Designation: D909 – 16

Method 6012.6—Federal Test Method Standard No. 791b

Designation: 119/96

Standard Test Method for Supercharge Rating of Spark-Ignition Aviation Gasoline[1]

This standard is issued under the fixed designation D909; 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 laboratory test method covers the quantitative determination of supercharge ratings of spark-ignition aviation gasoline. The sample fuel is tested using a standardized single cylinder, four-stroke cycle, indirect injected, liquid cooled, CFR engine run in accordance with a defined set of operating conditions.

1.2 The supercharge rating is calculated by linear interpolation of the knock limited power of the sample compared to the knock limited power of bracketing reference fuel blends.

1.3 The rating scale covers the range from 85 octane number to *Iso*octane + 6.0 mL TEL/U.S. gal.

1.4 The values of operating conditions are stated in SI units and are considered standard. The values in parentheses are the historical inch-pound units. The standardized CFR engine measurements and reference fuel concentrations continue to be in historical units.

1.5 *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.* Specific precautionary statements are given in Annex A1.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1193 Specification for Reagent Water

D2268 Test Method for Analysis of High-Purity *n*-Heptane and *Iso*octane by Capillary Gas Chromatography

D3237 Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy

D3341 Test Method for Lead in Gasoline—Iodine Monochloride Method

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D5059 Test Methods for Lead in Gasoline by X-Ray Spectroscopy

E344 Terminology Relating to Thermometry and Hydrometry

E456 Terminology Relating to Quality and Statistics

2.2 *CFR Engine Manuals:*[3]

CFR F-4 Form 846 Supercharge Method Aviation Gasoline Rating Unit Installation Manual

CFR F-4 Form 893 Supercharge Method Aviation Gasoline Rating Unit Operation & Maintenance

2.3 *Energy Institute Standard:*[4]

IP 224/02 Determination of Low Lead Content of Light Petroleum Distillates by Dithizone Extraction and Colorimetric Method

2.4 *ASTM Adjuncts:*

Rating Data Sheet[5]

Reference Fuel Framework Graphs[6]

3. Terminology

3.1 *Definitions:*

3.1.1 *accepted reference value, n*—a value that serves as an agreed-upon reference for comparison, and which is derived as: *(1)* a theoretical or established value, based on scientific principles, or *(2)* an assigned or certified value, based on

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.01 on Combustion Characteristics.

Current edition approved Dec. 15, 2016. Published January 2017. Originally approved in 1958. Last previous edition approved in 2014 as D909 – 14. DOI: 10.1520/D0909-16.

[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] Available from CFR Engines, Inc., N8 W22577, Johnson Dr., Pewaukee, WI 53186.

[4] Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K.

[5] Available from ASTM International Headquarters. Order Adjunct No. ADJD090901. Original adjunct produced in 1953.

[6] Available from ASTM International Headquarters. Order Adjunct No. ADJD090902. Original adjunct produced in 1953.

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

experimental work of some national or international organization, or *(3)* a consensus or certified value, based on collaborative experimental work under the auspices of a scientific or engineering group. **E456**

3.1.1.1 *Discussion*—In the context of this test method, accepted reference value is understood to apply to the Supercharge and octane number ratings of specific reference materials determined empirically under reproducibility conditions by the National Exchange Group or another recognized exchange testing organization.

3.1.2 *check fuel, n—for quality control testing*, a spark-ignition aviation gasoline having supercharge rating ARV determined by the National Exchange Group.

3.1.3 *firing, n—for the CFR engine*, operation of the CFR engine with fuel and ignition.

3.1.4 *fuel-air ratio, n*—mass ratio of fuel to air in the mixture delivered to the combustion chamber.

3.1.5 *intake manifold pressure, n—for supercharged engines*, the positive pressure in the intake manifold.

3.1.6 *octane number, n*—for spark-ignition engine fuel, any one of several numerical indicators of resistance to knock obtained by comparison with reference fuels in standardized engine or vehicle tests. **D4175**

3.1.7 *supercharge rating, n*—the numerical rating of the knock resistance of a fuel obtained by comparison of its knock-limited power with that of primary reference fuel blends when both are tested in a standard CFR engine operating under the conditions specified in this test method.

3.1.8 *supercharge performance number, n*— a numerical value arbitrarily assigned to the supercharge ratings above 100 ON.

3.1.9 *primary reference fuels, n—for knock testing*, volumetrically proportioned mixtures of *iso*octane with *n*-heptane, or blends of tetraethyllead in *iso*octane which define the supercharge rating scale.

3.1.10 *standard knock intensity, n—for supercharge method knock testing*, trace or light knock as determined by ear.

3.1.10.1 *Discussion*—Light knock intensity is a level definitely above the commonly defined least audible "trace knock"; it is the softest knock that the operator can definitely and repeatedly recognize by ear although it may not be audible on every combustion cycle (intermittent knock). The variations in knock intensity can occasionally include loud knocks and very light knocks. These variations can also change with mixture ratio; the steadiest knock typically occurring in the vicinity of 0.09 fuel-air ratio.

3.1.11 *power curve, n—for supercharge method knock rating*, the characteristic power output, expressed as indicated mean effective pressure, over a range of fuel-air ratios from approximately 0.08 to approximately 0.12, when a supercharge test engine is operated on *iso*octane plus 6 ml of tetraethyllead per U.S. gallon under standard conditions at a constant intake manifold pressure of 40 in. of Hg (134.3 kPa) absolute.

3.1.12 *knock-limited power curve, n—for supercharge method knock rating*, the non-linear standard knock intensity characteristic of a primary reference fuel blend or a sample fuel, expressed as indicated mean effective pressures, over the range of fuel-air ratios from approximately 0.08 to approximately 0.12.

3.1.13 *reference fuel framework, n—for supercharge method knock rating*, the graphic representation of the knock-limited power curves for the specified primary reference fuel blends of *iso*octane + *n*-heptane and *iso*octane + TEL (mL/U.S. gal) that defines the expected indicated mean effective pressure versus fuel-air ratio characteristics for supercharge test engines operating properly under standardized conditions.

3.1.14 *mean effective pressure, n*—for internal-combustion engines, the steady state pressure which, if applied to the piston during the expansion stroke is a function of the measured power.[7]

3.1.15 *indicated mean effective pressure, n— for spark-ignition engines*, the measure of engine power developed in the engine cylinder or combustion chamber.

3.1.16 *brake mean effective pressure, n— for spark-ignition engines*, the measure of engine power at the output shaft as typically measured by an absorption dynamometer or brake.

3.1.17 *friction mean effective pressure, n— for spark-ignition engines*, the measure of the difference between IMEP and BMEP or power absorbed in mechanical friction and any auxiliaries.

3.1.18 *repeatability conditions, n*—conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time. **E456**

3.1.18.1 *Discussion*—In the context of this method, a short time interval is understood to be the time for two back-to-back ratings because of the length of time required for each rating.

3.1.19 *reproducibility conditions, n*—conditions where test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment. **E456**

3.2 *Abbreviations:*

3.2.1 *ARV*—accepted reference value

3.2.2 *ABDC*—after bottom dead center

3.2.3 *ATDC*—after top dead center

3.2.4 *BBDC*—before bottom dead center

3.2.5 *BMEP*—break mean effective pressure

3.2.6 *BTDC*—before top dead center

3.2.7 *C.R.*—compression ratio

3.2.8 *FMEP*—friction mean effective pressure

3.2.9 *IAT*—intake air temperature

3.2.10 *IMEP*—indicated mean effective pressure

3.2.11 *NEG*—National Exchange Group

3.2.12 *O.N.*—octane number

3.2.13 *PN*—performance number

[7] See *The Internal-Combustion Engine* by Taylor and Taylor, International Textbook Company, Scranton, PA.

3.2.14 *PRF*—primary reference fuel

3.2.15 *RTD*—resistance thermometer device (Terminology E344) platinum type

3.2.16 *TDC*—top dead center

3.2.17 *TEL*—tetraethyllead

3.2.18 *UV*—ultra violet

4. Summary of Test Method

4.1 The supercharge method rating of a fuel is determined by comparing the knock-limited power of the sample to those for bracketing blends of reference fuels under standard operating conditions. Testing is performed at fixed compression ratio by varying the intake manifold pressure and fuel flow rate, and measuring IMEP at a minimum of six points to define the mixture response curves, IMEP versus fuel-air ratio, for the sample and reference fuels. The knock-limited power for the sample is bracketed between those for two adjacent reference fuels, and the rating for the sample is calculated by interpolation of the IMEP at the fuel-air ratio which produces maximum power (IMEP) for the lower bracketing reference fuel.

5. Significance and Use

5.1 Supercharge method ratings can provide an indication of the rich-mixture antiknock performance of aviation gasoline in aviation piston engines.

5.2 Supercharge method ratings are used by petroleum refiners and marketers and in commerce as a primary specification measurement to insure proper matching of fuel antiknock quality and engine requirement.

5.3 Supercharge method ratings may be used by aviation engine and aircraft manufacturers as a specification measurement related to matching of fuels and engines.

6. Interferences

6.1 *Precaution*—Avoid exposure of sample fuels to sunlight or fluorescent lamp UV emissions to minimize induced chemical reactions that can affect octane number ratings.[8]

6.1.1 Exposure of these fuels to UV wavelengths shorter than 550 nm for a short period of time can significantly affect octane number ratings.

6.2 Electrical power subject to transient voltage or frequency surges or distortion can alter CFR engine operating conditions or knock measuring instrumentation performance and thus affect the supercharge rating obtained for sample fuels.

7. Apparatus

7.1 *Engine Equipment*[9,10]—This test method uses a single cylinder, CFR engine that consists of standard components as follows: crankcase, a cylinder/clamping sleeve, a thermal siphon recirculating jacket coolant system, an intake air system with controlled temperature and pressure equipment, electrical controls, and a suitable exhaust pipe. The engine flywheel is connected to a special electric dynamometer utilized to both start the engine and as a means to absorb power at constant speed when combustion is occurring (engine firing). See Fig. 1 and Table 1.

7.1.1 The CFR Engines, Inc. designation for the apparatus required for this test method is Model CFR F-4 Supercharge Method Octane Rating Unit.

7.2 *Auxiliary Equipment*—A number of components and devices have been developed to integrate the basic engine equipment into complete laboratory measurement system.

8. Reference Materials

8.1 *Cylinder Jacket Coolant*—Ethylene Glycol shall be used in the cylinder jacket with the required amount of water to obtain a boiling temperature of 191 °C ± 3 °C (375 °F ± 5 °F). (**Warning—**Ethylene glycol based antifreeze is poisonous and may be harmful or fatal if inhaled or swallowed. See Annex A1.)

8.1.1 Water shall be understood to mean reagent water conforming to Type IV of Specification D1193.

8.2 *Engine Crankcase Lubricating Oil*—An SAE 50 viscosity grade oil meeting the current API service classification for spark-ignition engines shall be used. It shall contain a detergent additive and have a kinematic viscosity of 16.77 mm^2/s to 25.0 mm^2/s (cSt) at 100 °C (212 °F) and a viscosity index of not less than 85. Oils containing viscosity index improvers shall not be used. Multigraded oils shall not be used. (**Warning—**Lubricating oil is combustible and its vapor is harmful. See Annex A1.)

8.3 *PRF,*[10,11] *iso*octane (2,2,4-trimethylpentane) and *n*-heptane meeting the specifications in Table 2. (**Warning—**Primary reference fuel is flammable and its vapors are harmful. Vapors may cause flash fire. See Annex A1.)

8.4 *Tetraethyllead* concentrated antiknock mixture (aviation mix) containing not less than 61.0 weight % of tetraethyllead and sufficient ethylene dibromide to provide two bromine atoms per atom of lead. The balance of the antiknock mixture shall be a suitable oxidation inhibitor, an oil-soluble dye to provide a distinctive color for identification and kerosene.

8.4.1 *Temperature Corrections*—If the temperature of the fuel is below that of the TEL, the quantity of the TEL is increased and vice versa as calculated by the coefficient of expansion, obtained from the supplier, of concentrated TEL.

8.4.2 *Analysis for TEL*—It is recommended that each blend of fuel, particularly drum blends, be analyzed for lead content in accordance with standard test methods (see Test Methods D3237, D3341, and D5059.)

8.5 Iso*octane+6.0 mL TEL*—a mixture of *iso*octane and aviation mix tetraethyllead that contains 6.00 mL ± 0.05 mL of

[8] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1502.

[9] The sole source of supply of the engine equipment and instrumentation known to the committee at this time is CFR Engines, Inc., N8 W22577, Johnson Dr., Pewaukee, WI 53186.

[10] 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.

[11] Primary Reference Fuels are currently available from Chevron Phillips Chemical Company LP., 1301 McKinney, Suite 2130, Houston, TX 77010–3030.

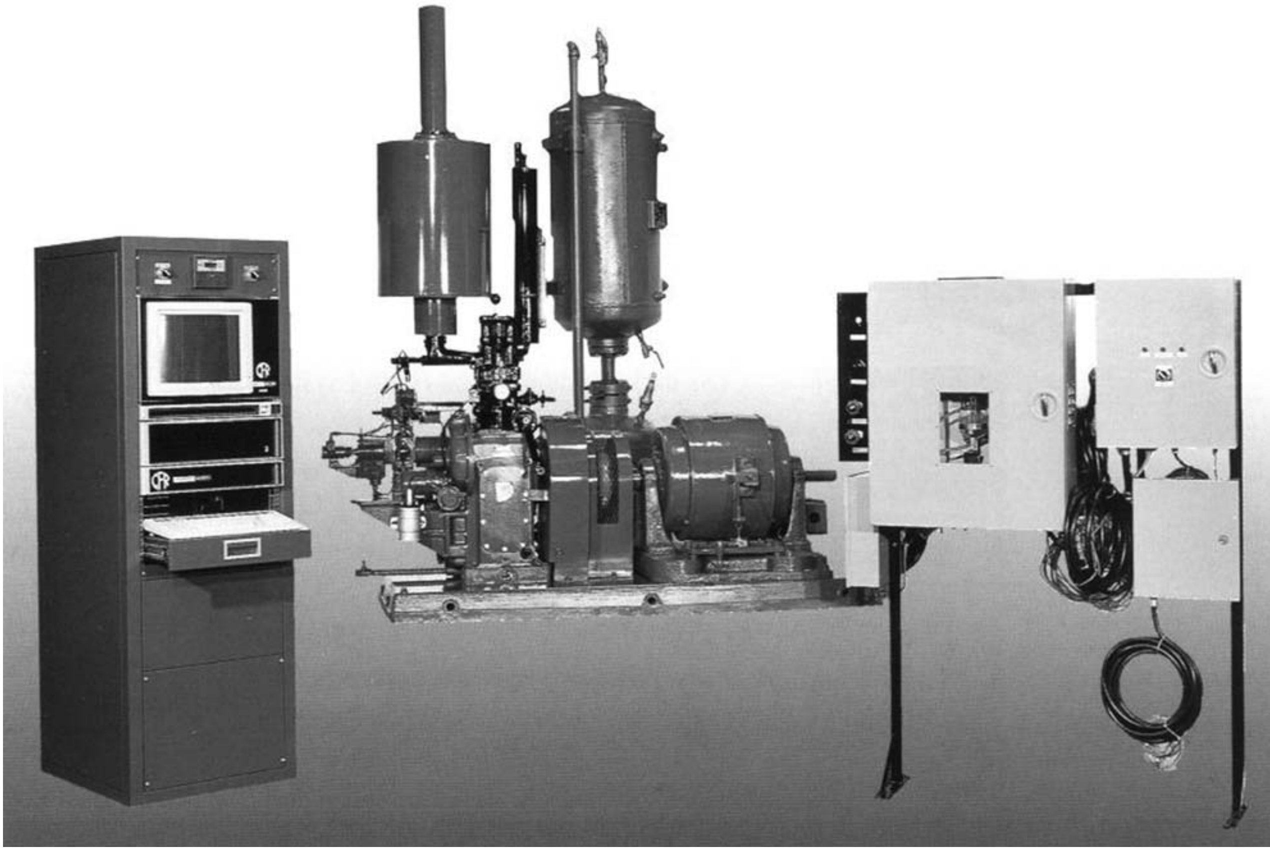


FIG. 1 Supercharge Unit

tetraethyllead per U.S. gallon (1.68 g ± 0.014 g of elemental lead per litre) which may be blended with *iso*octane to prepare reference fuel blends.

8.5.1 Blend ratios for diluting *iso*octane+6.0 mL TEL with *iso*octane to prepare the reference fuel compositions that are employed in this test method are shown in Table 3.

8.6 *Aviation Check Fuel*—A typical aviation gasoline for which the Supercharge Rating ARV has been determined by the NEG that is used for checking engine performance. This fuel (Aviation Grade 100LL) and supporting statistical data from the ARV determination program are available from the supplier.[10,12] (**Warning—**Check Fuel is flammable and its vapors are harmful. Vapors may cause flash fire. See Annex A1.)

9. Sampling

9.1 Collect samples in accordance with Practices D4057.

9.2 *Protection from Light*—Collect and store sample fuels in an opaque container, such as a dark brown glass bottle, metal can, or a minimally reactive plastic container to minimize exposure to UV emissions from sources such as sunlight or fluorescent lamps.

10. Basic Engine and Instrumentation Settings and Standard Operating Conditions

10.1 *Installation of Engine Equipment and Instrumentation*—Installation of the engine and instrumentation requires placement of the engine on a suitable foundation and hook-up of all utilities. Engineering and technical support for this function is required, and the user shall be responsible to comply with all local and national codes and installation requirements.

10.1.1 Proper operation of the CFR engine requires assembly of a number of engine components and adjustment of a series of engine variables to prescribed specifications. Some of these settings are established by component specifications, others are established at the time of engine assembly or after overhaul, and still others are engine running conditions that must be observed or determined by the operator during the testing process.

10.2 *Conditions Based on Component Specifications:*

10.2.1 *Engine Speed,* 1800 r/min ± 45 r/min, under both firing and non-firing conditions. The maximum variation throughout a test shall not exceed 45 r/min, exclusive of friction measurement.

10.2.2 *Compression Ratio,* 7.0 to 1, fixed by adjustment of the clearance volume to 108 mL ± 0.5 mL on cylinders of standard bore by the bench tilt procedure.

[12] The sole source of supply of the aviation check fuel known to the committee at this time is Chevron Phillips Chemical Company LP., 1301 McKinney, Suite 2130, Houston, TX 77010–3030.

TABLE 1 General Rating Unit Characteristics and Information

Cylinder	7.0 : 1 C.R. - Fixed
Standard Bore, in.	3.25
Stroke, in.	4.5
Displacement, cu in.	37.33
Valve gear	enclosed
Rocker arm bushing	needle
Intake valve	plain with rotator
Exhaust valve	sodium cooled with rotator
Valve felts	both valves
Piston	aluminum
Compression rings:	
Type	keystone
Number required	3
Oil control rings:	
Type	keystone
Number required	2
Crankcase	CFR48
Rotating balance weights	CFR48, non-leaded version
Camshaft, deg overlap	30
Ignition	capacitor discharge
Spark plug	
Type	Aviation
Gasket	solid Copper
Humidity control	compressed air
Fuel system	manifold injection
Pump timing	inlet port closes at 50 ± 5 deg ATDC, intake stroke
Injection pump:	
Plunger diameter, mm	8
Lift at port closure, in.	0.100 to 0.116
Injector	Pintle type
Injector line	
Bore, in.	1/8
Length, in.	20 ± 2

TABLE 2 Specifications for ASTM Knock Test Reference Fuels

	ASTM *Iso*octane	ASTM *n*-Heptane	Test Method
*Iso*octane, %	not less than 99.75	not greater than 0.10	ASTM D2268
n-Heptane, %	not greater than 0.10	not less than 99.75	ASTM D2268
Lead Content, g/gal	not greater than 0.002	not greater than 0.002	IP 224/02

TABLE 3 Blends of *Iso*octane+6.0 mL TEL per U.S. Gallon

mL *Iso*octane + 6.0 mL TEL per U.S. gallon	mL *Iso*octane	mL TEL per U.S. gallon
0	4800	0.00
400	4400	0.50
1000	3800	1.25
1600	3200	2.00
2400	2400	3.00
3200	1600	4.00
4800	0	6.00

10.2.3 *Indexing Flywheel to TDC*—With the piston at the highest point of travel in the cylinder, set the flywheel pointer mark in alignment with the 0° mark on the flywheel in accordance with the instructions of the manufacturer.

10.2.4 *Valve Timing*—The engine uses a four-stroke cycle with two crankshaft revolutions for each complete combustion cycle. The two critical valve events are those that occur near TDC; intake valve opening and exhaust valve closing.

10.2.4.1 Intake valve opening shall occur at 15.0° ± 2.5° BTDC with closing at 50° ABDC on one revolution of the crankshaft and flywheel.

10.2.4.2 Exhaust valve opening shall occur 50° BBDC on the second revolution of the crankshaft and flywheel, with closing at 15.0° ± 2.5° ATDC on the next revolution of the crankshaft and flywheel.

10.2.5 *Valve Lift*—Intake and exhaust cam lobe contours, while different in shape, shall have a contour rise of 8.00 mm to 8.25 mm (0.315 in. to 0.325 in.) from the base circle to the top of the lobe.

10.3 *Assembly Settings and Operating Conditions:*

10.3.1 *Spark Advance,* constant, 45°.

10.3.2 *Spark-Plug Gap,* 0.51 mm ± 0.13 mm (0.020 in. ± 0.003 in.).

10.3.3 *Ignition Settings:*

10.3.3.1 Breakerless ignition system basic setting for transducer to rotor (vane) gap is 0.08 mm to 0.13 mm (0.003 in. to 0.005 in.).

10.3.4 *Valve Clearances,* 0.20 mm ± 0.03 mm (0.008 in. ± 0.001 in.) for the intake, 0.25 mm ± 0.03 mm (0.010 in. ± 0.001 in.) for the exhaust, measured with the engine hot and running at equilibrium under standard operating conditions on a reference fuel of 100 octane number at the fuel-air ratio for maximum power and an absolute manifold pressure of 101.6 kPa (30 in. Hg).

10.3.5 *Oil Pressure,* 0.41 MPa ± 0.03 MPa (60 psi ± 5 psi) gage in the oil gallery leading to the crankshaft bearings.

10.3.6 *Oil Temperature,* 74 °C ± 3 °C (165 °F ± 5 °F) at the entrance to the oil gallery.

10.3.6.1 *Engine Crankcase Lubricating Oil Level:*

(1) Engine Stopped and Cold—Oil added to the crankcase so that the level is near the top of the sight glass will typically provide the controlling engine running and hot operating level.

(2) Engine Running and Hot—Oil level shall be approximately mid-position in the crankcase oil sight glass.

10.3.7 *Coolant Temperature,* 191 °C ± 3 °C (375 °F ± 5 °F) in the top of the coolant return line from the condenser to the cylinder.

10.3.8 *Fuel Pump Pressure,* 0.10 MPa ± 0.01 MPa (15 psi ± 2 psi) in the gallery.

10.3.9 *Fuel Injector Opening Pressure,* 8.2 MPa ± 0.69 MPa (1200 psi ± 100 psi) for Bosch nozzle; 9.9 MPa ± 0.34 MPa (1450 psi ± 50 psi) for Ex-Cell-O nozzle.

10.3.10 *Fuel Injector Timing*—The pump plunger must close the fuel-inlet port at 50° ± 5° ATDC on the intake stroke.

10.3.11 *Air Pressure,* 0.37 MPa ± 0.003 MPa (54.4 psi ± 0.5 psi) absolute at the upstream flange tap of the air flow meter.

10.3.12 *Air Temperatures,* 52 °C ± 3 °C (125 °F ± 5 °F) in the downstream leg of the air-flow meter and 107 °C ± 3 °C (225 °F ± 5 °F) in the intake manifold surge tank.

10.3.13 *Intake Air Humidity,* 0.00997 kg of water/kg (max) (70 grains of water/lb) of dry air.

10.3.14 *Standard Knock Intensity,* light knock as determined by ear. In determining the light knock point, it is advisable to adjust first to a fairly heavy knock by varying either the manifold pressure or the fuel flow, return to knock-free operation, and finally adjust to the light-knock conditions. Light knock intensity is a level definitely above the commonly defined least audible "trace knock;" it is the least knock that the operator can definitely and repeatedly recognize by ear.

10.3.15 *Satisfactory Engine Condition*—The engine should cease firing instantly when the ignition is turned off. If it does not, operating conditions are unsatisfactory. Examine the engine for defects, particularly for combustion chamber and spark plug deposits, and remedy such conditions before rating fuels.

10.3.16 *Crankcase Internal Pressure*—As measured by a gage or manometer connected to an opening to the inside of the crankcase through a snubber orifice to minimize pulsations, the pressure shall be less than zero (a vacuum) and is typically from 25 mm to 150 mm (1 in. to 6 in.) of water less than atmospheric pressure. Vacuum shall not exceed 255 mm (10 in.) of water.

10.3.17 *Exhaust Back Pressure*—As measured by a gage or manometer connected to an opening in the exhaust surge tank or main exhaust stack through a snubber orifice to minimize pulsations, the static pressure should be as low as possible, but shall not create a vacuum nor exceed 255 mm (10 in.) of water differential in excess of atmospheric pressure.

10.3.18 *Exhaust and Crankcase Breather System Resonance*—The exhaust and crankcase breather piping systems shall have sufficient internal volume and length dimensions such that gas resonance does not result.

10.3.19 *Valve Stem Lubrication*—Positive pressure lubrication to the rocker arms is provided. Felt washers are used on the valve stems. A valve and rocker arm cover ensures an oil mist around the valves.

10.3.20 *Cylinder Jacket Coolant Level:*

10.3.20.1 *Engine Stopped and Cold*—Treated water/coolant added to the cooling condenser-cylinder jacket to a level just observable in the bottom of the condenser sight glass will typically provide the controlling engine running and hot operating level.

10.3.20.2 *Engine Running and Hot*—Coolant level in the condenser sight glass shall be within ±1 cm (±0.4 in.) of the LEVEL HOT mark on the coolant condenser.

10.3.21 *Basic Rocker Arm Carrier Adjustment:*

10.3.21.1 *Basic Rocker Arm Carrier Support Setting*—Each rocker arm carrier support shall be threaded into the cylinder so that the distance between the machined surface of the valve tray and the underside of the fork is 19 mm (¾ in.).

10.3.21.2 *Basic Rocker Arm Carrier Setting*—With the cylinder positioned so that the distance between the underside of the cylinder and the top of the clamping sleeve is approximately 16 mm (⅝ in.), the rocker arm carrier shall be set horizontal before tightening the bolts that fasten the long carrier support to the clamping sleeve.

10.3.21.3 *Basic Rocker Arm Setting*—With the engine on TDC on the compression stroke, and the rocker arm carrier set at the basic setting, set the valve adjusting screw to approximately the mid-position in each rocker arm. Then adjust the length of the push rods so that the rocker arms shall be in the horizontal position.

11. Engine Fit-for-Use Qualification

11.1 Before conducting either of the fit-for-use tests, operate the engine on an aviation gasoline or reference fuel blend in compliance with the basic engine and instrumentation settings and standard operating conditions for approximately one hour to bring the unit to temperature equilibrium.

TABLE 4 Composition for ASTM Knock Test Reference Fuels

ASTM *Iso*octane, vol %	ASTM *n*-Heptane, vol %	Tetraethyllead in *Iso*octane, mL/U.S. gal
85	15	...
90	10	...
95	5	...
100	...	...
100	...	0.50 ± 0.05
100	...	1.25 ± 0.05
100	...	2.00 ± 0.05
100	...	3.00 ± 0.05
100	...	4.00 ± 0.05
100	...	6.00 ± 0.05

11.2 *Fit-for-Use Qualification after Maintenance*—After each top overhaul and whenever any maintenance has been performed other than coolant or lubricant fluid level adjustment or spark plug replacement, the engine shall be qualified as fit-for-use by establishing its power curve.

11.2.1 Test the reference fuel blend of *iso*octane + 6.0 mL of TEL per U.S. gallon under standard operating conditions at a constant manifold pressure of 135.4 kPa (40 in. Hg) while varying the fuel flow from lean to rich to cover the fuel-air ratio range from approximately 0.07 to approximately 0.10.

11.2.2 Obtain at least five IMEP v fuel-air ratio data pairs. Plot the data and fit a smooth curve to determine the maximum IMEP.

11.2.3 The engine is fit-for-use if the maximum IMEP of the power curve is 164 ± 5 IMEP. (See Fig. A2.1 and Fig. A2.5 for expected power curve) and the observed FMEP is no more than 3.0 psi from the expected value for the manifold pressure (see Fig. A2.3).

11.3 *Fit-for-Use Test for Each Sample*—The fit-for-use condition of the engine shall be verified with every sample rating by conformance with the following limits:

11.3.1 For every sample rating, the IMEP values determined for the reference fuels at any fuel-air ratio from approximately 0.09 to approximately 0.12 shall be within ±5 % of the value shown in the reference fuel framework at that fuel-air ratio.

11.3.2 For every sample rating, at any fuel-air ratio from approximately 0.09 to approximately 0.12, the spread (difference) between the knock-limited power curves for the bracketing reference fuels shall be within ±30 % of the spread shown in the reference fuel framework at that fuel-air ratio.

12. Rating Procedure

12.1 The Supercharge rating of the sample fuel is determined by comparison of its knock-limited power curve to the knock-limited power curves of two bracketing reference fuels.

12.1.1 The compositions of the reference fuel blends that are employed for this method are shown in Table 4.

12.2 The knock-limited power curve of either a sample or reference fuel is determined by measuring the power output (IMEP) of the engine as a function of fuel-air ratio.

12.2.1 The accepted knock-limited power curves for the set of reference fuels specified for this test method are plotted in Fig. A2.2.

12.2.2 The curves of the reference fuel framework (Fig. A2.2) were adopted with the initial issue of the test method and are used as criteria for determining acceptable limits of engine performance for every sample rating.

12.3 A minimum of six points (pairs of IMEP and fuel-air ratio data) are required to define each of the three knock limited power curves (one for the sample fuel and two for the bracketing reference fuels) needed to determine a sample fuel rating. See Fig. A2.4 as an example of a fuel rating.

12.3.1 The IMEP points must be determined in the range of fuel-air ratios from 0.75 to 1.30 and meet the following criteria:

12.3.2 The measured IMEP values must pass through a maximum value.

12.3.2.1 The maximum IMEP value must be demonstrated by obtaining at least one measured IMEP at a fuel-air ratio greater than that of the maximum IMEP.

NOTE 1—It has been found that some experimental aviation gasoline compositions do not reach a maximum IMEP value at fuel-air ratios below 1.3. However, Supercharge ratings for these samples may still be calculated by interpolation of the bracketing reference fuels as described below.

12.3.3 At least one IMEP point must be obtained at a fuel-air ratio between 0.75 and 0.90.

12.3.4 At least four IMEP points must be obtained at fuel-air ratios less than that of the maximum IMEP.

12.4 *Engine Operation for Obtaining Knock-Limited Power Curve:*

12.4.1 Operate the engine on an aviation gasoline or reference fuel blend in compliance with the basic engine and instrumentation settings and standard operating conditions for approximately one hour to bring the unit to temperature equilibrium.

12.4.2 Purge the warm-up fuel from the pump and lines and switch to the first fuel (sample or reference fuel) to be tested.

12.4.3 Starting at a low manifold pressure, adjust the manifold pressure and fuel flow rate to establish standard knock intensity at a fuel-air ratio between 0.75 and 0.90.

12.4.4 After establishing standard knock intensity, allow conditions to stabilize and obtain measurements of the fuel and air consumption rates, BMEP and FMEP.

12.4.4.1 Various techniques for making the adjustments to manifold pressure and fuel flow have been utilized, depending on equipment configuration (extent of computerized control and measurement) and operator preference. Appendix X1 contains an example of an acceptable technique for manually establishing standard knock intensity and obtaining the related data.

12.4.5 Calculate IMEP and plot the result as the ordinate on a Reference Fuel Framework (Fig. A2.2) with the fuel-air ratio as the abscissa.

NOTE 2—It is recommended that the individual IMEP/fuel-air ratio points each be plotted when determined. This allows for immediate evaluation of the reference fuel data points for compliance with the fit-for-use criteria.

12.4.6 Make additional measurements of IMEP and fuel-air ratio data at various manifold pressures until the requirements for defining the knock-limited power curve of the fuel have been met.

12.4.7 Purge the first fuel from the pump and lines, switch to the next fuel and repeat the process to define the knock limited power curve for the two remaining fuels.

13. Calculation of Supercharge Rating

13.1 Obtain the knock limited power curve for each fuel by fitting a smooth curve to the set of IMEP/fuel-air ratio points that were determined for the fuel.

13.1.1 This task has historically been accomplished by manually applying a French curve or flexible ruler to the data points.

13.1.2 Use of peak-fitting computer software is currently recommended to obtain the best curve fit to the data.

NOTE 3—The Lorentzian peak function has been successfully applied using commercially available peak-fitting software to test data generated by the Aviation NEG in recent years.

13.1.3 Determine the fuel-air ratio that corresponds to the maximum IMEP value on the knock-limited power curve of the lower bracketing reference fuel.

13.1.4 Evaluate the knock-limited power curves of the sample and upper bracketing reference fuel to determine the IMEP values of these fuels at the same fuel-air ratio as that of the maximum IMEP for the lower bracketing reference fuel.

13.1.5 Calculate the Supercharge rating of the sample by interpolation of these IMEP values using the corresponding ratings of the bracketing reference fuels, as follows:

For reference fuel pairs of 100 and lower octane number:

$$ON_{SAMPLE} = \left[\frac{(IMEP_{SAMPLE} - IMEP_{LOBRF})}{(IMEP_{HIBRF} - IMEP_{LOBRF})}\right] \times [(ON_{HIBRF} - ON_{LOBRF})] + ON_{LOBRF}$$

For reference fuel pairs at or above 100 octane number:

$$mLTEL_{SAMPLE} = \left[\frac{(IMEP_{SAMPLE} - IMEP_{LOBRF})}{(IMEP_{HIBRF} - IMEP_{LOBRF})}\right] \times [(mLTEL_{HIBRF} - mLTEL_{LOBRF})] + mLTEL_{LOBRF}$$

where:

ON_{SAMPLE} = supercharge rating of a sample fuel at or below 100 octane number,

$mLTEL_{SAMPLE}$ = supercharge rating of a sample fuel greater than 100 octane number,

$IMEP_{SAMPLE}$ = IMEP value on the knock-limited power curve of the sample fuel at the same fuel-air ratio as that of the maximum IMEP of the knock-limited power curve of the lower bracketing reference fuel,

$IMEP_{LOBRF}$ = maximum IMEP of the knock-limited power curve for the lower bracketing reference fuel,

$IMEP_{HIBRF}$ = IMEP value on the knock-limited power curve of the upper bracketing reference fuel at the same fuel-air ratio as that of the maximum IMEP of the knock-limited power curve of the lower bracketing reference fuel,
ON_{LOBRF} = octane number of the lower bracketing reference fuel,
ON_{HIBRF} = octane number of the upper bracketing reference fuel,
$mLTEL_{LOBRF}$ = mL TEL per U.S. gallon of the lower bracketing reference fuel, and
$mLTEL_{HIBRF}$ = mL TEL per U.S. gallon of the upper bracketing reference fuel.

NOTE 4—If the blends of TEL in *iso*octane were analyzed for tetraethyl lead content, the determined values for mL TEL may be substituted in the formulas above.

13.1.5.1 In rare instances, the knock-limited power curves of the sample fuel and/or one of the reference fuels are displaced along the horizontal fuel-air axis in such a manner that vertical interpolation of the IMEP data is not possible. In these instances, apply the above interpolation formula with the following modifications: set $IMEP_{SAMPLE}$ equal to the value at the intersection of the sample fuel knock-limited power curve with a straight line that connects the maximum IMEP values of the knock-limited power curves for the two bracketing reference fuels, and set $IMEP_{HIIBRF}$ equal to the maximum IMEP of the knock-limited power curve for the upper bracketing reference fuel.

14. Report

14.1 Report ratings below 100 octane number to the nearest integer. When the calculated result ends with exactly 0.5, round to the nearest even number; for example, report 91.50 as 92, not 91.

14.1.1 Convert octane number to performance number, if required, using Table A2.1.

14.2 Report ratings above 100 octane number in units of mL TEL per U.S. gallon rounded to the nearest 0.01 mL TEL/gal.

14.2.1 Convert mLTEL per U.S. gallon in *iso*octane ratings to performance numbers, if required, using Table A2.2.

15. Precision and Bias

15.1 *Precision:*

15.1.1 *Repeatability*—In the range from 1.25 mL to 2.00 mL TEL/U.S. gal (129.6 to 138.4 performance number), the difference between two test results obtained by the same operator with the same engine under constant operating conditions on identical test specimens within the same day would, in the long run, in the normal and correct operation of the test method, exceed 0.145 mL TEL/U.S. gal in only one case in twenty. Since the relationship between mL TEL/U.S. gal and performance number is not linear, representative repeatability statistics in units of performance number are tabulated in Table 5.

TABLE 5 Repeatability and Reproducibility Values

Supercharge Rating		Repeatability		Reproducibility	
ML TEL/US gal	PN	ML TEL/US gal	PN	ML TEL/US gal	PN
1.25	129.6	0.14	2.0	0.23	3.2
1.30	130.2	0.14	1.9	0.26	3.6
1.40	131.6	0.14	1.8	0.32	4.2
1.50	132.9	0.14	1.7	0.39	5.0
1.60	134.1	0.14	1.7	0.48	5.6
1.70	135.2	0.14	1.6	0.57	6.6
1.80	136.3	0.14	1.5	0.68	7.3
1.90	137.4	0.14	1.5	0.80	8.2
2.00	138.4	0.14	1.3	0.93	9.2

15.1.2 *Reproducibility*—In the range from 1.25 mL to 2.00 mL TEL/U.S. gal (129.6 to 138.4 performance number), the difference between two single and independent test results obtained by different operators in different laboratories on identical test specimens would, in the long run, in the normal and correct operation of the test method, exceed the value of R in only one case in twenty, where R is defined by the equation:

$$R = 0.116x^3 \quad (1)$$

where:

x = the average of the two test results in mL TEL/U.S. gal.

15.1.2.1 The reproducibility values in Table 5 exemplify the values of R over the applicable range. Since reproducibility varies with level and the relationship between mL TEL and performance number is not linear, reproducibility limits in units of performance number are also tabulated in Table 5.

15.1.3 *Interlaboratory Test Program*—The above precision statements are based on test results obtained by the ASTM Aviation National Exchange Group from 1988 to 1998. During this period, four aviation gasoline samples having supercharge ratings in the range from 1.25 mL to 2.00 mL TEL/U.S. gal were tested each year by 15 to 23 participating laboratories. A report of the data and analysis used to establish the precision statements is available as a research report.[13]

15.1.4 *Precision Below 1.25 mL TEL/U.S. Gal and Above 2.00 mL TEL/U.S. Gal*—There is not sufficient data to establish the precision of this test method for samples having supercharge ratings below 1.25 mL TEL/U.S. gal or above 2.00 mL TEL/U.S. gal.

15.2 *Bias*—This test method has no bias because the supercharge rating of aviation gasoline is defined only in terms of this test method.

[13] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1467. Contact ASTM Customer Service at service@astm.org.

ANNEXES

(Mandatory Information)

A1. HAZARDS INFORMATION

A1.1 *Introduction*:

A1.1.1 In the performance of this test method there are hazards to personnel. These are indicated in the text. The classification of the hazard or **Warning**, is noted with the appropriate key words of definition. For more detailed information regarding the hazards, refer to the appropriate Material Safety Data Sheet (MSDS) for each of the applicable substances to establish risks, proper handling, and safety precautions.

A1.2 (**Warning—**Combustible. Vapor Harmful.)

A1.2.1 *Applicable Substances:*
A1.2.1.1 Engine crankcase lubricating oil

A1.3 (**Warning—**Flammable. Vapors are harmful if inhaled. Vapors may cause flash fire.)

A1.3.1 *Applicable Substances:*
A1.3.1.1 Aviation gasoline
A1.3.1.2 Aviation Check Fuel
A1.3.1.3 Fuel blend
A1.3.1.4 *Iso*octane
A1.3.1.5 Leaded *iso*octane PRF
A1.3.1.6 *n*-heptane
A1.3.1.7 Oxygenate
A1.3.1.8 PRF
A1.3.1.9 PRF blend
A1.3.1.10 Reference fuel
A1.3.1.11 Sample fuel
A1.3.1.12 Spark-ignition engine fuel

A1.4 (**Warning—**Poison. May be harmful or fatal if inhaled or swallowed.)

A1.4.1 *Applicable Substances:*
A1.4.1.1 Antifreeze mixture
A1.4.1.2 Aviation mix tetraethyllead antiknock compound
A1.4.1.3 Dilute tetraethyllead
A1.4.1.4 Glycol based antifreeze
A1.4.1.5 Halogenated refrigerant
A1.4.1.6 Halogenated solvents

A2. REFERENCE TABLES AND FRAMEWORKS

TABLE A2.1 ASTM Conversion of Octane Numbers to Performance Numbers

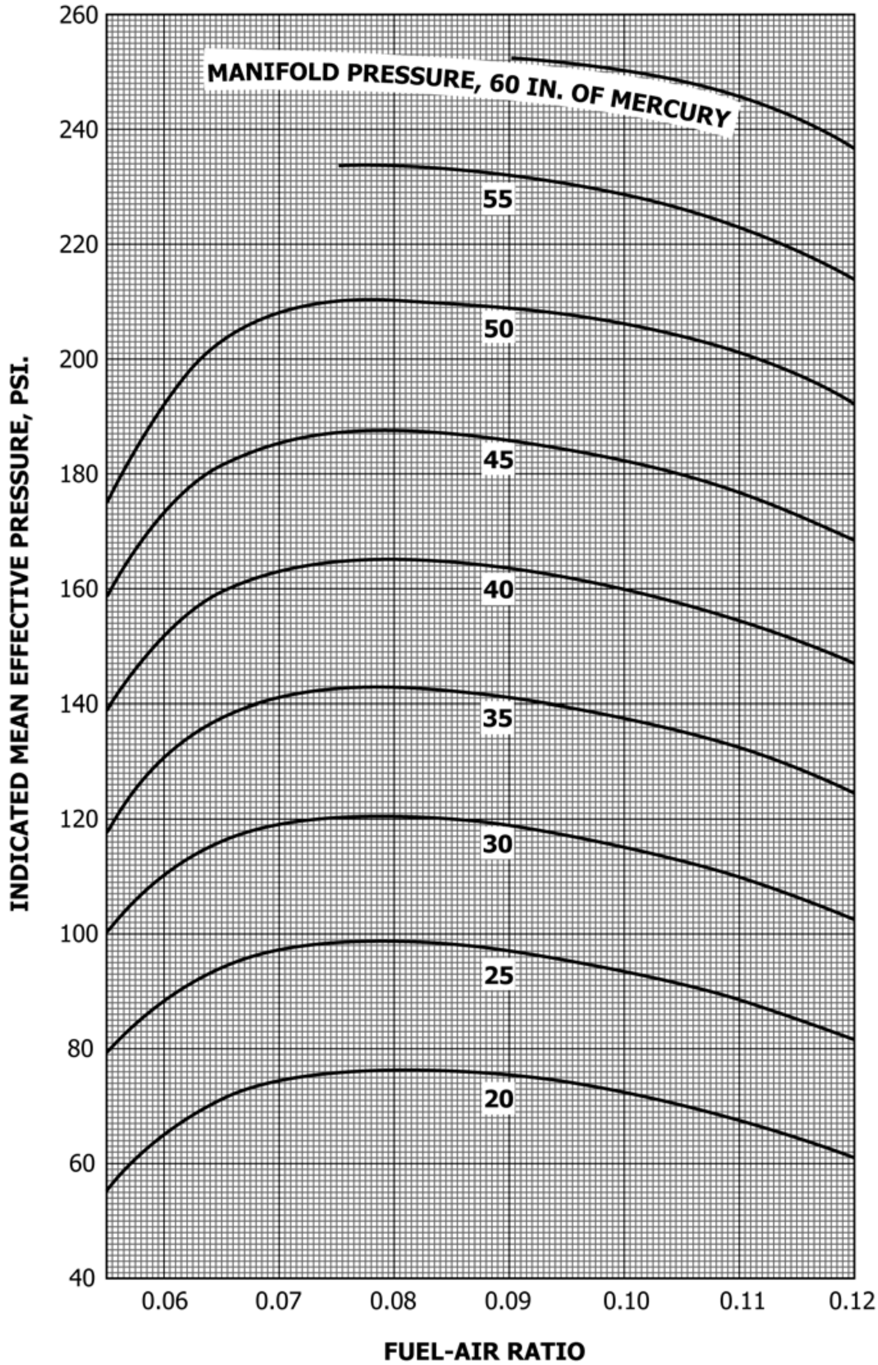
Octane Number	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Octane Number
	Performance Number										
70	48.3	48.4	48.4	48.5	48.6	48.7	48.8	48.9	49.0	49.0	70
71	49.1	49.2	49.3	49.4	49.5	49.6	49.6	49.7	49.8	49.9	71
72	50.0	50.1	50.2	50.3	50.4	50.5	50.5	50.6	50.7	50.8	72
73	50.9	51.0	51.1	51.2	51.3	51.4	51.5	51.6	51.7	51.8	73
74	51.9	51.9	52.0	52.1	52.2	52.3	52.4	52.5	52.6	52.7	74
75	52.8	52.9	53.0	53.1	53.2	53.3	53.4	53.5	53.6	53.7	75
76	53.8	53.9	54.1	54.2	54.3	54.4	54.5	54.6	54.7	54.8	76
77	54.9	55.0	55.1	55.2	55.3	55.4	55.6	55.7	55.8	55.9	77
78	56.0	56.1	56.2	56.3	56.5	56.6	56.7	56.8	56.9	57.0	78
79	57.1	57.3	57.4	57.5	57.6	57.7	57.9	58.0	58.1	58.2	79
80	58.3	58.5	58.6	58.7	58.8	58.9	59.1	59.2	59.3	59.4	80
81	59.6	59.7	59.8	60.0	60.1	60.2	60.3	60.5	60.6	60.7	81
82	60.9	61.0	61.1	61.3	61.4	61.5	61.7	61.8	61.9	62.1	82
83	62.2	62.4	62.5	62.6	62.8	62.9	63.1	63.2	63.3	63.5	83
84	63.6	63.8	63.9	64.1	64.2	64.4	64.5	64.7	64.8	65.0	84
85	65.1	65.3	65.4	65.6	65.7	65.9	66.0	66.2	66.4	66.5	85
86	66.7	66.8	67.0	67.2	67.3	67.5	67.6	67.8	68.0	68.1	86
87	68.3	68.5	68.6	68.8	69.0	69.1	69.3	69.5	69.7	69.8	87
88	70.0	70.2	70.4	70.5	70.7	70.9	71.1	71.2	71.4	71.6	88
89	71.8	72.0	72.2	72.4	72.5	72.7	72.9	73.1	73.3	73.5	89
90	73.7	73.9	74.1	74.3	74.5	74.7	74.9	75.1	75.3	75.5	90
91	75.7	75.9	76.1	76.3	76.5	76.7	76.9	77.1	77.3	77.6	91
92	77.8	78.0	78.2	78.4	78.7	78.9	79.1	79.3	79.5	79.8	92
93	80.0	80.2	80.5	80.7	80.9	81.2	81.4	81.6	81.9	82.1	93
94	82.4	82.6	82.8	83.1	83.3	83.6	83.8	84.1	84.3	84.6	94
95	84.8	85.1	85.4	85.6	85.9	86.2	86.4	86.7	87.0	87.2	95
96	87.5	87.8	88.1	88.3	88.6	88.9	89.2	89.5	89.7	90.0	96
97	90.3	90.6	90.9	91.2	91.5	91.8	92.1	92.4	92.7	93.0	97
98	93.3	93.6	94.0	94.3	94.6	94.9	95.2	95.6	95.9	96.2	98
99	96.6	96.9	97.2	97.6	97.9	98.2	98.6	98.9	99.3	99.6	99
100	100.0	...	...	...	...	...	...	...	...	...	100

Conversion Equation for Performance Number (PN):

$PN = 2800/(128 - \text{Octane number})$

TABLE A2.2 ASTM Conversion of Tetraethyllead in *Iso*octane to Performance Numbers

Tetraethyllead in *Iso*octane, mL per U.S. gal	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	Tetraethyllead in *Iso*octane, mL per U.S. gal
	Performance Number										
0.0	100.0	100.4	100.8	101.2	101.6	102.0	102.4	102.8	103.2	103.6	0.0
0.1	104.0	104.3	104.7	105.0	105.4	105.7	106.1	106.4	106.8	107.1	0.1
0.2	107.4	107.8	108.1	108.4	108.7	109.0	109.3	109.6	109.9	110.2	0.2
0.3	110.5	110.8	111.1	111.4	111.7	111.9	112.2	112.5	112.8	113.0	0.3
0.4	113.3	113.6	113.8	114.1	114.3	114.6	114.8	115.1	115.3	115.6	0.4
0.5	115.8	116.1	116.3	116.5	116.8	117.0	117.2	117.4	117.7	117.9	0.5
0.6	118.1	118.3	118.6	118.8	119.0	119.2	119.4	119.6	119.8	120.0	0.6
0.7	120.2	120.4	120.6	120.8	121.0	121.2	121.4	121.6	121.8	122.0	0.7
0.8	122.2	122.4	122.6	122.8	122.9	123.1	123.3	123.5	123.7	123.9	0.8
0.9	124.0	124.2	124.4	124.5	124.7	124.9	125.1	125.2	125.4	125.6	0.9
1.0	125.7	125.9	126.1	126.2	126.4	126.5	126.7	126.9	127.0	127.2	1.0
1.1	127.3	127.5	127.6	127.8	127.9	128.1	128.2	128.4	128.5	128.7	1.1
1.2	128.8	129.0	129.1	129.3	129.4	129.6	129.7	129.8	130.0	130.1	1.2
1.3	130.2	130.4	130.5	130.7	130.8	130.9	131.1	131.2	131.3	131.5	1.3
1.4	131.6	131.7	131.8	132.0	132.1	132.2	132.4	132.5	132.6	132.7	1.4
1.5	132.9	133.0	133.1	133.2	133.3	133.5	133.6	133.7	133.8	133.9	1.5
1.6	134.1	134.2	134.3	134.4	134.5	134.6	134.8	134.9	135.0	135.1	1.6
1.7	135.2	135.3	135.4	135.6	135.7	135.8	135.9	136.0	136.1	136.2	1.7
1.8	136.3	136.4	136.5	136.6	136.7	136.8	137.0	137.1	137.2	137.3	1.8
1.9	137.4	137.5	137.6	137.7	137.8	137.9	138.0	138.1	138.2	138.3	1.9
2.0	138.4	138.5	138.6	138.7	138.8	138.9	139.0	139.0	139.1	139.2	2.0
2.1	139.3	139.4	139.5	139.6	139.7	139.8	139.9	140.0	140.1	140.2	2.1
2.2	140.3	140.4	140.4	140.5	140.6	140.7	140.8	140.9	141.0	141.1	2.2
2.3	141.1	141.2	141.3	141.4	141.5	141.6	141.7	141.8	141.8	141.9	2.3
2.4	142.0	142.1	142.2	142.3	142.3	142.4	142.5	142.6	142.7	142.8	2.4
2.5	142.8	142.9	143.0	143.1	143.2	143.2	143.3	143.4	143.5	143.6	2.5
2.6	143.6	143.7	143.8	143.9	143.9	144.0	144.1	144.2	144.2	144.3	2.6
2.7	144.4	144.5	144.6	144.6	144.7	144.8	144.8	144.9	145.0	145.1	2.7
2.8	145.1	145.2	145.3	145.4	145.4	145.5	145.6	145.7	145.7	145.8	2.8
2.9	145.9	145.9	146.0	146.1	146.1	146.2	146.3	146.4	146.4	146.5	2.9
3.0	146.6	146.6	146.7	146.8	146.8	146.9	147.0	147.0	147.1	147.2	3.0
3.1	147.2	147.3	147.4	147.4	147.5	147.6	147.6	147.7	147.8	147.8	3.1
3.2	147.9	148.0	148.0	148.1	148.2	148.2	148.3	148.3	148.4	148.5	3.2
3.3	148.5	148.6	148.7	148.7	148.8	148.8	148.9	149.0	149.0	149.1	3.3
3.4	149.2	149.2	149.3	149.3	149.4	149.5	149.5	149.6	149.6	149.7	3.4
3.5	149.8	149.8	149.9	149.9	150.0	150.1	150.1	150.2	150.2	150.3	3.5
3.6	150.3	150.4	150.5	150.5	150.6	150.6	150.7	150.7	150.8	150.9	3.6
3.7	150.9	151.0	151.0	151.1	151.1	151.2	151.2	151.3	151.4	151.4	3.7
3.8	151.5	151.5	151.6	151.6	151.7	151.7	151.8	151.8	151.9	152.0	3.8
3.9	152.0	152.1	152.1	152.2	152.2	152.3	152.3	152.4	152.4	152.5	3.9
4.0	152.5	152.6	152.6	152.7	152.7	152.8	152.8	152.9	153.0	153.0	4.0
4.1	153.1	153.1	153.2	153.2	153.3	153.3	153.4	153.4	153.5	153.5	4.1
4.2	153.6	153.6	153.7	153.7	153.8	153.8	153.9	153.9	154.0	154.0	4.2
4.3	154.1	154.1	154.1	154.2	154.2	154.3	154.3	154.4	154.4	154.5	4.3
4.4	154.5	154.6	154.6	154.7	154.7	154.8	154.8	154.9	154.9	155.0	4.4
4.5	155.0	155.1	155.1	155.1	155.2	155.2	155.3	155.3	155.4	155.4	4.5
4.6	155.5	155.5	155.6	155.6	155.6	155.7	155.7	155.8	155.8	155.9	4.6
4.7	155.9	156.0	156.0	156.0	156.1	156.1	156.2	156.2	156.3	156.3	4.7
4.8	156.4	156.4	156.4	156.5	156.5	156.6	156.6	156.7	156.7	156.7	4.8
4.9	156.8	156.8	156.9	156.9	157.0	157.0	157.0	157.1	157.1	157.2	4.9
5.0	157.2	157.2	157.3	157.3	157.4	157.4	157.5	157.5	157.5	157.6	5.0
5.1	157.6	157.7	157.7	157.7	157.8	157.8	157.9	157.9	157.9	158.0	5.1
5.2	158.0	158.1	158.1	158.1	158.2	158.2	158.3	158.3	158.3	158.4	5.2
5.3	158.4	158.5	158.5	158.5	158.6	158.6	158.7	158.7	158.7	158.8	5.3
5.4	158.8	158.9	158.9	158.9	159.0	159.0	159.0	159.1	159.1	159.2	5.4
5.5	159.2	159.2	159.3	159.3	159.3	159.4	159.4	159.5	159.5	159.5	5.5
5.6	159.6	159.6	159.6	159.7	159.7	159.8	159.8	159.8	159.9	159.9	5.6
5.7	159.9	160.0	160.0	160.1	160.1	160.1	160.2	160.2	160.2	160.3	5.7
5.8	160.3	160.3	160.4	160.4	160.4	160.5	160.5	160.6	160.6	160.6	5.8
5.9	160.7	160.7	160.7	160.8	160.8	160.8	160.9	160.9	160.9	161.0	5.9
6.0	161.0	...	...	...	...	...	...	...	...	...	6.0



These Curves are for *Iso*octane plus 6.0 mL of Tetraethyllead per U.S. Gallon.

FIG. A2.1 Average Power Curves at Several Constant Manifold Pressures

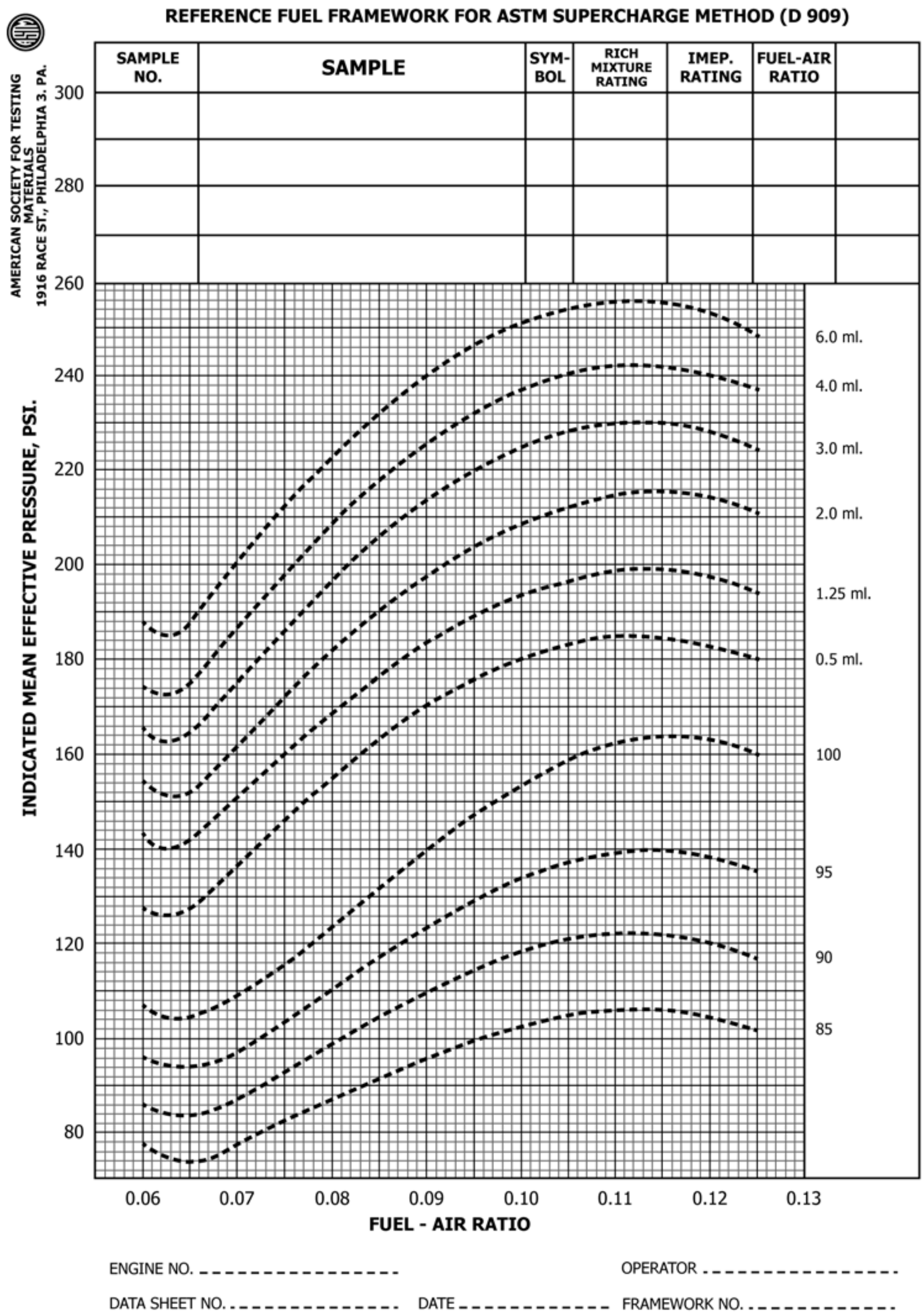
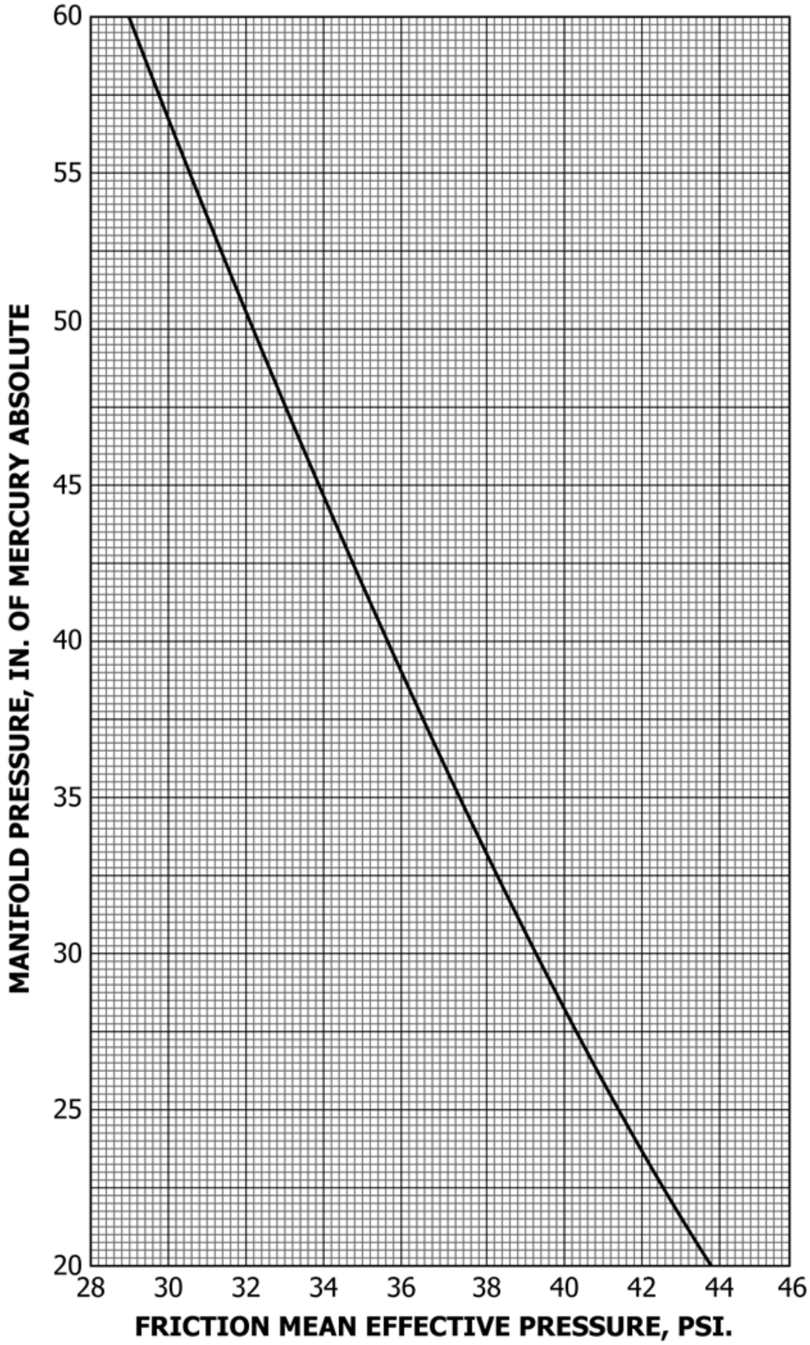


FIG. A2.2 Reference Fuel Framework



Any observed fmep should not deviate from this curve by more than 3.0 psi.

FIG. A2.3 Average Friction Mean Effective Pressure Curve

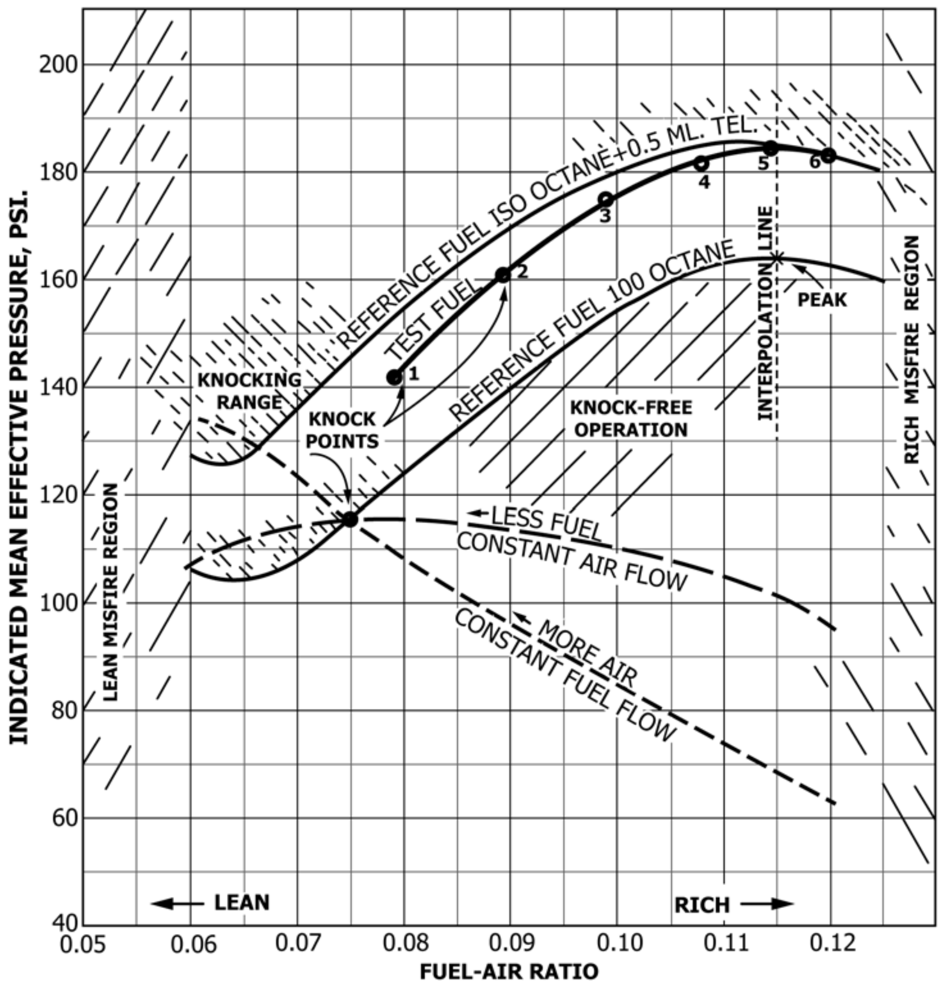


FIG. A2.4 Development of Knock-Limited Power Curves

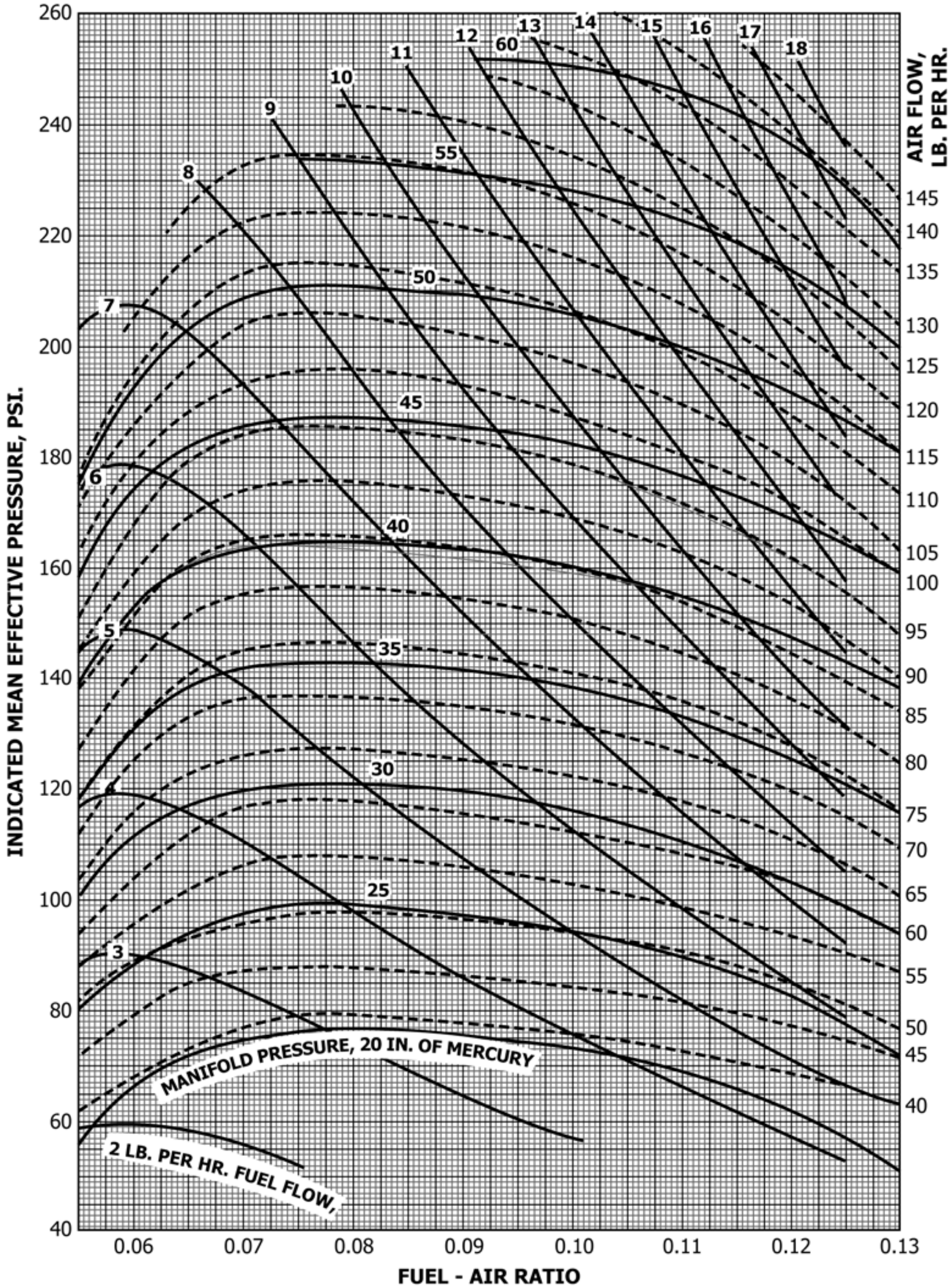


FIG. A2.5 Average Power, Fuel Flow, and Air Flow Curves at Several Constant Manifold Pressures

APPENDIX

(Nonmandatory Information)

X1. TYPICAL ENGINE OPERATING STEPS FOR OBTAINING A SUPERCHARGE RATING

NOTE X1.1—The procedure below is presented to provide a basic statement of the steps involved in rating an aviation gasoline. Some of the steps below include references applicable to the engine apparatus as originally developed compared to current units (for example, dynamometer scale versus load cell) and the indicated measurements or calculations may be accomplished without operator intervention on the more recently introduced computer-interfaced units. However, the sequence of operations is representative of those employed for both historical and current apparatus.

X1.1 Using a manifold pressure that does not produce knocking, purge the pumps and lines of the previous fuel.

X1.2 Adjust the fuel flow until the maximum BMEP is indicated at approximately 0.08 fuel-air ratio. If knock occurs, reduce the manifold pressure until the knock disappears and readjust the fuel control for maximum BMEP.

X1.3 Without changing the position of the fuel injection control, gradually increase the manifold pressure until standard knock intensity is obtained.

X1.3.1 After standard knock intensity has been obtained, operate the engine for several minutes to allow engine temperatures to stabilize. During this period minor adjustments of the manifold pressure control may be required to maintain standard intensity.

X1.4 When the conditions have been stabilized, record the following engine conditions:

X1.4.1 BMEP as indicated on the dynamometer scale.

X1.4.2 *Fuel Consumption Rate*—This is typically accomplished by recording the time required to consume 0.25 lb of fuel.

X1.4.3 *Air Consumption Rate*—This is typically accomplished by recording the time required to consume 0.25 lb of air, which can be read from the scale on the water manometer.

X1.4.4 *FMEP*—Quickly move the fuel injection control to the cut-off position, allow the dynamometer and record the FMEP indicated on the dynamometer scale. Do this within 10 s and then return the fuel control to its previous position so that the engine resumes firing.

X1.5 From the recorded data observations, calculate IMEP and fuel-air ratio as follows:

$$\text{IMEP} = \text{BMEP} + \text{FMEP} \tag{X1.1}$$

X1.5.1 *Fuel-Air Ratio*—Time required for the engine to consume 0.25 lb of air divided by the time required for 0.25 lb of fuel.

X1.6 To ensure that the test points are adequately defining the knock-limited power curves, plot the data on the reference fuel framework as the points are determined and evaluate them for conformance with fit-for-use requirements.

X1.7 Determine a minimum of five additional points at other fuel-air ratios. For each new point, enrich the fuel-air ratio by increasing the fuel-injection control an arbitrary amount and then gradually increase the manifold pressure until standard knock intensity is obtained. Allow the engine conditions to equilibrate at the new settings and record the required data and calculate IMEP and fuel-air ratio as described in X1.5.

SUMMARY OF CHANGES

Subcommittee D02.01 has identified the location of selected changes to this standard since the last issue (D909 – 14) that may impact the use of this standard. (Approved Dec. 15, 2016.)

(1) Revised engine and instrumentation supplier information in subsection 7.1.1, footnote 3 in 2.2, and footnote 9 in 7.1.