Designation: D2670 – 95 (Reapproved 2016)

Standard Test Method for Measuring Wear Properties of Fluid Lubricants (Falex Pin and Vee Block Method)[1]

This standard is issued under the fixed designation D2670; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers a procedure for making a preliminary evaluation of the wear properties of fluid lubricants by means of the Falex Pin and Vee Block Lubricant Test Machine.

NOTE 1—Certain fluid lubricants may require different test parameters depending upon their performance characteristics.

1.2 The values stated in inch-pound 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B16/B16M Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *actual gauge load, n*—the value obtained from the gauge while running the test and before any corrections are made.

3.1.1.1 *Discussion*—The gauge reading is irrespective of the particular gauge used, and corrections are made by comparison to a standard reference.

3.1.2 *direct load, n*—the load that is applied linearly, bisecting the angle of the vee block corrected to either the 800 lbf or 3000 lbf gauge reference.

3.1.2.1 *Discussion*—This load is equivalent to the true load times the cos 42°.

3.1.3 *true load, n*—the sum of the applied forces normal to the tangents of contact between the faces of one vee block and the journal pin corrected to the 4500 lbf gauge reference line.

3.1.4 *wear teeth, n*—a measurement of wear, which in this test, is based on the number of ratchet wheel teeth advanced during the test while maintaining load.

3.1.4.1 *Discussion*—The number of teeth is directly related to the total wear (inches).

4. Summary of Test Method

4.1 The test consists of running a rotating steel journal against two stationary steel V-blocks immersed in the lubricant sample. Load is applied to the V-blocks and maintained by a ratchet mechanism. Wear is determined and recorded as the number of teeth of the ratchet mechanism advanced to maintain load constant during the prescribed testing time.

5. Significance and Use

5.1 This test method may be used to determine wear obtained with fluid lubricants under the prescribed test conditions. The user of this test method should determine to his or her own satisfaction whether results of this test procedure correlate with field performance or other bench test machines. If the test conditions are changed, wear values may change and relative ratings of fluids may be different.

6. Apparatus

6.1 *Falex Pin and Vee Block Lubricant Test Machine,* [3]illustrated in Figs. 1-3.

[1] This test method is under the jurisdiction of Committee D02 on Petroleum Products, Liquid Fuels, and Lubricantsand is the direct responsibility of Subcommittee D02.L0.11 on Tribological Properties of Industrial Fluids and Lubricates.

This test method was prepared under the joint sponsorship of the American Society of Lubrication Engineers. Accepted by ASLE in May 1967.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The Falex Pin and Vee Block Test Machine available from Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554 has been found satisfactory for this purpose. A new model of this machine has been available since 1983. Certain operating procedures are different for this new model. Consult the instruction manual of machine for this information.

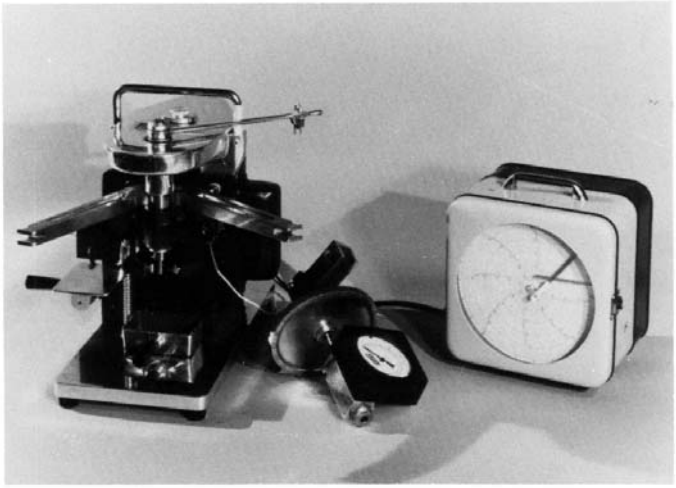

FIG. 1 Falex Pin and Vee Block Test Machine

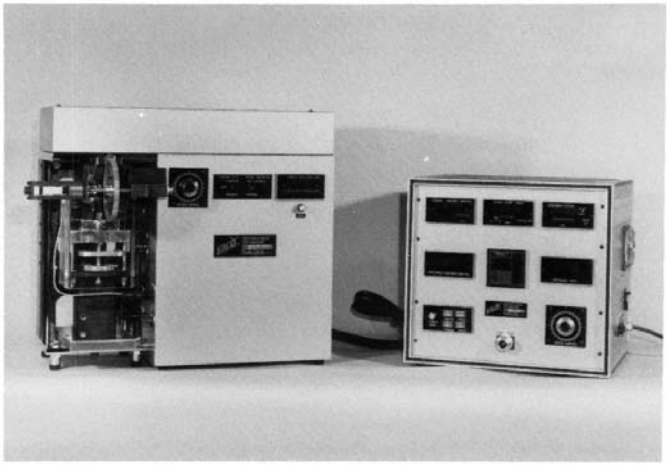

FIG. 2 Falex Digital Pin and Vee Block Test Machine

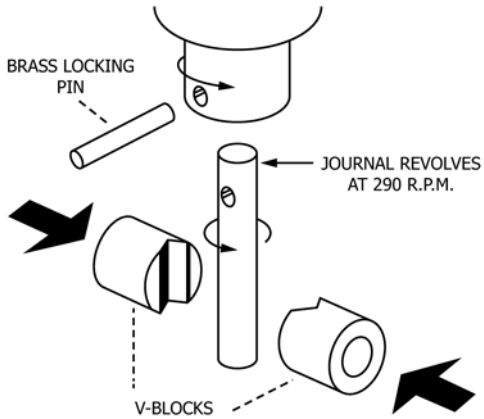

FIG. 3 Exploded View of V-Blocks and Journal Arrangement, Falex Pin and Vee Block Lubricant Test Machine

7. Reagents and Materials

7.1 *Required for Calibration of Load Gauge:*

7.1.1 *Allen Screw,* with attached 10 mm Brinell ball.[4]

7.1.2 *Back-Up Plug.* [4]

7.1.3 *Standard Test Coupon,* [4] soft, annealed copper, HB 37 to 39.

7.1.4 *Brinell Microscope,* or equivalent,

7.1.5 *Timer,* graduated in seconds and minutes, and

7.1.6 *Rule,* steel, 6 in. (approximately 150 mm) long.

7.2 *Required for Test:* [4]

7.2.1 *Standard Coined V-Blocks,* [4] 96° ± 1° angle, AISI C-1137 steel HRC 20 to 24, surface finish 5 µin. to 10 µin. (1.3×10^{-7} to 2.5×10^{-7} m), rms,

7.2.2 *Standard Test Journals,* [4] ¼ in. (6.35 mm) outside diameter by 1¼ in. (31.75 mm) long, AISI 3135 steel, HRB 87 to 91 on a ground flat surface, surface finish 5 µin. to 10 µin., (1.3×10^{-7} to 2.5×10^{-7} m), rms,

7.2.3 *Locking Pins,* [4] ½ H brass, conforming to Specification B16/B16M.

7.2.4 *Timer,* graduated in seconds and minutes.

7.2.5 *Solvent,* safe, nonfilming, nonchlorinated.

NOTE 2—Petroleum distillate and benzene, formerly used as solvents in this test method, have been eliminated due to possible toxic effects. Each user should select a solvent that can meet applicable safety standards and still thoroughly clean the parts.

8. Calibration of Load Gauges

8.1 *Apparatus with 800 lb or 3000 lb Gauge:*

8.1.1 Remove the Allen set screw and ½ in. (12.70 mm) ball from the left jaw socket (Fig. 4).

8.1.2 Insert the special Allen screw with the attached 10 mm Brinell ball into the working face of the left jaw. Adjust so that ball projects about 5⁄32 (approximately 4 mm) from face of jaw.

8.1.3 Insert the back-up plug in the counterbore of the right-hand jaw. Adjust so that the plug projects about 1⁄32 in. (approximately 0.8 mm) from the face.

8.1.4 Support the standard test coupon so that the upper edge of the coupon is about 3⁄32 in. (approximately 2.5 mm) below the upper surface of the jaws. Place a steel rule across the face of the jaws. Adjust the Allen screw with the attached 10 mm ball until the face of the jaws are parallel to the steel rule with the test coupon in position for indentation.

8.1.5 With the test coupon in position for the first impression, place the load gauge assembly on the lever arms.

8.1.6 Place the loading arm on the ratchet wheel and actuate the motor. Allow the motor to run until the load gauge indicates a load of 200 lb. A slight takeup on the ratchet wheel is required to hold the load due to the ball sinking into the test coupon. After a 200 lb load is obtained, hold for 1 min for the indentation to form.

8.1.7 Turn off the machine and back off the load until the test coupon is free from the jaws. Advance the test coupon approximately 3⁄8 in. (approximately 9.5 mm) (additional indentations should be separated by a minimum distance of 2.5× the diameter of the initial indentation). Check the alignment of the jaws, and repeat the procedure described in 8.1.6 at

[4] Available from Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554.

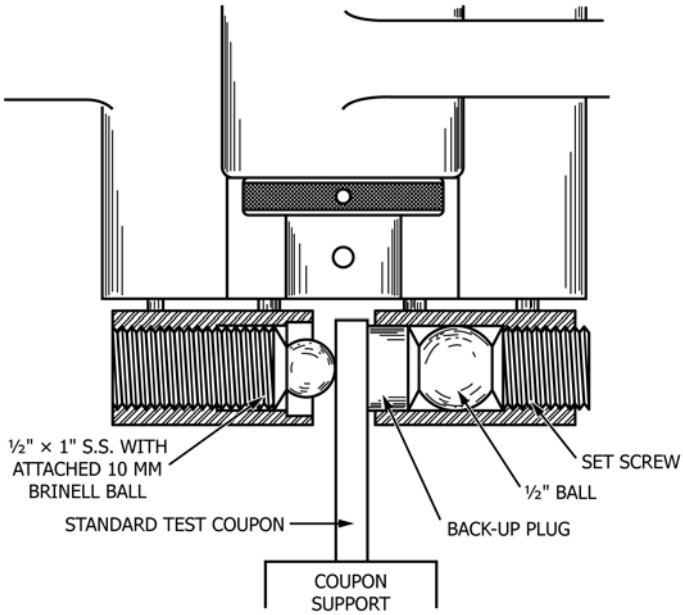

FIG. 4 Schematic Drawing of Calibration Accessories for Falex Pin and Vee Block Lubricant Test Machine

gauge loads of 400 lb, 600 lb, and 800 lb when using an 800 lb gauge. If a 3000 lb gauge is used, check at 800 lb, 1500 lb, and 2500 lb.

8.1.8 Remove the load gauge assembly and test coupon and measure the diameter of each indentation to 0.01 mm with a microscope. Make three measurements of the indentation diameter, rotating the test coupon to ensure that no two measurements represent the same points. Average the three measurements of each impression and record.

8.1.9 Plot the four impression readings versus gauge load readings on log-log paper (K and E 467080 or equivalent). From the plot determine the gauge load reading corresponding to an impression diameter of 3.30 mm. Typically, this gauge load reading will be about 700 lb. This gauge load shall be used in Section 12. A typical plot of impression diameter versus gauge readings is shown in Fig. 5.

8.2 *Apparatus with 4500 lb Gauge*—Use the same procedure as with 800 lb gauge, above, except obtain impressions at gauge readings of 300 lb, 500 lb, 750 lb, and 1000 lb. Plot the impression readings and determine the gauge load corresponding to an impression diameter of 3.30 mm. Typically, this gauge load reading will be about 900 lb. This gauge load shall be used in the procedure, (Section 13). Fig. 4 includes a typical plot of impression diameter versus gauge readings for the 4500 lb gauge.

9. Test Standards Check

9.1 Prepare a blend containing 0.10 weight % of sulfur,[5] precipitated powder, USP, and 99.90 weight percent white mineral oil,[6] USP, having a viscosity at 100 °F (37.8 °C) of 340 to 390 SUS (73.4 to 84.2 cSt). Heat the blend, in a glass beaker, to 240 °F to 250 °F (116 °C to 121 °C) and stir (glass stirrer) for 15 min. Designate this mixture as Blend A.

9.2 Prepare, similarly, a blend containing 0.20 weight % of sulfur and 99.80 weight % of white mineral oil. Designate this mixture as Blend B.

9.3 Refer to Section 8 for recommended use of these standards.

10. Apparatus and Testing Check

10.1 The purpose of this check is to establish that the apparatus is in satisfactory condition and that the test is being run in conformance to the procedure covered in Section 13. For such check purposes the fluid standards covered in Section 9 should be used (Note 3). The average of triplicate runs on the fluid standards should fall within the following limits (Note 4):

Blend	Total Teeth Wear, avg. of triplicate runs
A	36 to 71
B	101 to 127

Repeatability of test data should conform to precision limits set forth in Section 15.

NOTE 3—Three commercial cutting oils were initially chosen as reference fluid standards. These were replaced by the specified white oil-sulfur blends because of greater availability, uniformity, and purity. Results of the cooperative tests on the cutting oils are covered in Appendix X1.

NOTE 4—These limits were derived from data in Appendix X1. The limits shown for Blend A are the minimum and maximum averages

[5] Sulfur, so specified, from J. T. Baker Chemical Co. has been found satisfactory. 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 [1], which you may attend.

[6] Available from most petroleum refining companies. Also available from most drug stores, typically labeled White Mineral Oil Extra Heavy. See Table X1.1 for specific products found satisfactory in cooperative test work.

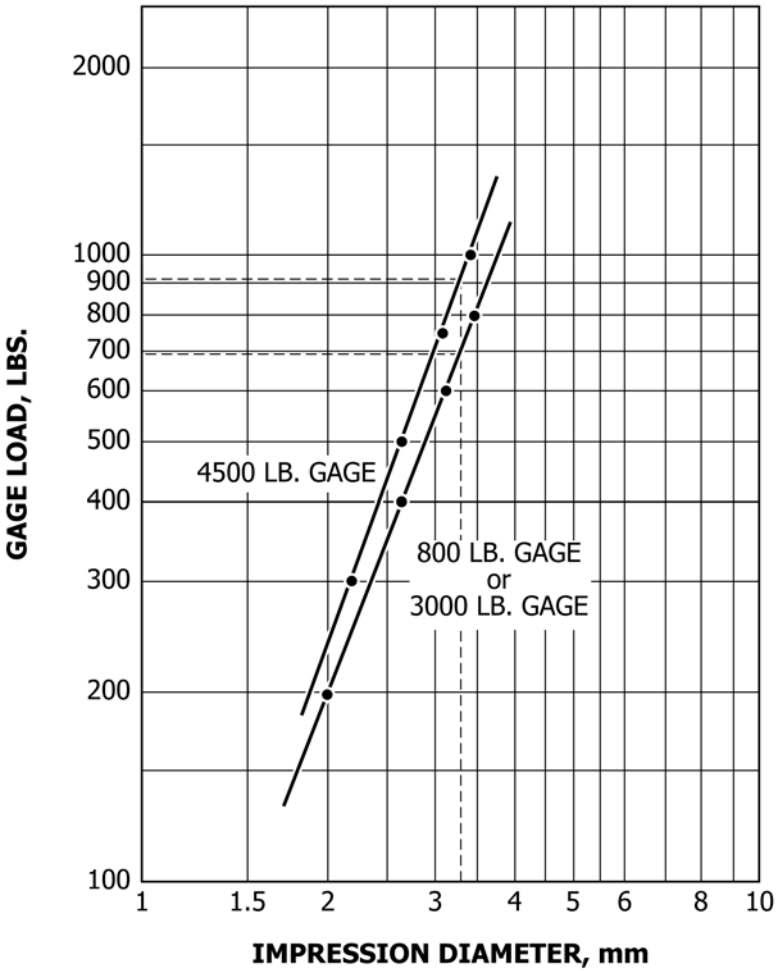

FIG. 5 Typical Curves of Gauge Load Readings versus Impression Diameter, Using 800 lb, 3000 lb, and 4500 lb Gauges and BHN 37 to 39 Standard Test Coupons

obtained in the Series 2 tests. Essentially the same averages were obtained in the Series 1 and 3 tests.

The limits shown for Blend B are the minimum and maximum averages obtained in the Series 1 tests. Essentially the same averages were obtained in the Series 3 tests.

11. Test Conditions

11.1 The test shall be conducted under the following conditions (Note 5):

Oil temperature at start of test	75 °F ± 10 °F (24 °C ± 3 °C)
Speed	290 r/min ± 10 r/minm
Gauge load	corresponding to 3.30 mm diameter impression on standard test coupon
Duration of test	15 min ± 5 s

NOTE 5—Although the test can be run under other test conditions, the precision limits described in Section 14 apply only to tests conducted under the conditions shown above and the procedure specified in Section 13.

12. Preparation of Apparatus

12.1 Thoroughly clean the V-blocks, test journals, lubricant cup, and supports for V-blocks and test journals by washing with the solvent selected in 7.2.5. Dry the V-blocks, test journals, lubricant cup, and supports, by allowing the solvent to evaporate in air.

12.2 After cleaning, handle the test pieces with care to prevent contamination. Particularly, avoid contact of fingers with mating surfaces of V-blocks and test journals.

13. Procedure

13.1 Insert the test journal in the test shaft and secure with a new brass locking pin, as shown in Figs. 1-3.

13.2 Insert the V-blocks into the recesses of the loading device and swing the V-blocks inward to contact the journal so that the V-grooves are aligned with the journal major axis, as shown in Fig. 1 and Fig. 2.

13.3 Place 60 mL of test lubricant in the lubricant cup and raise the cup so that the V-blocks are immersed in the test lubricant.

13.4 Place the automatic loading device with attached gauge, on the jaw arms.

13.5 Remove slack from assembly by moving the ratchet wheel by hand. At this setting the torque gauge should read zero, or be adjusted to read zero.

13.6 Actuate the motor, engage the automatic loading ratchet and increase the gauge load to 250 lb if the 800 lb or

3000 lb gauge is used, or 350 lb if the 4500 lb gauge is used. Disengage the loading ratchet, start the timer, and allow the machine to run at this loading for a 5 min break-in period.

13.7 Re-engage the automatic loading ratchet and leave it engaged until the gauge load corresponding to 3.30 mm diameter indentation on the standard test coupon (7.1 and 7.2) is reached (Note 6). When this gauge load is reached, disengage the loading device, start the time, and record the gear tooth number (Note 7). Run the test for 15 min, maintaining the load at near constant during the test by taking up the load, by means of the ratchet wheel, whenever wear causes a drop in load of 5 lb on the 800 lb gauge or 50 lb on the 4500 lb gauge. After 15 min running at the test load, reduce the load by 100 lb on the gauge and then return to the test load, by means of the ratchet wheel. Scribe the ratchet wheel, determine and record the total teeth wear. Stop the motor.

NOTE 6—With lubricants having relatively low load-carrying properties, such as non-additive petroleum oils, seizure of the V-blocks and journal will occur at the test load. Discontinue test if seizure occurs. Test conditions should be altered.

NOTE 7—The gear tooth number is conveniently located by scribing the aluminum ratchet wheel by laying a pencil across the loading arms. The difference between the gear tooth number at the start of the test and the gear tooth number at the end of the test gives the total teeth wear.

14. Report

14.1 Report seizure if V-block and journal seize at test load.

14.2 Report total teeth wear for test completing the prescribed test time.

15. Precision and Bias[7]

15.1 The following criteria should be used for judging the acceptability of results (95 % confidence) (Note 8):

15.1.1 *Repeatability*—The difference between successive test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, and in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

22 % of the mean

15.1.2 *Reproducibility*—The difference between two, single and independent results, obtained by different operators working in different laboratories on identical test material would, in the long run, and in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

49 % of the mean

NOTE 8—The precision data were derived from results of cooperative test on reference fluids Blends *A* and *B*, covered in Table X1.1. The repeatability value shown, 17, is the largest of calculated values from all tests. The reproducibility value shown, 25, is the larger of the values obtained in the Series 1 tests, the only test in which identical fluids were tested by the cooperators.

15.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Method D2670 for measuring wear, no statement on bias is being made.

16. Keywords

16.1 pin and vee; tooth count; wear

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1135.

APPENDIX

(Nonmandatory Information)

X1. RESULTS OF COOPERATIVE TESTS

X1.1 The results of cooperative tests on reference fluid Blends A and B are presented in Table X1.1 and the results of cooperative tests on commercial cutting oils are presented in Table X1.2.

TABLE X1.1 Results of Cooperative Tests on Reference Fluids Blends A and B

Laboratory	Series 1 Tests Preblended fluids supplied to each cooperator. White Oil: American White Oil, No. 35, USP[A] Sulfur: Sulfur, Precipitated Powder, USP[B]								Series 2 Tests Fluids blended by each cooperator. White Oil, Same as in Series 1 Sulfur: Same as in Series 1								Series 3 Tests Fluids blended by each cooperator. White Oil, Various sources[C] Sulfur: Same as in Series 1							
	Blend A (0.1 % S), Teeth Wear				Blend B (0.2 % S), Teeth Wear				Blend A (0.1 % S), Teeth Wear				Blend B (0.2 % S), Teeth Wear				Blend A (0.1 % S), Teeth Wear				Blend B (0.2 % S), Teeth Wear			
	Single Tests			Avg.	Single Tests			Avg.	Single Tests			Avg.	Single Tests			Avg.	Single Tests			Avg.	Single Tests			Avg.
1	47	53	54	51	118	115	116	116	58	66	60	61	120	111	123	118	65	53	60	59	120	116	120	119
2	52	51	48	50	125	115	120	120	57	51	57	55	119	121	128	123	...	...	...	...	...	...	...	...
3	38	29	43	37	98	101	103	101	36	38	34	36	93	97	101	97	50	35	30	38	105	106	96	102
4	51	53	64	56	131	127	114	125	52	50	70	57	118	106	102	109	64	43	48	52	102	129	118	116
5	64	52	50	55	99	107	112	106	57	53	49	53	99	96	98	98	51	47	48	49	107	106	111	108
6	55	63	56	58	108	106	118	111	40	41	38	40	85	94	94	91	40	46	43	43	130	126	119	125
7	48	52	53	51	114	110	113	112	52	55	59	55	114	123	115	117	57	56	52	55	113	112	108	111
8	64	65	64	64	115	104	114	111	46	40	37	41	96	115	102	104	44	50	46	47	96	100	104	103
9	52	49	54	52	130	126	124	127	49	53	55	52	120	122	118	120	52	55	54	54	128	118	107	118
10	54	50	52	52	99[A]	123	124	115	47	54	43	48	129	110	115	118	50	51	51	51	112	114	126	117
11	54	55	56	55	124	123	112	120	74	69	66	70	135	128	129	131	61	58	62	60	122	127	129	126
12	47	44	50	47	120	121	120	120	60	53	54	56	115	112	109	112	58	52	58	56	113	107	109	110
13	65	80	63	69	133	119	129	127	84	63	66	71	130	128	137	132	66	64	62	64	120	126	124	123
14	56	58	54	56	128	117	117	121	55	57	70	61	104	111	109	108	51	56	49	52	106	95	105	103
Grand avg	54				117				52				114				52				114			
Min avg	37				101				36				91				38				102			
Max avg	69				127				71				132				64				126			
Repeatability	s = 4.7				s = 5.2				s = 5.8				s = 5.7				s = 5.0				s = 5.6			
	r = 14				r = 15				r = 17				r = 17				r = 15				r = 16			
Reproducibility	S = 7.9				S = 8.2				S = 10.6				S = 12.5				S = 7.4				S = 9.1			
	R = 24				R = 25				R = 32				R = 38				R = 22				R = 28			

[A] American Oil Co.
[B] J. T. Baker Chemical Co.
[C] Walgreen White Oil Extra Heavy; Atreol (Atlantic Richfield Co.); Squibb White Oil Extra Heavy; Primol 355 (Esso); Extra Heavy Liquid Petrolatum (Rochester Drug Corp.); Kaydol White Oil (Quad Chemical Corp.); Chevron No. 15 White Oil USP (Standard Oil Company of California); Drakeol White Oil No. 35 USP (Pennsylvania Refining Co.); Nujol (Plough, Inc.); Rexall White Oil Extra Heavy USP; Carnes 340 White Oil (Carnes Co.); Sohiopure USP 350 White Oil (Standard Oil of Ohio); Primol D White Oil (Imperial Oil Co.).
[D] Outlier, dropped from analysis.

TABLE X1.2 Results of Cooperative Tests on Commercial Cutting Oils[A]

Laboratory	TCK-17	TCK-19 Teeth Wear			TCK-21 Teeth Wear		
		Single Tests		Avg of 5 Tests	Single Tests		Avg of 5 Tests
		Min	Max		Min	Max	
A	Seizure	245	345	308	10	13	11
B	Seizure	[B]	[B]	345	9	10	10
C	Seizure	252	261	255	0	9	2
D	Seizure	294	333	318[C]	9	10	9[C]
E	Seizure	302	318	313[D]	7	9	8[D]
F	Seizure	[B]	[B]	295	[B]	[B]	2
G	Seizure	265	282	276	16	22	19
H	Seizure	313	340	333	7	10	8
I	Seizure	288	312	301	2	3	3[C]
J	Seizure	273	291	285	5	12	10
K	Seizure	300	324	312[C]	10	12	11[C]
L	Seizure	[B]	[B]	321	[B]	[B]	7
M	Seizure	297	319	308	5	7	6
N	Seizure	298	306	302	7	8	7
O	Seizure	306	327	317	6	17	11
Grand avg				305			8
Min avg				276			2
Max avg				345			19
Repeatability				s = 10			s = 1.7
				t = 30			r = 5.0

[A] TCK-17 = Straight Mineral Oil, 0.5 % natural sulfur, 125 to 150 SUS at 100 °F.
TCK-19 = Sulfurized Mineral Oil, 0.5 % natural sulfur, 0.8 % added sulfur, 125 to 150 SUS at 100 °F.
TCK-21 = Heavy Duty Cutting Oil, 0.5 % natural sulfur, 1.5 % added sulfur, 1.0 % added chlorine, 10.0 % added fatty material, 125 to 150 SUS at 100 °F.
[B] Not reported.
[C] 3 tests.
[D] 6 tests.
[E] 2 tests.
[F] Insufficient data for valid reproducibility calculations.