2. RATING

CONTENTS

RATING

Engine output indications are standardized in accordance with engine application and type in each country and test methods specified accordingly.

Indications for KUBOTA engine ratings conform to the Japan Industrial Standards (JIS), SAE and ISO.

1. ENGINE TESTING METHODS

Normally, testing methods for engine performance vary according to use. These methods also vary by countries, although in most major respects they are the same.
Engine performance is determined by the following factors and the presence of accessories.

1) Fixed factors -
   Piston displacement, compression ratio, cam timing and other factors that cannot be changed during operation.
2) Variable factors -
   Revolution speed and other factors that can be changed during operation.
3) Environmental factors -
   Atmospheric pressure, temperature, humidity and others.
4) Accessories -
   Fan, muffler, air cleaner, speed change gears and other auxiliary equipment and accessories.

Therefor, engine performance can be determined only after taking into account the setting of variable factors, atmospheric conditions, and use of optional accessories. It is a common practice to select the annual mean value of the atmospheric conditions of the country in which the engine is used to minimize the error which must be corrected.
Engine performance is usually tested with the minimum number of accessories required for operation only.

Major standards for diesel engines are described below

2. STANDARD OF JAPAN, USA AND EUROPE

[1] PERFORMANCE TESTING METHODS

Country	Code number	Title
JAPAN	JIS B8002-1	Reciprocating internal combustion engines - Performance - Part 1 : Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods Part 3 : Test measurements Part 4 : Speed governing Part 5 : Torsional vibrations Part 6 : Overspeed protection Part 7 : Codes for engine power
	JIS B8014	Performance test method for constant revolution diesel engines
U.S.A.	SAE J1349	ENGINE POWER TEST CODE - SPARK IGNITION AND COMPRESSION IGNITION - NET POWER RATING
	SAE J1995	ENGINE POWER TEST CODE - SPARK IGNITION AND COMPRESSION IGNITION - GROSS POWER RATING
EUROPE	ISO 3046-1	Reciprocating internal combustion engines - Performance - Part 1 : Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods Part 3 : Test measurements Part 4 : Speed governing Part 5 : Torsional vibrations Part 6 : Overspeed protection Part 7 : Codes for engine power

[2] SCOPE, DECLARATIONS OF POWER AND STANDARD REFERENCE CONDITIONS

<table>
<tr><th></th><th>JIS B8002-1, ISO 3046-1</th><th>SAE J1995</th><th>SAE J1349</th></tr>
<tr><td rowspan="2">Scope</td><td>JIS B8002 :
All reciprocating internal combustion (R.I.C.) engines excluding engines used to aircraft.</td><td colspan="2" rowspan="2">1) 4 or 2 cycle engine.
2) Spark ignition or compression ignition engine.
3) N/A engine or engine with T/C or S/C and I/C.
4) Excluding engines used to aircraft or marine.</td></tr>
<tr><td>ISO 3046 :
R.I.C engines for land, rail - traction and marine use, excluding engines used to propel agricultural tractors, road vehicles and aircraft.</td></tr>
<tr><td rowspan="3">Declarations of power</td><td>1) Types of statement of power
ISO power :
The power determined under the operating conditions of the manufacturer’ s test bed and adjusted or corrected as determined by the manufacturer to the standard reference conditions.
Service power :
The power delivered under the ambient and operating conditions of an engine application.</td><td rowspan="3">Gross</td><td rowspan="3">Net</td></tr>
<tr><td>2) Types of power application
a) Continuous power
b) Overload power
c) Fuel stop power</td></tr>
<tr><td>3) Types of power
• Indicated power
• Brake power with
a) essential dependent auxiliaries.
b) essential independent auxiliaries.
c) non - essential dependent auxiliaries.</td></tr>
<tr><td rowspan="4">Standard reference conditions</td><td>Total barometric pressure :
Pr=100 kPa</td><td colspan="2">Inlet Air Supply Pressure (absolute) :
Pr=100 kPa</td></tr>
<tr><td>Ambient air temperature :
Tr=25 °C (77 °F)</td><td colspan="2">Inlet Air Supply Temperature :
Tr=25 °C (77 °F)</td></tr>
<tr><td>Relative humidity :
ϕr=30%
Relative humidity of 30% at a temperature of 25 °C (77 °F) corresponds to a water vapour pressure of 1 kPa.</td><td colspan="2">Dry Air Pressure (absolute)
Pb dry=99 kPa</td></tr>
<tr><td>Charge air coolant temperature :
Tcr=25 °C (77 °F)</td><td colspan="2">REFERENCE CI FUEL SPECIFICATIONS
Fuel Density at 15 °C (59 °F) =0.850 kg/L
Fuel Kinematic Viscosity at 40 °C (104 °F) =2.6 mm^2/s
Fuel Inlet Temperature=40 °C (104 °F)</td></tr>
</table>

[3] METHOD OF POWER CORRECTION

	JIS B8002-1, ISO 3046-1	SAE J1995	SAE J1349
Formula of power correction	Standard power = α × Text power ≒ α × Test power	Standard power = (CA × CF) × Test power CA ; Air correction factor CF ; Fuel correction factor	
Correction factor	$\alpha = (fa)^{fm}$	CA = $(fa)^{fm}$ CF = fd × fv	
Effective scope	0.9 < α <1.1 10 °C (50 °F) ≦ Intake air temperature ≦ 40 °C (104 °F) 80 kPa ≦ Dry air pressure ≦ 110 kPa	15 °C (59 °F) ≦ Intake air temperature ≦ 40 °C (104 °F) 90 kPa ≦ Dry air pressure ≦ 105 kPa	
Coefficient	Atmospheric factor : fa [For naturally aspirated engines mechanically pressure - charged engines and turbocharged engines with waste - gates operating] $fa = \left(\frac{99}{Pbdry}\right) \times \left(\frac{Tai + 273}{298}\right)^{0.7}$ [For turbocharged engines without charge air cooling or with charge cooling by air/air cooler] $fa = \left(\frac{99}{Pbdry}\right)^{0.7} \times \left(\frac{Tai + 273}{298}\right)^{1.2}$ [For turbocharged engines with charge air cooling by engine coolant] $fa = \left(\frac{99}{Pbdry}\right)^{0.7} \times \left(\frac{Tai + 273}{298}\right)^{0.7}$	1. Calculation of CA Atmospheric factor : fa [For naturally aspirated engines mechanically pressure - charged engines.] $fa = \left(\frac{99}{Pbdry}\right) \times \left(\frac{Tai + 273}{298}\right)^{0.7}$ [For turbocharged engines without charge air cooling or with charge cooling by air/air cooler] $fa = \left(\frac{99}{Pbdry}\right)^{0.7} \times \left(\frac{Tai + 273}{298}\right)^{1.2}$ [For turbocharged engines with charge air cooling by engine coolant] $fa = \left(\frac{99}{Pbdry}\right)^{0.7} \times \left(\frac{Tai + 273}{298}\right)^{0.7}$	
	Engine factor : fm $fm = 0.036 \times \frac{q}{R} - 1.14$ (37.2 < q/R < 65) fm = 0.2 (q/R ≦ 37.2) fm = 1.2 (65 ≦ q/R)	Engine factor : fm $fm = 0.036 \times \frac{q}{R} - 1.14$ (37.2 < q/R < 65) fm = 0.2 (q/R ≦ 37.2) fm = 1.2 (65 ≦ q/R)	
	Boost pressure ratio $R = \frac{PB + Pbc}{PB}$ (NA ; R=1)	Boost pressure ratio $R = \frac{PB + Pbc}{PB}$ (NA ; R=1)	
	Fuel mass per cycle per litre of engine swept volume $q = \frac{10^2 \times Be}{3 \times Ne \times Ve}$ mg/cyl.l	Fuel mass per cycle per litre of engine swept volume $q = \frac{10^2 \times Be}{3 \times Ne \times Ve}$ mg/cyl.l	
		2. Calculation of CF $fd = 1 + 0.70 \times \frac{0.850 - Sgo}{Sgo}$ $fv = \frac{1 + S/Vo}{1 + S/2.6} = \frac{1 + 0.15/Vo}{1 + 0.15/2.6}$ Sgo : Fuel density at testing (kg/L) Vo : Fuel viscosity at testing (mm^2/s)	

	JIS B8002-1, ISO 3046-1	SAE J1995	SAE J1349
Engine equipments	ISO standard power With essential dependent auxiliaries	Gross	Net
Intake air system	○	Option Minimum level restriction	○
Intake pipe	○		○
Air cleaner	○		○
Air heater		×	×
Charge air system Boost control settings	○	○	○
		○: In-use settings	○: In-use settings
Charge air cooling system	○	○	○
Charge air cooler	○	○	○
Fuel supply system	○	○	○
Fuel filter	○	Option	Option
Fuel feed pump	○	○	○
Fuel injection pump	○	○: In-use settings	○: In-use settings
Cooling system	○	○	○
Cooling water pump	○	○	○
Cooling fan	○	×	○
Thermostat		Option	Option
Lubricating system	○	○	○
Lubricating pump	○	○	○
Exhaust system	○	Option Minimum level restriction	○
Muffler	○		
			○
Emission control system	○	Option	○
Oil pump	×	×	×
Compressor for engine start	×	×	×
Ventilation fan	×	×	×