing is sometimes used as a synonym for scoring.

3.1.3 *seizure or welding, n*—localized fusion of rubbing metal, usually indicated by streaks of transferred metal, increased friction and wear, or unusual noise and vibration.

3.1.4 *wear, n*—the removal of metal from a rubbing surface by mechanical action, or by a combination of mechanical and chemical actions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *extreme pressure (EP) additives, n*—tribologically reactive species that prevent mating metallic surfaces from adhering to each other under concentrated contact conditions with high PV values. **PV Product, G40**

3.2.1.1 *Discussion*—The PV value is the product of the contact pressure (MPa) and sliding velocity (m/s).

3.2.2 *extreme pressure (EP) lubricants, n*—formulations whose effects may become observable at different operating conditions, preventing adhesive wear under mixed or boundary lubrication regimes and are characterized by an increased load carrying capacity, or increased tribofilm strength.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.G0.04 on Functional Tests - Tribology.

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<sup>2</sup> Available from ASTM International Headquarters. Order Adjunct No. ADJD2509. Original adjunct produced in 1972.

\*A Summary of Changes section appears at the end of this standard

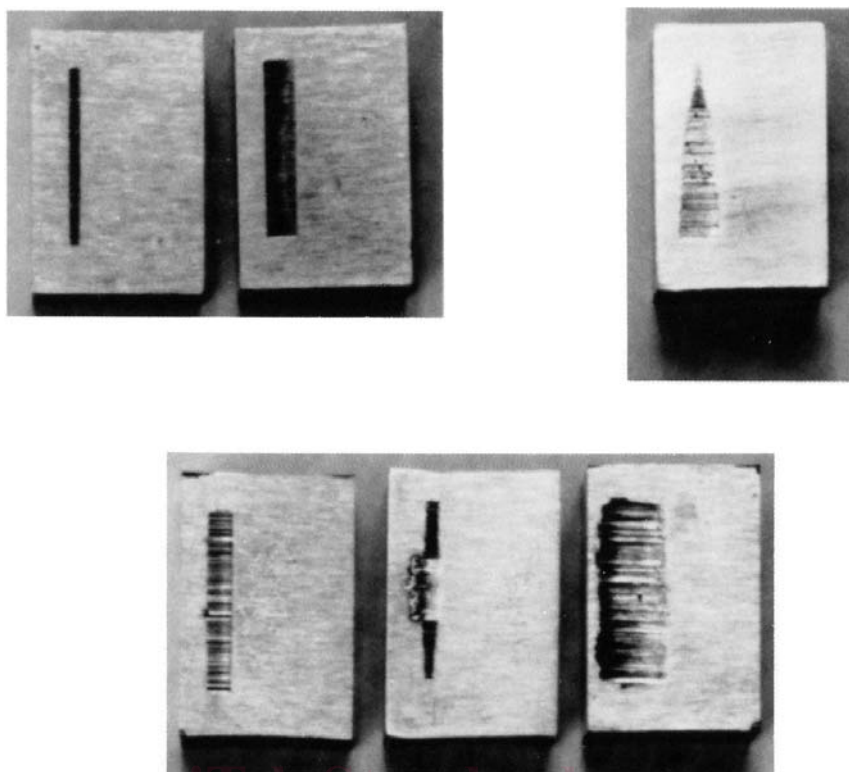


FIG. 1 Test Blocks Showing Various Types of Scar

3.2.3 *load carrying capacity, n*—of a lubricant, the maximum PV value [PV Limit, G40] that can be sustained by the lubricant at a reported temperature without failure of the sliding contact surfaces as evidenced by adhesive wear or localized welding.

3.2.3.1 *Discussion*—The PV value is the product of the contact pressure (MPa) and sliding velocity (m/s).

3.2.4 *OK value, n*—the maximum mass (weight) added to the load lever mass (weight) pan, at which no scoring or seizure occurs.

3.2.5 *score value, n*—the minimum mass (weight) added to the load lever mass (weight) pan, at which scoring or seizure occurs.

#### 4. Summary of Test Method

4.1 The tester is operated with a steel test cup rotating against a steel test block. The rotational speed is 800 r/min  $\pm$  5 r/min, which is equivalent to a linear speed of 123.71 m/min  $\pm$  0.77 m/min (405.88 ft/min  $\pm$  2.54 ft/min). Grease samples are brought to and applied at 24 °C  $\pm$  6 °C (75 °F  $\pm$  10 °F).

4.2 Two determinations are made: the minimum load (score value) that will rupture the lubricant film being tested between the rotating cup and the stationary block and cause adhesion; and the maximum load (OK value) at which the rotating cup will not rupture the lubricant film and cause adhesion between the rotating cup and the stationary block.

#### 5. Significance and Use

5.1 The test method is used widely for specification purposes and is used to differentiate between greases having low,

medium, or high levels of extreme pressure characteristics. The results may not correlate with results from service.

#### 6. Apparatus and Materials

6.1 *Timken Extreme Pressure Tester*, described in detail in Annex A1 and illustrated in Fig. 2.

6.2 *Sample Feed Devices*, for supplying the test specimens with grease are described in Annex A1.

6.3 *Loading Mechanism*, for applying and removing the load mass (weight) without shock at the uniform rate 0.91 kg/s to 1.36 kg/s (2 lb/s to 3 lb/s). A detailed description is given in Annex A1.

6.4 *Test Cups*,<sup>3,4</sup> of carburized steel, having a Rockwell Hardness C Scale Number of 58 to 62, or a Vickers Hardness Number of 653 to 746. The cups have a width of 13.06 mm  $\pm$  0.05 mm (0.514 in.  $\pm$  0.002 in.), a perimeter of 154.51 mm  $\pm$  0.23 mm (6.083 in.  $\pm$  0.009 in.), a diameter of 49.22 mm +0.025 mm, -0.127 mm (1.938 in. +0.001 in., -0.005 in.), and a maximum radial run-out of 0.013 mm (0.0005 in.). The axial surface roughness should lie between 0.51  $\mu$ m and 0.76  $\mu$ m (20  $\mu$ in. and 30  $\mu$ in.) C.L.A.

<sup>3</sup> The sole source of supply of the test cups known to the committee at this time is Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585 under Part No. F-25061.

<sup>4</sup> If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

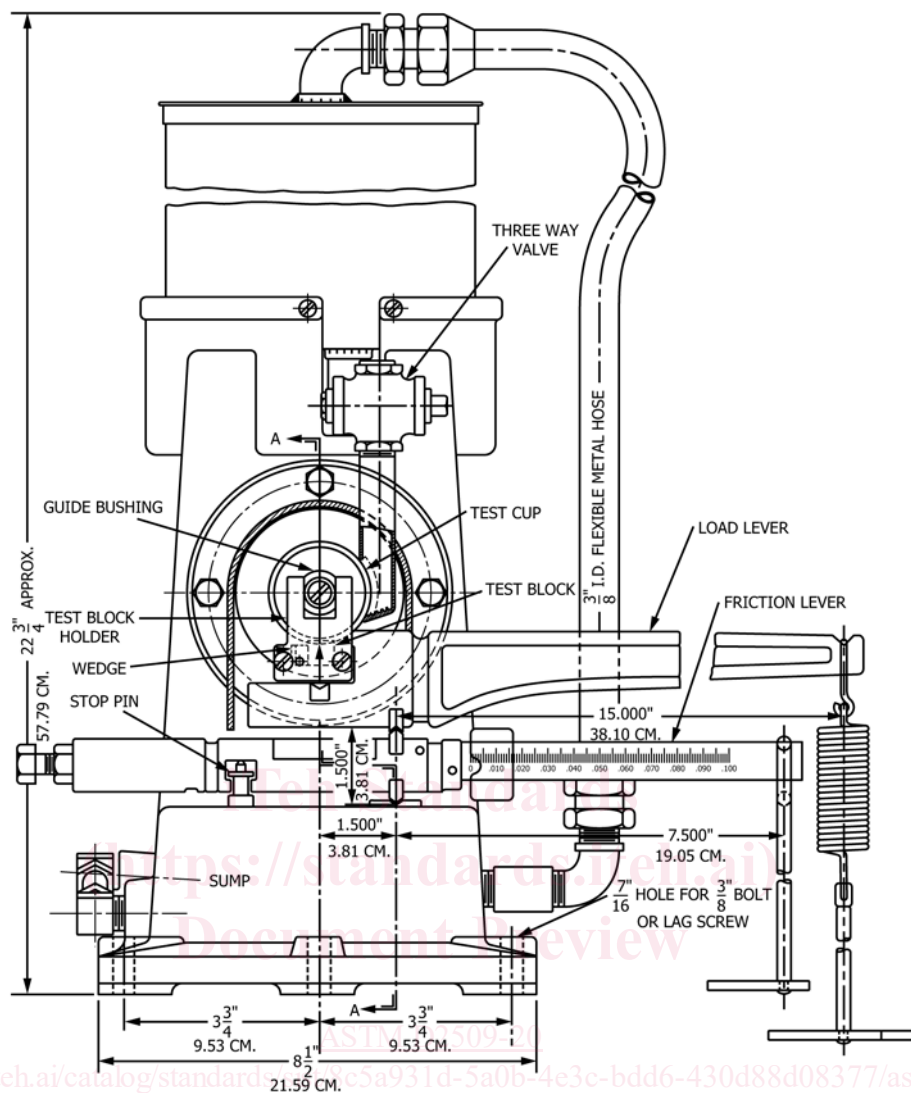


FIG. 2 Timken Tester

6.5 *Test Blocks*<sup>4,5</sup> with test surfaces  $12.32 \text{ mm} \pm 0.10 \text{ mm}$  ( $0.485 \text{ in.} \pm 0.004 \text{ in.}$ ) wide and  $19.05 \text{ mm} \pm 0.41 \text{ mm}$  ( $0.750 \text{ in.} \pm 0.016 \text{ in.}$ ) long, of carburized steel, having a Rockwell Hardness C Scale Number of 58 to 62, or a Vickers Hardness Number of 653 to 746. Each block is supplied with four ground faces and the surface roughness should lie between  $0.51 \mu\text{m}$  and  $0.76 \mu\text{m}$  ( $20 \mu\text{in.}$  and  $30 \mu\text{in.}$ ) C.L.A.

6.6 *Microscope*,<sup>4,6</sup> low-power ( $50\times$  to  $60\times$ ), having sufficient clearance under objective to accommodate the test block. It should be fitted with a filar micrometer so that the scar width may be measured with an accuracy of  $\pm 0.05 \text{ mm}$  ( $\pm 0.002 \text{ in.}$ ).

6.7 *Timer*; graduated in minutes and seconds.

## 7. Reagents

7.1 *Acetone*, reagent grade, minimum purity. (**Warning**—Extremely flammable. Vapors can cause flash fire.)

7.2 *Stoddard Solvent*, also known as Mineral Spirits, reagent grade. (**Warning**—Combustible. Vapor harmful.)

## 8. Preparation of Apparatus

8.1 Clean the apparatus with Stoddard solvent and acetone (see 7.1 and 7.2), and blow dry. Shield the sump outlet and disconnect the oil pump to eliminate wear on the unused pump. Replace the oil reservoir with the grease feed device.

8.2 Select a new test cup and block, wash with Stoddard solvent, and dry with a clean soft cloth or paper. Immediately before use rinse the test cup and block with acetone and blow them dry. Do not use solvents such as carbon tetrachloride or others that may inherently possess load-carrying properties which may affect the results.

<sup>5</sup> The sole source of supply of the test blocks known to the committee at this time is Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585 under Part No. F-25001.

<sup>6</sup> The sole source of supply of the apparatus known to the committee at this time is Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585.

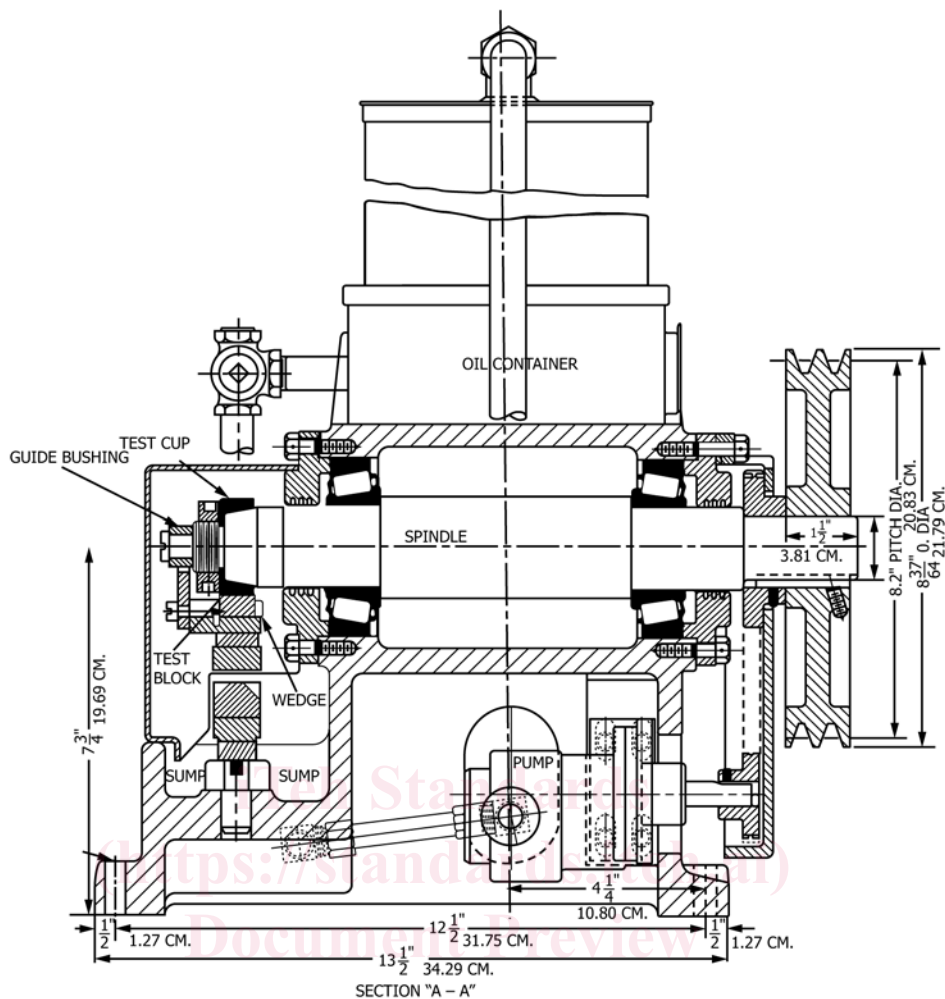


FIG. 2 Timken Tester (continued)

8.3 Assemble the tester carefully (Fig. 3), placing the test cup on the spindle and making certain that it is well seated, drawing it up firmly but avoiding possible distortion from excessive tightening (Note 1). Place the test block in the test block holder and adjust the levers so that all the knife edges are in proper alignment. Exercise special care in placing the stirrup of the spring-weight platform assembly (selection of which will depend on the loading device) in the groove of the load-lever arm to avoid premature shock to the test block when

the load is applied. To ensure the test block, test block holder, and lever arms are properly aligned and seated, coat the test block and test cup with the grease to be tested, and rotate the machine slowly for a few revolutions either by hand or by suitable control mechanism. If the parts are in alignment, the grease will be wiped off the cup over its entire width.

NOTE 1—At this point it is recommended that a dial indicator be used to check that the radial run-out of the cup *in situ* does not exceed 0.001 in. (0.025 mm) total indicator movement.

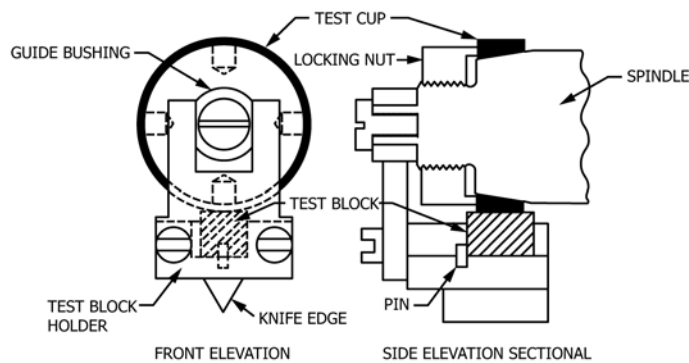


FIG. 3 Assembly of Tester Showing Test Pieces

## 9. Procedure

9.1 Bring the grease to  $24\text{ }^{\circ}\text{C} \pm 6\text{ }^{\circ}\text{C}$  ( $75\text{ }^{\circ}\text{F} \pm 10\text{ }^{\circ}\text{F}$ ). Fill the grease-feeding device with grease, avoiding the inclusion of air bubbles. Apply a film of grease to the test cup and block and thoroughly grease the guide bushing with the test grease. Do not heat the grease.

9.2 Apply the grease at  $24\text{ }^{\circ}\text{C} \pm 6\text{ }^{\circ}\text{C}$  ( $75\text{ }^{\circ}\text{F} \pm 10\text{ }^{\circ}\text{F}$ ) to the test block through the grease-feed mechanism at the uniform rate of  $45\text{ g/min} \pm 9\text{ g/min}$  ( $0.1\text{ lb/min} \pm 0.02\text{ lb/min}$ ). Start the motor and run for 30 s to break-in. If the equipment used is equipped with acceleration control, start the motor and gradually increase the rotational speed of the spindle to achieve  $800\text{ rpm} \pm 5\text{ rpm}$  after 15 s. Run for a further 15 s to complete the break-in.

9.3 After the break-in period of 30 s, start the timer and apply at  $8.9\text{ N/s}$  to  $13.3\text{ N/s}$  ( $2\text{ lbf/s}$  to  $3\text{ lbf/s}$ ), a load of  $133.4\text{ N}$  ( $30\text{ lbf}$ ). (A starting load of  $133.4\text{ N}$  ( $30\text{ lbf/s}$ ) is recommended. The load lever arm, spring, and mass (weight) carrier assembly are not considered part of the applied load.) Then allow the machine to run at  $800\text{ rpm} \pm 5\text{ rpm}$  for  $10\text{ min} \pm 15\text{ s}$  after load application is initiated, unless a score is detected before that period. Excessive noise and fluctuations in the spindle speed indicate scoring of the test components. Stop the machine at once, turn off the supply of grease lubricant, and remove the load.

9.4 If, after the load has been applied, scoring is evident by vibration or noise, stop the tester at once, remove the load, and turn off the flow of lubricant. Since the excessive heat developed with deep scoring may alter the surface characteristics of the entire block, discard the test block. (**Warning**—The machine and test pieces may be hot at this point and care should be exercised in their handling.)

9.5 If no scoring/scuffing is detected, allow the tester to run for  $10\text{ min} \pm 15\text{ s}$  from the start of the application of the load. At the end of the  $10\text{ min} \pm 15\text{ s}$  period, reverse the loading device and remove the load from the lever arm. Turn off the motor, allow the spindle to come to rest, then turn off the flow of grease. Remove the load lever and inspect the condition of the test block surface. The lubricant has failed at the imposed load if the wear scar indicates any scoring/scuffing or welding. Significant tapering indicates improper alignment or setup and test run should be repeated. See Fig. 1.

NOTE 2—Microscopical observations should not be used to define if scoring has occurred, but a skilled operator may use a microscope to examine the wear scar for further information.

9.6 If no score is observed, turn the test block to expose a new surface of contact and, with a new test cup, repeat the test with a load  $44.5\text{ N}$  ( $10\text{ lbf}$ ) heavier and in successive tests increase it in  $44.5\text{ N}$  ( $10\text{ lbf}$ ) increments until a load that produces a score is reached. At this point decrease the load by  $22.2\text{ N}$  ( $5\text{ lbf}$ ) for the final determination.

9.7 If a score is produced at the  $133.4\text{ N}$  ( $30\text{ lbf}$ ) load, reduce the load by  $26.7\text{ N}$  ( $6\text{ lbf}$ ) decrements until no scoring is realized. At this point, increase the load by  $13.3\text{ N}$  ( $3\text{ lbf}$ ) for the final determination.

9.8 When the wear scar evidence at any load stage makes the definition of the onset of scoring questionable, repeat the test at the same load. If the second test produces a score, record a score rating for this load. Similarly, if the second test produces no scoring, record a no score rating. If the second test again yields a questionable result, simply withhold judgment of the rating at this load stage and test the grease at the immediately next higher and lower load stages. Then assign a rating to the load stage in question which is identical to the rating obtained at the immediately next higher load stage employed (see Annex A2).

NOTE 3—Two other procedures that may be conducted with this apparatus are described by Appendix X1 and Appendix X2.

## 10. Calculation and Report

10.1 Report the OK and score values in terms of the masses (weights) placed on the mass (weight) pan hanging from the end of the load-lever arm; do not include the mass (weight) of the pan assembly. Report the values in multiples of  $2.27\text{ kg}$  ( $5\text{ lb}$ ) above  $13.71\text{ kg}$  ( $30\text{ lb}$ ) and in multiples of  $1.36\text{ kg}$  ( $3\text{ lb}$ ) below  $30\text{ lb}$ .

10.2 When desired, the contact (unit) pressure which exists between the cup and block at the conclusion of the test may be calculated.<sup>7</sup> After the OK value has been determined, remove the test block and wash with Stoddard solvent, rinse with acetone, and blow dry. By means of a filar micrometer microscope, measure the width of the scars on those blocks which successfully carried this load. Make all measurements to  $0.05\text{ mm}$  ( $0.002\text{ in.}$ ) Calculate the contact pressure,  $C$ , as follows:

$$C, \text{ psi} = [L(X+G)]/YZ \text{ or } [20(X+G)]/Z \quad (1)$$

$$C, \text{ MPa} = 9.81 [L(X'+0.454G)]/Y'Z' \quad (2)$$

where:

- $L$  = 10 = mechanical advantage of load-lever arm,
- $G$  = load-lever constant (value is stamped on lever arm of each tester),
- $X$  = mass (weight) placed on the weight pan, lb
- $X'$  = mass (weight) placed on the weight pan, kg,
- $Y$  = length of test scar ( $\frac{1}{2}\text{ in.}$ ),
- $Y'$  = length of test scar ( $12.7\text{ mm}$ ),
- $Z$  = average width of test scar, in., and
- $Z'$  = average width of test scar, mm.

## 11. Precision and Bias

11.1 The precision of this test is not known to have been obtained in accordance with currently accepted guidelines (for example, Research Report RR:D02-1007).

11.2 The following criteria should be used for judging the acceptability of OK load results (95 % confidence):

11.2.1 *Repeatability*—Duplicate results by the same operator should be considered suspect if they differ by more than 23 % of their mean. Table X3.1, based on this level of repeatability, and the use of the load increments specified in the

<sup>7</sup> For convenience, contact (unit) pressure tables are available from Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585.