



# 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 specimen (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).

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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



TABLE 1 Description of Test Device and Techniques

1. DESCRIPTION OF TEST DEVICE		DATE
1.1 Preferred Designation, Manufacturer, and Modifications		
1.2 Orientation of Carbon Specimen Test Surface:		
1.2.1 Horizontal	<input type="checkbox"/>	
1.2.2 Vertical	<input type="checkbox"/>	
1.2.3 Other (describe)		
1.3 Description of Sliding:		
1.3.1 Linear	<input type="checkbox"/>	
1.3.2 Rotational	<input type="checkbox"/>	
1.3.3 Discontinuous motion	<input type="checkbox"/> Describe	
1.3.4 Continuous motion	<input type="checkbox"/> Describe	
1.3.5 Discontinuous contact	<input type="checkbox"/> Describe	
1.3.6 Continuous contact	<input type="checkbox"/> 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	
	Before Test	After Test
2.3	Microstructure (provide sketch or photo)	
2.4	Surface Coating	
2.5	Dimensions and Tolerances (provide print)	
2.6	Test Surface Condition:	
2.6.1	Roughness (specify method used)	μm aa
2.6.2	Waviness (specify method used)	
2.6.3	Flatness (specify method used)	μm
2.7	Hardness and Location Where Measured	
2.8	Density and Method Used	

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 <input type="checkbox"/> , polycrystalline <input type="checkbox"/> , amorphous <input type="checkbox"/> , other	
	(provide sketch or photo)	
	Before Test	After Test
2.4	Dimension and Tolerances (provide print)	
2.5	Test Surface Condition:	
2.5.1	Roughness (specify method used)	μm aa
2.5.2	Waviness (specify method used)	
2.5.3	Flatness (specify method used)	μm
2.6	Hardness and Location Where Measured	



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 _____			
<b>5. TEST CONDITIONS</b>			
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 _____			
<b>6. CARBON TEST SPECIMEN TEMPERATURE</b>			
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 _____			
<b>7. FRICTION</b>			
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 _____			
<b>8. WEAR</b>			
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 (µm 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 (µm aa): before test _____ after test _____			
8.2.7 Hardness: before test _____ after test _____			
<b>9. FLOW ACROSS TEST SPECIMENS</b>			
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 _____			
<b>10. SUSPENDED TEST</b>			
10.1 Reason for Test Suspension _____			
10.2 Time Duration Before Suspension _____ minutes, _____ hours			

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