



# Standard Guide for Reporting Friction and Wear Test Results of Manufactured Carbon and Graphite Bearing and Seal Materials<sup>1</sup>

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## 1. Scope

1.1 This guide covers the following areas for reporting friction and wear test results of manufactured carbon and graphite bearing and seal materials:

1.1.1 Description of test device and techniques (Table 1 and Table 2.)

1.1.2 Description of carbon and graphite material test specimens (Table 3).

1.1.3 Description of mating member test specimen (Table 4).

1.1.4 Report of friction and wear test results (Table 5).

1.2 Many types of equipment and techniques will yield consistent data characterizing the friction and wear of carbon

and graphite materials. However, the ranking of the materials by the various test methods used is not necessarily the same. This guide is an initial effort to promote more complete description of the test methods, whatever they may be. It is the eventual intent to identify one or more specific standard test methods when sufficient information becomes available.

## 2. Significance and Use

2.1 The purpose of this guide is twofold. First, it is a research tool that will aid in the analysis and correlation of test results obtained on various test devices by different investigators. Second, it serves to identify important considerations that must be made in testing to make the results easily understood and comparable with the results of other investigators.

## 3. Keywords

3.1 carbon; friction; graphite; reporting; wear

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TABLE 1 Description of Test Device and Techniques

DATE \_\_\_\_\_

1. DESCRIPTION OF TEST DEVICE

1.1 Preferred Designation, Manufacturer, and Modifications \_\_\_\_\_

1.2 Orientation of Carbon Specimen Test Surface:

1.2.1 Horizontal

1.2.2 Vertical

1.2.3 Other (describe) \_\_\_\_\_

1.3 Description of Sliding:

1.3.1 Linear

1.3.2 Rotational

1.3.3 Discontinuous motion  Describe \_\_\_\_\_

1.3.4 Continuous motion  Describe \_\_\_\_\_

1.3.5 Discontinuous contact  Describe \_\_\_\_\_

1.3.6 Continuous contact  Describe \_\_\_\_\_

1.3.7 Approximate duration of test \_\_\_\_\_ minutes, \_\_\_\_\_ hours, \_\_\_\_\_ days

1.4 Description of Loading System:

1.4.1 Maximum capacity \_\_\_\_\_ N (\_\_\_\_\_ lbf)

1.4.2 Type of measuring element \_\_\_\_\_

1.4.3 Type of recording device \_\_\_\_\_

1.4.4 Estimate of error \_\_\_\_\_

1.4.5 Calibration procedure and frequency \_\_\_\_\_

1.5 Description of Speed-Measuring System:

1.5.1 Maximum capacity \_\_\_\_\_ m/s (\_\_\_\_\_ ft/s), \_\_\_\_\_ rev/min, other \_\_\_\_\_

1.5.2 Type of measuring element \_\_\_\_\_

1.5.3 Type of recording device \_\_\_\_\_

1.5.4 Estimate of error \_\_\_\_\_

1.5.5 Calibration procedure and frequency \_\_\_\_\_

1.6 Description of Temperature-Measuring System:

1.6.1 Location (describe):

1.6.1.1 Carbon test specimen \_\_\_\_\_

1.6.1.2 Mating member test specimen \_\_\_\_\_

1.6.1.3 Fluid (for example, upstream and downstream of test specimens and test cavity) \_\_\_\_\_

1.6.2 Maximum value:

1.6.2.1 Carbon test specimen \_\_\_\_\_ K (\_\_\_\_\_ °F)

1.6.2.2 Mating member test specimen \_\_\_\_\_ K (\_\_\_\_\_ °F)

1.6.2.3 Fluid \_\_\_\_\_ K (\_\_\_\_\_ °F)

1.6.3 Type of measuring element:

1.6.3.1 Carbon test specimen \_\_\_\_\_

1.6.3.2 Mating member test specimen \_\_\_\_\_

1.6.3.3 Fluid \_\_\_\_\_

1.6.4 Type of recording device:

1.6.4.1 Carbon test specimen \_\_\_\_\_

1.6.4.2 Mating member test specimen \_\_\_\_\_

1.6.4.3 Fluid \_\_\_\_\_

1.6.5 Estimate of error:

1.6.5.1 Carbon test specimen \_\_\_\_\_

1.6.5.2 Mating member test specimen \_\_\_\_\_

1.6.5.3 Fluid \_\_\_\_\_

1.6.6 Calibration procedure and frequency:

1.6.6.1 Carbon test specimen \_\_\_\_\_

1.6.6.2 Mating member test specimen \_\_\_\_\_

1.6.6.3 Fluid \_\_\_\_\_

1.7 Description of Pressure-Measuring System Across Test Specimens:

1.7.1 Maximum value:

1.7.1.1 Upstream \_\_\_\_\_ Pa absolute (\_\_\_\_\_ psia)

1.7.1.2 Downstream \_\_\_\_\_ Pa absolute (\_\_\_\_\_ psia)

1.7.1.3 Differential \_\_\_\_\_ Pa differential (\_\_\_\_\_ psid)

1.7.2 Type of measuring element:

1.7.2.1 Upstream \_\_\_\_\_

1.7.2.2 Downstream \_\_\_\_\_

1.7.2.3 Differential \_\_\_\_\_

1.7.3 Type of recording device:

1.7.3.1 Upstream \_\_\_\_\_

1.7.3.2 Downstream \_\_\_\_\_

1.7.3.3 Differential \_\_\_\_\_

1.7.4 Estimate of error:

1.7.4.1 Upstream \_\_\_\_\_

1.7.4.2 Downstream \_\_\_\_\_

1.7.4.3 Differential \_\_\_\_\_

1.7.5 Calibration procedure and frequency:

1.7.5.1 Upstream \_\_\_\_\_



TABLE 2 Description of Test Device and Techniques *Continued*

- 1.7.5.2 Downstream \_\_\_\_\_
- 1.7.5.3 Differential \_\_\_\_\_
- 1.8 *Description of Fluid Flow Rate Measuring Systems:*
- 1.8.1 Maximum value:
  - 1.8.1.1 Across test specimens \_\_\_\_\_
  - 1.8.1.2 Through test cavity \_\_\_\_\_
- 1.8.2 Type of measuring element:
  - 1.8.2.1 Across test specimens \_\_\_\_\_
  - 1.8.2.2 Through test cavity \_\_\_\_\_
- 1.8.3 Type of recording device:
  - 1.8.3.1 Across test specimens \_\_\_\_\_
  - 1.8.3.2 Through test cavity \_\_\_\_\_
- 1.8.4 Estimate of error:
  - 1.8.4.1 Across test specimens \_\_\_\_\_
  - 1.8.4.2 Through test cavity \_\_\_\_\_
- 1.8.5 Calibration procedure and frequency:
  - 1.8.5.1 Across test specimens \_\_\_\_\_
  - 1.8.5.2 Through test cavity \_\_\_\_\_
- 1.9 *Description of Friction-Measuring System:*
- 1.9.1 Maximum capacity \_\_\_\_\_ N (\_\_\_\_\_ lbf), \_\_\_\_\_ N·m (\_\_\_\_\_ lbf·ft), other \_\_\_\_\_
- 1.9.2 Type of measuring element \_\_\_\_\_
- 1.9.3 Type of recording device \_\_\_\_\_
- 1.9.4 Estimate of error \_\_\_\_\_
- 1.9.5 Calibration procedure and frequency \_\_\_\_\_

**2. METHOD OF FIXTURING CARBON TEST SPECIMEN**

- 2.1 *Rigid*
- 2.2 *Pivot* (1-D rotational freedom)
- 2.3 *Swivel, Universal* (2-D rotational freedom)
- 2.4 *Hydraulic*
- 2.5 *Pneumatic*
- 2.6 *Misalignment* \_\_\_\_\_ radians, other \_\_\_\_\_
- 2.7 *Installed Eccentricity* (TIR) \_\_\_\_\_ m (\_\_\_\_\_ in.)
- 2.8 *Axial Runout* (TIR) \_\_\_\_\_ m (\_\_\_\_\_ in.)
- 2.9 *Radial Runout* (TIR) \_\_\_\_\_ m (\_\_\_\_\_ in.)

**3. METHOD OF FIXTURING MATING MEMBER**

- 3.1 *Rigid*
- 3.2 *Pivot* (1-D rotational freedom)
- 3.3 *Swivel, Universal* (2-D rotational freedom)
- 3.4 *Hydraulic*
- 3.5 *Pneumatic*
- 3.6 *Misalignment* \_\_\_\_\_ radians, other \_\_\_\_\_
- 3.7 *Installed Eccentricity* (TIR) \_\_\_\_\_ m (\_\_\_\_\_ in.)
- 3.8 *Axial Runout* (TIR) \_\_\_\_\_ m (\_\_\_\_\_ in.)
- 3.9 *Radial Runout* (TIR) \_\_\_\_\_ m (\_\_\_\_\_ in.)

**4. ENVIRONMENTAL CONDITIONS**

- 4.1 *Carbon Test Specimen Conditioning Environment:*
- 4.1.1 Fluid medium: air  (specify moisture content \_\_\_\_\_), distilled water , deionized water , other (specify composition quantitatively) \_\_\_\_\_
- 4.1.2 Temperature \_\_\_\_\_ K (\_\_\_\_\_ °F)
- 4.1.3 Pressure: ambient , other \_\_\_\_\_
- 4.1.4 Time at these conditions \_\_\_\_\_ minutes, \_\_\_\_\_ hours, \_\_\_\_\_ days
- 4.2 *Mating Member Test Specimen Conditioning Environment:*
- 4.2.1 Fluid medium: air  (specify moisture content \_\_\_\_\_), distilled water , deionized water , other (specify composition quantitatively) \_\_\_\_\_
- 4.2.2 Temperature \_\_\_\_\_ K (\_\_\_\_\_ °F)
- 4.2.3 Pressure: ambient , other \_\_\_\_\_
- 4.2.4 Time at these conditions \_\_\_\_\_ minutes, \_\_\_\_\_ hours, \_\_\_\_\_ days
- 4.3 *Test Environment:*
- 4.3.1 Fluid medium:
  - 4.3.1.1 Before test condition: air  (specify moisture content \_\_\_\_\_), distilled water , deionized water , other (specify composition quantitatively) \_\_\_\_\_
  - 4.3.1.2 During test condition (specify how monitored and controlled, including limits) \_\_\_\_\_
  - 4.3.1.3 After test condition (describe quantitatively, if possible, the change in composition or quality) \_\_\_\_\_
- 4.3.2 Substance other than fluid medium initially applied at test specimens interface (for example, lubricating oil) \_\_\_\_\_
- 4.3.3 Fluid temperature:
  - 4.3.3.1 Upstream \_\_\_\_\_ K (\_\_\_\_\_ °F)
  - 4.3.3.2 Downstream \_\_\_\_\_ K (\_\_\_\_\_ °F)
- 4.3.4 Fluid pressure:
  - 4.3.4.1 Upstream \_\_\_\_\_ Pa absolute (\_\_\_\_\_ psia)
  - 4.3.4.2 Downstream \_\_\_\_\_ Pa absolute (\_\_\_\_\_ psia)
  - 4.3.4.3 Differential \_\_\_\_\_ Pa differential (\_\_\_\_\_ psid)
- 4.3.5 Fluid flow through test cavity \_\_\_\_\_
- 4.3.6 Time to reach test conditions \_\_\_\_\_ minutes, \_\_\_\_\_ hours
- 4.3.7 Time at test conditions prior to test \_\_\_\_\_ minutes, \_\_\_\_\_ hours



TABLE 3 Description of Carbon Test Specimen

**1. DESCRIPTION OF CARBON MATERIAL**

1.1 *Manufacturer* \_\_\_\_\_

1.2 *Grade Number* \_\_\_\_\_

1.3 *Lot Number* \_\_\_\_\_

1.4 *Raw Ingredients, if not Proprietary:*

1.4.1 *Filler* \_\_\_\_\_

1.4.2 *Binder* \_\_\_\_\_

1.4.3 *Additives* \_\_\_\_\_

1.4.4 *Impregnants* \_\_\_\_\_

1.4.5 *Other* \_\_\_\_\_

1.5 *Original Billet Forming Process* \_\_\_\_\_

1.6 *Original Billet Size* \_\_\_\_\_

1.7 *Heat Treatment, if not Proprietary:*

1.7.1 *Graphitizing temperature* \_\_\_\_\_ K (\_\_\_\_\_ °F)

1.7.2 *Rate of heating* \_\_\_\_\_ K/min (\_\_\_\_\_ °F/min)

1.7.3 *Soak time* \_\_\_\_\_ minutes, \_\_\_\_\_ hours

**2. DESCRIPTION OF TEST SPECIMEN**

2.1 *Location and Orientation in Original Billet* \_\_\_\_\_

2.2 *Grain Size and Orientation in Test Specimen* \_\_\_\_\_

	<i>Before Test</i>	<i>After Test</i>
2.3 <i>Microstructure</i> (provide sketch or photo)	_____	_____
2.4 <i>Surface Coating</i>	_____	_____
2.5 <i>Dimensions and Tolerances</i> (provide print)	_____	_____
2.6 <i>Test Surface Condition:</i>		
2.6.1 <i>Roughness</i> (specify method used)	_____ μm aa	_____ μm aa
2.6.2 <i>Waviness</i> (specify method used)	_____	_____
2.6.3 <i>Flatness</i> (specify method used)	_____ μm	_____ μm
2.7 <i>Hardness and Location Where Measured</i>	_____	_____
2.8 <i>Density and Method Used</i>	_____	_____

TABLE 4 Description of Mating Member Test Specimen

**1. DESCRIPTION OF MATING MEMBER MATERIAL**

1.1 *Manufacturer* \_\_\_\_\_

1.2 *Commercial Name* \_\_\_\_\_

1.3 *Chemical Composition Limits* \_\_\_\_\_

1.4.1 *Processing* \_\_\_\_\_

1.4.2 *Heat treatment* \_\_\_\_\_

**2. DESCRIPTION OF TEST SPECIMEN**

2.1 *Location and Orientation in As-Received Piece* \_\_\_\_\_

2.2 *Grain Size and Orientation in Test Specimen* \_\_\_\_\_

2.3 *Microstructure:* crystalline , polycrystalline , amorphous , other \_\_\_\_\_  
(provide sketch or photo)

	<i>Before Test</i>	<i>After Test</i>
2.4 <i>Dimension and Tolerances</i> (provide print)	_____	_____
2.5 <i>Test Surface Condition:</i>		
2.5.1 <i>Roughness</i> (specify method used)	_____ μm aa	_____ μm aa
2.5.2 <i>Waviness</i> (specify method used)	_____	_____
2.5.3 <i>Flatness</i> (specify method used)	_____ μm	_____ μm
2.6 <i>Hardness and Location Where Measured</i>	_____	_____



TABLE 5 Report of Friction and Wear Test Results

1. DATE OF TEST \_\_\_\_\_ TEST NO. \_\_\_\_\_ MACHINE NO. \_\_\_\_\_ OPERATOR \_\_\_\_\_

2. CARBON TEST SPECIMEN IDENTIFICATION: GRADE NO. \_\_\_\_\_ LOT NO. \_\_\_\_\_ SPECIMEN NO. \_\_\_\_\_

3. MATING MEMBER TEST SPECIMEN IDENTIFICATION: SPECIMEN NO. \_\_\_\_\_

4. NUMBER OF TESTS IN THIS SERIES: FRICTION \_\_\_\_\_ WEAR \_\_\_\_\_

5. TEST CONDITIONS

5.1 Unit Load \_\_\_\_\_ Pa (\_\_\_\_\_ psi). Specify whether net or applied load, and describe method of calculation \_\_\_\_\_

5.2 Speed \_\_\_\_\_ m/s \_\_\_\_\_ (\_\_\_\_\_ ft/s), \_\_\_\_\_ rev/min, other \_\_\_\_\_

5.3 Fluid Temperature:

5.3.1 Upstream \_\_\_\_\_ K (\_\_\_\_\_ °F)

5.3.2 Downstream \_\_\_\_\_ K (\_\_\_\_\_ °F)

5.4 Fluid Pressure:

5.4.1 Upstream \_\_\_\_\_ Pa absolute (\_\_\_\_\_ psia)

5.4.2 Downstream \_\_\_\_\_ Pa absolute (\_\_\_\_\_ psia)

5.4.3 Differential \_\_\_\_\_ Pa differential (\_\_\_\_\_ psid)

5.5 Flow Across Test Specimens (if controlled) \_\_\_\_\_

5.6 Flow Through Test Cavity \_\_\_\_\_

6. CARBON TEST SPECIMEN TEMPERATURE

6.1 Start-Up Temperature \_\_\_\_\_ K (\_\_\_\_\_ °F); how and when obtained \_\_\_\_\_

6.2 Equilibrium or Average Temperature \_\_\_\_\_ K (\_\_\_\_\_ °F); how and when obtained \_\_\_\_\_

6.3 Maximum Temperature \_\_\_\_\_ K (\_\_\_\_\_ °F); how and when obtained \_\_\_\_\_

6.4 Final Temperature \_\_\_\_\_ K (\_\_\_\_\_ °F); how and when obtained \_\_\_\_\_

7. FRICTION

7.1 Break-Away or Static Friction \_\_\_\_\_ N (\_\_\_\_\_ lbf), \_\_\_\_\_ N·m (\_\_\_\_\_ lbf·ft), other \_\_\_\_\_; how obtained \_\_\_\_\_

7.2 Start-Up Friction (if different from break-away friction) \_\_\_\_\_ N (\_\_\_\_\_ lbf), \_\_\_\_\_ N·m (\_\_\_\_\_ lbf·ft), other \_\_\_\_\_; how and when obtained \_\_\_\_\_

7.3 Equilibrium or Average Friction \_\_\_\_\_ N (\_\_\_\_\_ lbf), \_\_\_\_\_ N·m (\_\_\_\_\_ lbf·ft), other \_\_\_\_\_; how and when obtained \_\_\_\_\_

7.4 Maximum Friction \_\_\_\_\_ N (\_\_\_\_\_ lbf), \_\_\_\_\_ N·m (\_\_\_\_\_ lbf·ft), other \_\_\_\_\_; how and when obtained \_\_\_\_\_

7.5 Final Friction \_\_\_\_\_ N (\_\_\_\_\_ lbf), \_\_\_\_\_ N·m (\_\_\_\_\_ lbf·ft), other \_\_\_\_\_; how and when obtained \_\_\_\_\_

8. WEAR

8.1 Carbon Test Specimen:

8.1.1 Wear measurement \_\_\_\_\_ length, \_\_\_\_\_ weight, \_\_\_\_\_ volume; accuracy and how obtained \_\_\_\_\_

8.1.2 If length used, linear dimensional change of some reference dimension other than that used to measure wear \_\_\_\_\_ m/m (\_\_\_\_\_ in./in.); how and where measured \_\_\_\_\_

8.1.3 Time duration of wear \_\_\_\_\_ minutes, \_\_\_\_\_ hours

8.1.4 Wear: per unit time \_\_\_\_\_, per unit of distance traveled \_\_\_\_\_

8.1.5 Description of worn surface (provide sketch or photo) \_\_\_\_\_

8.1.6 Surface roughness ( $\mu\text{m aa}$ ): before test \_\_\_\_\_ after test \_\_\_\_\_

8.1.7 Hardness: before test \_\_\_\_\_ after test \_\_\_\_\_

8.2 Mating Member Test Specimen:

8.2.1 Wear measurement \_\_\_\_\_ length \_\_\_\_\_ weight \_\_\_\_\_ volume; accuracy and how obtained \_\_\_\_\_

8.2.2 If length used, linear dimensional change of some reference dimension other than that used to measure wear \_\_\_\_\_ m/m (\_\_\_\_\_ in./in.); how and where measured \_\_\_\_\_

8.2.3 Time duration of wearing \_\_\_\_\_ minutes, \_\_\_\_\_ hours

8.2.4 Wear: per unit time \_\_\_\_\_ per unit of distance traveled \_\_\_\_\_

8.2.5 Description of worn surface (provide sketch or photo) \_\_\_\_\_

8.2.6 Surface roughness ( $\mu\text{m aa}$ ): before test \_\_\_\_\_ after test \_\_\_\_\_

8.2.7 Hardness: before test \_\_\_\_\_ after test \_\_\_\_\_

9. FLOW ACROSS TEST SPECIMENS

9.1 Start-Up Flow \_\_\_\_\_; how and when obtained \_\_\_\_\_

9.2 Equilibrium or Average Flow \_\_\_\_\_; how and when obtained \_\_\_\_\_


9.3 Maximum Flow \_\_\_\_\_; how and when obtained \_\_\_\_\_

9.4 Final Flow \_\_\_\_\_; how and when obtained \_\_\_\_\_

10. SUSPENDED TEST

10.1 Reason for Test Suspension \_\_\_\_\_

10.2 Time Duration Before Suspension \_\_\_\_\_ minutes, \_\_\_\_\_ hours

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