Standard Test Method for Galling Resistance of Materials[1]

This standard is issued under the fixed designation G 98; 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 a laboratory test which ranks the galling resistance of material couples. Most galling studies have been conducted on bare metals and alloys; however, non-metallics, coatings, and surface modified alloys may also be evaluated by this test method.

1.2 This test method is not designed for evaluating the galling resistance of material couples sliding under lubricated conditions because galling usually will not occur under lubricated sliding conditions using this test method.

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:*

G 40 Terminology Relating to Wear and Erosion[2]

G 83 Test Method for Wear Testing with a Crossed-Cylinder Apparatus[2]

3. Terminology

3.1 *Definition: Definition used in this test method is given in Terminology G 40*.

3.1.1 *galling*—a form of surface damage arising between sliding solids, distinguished by macroscopic, usually localized, roughening and creation of protrusions above the original surface; it often includes plastic flow or material transfer, or both.

3.1.1.1 *Discussion*—The onset of galling usually requires that the contact pressure exceeds some threshold value. Galling can be a precursor to seizing or loss of function. The identification of galling is somewhat subjective, and complete agreement does not exist, even among experts.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *threshold galling stress*—the stress midway between the highest non-galled stress and the lowest galled stress as determined by this test method.

4. Summary of Test Method

4.1 This test method uses available laboratory equipment capable of maintaining a constant, compressive load between two flat specimens, such as hydraulic or screw feed compression testing machines. One specimen is slowly rotated one revolution 360° relative to the other specimen. The surfaces are examined for galling after sliding. The criterion for whether galling occurs is the appearance of the specimens based on unassisted visual examination. If the specimens have not galled, a new set of specimens is tested at increased load. This process is continued until galling occurs.

4.2 Appropriate load intervals are chosen to determine the threshold galling stress within an acceptable range.

4.3 The higher the threshold galling stressing, the more galling resistant is the test couple.

5. Significance and Use

5.1 This test method is designed to rank material couples in their resistance to the failure mode caused by galling and not merely to classify the surface appearance of sliding surfaces.

5.2 This test method should be considered when damaged (galled) surfaces render components non-serviceable. Experience has shown that galling is most prevalent in sliding systems that are slow moving and operate intermittently. The galling and seizure of threaded components is a classic example which this test method most closely simulates.

5.3 Other galling-prone examples include: sealing surfaces of value trim which may leak excessively due to galling; and pump wear rings that may function ineffectively due to galling.

5.4 If the equipment continues to operate satisfactorily and loses dimension gradually, then mechanical wear should be evaluated by a different test such as the crossed cylinder Test Method (see Test Method G 83). Chain belt pins and bushings are examples of this type of problem.

5.5 This test method should not be used for quantitative or final design purposes since many environmental factors influence the galling performance of materials in service. Lubrication, alignment, stiffness and geometry are only some of the factors that can affect how materials perform. This test method

[1] This test method is under the jurisdiction of ASTM Committee G02 on Wear and Erosion and is the direct responsibility of Subcommittee G02.40 on Non-Abrasive Wear.

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[2] *Annual Book of ASTM Standards*, Vol 03.02.

has proven valuable in screening materials for prototypical testing that more closely simulates actual service conditions.

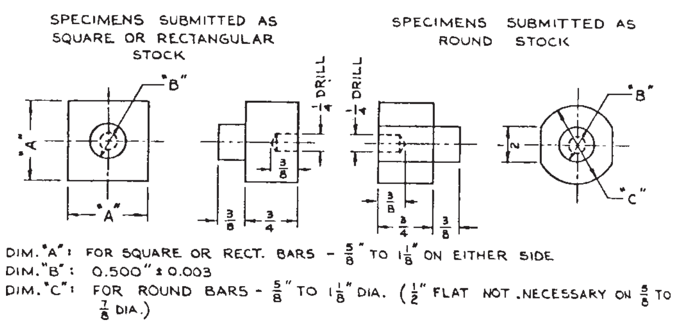
6. Apparatus

6.1 Commonly available laboratory equipment has been used to conduct galling tests. Both Brinell hardness testers and servo-hydraulic testing machines have proven to be satisfactory as loading devices. Any apparatus that can apply and maintain a constant compressive load should be acceptable.

7. Test Specimens

7.1 This test method uses a cylindrical flat-on-flat geometry. One specimen is called the button (or pin) and is generally (but not necessarily) rotated about its axis on the flat specimen called the block.

7.2 Some typical button geometries are shown in Fig. 1.



Metric Equivalents

in.	mm	in.	mm
1⁄4	6.4	5⁄8	16
3⁄8	10	3⁄4	19
1⁄2	13	7⁄8	22
0.500 ± 0.003	12.7 ± 0.08	1 1⁄8	29

FIG. 1 Typical Button Geometries

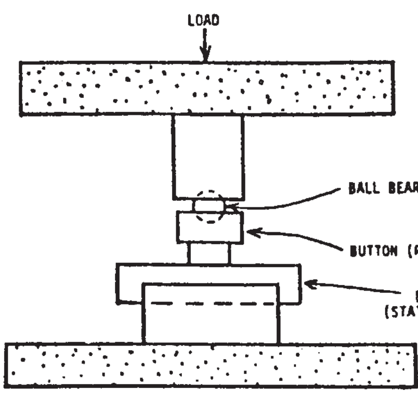


FIG. 2 Schematic Diagram of Galling Test Set-Up

7.3 The only critical dimension is diameter "B'' of the contact area. The 6.4-mm (0.25-in.) diameter hole accommodates a ball bearing for alignment purposes during the test. All other dimensions may be varied to the user's convenience.

7.4 The block specimen must have sufficient area to accommodate at least one test; however, most users have found that blocks of length 76 mm (3 in.) to 152 mm (6 in.) are ideal for multiple tests. A reasonable width is 19 mm (0.75 in.). Thickness is not critical. Tests have been successfully run on blocks with thicknesses from 1.5 mm (0.06 in.) to 25.4 mm (1 in.).

7.5 Maintain block flatness at 0.33 mm/m (0.004 in./ft).

7.6 The arithmetic average surface finish of both test surfaces should be between 0.25 and 1.1 µm (10 and 45 µin.). Leave specimens as-ground or polished with abrasive paper to achieve the finish.

8. Procedure

8.1 An overall view of the galling test set-up is shown in Fig. 2.

8.2 *Cleaning*—Immediately prior to testing, clean the test surfaces of the specimens using a procedure that will remove any scale, oil film, or foreign matter. The following cleaning technique is suggested for metallic specimens: clean the button and block in trichloroethane, ultrasonically, if possible; a methanol rinse may be used to remove any traces of trichloroethane residue.[3] Materials with open grains (some powder metals) must be dried to remove all traces of the cleaning solvent which may be entrapped in the material. Demagnetize steel specimens having residual magnetism.

8.3 Mount specimens in the loading device and degrease again if possible. Lightly load the specimens. Twist the button by hand to make sure it is seated flat on the block.

8.4 Apply the selected load. If there is no estimate of the galling resistance of the test couple, it is advisable to start with 890 N (200 lb) and increase the stress in subsequent tests as desired. This will minimize damage to the specimens so that they may be remachined and used for further testing.

8.5 Immediately rotate one specimen (usually the button, but not necessarily) one revolution. Use an open-end wrench, adjustable wrench, or some other special tool in order to grip the specimen for rotating by hand. A mechanized system may also be used to rotate one specimen relative to the other. This may allow torque measurement during testing which may provide useful data on incipient scoring.

8.6 Actual sliding time should be between 3 to 20 s. Stopping for regripping the turning tool is permitted, but this elapsed time is not counted in the 3 to 20 s test time.

8.7 Release the load.

8.8 Examine both specimens for galling. If the specimens appear smooth and undamaged (burnishing does not constitute damage) to the unaided eye, repeat the procedure at a higher load with untested specimens.

8.9 If the surfaces exhibit scratch marks, this is not galling. A wavy surface is not considered galled. At least one of the contacting surfaces must exhibit torn metal for galling to have occurred. If fracture of any cold welded areas has taken place in the plane of the surfaces and no distinct raised metal (protrusion) is found, galling has not occurred for the purposes of this test method.

8.10 If galling has occurred even on just one specimen, test at a lower load to establish an interval between the highest

[3] This cleaning procedure is not appropriate for polymers. If a polymer is being tested, a cleaning procedure that does not alter the chemistry or surface should be determined.

non-galled stress and the galled stress. This interval should be no greater than 34.5 MPa (5 ksi) for threshold galling stresses greater than 138 MPa (20 ksi) and no greater than 21 MPa (3 ksi) for stresses 138 MPa (20 ksi) or less.

8.11 If galling is questionable or borderline, repeat at a higher load to confirm the previous test stress.

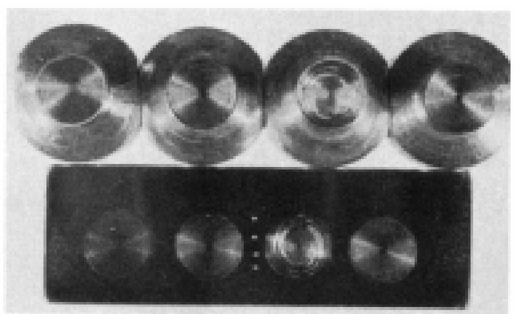
8.12 A typical series of test specimens is shown in Fig. 3.

8.13 Calculate the threshold galling stress as the stress midway between the highest non-galled test and the lowest galled test. Use the original diameter of the button to calculate the contact stress. Assume full contact of the button diameter even though in some lightly loaded tests, this may not always be the case.

9. Report

9.1 The following data should be included in the test report:

9.1.1 Composition and hardness of specimens,



Contact Stress (MPa)	131.7	169.6	247.5	193.0
· (ksi)	19.1	24.6	35.9	28.0
Comment	OK	OK	Galled	OK

NOTE 1—Another test at 220.6 MPa (32 ksi) would be necessary to establish the threshold gall stress within acceptable limits.

FIG. 3 Typical Gall Test Series

9.1.2 Thermal history of specimens,

9.1.3 Threshold galling stress for test couples, interval used, and rotation time,

9.1.4 Initial surface finish, preparation, and cleaning technique,

9.1.5 Any unusual event during the test, for example, buckling of the button,

9.1.6 Mechanical test system used, such as mechanical or hydraulic, type, size, and

9.1.7 Temperature, humidity, atmosphere.

10. Precision and Bias

10.1 The subjective determination of the threshold galling stress by visual examination of surfaces makes it difficult to have high precision in test results from different laboratories. However, to minimize subjectivity, several examples of tested specimens are shown for guidance in Fig. 4. This may not be a serious drawback since experience has shown that large differences in the order of 34.5 to 69.0 MPa (5 to 10 ksi) are necessary to achieve noticeable improvements in service.

10.2 In interlaboratory testing, three laboratories reported a threshold galling stress of exactly 7 MPa (1 ksi) for self-mated AISI 316 stainless steel. In other tests, three laboratories reported stresses of over 360 MPa (52 ksi) without any galling for self-mated aluminum bronze.

10.3 No rigorous statement can be made regarding bias since there is no independent measure of galling resistance.

11. Keywords

11.1 button-on-block test; galling; galling resistance ranking; macroscopic surface damage; seized components; sliding metallic surfaces; threshold galling stress

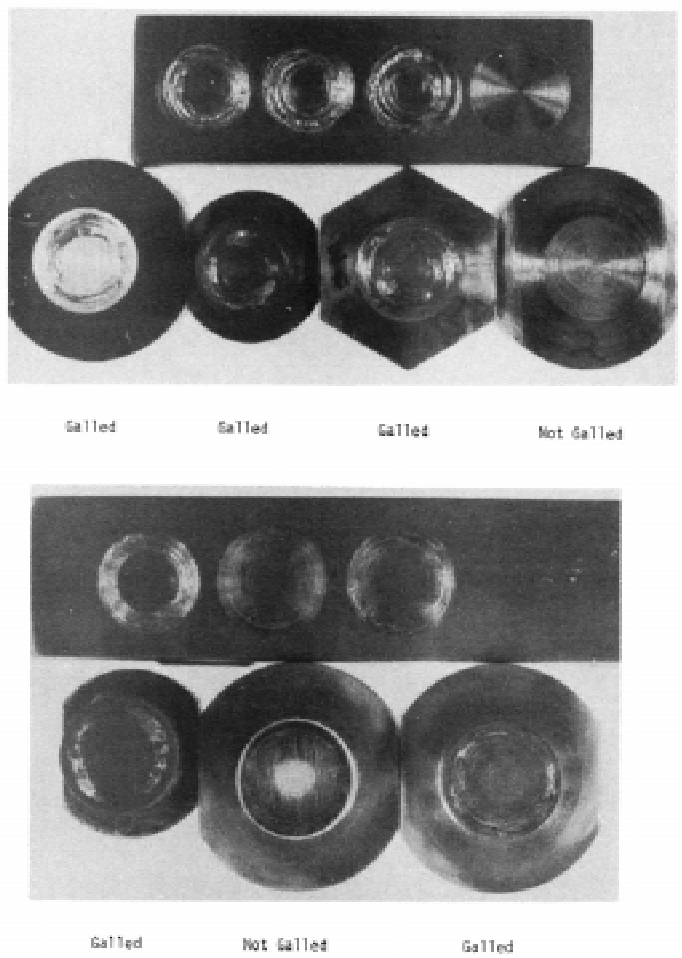


FIG. 4 Test Specimens