SURFACE VEHICLE STANDARD

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Engine Power Test Code - Engine Power and Torque Certification

RATIONALE

SAE J2723 provides a means for certifying naturally-aspirated engines in multiple applications using "isopower charts" to show the effect of intake restriction and exhaust backpressure. The sharp rise in the use of turbocharged engines has made it highly desirable to have a similar isopower option available for manufacturers who wish to certify boosted engines.

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http://www.sae.org/technical/standards/J2723_201509

1. SCOPE

This document specifies the procedure to be used for a manufacturer to certify the net power and torque rating of a production engine according to SAE J1349 (Rev. 8/04) or the gross engine power of a production engine according to SAE J1995.

Manufacturers who advertise their engine power and torque ratings as Certified to SAE J1349 or SAE J1995 shall follow this procedure. Certification of engine power and torque to SAE J1349 or SAE J1995 is voluntary, however, this power certification process is mandatory for those advertising power ratings as “Certified to SAE J1349” or “Certified to SAE J1995.”

In the event that an engine made by one manufacturer is sold to a consumer in a vehicle produced by a second manufacturer, engine certification may be completed by either manufacturer or by both manufacturers working together. An example of the latter would be the completion of witness testing by the engine manufacturer with the submission of certification documents by the vehicle manufacturer.

1.1 Purpose of Standard

This SAE Standard has been written to provide manufacturers with a method of certifying the power of engines to SAE J1349 or SAE J1995.

1.2 Field of Application

This certification process is applicable to all engines tested under SAE J1349 or SAE J1995.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1349 Engine Power Test Code - Spark Ignition and Compression Ignition - As Installed Net Power Rating

SAE J1995 Engine Power Test Code - Spark Ignition and Compression Ignition - Gross Power and Torque Rating

3. TERMS AND DEFINITIONS

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

3.1 Certified Brake Power and Torque

The power and torque which a manufacturer certifies an engine will develop when tested under the conditions as specified in SAE J1349 or SAE J1995.

4. SELECTION, DOCUMENTATION AND VERIFICATION OF TEST ARTICLE

The engine to be tested shall be selected by the manufacturer as representative of the engine in the application being certified. It is preferable to test engines from regular series production. Engines built from production-intent parts with production-intent processes and tooling may be used in the testing provided that all components conform to production intent design and comply with the requirements of the applicable standard (SAE J1349 or SAE J1995). It is the intent of this process that the level of hardware and calibration compliance to production specifications will be that which is required for US EPA Emissions Certification.

5. WITNESS TESTING

5.1 Definition

Witness testing is defined to mean testing in an appropriate facility that is witnessed by a qualified witness, independent of the engine manufacturer, who is able to verify equipment function and calibrations, computations, and engine test settings as specified in the applicable standard. Testing for conformance to this standard may be done in the manufacturer's facility or in any qualified independent facility conforming to ISO 9000/9002. Qualification is established by the ability to meet the requirements for testing according to SAE J1349 or SAE J1995.

5.2 Qualifications of Witness

Witnesses for engine power and torque certification testing shall be registered with SAE. Witnesses shall be competent engineers who are experienced in engine testing and familiar with the requirements of the SAE J1349 and SAE J1995 standards.

Witnesses registered by SAE shall meet one of the following criteria:

5.2.1 Prior registration as a witness for European homologation testing and a signed statement acknowledging that the individual has studied and understands the SAE procedures.

5.2.2 Documented and verified experience in engine testing with three recommendations from individuals who are registered witnesses themselves or whose technical training and experience establish them as competent to evaluate the individual's skills as a witness. In addition, a signed statement is required acknowledging that the individual to be registered has studied and understands the SAE J1349 and SAE J1995 testing procedures.

5.2.3 A Bachelor's Degree in Engineering or equivalent plus 5 years of related engine testing experience and completion of an SAE-approved training course. Documented participation as an "apprentice witness" in at least three (3) SAE J1349 or SAE J1995 test procedures conducted by an SAE-certified witness who attests to the competency of that individual to conduct witness tests may be substituted for completion of an SAE-approved training course.

5.2.4 Other qualified individuals who are identified and appointed by the SAE Engine Power Test Code Committee. The witness will provide a signed statement acknowledging that the individual has studied and understands the relevant SAE test procedures.

5.3 Responsibility of Witness

5.3.1 Confirm that the laboratory doing the testing is capable of meeting the requirements for SAE J1349 or SAE J1995 and that the calibration of measurement devices is in accordance with ISO 9000/9002. If the facility is ISO certified to ISO 9000/9002, the witness shall attach a valid certificate of compliance to the test results. If testing is done in a facility which is not ISO certified, the witness shall provide documentation to establish the capability of the laboratory to conduct testing as specified in the appropriate standard.

5.3.2 Verify that the engine tested is consistent with that described in the manufacturer's submission.

5.3.3 Verify that the engine induction and exhaust system are those for the application being evaluated or, if applicable, verify that the exhaust backpressure is set appropriately.

5.3.4 If applicable, review data on vehicle transient testing to ensure that engine settings for dynamometer testing are correct. The data required for this shall include identification of the vehicle from which test data were obtained and the transient test data determined using the procedure in SAE J1349. These data shall include: engine control settings, temperatures, intake manifold pressure and exhaust back pressure as functions of time and vehicle speed.

5.3.5 Verify that fuel, coolant and lubricants used in testing are consistent with the manufacturer's specification for the application being rated.

5.3.6 The witness shall verify by appropriate means that critical measurements required for engine power and torque measurement are accurate. This may include testing of instrumentation.

5.3.7 Verify calculations by checking the output of the calculations with a test data set and by processing raw data from a test condition independently.

5.3.8 Verify that all control settings and test cell conditions are within the tolerance specified by the applicable standard.

5.3.9 Verify that the instrumentation is appropriately installed and that the signals from the instrumentation are accurately recorded and entered into the calculations.

5.3.10 Witness completion of the SAE J1349 or SAE J1995 Engine Power and Torque test procedure.

6. MANUFACTURER'S RESPONSIBILITIES FOR CERTIFICATION

A manufacturer wishing to certify an engine shall provide the following:

6.1 Test Article

The manufacturer shall provide an engine that is representative of the production engines being certified.

6.2 Manufacturer's Statement

The manufacturer shall supply documentation to SAE that includes the information listed in the following sections.

6.2.1 Engine Description

- All measurements and descriptions as listed in the appropriate standard
- Induction and exhaust system part name and part number list
- Listing of oil, fuel and coolant used with appropriate specifications
- Completed Form J2723 A. Engine Content Description
- ECU part number with software and calibration identifier/version
- Engine build phase

6.2.2 Declaration of Power and Torque

The manufacturer shall report the declared power, declared torque and the respective speeds at which those values are achieved. The power and torque shall be designated as net (SAE J1349) or gross (SAE J1995). The declared values are those values that the manufacturer can use as "SAE Certified" in their product advertising and sales literature. The measured values of torque and power must be at least 99% of the declared values to be certified.

6.2.3 Test results as documented in SAE J1349 or SAE J1995.

6.2.4 Certification Statement

The manufacturer shall complete and submit form SAE J2723B as the actual certification document.

6.2.5 Production Variation

Engines certified under this standard are subject to normal production variation. It is expected that most engines, when fully friction stabilized and tested in accordance with SAE J1349 or SAE J1995 will produce power and torque values that are at least 98% of their certified values.

7. SAE RESPONSIBILITY

7.1 Review of Certification Data

SAE shall do the following prior to adding an engine to its listing of Certified Power and Torque:

a. Review all documentation to establish:

   1. The engine description documentation is complete.

   2. The witness for engine testing was an SAE-qualified witness.

   3. The test data submitted are complete as required by SAE J1349 or SAE J1995.

   4. The manufacturer has completed and an authorized representative has signed the certification statement.

7.2 Maintaining of Data Repository

SAE shall maintain a database of the certification data submitted by the manufacturers.

8. OPTIONAL METHOD FOR MANUFACTURERS TO CERTIFY NATURALLY-ASPIRATED ENGINES FOR APPLICATIONS WITH VARYING BACKPRESSURE AND INDUCTION RESTRICTION

A manufacturer may elect to test only one engine in order to certify multiple power ratings of a base engine configuration where the only differences among the ratings result from changes in restriction of the induction system ahead of the throttle and/or exhaust restriction after the exhaust manifold. The architecture of the induction and exhaust systems and manifolds of the different applications must be sufficiently similar that there are not any tuning differences among them. Use of this procedure requires that the engine calibration provide equivalent combustion timing and fueling for applications rated. Equivalence for combustion timing and fueling is to be interpreted as allowing slight alterations due to the intake and exhaust restrictions but not allowing changes in air-fuel ratio or combustion timing which would degrade power beyond the effects of the intake and exhaust restrictions.

When it is desired to certify an engine with multiple ratings, the manufacturer shall provide a chart similar to Figure 1 showing the power of the engine as a function of intake restriction and exhaust back pressure. The "base value" for this chart shall be defined by the intake and exhaust restriction values determined using procedure SAE J1349. The witness shall verify the power determined for the "base value" and may require additional test points to verify the accuracy of the chart.

Charts such as Figure 1 may also be used for engine torque ratings. In this case, it is understood that some minor variation may occur in the speed at which peak torque is achieved. When a single engine is rated at multiple torque levels through this method, the torque ratings shall be those corresponding to the torque at the rated speed of the base application. Alternatively, a manufacturer may elect to provide tabular data for multiple power and torque ratings of the same engine. The witness may elect to validate any of those data.

The rationale for allowing the certification of multiple applications through a limited number of tests lies in the concept that the manufacturer is certifying the product, and the role of SAE is to serve as the registrar and to confirm that testing of a representative engine was conducted according to SAE procedures.

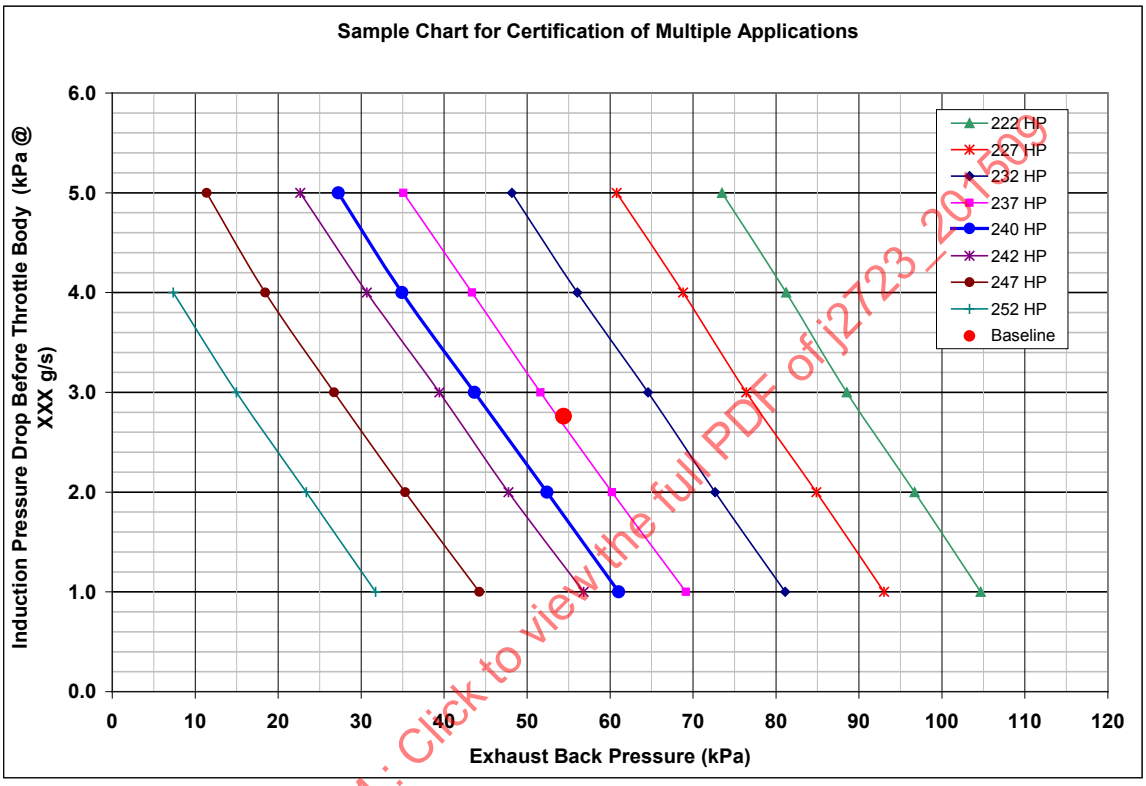

FIGURE 1 - SAMPLE ISOPOWER PLOT

9. OPTIONAL METHOD FOR MANUFACTURERS TO CERTIFY BOOSTED ENGINES FOR APPLICATIONS WITH VARYING BACKPRESSURE, INDUCTION RESTRICTION, AND / OR CHARGE AIR COOLER EFFECTIVENESS / MANIFOLD CHARGE TEMPERATURE

As with naturally aspirated engines, a manufacturer may elect to test only one engine in order to certify multiple power ratings of a base boosted engine configuration where the only differences among the ratings result from changes in the restriction of the induction system ahead of the throttle, charge air cooler effectiveness and / or exhaust restriction after the exhaust manifold, for supercharged applications or after the turbine outlet for turbocharged applications. The architecture of the induction and exhaust systems and manifolds of the different applications must be sufficiently similar that there are not any tuning differences among them. Also, the compressor map and / or turbine map must be consistent over the applications to be rated.

Unlike naturally-aspirated engines, it is expected that combustion phasing, manifold absolute pressure and potentially fueling may change as the differential pressure across the compressor or turbine (in the case of turbocharged applications) and / or the manifold charge temperature (MCT) varies. These changes can no longer be accommodated by a single isopower plot. Multiple isopower plots are required to cover the additional factors which affect engine performance. These plots can be generated experimentally or through the inclusion of a combustion / engine model. The use of a combustion / engine model is strongly recommended due to the time that would be required to complete the experimental process. The output of the combustion / engine model could be a regression equation.

When it is desired to certify a boosted engine with multiple ratings, the manufacturer shall provide a series of plots similar to Figure 2 showing the power of the engine as a function of the following four performance factors; 1) low pressure induction system, 2) high pressure induction system, 3) MCT or charge air cooler effectiveness and 4) exhaust back pressure. Individual plots will show the effect of two performance factors (exhaust backpressure and low pressure induction system restriction shown here) as the other two performance factors (high pressure restriction and charge air cooler (CAC) effectiveness in this example) are held constant. The number of plots submitted for this method must be sufficient to cover the complete range of the four performance factors for all the applications the manufacturer plans to certify. The “base value” for this plot shall be defined by the intake and exhaust restriction values determined using procedure SAE J1349. The witness shall verify the power determined for the “base value” and will require at least one additional test point to verify the accuracy of each plot. Manual setting of the calibration parameters, required per the combustion model to achieve the target power level, is acceptable for the setting of the validation test point.

In validating the accuracy of the plots, the power from any additional test points must be at least 99% of the power predicted by the plots / model.

9.1 DEFINITION OF THE HARDWARE

9.1.1 Low Pressure Air Induction System (AIS)

The low pressure air induction system begins at the point where air enters from the atmosphere and ends at the entrance to the compressor inlet.

9.1.2 High Pressure Air Induction System

The high pressure air induction system begins at the point where air exits the compressor and ends at the entrance to the cylinder head. The high pressure AIS includes the charge air cooler. If changes to the high pressure induction system significantly change engine tuning, an engine must be recertified through dynamometer testing.

9.1.3 Exhaust System

The exhaust system begins at the exit of the turbine or exhaust manifold and ends where the exhaust exits to the atmosphere.

9.1.4 Charge Air Cooler Effectiveness

Defined as:

$$100\% * \frac{Tcomp.out - MCT}{Tcomp.out - T\ ambient}$$

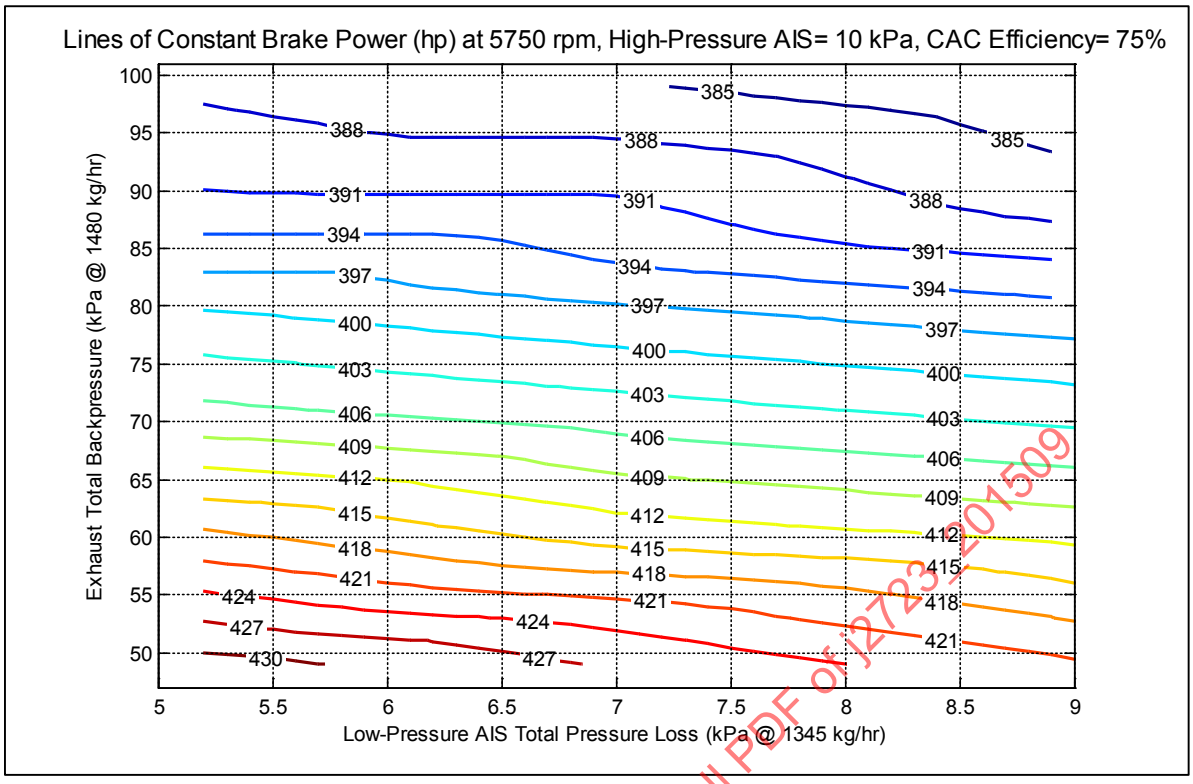

FIGURE 2 - SAMPLE ISOPOWER PLOT FOR BOOSTED APPLICATION

10. AMENDMENTS TO CERTIFICATION

It is inevitable that engines in production will see slight changes from year to year or within a year. An example of such a change might be the resourcing of a component from a different supplier, or the revision of a calibration to correct a problem or improve fuel consumption or emissions. When these changes result in a change in the power and torque values of an engine that are less than or equal to 2% of the previously certified values, a manufacturer may file an amendment to the certification and advertise those values as certified without performing additional witness tests. In no case shall the amended values deviate from the original witnessed values by more than 2%. Specifically, amended values can be amended a second time only if the values remain within 2% of the original values certified through witness testing.

Any amendment to an existing certification must be filed with SAE to be valid and must include a description of the changes in hardware or calibration that occurred as well as the new power and torque values resulting from the changes. The vehicles for which the amended values apply must also be indicated.

SAE J1349 CERTIFIED POWER. An SAE International Standard

SAE J1995 CERTIFIED POWER. An SAE International Standard

SAE Power Certification Form J2723 A

ENGINE DESCRIPTION SAMPLE (As Tested):

Displacement:	3700 cc
Configuration/Number of Cylinders:	60° V-6
Valve Train:	SOHC
Type:	Gasoline
Combustion Cycle:	Four Stroke
Pressure Charging:	Naturally Aspirated
Charge Air Cooling:	None
Bore:	93 mm
Stroke:	90.8 mm
Cylinder Numbering Convention	From front of crank nose rearward
Firing Order:	1-6-5-4-3-2 (120° Even Fire)
Compression Ratio:	9.7:1
Fuel System:	Port Fuel Injection
Fuel System Pressure	400 kPa (Nominal)
Ignition System:	Electronic Spark Ignited Coil on Plug
Knock Control:	Dual Wide-Band Knock Sensors
Intake Manifold:	Passive plastic shell molding
Exhaust Manifolds:	Cast Iron - Log Style
Cooling System:	Forced flow liquid cooling
Coolant Liquid:	50% water and 50% HOAT ethylene glycol (by volume)
Thermostat:	Inlet side – blocked open
Cooling Fan	Electric Motor Driven
Lubricating Oil:	SAE 5w30
Fuel:	Regular (87 PON)
Fuel Shut Off Speed:	6000 RPM

SAE J1349 CERTIFIED POWER. An SAE International Standard

SAE J1995 CERTIFIED POWER. An SAE International Standard

SAE Power Certification

Form J2723 B

MANUFACTURER: _____

ENGINE: _____

MODEL YEAR & VEHICLE APPLICATION: _____

TEST STANDARD: _____

TEST LOCATION: _____

ENGINE SERIAL NUMBER: _____

TEST/RUN NUMBER: _____

RESULTS:

The engine described herein was tested on Month, day, year, according to the requirements prescribed in SAE J_____, Engine Power Test Code in the presence of a qualified SAE witness, and was determined to produce the following results:

Parameter	Rated Speed	Rated Output	Measured Speed	Measured Output	% Difference
Power (hp/kW)					
Torque (lb-ft/Nm)					

APPROVALS:

_____

SAE Certified Witness, Date

The manufacturer declares that the engine tested for this report is representative of engines in series production. The manufacturer further declares that the performance of engines in series production will characteristically be at least 98% of the rated torque and power values indicated on this report.

_____

Name Title Date

WOT ENGINE TEST DATA SAMPLE

Parameter	Units											
Test Point		1	2	3	…	…	…	…	…	…	n-1	n
Engine Speed	rpm											
Observed Torque	lb-ft											
Observed Torque SI	N-m											
Corrected Torque	lb-ft											
Corrected Torque SI	N-m											
SAE Corrected Brake Power	hp											
Corrected Brake Power SI	kW											
Motoring Friction Torque	N-m											
Motoring Friction Power	kW											
Cooling Fan Loss (if applicable)	kW											
PS Pump Loss (if applicable)	kW											
SAE J1349 Correction Factor												
BMEP	kPa											
Air/Fuel Ratio (Left)	:1											
Air/Fuel Ratio (Right)	:1											
Mass Airlflow	g/sec											
Mass Fuel Flow	g/sec											
Fuel Meter Temperature	°C											
Fuel Rail Temperature	°C											
Coolant Outlet Temperature	°C											
Coolant Inlet Temperature	°C											
Oil Sump Temperature	°C											
Exhaust Gas Temperature (Left)	°C											
Exhaust Gas Temperature (Right)	°C											
Ambient Temperature	°C											
Inlet Air Temperature	°C											
Ambient Pressure	kPa											
Inlet Air Vapor Pressure	kPa											
Inlet Air Pressure	kPa											
Intake Manifold Pressure	kPa											
Fuel Rail Pressure	kPa											
Oil Pressure	kPa											
Exhaust Manifold Pressure (Left)	kPa											
Exhaust Manifold Pressure (Right)	kPa											
ecu_Engine Speed	rpm											
ecu_Mass Airflow	g/sec											
ecu_MAP	kPa											
ecu_Spark Advance	BTDC											
ecu_Intake Cam Phase Position	deg											
ecu_Exhaust Cam Phase Position	deg											
ecu_Commanded AFR (Left)	:1											
ecu_Commanded AFR (Right)	:1											
ecu_Throttle Position	volts											
ecu_Battery Voltage	volts											
ecu_Coolant Temperature	°C											
ecu_Charge Air Temperature	°C											
ecu_Barometric Pressure	kPa											
Boosted Engines Only												
Compressor Outlet Temperature	°C											
Manifold Inlet Temperature	°C											