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Standard Test Methods for Measurement of Extreme Pressure Properties of Fluid Lubricants (Falex Pin and Vee Block Methods)[1]

This standard is issued under the fixed designation D3233; 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 These test methods cover two procedures for making a preliminary evaluation of the load-carrying properties of fluid lubricants by means of the Falex Pin and Vee Block Test Machine.

NOTE 1—Additional information can be found in Appendix X1 regarding coefficient of friction, load gauge conversions, and load gauge calibration curve.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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.*

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:*[2]

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

D2670 Test Method for Measuring Wear Properties of Fluid Lubricants (Falex Pin and Vee Block Method)

D2783 Test Method for Measurement of Extreme-Pressure Properties of Lubricating Fluids (Four-Ball Method)

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*—This 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*—that which 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 *true load failure value, n*—the true load at which the lubricant tested can no longer support the applied load resulting in either test pin or shear pin breakage, or inability to maintain or increase load.

3.1.4.1 *Discussion*—This value is also referred to as the limit of extreme pressure.

4. Summary of Test Methods

4.1 Both test methods consist of running a rotating steel journal at 290 rpm ± 10 rpm against two stationary V-blocks immersed in the lubricant sample. Load is applied to the V-blocks by a ratchet mechanism. In Test Method A (Note 1), increasing load is applied continuously. In Test Method B (Note 1), load is applied in 250 lbf (1112 N) increments with load maintained constant for 1 min at each load increment. In both methods the load-fail value obtained is the criteria for level of load-carrying properties. Both methods require calibration of the load gauge and reporting of test results as true (corrected) loads rather than actual gauge loads.

NOTE 2—Test Method A is referred to as the Falex Run-Up Test. Test Method B is referred to as the Falex One-Minute Step Test.

[1] These test methods are under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.L0.11 on Tribological Properties of Industrial Fluids and Lubricates.

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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.

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

5. Significance and Use

5.1 Evaluations by both test methods differentiate between fluids having low, medium, and high levels of extreme-pressure properties. The user should establish any correlation between results by either method and service performance.

NOTE 3—Relative ratings by both test methods on the fluids covered in Table X2.1 and Table X2.2 are in good general agreement with four-ball weld-point relative ratings obtained on these same fluids, covered in Test Method D2783.

6. Apparatus

6.1 *Falex Pin and Vee Block Test Machine,*[3] illustrated in Fig. 1, Fig. 2, and Fig. 3, fitted with 4500 lbf (20 000 N) gauge or 3000 lbf (13 350 N) gauge.

6.2 *Required for Calibration:*

6.2.1 *Allen Screw,* with attached 10 mm Brinnell ball.[4]

6.2.2 *Back-Up Plug.*[4]

6.2.3 *Standard Test Coupon,*[4]soft, annealed copper, Hb 37–39.

6.2.4 *Brinnell Microscope,* or equivalent.

6.2.5 *Timer,* graduated in seconds and minutes.

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

7. Reagents and Materials

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

7.2 *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} m to 2.5×10^{-7} m) rms.

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

7.4 *Solvent,* safe, nonfilming, nonchlorinated.

NOTE 4—Petroleum distillate and benzene, formerly used as solvents in this 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. Preparation of Apparatus

8.1 *Cleaning:*

8.1.1 Thoroughly clean the V-blocks, test journals, lubricant cup, and supports for V-blocks and test journals by washing, successively, with solvent selected in 7.4. Dry the V-blocks, test journals, lubricant cup, and supports by allowing the final solvent to evaporate in air.

8.1.2 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.

8.2 *Assembly:*

8.2.1 Insert the test journal into the test shaft and secure with a new brass locking pin, as shown in Fig. 1 and Fig. 3.

8.2.2 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. 3.

8.2.3 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. With highly viscous fluids, open the jaws slightly to ensure that the wear surfaces are covered with the lubricant.

[3] The Falex Pin and Vee Block Test Machine, available from the 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 instruction manual of machine for this information.

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

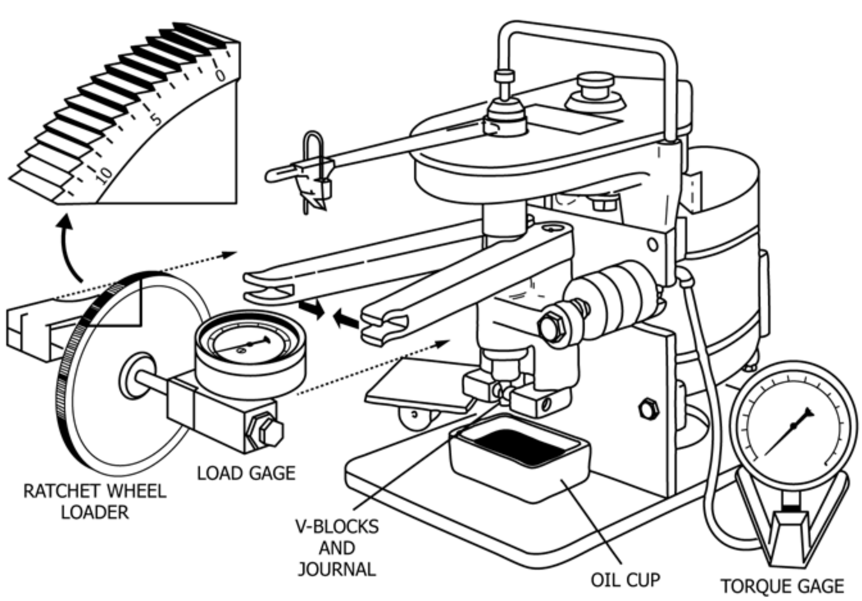


FIG. 1 Schematic Diagram of Falex Standard Pin and Vee Block Test Machine

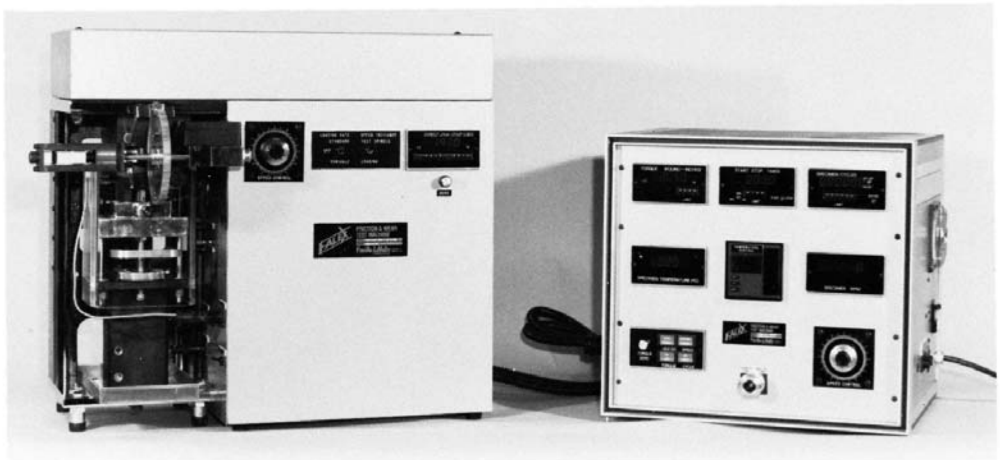


FIG. 2 Falex Digital Pin and Vee Block Test Machine

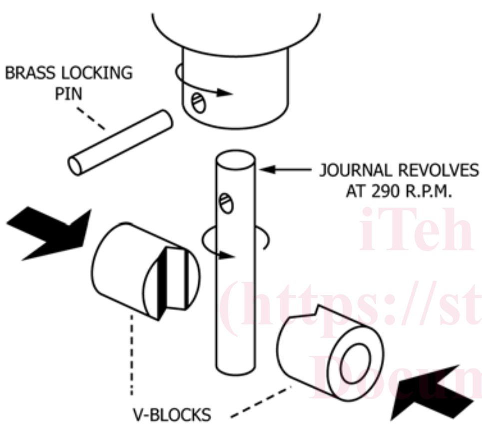


FIG. 3 Exploded View of V-Blocks and Journal Arrangement, Falex Pin and Vee Block Test Machines

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

TEST METHOD A

9. Run-In

9.1 The procedure, Section 10, requires a run-in at a 300 lbf (1334 N) true load (264 lbf direct load).

NOTE 5—Newer instruments use electronic calibration for true load and do not require calculation and plotting of true load versus gauge load curves. For older machines these calculations are in Appendix X3 and Appendix X4.

NOTE 6—A suitable reporting form for Test Methods A and B, and data obtained on one of the fluids by one of the cooperating laboratories, is shown in Table 1.

10. Procedure

10.1 *Run-In:*

10.1.1 Turn on "Heat Control" switch and heat test lubricant to 120 °F ± 5 °F (48.89 °C ± 3 °C); then turn off the switch.

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

10.1.3 Actuate the motor, engage the automatic loading ratchet, and increase the load to 300 lbf (1334 N) true load (264 lbf direct load). Disengage the loading ratchet, start the timer, and allow the machine to run at this loading for a 5 min run-in period.

NOTE 7—Maintain load at near constant by taking up the load manually or automatically by means of the ratchet wheel if necessary.

10.2 *Test:*

10.2.1 Re-engage the automatic loading ratchet and leave it engaged until failure (Note 8) and stop the motor at failure or at the highest indicated actual gauge load when no failure is obtained.

NOTE 8—Failure is indicated by (*a*) breakage of shear pin or test pin, or (*b*) inability to take up the load automatically by means of the ratchet wheel.

10.2.2 Record the true load failure, or, if no failure, the true load with a plus (+) sign after the true load value.

TEST METHOD B

11. Run-In and 250 lbf (1112 N) True Load Increments

11.1 The procedure, Section 12, requires a run-in at 300 lbf (1334 N) true load (264 lbf direct load), and testing at incremental 250 lbf (1112 N) true load (224 lbf direct load) over the range from 500 lbf to 4500 lbf (2224 N to 20 000 N) true load (412 lbf to 2885 lbf direct load). Record on a suitable reporting form, such as shown in Table 1.

12. Procedure

12.1 *Run-In*—Use the same procedure as prescribed in 10.1, Test Method A.

12.2 *Test:*

12.2.1 Re-engage the automatic loading ratchet and leave it engaged until 500 lbf (2224 N) true load (412 lbf direct load). Run for 1 min at this loading.

NOTE 9—Maintain load at near constant at this load and at subsequent incremental loading by taking up the load by means of the ratchet wheel when necessary.

NOTE 10—Keep the motor running after run-in and throughout subsequent loadings.

TABLE 1 Suggested Report Form, Test Methods A and B, Showing Data

Operator: Laboratory A
Test Sample: L-XI-1-2-E
TEST METHOD A
Run-In: 5 min at 300 lbf true load.

	True Load, lbf at Failure
Test No. 1	2100
Test No. 2	1925

TEST METHOD B
Run-In: 5 min at 300 lbf true load.

True Load, lbf	Test No. 1	Test No. 2
500	pass	pass
750	pass	pass
1000	pass	pass
1250	pass	pass
1500	pass	pass
1750	pass	fail
2000	pass	
2250	fail	
2500		
2750		
3000		
3250		
3500		
3750		
4000		
4250		
4500		

12.2.2 Increase load by 250 lbf (1112 N) true load (224 lbf direct load), running for 1 min at each increment loading. Record the load at which failure occurs (Note 12, Note 13). If no failure is obtained, record the last load run with a plus (+) sign after the value.

NOTE 11—Failure is indicated by (*a*) breakage of shear pin or test pin, or (*b*) inability to increase or maintain load by means of the ratchet wheel.

NOTE 12—If failure occurs during run-up between load increments, record the higher increment load as fail.

TEST METHODS A AND B

13. Report

13.1 Report the true load value at which failure occurred.

13.2 If no failure is obtained, report the last true load run, with a plus (+) sign after the value.

14. Precision and Bias

14.1 The precision of these test methods as determined by statistical examination of interlaboratory results is as follows (see Note 13):

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

Test Method A, 27 % of the mean
Test Method B, 24 % of the mean

14.1.2 *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, in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

Test Method A, 40 % of the mean
Test Method B, 43 % of the mean

14.2 *Bias*—The procedure in this test method has no bias because the value of the Falex Extreme Pressure Failure Load can be defined only in terms of a test method.

NOTE 13—The precision data were derived from results of cooperative tests on L-XI-1-2-A, B, C, D, and E, covered in Table X2.1 and Table X2.2. These are the same fluids used and described in Test Method D2783.

15. Keywords

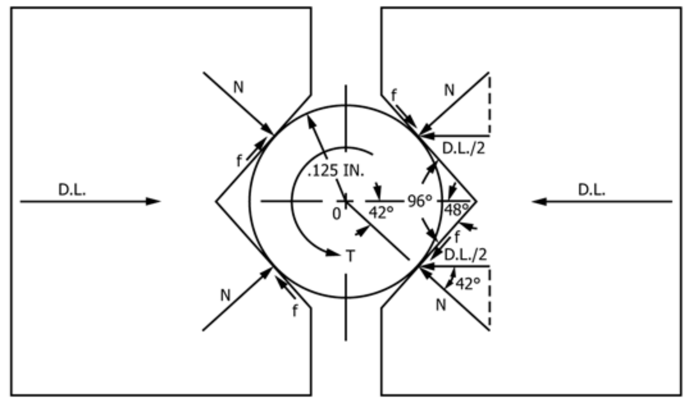
15.1 extreme pressure; Falex Pin and Vee Block; load-carrying; lubricant; wear

APPENDIXES

(Nonmandatory Information)

X1. COEFFICIENT OF FRICTION CALCULATION AND LOAD GAUGE CONVERSIONS

X1.1 See Figs. X1.1-X1.3.



D.L. = DIRECT LOAD, LBS.
T = TORQUE, IN. LBS.
N = NORMAL LOAD PER FACE, LBS.
u = COEFFICIENT OF FRICTION
M_O = SUMMATION OF MOMENTS ABOUT POINT "O"
f = FRICTION FORCE

$M_O = 0 = T-(4F \times 0.125)$
$f = T/(4 \times 0.125)$
$f = 2T$

$D.L./2 = N \times COS\ 42°$
$N = D.L./(2 \times COS\ 42°)$
$N = 0.672816\ D.L.$

$u = f/N = 2T/(0.672816 \times D.L.)$
$u = 2.9726\ T/D.L.$

FIG. X1.1 Falex #0 Pin and Vee Block Coefficient of Friction Calculation

(From Load Gage Calibration Curve 12/15/68)
FROM 800# OR 3000# GAGES TO 4500# GAGE

Direct Load 800# or 3000# Gage Reading	Equivalent Load on 4500# Reference Gage	Contact Load (Normal) per Vee Block Face	Brinell Impression Diameter (mm)
200	220	134.56	1.92
250	283	168.20	2.12
300	350	201.85	2.28
400	482	269.13	2.58
500	620	336.41	2.85
600	765	403.69	3.09
700	900	470.97	3.29
705	910	474.34	3.30
750	975	504.61	3.39
800	1050	538.25	3.49
1000	1355	672.82	3.85
1100	1500	740.10	4.00
1250	1750	841.02	4.24
1500	2140	1009.22	4.59
1700	2465	1143.79	4.84
1750	2540	1177.43	4.90
2000	2970	1345.63	5.20
2250	3400	1513.84	5.48
2500	3825	1682.04	5.73
2750	4280	1850.25	5.98
3000	4700	2018.45	6.20

4500# Reference Gage Reading	Equivalent Load on 800# or 3000# Gage	Contact Load (Normal) per Vee Block Face	Brinell Impression Diameter (mm)
250	224	150.71	2.01
300	264	177.62	2.16
350	300	201.85	2.28
500	412	277.20	2.62
750	590	396.96	3.06
910	705	474.34	3.30
1000	765	514.71	3.42
1250	930	625.72	3.73
1500	1100	740.10	4.00
1750	1250	841.02	4.24
2000	1410	948.67	4.47
2250	1555	1046.23	4.68
2500	1720	1157.24	4.88
2750	1870	1258.17	5.04
3000	2015	1355.73	5.22
3250	2155	1449.92	5.39
3500	2315	1557.57	5.53
3750	2450	1648.40	5.69
4000	2600	1749.32	5.82
4250	2740	1843.52	5.96
4500	2885	1941.08	6.09

FIG. X1.2 Contact Load (Normal) per Vee Block Face and Typical Falex Load Gauge Conversions