SAE International™

SURFACE VEHICLE STANDARD

SAE J1349

REV. MAR2004

Issued 1980-12
Revised 2004-03

Superseding J1349 JUN1995

Engine Power Test Code—Spark Ignition and Compression Ignition—Net Power Rating

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1. Scope

This standard is intended to provide a method to obtain repeatable measurements that accurately reflect true engine performance in customer service. Whenever there is an opportunity for interpretation of the standard, a good faith effort shall be made to obtain the engine's typical in-service performance and avoid finding the best possible performance under the best possible conditions. Intentional biasing of engine component or assembly tolerances to optimize performance for this test is prohibited.

1.1 Purpose of Standard

This SAE Standard has been adopted by SAE to specify:

a. A basis for net engine power and torque rating
b. Reference inlet air and fuel supply test conditions
c. A method for correcting observed power and torque to reference conditions
d. A method for determining net full load engine power and torque with a dynamometer
e. A procedure to ensure that engine controls are operating in a manner consistent with customer operation.

1.2 Field of Application

This test code document is applicable to both spark ignition (SI) and compression ignition (CI) engines, naturally aspirated and pressure-charged, with and without charge air cooling. This document does not apply to aircraft or marine engines.

1.2.1 This test code supersedes those portions of SAE J1349 JUN1995 dealing with net power rating. It can be used immediately, and it shall be used for testing after January 1, 2005.

1.2.2 Standard CI diesel fuel specifications are range mean values for Type 2-D EPA test fuel per Title 40, Code of Federal Regulations, Part 86.1313-87.

1.2.3 The corresponding test code for gross power and torque rating is SAE J1995.

1.2.4 The document for mapping engine performance is SAE J1312.

1.3 Relationship to ISO 1585

ISO 1585 (DIS in 1989) differs from SAE J1349 in several areas, among which the most important are:

a. This document is not limited to road vehicles.
b. This document requires inlet fuel temperature be controlled to 40 °C on CI engines.
c. This document includes a reference fuel specification and requires that engine power be corrected to that specification on all CI engines.
d. This document includes a different procedure for testing engines with a laboratory charge air cooler.
e. This document stipulates a 20% duty cycle limit on variable speed cooling fans in order to qualify for testing at the minimum power loss settings.
f. This document provides procedures for transient testing of light duty vehicles with the associated changes in control parameters and exhaust back pressure.
g. This document includes accessory losses if the accessories are standard on the vehicle application.

2. References

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or at www.SAE.org.

SAE J1312 - Procedure for Mapping Engine Performance—SI and CI Engines
SAE J1995 - Engine Power Test Code—SI and CI—Gross Power Rating

2.1.2 ISO PUBLICATIONS

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 1585—Road vehicles—Engine test code—Net power
ISO 2288—Agricultural tractors and machines—Engine test code (bench test)—Net power
ISO 3046—Reciprocating internal combustion engines—Performance
ISO 4106—Motorcycles—Engine test code—Net power
ISO 9249—Earth-moving machinery—Engine test code—Net power

2.1.3 FEDERAL REGULATION

Available from The Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. (http://bookstore.gpo.gov/cgi-bin/spcgate2001.cgi)

CFR 40 Part 86.1313-87

3. *Terms and Definitions*

This section contains the definitions of key terms used to describe the net power and torque test.

3.1 Net Brake Power and Torque
The power and torque produced by an engine at any speed when configured as a "fully equipped" engine (per 3.5), corrected to the reference atmospheric conditions and/or reference diesel fuel specifications per section 5, and tested in accordance to the applicable procedures contained in this standard.

3.2 Rated Net Power and Torque
The peak Net Brake Power and Torque produced by the engine within the operating speed range in the application for which it is rated.

3.3 Rated Power Speed
The engine speed at which the peak Net Brake Power is measured. The rated power speed must be achievable in the application for which the engine is rated.

3.4 Rated Torque Speed
The engine speed at which the peak Net Brake Torque is measured. The rated torque speed must be achievable in the application for which the engine is rated.

3.5 Fully Equipped Engine
A "fully equipped" engine is an engine equipped with only those accessories necessary to perform its intended service. Accessory components that are installed on all engines in the application, e.g., power steering pump, are also included on the engine for test. Table 1 in section 6 lists the engine equipment and accessories required for the net power test.

3.6 Reference Test Conditions
The standard (reference) engine inlet air supply and inlet fuel conditions to which all power corrections are made.

3.7 Friction Power
The power required to drive the engine as equipped for the net power test. Friction power may be established by one of the following methods.

a. Preferred Method: Hot Motoring Friction—Record friction torque at wide-open throttle at each test speed run on the power test. All readings are to be taken at the same coolant and oil temperature as observed on the power test points ± 3 °C, and variable engine devices should be at the as calibrated settings.
b. Alternative Method: If measured friction data are not available, it is permissible to assume 85% mechanical efficiency. When measured friction data are available, they must be used in computing mechanical efficiency. When this alternative method is used, it should be noted in the reported data that the results were corrected using an assumed mechanical efficiency of 85%.

3.8 Indicated Power
Indicated power is defined as the sum of the brake power and friction power for the purpose of this document.

4. *Symbols, Units, and Subscripts*

4.1 Symbols and Units

SI units shall be used for all measurements unless otherwise specified.

Table 1—SYMBOLS AND UNITS

Symbol	Term	Unit(s)
CA	Air correction factor	
CF	Fuel correction factor	
Fa	Atmospheric factor	
Fm	Engine factor	
Fd	Fuel density factor	
Fv	Fuel viscosity factor	
α	Pressure sensitivity exponent	
β	Temperature sensitivity exponent	
S	Viscosity sensitivity coefficient	
D	Engine displacement	L
Pa	Inlet air supply total pressure	kPa
t	Inlet air supply temperature	°C
T	Brake Torque *	N-m, lb-ft
Pm	Inlet manifold total pressure	kPa
R	Pressure ratio	
Q	Fuel delivery	Mg/L cycle
Bp	Brake power*	KW, hp
Fp	Friction power*	KW, hp
Ip	Indicated power*	KW, hp
N	Engine speed	min^{-1}
F	Fuel flow	G/s
SG	Fuel density at 15 °C	kg/L
V	Fuel viscosity at 40 °C	mm^2/s

* Power and torque may be expressed as HP (0.746 kW) and lb-ft (1.356 N-m). This departure from metric standards is allowed due to the common use of English units in the advertising of power and torque to consumers.

4.2 Subscripts

c = Refers to data corrected to reference inlet air and fuel supply conditions
o = Refers to data observed at the actual test conditions
d = Refers to the dry air portion of the total inlet air supply pressure
r = Refers to the reference test conditions per section 5

5. *Reference Test Conditions and Corrections*

This section contains reference air and fuel supply test conditions and specifications, recommended test ranges, and applicability of the correction procedures.

5.1 Reference Atmospheric Conditions

Table 2 defines reference atmospheric conditions and test ranges for which correction factors are valid.

Table 2—REFERENCE ATMOSPHERIC CONDITIONS

	Standard Condition	Test Range Limits
Inlet Air Supply Pressure (absolute)	100 kPa	—
Dry Air Pressure (absolute)	99 kPa	90-105 kPa
Inlet Air Supply Temperature	25 °C	15-35 °C

With the exception of humidity, no modification to the composition of intake air is permitted. Available laboratory equipment shall be set to minimize correction factors by controlling inlet air as close as possible to "reference atmospheric conditions".

5.2 Reference SI Gasoline Specifications

Rated power tests must be performed using fuel which contains energy (defined as lower heating value) equivalent to fuel specified for customer use. Reference gasoline research and motor octane numbers in Table 3 have been determined corresponding to "regular", "mid-grade", and "premium" test fuels.

Reference gasoline is required for all SI engines equipped with knock sensors or other devices that control spark advance as a function of spark knock. Other SI engines may use any gasoline with an octane number sufficient to prevent knock provided that the engine does not have electronic controls which will result in the engine producing more power than the customer would obtain on the manufacturer's specified fuel.

Table 3—REFERENCE SI GASOLINE SPECIFICATIONS

	Regular Fuel	Mid-Grade Fuel	Premium Fuel
Research Octane No.:	92 ± 0.5	93 ± 0.5	97 ± 0.5
Motor Octane No.:	83 ± 0.5	85 ± 0.5	87 ± 0.5
Lower Heating Value:	43.3 MJ/kg ± 0.1 MJ/kg	43.3 MJ/kg ± 0.1 MJ/kg	43.1 MJ/kg ± 0.1 MJ/kg

5.3 Reference CI Fuel Specifications

Reference fuel specifications are defined by Title 40, Code of Federal Regulations, Part 86.1313-87, and represent range mean values for Type 2-D diesel fuel. The reference fuel characteristics in Table 4 have been determined to affect engine test power, and are listed with the applicable test ranges for which correction factors are valid.

Table 4—REFERENCE CI FUEL SPECIFICATIONS

	Standard Condition	Test Range Limits
Fuel Density at 15 °C	0.850 kg/L	0.840 - 0.860 kg/L
Fuel Kinematic Viscosity at 40 °C	2.6 mm^2/s	2.0 - 3.2 mm^2/s
Fuel Inlet Temperature	40 °C	39 - 41 °C (pump/line/nozzles/common rail) or 37 - 43 °C (unit injectors)

Observed engine power is also corrected for variations in lower heating value (LHV) based on an empirical relationship between LHV and fuel density per 5.6.2.2.

5.4 Alternative Fuels

Reference values for alternative SI and CI fuels, both liquid and gaseous, are not presented in this document. Therefore, when alternative fuels are used for the net power engine test, no corrections to reference fuel conditions shall be made. Any reference to the rated power and torque for an engine rated on alternative fuel should specify the fuel used in rating the engine.

5.5 Power Correction Factor

The performance of SI and CI engines is affected by the density of the inlet combustion air as well as by the characteristics of the test fuel. Whenever possible, tests should be run at the standard conditions with reference fuels. When this is not possible, in order to provide a common basis of comparison, correction factors should be applied to the observed net power and torque to account for differences between reference air and fuel conditions and those at which the test data were acquired.

5.5.1 All power and torque correction procedures for atmospheric air are based on the conditions of the engine inlet air supply immediately prior to the entrance into the engine air induction system. This may be ambient (atmospheric) air or a laboratory air plenum that maintains air supply conditions within the range limits defined per 5.1. Air supply systems that provide tuning or pressure charging in violation of the intent of this procedure are prohibited.

5.5.2 On any engine where the power output is automatically controlled to compensate for changes in one or more of the listed inlet air and fuel supply test conditions, no correction for that test parameter shall be made. For example, boosted engines with absolute pressure controls shall not be corrected for ambient barometric pressure.

5.5.3 The magnitude of the power correction for tests run at non-standard conditions should not exceed 3% for inlet air or 3% for inlet fuel corrections. If the correction factor exceeds these values, it shall be noted as a nonstandard test in accordance with 8.1.

5.6 Correction Formulas

The applicable correction formulas for spark ignition and compression ignition engines are listed in this section. These correction formulas are designed for correction of net brake power at full throttle operation; however, for CI engines the formulas may also be used to correct partial load power for the purpose of determining specific fuel consumption. These correction formulas are not intended for altitude de-rating. This section includes all formulas necessary to correct observed engine power performance for deviations in inlet air and fuel supply conditions.

5.6.1 Spark Ignition Engine Correction Formulas

These spark ignition engine correction formulas are only applicable at full (WOT) throttle positions.

$$Bp_c = Ip_c - Fp_o \qquad \text{(Eq. 1)}$$

where:

$$Ip_c = CA \times Ip_o = CA \times (Bp_o + Fp_o) \qquad \text{(Eq. 2)}$$

and the atmospheric correction factor, CA, is defined as:

$$CA = \left(\frac{99}{Pa_{do}}\right)\left(\frac{t_o + 273}{298}\right)^{0.5} \qquad \text{(Eq. 3)}$$

If friction is measured then brake power can be calculated by combining Eqs. 1 and 2:

$$Bp_c = CA \times Bp_o + (CA - 1) \times Fp_o \qquad \text{(Eq. 4)}$$

If friction is **not** measured and 85% mechanical efficiency is assumed per 3.7 then:

$$Fp_o = \frac{(1 - ME) \times Bp_o}{ME} = \frac{(1 - 0.85) \times Bp_o}{0.85} = 0.176 \times Bp_o \qquad \text{(Eq. 5)}$$

Brake power assuming 85% mechanical efficiency can then be calculated by substituting Eq. 5 into Eq. 4:

$$Bp_c = (1.176 \times CA - 0.176) \times Bp_o \qquad \text{(Eq. 6)}$$

NOTE—If a lab auxiliary charge air cooler is used in conjunction with the standard test method per 6.2.3, no inlet air temperature corrections shall be made. In this case, the temperature correction exponent becomes zero. Otherwise use equation 3.

5.6.2 COMPRESSION IGNITION ENGINE CORRECTION FORMULAS

These CI engine correction formulas are applicable at all speed and load levels.

$$Bp_c = (CA \times CF) \times Bp_o \qquad \text{(Eq. 7)}$$

5.6.2.1 Calculation of Atmospheric Correction Factor, CA

$$CA = (Fa)^{Fm} \qquad \text{(Eq. 8)}$$

where:

$$Fa = \left(\frac{Pa_{dr}}{Pa_{do}}\right)^{\alpha} \cdot \left(\frac{t_o + 273}{t_r + 273}\right)^{\beta} = \left(\frac{99}{Pa_{do}}\right)^{\alpha} \left(\frac{t_o + 273}{298}\right)^{\beta} \qquad \text{(Eq. 9)}$$

and values for α and β, are summarized in Table 5:

Table 5—ATMOSPHERIC CORRECTION FACTOR EXPONENTS

Pressure Charging System	Charge Air Cooling System	α	β
Naturally Aspirated	None	1.0	0.7
Mechanically Supercharged	All	1.0	0.7
Turbocharged	None	0.7	1.2
Turbocharged	Air-to-Air	0.7	1.2
Turbocharged	Jacket Water	0.7	0.7
Turbocharged	Lab Auxiliary (Standard)	0.7	0.4
Turbocharged	Lab Auxiliary (Optional)	0.7	1.2

Where “standard” and “optional” refer to the lab auxiliary cooler test method described in 6.2.3.

The value of the engine factor fm is determined from Table 6:

Table 6—ENGINE FACTOR CALCULATION

	FM
$\frac{Q}{R} < 37.2$	0.2
$37.2 > \frac{Q}{R} < 65$	$\left(0.036 \times \frac{Q}{R}\right) - 1.14$
$65 > \frac{Q}{R}$	1.2

where:

Q = 120 000 x F/(D x N) for four-stroke engines
Q = 60 000 x F/(D x N) for two-stroke engines
R = Pm_o/Pa_o for all engines (R = 1 if naturally aspirated)

5.6.2.2 *Calculation of Fuel Correction Factor, CF*

$$CF = Fd \times Fv \quad \text{(Eq. 10)}$$

where:

$$Fd = 1 + 0.70\left(\frac{SG_r - SG_o}{SG_o}\right) = 1 + 0.70\left(\frac{0.850 - SG_o}{SG_o}\right) \quad \text{(Eq. 11)}$$

and:

$$Fv = \frac{1 + S/V_o}{1 + S/V_r} = \frac{1 + S/V_o}{1 + S/2.6} \quad \text{(Eq. 12)}$$

NOTE—The previous equations correct observed power to reference fuel density and viscosity levels. A correction coefficient of 0.70 in the previous density factor equation is added to account for typical changes in lower heating value at differing density levels, based on an empirical LHV-SG relationship.

Values of S shall be determined by the engine manufacturer. If no values are available, the following shall be used:

a. Pump/Line/Nozzle Systems—0.15
b. Unit Injectors—0.0
c. Common Rail—0.15

NOTE—If used for the purpose of determining specific fuel consumption, the corrected fuel flow is given by the following:

$$F_c = \left(SG_r / SG_o \times Fv\right) F_o \quad \text{(Eq. 13)}$$

Correction Formulas Prepared By the SAE Power Test Code Committee

6. *Laboratory and Engine Equipment*

This section contains a list of laboratory and engine equipment used in the net power and torque test.

6.1 Engine Equipment

A "fully equipped" engine, as defined in 3.5, is required for the net power and torque test. Table 7 lists the engine accessories and control settings that are required for this test.

Table 7—ENGINE EQUIPMENT

System	Required	Comments
1. Air Induction System	Yes	The complete Air Induction System including all active or passive tuning and/or NVH devices is required. The Air Induction System begins at the point where air enters from the atmosphere and ends at the entrance to the throttle body, inlet manifold, or turbocharger inlet, on engines as appropriate
Air Ducting	Yes	
Air Cleaner	Yes	
Air Preheat	No	
Active Tuning Device	Yes	
2. Pressure Charging System	Yes	
Boost Control Settings	Manufacturer's Specification	For all engines equipped with variable boost as a function of other engine parameters (speed/ load/fuel octane, etc.), the boost pressure controls must be set to reflect intended in-service operation.
3. Charge Air Cooling System	Yes	If applicable.
Charge Air Cooler	Yes	See 6.2.3 for laboratory auxiliary cooler provisions.
Cooling Pump or Fan	Conditional	If active at rated conditions.
4. Electrical System	Yes	.
Ignition System	Yes	
Starter	No	
Generator/Alternator	Conditional	Required if standard equipment in the application. A generator/alternator shall operate at a load level sufficient to power only the required components (i.e., fuel injectors, ignition system, electronic controller, electric fuel pump, cooling fans, coolant pumps). If an auxiliary power supply is used, the actual generator/alternator load for the required components must be determined and the generator/alternator input required to produce that power subtracted from the measured torque and power data. See 6.2.4 for laboratory equipment provisions.
Ignition Timing Control Settings	Manufacturer's Specification	For any engine equipped with electronic controls and/or knock sensors, the spark or timing advance shall reflect intended in-service operation. See 7.5
5. Emissions Control System	Yes	All control settings or adjustments must be set to reflect intended in-service operation.

System	Required	Comments
6. Fuel Supply System	Yes	See 6.2.2 for laboratory fuel supply system provisions.
Fuel Filters/Prefilters	Optional	
Fuel Supply Pump	Yes	Or equivalent electrical load if applicable.
Injection Pump/ Carburetor or Fuel Metering Control Settings	Manufacturer's Specification	Control settings must reflect intended in-service operation.
7. Engine Cooling System (Liquid)	Yes	
Cooling Pump	Yes	
Radiator	Optional	Functionally equivalent laboratory system recommended.
Thermostat	Yes	Production intent thermostat required. Blocked open thermostat is recommended.
Cooling Fan	Optional	Cooling fans represent a significant parasitic load on an engine and must be considered in rating power and torque. A fan used in dynamometer testing shall be mounted behind a radiator with the same shrouding as in the application for which it is being rated. For applications in which the cooling fan runs less than 20% of the time during operation at the rated power conditions, the fan may be run in its minimum power setting. For all other applications, at each engine speed, a variable fan should be run at the minimum fan power required to provide steady-state cooling of the engine at maximum brake load when operated at reference atmospheric conditions. NOTE: If the fan is omitted for dynamometer testing , the minimum allowable fan power as described above should be determined and subtracted from the net brake power. If run at full output, the fan power absorbed should be calculated and the difference between it and the minimum allowable fan power shall be added to the net brake power
Engine Cooling System (Air)	Yes	
Blower	Yes	See previous comments same as liquid cooling fan.
8. Lubrication System	Yes	The fully equipped engine closed loop lubrication system is used. Oil fill shall be at manufacturer's full level. Oil temperatures shall reflect in-service levels at reference test conditions. The production oil pan is mandatory.
9. Exhaust System	Yes	See 6.2.1 for exhaust system laboratory equipment provisions.
10. Engine Driven Auxiliary Devices	Conditional	Required if standard equipment. It is permissible to run without a specific accessory and subtract the parasitic loss of the accessory from the engine brake output.
Power Steering Pump	Conditional	Plumb fully operational pump for minimum parasitic loss at rated speed.
Air Conditioning Compressor	Conditional	Should be de-clutched
Vacuum Pumps	Conditional	Required only if needed to drive other required systems listed, and it functions in that capacity more than 20% of engine running time during intended in-service operation at rated power condition.
Air Compressors	Conditional	See previous comments - same as vacuum pumps.
Auxiliary Hydraulic Pump	Conditional	If required for engine operation or if standard equipment
11. Transmission	No	The correction of engine power or torque for transmission losses is not permitted.

6.2 Laboratory Equipment

The following provisions are made for use of standard laboratory test equipment for the net power test.

6.2.1 EXHAUST SYSTEM:

A complete series production Exhaust System (including mufflers, active catalytic converters, resonators) or any laboratory system that provides equivalent restriction at the peak power engine speed. If a complete vehicle exhaust system is not used, the laboratory system must include the vehicle system at least through the first major restriction (e.g., close-coupled catalytic converter.) It is strongly recommended that a full vehicle exhaust be used with four-cylinder engines that are typically most sensitive to exhaust system tuning. Procedures for determining application specific exhaust backpressure are given in section 9.

6.2.2 FUEL SUPPLY SYSTEM:

Any laboratory system that provides a supply of fuel to the fuel inlet of the fully equipped engine is acceptable. Fuel supply pressure should be controlled to application specific values. The fuel supply system must be capable of controlling fuel supply temperature to within the ranges specified in 5.3 for CI engines. The fuel supply system shall not exceed the manufacturer's maximum permissible restriction requirements, if applicable.

6.2.3 CHARGE AIR COOLER:

A Charge Air Cooler is recognized to have a significant impact on engine performance. For this reason, to obtain an accurate measure of rated engine power for all engines equipped with a Charge Air Cooler, the charge air temperature and pressure at the outlet of the Charge Air Cooler must be set to reflect in-service operation at standard inlet conditions. For charge-cooled engines, use of the production Charge Air Cooler is preferred, however, a laboratory auxiliary cooler may be employed for test purposes. The test methods required to control the auxiliary lab charge air cooler are defined in 7.5.5.

6.2.4 AUXILIARY POWER SUPPLY:

Even when an alternator/generator is installed, electrically driven engine components determined to be part of the basic engine may be operated via an external power supply. In such cases, the alternator/generator input power required to generate the electrical load must be determined and subtracted from the corrected net brake power.

7. Test Procedures

7.1 Instrumentation Accuracy

The following minimum test instrumentation accuracy is required:

a. Torque —±0.5% of measured value
b. Speed —±0.2% of measured value
c. Fuel Flow —±1% of measured value
d. General Temperature measurements —±2 °C
e. Inlet Air Temperature —±0.5 °C
f.. Air Supply, Inlet and Exhaust Pressures —±0.1 kPa
g.. Other Gas Pressures —±0.5 kPa

7.2 Measurement Requirements

7.2.1 INLET AIR SUPPLY PRESSURE AND TEMPERATURE:
Pressure and temperature of the inlet air supply, used for the purpose of correcting engine power, shall be measured in a manner to obtain the total (stagnation) condition at the entrance to the engine air induction system. This measurement shall be made within 0.15 m of the entrance to the Air Induction System inlet duct. On those tests where the engine air supply is ambient air, this pressure is the barometric pressure; on those tests where the air supply is test cell ambient air, this pressure is the cell barometric pressure; on those tests where the inlet air supply is plumbed directly to the Air Induction System, the correction pressure is the pressure measured inside the lab plenum.

7.2.2 INTAKE MANIFOLD PRESSURE AND TEMPERATURE
Intake manifold pressure and temperature shall be measured as static values with probes located in a section common to several cylinders. In such installations, dynamic pressure is assumed zero.

7.2.3 CHARGE AIR COOLER PRESSURE AND TEMPERATURE:
For engines equipped with a charge air cooler, instrument the engine with thermocouples and pressure probes midstream at the air inlet and outlet of the Charge Air Cooler. On charge air-cooled engines in which a laboratory cooler is employed for testing, pre-cooler charge air pressure must also be measured for the purpose of setting in-service restrictions per 7.5.5. Pre-cooler pressure must be measured upstream of the auxiliary unit in a manner to obtain the total (stagnation) value. Auxiliary cooler restriction is the difference between the pre-cooler and intake manifold pressures.

7.2.4 COOLANT TEMPERATURE:
Coolant temperature in liquid-cooled engines shall be measured at the inlet and outlet of the engine, in air-cooled engines at points specified by the manufacturer.

7.2.5 OIL PRESSURE AND TEMPERATURE:
Oil pressure shall be measured at the entrance to the main oil gallery. Oil temperature can be measured at the same location or inside the oil sump.

7.2.6 FUEL TEMPERATURE AND PRESSURE:
Fuel temperature and pressure shall be measured at the inlet to the carburetor or fuel injector rail for SI engines, and at the inlet to the high-pressure injection pump or unit injector rail for CI engines, and at the outlet of the volumetric flow meter for gaseous-fueled engines. Fuel temperature must also be measured at the entrance to the fuel flow meter for the purposes of density correction in the mass fuel flow calculation.

7.2.7 EXHAUST SYSTEM PRESSURE AND TEMPERATURE:
Exhaust system pressure shall be measured to obtain the total (stagnation) pressure downstream of the exhaust runner collector(s). Exhaust System temperature shall be measured in approximately the same location as the pressure measurement. In the event that the engine is equipped with close-coupled catalysts, the pressure probe can be located downstream of the catalysts. For applications that use laboratory exhaust equipment to mimic backpressure in service (steady state or transient), the pressure probes must be installed in the same location for both the vehicle test and the dynamometer net power test.

7.2.8 AIR/FUEL RATIO:
The air/fuel ratio shall be measured for the purpose of ensuring that the air/fuel run on the dynamometer is the same as that run in the application.

7.3 Adjustments and Run-In

7.3.1 ADJUSTMENTS
No component, assembly, or calibration adjustments are allowed during the test.

7.3.2 RUN-IN
The engine shall be run-in according to the manufacturer's recommendation. If no such recommendation is available, the engine shall be run-in until friction has stabilized as determined by brake torque readings that are repeatable within 1%.

7.4 Test Operating Conditions
There are two alternative methods for determining the engine control settings and operating conditions used in rating engine power and torque; steady-state and transient.

7.4.1 STEADY-STATE
Steady-state procedures have historically been used for all engine rating. They are still appropriate for engines that usually operate at constant speed and load such as industrial engines, generator sets, small hand-held engines, utility, lawn and garden engines, off-highway vehicles and medium or heavy duty on-highway vehicles. It is acceptable to use steady-state procedures and operating conditions for rating of any engine.

7.4.2 TRANSIENT
Power achieved during transient maneuvers such as acceleration from a stop or passing on the highway can be more meaningful to consumers of light duty vehicles than steady-state power. The widespread application of sophisticated electronic controls has provided engine manufacturers with the opportunity to regulate engine operation as a function of time as well as environmental conditions and fuel type. Examples of engine control parameters that may vary with time are variable valve actuation, active intake manifolds, electronic spark control, catalyst protection algorithms, active exhaust controls, variable boost control, electronic throttle control, knock control, traction and vehicle stability control, variable compression ratio, injection timing and pressure. It is the intent of this procedure to rate engine power and torque with these controls set as they would be for the customer in the most likely operating condition.

The method for determining test conditions used for rating engines from light duty vehicles is to obtain and record time synchronized data on all engine control parameters from an engine installed in a vehicle during a transient maneuver and then to duplicate these control settings during steady state engine operation on a dynamometer. The procedure for obtaining these data can be found in section 9.

7.5 Power and Torque Determination

7.5.1 TEST PROCEDURE
This section defines the actual dynamometer test procedure used in obtaining Rated Net Power and Torque. The test shall consist of a run at full throttle for spark-ignited engines and at a fixed full-load fuel injection pump setting for CI engines. The following test controls and operating conditions must be adhered to meet the requirements of this standard:

7.5.2 TEST POINTS

Measurements shall be taken at increments of no more than 500 RPM in sequence from the lowest to the highest engine speeds recommended by the manufacturer. The operating speeds shall include those for peak power and peak torque. Data at 100 RPM increments around peak torque and peak power are recommended to accurately distinguish their respective rated speeds. Engine speed shall not deviate from the nominal set speed by more than ±1% or 5 RPM, whichever is greater.

7.5.3 LOGGING OF MEASUREMENTS

No data shall be taken until torque and speed measurements have remained stable within 1% and controlled temperatures have remained stable within ± 2 °C for at least 1 minute. The recorded measurements shall be the average of readings over a span of 1 minute. Alternatively, data can be taken by stabilizing the torque and speed for 5 seconds and then acquiring data at a minimum 10 Hz rate for at least ten seconds. If this alternative procedure is used, the entire speed sweep shall be repeated at least three times. The results are considered valid if the repeatability of at least three measurements is within 1% of the mean.

7.5.4 ENGINE CALIBRATION CONTROLS

The engine calibration settings (including spark advance and air/fuel ratio) shall be representative of the in-service controls. For light duty vehicles, the engine control settings can be set to values equivalent to those recorded during the vehicle transient test described in section 9. Replication of transient control settings used during the steady state power test on dynamometer must include any time-based delays that would occur in the transient vehicle test. Engines equipped with active knock control are required to run at the spark advance established with the minimum octane fuel recommended by the manufacturer.

7.5.5 CHARGE AIR COOLER SETTINGS

For any engine equipped with a Charge Air Cooler, the air temperature at the outlet of the Charge Air Cooler must be set to reflect the conditions exhibited during in-service operation. For light duty vehicles, the transient vehicle test procedure described in section 9 can be used to derive the Charge Air Cooler outlet air temperature at all engine speeds. For all other engine applications, the Charge Air Cooler outlet temperatures should be set to replicate the values exhibited during fully warmed up, steady-state operation. For either of these tests, the Charge Air Cooler temperature shall be maintained within a tolerance of ± 2 °C at all engine speeds tested. If no vehicle testing was performed to determine the Charge Air Cooler outlet temperature, a fixed charge air cooler outlet temperature of 60°C can be used.

7.5.6 BOOSTED ENGINE SETTINGS

For engines equipped with variable boost as a function of charge or inlet air temperature, octane rating, and/or engine speed, the boost pressure shall be set to replicate the in-service conditions established with the minimum octane fuel recommended by the manufacturer.

7.5.7 AMBIENT TEMPERATURE

Ambient test cell temperature control is not required by this standard.

7.5.8 INLET AIR CONDITIONS
The pressure, temperature, and humidity of the engine's inlet air supply shall be controlled as close to the standard reference conditions per 5.1 as possible to minimize the correction factor. The inlet air pressure temperature and humidity shall not deviate from the controlled set points by more than 3% for the entire test. If a laboratory plenum is plumbed to the engine for the purposes of controlling inlet air supply conditions, the inlet air pressure supplied to the engine shall not exceed the barometric pressure measured at the time of test by more than 0.5 kPa.

7.5.9 COOLANT TEMPERATURE
Coolant temperature, measured at the thermostat location for a liquid-cooled engine, shall be controlled to within ± 3 °C of the nominal thermostat control temperature specified by the manufacturer. If no temperature is specified, the coolant temperature shall be controlled to 90 °C ± 3 °C. Cooling air supply temperature for an air-cooled engine is regulated to 35 °C ± 5 °C.

7.5.10 COOLANT TYPE
For liquid cooled engines, the type of coolant and water-mix ratio shall match the engine coolant used in series production by the manufacturer.

7.5.11 OIL TEMPERATURE
Although oil temperature control is not an expressed requirement of this standard, the oil temperatures run in the dynamometer rating test must be representative of the temperatures exhibited in service with a fully warmed up engine. The temperature must be controlled to a value no greater than the maximum limits specified by the manufacturer.

7.5.12 OIL TYPE
The type of engine oil used for the test shall match the SAE designated oil type recommended by the manufacture for the application.

7.5.13 FUEL TEMPERATURE
Fuel inlet temperature for diesel fuel injection shall be controlled to 40 °C ± 3 °C for unit injector systems, and 40 °C ± 1 °C for pump/line/nozzle systems. Test fuel temperature control is not required on SI engine power tests.

7.5.14 FUEL PRESSURE
The fuel pressure shall be controlled to match the operating pressure specified by the manufacture in series production.

7.5.15 EXHAUST BACKPRESSURE
As indicated in 7.4, for light duty vehicles, the exhaust backpressure can be set to replicate the values measured in a vehicle transient maneuver. For all other applications, if a laboratory exhaust system is used, the exhaust backpressure must be set to replicate the values measured under the steady state conditions exhibited in service. The exhaust backpressure setting used at peak power must match the exact value recorded during in service conditions within ± 1.5 kPa.

7.5.16 TEST CELL EXHAUST VENTING
The exhaust gas from the engine must be vented to a reservoir having a total pressure within 0.75 kPa of the inlet air supply pressure.

8. Presentation of Results

This section contains a listing of test data to be recorded and procedures for presenting results.

8.1 Reporting Requirements

All reported engine test data shall carry the notation: “Performance obtained and corrected in accordance with SAE J1349.Revised Jan04. Any deviation from this document, its procedures, or limits shall be noted (e.g., Correction factors used exceed valid range defined in the SAE J1349 Procedure Revised Dec03, Correction factors determined using assumed mechanical efficiency of 85% rather than actual test data.) The following information is to be provided in the engine power rating report:

8.1.1 GENERAL TEST INFORMATION

a. Date of test
b. Engine serial number
c. Test/run number
d. Test location and test cell number
e. Additional engine equipment listed per 6.1

8.1.2 ENGINE DESCRIPTION

a. Engine Displacement
b. Bore and stroke
c. Number and configuration of cylinders
d. Ignition type (Spark, Compression)
e. Combustion cycle (2-Stroke, 4-Stroke)
f. Fuel system (Carburetion, Throttle Body Injection, Multi-port injection, etc)
g. Valve train (Push Rod - 2 Valve, Dual Overhead Cam - 4 Valve, Electro-Mechanical, etc)
h. Pressure charging (naturally aspirated, turbocharged, supercharged)
i. Charge air cooling (if applicable)
j. Fan system (Electric, Clutch Driven, Hydraulic, etc)
k. Knock control system (if applicable)
l. Manufacturer’s recommended minimum fuel octane number.

8.1.3 LIQUID FUEL - SPARK IGNITION ENGINE

a. Fuel type and/or blend
b. Research and motor octane numbers
c. H:C Ratio
d. Fuel density/specific gravity at 15 °C
e. Lower heating value

8.1.4 GASEOUS FUEL - SPARK IGNITION ENGINE

a. Fuel type or grade
b. Composition
c. Density at 15 °C and 101 kPa
d. Lower heating value

8.1.5 DIESEL FUELS

a. ASTM or other fuel grade
b. Density at 15 °C
c. Viscosity at 40 °C
d. Lower heating value (optional)