รายการอ้างอิง

[1] Heywoob, J.B. Internal combustion engine fundamentals. Singapore: McGraw-Hill, 1988.

[2] Sher, E. Handbook of air pollution from internal combustion engines – Pollutant formation and control. United States of America: Academic Press, 1998.

[3] ธำรง โชตะมังสะ,สุจิตต์ สนองคุณ.เชื้อเพลิงและวัสดุหล่อลื่น,เม็ดทรายพริ้นติ้ง

[4] สุรพล ราษฎร์นุ้ย. วิศวกรรมการบำรุงรักษา. กรุงเทพมหานคร: ซีเอ็ดยูเคชั่น, 2545.

[5] Focus Laboratories Ltd. Oil Analysis the complete course for maintenance professionals, (เอกสารประกอบการสัมมนา 15-17 ตุลาคม 2546).

[6] University of Idaho Department of Agricultural Engineering.EMA 200 Hour Test Hydrogenated Soy Ethyl Ester and Diesel Fuel

[7] J.Lyyranen , J.Jokiniemi , E. Kauppinen , J.Joutsensaari และ A. Auvinen,Particle Formation in medium speed diesel engines operating with heavy fuel oils.J.Aerasol Sci. Vol 29 Suppl.I,pp-s1003-s1004,1998

[8] J. Lyyranen, J. Jokiniemi, E. Kurkela, A. Auvinen and E. Norrmen,Particle Formation in medium speed diesel engines:THE EFFECT OF FUEL OIL ADDITIVE, J.Aerasol Sci. Vol 28 Suppl.I,pp-s47-s48,1997

[9] พิชญ์ ปริญญาจารย์., ผลของการใช้น้ำมันปาล์มดีเซลในเครื่องยนต์ CI ขนาดเล็กที่ใช้ในการเกษตร. วิทยานิพนธ์ปริญญามหาบัณฑิต ภาควิชาวิศวกรรมเครื่องกล คณะวิศวกรรมศาสตร์ บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย, 2546.

[10] บริษัท ระยองเพียวริฟายเออร์ จำกัด(มหาชน),TESTING REPORT OF DIESEL Doc.No:FM-OTS-009

[11] บริษัท ระยองเพียวริฟายเออร์ จำกัด(มหาชน),TESTING REPORT OF LSWR;IK(30:70) Doc.No:FM-TDS-009

[12] บริษัท ระยองเพียวริฟายเออร์ จำกัด(มหาชน),TESTING REPORT OF FUEL OIL Doc.No:FM-OTS-009

[13] บริษัท ระยองเพียวริฟายเออร์ จำกัด(มหาชน),TESTING REPORT OF IK Doc.No:FM-OTS-009

[14] Weng, W.,and D.E. Richardson. Cummins smart oil consumption measuring system. SAE paper No. 2000-01-0927 March 6-9 (2002): 3-4.

[15] ISO 3046 Internal Combustion Engines – Performance

Part 1 - Engines for land, rail-traction and marine use - Standard reference conditions and declamations of power, fuel consumption and lubricating oil consumption.

[16] Plint, M.,and Martyr, A. Engine Testing Theory and practice. 2 nd edition. Great Britain: Butterworth-Heinemann, 1999. Cited in Kastner, L.J. The air box method of measuring air consumption. Proc. I. Mech. E.,1947, 194.

บรรณานุกรม

1. Bary Blevins. Silicon enemy number one. [Online] WearCheck Africa 1990. Available from: http://www.wearcheck.com/literature/techdoc/WZA003.htm [12 March 2006]
2. Blaich, B. Diesel Fuel Injection. 1 st edition. Germany: Robert Bosch GmbH, 1994.
3. Ding, J. Determining Fatigue Wear Using Wear Particle Analysis Tools [Online]. Available from: http://www.practicingoilanalysis.com/article_detail.asp?articleid=526&relatedbookgroup=WearDebris [12 March 2006]
4. Geach, A. Detecting particles in oil (Part 1). Technical bulletin issue 24 [Online] 2002. Available from: http://www.wearcheck.com/literature/techdoc/WZA024.pdf [12 March 2006]
5. Geach, A. Detecting particles in oil (Part 2). Technical bulletin issue 25 [Online] 2002. Available from: http://www.wearcheck.com/literature/techdoc/WZA025.pdf [12 March 2006]
6. Geach, A. Infrared Analysis as a Tool for Assessing Degradation in Used Engine Lubricants [Online]. WearCheck Africa. 1996. Available from: http://www.wearcheck.com/literature/techdoc/WCA002.htm [12 March 2006]
7. John S Evans, B. Sc. and Neil Robinson, B. Sc. Hons, A. We are ready for more soot. Technical bulletin issue 26 [Online] 2005. Available from: http://www.wearcheck.com/literature/techdoc/WZA026.pdf [12 March 2006]
8. Owen, K.,and Trevor Coley. Automotive Fuels Reference Book. 2 nd edition. United ststes of America: Society of Automotive Engineers, 1995.
9. Quesnel, B. Direct-Reading and Analytical Ferrography [Online]. WearCheck Canada 1995. Available from: http://www.wearcheck.com/literature/techdoc/WCA001.htm [12 March 2006]
10. Whith, F.M. Fluid Mechanics. 4 th edition. Boston: McGraw-Hill, 1999.

ภาคผนวก

ภาคผนวก ก

มาตรฐาน ISO 3046 ที่เกี่ยวข้องกับการทดสอบเครื่องยนต์

มาตรฐาน ISO 3046 ที่เกี่ยวข้องกับการทดสอบเครื่องยนต์ [15]

International Combustion Engines - Performance

Part 1 - Engines for land, rail-traction and marine use - Standard reference conditions and declamations of power, fuel consumption and lubricating oil consumption

ก.1 Scope

This report of ISO 3046 specifies the standard reference conditions and the methods of declaring of power, fuel consumption and lubricating oil consumption for reciprocating internal combustion engines using liquid or gaseous for particular engine applications.

ก.2 Field of application

This part of ISO 3046 covers reciprocating internal combustion engines for land, rail-traction and marine use, excluding engines to propel agricultural tractors, road vehicles and aircraft.

This part of ISO 3046 may be applied to engines used to proper road construction and earth-moving machines, industrial trucks and for other applications where no suitable International Standard for these engines exist.

ก.3 References

ISO1000, SI units and recommendation for the use of their multiples and of certain other units.

ISO 1204, Reciprocating internal combustion engines - Designation of the direction of rotation.

ISO 1205, Reciprocating internal combustion engines - Designation of the direction of cylinders.

ISO 1585, Road vehicles - Engine test code - Net power.

ISO 2534, Road vehicles - Engine test code - Gross power.

ISO 2710, Reciprocating internal combustion engines - General definitions.

ISO 3046/2, Reciprocating internal combustion engines - Performance - Part 2 : Engine tests.

ISO 3046/4, Reciprocating internal combustion engines - Performance - Part 4 : Speed governing.

ISO 3046/6, Reciprocating internal combustion engines - Performance - Part 6 : Overspeed protection

ก.4 Units and terms

ก.4.1 The units used are those of the International System of Units (SI Unit) described in ISO 1000.

ก.4.2 The general engine terms used are as defined in ISO 2710.

ก.5 Standard reference conditions

For the purpose of determining the power and fuel consumption of engines, the following standard reference conditions shall be used :

Total barometric pressure :

$P_r = 100$ kPa

Air temperature :

$T_r = 300$ K (27 °c)

Relative humidity :

$\phi_r = 60$ %

Charge air coolant temperature :

$T_{cr} = 300$ K (27 °C)

If other reference conditions are chosen, these shall be stated.

NOTES

1. Relative humidity of 60% corresponds to a water vapor pressure of 2,133 kPa (16 mmHg) at a temperature of 300 K.

2. The air density at the standard reference conditions is equivalent to that at 98 kPa (376 mmHg) and 20 °C and to that at 101 kPa (760 mrnHg) and 30 °C

3. For automotive type inboard and outboard marine propulsion engines, the standard reference conditions in ISO 1585 and ISO 2534 may be applied but they shall be stated.

ก.6. Auxiliaries

ก.6.1 Introduction

In order to show alertly the conditions under which a power is determined, it is necessary to distinguish those auxiliaries which affect the final shaft output of the engine and also those which are necessary for the continuous or repeated use of the engine.
Items of equipment fined to the engine and without which the engine could not in any circumstance operate at its declared power are considered to be engine components and are not therefore, classed as auxiliaries.
(Such as fuel injection pump, exhaust turbocharger and charge air cooler are in this category of engine components.)

ก.6.2 dependent auxiliary : Item of equipment, the presence or absence of which affects the final shaft output of the engine.

ก.6.3 independent auxiliary : Item of equipment which uses power supplied from a source other than the engine.

ก.6.4 essential auxiliary : Item of equipment which is essential for the continued or repeated operation of the engine.

ก.6.5 non-essential auxiliary : Item of equipment which is not essential for the continued or repeated operation of the engine.

ก.7 Declarations of power

ก.7.1 Introduction

ก.7.1.1 Purpose of statement of power

Statements of power are required for two main purposes :

a) the declaration by a manufacturer of the value of the power which his engine will deliver under a given set of circumstances. This declared value is known as the "rated power".

b) the verification by measurement that the engine delivers the power which has been declared in a), under the same set of circumstances or after proper allowance has been made for any difference in circumstance.

To specify the set of circumstances under which the declared value of a power would be achieved, the declaration shall state :

a) the kind of statement of power (see 7.4) and of necessary, the ambient and operating condition (see 7.4.2).

b) the kind of power output (see 7.3).

c) the kind of power (see 7.3).

d) the corresponding engine speed.

NOTE

1. The term used in a) to c) may be combined, for example, continuous net brake fuel stop power.

2. Where appropriate to the engine application and the method of manufacture, the power achieved may be subject to a tolerance on the declared power. The existence of and its magnitude shall be stated by the manufacturer.

3. Measurement of the powers referred to in this International Standad shall be determined in accordance with ISO 3046/2.

ก.7.1.2 Unit of power

Power shall be expressed in kilowatts (kW) The addition of the equivalent metric or imperial "horsepower" is permitted for a transitional period.

ก.7.1.3 Power and torque

For engines delivering power by a shaft or shafts, any power in this International Standard is a quantity proportional to the mean torque, calculated or shafts transmitting this torque.

For engines delivering power other than by a shaft or shafts, reference shall be made to the appropriate International Standard for the driven for the driven machine.

ก.7.1.4 Engine speed

The speed of an engine is the mean rotational speed of its crankshaft or crankshatts in revolution per minute, except in the case of "free piston" engines where the speed is the number of cycles per minute of the reciprocating components.

ก.7.1.5 Engine with integral gearing

When stating the power of an engine fined with an integral (built-in) speed increasing or reducing device, the speed of the driving shaft extremist shall also be given at the declared engine speed.

ก.7.2 Kinds of power

ก.7.2.1 Indicated power

The total power developed in the working cylinders by the gases on the combustion side of the working pistons.

ก.7.2.2 Brake power

The power of the sum of the powers measured at the extremity of the engine driving shaft or shafts.

ก.7.2.2.1 Any statement of brake powers shall be supported by the following list of auxiliaries :

a) essential dependent auxiliaries as defined in 6.2 and 6.4;

b) essential independent as define in 6.3 and 6.4;

c) non-essential dependent auxiliaries as defined in 6.2 and 6.5.

The power absorbed by the independent and the non-essential dependent auxiliaries may be significant, in such cases, their power requirement shall be declared.

Note - Examples of typical auxiliaries are listed in annex A for guidance purposes. These lists are not necessary complete.

ก.7.2.3 Net brake power

The brake power measured when the engine is using only the auxiliaries listed in 7.2.2 a).

ก.7.3 Kinds of power output

ก.7.3.1 continuous power

Power which an engine is capable of delivering continuous, between the normal maintenance nitervals stated by the manufacturer, at stated speed and under stated ambient conditions, the maintenance prescribed by the manufacturer being carried out.

ก.7.3.1 Overload power

Power which an engine may be permitted to deliver, at stated ambient conditions, immediately after working at the continuous power.

The duration and frequency of use of overload power which is permitted will depend on the service application but adequate allowance shall be made in setting the engine fuel stop permit the overload power shall be expressed as a percentage of the continuous power, together with the duration and frequency permtted and the appropriate engine speed.

Unless otherwise stated an overload power of 110% of the continuous power at a speed corresponding to the engine application is permitted for a period of 12 hours of operation.

NOTES

1. The power of marine main propulsion engines is normally limited to to continuous power, so that the overload power cannot be given in service. However, for special applications, marine mnain propulsion engines may develop overload power in service.
2. If the engine application is not determined, the engine manufacturer shall specify the overload power and the corresponding engine speed.

ก.7,3.2 Fuel stop power

Power which an engine is capable of delivering during a stated period corresponding to its application, and at stated speed and under stated ambient conditions, with the fuel limit so that the fuel stop power cannot exceeded.

ก.7.4 Kinds of statements of power

ก.7.4.1 ISO powers

ก.7.4.1.1 ISO power

Power determined under the operating conditions of the manufacturer's test bad and adjusied to the standard reference conditions in clause 5.

ก.7.4.1.2 ISO standard power

The name given of the continuous net brake power which the engine manufacturer declares that an engine is capable of delivering continuously, between the normal maintenance intervals stated by the manufacturer, and under the following conditions :

a) at a stated speed under the operating conditions of the engine manufacturer's test bed;

b) with the declared power adjusted to the standard reference conditions given in clause 5;

c) the maintenance prescribed by the engine manufacturer being carried out.

ก.7.4.2 Service power

Power determined under the ambient and operating conditions of an engine application.

To establish service power, the following conditions shall be taken into account :

a) the ambient conditions, or any nominal ambient conditions according to the special requirements of inspecting and/or legislative authorities and/or classification societies, as specified by the customer (see clause 12);

b) the normal duty of the engine;

c) the expected interval between maintenance periods;

d) the nature and amount of the supervision required;

e) all information relevant to the operation of the engine in service (see clauses 12 and 13).

ก.8. Declarations of fuel consumption

ก.8.1 Definitions

ก.8.1.1 Fuel consumption

The quantity of fuel consumed by an engine per unit of time at a state power and under stated conditions.

The quantity of liquid fuels shall be expressed in mass units (kg).

The quantity of gaseous fuels shall be expressed in energy units (J).

ก.8.1.2 Specific fuel consumption

The fuel consumption per unit of power.

ก.8.1.3 ISO specific fuel consumption

The name given in the specific fuel consumption at the ISO standard power.

If not otherwise specified by the manufacturer, a declared specific fuel consumption shall be considered to be the ISO specific fuel consumption.

ก.8.2 Reference calorific value of fuels

ก.8.2.1 Liquid fuel engines

The declared specific fuel consumption of a liquid fuel engine shall be related to a reference lower calorific value of 42,000 kJlkg (10,030 kcal/kg).

ก.8.2.2 Gas engines

The declared specific fuel consumption of a gas engines shall be related to a stated lower calorific value the gas. The type of gas shall be declared.

ก.8.2.3 Specific fuel consumption declarations

The specific fuel consumption of an engine shall be declared at :

a) the ISO standard power;

b) (if required by special agreement) at any other declared powers and at specific engine speeds appropriate to the particular engine application.

Unless otherwise states, a deviation of +5% is permitted for the specific fuel consumption for the declared power.

ก.9. Declarations of lubricating oil consumption 1 Lubricating oil consumption

ก.9.1 Lubricating oil consumption

The quantity of lubricating oil consumed by an engine per unit of time. This quantity is used for guidance. It shall be expressed in litres or kilograms per engine operating hour at the declared power and engine speed.

ก.9.2 The lubricating oil consumption after a stated period of running-in sha!l be declared.

ก.9.3 The oil discarded during an engine oil change shall be not included in the lubricating oil consumption declaration.

ก.10. Adjustment of net brake power for ambient conditions

ก.10.1 When it is required to operate the engine under conditions difference from the standard reference conditions given in clause 5, the net brake power output shall be adjusted to or from the standard reference conditions by the following formulae (see note 1) :

$$P_x = \alpha P_r \qquad (ก\text{-}1)$$

$$\alpha = k - 0.7(1-k)\left(\frac{1}{\eta_m} - 1\right) \quad \text{(see note 2)} \qquad (ก\text{-}2)$$

$$k = \left(\frac{p_x - a\phi_x p_{sx}}{p_r - a\phi_r p_{sr}}\right)^m \left(\frac{T_r}{T_x}\right)^n \left(\frac{T_{cr}}{T_{cx}}\right)^q \qquad (ก\text{-}3)$$

ก.10.2 In the case of turbocharged engines in which the limits of turbocharger speed and turbocharger turbine inlet temperature have not been reached at the declared power under standard reference conditions, the manufacturer may declare substitute reference conditions to or from which power adjustments is to be made.
The following formulae (4) and (5) will then be used instead of formua (3)

$$k = \left(\frac{p_x}{p_r}\right)^m \left(\frac{T_r}{T_x}\right)^n \left(\frac{T_{cr}}{T_{cx}}\right)^q \qquad (ก\text{-}4)$$

$$p_{ra} = P_r \times \left(\frac{\pi_r}{\pi_{max}}\right) \qquad (ก\text{-}5)$$

Where :

P_r is the brake power;

p_r is the standard reference total barometric pressure;

p_{sr} is the saturation vapour pressure under standard reference conditions;

ϕ_r is the standard reference relative humidity;

T_r is the standard reference absolute air temperature;

T_{cr} is the standard reference absolute charge or coolant temperature;

P_{ra} is the substitute reference total barometric pressure given by formula (5);

T_{ra} is the substitute reference absolute air temperature to be stated by the manufacturer;

π_r is the boost pressure ratio at declared power under standard reference conditions to be stated by the manufacturer;

π_{max} is the maximum available boost pressure ratio to be stated by the manufacturer;

α is the power adjustment factor;

k is the ratio of indicated power;

η_m is the mechanical efficiency (see note 4);

P_x is the brake power under the conditions being considered;

p_x is the total barometric pressure condition being considered;

p_{sx} is the saturation vapour pressure under pressure the conditions being conside,ed;

ϕ_x is the relative humidity condition being considered;

T_x is the absolute air temperature being considered;

T_{cr} is the absolute charge air coolant temperature at charge air cooler inlet being considered.

The factor a and exponent m, n, and q have the numerical value given in table 1 (see note 5).

NOTES

1. For the convenience of users of these formulae, reference may be made to tables and nomograms in annexes B to 0, which also include numerical examples.

2. When the ambient conditions are more favouravle than the standard reference conditions, the declared power under the ambient conditions may be limit by the manufacturer to the declared power at the standard reference conditions.

3. If the relative humidity us not known, a value of 60% should be assumed in formulae references A, E and G in table 1.

For all other formulae references the power adjustment is independent of humidity (a =0).

4. The value of mechanical efficiency shall be stated by the engine manufacturer. In the absence of any such statement, the value of $\eta_m = 0.80$ will be assumed.

5. When declaring the ISO standard power the engine manufacturer shall state which of the fomulae references in table 1 is applicable.

Table n-1 - Numerical values for power adjustment

Engine type	Condition		Formula reference	Factor	Exponents		
				a	m	n	q
Compression ignition oil engine and dual-fuel engines	Non - turbocharged	Power limited by air excess	A	1	1	0.75	0
		Power limited by thermal reason	B	0	1	1	0
	Turbocarged without charge air cooling	Low and medium speed four-stroke engine	C	0	0.7	2	0
	Turbocarged with charge air cooling		D	0	0.7	1.2	1
Spark ignition engines using gaseous fuel	Non - turbocharged		E	1	0.86	0.56	0
	Turbocharged with charge air cooling	Low and medium speed four-speed engine	F	0	0.57	0.55	1.75
Spark ignition engines using liquid fuel	Naturally aspirated		G	1	1	0.5	0

NOTE - The factors and exponents given in table 1 have been established by tests on a number of engines to be generally representative and shall be used in the absence of nay other specific information; for example in formula reference D, for an engine with the charge air cooled by engine jacket water, the value for exponent q could be zero. At present, they apply only to the type of engines specified but table 1 will be extended to include other types when sufficient are available.

ก.11 Aajustment of fuel consumption for ambient conditions

ก.11.1 When it is required to operate the engine under conditions different from the standard reference conditions given in clause 5, the fuel consumption will differ from that declared for the standard reference conditions and shall be adjusted to or from the standard reference conditions.

The following formulae shall be used if other methods are not declared by the engine manufacturers :

$$b_x = \beta b_r \qquad (ก\text{-}6)$$

where

$$\beta = k/\alpha \qquad (ก\text{-}7)$$

where :

b is the specific fuel consumption

β is the fuel consumption adjustment factor

α is the power adjustment factor (see 10.1)

k is the ratio of indicated power (see 10.1)

Subscript r corresponds to values under the standard reference conditions.

Subscript x corresponds to values the conditions being considered.

NOTE - For the convenience of users of these formulae, reference may be made to the tables and nomograms in annexes B to 0, which also include numerical examples.

ก.12 Information to be supplied by the customer

The customer shall supply the following information concerning the required power :

a) The application and the power required from the engine and details arising therefrom.

b) The expected frequency and duration of the required powered and the corresponding engine speeds.

c) Site conditions

1) Site barometric pressure (highest and lowest reading available; if no pressure data are available the altitude above see level).

2) The monthly mean minimum and maximum air temperatures during the hottest and coldest months of the year.

3) The highest and lowest ambient air temperatures around the engine.

4) The relative humidity (or alternatively the water vapour pressure or the wet and dry bulb temperature) ruling at the maximum temperature conditions.

5) The maximum and minimum temperature of the cooling water available.

d) The specification and lower calorific value of the fuel available.

e) Whether the engine is to comply with the requirements of any classification society or with special requirements.

f) The probable period for which the engine will be running continuously, and the duration of maximum and minimum load.

g) Any other information appropriate to the particular engine application.

ก.13 Information to supplied by the engine manufacturer

The engine manufacturer shall supply the following information :

a) The declared powers.

b) The corresponding crankshaft and output shaft speeds.

NOTE - For certain applications of variable engines it is common practice to supply a power/speed diagram covering the ranges of power over which the engine can be used in continuous and in short period operation.

c) The direction of rotation (see ISO 1204).

d) The number and arrangement of cylinders (see ISO 1205).

e) Whether the engine is two-stroke or four-stroke, naturally aspired, mechanically pressure charge or turbocaharged and whether with or without charge air cooler.

f) The quantity of air required for the operation of the engine for :

1) combustion and scavenging;

2) cooling and ventilation.

g) The method of starting, apparatus supplied and additional apparatus required.

h) The type and grade of lubricating oil(s) recommended.

j) The type of governing, with speed droop of required (see ISO 3046/4 and ISO 3046/6).

If for variable speed duties, the working speed range and the idling speed.

If necessary, the critical speed range shall be indicated.

k) The method of cooling and the capacity of the cooing system with the rates of circulation of the cooling fluids.

m) (From air cooled engines only.) Whether hot air discharge ducting can be fitted.

n) A schedule recommended maintenance and overhaul periods.

p) Specifications and lower calorific values of fuels recommended.

q) Maximum permissible back-pressure in the exhaust system and the maximum permissible intake depression.

r) Any other information appropriate to the particular engine application.

ภาคผนวก ข

การวัดอัตราการไหลของอากาศ

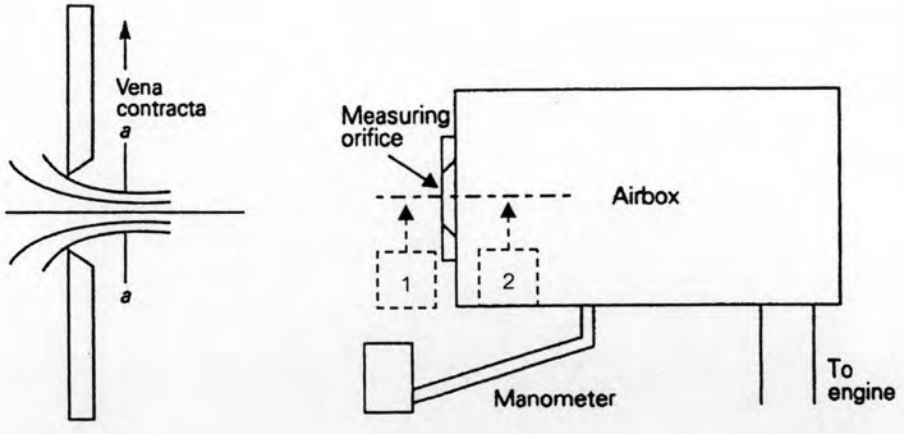
การวัดอัตราการไหลของอากาศด้วยวิธี Air box method [16]

การวัดอัตราการไหลของอากาศด้วยวิธี Air box method เป็นการวัดโดยใช้แผ่นออริฟิซประกอบกับถังพักอากาศ ซึ่งถังพักอากาศจะช่วยลดการกระเพื่อมของอากาศที่ถูกดูดตามจังหวะการทำงานของเครื่องยนต์ ทำให้อากาศที่ไหลผ่านออริฟิซมีอัตราการไหลที่สม่ำเสมอสามารถวัดความดันตกคล่อมได้ถูกต้องมากขึ้น

ขนาดเส้นผ่านศูนย์กลางของแผ่นออริฟิซโดยประมาณ ที่อัตราการไหลต่างๆ แสดงดังตาราง ข-1

ตาราง ข-1 แสดงขนาดเส้นผ่านศูนย์กลางของออริฟิซโดยประมาณที่อัตราการไหลต่างๆ

Orifice diameter (mm.)	Air Flow rate (m^3/s)	Mass Flow rate (kg/s)
10	0.002	0.002
20	0.008	0.009
50	0.048	0.057
100	0.19	0.23
150	0.43	0.51



รูปที่ ข-1 แสดงภาพการวัดอัตราการไหลของอากาศโดยวิธี Air box method [16]
ภาพซ้ายแสดงการไหลของอากาศผ่านแผ่น orifice plate
ภาพขวาแสดงภาพ Orifice flow meter

ปริมาตรของถังที่เล็กที่สุดที่จะทำให้ไม่เกิดการกระเพื่อมของอากาศที่ไหล ได้ถูกวิเคราะห์โดย Kastner [16] ดังสมการ (ข-1)

$$V_b = \frac{417x10^6 K^4 d^2}{N_c V_s n_{min}^2} \qquad (ข-1)$$

โดยที่ V_b คือ ปริมาตรถังพักอากาศที่เล็กที่สุด (m^3)

K คือ ค่าคงที่ มีค่าเท่ากับ 1 สำหรับเครื่องยนต์ 2 จังหวะ และ มีค่าเท่ากับ 2 สำหรับเครื่องยนต์ 4 จังหวะ

d คือ เส้นผ่านศูนย์กลางของ orifice plate (m)

N_c คือ จำนวนกระบอกสูบของเครื่องยนต์

V_s คือ ปริมาตรช่วงชักลูกสูบ (m^3)

N_{min} คือ ความเร็วรอบเครื่องยนต์ที่น้อยที่สุด (rev/min)

สมมติให้อากาศที่ไหลผ่าน orfice plate เป็นของไหลอัดตัวไม่ได้ (Incompressible flow) และพิจารณาให้ความหนาแน่นของอากาศคงที่ จากสมการเบอนูลี จะได้ว่า

$$\frac{p_1}{\gamma_{air}} + \frac{v_1^2}{2g} + Z_1 = \frac{p_2}{\gamma_{air}} + \frac{v_2^2}{2g} + Z_2 \qquad (ข-2)$$

โดยที่ p คือ ความดัน (kPa)

v คือ ความเร็วอากาศ (m/s)

γ_{air} คือ น้ำหนักจำเพาะของอากาศ ($kg/m^2\text{-}s^2$) = $\rho_{air} g$

ρ_{air} คือ ความหนาแน่นของอากาศ (kg/m^3) เท่ากับ 1.165 kg/m^3 ที่ 30°C

Z คือ ระดับความสูง (m)

g คือ ค่าความเร่งเนื่องจากแรงโน้มถ่วงของโลก (m/s^2) เท่ากับ 9.807 m/s^2

ตัวห้อย 1 และ 2 คือตำแหน่งสภาวะ 1 และ 2 ในรูป ข-1 ขวา ตามลำดับ

เนื่องจากสภาวะ 1 เป็นอากาศนิ่ง และทั้งสองสภาวะอยู่ในระดับความสูงเดียวกัน ดังนั้น จะได้ความเร็วของอากาศ ตามสมการที่ (ข-5)

$$v_2 = \sqrt{\frac{2\Delta p}{\rho_{air}}} \qquad (ข-3)$$

การไหลผ่าน orifice จะเกิด Vena contracta ซึ่งจะทำให้การไหลจริงน้อยกว่าทฤษฎีเสมอ ดังนั้นเมื่อคิดการไหลแบบคงตัว จะได้อัตราการไหลโดยมวลของอากาศ คือ

$$\dot{m}_a = C_{DO}\rho_{air} v A_o \qquad (ข\text{-}4)$$

โดยที่ C_{DO} คือ Discharge coefficient ของ orifice plate

A_o คือขนาดของ orifice (m^2)

การวัดผลต่างความดันตกคร่อม orifice plate จะวัดโดยใช้มานอมิเตอร์ ซึ่งจะได้ค่า head ในหน่วย mm.H_2O ซึ่งสามารถนำมาคำนวณหาผลต่างความดันตกคร่อม orifice plate ได้จากสมการ

$$\Delta p = \rho_{H_2O} g\ \Delta h \qquad (ข\text{-}5)$$

โดยที่ Δh คือ ผลต่าง Head ที่อ่านได้จากมานอมิเตอร์ (mmH_2O)

ρ_{H_2O} คือ ความหนาแน่นของอากาศ (kg/m^3) เท่ากับ 997 kg/m^3

เมื่อนำสมการ (ข-5) และ (ข-7) มาแทนลงในสมการ (ข-6) จะได้สมการที่นำไปใช้งาน คือ

$$\dot{m}_a = C_{DO} A_o \sqrt{2\rho_{air}\rho_{H_2O} g\ \Delta h} \qquad (ข\text{-}6)$$

ดังนั้นจากสมการ (ข-2) และ (ข-8) จะสามารถหาอัตราส่วนผสมเชื้อเพลิงต่ออากาศ และ Equivalent ratio ได้จากสมการดังต่อไปนี้

$$F/A = \frac{\rho_f V / t}{C_{DO} A_o \sqrt{2\rho_{air}\rho_{H_2O} g\ \Delta h}} \qquad (ข\text{-}7)$$

$$\text{Equivalent ratio} = \frac{(F/A)}{(F/A)_s}$$

ภาคผนวก ค

ข้อมูลผลการทดสอบสมรรถนะ

ตารางที่ ค-1 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 1,000 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1000	0.00	0.00	0.00	0.00	7.15	837	0.000100	0.000100	-	-	-	16.5	161.33	0.00927
500	1000	8.87	8.97	0.93	0.94	9.24	837	0.000129	0.000130	498.85	22.72	15.84	13.5	132.00	0.00834
1000	1000	11.57	11.71	1.21	1.23	11.59	837	0.000162	0.000163	479.53	21.85	16.48	13.2	129.06	0.00827
1500	1000	16.46	16.66	1.72	1.74	14.00	837	0.000195	0.000197	407.06	18.55	19.41	12.5	122.22	0.00806
2000	1000	21.46	21.71	2.25	2.27	16.47	837	0.000230	0.000232	367.45	16.74	21.50	12.2	119.29	0.00796
2500	1000	24.91	25.18	2.61	2.64	19.00	837	0.000265	0.000267	365.19	16.64	21.64	11.8	115.38	0.00784
FL	1000	32.39	32.59	3.39	3.41	22.07	837	0.000308	0.000309	326.46	14.87	24.20	11.2	109.51	0.00766

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1000	0	0.0108	0.16	56	72	30.2	136	33	755	0.9955	0.9947	1.0008	1.143755	0.08
500	1000	8.87	0.0155	0.22	58	76	30.2	167	35	751	0.9902	0.9885	1.0017	1.130311	0.21
1000	1000	11.57	0.0196	0.28	61	82	30.2	201	33	751	0.9902	0.9885	1.0017	1.137695	0.44
1500	1000	16.46	0.0242	0.35	63	90	30.2	244	32	751	0.9902	0.9885	1.0017	1.141424	2.53
2000	1000	21.46	0.0289	0.42	64	96	30.2	284	32	751	0.9902	0.9885	1.0017	1.141424	3.47
2500	1000	24.91	0.0338	0.49	66	101	30	332	31	751	0.9908	0.9892	1.0016	1.145177	3.79
FL	1000	32.39	0.0402	0.58	70	102	30	355	31	754	0.9948	0.9939	1.0009	1.149751	4.19

ตารางที่ ค-2 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 1,200 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1200	0	0	0	0	8.2	837	0.000114	0.000116	-	-	-	20.3	198.48	0.01025
500	1200	7.96	8.05	1	1.01	9.88	837	0.000138	0.000139	495.32	22.63	15.95	19.8	193.6	0.01013
1000	1200	11.14	11.27	1.4	1.42	12	837	0.000167	0.000169	429.71	19.54	18.39	19.3	188.71	0.01
1500	1200	15.44	15.64	1.94	1.97	14.39	837	0.000201	0.000203	371.78	16.93	21.25	18.9	184.8	0.00988
2000	1200	19.1	19.35	2.4	2.43	16.62	837	0.000232	0.000234	347.09	15.8	22.77	18.3	178.93	0.00972
2500	1200	23.32	23.62	2.93	2.97	19.38	837	0.00027	0.000273	331.52	15.11	23.83	17.2	168.17	0.00942
3000	1200	28.33	28.7	3.56	3.61	22.99	837	0.000321	0.000324	323.68	14.74	24.41	16.5	161.33	0.00923
3500	1200	33.5	33.7	4.21	4.24	24.26	837	0.000338	0.00034	289.13	13.22	27.33	12	117.33	0.00793
FL	1200	36.61	36.79	4.6	4.62	27.5	837	0.000384	0.000385	300	13.59	26.34	10.8	105.6	0.00753

ตารางที่ ค-2 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 1,200 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1200	0	0.0112	0.16	62	73	31.2	141	34	753	0.9898	0.988	1.0018	1.137313	0.11
500	1200	7.96	0.0136	0.2	67	77	31.2	165	34	754	0.9902	0.9885	1.0017	1.137766	0.11
1000	1200	11.14	0.0167	0.24	70	81	31.2	195	34	754	0.9902	0.9885	1.0017	1.137766	0.13
1500	1200	15.44	0.0203	0.29	74	87	31.4	229	35	753	0.9889	0.987	1.002	1.133321	0.21
2000	1200	19.1	0.0239	0.35	79	94	31.4	259	35	753	0.9889	0.987	1.002	1.133321	0.4
2500	1200	23.32	0.0287	0.42	82	96	31.4	305	35	753	0.9889	0.987	1.002	1.133321	1.91
3000	1200	28.33	0.0348	0.5	84	97	31.4	344	35	753	0.9889	0.987	1.002	1.133321	2.64
3500	1200	33.5	0.0427	0.62	88	98	30.2	370	31	755	0.9949	0.9941	1.0009	1.150666	3.47
FL	1200	36.61	0.051	0.74	90	104	30.2	418	31	755	0.9957	0.995	1.0008	1.151581	3.83

ตารางที่ ค-3 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 1,500 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1500	0.00	0.00	0.00	0.00	9.22	837	0.000129	0.000130	-	-	-	26.75	261.55	0.01181
500	1500	6.37	6.44	1.00	1.01	10.74	837	0.000150	0.000151	538.49	24.61	14.67	26	254.22	0.01163
1000	1500	9.61	9.72	1.51	1.53	12.64	837	0.000176	0.000178	419.71	19.15	18.83	25.2	246.39	0.01145
1500	1500	13.31	13.45	2.09	2.11	15.26	837	0.000213	0.000215	366.09	16.71	21.58	24.4	238.57	0.01127
2000	1500	16.42	16.60	2.58	2.61	17.05	837	0.000238	0.000240	331.35	15.09	23.85	24	234.66	0.01117
2500	1500	20.44	20.69	3.21	3.25	20.50	837	0.000286	0.000289	320.13	14.59	24.68	23.6	230.75	0.01109
3000	1500	24.00	24.30	3.77	3.82	22.27	837	0.000311	0.000314	296.11	13.50	26.68	22.5	220.00	0.01083
3500	1500	27.63	27.82	4.34	4.37	25.03	837	0.000349	0.000351	289.33	13.17	27.31	22.2	217.06	0.01076
4000	1500	31.39	31.60	4.93	4.96	26.74	837	0.000373	0.000375	272.11	12.39	29.04	21.1	206.31	0.01051
4500	1500	34.57	34.81	5.43	5.47	29.89	837	0.000417	0.000419	276.16	12.63	28.61	20.7	202.40	0.01041
FL	1500	38.52	38.68	6.05	6.08	36.85	837	0.000514	0.000516	305.69	13.93	25.85	19.6	191.64	0.01014

ตารางที่ ค-3 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 1,500 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1500	0.00	0.0109	0.16	66	72	30.5	141	32	754	0.9926	0.9913	1.0013	1.145375	0.08
500	1500	6.37	0.0129	0.19	70	75	31.2	160	33	754	0.9909	0.9893	1.0016	1.14224	0.21
1000	1500	9.61	0.0154	0.22	74	80	31.2	181	33	754	0.9909	0.9893	1.0016	1.14224	0.53
1500	1500	13.31	0.0189	0.27	77	85	31.2	208	33	754	0.9909	0.9893	1.0016	1.14224	0.87
2000	1500	16.42	0.0213	0.31	79	88	31.2	233	33	754	0.9909	0.9893	1.0016	1.14224	1.18
2500	1500	20.44	0.0258	0.37	84	97	31.4	262	32	754	0.9896	0.9877	1.0018	1.145223	1.59
3000	1500	24.00	0.0287	0.42	86	98	31.4	297	32	754	0.9896	0.9877	1.0018	1.145223	1.83
3500	1500	27.63	0.0325	0.47	88	99	30.0	327	32	754	0.9941	0.9931	1.0010	1.145223	2.29
4000	1500	31.39	0.0355	0.51	89	102	30.0	358	31	754	0.9941	0.9931	1.0010	1.148989	2.65
4500	1500	34.57	0.0401	0.58	91	106	30.0	410	31	754	0.9941	0.9931	1.0010	1.148989	3.03
FL	1500	38.52	0.0507	0.73	93	107	30.0	456	31	755	0.9964	0.9958	1.0006	1.151581	3.53

ตารางที่ ค-4 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 1,800 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1800	0.00	0.00	0.00	0.00	11.44	837	0.000160	0.000161	-	-	-	31	303.10	0.01270
500	1800	5.73	5.78	1.08	1.09	12.92	837	0.000180	0.000182	599.95	27.31	13.17	30	293.33	0.01250
1000	1800	7.69	7.76	1.45	1.46	14.71	837	0.000205	0.000207	508.77	23.25	15.53	29.8	291.37	0.01243
1500	1800	11.09	11.19	2.09	2.11	16.92	837	0.000236	0.000238	406.01	18.46	19.46	29.5	288.44	0.01239
2000	1800	14.11	14.24	2.66	2.68	18.89	837	0.000264	0.000266	356.15	16.23	22.19	29.3	286.48	0.01235
2500	1800	16.87	17.03	3.18	3.21	21.35	837	0.000298	0.000300	336.70	15.32	23.47	28.5	278.66	0.01218
3000	1800	20.37	20.52	3.84	3.87	23.91	837	0.000334	0.000336	312.36	14.24	25.30	28	273.77	0.01207
3500	1800	22.87	23.03	4.31	4.34	25.50	837	0.000356	0.000358	296.80	13.51	26.62	27.5	268.88	0.01198
4000	1800	25.89	26.08	4.88	4.92	28.00	837	0.000391	0.000393	287.83	13.11	27.45	27	263.99	0.01187
4500	1800	28.59	28.80	5.39	5.43	30.49	837	0.000425	0.000428	283.77	12.93	27.84	26	254.22	0.01165
5000	1800	31.51	31.74	5.94	5.98	33.80	837	0.000472	0.000474	285.45	13.01	27.68	25.5	249.33	0.01154
5500	1800	34.85	35.11	6.57	6.62	38.90	837	0.000543	0.000546	297.02	13.53	26.60	23.7	231.73	0.01112
FL	1800	38.73	38.99	7.30	7.35	45.00	837	0.000628	0.000631	309.26	14.08	25.55	22.5	220.00	0.01086

ตารางที่ ค-4 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 1,800 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1800	0.00	0.0126	0.18	71	77	31.0	156	33	755	0.9922	0.9908	1.0014	1.142997	0.09
500	1800	5.73	0.0144	0.21	77	78	31.0	172	33	755	0.9922	0.9908	1.0014	1.142997	0.19
1000	1800	7.69	0.0165	0.24	79	81	31.0	188	34	755	0.9922	0.9908	1.0014	1.139276	0.29
1500	1800	11.09	0.0190	0.28	81	83	31.0	210	33	755	0.9922	0.9908	1.0014	1.142997	0.40
2000	1800	14.11	0.0213	0.31	85	86	31.0	232	33	755	0.9922	0.9908	1.0014	1.142997	0.50
2500	1800	16.87	0.0245	0.35	88	91	31.0	255	33	755	0.9922	0.9908	1.0014	1.142997	0.59
3000	1800	20.37	0.0276	0.40	88	94	30.5	282	33	755	0.9938	0.9927	1.0011	1.142997	0.68
3500	1800	22.87	0.0297	0.43	90	97	30.5	307	32	755	0.9938	0.9927	1.0011	1.146743	0.77
4000	1800	25.89	0.0329	0.48	91	100	30.5	334	32	755	0.9938	0.9927	1.0011	1.146743	0.88
4500	1800	28.59	0.0365	0.53	93	104	30.5	364	32	755	0.9938	0.9927	1.0011	1.146743	0.98
5000	1800	31.51	0.0409	0.59	95	105	30.5	396	32	755	0.9938	0.9927	1.0011	1.146743	1.12
5500	1800	34.85	0.0488	0.71	96	107	30.5	440	32	755	0.9938	0.9927	1.0011	1.146743	1.21
FL	1800	38.73	0.0578	0.84	98	108	30.5	471	31	755	0.9942	0.9932	1.0010	1.151691	1.86

ตารางที่ ค-5 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 2,000 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	2000	0.00	0.00	0.00	0.00	12.67	837	0.000177	0.000178	-	-	-	32.2	314.84	0.01288
500	2000	4.49	4.54	0.94	0.95	15.65	837	0.000218	0.000220	834.71	38.05	9.47	32.7	319.73	0.01296
1000	2000	5.83	5.89	1.22	1.23	17.13	837	0.000239	0.000241	703.96	32.09	11.22	32.5	317.77	0.01292
1500	2000	9.36	9.46	1.96	1.98	19.70	837	0.000275	0.000277	503.92	22.91	15.68	32	312.88	0.01282
2000	2000	11.89	12.02	2.49	2.52	21.51	837	0.000300	0.000303	433.10	19.72	18.24	32	312.88	0.01282
2500	2000	14.28	14.44	2.99	3.02	23.69	837	0.000330	0.000334	397.23	18.08	19.89	31.6	308.97	0.01274
3000	2000	17.43	17.62	3.65	3.69	26.66	837	0.000372	0.000375	366.20	16.70	21.58	31.9	311.90	0.01280
3500	2000	19.67	19.89	4.12	4.17	28.82	837	0.000402	0.000406	350.71	15.97	22.53	31.5	307.99	0.01274
4000	2000	22.20	22.45	4.65	4.70	31.03	837	0.000433	0.000437	334.56	15.24	23.62	31	303.10	0.01264
4500	2000	25.50	25.78	5.34	5.40	33.91	837	0.000473	0.000478	318.37	14.49	24.82	31	303.10	0.01266
5000	2000	27.93	28.18	5.85	5.90	36.77	837	0.000513	0.000517	315.24	14.36	25.07	30.5	298.22	0.01255
5500	2000	30.70	30.97	6.43	6.49	39.89	837	0.000556	0.000561	311.14	14.17	25.40	30.5	298.22	0.01255
6000	2000	32.71	33.00	6.85	6.91	42.89	837	0.000598	0.000603	314.03	14.30	25.16	31	303.10	0.01263
FL	2000	35.62	35.94	7.46	7.53	46.88	837	0.000654	0.000659	315.17	14.37	25.07	31	303.10	0.01269

ตารางที่ ค-5 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 2,000 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	2000	0.00	0.0137	0.20	78	84	30.5	185	35	752	0.9905	0.9889	1.0017	1.131816	0.07
500	2000	4.49	0.0168	0.24	87	90	30.5	197	36	752	0.9905	0.9889	1.0017	1.128154	0.10
1000	2000	5.83	0.0185	0.27	90	93	30.5	213	36	752	0.9905	0.9889	1.0017	1.128154	0.15
1500	2000	9.36	0.0214	0.31	91	94	30.5	232	36	752	0.9905	0.9889	1.0017	1.128154	0.28
2000	2000	11.89	0.0234	0.34	93	96	30.5	254	36	752	0.9905	0.9889	1.0017	1.128154	0.55
2500	2000	14.28	0.0259	0.38	93	97	30.5	276	36	752	0.9905	0.9889	1.0017	1.128154	0.66
3000	2000	17.43	0.0291	0.42	95	98	30.5	303	36	752	0.9905	0.9889	1.0017	1.128154	0.78
3500	2000	19.67	0.0316	0.46	96	101	30.5	322	35	752	0.9905	0.9889	1.0017	1.131816	0.90
4000	2000	22.20	0.0342	0.50	97	103	30.5	347	35	752	0.9905	0.9889	1.0017	1.131816	0.98
4500	2000	25.50	0.0374	0.54	99	103	30.5	371	34	752	0.9905	0.9889	1.0017	1.135501	1.07
5000	2000	27.93	0.0409	0.59	100	105	30.5	398	35	754	0.9925	0.9912	1.0013	1.134073	1.18
5500	2000	30.70	0.0443	0.64	101	106	30.5	432	35	754	0.9925	0.9912	1.0013	1.134073	2.24
6000	2000	32.71	0.0474	0.69	104	109	30.5	465	36	754	0.9925	0.9912	1.0013	1.130405	1.56
FL	2000	35.62	0.0515	0.75	105	110	30.5	488	33	754	0.9925	0.9912	1.0013	1.141482	1.85

ตารางที่ ค-6 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 2,400 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	2400	0.00	0.00	0.00	0.00	18.15	837	0.000253	0.000255	-	-	-	43	420.44	0.01501
500	2400	4.18	4.21	1.05	1.06	19.22	837	0.000268	0.000270	918.37	41.84	8.60	45.7	446.84	0.01548
1000	2400	5.57	5.61	1.40	1.41	21.26	837	0.000297	0.000298	761.89	34.71	10.37	45.7	446.84	0.01548
1500	2400	8.40	8.45	2.11	2.12	23.37	837	0.000326	0.000328	555.69	25.32	14.22	45.7	446.84	0.01548
2000	2400	10.35	10.41	2.60	2.62	25.05	837	0.000349	0.000351	483.38	22.02	16.35	45.5	444.88	0.01544
2500	2400	11.90	11.97	2.99	3.01	26.75	837	0.000373	0.000375	448.86	20.45	17.60	45	439.99	0.01536
3000	2400	13.81	13.90	3.47	3.49	28.82	837	0.000402	0.000404	416.70	18.98	18.96	44.5	435.10	0.01530
3500	2400	16.83	16.94	4.23	4.26	31.05	837	0.000433	0.000436	368.28	16.78	21.46	44	430.21	0.01521
4000	2400	18.34	18.47	4.61	4.64	33.37	837	0.000466	0.000468	363.14	16.54	21.76	47	459.55	0.01562
4560	2400	21.80	21.96	5.48	5.52	36.56	837	0.000510	0.000513	334.69	15.25	23.61	46.8	457.59	0.01556
5000	2400	23.32	23.48	5.86	5.90	39.01	837	0.000544	0.000547	333.96	15.22	23.66	46.4	453.68	0.01552
5500	2400	25.86	26.05	6.50	6.55	42.15	837	0.000588	0.000592	325.31	14.82	24.29	45.4	443.90	0.01535
6000	2400	28.01	28.21	7.04	7.09	44.89	837	0.000626	0.000630	319.88	14.57	24.70	44.2	432.17	0.01514
6500	2400	30.56	30.78	7.68	7.73	48.87	837	0.000682	0.000686	319.22	14.54	24.75	42.8	418.48	0.01490
FL	2400	32.31	32.52	8.12	8.17	50.84	837	0.000709	0.000713	314.13	14.31	25.15	40	391.10	0.01443

ตารางที่ ค-6 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Diesel ที่ความเร็วรอบ 2,400 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	2400	0.00	0.0169	0.24	69	81	30.5	197	31	755	0.9945	0.9935	1.0010	1.151276	0.06
500	2400	4.18	0.0173	0.25	89	93	30.5	211	31	755	0.9945	0.9935	1.0010	1.151276	0.09
1000	2400	5.57	0.0192	0.28	94	92	30.5	224	31	755	0.9945	0.9935	1.0010	1.151276	0.08
1500	2400	8.40	0.0211	0.31	96	93	30.5	241	31	755	0.9945	0.9935	1.0010	1.151276	0.08
2000	2400	10.35	0.0226	0.33	97	94	30.5	257	31	755	0.9945	0.9935	1.0010	1.151276	0.18
2500	2400	11.90	0.0243	0.35	98	97	30.5	277	31	755	0.9945	0.9935	1.0010	1.151276	0.20
3000	2400	13.81	0.0263	0.38	99	97	30.5	294	30	755	0.9945	0.9935	1.0010	1.155074	0.26
3500	2400	16.83	0.0285	0.41	99	97	30.5	313	30	755	0.9945	0.9935	1.0010	1.155074	0.29
4000	2400	18.34	0.0298	0.43	98	101	30.5	333	34	755	0.9940	0.9929	1.0011	1.139427	0.36
4560	2400	21.80	0.0328	0.48	100	103	30.5	362	35	755	0.9940	0.9929	1.0011	1.135729	0.44
5000	2400	23.32	0.0351	0.51	102	104	30.5	384	34	755	0.9940	0.9929	1.0011	1.139427	0.59
5500	2400	25.86	0.0383	0.56	104	106	30.5	411	34	755	0.9940	0.9929	1.0011	1.139427	0.69
6000	2400	28.01	0.0414	0.60	105	108	30.5	438	34	755	0.9940	0.9929	1.0011	1.139427	1.20
6500	2400	30.56	0.0457	0.66	106	110	30.5	470	34	755	0.9940	0.9929	1.0011	1.139427	1.41
FL	2400	32.31	0.0491	0.71	108	110	30.5	479	33	755	0.9945	0.9935	1.0010	1.143755	1.81

ตารางที่ ค-7 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทาน ที่ความเร็วรอบ 1,000 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1000	0.00	0.00	0.00	0.00	7.75	841.1	0.000109	0.000109	-	-	-	10.3	100.71	0.00736
500	1000	10.45	10.49	1.09	1.10	10.29	841.1	0.000144	0.000145	474.26	21.18	17.00	11	107.55	0.00758
1000	1000	13.14	13.19	1.38	1.38	12.07	841.1	0.000169	0.000170	442.36	19.76	18.22	10.5	102.66	0.00741
1500	1000	19.51	19.59	2.04	2.05	14.84	841.1	0.000208	0.000209	366.29	16.36	22.01	10.4	101.69	0.00737
2000	1000	25.23	25.33	2.64	2.65	17.52	841.1	0.000246	0.000246	334.37	14.93	24.11	10.4	101.69	0.00737
2500	1000	30.41	30.53	3.18	3.20	20.67	841.1	0.000290	0.000291	327.34	14.62	24.63	10	97.78	0.00723
FL	1000	32.55	32.67	3.41	3.42	24.18	841.1	0.000339	0.000340	357.81	15.98	22.53	12.3	120.26	0.00802

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1000	0.00	0.0148	0.21	62	71	29	139	30	753	0.9968	0.9962	1.0006	1.153469	0.12
500	1000	10.45	0.0190	0.28	65	73	29	176	31	753	0.9968	0.9962	1.0006	1.148226	0.29
1000	1000	13.14	0.0228	0.33	66	78	29	203	31	753	0.9968	0.9962	1.0006	1.148226	0.61
1500	1000	19.51	0.0282	0.41	70	84	29	251	31	753	0.9968	0.9962	1.0006	1.148226	2.65
2000	1000	25.23	0.0333	0.48	74	89	29	291	31	753	0.9968	0.9962	1.0006	1.148449	3.33
2500	1000	30.41	0.0401	0.58	79	96	29	342	31	753	0.9968	0.9962	1.0006	1.148226	3.79
FL	1000	32.55	0.0423	0.61	84	101	29	383	31	753	0.9968	0.9962	1.0006	1.148226	4.00

ตารางที่ ค-8 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทาน ที่ความเร็วรอบ 1,200 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1200	0.00	0.00	0.00	0.00	8.69	841.1	0.000122	0.000122	-	-	-	18	176.00	0.00970
500	1200	8.38	8.39	1.05	1.05	10.13	841.1	0.000142	0.000142	485.38	21.68	16.61	18	176.00	0.00970
1000	1200	11.17	11.17	1.40	1.40	12.25	841.1	0.000172	0.000172	440.62	19.68	18.29	17.9	175.02	0.00967
1500	1200	17.29	17.32	2.17	2.18	14.68	841.1	0.000206	0.000206	340.94	15.23	23.64	17.5	171.11	0.00957
2000	1200	21.78	21.82	2.74	2.74	17.27	841.1	0.000242	0.000242	318.29	14.22	25.33	17.4	170.13	0.00952
2500	1200	25.71	25.81	3.23	3.24	20.40	841.1	0.000286	0.000287	318.37	14.22	25.32	16.4	160.35	0.00924
3000	1200	29.30	29.41	3.68	3.70	22.95	841.1	0.000322	0.000323	314.44	14.04	25.64	16.4	160.35	0.00923
3500	1200	33.29	33.44	4.18	4.20	26.49	841.1	0.000371	0.000373	319.35	14.26	25.24	16.9	165.24	0.00938
FL	1200	35.62	35.78	4.48	4.50	28.41	841.1	0.000398	0.000400	320.04	14.29	25.19	16	156.44	0.00913

ตารางที่ ค-8 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทานที่ความเร็วรอบ 1,200 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1200	0.00	0.0126	0.18	62	71	28	142	31	753	1.0001	1.0001	1.0000	1.148226	0.12
500	1200	8.38	0.0146	0.21	67	74	28	165	31	753	0.9994	0.9993	1.0001	1.148226	0.10
1000	1200	11.17	0.0178	0.26	69	77	28	190	31	753	0.9994	0.9993	1.0001	1.148226	0.11
1500	1200	17.29	0.0215	0.31	72	81	29	229	31	753	0.9984	0.9981	1.0003	1.148226	0.18
2000	1200	21.78	0.0254	0.37	75	86	29	265	32	753	0.9984	0.9981	1.0003	1.144463	0.67
2500	1200	25.71	0.0309	0.45	77	88	29	293	32	753	0.9968	0.9962	1.0006	1.144463	2.06
3000	1200	29.30	0.0349	0.51	79	95	29	351	33	753	0.9968	0.9962	1.0006	1.140725	2.86
3500	1200	33.29	0.0396	0.57	85	104	29	404	32	753	0.9961	0.9954	1.0007	1.143802	3.50
FL	1200	35.62	0.0436	0.63	88	103	29	426	32	753	0.9961	0.9954	1.0007	1.144463	3.86

ตารางที่ ค-9 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทาน ที่ความเร็วรอบ 1,500 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1500	0.00	0.00	0.00	0.00	9.58	841.1	0.000134	0.0001347	-	-	-	20.3	198.48	0.01030
500	1500	6.88	6.91	1.08	1.09	10.93	841.1	0.000153	0.0001537	509.95	22.78	15.81	20.5	200.44	0.01030
1000	1500	8.88	8.92	1.40	1.40	12.83	841.1	0.00018	0.0001804	463.71	20.71	17.38	21	205.33	0.01050
1500	1500	13.81	13.87	2.17	2.18	15.74	841.1	0.000221	0.0002215	365.98	16.35	22.03	22.3	218.04	0.01080
2000	1500	17.41	17.51	2.74	2.75	17.84	841.1	0.00025	0.0002513	328.89	14.69	24.51	22.4	219.02	0.01080
2500	1500	20.66	20.80	3.25	3.27	19.88	841.1	0.000279	0.0002803	308.79	13.79	26.10	22.3	218.04	0.01080
3000	1500	24.72	24.89	3.88	3.91	22.93	841.1	0.000321	0.0003233	297.78	13.30	27.07	22.4	219.02	0.01080
3500	1500	28.13	28.32	4.42	4.45	25.48	841.1	0.000357	0.0003594	290.79	12.99	27.72	22.4	219.02	0.01080
4000	1500	31.59	31.81	4.96	5.00	28.19	841.1	0.000395	0.0003976	286.41	12.79	28.14	22.3	218.04	0.01080
4500	1500	34.48	34.72	5.42	5.45	31.37	841.1	0.00044	0.0004424	292.07	13.05	27.60	22.4	219.02	0.01080
FL	1500	39.68	39.95	6.23	6.28	38.40	841.1	0.000538	0.0005415	310.61	13.87	25.95	22	215.11	0.01070

ตารางที่ ค-9 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทานที่ความเร็วรอบ 1,500 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1500	0.00	0.0130	0.19	63	72	29	141	31	752.9	0.9966	0.9961	1.0006	1.146660	0.10
500	1500	6.88	0.0148	0.21	70	75	29	159	32	753	0.9968	0.9962	1.0006	1.146342	0.23
1000	1500	8.88	0.0172	0.25	74	79	29	179	32	753	0.9968	0.9962	1.0006	1.144463	0.51
1500	1500	13.81	0.0205	0.30	77	83	29.2	208	32	753	0.9961	0.9954	1.0007	1.144463	0.82
2000	1500	17.41	0.0231	0.34	81	90	29.5	232	32	753	0.9951	0.9943	1.0009	1.144463	1.11
2500	1500	20.66	0.0258	0.37	85	95	29.8	259	32	753	0.9941	0.9931	1.0010	1.144463	1.49
3000	1500	24.72	0.0298	0.43	87	96	29.8	294	32	753	0.9941	0.9931	1.0010	1.144463	1.83
3500	1500	28.13	0.0331	0.48	88	97	29.8	329	32	753	0.9941	0.9931	1.0010	1.144463	2.14
4000	1500	31.59	0.0367	0.53	90	100	29.8	367	32	753	0.9941	0.9931	1.0010	1.144463	2.42
4500	1500	34.48	0.0407	0.59	93	106	29.8	404	32	753	0.9941	0.9931	1.0010	1.145872	2.82
FL	1500	39.68	0.0502	0.73	96	109	29.8	468	31	753	0.9941	0.9931	1.0010	1.148226	3.78

ตารางที่ ค-10 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทาน ที่ความเร็วรอบ 1,800 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1800	0.00	0.00	0.00	0.00	12.59	841.1	0.000176	0.0001762	-	-	-	28	273.77	0.01210
500	1800	5.24	5.23	0.99	0.99	14.19	841.1	0.000199	0.0001986	725.69	32.41	11.11	28	273.77	0.01210
1000	1800	7.16	7.15	1.35	1.35	15.93	841.1	0.000223	0.0002231	596.05	26.62	13.52	28	273.77	0.01210
1500	1800	11.61	11.60	2.19	2.19	18.29	841.1	0.000256	0.0002562	421.91	18.84	19.11	28	273.77	0.01210
2000	1800	14.95	14.94	2.82	2.82	20.22	841.1	0.000283	0.0002834	362.18	16.18	22.26	28	273.77	0.01210
2500	1800	17.98	17.99	3.39	3.39	22.30	841.1	0.000313	0.0003127	331.92	14.83	24.29	28	273.77	0.01210
3000	1800	20.25	20.25	3.82	3.82	24.47	841.1	0.000343	0.0003431	323.50	14.45	24.92	28	273.77	0.01210
3500	1800	23.28	23.29	4.39	4.39	26.51	841.1	0.000372	0.0003717	304.79	13.61	26.45	27.9	272.79	0.01210
4000	1800	26.25	26.26	4.95	4.95	29.51	841.1	0.000414	0.0004137	300.87	13.44	26.79	27.9	272.79	0.01210
4500	1800	29.00	29.03	5.47	5.47	32.34	841.1	0.000453	0.0004538	298.48	13.33	27.01	27.9	272.79	0.01210
5000	1800	31.73	31.76	5.98	5.99	35.39	841.1	0.000496	0.0004966	298.60	13.34	27.00	27.9	272.79	0.01210
5500	1800	34.70	34.74	6.54	6.55	38.87	841.1	0.000545	0.0005454	299.85	13.39	26.88	27.8	271.82	0.01200
FL	1800	39.92	39.96	7.52	7.53	46.37	841.1	0.00065	0.0006506	310.96	13.89	25.92	27	263.99	0.01190

ตารางที่ ค-10 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทานที่ความเร็วรอบ 1,800 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1800	0.00	0.0146	0.21	66	75	28.5	162	31	755.25	1.0014	1.0017	0.9998	1.151657	0.19
500	1800	5.24	0.0164	0.24	75	78	28.5	176	32	755.25	1.0014	1.0017	0.9998	1.149767	0.31
1000	1800	7.16	0.0185	0.27	79	80	28.7	193	32	755.25	1.0007	1.0009	0.9999	1.147883	0.40
1500	1800	11.61	0.0212	0.31	82	83	28.7	216	32	755.25	1.0007	1.0009	0.9999	1.147883	0.48
2000	1800	14.95	0.0234	0.34	85	92	28.8	236	32	755.25	1.0004	1.0005	0.9999	1.147883	0.51
2500	1800	17.98	0.0258	0.37	89	96	29	259	32	755.25	0.9997	0.9997	1.0000	1.147092	0.77
3000	1800	20.25	0.0284	0.41	91	96	29	279	32	755.25	0.9997	0.9997	1.0000	1.147883	0.81
3500	1800	23.28	0.0308	0.45	93	97	29	302	33	755.25	0.9997	0.9997	1.0000	1.145537	0.69
4000	1800	26.25	0.0343	0.50	94	99	29	331	33	755.25	0.9997	0.9997	1.0000	1.144573	0.76
4500	1800	29.00	0.0375	0.54	95	101	29.2	356	32	755.25	0.9991	0.9989	1.0002	1.147382	0.76
5000	1800	31.73	0.0411	0.60	96	104	29.2	391	33	755.25	0.9991	0.9989	1.0002	1.145709	1.13
5500	1800	34.70	0.0453	0.66	98	107	29.2	432	33	755.25	0.9991	0.9989	1.0002	1.144133	1.30
FL	1800	39.92	0.0548	0.79	100	107	29.2	478	33	755.25	0.9991	0.9989	1.0002	1.144133	2.05

ตารางที่ ค-11 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทาน ที่ความเร็วรอบ 2,000 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	2000	0.00	0.00	0.00	0.00	14.64	841.1	0.000205	0.000206	-	-	-	30.5	298.22	0.01260
500	2000	4.98	4.99	1.04	1.05	15.74	841.1	0.000221	0.000221	760.62	33.97	10.60	31	303.10	0.01280
1000	2000	6.52	6.53	1.37	1.37	16.55	841.1	0.000232	0.000232	611.65	27.32	13.18	31	303.10	0.01280
1500	2000	10.06	10.08	2.11	2.11	18.88	841.1	0.000265	0.000265	452.27	20.20	17.82	33	322.66	0.01320
2000	2000	13.11	13.15	2.75	2.75	20.71	841.1	0.000290	0.000291	380.46	16.99	21.19	34	332.44	0.01340
2500	2000	15.42	15.47	3.23	3.24	22.90	841.1	0.000321	0.000322	357.70	15.98	22.54	33	322.66	0.01320
3000	2000	18.14	18.18	3.80	3.81	24.76	841.1	0.000347	0.000348	328.78	14.68	24.52	33	322.66	0.01320
3500	2000	21.10	21.16	4.42	4.43	28.05	841.1	0.000393	0.000394	320.12	14.30	25.18	33	322.66	0.01320
4000	2000	23.63	23.70	4.95	4.96	30.71	841.1	0.000431	0.000432	313.08	13.98	25.75	37	361.77	0.01390
4500	2000	26.69	26.77	5.59	5.61	34.08	841.1	0.000478	0.000479	307.50	13.73	26.21	36	351.99	0.01370
5000	2000	29.08	29.13	6.09	6.10	36.96	841.1	0.000518	0.000519	306.14	13.67	26.33	36	351.99	0.01370
5500	2000	32.02	32.08	6.71	6.72	40.37	841.1	0.000566	0.000567	303.70	13.56	26.54	36.9	360.79	0.01390
6000	2000	34.96	35.02	7.32	7.33	45.05	841.1	0.000631	0.000633	310.42	13.86	25.97	36.6	357.86	0.01390
FL	2000	36.02	36.08	7.54	7.56	47.74	841.1	0.000669	0.000670	319.31	14.26	25.24	21	205.33	0.01050

ตารางที่ ค-11 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทานที่ความเร็วรอบ 2,000 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	2000	0.00	0.0162	0.24	66	75	28.5	174	30	752.85	0.9982	0.9979	1.0003	1.151785	0.13
500	2000	4.98	0.0173	0.25	78	80	28.5	187	29	752.85	0.9982	0.9979	1.0003	1.154006	0.29
1000	2000	6.52	0.0182	0.26	84	81	28.5	201	29	753	0.9984	0.9981	1.0003	1.155827	0.39
1500	2000	10.06	0.0201	0.29	87	85	28.5	223	29	753	0.9984	0.9981	1.0003	1.155827	0.49
2000	2000	13.11	0.0217	0.31	88	88	28.8	236	29	753	0.9974	0.9970	1.0005	1.155827	0.62
2500	2000	15.42	0.0244	0.35	92	92	28.8	256	29	753	0.9974	0.9970	1.0005	1.155827	0.81
3000	2000	18.14	0.0263	0.38	94	93	28.5	271	29	753	0.9984	0.9981	1.0003	1.155827	0.87
3500	2000	21.10	0.0299	0.43	94	94	28.8	298	30	753	0.9974	0.9970	1.0005	1.153600	0.95
4000	2000	23.63	0.0309	0.45	96	96	28.8	316	30	753	0.9974	0.9970	1.0005	1.152014	1.04
4500	2000	26.69	0.0348	0.50	98	101	28.8	343	30	753	0.9974	0.9970	1.0005	1.152014	1.08
5000	2000	29.08	0.0377	0.55	99	104	28.5	371	30	753	0.9984	0.9981	1.0003	1.152014	1.18
5500	2000	32.02	0.0407	0.59	101	106	28.5	396	30	753	0.9984	0.9981	1.0003	1.152014	1.55
6000	2000	34.96	0.0456	0.66	102	107	28.5	442	30	753	0.9984	0.9981	1.0003	1.152307	1.68
FL	2000	36.02	0.0638	0.92	103	108	28.5	471	30	753	0.9984	0.9981	1.0003	1.152014	1.83

ตารางที่ ค-12 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทาน ที่ความเร็วรอบ 2,400 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	2400	0.00	0.00	0.00	0.00	17.05	841.1	0.000239	0.0002402	-	-	-	48.2	471.28	0.01590
500	2400	4.44	4.47	1.12	1.12	18.96	841.1	0.000266	0.0002672	855.90	38.23	9.42	49.4	483.01	0.01610
1000	2400	5.82	5.85	1.46	1.47	20.49	841.1	0.000287	0.0002888	706.77	31.57	11.41	49.4	483.01	0.01610
1500	2400	8.77	8.83	2.20	2.22	22.54	841.1	0.000316	0.0003176	515.49	23.02	15.64	49.4	483.01	0.01610
2000	2400	11.22	11.28	2.82	2.84	24.23	841.1	0.00034	0.0003414	433.36	19.36	18.60	49	479.10	0.01600
2500	2400	13.40	13.48	3.37	3.39	26.52	841.1	0.000372	0.0003737	396.95	17.73	20.31	49.2	481.06	0.01600
3000	2400	15.28	15.37	3.84	3.86	28.05	841.1	0.000393	0.0003953	368.32	16.45	21.89	47.8	467.37	0.01580
3500	2400	17.63	17.74	4.43	4.46	31.23	841.1	0.000438	0.0004401	355.32	15.87	22.69	47.8	467.37	0.01580
4000	2400	19.93	20.05	5.01	5.04	33.39	841.1	0.000468	0.0004705	336.16	15.01	23.98	48.8	477.15	0.01600
4500	2400	22.20	22.34	5.58	5.61	36.51	841.1	0.000512	0.0005145	329.89	14.73	24.43	48.5	474.21	0.01600
5000	2400	24.07	24.22	6.05	6.09	39.30	841.1	0.000551	0.0005538	327.48	14.63	24.61	48.5	474.21	0.01600
5500	2400	26.66	26.74	6.70	6.72	43.09	841.1	0.000604	0.0006056	324.40	14.49	24.85	48.5	474.21	0.01600
6000	2400	29.24	29.32	7.35	7.37	46.78	841.1	0.000656	0.0006574	321.12	14.34	25.10	48.25	471.77	0.01600
6500	2400	31.62	31.71	7.95	7.97	49.90	841.1	0.0007	0.0007013	316.78	14.15	25.45	48.8	477.15	0.01610
FL	2400	33.39	33.50	8.39	8.42	53.26	841.1	0.000747	0.0007485	320.07	14.30	25.18	48	469.32	0.01590

ตารางที่ ค-12 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel ก่อนทดสอบความทนทานที่ความเร็วรอบ 2,400 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	2400	0.00	0.0150	0.22	81	84	28.8	191	30	751	0.9948	0.9939	1.0009	1.148955	0.06
500	2400	4.44	0.0165	0.24	90	87	28.8	206	30	751	0.9948	0.9939	1.0009	1.148955	0.09
1000	2400	5.82	0.0179	0.26	93	88	28.8	219	30	751	0.9948	0.9939	1.0009	1.148955	0.17
1500	2400	8.77	0.0197	0.28	96	91	28.8	234	30	751	0.9948	0.9939	1.0009	1.148955	0.25
2000	2400	11.22	0.0212	0.31	96	92	28.8	253	30	751	0.9948	0.9939	1.0009	1.148955	0.27
2500	2400	13.40	0.0232	0.34	98	94	28.8	267	30	751	0.9948	0.9939	1.0009	1.149553	0.27
3000	2400	15.28	0.0249	0.36	99	96	28.8	282	30	751	0.9948	0.9939	1.0009	1.149429	0.25
3500	2400	17.63	0.0277	0.40	101	98	28.8	300	30	751	0.9948	0.9939	1.0009	1.150581	0.31
4000	2400	19.93	0.0293	0.42	102	100	28.8	319	30	751	0.9948	0.9939	1.0009	1.149903	0.34
4500	2400	22.20	0.0321	0.46	102	101	28.8	339	29	751	0.9948	0.9939	1.0009	1.152757	0.45
5000	2400	24.07	0.0344	0.50	103	101	28.8	355	28	751	0.9948	0.9939	1.0009	1.157984	0.71
5500	2400	26.66	0.0377	0.55	104	102	28	377	27	751	0.9974	0.9970	1.0005	1.160439	0.77
6000	2400	29.24	0.0410	0.59	104	102	28	403	27	751	0.9974	0.9970	1.0005	1.161407	1.30
6500	2400	31.62	0.0436	0.63	105	105	28	435	27	751	0.9974	0.9970	1.0005	1.160791	1.41
FL	2400	33.39	0.0469	0.68	105	107	28	468	27	751	0.9974	0.9970	1.0005	1.160439	1.87

ตารางที่ ค-13 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel หลังทดสอบความทนทาน ที่ความเร็วรอบ 1,000 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1000	0.00	0.00	0.00	0.00	7.76	841.1	0.000109	0.000110	-	-	-	14.0	136.89	0.0086
500	1000	10.48	10.59	1.10	1.11	10.09	841.1	0.000141	0.000143	463.26	20.69	17.40	14.0	136.89	0.0086
1000	1000	14.58	14.71	1.53	1.54	11.86	841.1	0.000166	0.000168	391.41	17.48	20.59	14.0	136.89	0.0086
1500	1000	20.64	20.84	2.16	2.18	14.92	841.1	0.000209	0.000211	347.87	15.54	23.17	14.0	136.89	0.0086
2000	1000	25.28	25.54	2.65	2.67	17.60	841.1	0.000247	0.000249	334.97	14.96	24.06	14.0	136.89	0.0086
FL	1000	28.66	28.95	3.00	3.03	20.28	841.1	0.000284	0.000287	340.46	15.21	23.68	13.8	134.93	0.0085

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1000	0.00	0.0127	0.18	60	74	31.4	157	30	754.80	0.9913	0.9898	1.0015	1.154768	0.73
500	1000	10.48	0.0165	0.24	66	78	31.4	192	30	755.00	0.9915	0.9901	1.0015	1.155074	0.83
1000	1000	14.58	0.0194	0.28	69	81	31.2	227	30	755.40	0.9927	0.9914	1.0013	1.155686	0.95
1500	1000	20.64	0.0243	0.35	71	85	31.6	269	30	755.85	0.9920	0.9906	1.0014	1.158094	2.13
2000	1000	25.28	0.0287	0.42	74	88	31.8	293	30	755.85	0.9914	0.9898	1.0015	1.156375	3.47
FL	1000	28.66	0.0333	0.48	79	99	31.8	356	30	756.00	0.9916	0.9901	1.0015	1.156604	3.87

ตารางที่ ค-14 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel หลังทดสอบความทนทาน ที่ความเร็วรอบ 1,200 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1200	0.00	0.00	0.00	0.00	8.27	841.1	0.000116	0.000117	-	-	-	18.3	178.93	0.0098
500	1200	7.73	7.79	0.97	0.98	9.93	841.1	0.000139	0.000140	515.33	23.02	15.64	18.3	178.93	0.0098
1000	1200	12.29	12.38	1.54	1.56	11.44	841.1	0.000160	0.000161	373.48	16.68	21.58	18.3	178.93	0.0098
1500	1200	16.41	16.52	2.06	2.08	14.00	841.1	0.000196	0.000197	342.25	15.29	23.55	18.3	178.93	0.0098
2000	1200	21.06	21.02	2.65	2.64	17.63	841.1	0.000247	0.000247	336.28	15.02	23.97	18.3	178.93	0.0098
2500	1200	25.54	25.69	3.21	3.23	21.12	841.1	0.000296	0.000298	331.79	14.82	24.30	18.3	178.93	0.0098
3000	1200	29.30	29.48	3.68	3.70	24.65	841.1	0.000346	0.000347	337.60	15.08	23.88	18.5	180.89	0.0099
3500	1200	32.48	32.68	4.08	4.11	28.11	841.1	0.000394	0.000396	347.18	15.51	23.22	18.5	180.89	0.0099
FL	1200	32.86	33.06	4.13	4.15	29.59	841.1	0.000415	0.000417	361.27	16.14	22.31	18.5	180.89	0.0099

ตารางที่ ค-14 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel

หลังทดสอบความทนทานที่ความเร็วรอบ 1,200 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1200	0.00	0.0118	0.17	65	71	30.6	143	30	755.00	0.9942	0.9931	1.0010	1.153362	0.57
500	1200	7.73	0.0142	0.21	67	72	30.8	170	30	755.00	0.9935	0.9924	1.0011	1.155074	0.69
1000	1200	12.29	0.0163	0.24	68	75	30.8	205	30	755.16	0.9937	0.9926	1.0011	1.155319	0.67
1500	1200	16.41	0.0200	0.29	70	76	30.7	239	30	755.25	0.9942	0.9931	1.0010	1.155457	0.77
2000	1200	21.06	0.0252	0.37	73	79	28.5	279	30	755.25	1.0014	1.0017	0.9998	1.155457	0.88
2500	1200	25.54	0.0302	0.44	77	85	30.8	314	30	756.00	0.9948	0.9939	1.0009	1.156604	1.68
3000	1200	29.30	0.0350	0.51	80	91	30.8	365	30	756.00	0.9948	0.9939	1.0009	1.156604	2.70
3500	1200	32.48	0.0399	0.58	82	101	30.8	398	30	756.10	0.9949	0.9941	1.0009	1.156757	3.07
FL	1200	32.86	0.0420	0.61	86	103	30.8	424	30	756.10	0.9949	0.9941	1.0009	1.156757	3.41

ตารางที่ ค-15 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel หลังทดสอบความทนทาน ที่ความเร็วรอบ 1,500 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1500	0.00	0.00	0.00	0.00	9.71	841.1	0.000136	0.000137	-	-	-	19.8	193.60	0.0102
500	1500	6.98	7.02	1.10	1.10	12.09	841.1	0.000170	0.000171	556.25	24.84	14.49	20.0	195.55	0.0103
1000	1500	10.10	10.16	1.59	1.60	13.16	841.1	0.000185	0.000186	418.49	18.69	19.26	20.2	197.51	0.0103
1500	1500	12.92	12.99	2.03	2.04	15.91	841.1	0.000223	0.000224	395.17	17.65	20.40	21.0	205.33	0.0105
2000	1500	17.23	17.32	2.71	2.72	17.73	841.1	0.000249	0.000250	330.25	14.75	24.41	21.0	205.33	0.0105
2500	1500	20.80	20.89	3.27	3.28	20.34	841.1	0.000285	0.000286	313.90	14.02	25.68	21.4	209.24	0.0106
3000	1500	23.36	23.45	3.67	3.68	22.56	841.1	0.000316	0.000317	310.05	13.85	26.00	21.4	209.24	0.0106
3500	1500	27.42	27.52	4.31	4.32	25.61	841.1	0.000359	0.000360	299.94	13.40	26.87	21.6	211.20	0.0107
4000	1500	30.06	30.20	4.72	4.74	28.64	841.1	0.000401	0.000403	305.91	13.66	26.35	21.8	213.15	0.0107
FL	1500	33.93	34.12	5.33	5.36	33.34	841.1	0.000467	0.000470	315.37	14.09	25.56	22.0	215.11	0.0108

ตารางที่ ค-15 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel

หลังทดสอบความทนทานที่ความเร็วรอบ 1,500 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1500	0.00	0.0133	0.19	71	74	30.7	169	30	755.4	0.9944	0.9934	1.0010	1.155686	0.50
500	1500	6.98	0.0165	0.24	75	77	30.7	192	30	755.4	0.9944	0.9934	1.0010	1.155686	0.69
1000	1500	10.10	0.0179	0.26	78	79	30.7	217	30	755.4	0.9944	0.9934	1.0010	1.155686	0.79
1500	1500	12.92	0.0212	0.31	79	83	30.6	233	30	756	0.9955	0.9947	1.0008	1.156604	0.94
2000	1500	17.23	0.0236	0.34	82	88	30.6	256	30	756.2	0.9957	0.9950	1.0008	1.156910	1.27
2500	1500	20.80	0.0269	0.39	86	95	30.4	268	30	756.2	0.9964	0.9958	1.0006	1.156910	1.45
3000	1500	23.36	0.0298	0.43	88	97	30.4	333	30	756.5	0.9968	0.9962	1.0006	1.157369	1.78
3500	1500	27.42	0.0336	0.49	91	100	30.4	346	30	756.5	0.9968	0.9962	1.0006	1.157369	2.01
4000	1500	30.06	0.0375	0.54	93	101	30.6	395	30	756.35	0.9959	0.9952	1.0007	1.157140	2.25
FL	1500	33.93	0.0434	0.63	97	104	30.7	459	30	756.1	0.9953	0.9944	1.0008	1.156757	2.82

ตารางที่ ค-16 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel หลังทดสอบความทนทาน ที่ความเร็วรอบ 1,800 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	1800	0.00	0.00	0.00	0.00	11.53	841.1	0.000162	0.000163	-	-	-	31.0	303.10	0.0127
500	1800	5.20	5.25	0.98	0.99	13.46	841.1	0.000189	0.000190	692.06	30.91	11.65	31.0	303.10	0.0127
1000	1800	7.37	7.45	1.39	1.40	15.22	841.1	0.000213	0.000215	551.73	24.64	14.61	31.0	303.10	0.0127
1500	1800	11.30	11.42	2.13	2.15	17.52	841.1	0.000246	0.000248	414.43	18.51	19.45	31.0	303.10	0.0127
2000	1800	13.85	14.01	2.61	2.64	19.64	841.1	0.000275	0.000278	379.10	16.93	21.26	31.0	303.10	0.0127
2500	1800	17.72	17.94	3.34	3.38	22.16	841.1	0.000311	0.000314	334.21	14.93	24.12	31.0	303.10	0.0127
3000	1800	19.47	19.71	3.67	3.72	23.96	841.1	0.000336	0.000339	328.87	14.69	24.51	31.0	303.10	0.0127
3500	1800	22.33	22.52	4.21	4.24	27.29	841.1	0.000383	0.000385	326.74	14.59	24.67	31.0	303.10	0.0128
4000	1800	25.41	25.62	4.79	4.83	30.96	841.1	0.000434	0.000437	325.79	14.55	24.74	31.0	303.10	0.0128
4500	1800	27.53	27.80	5.19	5.24	33.68	841.1	0.000472	0.000476	327.02	14.61	24.65	31.0	303.10	0.0128
5000	1800	30.29	30.56	5.71	5.76	37.11	841.1	0.000520	0.000524	327.55	14.63	24.61	31.0	303.10	0.0128
FL	1800	33.74	34.04	6.36	6.42	41.53	841.1	0.000582	0.000587	329.10	14.70	24.49	31.0	303.10	0.0128

ตารางที่ ค-16 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel

หลังทดสอบความทนทานที่ความเร็วรอบ1,800 rev/min(ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	1800	0.00	0.0127	0.18	69	78	31.4	160	33	754.5	0.9909	0.9893	1.0016	1.142997	0.52
500	1800	5.20	0.0149	0.22	71	78	31.3	178	33	754.5	0.9912	0.9897	1.0016	1.142997	0.72
1000	1800	7.37	0.0168	0.24	75	79	31.3	196	32	754.5	0.9912	0.9897	1.0016	1.146743	0.88
1500	1800	11.30	0.0193	0.28	79	83	31.5	221	31	754.75	0.9909	0.9893	1.0016	1.150895	0.89
2000	1800	13.85	0.0216	0.31	85	90	31.7	256	31	754.75	0.9902	0.9885	1.0017	1.150895	0.86
2500	1800	17.72	0.0244	0.35	88	94	32.0	277	31	755	0.9896	0.9878	1.0018	1.151276	0.97
3000	1800	19.47	0.0264	0.38	92	98	32.0	298	32	755	0.9896	0.9878	1.0018	1.147503	0.99
3500	1800	22.33	0.0300	0.43	93	98	31.0	316	31	755.25	0.9932	0.9920	1.0012	1.151657	0.97
4000	1800	25.41	0.0340	0.49	94	99	31.0	339	31	755.25	0.9932	0.9920	1.0012	1.151657	1.03
4500	1800	27.53	0.0370	0.54	95	101	31.4	373	31	755.25	0.9919	0.9904	1.0014	1.151657	1.16
5000	1800	30.29	0.0408	0.59	97	102	31.2	398	31	755.25	0.9925	0.9912	1.0013	1.151657	1.25
FL	1800	33.74	0.0457	0.66	99	104	31.2	462	31	755.25	0.9925	0.9912	1.0013	1.151657	1.72

ตารางที่ ค-17 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel หลังทดสอบความทนทาน ที่ความเร็วรอบ 2,000 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_f (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	2000	0.00	0.00	0.00	0.00	14.74	841.1	0.000207	0.000209	-	-	-	29.5	288.44	0.0124
500	2000	4.60	4.65	0.96	0.97	15.65	841.1	0.000219	0.000221	818.28	36.55	9.85	29.0	283.55	0.0123
1000	2000	7.06	7.14	1.48	1.50	16.54	841.1	0.000232	0.000234	563.37	25.16	14.31	29.0	283.55	0.0123
1500	2000	9.71	9.82	2.03	2.06	19.10	841.1	0.000268	0.000270	473.22	21.14	17.03	29.0	283.55	0.0123
2000	2000	12.68	12.83	2.66	2.69	20.40	841.1	0.000286	0.000289	386.91	17.28	20.83	29.0	283.55	0.0123
2500	2000	14.85	15.00	3.11	3.14	22.93	841.1	0.000322	0.000324	371.60	16.60	21.69	29.5	288.24	0.0124
3000	2000	17.25	17.43	3.61	3.65	25.66	841.1	0.000360	0.000363	357.93	15.99	22.52	29.4	287.46	0.0124
3500	2000	19.80	20.00	4.15	4.19	27.78	841.1	0.000389	0.000393	337.54	15.08	23.88	30.0	293.33	0.0125
4000	2000	22.39	22.64	4.69	4.74	30.91	841.1	0.000433	0.000437	332.05	14.83	24.28	30.0	293.33	0.0125
4500	2000	24.52	24.79	5.14	5.19	34.02	841.1	0.000477	0.000481	333.72	14.91	24.15	30.0	293.33	0.0125
5000	2000	27.80	28.10	5.82	5.88	37.41	841.1	0.000524	0.000529	323.77	14.46	24.90	30.0	293.33	0.0125
5500	2000	30.98	31.29	6.49	6.55	41.69	841.1	0.000584	0.000589	323.80	14.46	24.89	31.0	303.10	0.0128
FL	2000	34.37	34.71	7.20	7.27	46.94	841.1	0.000658	0.000664	328.63	14.68	24.53	31.0	303.10	0.0128

ตารางที่ ค-17 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel

หลังทดสอบความทนทานที่ความเร็วรอบ 2,000 rev/min (ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	2000	0.00	0.0166	0.24	65	82	31.0	181	31	753.5	0.9909	0.9893	1.0016	1.148989	0.41
500	2000	4.60	0.0178	0.26	68	84	31.0	197	32	753.5	0.9909	0.9893	1.0016	1.145223	0.57
1000	2000	7.06	0.0189	0.27	71	85	31.0	198	32	753.5	0.9909	0.9893	1.0016	1.145223	0.58
1500	2000	9.71	0.0218	0.32	72	89	30.9	243	32	753	0.9905	0.9889	1.0017	1.144463	0.57
2000	2000	12.68	0.0233	0.34	83	90	30.9	262	32	753	0.9905	0.9889	1.0017	1.144463	0.73
2500	2000	14.85	0.0259	0.38	85	94	30.7	285	32	753	0.9912	0.9897	1.0016	1.145214	0.89
3000	2000	17.25	0.0290	0.42	86	97	30.7	305	32	753	0.9912	0.9897	1.0016	1.145715	0.92
3500	2000	19.80	0.0311	0.45	88	99	30.7	328	30	753	0.9912	0.9897	1.0016	1.150452	1.03
4000	2000	22.39	0.0345	0.50	90	102	30.8	347	30	753	0.9909	0.9893	1.0016	1.152014	1.32
4500	2000	24.52	0.0380	0.55	99	102	30.8	372	30	753	0.9909	0.9893	1.0016	1.152014	1.37
5000	2000	27.80	0.0418	0.61	100	104	30.8	384	30	753	0.9909	0.9893	1.0016	1.152014	1.57
5500	2000	30.98	0.0458	0.66	103	106	30.6	441	30	753	0.9915	0.9900	1.0015	1.152014	1.64
FL	2000	34.37	0.0516	0.75	105	107	30.6	471	30	753	0.9915	0.9900	1.0015	1.152307	2.02

ตารางที่ ค-18 แสดงข้อมูลจากการทดสอบ และผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel หลังทดสอบความทนทาน ที่ความเร็วรอบ 2,400 rev/min

LOAD (N)	Speed (rpm)	T (Nm)	Crted T (Nm)	Power (kW)	Crted Power (kW)	FC (cc/min)	density (kg/m^3)	m_f (kg/s)	Crted m_f (kg/s)	sfc (g/kW.h)	STEC (MJ/kW.h)	h_t (%)	air Dp (mm H_2O)	air Dp (kPa)	m_a (kg/s)
0	2400	0.00	0.00	0.00	0.00	18.14	841.1	0.000254	0.000257	#DIV/0!	#DIV/0!	#DIV/0!	42.5	415.55	0.0149
500	2400	3.54	3.57	0.89	0.90	19.80	841.1	0.000278	0.000280	1121.18	50.08	7.19	42.9	419.46	0.0150
1000	2400	5.41	5.46	1.36	1.37	21.38	841.1	0.000300	0.000302	792.19	35.38	10.18	43.2	422.20	0.0150
1500	2400	8.91	8.99	2.24	2.26	23.28	841.1	0.000326	0.000329	523.78	23.39	15.39	45.4	443.90	0.0155
2000	2400	10.54	10.63	2.65	2.67	24.74	841.1	0.000347	0.000349	470.56	21.02	17.13	45.4	443.90	0.0155
2500	2400	13.01	13.20	3.27	3.32	27.10	841.1	0.000380	0.000385	417.32	18.64	19.32	44.5	435.10	0.0153
3000	2400	14.60	14.72	3.67	3.70	28.98	841.1	0.000406	0.000409	398.03	17.78	20.25	44.3	433.15	0.0153
3500	2400	16.71	16.83	4.20	4.23	31.52	841.1	0.000442	0.000445	378.33	16.90	21.31	44.2	432.17	0.0153
4000	2400	20.05	20.18	5.04	5.07	35.05	841.1	0.000491	0.000494	350.64	15.66	22.99	45.2	441.95	0.0154
4500	2400	21.45	21.61	5.39	5.43	37.19	841.1	0.000521	0.000525	347.81	15.53	23.18	44.2	432.17	0.0152
5000	2400	23.24	23.42	5.84	5.88	40.06	841.1	0.000562	0.000565	345.78	15.44	23.31	44.2	432.17	0.0152
5500	2400	25.98	26.24	6.53	6.60	43.62	841.1	0.000617	0.000622	339.62	15.17	23.74	44.2	432.17	0.0152
6000	2400	28.53	28.82	7.17	7.24	46.99	841.1	0.000666	0.000672	333.90	14.91	24.14	44.2	432.17	0.0152
6500	2400	30.96	31.27	7.78	7.86	51.23	841.1	0.000729	0.000735	336.74	15.04	23.94	44.2	432.17	0.0152
FL	2400	31.95	31.90	8.03	8.02	53.38	841.1	0.000757	0.000756	339.52	15.16	23.74	44.0	430.21	0.0152

ตารางที่ ค-18 แสดงข้อมูลจากการทดสอบและผลการคำนวณจากเครื่องยนต์ที่ใช้น้ำมัน Alternative Diesel

หลังทดสอบความทนทานที่ความเร็วรอบ 2,400 rev/min(ต่อ)

LOAD (N)	Speed (rpm)	T (Nm)	F/A	ϕ	Oil T. (°C)	W.T. (°C)	DB T. (°C)	Ex.T. (°C)	A.B.T. (°C)	atm.P. (mm Hg)	Correction Factor			den Air kg/m3	smoke
											k	a	b		
0	2400	0.00	0.0171	0.25	80	88	31.4	212	32	755	0.9915	0.9901	1.0015	1.147503	0.31
500	2400	3.54	0.0185	0.27	84	90	31.2	232	32	755	0.9922	0.9908	1.0014	1.147503	0.51
1000	2400	5.41	0.0199	0.29	87	92	31.2	249	31	754.6	0.9917	0.9902	1.0015	1.150666	0.62
1500	2400	8.91	0.0211	0.31	88	94	31.2	275	30	755.1	0.9923	0.9910	1.0014	1.155227	0.63
2000	2400	10.54	0.0224	0.33	89	95	31.0	289	30	755.1	0.9930	0.9917	1.0012	1.155227	0.78
2500	2400	13.01	0.0249	0.36	91	97	31.0	308	30	751	0.9876	0.9854	1.0022	1.148955	0.79
3000	2400	14.60	0.0266	0.39	92	98	30.8	328	30	754.85	0.9933	0.9921	1.0012	1.154845	0.81
3500	2400	16.71	0.0290	0.42	93	100	31.0	347	30	755.8	0.9939	0.9928	1.0011	1.156298	0.80
4000	2400	20.05	0.0318	0.46	96	101	30.8	369	30	756	0.9948	0.9939	1.0009	1.156604	0.80
4500	2400	21.45	0.0342	0.50	99	102	30.8	390	30	755	0.9935	0.9924	1.0011	1.155074	0.79
5000	2400	23.24	0.0368	0.53	101	102	30.8	423	30	755	0.9935	0.9924	1.0011	1.155074	0.78
5500	2400	25.98	0.0401	0.58	102	104	31.0	451	30	754	0.9915	0.9900	1.0015	1.153544	0.83
6000	2400	28.53	0.0432	0.63	103	106	31.0	478	30	754	0.9915	0.9900	1.0015	1.153544	1.21
6500	2400	30.96	0.0471	0.68	105	106	31.0	509	30	754	0.9915	0.9900	1.0015	1.153544	1.24
FL	2400	31.95	0.0493	0.71	106	107	28.0	515	31	754	1.0014	1.0017	0.9998	1.149751	2.20

ภาคผนวก ง

ข้อมูลผลการทดสอบความทนทาน

ตารางที่ ง-1 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 0-15

Load	Time	FC (sec/10cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	8:15	22.76	22.82	22.8	535	105	101	32	30	29.8	29.2	41.3	756.2	52	7.00	0.111	0	0
	9:00	22.81	22.79	22.75	534	105	101	32	30	29.6	29.2	41.3	756.2	52	7.00	0.111	1	1
	10:00	22.77	22.69	22.72	535	105	101	32	30	29.6	29	41.3	756.5	52	7.00	0.111	2	2
	11:00	22.68	22.65	22.69	535	105	102	32	30	29.2	29	41.3	756.75	52	7.00	0.111	3	3
90 %	11:15	24.38	24.42	24.41	502	106	100	33	31	29.4	29	39.5	756.5	52	7.00	0.089		
	11:30	24.42	24.51	24.51	502	106	101	33	31	29.4	29	39.5	756.5	52	7.00	0.089		
	11:45	24.39	24.43	24.43	501	106	100	33	31	29.2	29	39.5	756.5	52	7.00	0.089		
	12:00	24.50	24.53	24.51	501	106	100	33	31	29.2	29	39.5	756.5	52	7.00	0.089	4	4
80 %	12:15	26.32	26.28	26.27	459	104	99	33	31	29.2	28.8	39.5	755.8	52	7.00	0.065		
	12:30	26.21	26.24	26.23	459	104	99	33	31	29.2	28.8	39.5	755.8	52	7.00	0.065		
	12:45	26.33	26.27	26.33	458	103	99	33	31	29	28.8	39.5	755.8	52	7.00	0.065		
	13:00	26.41	26.42	26.38	458	104	99	33	31	29	28.8	39.5	755.8	52	7.00	0.065	5	5
Full	13:!5	22.60	22.54	22.62	539	105	99	34	31	29	28.6	42.4	755.75	52	7.00	0.111		
	14:00	22.72	22.75	22.76	538	106	100	34	31	29	28.6	42.4	755.75	52	7.00	0.111	6	6
	15:00	22.45	22.36	22.38	538	106	101	34	31	29	28.4	42.4	755.75	52	7.00	0.111	7	7
	16:00	22.71	22.81	22.94	539	106	101	34	31	29	28.4	42.4	755.75	52	7.00	0.111	8	8

ตารางที่ ง-1 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 0-15 (ต่อ)

Load	Time	FC (sec/10cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	16:15	24.58	24.48	24.54	498	105	100	33	31	29.2	28.4	42	755.75	52	7.00	0.089		
	16:30	24.51	24.49	24.48	498	105	100	33	31	29.2	28.4	42	755.8	52	7.00	0.089		
	16:45	24.61	24.63	24.62	499	104	100	33	30.8	29.4	28.4	42	755.8	52	7.00	0.089		
	17:00	24.74	24.76	24.71	499	104	98	33	30.8	29.4	28.4	42	755.75	52	7.00	0.089	9	9
80 %	17:15	26.34	26.49	26.5	461	103	98	33	30.8	29.2	28.2	42	755.75	52	7.00	0.065		
	17:30	26.35	26.37	26.39	460	103	98	33	30.8	29.2	28.2	42	755.8	52	7.00	0.065		
	17:45	26.55	26.58	26.5	460	103	98	33	30.6	29.2	28.2	42	755.8	52	7.00	0.065		
	18:00	26.48	26.47	26.52	459	102	98	33	30.6	29.2	28.2	42	755.8	52	7.00	0.065	10	10
Full	18:15	22.28	22.23	22.22	542	106	101	34	30	29.2	28.2	41.8	755.6	52	7.00	0.111		
	19:00	22.33	22.31	22.32	542	106	101	34	30	29.2	28.2	41.8	755.6	52	7.00	0.111	11	11
	20:00	22.48	22.46	22.37	542	107	101	34	30	29	28	41.8	755.8	52	7.00	0.111	12	12
	21:00	22.55	22.48	22.61	542	107	101	34	30	29	28	41.8	755.6	52	7.00	0.111	13	13
90 %	21:15	24.42	24.32	24.44	501	105	100	33	29.8	29	28	41.8	755.8	52	7.00	0.089		
	21:30	24.33	24.48	24.46	501	106	100	33	29.8	29	28	41.8	755.6	52	7.00	0.089		
	21:45	24.52	24.58	24.39	500	106	100	33	29.5	28.8	27.8	41.8	755.6	52	7.00	0.089		
	22:00	24.50	24.61	24.58	500	105	100	33	29.5	28.8	27.8	41.8	755.6	52	7.00	0.089	14	14
80 %	22:15	26.17	26.25	26.21	470	104	100	33	29.5	28.8	27.8	41.6	755.25	52	7.00	0.065		
	22:30	26.32	26.23	26.22	469	104	100	33	29.5	28.8	27.8	41.5	755.25	52	7.00	0.065		
	22:45	26.25	26.29	26.37	469	104	100	33	29.5	28.8	27.8	41.5	755.25	52	7.00	0.065		
	23:00	26.28	26.32	26.36	469	104	100	33	29.5	28.8	27.8	41.5	755.25	52	7.00	0.065	15	15

ตารางที่ ง-2 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 15-30

Load	Time	FC (sec/10cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	8:15	22.80	22.79	22.84	528	101	101	33	29.0	29.4	28.7	42.5	757.40	52	7	0.111		
	9:00	22.77	22.84	22.86	528	104	101	33	29.0	29.4	28.7	42.5	757.40	52	7	0.111	16	16
	10:00	22.64	22.62	22.59	529	104	102	33	31.0	30.0	28.9	42.5	757.40	52	7	0.111	17	17
	11:00	22.78	22.74	22.72	529	104	102	33	31.0	30.8	29.6	42.5	757.40	52	7	0.111	18	18
90 %	11:15	24.44	24.38	24.32	494	105	99	34	31.2	32.2	31.2	38.4	756.80	52	7	0.089		
	11:30	24.11	24.21	24.19	494	105	98	34	30.8	31.8	31.2	38.6	756.80	52	7	0.089		
	11:45	24.37	24.39	24.36	496	106	98	34	31.0	31.2	30.0	38.4	756.80	52	7	0.089		
	12:00	24.26	24.19	24.22	496	106	98	34	31.0	31.4	29.8	38.4	756.80	52	7	0.089	19	19
80 %	12:15	26.16	26.24	26.11	454	105	97	36	31.0	31.6	29.4	35.2	756.60	52	7	0.065		
	12:30	26.23	26.32	26.29	454	105	97	36	31.0	31.6	29.4	35.2	756.60	52	7	0.065		
	12:45	25.84	26.06	25.89	456	106	96	36	31.0	31.6	29.2	35.2	756.60	52	7	0.065		
	13:00	26.01	26.06	26.09	456	105	96	36	31.0	31.6	29.2	35.2	756.60	52	7	0.065		
Full	13:!5	22.64	22.68	22.61	540	104	100	36	32.0	31.8	30.0	40.3	755.30	52	7	0.111	20	20
	14:00	22.65	22.62	22.68	543	104	101	36	31.5	31.6	30.1	40.3	755.30	52	7	0.111	21	21
	15:00	22.65	22.79	22.72	543	105	100	35	31.5	31.4	29.6	40.3	755.30	52	7	0.111	22	22
	16:00	22.58	22.55	22.62	544	106	99	35	31.0	31.2	29.4	40.3	754.50	52	7	0.111	23	23

ตารางที่ ง-2 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 15-30 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	16:15	24.46	24.42	24.45	504	106	98	35	31.0	30.8	29.4	39.8	755.00	52	7	0.089		
	16:30	24.54	24.58	24.55	504	106	98	35	31.0	30.8	29.1	39.8	755.00	52	7	0.089		
	16:45	24.40	24.16	24.16	499	107	98	35	31.0	30.8	29.1	39.8	755.00	52	7	0.089		
	17:00	24.29	24.13	24.22	499	106	99	35	30.2	30.8	29.1	39.8	755.00	52	7	0.089	24	24
80 %	17:15	26.21	26.38	26.29	457	103	100	35	30.0	30.4	28.8	39.6	755.00	52	7	0.065		
	17:30	26.18	26.24	26.22	457	103	100	35	29.0	29.7	28.6	39.6	755.00	52	7	0.065		
	17:45	26.34	26.39	26.35	456	103	99	34	29.0	29.7	28.6	39.6	755.00	52	7	0.065		
	18:00	26.07	25.98	26.04	456	104	99	34	29.0	29.7	28.4	39.6	755.00	52	7	0.065	25	25
Full	18:15	22.03	22.12	22.05	529	105	101	34	29.0	29.7	28.4	39.2	756.20	52	7	0.111		
	19:00	22.64	22.70	22.68	529	106	102	34	29.0	29.5	28.4	39.2	756.20	52	7	0.111	26	26
	20:00	22.60	22.58	22.52	530	106	102	33	29.0	28.6	27.8	39.2	755.90	52	7	0.111	27	27
	21:00	22.48	22.52	22.46	529	107	101	33	29.0	28.6	27.8	39.2	756.50	52	7	0.111	28	28
90 %	21:15	23.95	24.05	23.98	504	105	100	34	28.5	28.2	27.6	38.6	756.00	52	7	0.089		
	21:30	24.21	24.25	24.19	504	106	100	34	28.5	28.2	27.6	38.6	756.00	52	7	0.089		
	21:45	24.43	24.52	24.48	503	106	99	34	28.5	28.2	27.6	38.6	756.00	52	7	0.089		
	22:00	24.37	24.29	24.33	504	106	99	33	28.5	28.2	27.6	38.6	756.00	52	7	0.089	29	29
80 %	22:15	26.40	26.48	26.45	456	104	100	33	28.5	28.2	27.6	38.4	756.40	52	7	0.065		
	22:30	26.52	26.52	26.57	458	104	101	33	28.3	28.1	27.6	38.4	756.40	52	7	0.065		
	22:45	26.46	26.43	26.39	458	104	101	33	28.3	28.1	27.4	38.4	757.00	52	7	0.065		
	23:00	26.47	26.20	26.57	457	104	100	32	28.3	28.1	27.4	38.4	757.00	52	7	0.065	30	30

ตารางที่ ง-3 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 30-45

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	8:15	22.51	22.42	22.44	532	105	100	32	30.0	30.6	29.8	37.0	754.25	52	7.00	0.111		
	9:00	22.16	22.15	22.11	530	107	101	32	31.0	30.6	29.8	37.0	754.25	52	7.00	0.111	31	31
	10:00	22.23	22.15	22.32	530	108	101	32	30.0	29.8	29.0	37.7	754.30	52	7.00	0.111	32	32
	11:00	22.47	22.57	22.49	529	105	102	32	30.0	29.6	28.8	37.5	754.30	52	7.00	0.111	33	33
90 %	11:15	24.64	24.57	24.63	495	105	99	34	29.0	29.6	28.4	37.7	754.30	52	7.00	0.089		
	11:30	24.35	24.25	24.22	497	104	99	34	29.0	29.6	28.4	37.7	754.30	52	7.00	0.089		
	11:45	24.13	24.22	24.28	497	104	99	33	29.0	29.4	28.4	37.7	754.30	52	7.00	0.089		
	12:00	24.22	24.28	24.35	498	104	100	33	29.0	29.0	28.2	37.7	755.00	52	7.00	0.089	34	34
80 %	12:15	26.54	26.63	26.70	460	102	97	34	29.0	29.0	28.0	36.4	755.00	52	7.00	0.065		
	12:30	26.81	26.66	26.72	459	102	97	34	29.0	29.0	28.0	36.4	755.00	52	7.00	0.065		
	12:45	26.78	26.31	26.46	459	102	97	34	29.0	28.8	27.8	36.4	755.20	52	7.00	0.065		
	13:00	26.75	26.25	26.38	458	103	98	34	29.0	28.8	27.8	36.4	755.40	52	7.00	0.065		
Full	21:15	22.83	22.87	22.76	539	107	103	33	29.0	28.8	27.8	37.4	755.50	52	7.00	0.111	35	35
	22:00	22.78	22.65	22.61	536	109	103	33	29.0	28.4	27.8	37.4	755.30	52	7.00	0.111	36	36
	23:00	22.83	22.54	22.56	532	106	102	33	29.5	28.2	27.8	37.4	755.30	52	7.00	0.111	37	37
	0:00	22.74	22.68	22.72	529	106	102	33	29.5	28.2	27.6	37.4	755.00	52	7.00	0.111	38	38

ตารางที่ ง-3 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 30-45 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.35	24.37	24.32	499	104	100	33	29.5	28.0	27.6	37.4	755.00	52	7.00	0.089		
	0:30	24.25	24.28	24.34	501	106	99	33	29.5	28.0	27.6	37.4	755.00	52	7.00	0.089		
	0:45	24.28	24.29	24.36	501	106	99	33	29.0	28.0	27.6	37.4	754.50	52	7.00	0.089		
	1:00	24.34	24.32	24.34	501	106	99	33	29.0	28.0	27.6	37.4	754.50	52	7.00	0.089	39	39
80 %	1:15	26.17	26.20	26.32	460	105	97	33	29.0	28.0	27.2	37.3	754.60	52	7.00	0.065		
	1:30	26.08	26.06	26.15	454	104	97	33	29.0	28.0	27.2	37.3	754.60	52	7.00	0.065		
	1:45	26.11	26.14	26.19	454	103	97	33	29.0	27.8	27.2	37.3	754.50	52	7.00	0.065		
	2:00	26.03	26.15	26.14	454	104	96	32	29.0	27.8	27.2	37.3	754.50	52	7.00	0.065	40	40
Full	2:15	22.05	22.19	22.03	532	106	100	32	29.0	28.0	27.2	37.2	754.50	52	7.00	0.111		
	3:00	22.01	22.03	22.03	530	108	102	31	29.0	27.8	27.2	37.2	754.50	52	7.00	0.111	41	41
	4:00	22.18	22.24	22.15	529	105	102	32	29.0	27.6	27.2	37.2	754.25	52	7.00	0.111	42	42
	5:00	22.38	22.29	22.00	529	106	102	32	29.0	27.6	27.0	37.2	754.00	52	7.00	0.111	43	43
90 %	5:15	24.19	24.25	24.03	495	105	99	31	29.0	27.6	27.2	35.6	754.00	52	7.00	0.089		
	5:30	24.09	24.00	24.16	492	104	99	30	29.5	27.6	27.2	35.6	754.00	52	7.00	0.089		
	5:45	24.18	24.16	24.07	492	103	99	31	29.5	27.6	27.0	35.6	754.00	52	7.00	0.089		
	6:00	24.25	24.35	24.28	493	103	98	30	29.5	27.6	27.0	35.6	754.00	52	7.00	0.089	44	44
80 %	6:15	26.15	26.25	26.12	459	103	96	30	29.0	27.6	27.0	35.6	754.50	52	7.00	0.065		
	6:30	26.18	26.12	26.15	459	102	95	29	29.0	27.6	27.0	35.6	745.50	52	7.00	0.065		
	6:45	26.18	26.08	26.21	460	103	95	29	29.0	27.6	27.0	35.6	754.50	52	7.00	0.065		
	7:00	26.24	26.08	26.02	459	102	96	30	29.0	27.6	27.0	35.6	754.50	52	7.00	0.065	45	45

ตารางที่ ง-4 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 45-60

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.77	22.83	22.88	530	104	100	34	30.0	30.6	29.2	37.0	754.00	52	7.00	0.111		
	17:00	22.58	22.55	22.62	530	108	101	34	30.0	30.6	29.2	37.0	754.00	52	7.00	0.111	46	46
	18:00	22.32	22.38	22.42	529	106	101	32	29.5	29.8	28.2	37.0	754.10	52	7.00	0.111	47	47
	19:00	22.45	22.36	22.37	529	106	101	32	30.0	29.6	28.0	37.0	754.10	52	7.00	0.111	48	48
90 %	19:15	24.40	24.31	24.31	495	101	100	32	30.0	29.2	27.8	36.2	754.10	52	7.00	0.089		
	19:30	24.16	24.15	24.13	494	102	100	32	29.0	29.2	27.8	36.2	754.60	52	7.00	0.089		
	19:45	24.39	24.33	24.43	494	102	99	32	29.0	29.2	27.8	36.2	754.80	52	7.00	0.089		
	20:00	24.25	24.18	24.28	494	103	99	32	29.0	29.2	27.8	36.2	754.80	52	7.00	0.089	49	49
80 %	20:15	26.91	26.53	26.72	451	101	100	32	29.0	29.2	27.8	36.2	754.60	52	7.00	0.065		
	20:30	26.22	26.25	26.27	452	101	101	32	29.0	29.0	27.8	35.8	754.60	52	7.00	0.065		
	20:45	26.39	26.39	26.42	452	100	101	32	29.0	28.8	27.8	35.8	754.60	52	7.00	0.065		
	21:00	26.23	26.38	26.28	452	100	101	32	29.0	28.8	27.8	35.8	754.60	52	7.00	0.065	50	50
Full	21:15	22.72	22.69	22.75	532	104	100	33	29.0	28.6	27.8	35.0	755.65	52	7.00	0.111		
	22:00	22.43	22.34	22.43	534	104	99	33	29.0	28.6	27.8	35.0	755.65	52	7.00	0.111	51	51
	23:00	22.44	22.47	22.52	534	104	99	34	29.0	28.6	27.8	35.0	755.00	52	7.00	0.111	52	52
	0:00	22.42	22.56	22.49	534	104	101	34	29.0	28.9	27.8	35.0	755.00	52	7.00	0.111	53	53

ตารางที่ ง-4 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 45-60 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.72	24.81	24.79	496	101	101	34	29.0	28.9	27.8	35.0	755.50	52	7.00	0.089		
	0:30	24.26	24.32	24.29	494	102	101	34	29.0	28.4	27.8	35.0	755.50	52	7.00	0.089		
	0:45	24.41	24.38	24.43	495	102	102	33	28.5	28.4	27.8	35.0	755.50	52	7.00	0.089		
	1:00	24.59	24.50	24.56	495	102	101	33	28.5	28.4	27.8	34.7	755.50	52	7.00	0.089	54	54
80 %	1:15	26.28	26.18	26.29	451	101	100	33	28.5	28.2	27.6	34.7	755.50	52	7.00	0.065		
	1:30	26.39	26.20	26.36	451	101	99	33	28.5	28.2	27.6	34.7	755.50	52	7.00	0.065		
	1:45	26.52	26.52	26.58	452	101	99	33	28.5	28.2	27.6	34.7	755.50	52	7.00	0.065		
	2:00	26.28	26.18	26.22	451	101	99	33	28.5	28.2	27.6	34.7	755.50	52	7.00	0.065	55	55
Full	2:15	22.75	22.82	22.86	529	104	101	34	28.0	28.2	27.6	34.2	755.50	52	7.00	0.111		
	3:00	22.87	22.94	22.95	529	106	100	33	28.0	28.0	27.4	34.2	755.80	52	7.00	0.111	56	56
	4:00	22.82	22.87	22.79	529	105	100	33	28.0	28.0	27.4	34.2	755.20	52	7.00	0.111	57	57
	5:00	22.81	22.88	22.89	529	105	99	33	28.0	28.0	27.4	34.2	755.30	52	7.00	0.111	58	58
90 %	5:15	24.63	24.68	24.71	500	103	99	32	28.0	27.8	27.4	34.2	755.30	52	7.00	0.089		
	5:30	24.35	24.28	24.32	497	103	98	32	28.0	27.6	27.4	33.8	755.30	52	7.00	0.089		
	5:45	24.67	24.54	24.56	495	102	98	33	28.0	27.6	27.4	33.8	755.30	52	7.00	0.089		
	6:00	24.28	24.42	24.38	496	102	99	32	28.0	27.6	27.0	33.8	755.30	52	7.00	0.089	59	59
80 %	6:15	26.23	26.39	26.35	495	101	100	32	27.5	27.4	27.0	33.8	755.80	52	7.00	0.065		
	6:30	26.22	26.11	26.19	489	101	98	32	27.5	27.4	27.0	33.8	755.80	52	7.00	0.065		
	6:45	26.30	26.41	26.38	489	101	98	32	27.5	27.4	27.0	33.8	755.80	52	7.00	0.065		
	7:00	26.26	26.14	26.24	489	101	99	33	27.5	27.2	27.2	33.8	755.80	52	7.00	0.065	60	60

ตารางที่ ง-5 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 60-75

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.75	22.78	22.82	548	99	98	33	30.0	30.2	29.0	39.4	754.80	52	7.00	0.111		
	17:00	22.67	22.59	22.64	542	102	98	33	30.0	30.0	29.0	39.4	754.80	52	7.00	0.111	61	61
	18:00	22.18	22.24	22.22	542	102	99	33	30.0	30.0	29.0	39.4	754.50	52	7.00	0.111	62	62
	19:00	22.47	22.50	22.38	542	102	100	34	29.5	29.8	28.8	39.4	754.50	52	7.00	0.111	63	63
90 %	19:15	24.09	24.19	24.12	501	101	102	34	29.5	29.8	28.6	39.4	754.60	52	7.00	0.089		
	19:30	24.25	24.22	24.39	500	100	102	34	29.5	30.0	28.6	39.4	754.60	52	7.00	0.089		
	19:45	24.11	24.17	24.16	501	100	103	34	29.5	30.0	28.6	39.9	754.60	52	7.00	0.089		
	20:00	24.03	24.11	24.16	501	101	103	33	29.5	29.8	28.4	38.8	754.50	52	7.00	0.089	64	64
80 %	20:15	26.07	26.12	26.11	468	100	102	33	29.5	29.8	28.4	38.8	755.00	52	7.00	0.065		
	20:30	26.25	26.31	26.33	469	99	102	33	30.0	29.8	28.4	38.8	755.00	52	7.00	0.065		
	20:45	26.12	26.08	26.17	468	100	101	33	30.0	29.8	28.2	38.8	755.20	52	7.00	0.065		
	21:00	26.00	26.27	26.18	468	101	101	34	30.0	29.8	28.2	38.8	755.20	52	7.00	0.065	65	65
Full	21:15	22.68	22.78	22.71	552	102	102	33	29.0	29.6	28.2	39.0	755.40	52	7.00	0.111		
	22:00	22.12	22.28	22.30	551	102	102	33	29.0	29.6	28.2	39.0	755.00	52	7.00	0.111	66	66
	23:00	22.52	22.45	22.41	551	103	101	33	29.0	29.2	28.0	39.0	755.00	52	7.00	0.111	67	67
	0:00	22.04	22.14	22.12	551	103	101	33	29.0	28.4	27.6	39.0	754.90	52	7.00	0.111	68	68

ตารางที่ ง-5 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 60-75 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:30	24.13	24.24	24.26	502	104	100	33	29.0	28.2	27.4	38.5	754.80	52	7.00	0.089		
	0:45	24.20	24.31	24.29	501	103	99	33	29.5	28.2	27.4	38.5	754.50	52	7.00	0.089		
	1:00	24.07	24.04	24.11	501	103	101	33	29.5	28.0	27.4	38.5	754.50	52	7.00	0.089	69	69
	1:15	26.69	26.66	26.68	471	103	102	33	29.5	28.0	27.4	38.5	754.50	52	7.00	0.065		
80 %	1:30	26.56	26.63	26.79	470	102	102	33	29.0	28.0	27.4	38.5	754.80	52	7.00	0.065		
	1:45	26.05	26.18	26.15	471	100	102	33	28.0	28.0	27.6	38.5	754.80	52	7.00	0.065		
	2:00	26.55	26.49	26.53	471	100	102	32	28.0	28.0	27.6	38.5	754.80	52	7.00	0.065	70	70
	2:15	22.78	22.75	22.81	553	99	100	32	28.0	28.0	27.6	38.4	754.75	52	7.00	0.111		
Full	3:00	22.12	22.19	22.08	552	101	101	32	28.0	27.2	27.6	38.4	754.75	52	7.00	0.111	71	71
	4:00	22.18	22.06	22.12	552	101	101	32	28.0	27.0	27.2	38.4	754.20	52	7.00	0.111	72	72
	5:00	22.21	22.32	22.28	552	101	101	32	28.0	27.2	27.0	38.4	754.50	52	7.00	0.111	73	73
	5:15	24.16	24.08	24.19	505	101	102	33	28.0	27.4	27.2	38.0	754.50	52	7.00	0.089		
90 %	5:30	24.05	24.15	24.21	505	102	102	33	28.0	27.4	27.2	38.0	754.30	52	7.00	0.089		
	5:45	24.28	24.23	24.31	504	102	100	33	28.0	27.4	27.4	38.0	754.30	52	7.00	0.089		
	6:00	24.48	24.32	24.42	503	102	100	32	28.0	27.2	27.4	38.0	755.00	52	7.00	0.089	74	74
	6:15	26.69	26.55	26.62	468	102	101	32	28.0	27.4	27.4	37.8	755.00	52	7.00	0.065		
80 %	6:30	26.97	26.82	26.85	469	102	101	32	28.0	27.4	27.4	37.8	755.20	52	7.00	0.065		
	6:45	26.44	26.52	26.48	469	103	100	32	28.0	27.4	27.4	37.8	755.50	52	7.00	0.065		
	7:00	26.22	26.18	26.28	469	102	99	32	28.0	27.4	27.4	37.8	755.50	52	7.00	0.065	75	75
	0:30	24.13	24.24	24.26	502	104	100	33	29.0	28.2	27.4	38.5	754.80	52	7.00	0.089		

ตารางที่ ง-6 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 75-90

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.41	22.38	22.43	528	101	102	32	31.5	30.8	29.0	34.8	754.50	52	7.00	0.111		
	17:00	22.60	22.76	22.74	528	101	102	34	31.5	31.6	29.0	34.8	754.50	52	7.00	0.111	76	76
	18:00	22.19	22.31	22.12	529	100	102	34	30.0	30.2	28.8	34.8	753.80	52	7.00	0.111	77	77
	19:00	22.55	22.59	22.61	529	100	104	34	30.0	30.0	28.2	34.8	754.00	52	7.00	0.111	78	78
90 %	19:15	24.20	24.13	24.22	495	100	101	33	29.5	30.0	28.2	34.8	754.00	52	7.00	0.089		
	19:30	24.25	24.13	24.27	495	101	100	33	29.0	29.8	28.2	34.5	753.60	52	7.00	0.089		
	19:45	24.37	24.31	24.47	495	102	100	33	29.0	29.6	28.2	34.5	753.60	52	7.00	0.089		
	20:00	24.07	24.01	24.55	495	102	100	33	29.0	29.6	28.2	34.5	754.00	52	7.00	0.089	79	79
80 %	20:15	26.28	26.33	26.40	468	103	99	32	29.0	29.4	28.2	39.5	754.40	52	7.00	0.065		
	20:30	26.50	26.47	26.48	468	103	98	32	29.0	29.2	28.0	39.5	754.40	52	7.00	0.065		
	20:45	26.31	26.25	26.32	468	103	98	32	29.0	29.0	28.0	39.5	754.40	52	7.00	0.065		
	21:00	26.45	26.47	26.41	468	103	98	32	29.0	29.0	28.0	39.5	754.40	52	7.00	0.065	80	80
Full	21:15	22.72	22.79	22.68	530	101	103	32	29.0	29.0	28.0	39.5	754.50	52	7.00	0.111		
	22:00	22.43	22.50	22.41	531	100	103	31	29.0	28.8	28.0	39.5	754.50	52	7.00	0.111	81	81
	23:00	22.84	22.97	22.85	531	101	103	31	28.5	28.9	27.9	39.5	754.20	52	7.00	0.111	82	82
	0:00	22.31	22.23	22.29	530	101	104	32	28.5	28.9	27.8	39.5	754.20	52	7.00	0.111	83	83

ตารางที่ ง-6 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 75-90 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:30	24.25	24.34	24.26	497	102	103	32	28.5	28.8	27.8	39.3	754.20	52	7.00	0.089		
	0:45	24.43	24.47	24.46	497	102	103	33	28.5	28.8	27.8	39.3	754.20	52	7.00	0.089		
	1:00	24.53	24.65	24.68	497	102	101	33	28.5	28.8	27.8	39.3	754.20	52	7.00	0.089	84	84
	1:15	26.22	26.32	26.39	469	100	101	32	28.5	28.6	27.6	39.3	754.60	52	7.00	0.065		
80 %	1:30	26.42	26.34	26.31	469	100	100	33	28.5	28.4	27.4	39.3	754.60	52	7.00	0.065		
	1:45	26.27	26.23	26.35	469	100	102	32	28.5	28.2	27.4	39.3	754.60	52	7.00	0.065		
	2:00	26.20	26.31	26.25	469	99	102	32	28.5	28.2	27.4	39.3	754.60	52	7.00	0.065	85	85
	2:15	22.35	22.47	22.38	527	99	99	32	28.5	28.2	27.4	39.3	754.60	52	7.00	0.111		
Full	3:00	22.37	22.31	22.22	527	102	98	32	28.5	28.2	27.4	39.3	754.60	52	7.00	0.111	86	86
	4:00	22.68	22.75	22.65	527	104	100	33	28.0	28.2	27.4	39.3	754.50	52	7.00	0.111	87	87
	5:00	22.08	22.19	22.17	527	105	101	33	28.0	28.2	27.4	39.3	754.50	52	7.00	0.111	88	88
	5:15	24.39	24.25	24.34	501	104	99	33	28.0	28.0	27.4	39.1	754.30	52	7.00	0.089		
90 %	5:30	24.23	24.28	24.10	501	104	99	32	28.0	28.0	27.4	39.1	754.40	52	7.00	0.089		
	5:45	24.35	24.14	24.15	500	103	100	32	28.0	28.0	27.4	39.1	754.40	52	7.00	0.089		
	6:00	24.59	24.54	24.68	500	103	100	33	28.0	28.0	27.4	39.1	754.75	52	7.00	0.089	89	89
	6:15	26.45	26.46	26.44	471	103	101	33	28.0	28.2	27.4	39.0	754.75	52	7.00	0.065		
80 %	6:30	26.29	26.32	26.27	472	103	101	32	28.0	28.2	27.6	39.0	754.75	52	7.00	0.065		
	6:45	26.19	26.35	26.26	472	101	100	31	28.0	28.2	27.6	39.0	754.80	52	7.00	0.065		
	7:00	26.67	26.64	26.52	472	101	101	31	28.0	28.2	27.4	39.0	754.80	52	7.00	0.065	90	90
	0:30	24.25	24.34	24.26	497	102	103	32	28.5	28.8	27.8	39.3	754.20	52	7.00	0.089		

ตารางที่ ง-7 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 90-105

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.67	22.81	22.61	541	100	100	34	31.0	30.8	29.4	42.0	754.25	52	7.00	0.111		
	17:00	22.37	22.26	22.28	541	101	102	34	31.0	30.6	29.4	42.0	754.25	52	7.00	0.111	91	91
	18:00	22.22	22.17	22.12	541	102	103	34	30.0	30.4	29.2	42.0	754.00	52	7.00	0.111	92	92
	19:00	22.33	22.30	22.25	540	102	102	34	29.0	30.0	29.2	42.0	754.80	52	7.00	0.111	93	93
90 %	19:15	24.97	24.91	24.99	501	101	100	33	29.0	29.8	29.0	42.0	754.80	52	7.00	0.089		
	19:30	24.16	24.03	24.03	498	101	100	33	29.5	29.8	28.8	42.0	754.50	52	7.00	0.089		
	19:45	24.28	24.23	24.32	498	101	99	33	29.5	29.6	28.2	42.0	754.50	52	7.00	0.089		
	20:00	24.39	24.33	24.40	498	100	100	33	29.0	29.7	28.7	42.0	754.50	52	7.00	0.089	94	94
80 %	20:15	26.59	26.71	26.49	471	101	99	33	29.5	29.5	28.5	42.0	754.50	52	7.00	0.065		
	20:30	26.70	26.87	26.77	471	100	99	33	29.5	29.4	28.4	42.0	754.50	52	7.00	0.065		
	20:45	26.34	26.19	26.16	470	102	98	33	29.0	29.4	28.3	42.0	754.50	52	7.00	0.065		
	21:00	26.35	26.50	26.71	470	102	97	33	29.0	29.4	28.3	42.0	754.50	52	7.00	0.065	95	95
Full	21:15	22.85	22.69	22.72	539	102	102	33	29.0	29.4	28.2	43.5	755.60	52	7.00	0.111		
	22:00	22.25	22.18	22.15	539	103	102	32	29.0	29.2	28.2	43.5	755.30	52	7.00	0.111	96	96
	23:00	22.35	22.31	22.35	539	103	102	32	28.8	28.8	27.6	43.5	755.50	52	7.00	0.111	97	97
	0:00	22.68	22.65	22.67	539	102	103	33	28.8	28.8	27.6	43.5	755.50	52	7.00	0.111	98	98

ตารางที่ ง-7 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 90-105 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.13	24.17	24.25	506	101	102	33	28.8	28.7	27.6	43.4	755.30	52	7.00	0.089		
	0:30	24.78	24.83	24.85	503	101	102	33	28.8	28.7	27.6	43.4	755.30	52	7.00	0.089		
	0:45	24.28	24.31	24.38	502	100	100	32	28.0	28.6	27.6	43.4	755.30	52	7.00	0.089		
	1:00	24.25	24.17	24.32	502	100	100	32	28.0	28.6	27.6	43.4	755.30	52	7.00	0.089	99	99
80 %	1:15	26.28	26.20	26.15	483	99	101	32	28.0	28.4	27.6	42.8	755.00	52	7.00	0.065		
	1:30	26.38	26.22	26.35	483	99	101	32	28.0	28.4	27.6	42.8	755.00	52	7.00	0.065		
	1:45	26.67	26.70	26.77	484	100	101	32	28.0	28.4	27.6	42.8	754.80	52	7.00	0.065		
	2:00	26.29	26.28	26.43	483	100	101	32	28.0	28.4	27.6	42.8	754.80	52	7.00	0.065	100	100
Full	2:15	22.28	22.37	22.36	535	100	99	31	28.0	28.4	27.6	42.0	754.80	52	7.00	0.111		
	3:00	22.12	22.20	22.16	535	102	97	31	28.0	28.4	27.6	42.0	754.80	52	7.00	0.111	101	1
	4:00	22.48	22.38	22.56	535	102	99	31	28.0	28.2	27.4	42.0	754.80	52	7.00	0.111	102	2
	5:00	22.41	22.41	22.48	535	102	100	32	28.0	28.2	27.2	40.9	754.80	52	7.00	0.111	103	3
90 %	5:15	24.13	24.07	24.07	507	100	98	31	28.8	28.4	27.2	40.2	754.60	52	7.00	0.089		
	5:30	24.27	24.31	24.38	506	99	98	31	28.8	28.5	27.4	40.2	755.00	52	7.00	0.089		
	5:45	24.61	24.70	24.68	506	99	97	30	28.8	28.7	27.5	40.2	755.00	52	7.00	0.089		
	6:00	24.04	24.05	24.11	507	99	98	31	28.0	28.7	27.5	40.2	755.00	52	7.00	0.089	104	4
80 %	6:15	26.14	26.08	26.11	486	99	98	31	28.0	28.7	27.5	40.1	755.00	52	7.00	0.065		
	6:30	26.27	26.18	26.14	484	98	96	31	28.0	28.7	28.1	40.1	755.00	52	7.00	0.065		
	6:45	26.00	26.05	26.11	483	98	96	31	28.0	28.6	28.1	40.1	755.00	52	7.00	0.065		
	7:00	26.18	26.03	26.10	486	100	96	31	29.0	28.6	27.6	40.1	755.00	52	7.00	0.065	105	5

ตารางที่ ง-8 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 105-115

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.68	22.71	22.76	542	103	100	33	31.0	29.2	28.4	42.8	754.25	52	7.00	0.111		
	17:00	22.12	22.04	22.16	542	103	100	33	31.0	29.2	28.4	42.8	754.25	52	7.00	0.111	106	6
	18:00	22.42	22.38	22.49	542	102	101	33	31.0	29.2	28.4	42.8	754.00	52	7.00	0.111	107	7
	19:00	22.25	22.18	22.22	541	102	101	33	31.0	29.2	28.4	42.8	754.80	52	7.00	0.111	108	8
90 %	19:15	24.81	24.74	24.86	497	103	99	33	30.5	29.2	28.4	41.0	754.80	52	7.00	0.089		
	19:30	24.12	24.17	24.25	497	103	99	33	30.5	29.0	28.2	41.0	754.50	52	7.00	0.089		
	19:45	24.33	24.29	24.31	497	103	99	32	30.5	29.0	28.2	41.0	754.50	52	7.00	0.089		
	20:00	24.65	24.58	24.54	497	103	100	32	30.0	29.0	28.2	41.0	754.50	52	7.00	0.089	109	9
80 %	20:15	26.72	26.64	26.76	464	102	100	32	30.0	28.8	27.8	41.0	754.50	52	7.00	0.065		
	20:30	26.08	26.22	26.19	464	102	101	31	30.0	28.8	27.8	39.8	754.50	52	7.00	0.065		
	20:45	26.33	26.39	26.42	464	102	101	31	30.0	28.8	27.8	39.8	754.50	52	7.00	0.065		
	21:00	26.44	26.51	26.42	464	102	101	31	30.0	28.8	27.8	39.8	754.50	52	7.00	0.065	110	10
Full	21:15	22.58	22.54	22.68	540	104	103	31	29.5	28.6	27.4	39.8	755.60	52	7.00	0.111		
	22:00	22.42	22.22	22.22	540	104	103	31	29.5	28.6	27.4	39.8	755.30	52	7.00	0.111	111	11
	23:00	22.52	22.47	22.43	539	103	102	30	29.0	28.6	27.4	39.8	755.50	52	7.00	0.111	112	12
	0:00	22.34	22.28	22.31	540	103	102	30	29.0	28.6	27.4	39.8	755.50	52	7.00	0.111	113	13

ตารางที่ ง-8 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 105-115 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.43	24.59	24.44	496	102	101	30	28.5	28.4	27.2	39.8	755.30	52	7.00	0.089		
	0:30	24.82	24.86	24.88	496	102	101	30	28.5	28.4	27.2	39.8	755.30	52	7.00	0.089		
	0:45	24.72	24.66	24.79	495	102	100	30	28.0	28.4	27.2	39.8	755.30	52	7.00	0.089		
	1:00	24.12	24.24	24.25	495	102	99	30	28.0	28.4	27.2	39.8	755.30	52	7.00	0.089	114	14
80 %	1:15	26.72	26.66	26.81	461	101	99	30	28.0	28.4	27.2	38.8	755.00	52	7.00	0.065		
	1:30	26.01	26.14	26.16	461	101	99	30	28.0	28.4	27.2	38.8	755.00	52	7.00	0.065		
	1:45	26.53	26.69	26.63	460	101	99	30	28.0	28.4	27.2	38.8	754.80	52	7.00	0.065		
	2:00	26.34	26.43	26.49	461	100	99	30	28.0	28.4	27.2	38.8	754.80	52	7.00	0.065	115	15
Full	21:15	22.58	22.54	22.68	540	104	103	31	29.5	28.6	27.4	39.8	755.60	52	7.00	0.111		
	22:00	22.42	22.22	22.22	540	104	103	31	29.5	28.6	27.4	39.8	755.30	52	7.00	0.111	111	11
	23:00	22.52	22.47	22.43	539	103	102	30	29.0	28.6	27.4	39.8	755.50	52	7.00	0.111	112	12
	0:00	22.34	22.28	22.31	540	103	102	30	29.0	28.6	27.4	39.8	755.50	52	7.00	0.111	113	13
90 %	0:15	24.43	24.59	24.44	496	102	101	30	28.5	28.4	27.2	39.8	755.30	52	7.00	0.089		
	0:30	24.82	24.86	24.88	496	102	101	30	28.5	28.4	27.2	39.8	755.30	52	7.00	0.089		
	0:45	24.72	24.66	24.79	495	102	100	30	28.0	28.4	27.2	39.8	755.30	52	7.00	0.089		
	1:00	24.12	24.24	24.25	495	102	99	30	28.0	28.4	27.2	39.8	755.30	52	7.00	0.089	114	14
80 %	1:15	26.72	26.66	26.81	461	101	99	30	28.0	28.4	27.2	38.8	755.00	52	7.00	0.065		
	1:30	26.01	26.14	26.16	461	101	99	30	28.0	28.4	27.2	38.8	755.00	52	7.00	0.065		
	1:45	26.53	26.69	26.63	460	101	99	30	28.0	28.4	27.2	38.8	754.80	52	7.00	0.065		
	2:00	26.34	26.43	26.49	461	100	99	30	28.0	28.4	27.2	38.8	754.80	52	7.00	0.065	115	15

ตารางที่ ง-9 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 115-130

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.34	22.31	22.42	543	100	101	32	32.0	31.0	28.0	42.2	754.00	52	7.00	0.111		
	17:00	22.50	22.56	22.53	543	103	102	31	31.0	31.0	28.7	42.2	753.80	52	7.00	0.111	116	16
	18:00	23.09	22.84	22.95	543	103	103	32	29.8	29.0	28.1	42.2	754.25	52	7.00	0.111	117	17
	19:00	22.28	22.25	22.32	543	102	102	33	29.9	29.4	28.0	42.2	754.80	52	7.00	0.111	118	18
90 %	19:15	24.56	24.66	24.50	501	103	101	33	29.2	29.4	28.0	42.2	754.80	52	7.00	0.089		
	19:30	24.87	24.91	24.92	501	104	101	32	29.3	29.2	28.0	41.4	754.80	52	7.00	0.089		
	19:45	24.40	24.58	24.51	500	104	101	32	29.0	29.2	28.0	41.4	754.80	52	7.00	0.089		
	20:00	24.19	24.36	24.32	500	105	101	32	29.0	29.2	27.9	41.4	754.50	52	7.00	0.089	119	19
80 %	20:15	26.40	26.31	26.37	470	103	99	32	28.0	29.2	28.0	41.4	754.50	52	7.00	0.065		
	20:30	26.31	26.47	26.53	470	101	99	32	28.8	29.0	28.0	41.4	754.50	52	7.00	0.065		
	20:45	26.23	26.24	26.31	470	102	99	32	28.8	28.8	27.8	41.4	754.00	52	7.00	0.065		
	21:00	26.44	26.48	24.46	469	101	98	31	28.8	28.8	27.6	41.4	754.00	52	7.00	0.065	120	20
Full	21:15	22.16	22.13	22.22	544	104	103	31	28.5	28.6	27.7	41.8	754.00	52	7.00	0.111		
	22:00	22.33	22.31	22.28	544	104	103	31	28.5	28.6	27.8	41.8	755.00	52	7.00	0.111	121	21
	23:00	22.38	22.37	22.41	544	106	103	31	28.2	28.4	27.8	41.8	755.40	52	7.00	0.111	122	22
	0:00	22.65	22.58	22.67	544	104	103	31	28.5	28.4	27.4	41.8	755.60	52	7.00	0.111	123	23

ตารางที่ ง-9 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 115-130 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.31	24.20	24.54	500	103	100	31	28.5	28.2	27.4	41.8	755.60	52	7.00	0.089		
	0:30	24.43	24.58	24.57	499	102	99	31	28.1	28.3	27.5	41.8	755.80	52	7.00	0.089		
	0:45	24.62	24.58	24.64	499	102	99	31	28.1	28.2	27.3	41.8	755.60	52	7.00	0.089		
	1:00	24.40	24.57	24.61	499	102	100	31	28.0	28.2	27.4	41.8	755.80	52	7.00	0.089	124	24
80 %	1:15	26.43	26.45	26.50	468	103	97	31	28.0	28.2	27.4	41.6	755.60	52	7.00	0.065		
	1:30	26.50	26.32	26.44	468	100	96	31	28.0	28.1	27.6	41.6	755.60	52	7.00	0.065		
	1:45	26.20	26.28	29.19	468	102	97	31	28.0	28.1	27.6	41.6	755.00	52	7.00	0.065		
	2:00	26.30	26.15	26.28	468	102	97	30	28.0	28.1	27.7	41.6	755.00	52	7.00	0.065	125	25
Full	2:15	22.28	22.15	22.39	536	104	102	31	28.0	29.0	27.2	40.8	754.80	52	7.00	0.111		
	3:00	22.35	22.28	22.42	536	104	103	31	28.0	29.0	27.2	40.8	754.80	52	7.00	0.111	126	26
	4:00	22.59	22.66	22.52	536	106	103	31	28.0	28.0	27.2	40.8	754.80	52	7.00	0.111	127	27
	5:00	22.69	22.78	22.75	537	106	103	31	28.0	28.0	27.2	40.8	754.80	52	7.00	0.111	128	28
90 %	5:15	24.59	24.43	24.44	503	105	102	31	28.0	27.9	27.2	40.8	754.80	52	7.00	0.089		
	5:30	24.43	24.57	24.63	502	104	101	30	28.0	27.9	27.2	40.8	754.80	52	7.00	0.089		
	5:45	24.10	24.12	24.07	502	104	101	30	28.0	27.9	27.2	40.8	754.80	52	7.00	0.089		
	6:00	24.37	24.36	24.36	502	104	100	30	28.0	27.9	27.2	40.8	754.80	52	7.00	0.089	129	29
80 %	6:15	26.28	26.35	26.31	480	103	98	30	28.0	27.8	27.2	40.6	754.80	52	7.00	0.065		
	6:30	26.52	26.43	26.42	481	103	98	30	28.0	27.8	27.2	40.6	755.20	52	7.00	0.065		
	6:45	26.45	26.39	26.47	481	102	97	30	28.0	27.8	27.2	40.6	755.20	52	7.00	0.065		
	7:00	26.29	26.33	26.38	481	102	98	30	28.0	27.8	27.2	40.6	755.20	52	7.00	0.065	130	30

ตารางที่ ง-10 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 130-145

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.25	22.37	22.22	563	97	98	30	31.0	29.8	29.6	38.0	754.00	52	7.00	0.111		
	17:00	22.98	23.06	22.96	569	101	102	31	30.5	29.8	29.4	38.0	754.20	52	7.00	0.111	131	31
	18:00	22.19	22.22	22.12	565	103	102	31	30.0	30.2	29.2	38.0	754.80	52	7.00	0.111	132	32
	19:00	22.25	22.17	22.27	568	103	102	31	30.0	30.2	29.2	38.0	754.00	52	7.00	0.111	133	33
90 %	19:15	24.69	24.88	24.77	528	103	101	31	29.5	29.4	28.6	38.4	754.80	52	7.00	0.089		
	19:30	24.68	24.75	24.70	524	105	100	32	29.5	29.6	28.6	38.4	754.80	52	7.00	0.089		
	19:45	24.58	24.59	24.62	518	103	100	31	29.5	29.3	28.5	38.4	754.60	52	7.00	0.089		
	20:00	24.50	24.50	24.55	524	102	100	31	29.0	29.2	28.5	38.4	755.00	52	7.00	0.089	134	34
80 %	20:15	26.50	26.57	26.53	479	102	98	31	29.0	29.1	28.4	38.3	755.25	52	7.00	0.065		
	20:30	26.85	26.87	26.82	481	101	98	31	28.8	29.0	28.4	38.2	755.25	52	7.00	0.065		
	20:45	26.37	26.39	26.38	485	101	98	30	28.8	28.9	28.3	38.2	755.25	52	7.00	0.065		
	21:00	26.50	26.51	26.56	482	99	97	31	28.8	28.9	28.3	38.2	755.30	52	7.00	0.065	135	35
Full	21:15	22.59	22.65	22.63	567	102	102	31	28.8	28.8	28.2	38.0	755.50	52	7.00	0.111		
	22:00	22.50	22.45	22.49	560	103	102	31	28.5	28.7	28.2	38.0	755.60	52	7.00	0.111	136	36
	23:00	22.34	22.36	22.31	565	102	102	30	28.0	28.7	28.1	37.5	756.10	52	7.00	0.111	137	37
	0:00	22.34	22.45	22.42	567	103	102	30	28.0	28.7	28.1	37.5	756.10	52	7.00	0.111	138	38

ตารางที่ ง-10 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 130-145 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.42	24.40	24.39	518	102	100	30	28.0	28.5	28.0	37.3	755.80	52	7.00	0.089		
	0:30	24.32	24.45	24.41	515	102	99	30	28.0	28.4	28.0	37.3	755.75	52	7.00	0.089		
	0:45	24.32	24.35	24.28	515	102	101	30	28.0	28.2	27.6	37.3	755.75	52	7.00	0.089		
	1:00	24.44	24.57	24.49	514	102	101	30	28.0	28.2	27.6	37.3	755.35	52	7.00	0.089	139	39
80 %	1:15	26.75	26.78	26.72	483	103	97	30	28.0	28.2	27.6	37.4	755.35	52	7.00	0.065		
	1:30	26.40	26.45	26.41	479	103	97	30	28.0	28.2	27.6	37.4	755.35	52	7.00	0.065		
	1:45	26.33	26.39	26.41	479	101	97	30	28.0	28.2	27.6	37.4	755.40	52	7.00	0.065		
	2:00	26.87	26.81	26.79	479	100	97	30	28.0	28.2	27.6	37.4	755.40	52	7.00	0.065	140	40
Full	2:15	22.75	22.66	22.69	552	104	102	30	28.0	28.2	27.4	36.6	755.40	52	7.00	0.111		
	3:00	22.43	22.48	22.53	552	103	101	30	28.0	28.2	27.6	36.6	755.25	52	7.00	0.111	141	41
	4:00	22.41	22.39	22.41	552	105	102	30	28.0	28.2	27.6	36.6	755.30	52	7.00	0.111	142	42
	5:00	22.25	22.21	22.19	553	104	102	30	28.0	28.2	27.5	36.6	754.90	52	7.00	0.111	143	43
90 %	5:15	24.62	24.64	24.67	510	102	100	30	28.0	28.2	27.5	36.4	754.90	52	7.00	0.089		
	5:30	24.53	24.48	24.56	509	103	100	30	28.0	28.2	27.5	36.4	754.90	52	7.00	0.089		
	5:45	24.47	24.49	24.51	509	102	99	30	28.0	28.2	27.6	36.4	755.20	52	7.00	0.089		
	6:00	24.39	24.33	24.39	509	103	99	30	28.0	28.2	27.5	36.4	755.20	52	7.00	0.089	144	44
80 %	6:15	26.44	26.25	26.34	478	102	98	30	28.0	28.2	27.6	36.3	755.80	52	7.00	0.065		
	6:30	26.04	26.06	26.01	477	102	97	30	28.0	28.2	27.6	36.3	755.80	52	7.00	0.065		
	6:45	26.59	26.62	26.57	477	102	97	30	28.0	28.2	27.6	36.3	755.80	52	7.00	0.065		
	7:00	26.33	26.28	26.31	478	102	97	30	28.0	28.4	27.8	36.3	756.10	52	7.00	0.065	145	45

ตารางที่ ง-11 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 145-160

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.47	22.38	22.46	547	102	99	30	30.0	30.2	28.6	42.2	754.60	52	7.00	0.111		
	17:00	22.22	22.23	22.20	542	104	102	31	320.0	30.2	28.6	42.2	754.60	52	7.00	0.111	146	46
	18:00	22.97	22.94	22.91	548	102	102	31	30.0	29.9	28.3	42.2	754.30	52	7.00	0.111	147	47
	19:00	22.91	22.94	22.95	542	102	102	31	30.0	29.8	28.2	42.2	754.30	52	7.00	0.111	148	48
90 %	19:15	24.97	24.95	24.91	493	102	101	31	29.5	29.4	28.0	42.2	755.10	52	7.00	0.089		
	19:30	24.46	24.43	24.41	494	99	99	31	29.5	29.4	28.0	42.2	755.10	52	7.00	0.089		
	19:45	24.63	24.62	24.60	494	100	99	31	29.5	29.4	27.8	42.2	755.20	52	7.00	0.089		
	20:00	24.11	24.21	24.19	494	99	99	31	29.5	29.4	27.8	42.2	755.20	52	7.00	0.089	149	49
80 %	20:15	26.25	26.21	26.19	457	99	99	31	29.5	29.4	27.8	42.2	755.40	52	7.00	0.065		
	20:30	26.19	26.07	26.12	457	98	99	31	29.5	29.4	27.8	42.2	755.40	52	7.00	0.065		
	20:45	26.74	26.71	26.69	457	98	98	31	29.5	29.4	27.8	42.2	755.60	52	7.00	0.065		
	21:00	26.04	26.11	26.09	457	98	98	31	29.5	29.4	27.8	42.2	755.60	52	7.00	0.065	150	50
Full	21:15	22.94	22.94	22.95	545	106	103	29	29.0	28.6	27.4	41.4	755.75	52	7.00	0.111		
	22:00	22.82	22.80	22.86	545	106	104	29	29.0	28.6	27.4	41.4	755.75	52	7.00	0.111	151	51
	23:00	22.21	22.24	22.24	545	104	104	30	28.5	28.4	27.4	41.4	755.70	52	7.00	0.111	152	52
	0:00	22.19	22.20	22.17	544	103	102	30	28.5	28.4	27.4	41.4	755.75	52	7.00	0.111	153	53

ตารางที่ ง-11 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 145-160 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.15	24.16	24.07	494	102	102	30	28.0	28.2	27.2	41.4	755.75	52	7.00	0.089		
	0:30	24.75	24.82	24.79	492	102	101	30	28.0	28.2	27.2	41.4	755.80	52	7.00	0.089		
	0:45	24.39	24.27	24.32	494	101	100	30	28.0	28.2	27.2	41.4	755.75	52	7.00	0.089		
	1:00	24.15	24.26	24.19	493	101	100	30	28.0	28.2	27.2	41.3	755.75	52	7.00	0.089	154	54
80 %	1:15	26.95	26.84	26.86	453	101	100	30	28.0	28.2	27.2	41.3	755.75	52	7.00	0.065		
	1:30	26.19	26.22	26.24	453	100	100	30	28.0	28.2	27.2	41.3	755.80	52	7.00	0.065		
	1:45	26.29	26.35	26.31	453	100	99	30	28.0	28.2	27.2	41.3	755.80	52	7.00	0.065		
	2:00	26.44	26.39	26.41	453	100	99	30	28.0	28.2	27.2	41.3	755.80	52	7.00	0.065	155	55
Full	2:15	22.12	22.16	22.22	545	105	104	30	28.0	28.2	27.2	41.3	755.75	52	7.00	0.111		
	3:00	22.94	22.90	22.98	547	106	104	29	28.0	27.9	27.0	41.3	755.50	52	7.00	0.111	156	56
	4:00	22.44	22.47	22.38	545	106	104	29	28.0	27.9	27.0	41.3	755.25	52	7.00	0.111	157	57
	5:00	22.31	22.24	22.29	542	104	104	29	28.0	27.8	27.2	41.3	755.65	52	7.00	0.111	158	58
90 %	5:15	24.78	24.69	24.71	495	104	102	29	28.0	27.8	27.2	40.0	755.50	52	7.00	0.089		
	5:30	24.34	24.30	24.31	494	104	102	29	28.0	27.9	27.2	40.0	755.90	52	7.00	0.089		
	5:45	24.52	24.53	24.52	493	104	102	30	28.0	27.9	27.2	40.0	755.90	52	7.00	0.089		
	6:00	24.09	24.11	24.12	493	103	102	30	28.0	27.9	27.2	40.0	755.90	52	7.00	0.089	159	59
80 %	6:15	26.03	26.04	26.09	449	100	100	30	27.8	27.8	27.2	40.0	755.90	52	7.00	0.065		
	6:30	26.45	26.62	26.59	448	100	99	30	27.8	27.8	27.2	40.0	755.90	52	7.00	0.065		
	6:45	26.18	26.13	26.21	448	100	99	30	27.8	27.9	27.4	40.0	756.10	52	7.00	0.065		
	7:00	26.22	26.24	26.28	448	100	99	30	27.8	28.0	27.4	40.0	756.25	52	7.00	0.065	160	60

ตารางที่ ง-12 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 160-175

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.80	22.81	22.75	532	99	99	30	30.5	30.2	29.1	43.1	754.50	52	7.00	0.111		
	17:00	22.78	22.65	22.55	528	103	100	31	30.7	30.8	29.1	44.0	754.50	52	7.00	0.111	161	61
	18:00	22.59	22.44	22.50	528	103	101	32	31.0	30.3	28.8	44.0	754.20	52	7.00	0.111	162	62
	19:00	22.47	22.62	22.72	529	103	101	32	29.5	29.5	28.8	44.0	754.65	52	7.00	0.111	163	63
90 %	19:15	24.38	24.22	24.33	495	102	99	32	29.5	29.5	28.4	43.8	754.65	52	7.00	0.089		
	19:30	24.23	24.23	24.25	490	101	98	31	29.5	29.4	28.1	43.8	754.65	52	7.00	0.089		
	19:45	24.26	24.18	24.32	489	101	98	31	29.0	29.2	28.2	43.8	754.20	52	7.00	0.089		
	20:00	24.18	24.25	24.16	495	102	98	31	29.0	29.1	27.9	43.8	754.20	52	7.00	0.089	164	64
80 %	20:15	26.35	26.42	26.40	452	100	97	31	29.0	29.1	28.0	43.8	754.80	52	7.00	0.065		
	20:30	26.41	26.52	26.41	449	99	95	31	29.0	29.0	28.2	43.8	754.80	52	7.00	0.065		
	20:45	26.53	26.66	26.47	450	98	96	31	28.8	28.8	28.2	43.8	755.00	52	7.00	0.065		
	21:00	26.62	26.62	26.81	448	100	95	31	28.8	28.8	28.0	43.8	755.00	52	7.00	0.065	165	65
Full	21:15	22.47	22.46	22.51	530	102	99	30	28.5	28.7	27.9	43.8	755.80	52	7.00	0.111		
	22:00	22.87	22.63	22.68	538	104	100	30	28.5	28.7	27.8	43.8	755.00	52	7.00	0.111	166	66
	23:00	22.38	22.43	22.34	540	104	101	30	28.0	28.6	27.8	43.8	755.30	52	7.00	0.111	167	67
	0:00	22.53	22.69	22.44	541	105	101	30	28.0	28.5	27.8	43.8	755.50	52	7.00	0.111	168	68

ตารางที่ ง-12 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 160-175 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.40	24.35	24.23	493	103	98	31	28.0	28.5	27.8	43.8	755.50	52	7.00	0.089		
	0:30	24.32	24.38	24.28	504	103	99	30	28.0	28.5	27.8	43.8	755.50	52	7.00	0.089		
	0:45	24.25	24.22	24.27	504	103	99	30	28.0	28.5	27.8	43.8	755.50	52	7.00	0.089		
	1:00	24.12	24.25	24.18	504	103	99	30	28.0	28.5	27.8	43.8	755.50	52	7.00	0.089	169	69
80 %	1:15	26.34	26.42	26.38	456	102	96	30	28.0	28.5	27.5	43.8	755.00	52	7.00	0.065		
	1:30	26.03	26.04	26.12	456	102	96	30	28.0	28.5	27.5	43.8	755.00	52	7.00	0.065		
	1:45	26.15	25.88	25.97	452	99	95	30	28.0	28.5	27.5	43.8	755.00	52	7.00	0.065		
	2:00	26.00	26.27	26.28	452	99	95	30	28.0	28.4	27.5	43.8	755.00	52	7.00	0.065	170	70
Full	2:15	22.40	22.48	22.87	528	100	99	30	28.0	28.2	27.4	43.8	755.00	52	7.00	0.111		
	3:00	22.97	22.86	22.94	528	100	99	30	28.0	28.2	27.4	43.8	755.30	52	7.00	0.111	171	71
	4:00	23.06	22.95	22.87	529	101	99	30	28.0	28.2	27.4	43.8	755.30	52	7.00	0.111	172	72
	5:00	22.21	22.32	22.34	529	101	99	30	28.0	28.8	27.2	43.8	754.60	52	7.00	0.111	173	73
90 %	5:15	24.55	24.44	24.35	488	101	98	30	28.0	28.8	27.2	43.8	754.60	52	7.00	0.089		
	5:30	24.12	24.15	24.23	488	100	98	30	28.0	28.6	27.2	43.8	754.60	52	7.00	0.089		
	5:45	24.66	24.65	24.44	488	101	98	30	28.0	28.0	27.2	43.8	754.60	52	7.00	0.089		
	6:00	24.66	24.66	24.61	488	100	97	30	27.5	27.6	26.8	43.8	754.60	52	7.00	0.089	174	74
80 %	6:15	26.63	26.62	26.68	452	100	96	30	27.5	27.6	27.0	43.8	755.00	52	7.00	0.065		
	6:30	26.23	26.28	26.35	452	100	96	30	27.5	27.6	27.0	43.8	755.00	52	7.00	0.065		
	6:45	26.72	26.73	26.66	452	98	95	30	27.5	27.6	26.8	43.8	755.00	52	7.00	0.065		
	7:00	26.38	26.56	26.47	452	98	95	30	27.5	27.6	26.8	43.8	755.00	52	7.00	0.065	175	75

ตารางที่ ง-13 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 175-190

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.58	22.53	22.38	525	102	99	30	30.0	29.4	28.0	39.5	754.00	52	7.00	0.111		
	17:00	22.84	22.91	22.69	524	103	100	31	29.8	29.2	28.0	39.5	753.50	52	7.00	0.111	176	76
	18:30	22.50	22.38	22.48	532	99	99	31	29.2	28.6	27.8	39.5	753.50	52	7.00	0.111	177	77
	19:00	22.69	22.56	22.60	529	100	99	30	29.0	29.3	28.1	39.5	753.50	52	7.00	0.111	178	78
90 %	19:15	24.31	24.31	24.43	489	101	98	30	29.0	29.2	28.1	39.4	753.50	52	7.00	0.089		
	19:30	24.62	24.68	24.77	485	101	98	31	28.8	29.0	28.0	39.4	753.50	52	7.00	0.089		
	19:45	24.78	24.62	24.56	493	102	99	31	28.5	29.0	27.7	39.4	752.70	52	7.00	0.089		
	20:00	24.36	24.47	24.53	490	102	99	31	28.5	28.8	27.7	39.4	754.60	52	7.00	0.089	179	79
80 %	20:15	26.42	26.38	26.42	459	100	97	31	29.0	28.8	28.1	39.4	755.00	52	7.00	0.065		
	20:30	26.52	26.56	26.60	452	100	95	31	29.0	28.8	28.2	39.4	754.55	52	7.00	0.065		
	20:45	26.60	26.58	26.67	450	99	95	31	29.0	28.8	28.0	39.4	754.80	52	7.00	0.065		
	21:00	26.54	26.65	26.59	448	98	95	31	29.0	28.8	27.6	39.4	754.80	52	7.00	0.065	180	80
Full	21:15	22.80	22.85	22.90	532	101	99	31	29.0	28.6	27.4	39.6	755.50	52	7.00	0.111		
	22:00	22.88	22.76	22.83	532	101	99	30	28.8	28.6	27.4	39.6	755.50	52	7.00	0.111	181	81
	23:00	22.62	22.43	22.66	531	100	100	31	28.5	28.5	27.5	39.6	755.20	52	7.00	0.111	182	82
	0:00	22.78	22.63	22.60	530	102	100	30	28.0	28.5	27.9	39.6	755.85	52	7.00	0.111	183	83

ตารางที่ ง-13 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 175-190 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.75	24.66	24.78	490	101	98	30	28.0	28.4	27.6	39.5	755.85	52	7.00	0.089		
	0:30	24.85	24.91	24.97	492	102	99	30	28.0	28.3	27.6	39.5	755.85	52	7.00	0.089		
	0:45	24.63	24.68	25.67	486	102	99	30	28.0	28.2	27.6	39.5	755.00	52	7.00	0.089		
	1:00	24.91	24.72	24.87	484	102	98	30	27.8	28.2	27.6	39.5	754.50	52	7.00	0.089	184	84
80 %	1:15	26.48	26.67	26.43	460	102	97	30	27.8	28.1	27.6	39.5	754.50	52	7.00	0.065		
	1:30	26.23	26.31	25.82	459	102	97	30	28.0	28.0	27.5	39.5	755.00	52	7.00	0.065		
	1:45	26.47	26.19	26.10	458	102	97	30	28.0	27.9	27.3	39.5	755.00	52	7.00	0.065		
	2:00	26.16	26.31	26.22	459	101	97	30	28.0	27.9	27.4	39.5	755.30	52	7.00	0.065	185	85
Full	2:15	22.53	22.66	22.91	539	102	99	30	28.0	27.9	27.4	39.5	755.30	52	7.00	0.111		
	3:00	22.54	22.75	22.41	534	101	98	30	27.9	28.0	27.2	39.5	754.75	52	7.00	0.111	186	86
	4:00	22.44	22.26	22.62	533	101	99	30	27.5	27.8	27.3	39.5	754.75	52	7.00	0.111	187	87
	5:00	22.42	22.48	22.31	529	101	99	30	27.8	27.8	27.2	39.5	754.90	52	7.00	0.111	188	88
90 %	5:15	24.72	24.62	24.41	488	102	98	30	28.0	27.7	27.2	39.5	754.90	52	7.00	0.089		
	5:30	24.31	24.35	24.42	485	101	98	30	28.0	27.8	27.2	39.5	754.80	52	7.00	0.089		
	5:45	24.75	24.87	25.06	486	100	97	29	28.0	27.8	27.2	39.5	754.80	52	7.00	0.089		
	6:00	24.50	24.40	24.35	485	100	97	30	28.0	27.8	27.2	39.5	754.80	52	7.00	0.089	189	89
80 %	6:15	24.47	25.25	25.59	457	101	96	30	27.5	27.7	27.3	39.5	754.80	52	7.00	0.065		
	6:30	26.28	26.59	26.40	455	101	96	30	27.5	27.7	27.3	39.5	754.80	52	7.00	0.065		
	6:45	26.57	26.57	26.64	452	99	96	29	28.0	27.8	27.4	39.5	754.80	52	7.00	0.065		
	7:00	26.50	26.38	26.44	453	100	96	29	28.0	27.8	27.4	39.5	755.00	52	7.00	0.065	190	90

ตารางที่ ง-14 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 190-205

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.32	22.48	22.50	538	103	100	32	31.0	31.0	30.0	39.0	754.25	52	7.00	0.111		
	17:00	22.78	22.82	22.66	542	103	100	32	31.0	31.3	30.0	39.0	754.25	52	7.00	0.111	191	91
	18:00	22.37	22.28	22.41	545	103	101	32	31.0	30.6	29.0	39.0	754.00	52	7.00	0.111	192	92
	19:00	22.25	22.21	22.22	543	102	100	31	30.0	29.8	28.4	39.0	754.00	52	7.00	0.111	193	93
90 %	19:15	24.38	24.50	24.66	502	102	98	31	29.0	29.5	28.4	40.0	754.00	52	7.00	0.089		
	19:30	24.18	24.25	24.31	505	101	96	31	29.0	29.6	28.4	40.0	754.85	52	7.00	0.089		
	19:45	24.18	24.28	24.27	502	101	96	31	29.0	29.4	28.4	40.0	754.85	52	7.00	0.089		
	20:00	24.32	24.38	24.48	503	100	96	31	29.0	29.4	28.4	40.0	754.85	52	7.00	0.089	194	94
80 %	20:15	26.12	26.04	26.18	478	100	95	30	29.0	29.3	28.2	40.0	754.75	52	7.00	0.065		
	20:30	26.02	26.02	26.09	479	99	95	30	29.0	29.3	28.2	40.0	754.75	52	7.00	0.065		
	20:45	26.05	26.11	26.07	475	98	94	30	29.0	29.0	28.1	40.0	755.00	52	7.00	0.065		
	21:00	26.01	26.00	26.15	474	98	94	30	29.0	29.0	28.1	40.0	755.00	52	7.00	0.065	195	95
Full	21:15	22.44	22.29	22.44	541	100	98	30	29.0	28.9	28.1	40.0	755.00	52	7.00	0.111		
	22:00	22.56	22.40	22.45	544	101	99	30	28.5	28.7	28.0	40.0	755.25	52	7.00	0.111	196	96
	23:00	22.87	22.60	22.50	541	102	99	30	28.5	28.6	27.9	40.0	755.30	52	7.00	0.111	197	97
	0:00	22.86	22.83	22.91	544	102	98	30	28.2	28.4	27.9	40.0	755.45	52	7.00	0.111	198	98

ตารางที่ ง-14 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 190-205 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.15	24.34	24.25	502	102	96	30	28.2	28.4	27.9	40.0	755.50	52	7.00	0.089		
	0:30	24.31	24.35	24.29	505	102	96	30	28.2	28.4	27.8	40.0	755.50	52	7.00	0.089		
	0:45	24.11	24.05	24.12	505	102	96	30	28.2	28.4	27.8	40.0	755.50	52	7.00	0.089		
	1:00	24.25	24.21	24.24	504	102	96	30	28.2	28.4	27.8	40.0	755.50	52	7.00	0.089	199	99
80 %	1:15	26.72	26.68	26.63	463	99	95	30	28.0	28.2	27.6	40.0	755.30	52	7.00	0.065		
	1:30	26.65	26.52	26.54	465	99	94	30	28.0	28.2	27.6	40.0	755.30	52	7.00	0.065		
	1:45	26.24	26.22	26.18	465	100	94	30	28.0	28.2	27.6	40.0	755.10	52	7.00	0.065		
	2:00	26.12	26.03	26.13	465	100	94	30	28.0	28.2	27.6	40.0	755.00	52	7.00	0.065	200	100
Full	2:15	22.68	22.72	22.75	535	101	99	29	28.0	28.2	27.4	38.0	754.80	52	7.00	0.111		
	3:00	22.23	22.36	22.39	535	101	99	29	28.0	28.2	27.4	38.0	754.80	52	7.00	0.111	201	101
	4:00	22.16	22.05	22.19	535	101	99	29	28.0	28.2	27.4	38.0	754.80	52	7.00	0.111	202	102
	5:00	22.81	22.85	22.72	533	102	100	29	28.0	28.4	27.2	38.0	754.80	52	7.00	0.111	203	103
90 %	5:15	24.31	24.19	24.26	502	102	99	30	28.0	28.4	27.2	38.0	754.80	52	7.00	0.089		
	5:30	24.13	24.20	24.18	500	103	99	30	28.0	28.4	27.2	38.0	754.80	52	7.00	0.089		
	5:45	24.41	24.57	24.58	498	101	98	30	28.0	28.2	27.0	38.0	754.80	52	7.00	0.089		
	6:00	24.25	24.32	24.29	498	101	98	30	28.0	28.2	27.0	38.0	755.00	52	7.00	0.089	204	104
80 %	6:15	26.25	26.16	26.27	465	101	97	30	28.0	28.1	27.0	38.0	755.00	52	7.00	0.065		
	6:30	26.35	26.56	26.45	478	102	99	30	28.0	28.1	27.0	38.0	755.20	52	7.00	0.065		
	6:45	26.03	26.14	26.16	479	101	98	30	28.0	28.0	27.0	38.0	755.30	52	7.00	0.065		
	7:00	26.54	26.47	26.44	479	103	97	30	28.0	28.0	27.0	38.0	755.40	52	7.00	0.065	205	105

ตารางที่ ง-15 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 205-220

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.95	22.88	22.98	538	99	100	30	30.5	30.2	29.2	37.0	753.50	52	7.00	0.111		
	17:00	22.71	22.88	22.79	534	105	102	31	29.8	30.0	28.9	37.0	753.90	52	7.00	0.111	206	106
	18:00	22.92	22.85	22.91	536	103	101	31	29.2	29.2	28.4	37.0	753.90	52	7.00	0.111	207	107
	19:00	22.94	22.63	22.75	539	104	102	31	29.0	29.0	28.2	37.0	754.00	52	7.00	0.111	208	108
90 %	19:15	24.75	24.75	24.94	502	103	100	31	28.8	28.9	28.1	36.2	754.90	52	7.00	0.089		
	19:30	24.13	24.09	24.22	503	102	100	31	28.8	28.9	28.1	36.2	755.00	52	7.00	0.089		
	19:45	24.38	24.45	24.44	503	102	100	31	28.8	28.9	28.2	36.2	755.00	52	7.00	0.089		
	20:00	24.21	24.35	24.19	503	102	100	30	28.8	28.7	28.0	36.2	755.00	52	7.00	0.089	209	109
80 %	20:15	26.45	26.41	26.38	479	103	99	30	28.8	28.6	28.0	36.2	755.10	52	7.00	0.065		
	20:30	26.53	26.03	26.48	479	103	99	30	28.8	28.6	28.0	36.2	755.10	52	7.00	0.065		
	20:45	26.08	26.11	26.18	479	103	99	31	28.8	28.6	28.0	36.2	755.10	52	7.00	0.065		
	21:00	26.12	26.18	26.19	478	103	99	31	28.8	28.4	28.0	36.2	755.20	52	7.00	0.065	210	110
Full	21:15	22.41	22.60	22.54	530	101	99	29	28.5	28.4	27.6	37.4	754.40	52	7.00	0.111		
	22:00	22.85	22.94	22.88	529	102	99	30	28.5	28.4	27.4	37.4	754.40	52	7.00	0.111	211	1
	23:00	22.74	22.82	22.85	539	102	100	30	28.0	28.2	27.2	37.4	754.25	52	7.00	0.111	212	2
	0:00	22.64	22.54	22.58	539	101	99	30	28.0	28.2	27.2	37.4	754.25	52	7.00	0.111	213	3

ตารางที่ ง-15 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 205-220 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.98	24.97	25.07	501	100	99	30	28.0	28.2	27.2	37.4	754.10	52	7.00	0.089		
	0:30	24.40	24.44	24.37	500	101	99	30	28.0	28.2	27.2	37.4	754.10	52	7.00	0.089		
	0:45	24.94	25.04	25.00	502	100	99	30	28.0	28.0	27.0	37.4	754.00	52	7.00	0.089		
	1:00	24.25	24.15	24.16	502	100	100	30	28.0	28.0	27.0	37.4	754.00	52	7.00	0.089	214	4
80 %	1:15	26.22	26.25	26.25	478	100	95	30	28.0	28.0	27.2	37.4	754.75	52	7.00	0.065		
	1:30	26.53	26.41	26.40	478	100	95	30	28.0	28.0	27.2	37.4	754.75	52	7.00	0.065		
	1:45	26.90	26.84	26.97	479	100	95	30	28.0	28.0	27.2	37.4	754.75	52	7.00	0.065		
	2:00	26.74	26.65	26.71	478	100	95	30	28.0	28.0	27.2	37.4	754.75	52	7.00	0.065	215	5
Full	2:15	22.69	22.81	22.91	536	105	99	30	28.0	28.0	27.2	37.4	754.75	52	7.00	0.111		
	3:00	22.88	22.90	22.93	540	104	100	30	28.0	28.0	27.2	37.4	754.75	52	7.00	0.111	216	6
	4:00	22.36	22.35	22.47	540	104	100	30	28.0	28.0	27.2	37.4	754.75	52	7.00	0.111	217	7
	5:00	22.28	22.18	22.36	537	102	99	30	28.0	28.0	27.2	37.4	754.75	52	7.00	0.111	218	8
90 %	5:15	24.45	24.36	24.38	503	103	100	30	28.5	28.2	27.4	37.4	754.30	52	7.00	0.089		
	5:30	24.94	24.86	24.83	503	100	100	31	29.0	28.6	28.0	37.4	755.30	52	7.00	0.089		
	5:45	24.12	24.26	24.30	502	101	100	31	29.0	28.6	28.0	37.4	755.30	52	7.00	0.089		
	6:00	24.24	24.32	24.28	502	102	99	31	29.0	29.4	28.8	37.4	755.20	52	7.00	0.089	219	9
80 %	6:15	26.47	26.58	26.39	482	101	99	31	30.0	30.0	28.8	37.4	755.30	52	7.00	0.065		
	6:30	26.54	26.34	26.45	481	100	99	31	30.0	30.0	29.0	37.4	755.30	52	7.00	0.065		
	6:45	26.66	26.28	26.39	481	100	98	31	30.0	30.2	29.0	37.4	755.30	52	7.00	0.065		
	7:00	26.74	26.67	26.71	481	100	98	31	30.0	30.2	29.0	37.4	755.30	52	7.00	0.065	220	10

ตารางที่ ง-16 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 220-235

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	23.06	22.98	22.95	538	102	100	32	32.8	31.8	30.6	42.8	753.00	52	7.00	0.111		
	17:00	22.53	22.50	22.53	539	104	102	33	32.8	31.8	30.6	42.8	753.00	52	7.00	0.111	221	11
	18:00	22.37	22.22	22.25	540	103	101	32	31.0	31.2	29.7	42.8	753.50	52	7.00	0.111	222	12
	19:00	22.31	22.29	22.22	547	105	100	31	30.0	29.9	28.1	42.8	753.80	52	7.00	0.111	223	13
90 %	19:15	24.22	24.25	24.29	495	100	97	30	29.5	29.7	28.1	42.8	753.80	52	7.00	0.089		
	19:30	24.41	24.52	24.37	498	100	96	30	29.0	29.5	28.1	42.8	754.00	52	7.00	0.089		
	19:45	24.32	24.31	24.43	496	101	98	30	28.8	29.5	28.3	42.8	754.00	52	7.00	0.089		
	20:00	24.35	24.30	24.41	494	100	97	30	28.8	29.0	28.3	42.8	754.25	52	7.00	0.089	224	14
80 %	20:15	26.21	26.28	26.25	480	99	96	30	28.8	28.8	28.1	42.8	754.25	52	7.00	0.065		
	20:30	26.35	26.34	26.26	478	98	95	30	28.8	28.8	28.1	42.8	754.25	52	7.00	0.065		
	20:45	26.57	26.13	26.72	480	96	94	30	28.8	28.8	28.1	42.8	754.25	52	7.00	0.065		
	21:00	26.45	23.53	26.45	482	98	94	30	28.8	28.7	28.0	42.8	754.50	52	7.00	0.065	225	15
Full	21:15	22.88	23.06	22.79	525	100	95	30	28.0	28.5	28.0	43.2	754.50	52	7.00	0.111		
	22:00	22.98	22.87	22.84	522	101	99	30	28.0	28.6	27.9	43.2	754.65	52	7.00	0.111	226	16
	23:00	22.78	22.81	22.83	522	101	99	30	28.0	28.4	27.8	43.3	754.50	52	7.00	0.111	227	17
	0:00	22.75	22.76	22.72	523	101	99	30	28.0	28.3	27.7	43.2	754.00	52	7.00	0.111	228	18

ตารางที่ ง-16 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 220-235 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.25	24.27	24.21	498	100	98	30	28.0	28.2	27.7	43.2	754.00	52	7.00	0.089		
	0:30	24.13	24.16	24.19	495	100	97	30	28.0	28.2	27.6	43.2	754.00	52	7.00	0.089		
	0:45	24.13	24.25	24.22	495	101	97	30	28.0	28.2	27.6	43.2	754.00	52	7.00	0.089		
	1:00	24.40	24.29	24.32	499	100	97	30	28.0	28.2	27.6	43.2	754.30	52	7.00	0.089	229	19
80 %	1:15	26.12	26.09	26.15	483	99	95	30	28.0	28.2	27.6	43.2	754.30	52	7.00	0.065		
	1:30	26.18	26.15	26.21	483	98	95	30	28.0	28.1	27.4	43.2	754.00	52	7.00	0.065		
	1:45	26.22	26.31	26.25	480	98	95	30	28.0	28.0	27.4	43.2	754.00	52	7.00	0.065		
	2:00	26.06	26.13	26.04	479	97	95	30	28.0	28.0	27.4	43.2	754.00	52	7.00	0.065	230	20
Full	2:15	22.31	22.41	22.38	542	98	99	30	28.0	28.0	27.4	43.2	754.00	52	7.00	0.111		
	3:00	22.44	22.35	22.38	542	102	99	30	28.0	28.0	27.4	43.2	754.10	52	7.00	0.111	231	21
	4:00	22.94	22.92	22.85	543	102	99	30	28.0	28.0	27.4	43.2	754.10	52	7.00	0.111	232	22
	5:00	22.13	22.03	22.24	544	102	99	30	28.0	28.0	27.4	43.2	754.30	52	7.00	0.111	233	23
90 %	5:15	24.78	24.78	24.77	495	100	99	30	28.0	28.0	27.2	43.2	754.55	52	7.00	0.089		
	5:30	26.69	24.66	24.64	495	100	98	30	28.0	28.0	27.2	43.2	754.55	52	7.00	0.089		
	5:45	24.12	24.25	24.19	495	100	99	30	28.0	28.0	27.2	43.2	754.50	52	7.00	0.089		
	6:00	24.06	24.08	24.11	494	101	99	30	28.0	28.0	27.2	43.2	754.50	52	7.00	0.089	234	24
80 %	6:15	26.23	26.34	26.29	484	98	95	30	28.0	27.9	27.0	43.2	754.50	52	7.00	0.065		
	6:30	26.85	26.92	26.87	484	99	96	30	28.0	27.9	27.0	43.2	754.50	52	7.00	0.065		
	6:45	26.43	26.41	26.39	484	99	96	30	28.0	27.8	27.0	43.2	754.50	52	7.00	0.065		
	7:00	26.12	26.24	26.31	485	98	96	30	28.0	27.8	27.0	43.2	754.50	52	7.00	0.065	235	25

ตารางที่ ง-17 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 235-150

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.88	22.75	22.88	537	95	96	30	30.8	30.8	29.6	39.2	754.65	52	7.00	0.111		
	17:00	22.53	22.40	22.47	537	103	100	31	30.5	30.8	29.6	39.2	754.65	52	7.00	0.111	236	26
	18:00	22.22	22.26	22.23	537	101	100	31	30.0	30.4	29.0	39.2	754.60	52	7.00	0.111	237	27
	19:00	22.13	22.19	22.24	538	103	100	31	30.0	29.8	28.4	39.2	754.60	52	7.00	0.111	238	28
90 %	19:15	24.53	24.67	24.56	506	99	95	31	29.5	29.6	28.2	39.2	754.80	52	7.00	0.089		
	19:30	24.12	24.01	24.07	507	99	95	31	29.5	29.6	27.9	39.2	754.80	52	7.00	0.089		
	19:45	24.52	24.56	24.53	507	99	95	31	29.5	29.4	27.9	39.2	754.80	52	7.00	0.089		
	20:00	24.21	24.22	24.21	508	99	96	31	29.0	29.4	27.8	39.2	754.80	52	7.00	0.089	239	29
80 %	20:15	26.62	26.50	26.56	473	96	95	31	29.0	29.2	27.6	39.2	754.85	52	7.00	0.065		
	20:30	26.81	26.69	26.76	473	97	95	31	29.0	29.2	28.2	39.2	755.50	52	7.00	0.065		
	20:45	26.85	26.86	26.91	474	95	95	31	28.8	29.0	27.8	39.2	755.50	52	7.00	0.065		
	21:00	26.58	26.57	26.54	476	95	95	31	28.8	29.0	27.8	39.2	755.40	52	7.00	0.065	240	30
Full	21:15	22.47	23.06	23.06	540	100	98	31	28.8	28.8	27.4	37.5	755.90	52	7.00	0.111		
	22:00	22.40	22.54	22.66	542	102	100	30	28.0	28.7	27.2	37.5	756.25	52	7.00	0.111	241	31
	23:00	22.47	22.35	22.37	548	102	99	30	28.0	28.6	27.3	37.5	756.00	52	7.00	0.111	242	32
	0:00	22.40	22.53	22.61	549	101	100	30	28.0	28.4	27.5	37.5	756.00	52	7.00	0.111	243	33

ตารางที่ ง-17 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 235-250 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.67	24.74	24.68	500	99	95	30	28.0	28.4	27.2	39.8	756.00	52	7.00	0.089		
	0:30	24.53	24.57	24.57	500	99	95	30	28.0	28.4	27.2	39.8	756.00	52	7.00	0.089		
	0:45	24.32	24.38	24.32	501	100	95	30	28.0	28.4	27.2	39.8	756.00	52	7.00	0.089		
	1:00	24.05	24.11	24.12	501	99	95	30	28.0	28.2	27.2	39.8	756.00	52	7.00	0.089	244	34
80 %	1:15	26.98	26.89	26.91	468	96	95	30	28.0	28.2	27.2	39.8	755.30	52	7.00	0.065		
	1:30	26.54	26.49	26.50	469	95	95	30	28.0	28.2	27.2	39.8	755.30	52	7.00	0.065		
	1:45	26.25	26.27	26.29	471	95	95	30	28.0	28.2	27.2	39.8	755.30	52	7.00	0.065		
	2:00	26.75	26.78	26.70	471	95	95	30	28.0	28.2	27.2	39.8	755.30	52	7.00	0.065	245	35
Full	2:15	22.66	22.56	22.68	539	100	98	30	27.8	28.0	27.0	36.3	755.65	52	7.00	0.111		
	3:00	22.84	22.75	22.78	538	101	108	30	28.0	28.0	27.2	36.3	755.50	52	7.00	0.111	246	36
	4:00	22.25	22.16	22.28	537	101	98	30	28.0	28.0	27.2	36.3	755.50	52	7.00	0.111	247	37
	5:00	22.91	23.01	22.94	538	101	97	30	27.8	27.8	26.8	36.3	755.40	52	7.00	0.111	248	38
90 %	5:15	24.57	24.44	24.54	498	99	95	30	27.8	27.8	26.9	38.6	755.40	52	7.00	0.089		
	5:30	24.41	24.39	24.39	498	99	95	30	27.8	27.8	26.9	38.6	755.40	52	7.00	0.089		
	5:45	24.62	24.64	24.63	499	99	95	30	27.8	27.8	26.9	38.6	755.40	52	7.00	0.089		
	6:00	24.75	24.76	24.72	499	99	96	30	27.8	27.8	27.0	38.6	755.50	52	7.00	0.089	249	39
80 %	6:15	26.02	26.04	26.08	472	98	95	30	28.0	27.6	26.6	38.6	755.40	52	7.00	0.065		
	6:30	26.55	26.57	26.54	472	98	95	30	28.0	27.6	26.4	38.6	755.40	52	7.00	0.065		
	6:45	26.16	26.10	26.06	472	100	95	30	28.2	27.8	26.7	38.6	755.75	52	7.00	0.065		
	7:00	26.34	26.28	26.36	472	100	95	30	28.2	27.6	26.2	38.6	755.75	52	7.00	0.065	250	40

ตารางที่ ง-18 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 250-265

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.67	22.74	22.78	530	101	100	32	31.0	31.0	28.2	42.1	755.40	52	7.00	0.111		
	17:00	22.73	22.82	22.75	532	102	101	32	31.0	31.0	28.2	42.1	755.40	52	7.00	0.111	251	41
	18:00	22.85	22.78	22.80	533	103	100	31	30.0	30.4	27.8	42.1	755.35	52	7.00	0.111	252	42
	19:00	22.76	22.81	22.85	536	102	100	31	30.0	29.8	27.8	42.1	755.40	52	7.00	0.111	253	43
90 %	19:15	24.47	24.69	24.44	499	101	98	31	29.5	29.8	28.3	42.1	756.30	52	7.00	0.089		
	19:30	24.64	24.75	24.63	496	103	98	31	30.0	29.8	28.2	42.1	756.40	52	7.00	0.089		
	19:45	24.61	24.65	24.62	497	104	98	31	30.0	29.8	28.1	42.1	756.50	52	7.00	0.089		
	20:00	24.60	24.58	24.56	495	103	98	31	30.0	29.8	28.1	42.1	756.50	52	7.00	0.089	254	44
80 %	20:15	26.25	26.32	26.28	477	100	97	31	30.0	29.6	28.1	42.1	756.70	52	7.00	0.065		
	20:30	26.36	26.38	26.29	478	101	97	31	30.0	29.4	28.0	42.1	756.80	52	7.00	0.065		
	20:45	26.48	26.33	26.61	478	100	96	31	30.0	29.2	27.8	42.1	756.90	52	7.00	0.065		
	21:00	26.67	26.56	26.49	478	100	96	31	30.0	29.2	27.8	42.1	756.90	52	7.00	0.065	255	45
Full	21:15	22.26	22.36	22.47	536	103	101	30	30.0	29.1	27.7	40.5	757.00	52	7.00	0.11		
	22:00	22.41	22.30	22.38	538	104	102	30	30.0	29.1	28.0	40.5	757.00	52	7.00	0.11	256	46
	23:00	22.53	22.51	22.60	538	105	101	30	29.5	29.0	28.0	40.5	756.80	52	7.00	0.11	257	47
	0:00	22.38	22.44	22.37	539	105	101	30	29.0	28.8	27.8	40.5	756.50	52	7.00	0.11	258	48

ตารางที่ ง-18 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 250-265 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.56	24.59	24.62	500	101	99	30	29.0	28.8	27.8	40.5	756.50	52	7.00	0.089		
	0:30	24.36	24.42	24.28	498	101	99	30	29.0	28.8	27.6	40.5	756.50	52	7.00	0.089		
	0:45	24.66	24.71	24.80	495	100	99	30	29.0	28.6	27.6	40.5	756.50	52	7.00	0.089		
	1:00	24.52	24.38	24.47	494	100	98	30	29.0	28.6	27.6	40.5	756.50	52	7.00	0.089	259	49
80 %	1:15	26.54	26.58	26.49	476	100	98	30	29.0	28.6	27.6	40.5	756.40	52	7.00	0.065		
	1:30	26.48	26.56	26.52	477	101	99	30	29.0	28.6	27.6	40.5	756.20	52	7.00	0.065		
	1:45	26.26	26.36	26.29	476	101	99	30	29.0	28.4	27.5	40.5	756.20	52	7.00	0.065		
	2:00	26.38	26.44	26.37	476	100	99	30	29.0	28.4	27.5	40.5	756.20	52	7.00	0.065	260	50
Full	2:15	22.54	22.58	22.45	532	101	100	30	29.0	28.3	27.4	38.2	756.00	52	7.00	0.111		
	3:00	22.67	22.62	22.54	532	102	99	30	29.0	28.3	27.4	38.2	756.00	52	7.00	0.111	261	51
	4:00	22.25	22.32	22.28	532	102	100	30	29.0	28.2	27.3	38.2	756.00	52	7.00	0.111	262	52
	5:00	22.36	22.42	22.38	532	102	100	30	29.0	28.2	27.3	38.2	756.00	52	7.00	0.111	263	53
90 %	5:15	24.85	24.75	24.84	513	104	100	30	28.0	28.2	27.6	38.2	755.80	52	7.00	0.089		
	5:30	24.13	24.25	24.22	512	104	100	30	28.0	28.2	27.6	38.2	755.80	52	7.00	0.089		
	5:45	24.53	24.50	24.52	512	104	100	30	28.0	28.2	27.4	38.2	755.90	52	7.00	0.089		
	6:00	24.87	24.79	24.84	512	104	100	30	28.0	28.2	27.4	38.2	755.90	52	7.00	0.089	264	54
80 %	6:15	26.53	26.49	26.48	478	103	100	30	28.0	28.4	27.8	38.2	756.00	52	7.00	0.065		
	6:30	26.25	26.22	26.21	478	103	100	30	28.0	28.4	27.8	38.2	756.00	52	7.00	0.065		
	6:45	26.38	26.44	26.39	478	103	99	30	29.0	28.4	27.8	38.2	756.00	52	7.00	0.065		
	7:00	26.56	26.59	26.62	478	103	100	30	29.0	28.4	27.8	38.2	756.00	52	7.00	0.065	265	55

ตารางที่ ง-19 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 265-280

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.69	22.56	22.66	549	102	101	31	30.0	30.6	29.7	41.8	755.70	52	7.00	0.111		
	17:00	22.59	22.31	22.60	546	104	101	31	30.0	30.8	29.6	41.8	755.50	52	7.00	0.111	266	56
	18:00	22.40	22.43	22.57	549	106	102	31	30.0	30.3	29.4	41.8	755.80	52	7.00	0.111	267	57
	19:00	22.72	22.55	22.87	545	104	100	31	29.8	29.8	29.1	41.8	756.25	52	7.00	0.111	268	58
90 %	19:15	24.28	24.22	24.30	500	100	96	30	29.0	29.8	27.8	42.3	756.35	52	7.00	0.089		
	19:30	24.20	24.18	24.25	500	101	96	30	29.0	29.2	27.8	42.3	756.35	52	7.00	0.089		
	19:45	24.40	24.47	24.38	502	101	96	31	29.0	29.2	28.0	42.3	756.50	52	7.00	0.089		
	20:00	24.35	24.37	24.36	503	102	97	31	29.0	29.2	28.0	42.3	756.50	52	7.00	0.089	269	59
80 %	20:15	26.34	26.28	26.32	479	102	96	30	29.0	29.2	28.0	42.3	756.50	52	7.00	0.065		
	20:30	26.12	26.12	26.11	479	102	96	30	29.0	29.2	28.0	42.3	756.50	52	7.00	0.065		
	20:45	26.61	26.64	26.61	478	101	96	30	29.0	29.2	28.0	42.3	756.50	52	7.00	0.065		
	21:00	26.42	26.40	26.44	479	101	95	30	29.0	29.2	28.0	42.3	756.50	52	7.00	0.065	270	60
Full	21:15	22.41	22.25	22.34	549	106	101	31	29.0	29.1	28.1	41.8	756.50	52	7.00	0.111		
	22:00	22.40	22.42	22.42	550	106	101	30	29.0	29.1	28.1	41.8	756.50	52	7.00	0.111	271	61
	23:00	22.44	22.41	22.42	546	105	101	31	29.0	29.0	27.8	41.8	756.50	52	7.00	0.111	272	62
	0:00	22.32	22.35	22.40	547	106	102	30	29.0	29.8	27.6	41.8	756.45	52	7.00	0.111	273	63

ตารางที่ ง-19 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 265-280 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.15	24.18	24.18	500	101	99	30	29.0	28.8	27.6	41.7	756.25	52	7.00	0.089		
	0:30	24.20	24.25	24.24	500	101	98	30	28.5	28.8	27.4	41.7	756.25	52	7.00	0.089		
	0:45	24.41	24.35	24.30	501	100	97	30	28.5	28.8	27.4	41.7	756.20	52	7.00	0.089		
	1:00	24.32	24.27	24.20	501	100	97	30	28.5	28.6	27.2	41.7	756.20	52	7.00	0.089	274	64
80 %	1:15	26.31	26.22	26.18	478	100	96	30	28.5	28.6	27.2	41.7	756.20	52	7.00	0.065		
	1:30	26.30	26.25	26.27	478	100	96	30	28.5	28.6	27.2	41.7	756.20	52	7.00	0.065		
	1:45	26.35	26.24	26.26	476	101	95	30	28.5	28.6	27.2	41.7	756.20	52	7.00	0.065		
	2:00	26.34	26.31	26.31	476	102	97	30	28.5	28.6	27.2	41.7	756.20	52	7.00	0.065	275	65
Full	2:15	22.51	22.45	22.46	550	102	100	30	28.5	28.6	27.3	41.0	756.20	52	7.00	0.11		
	3:00	22.46	22.42	22.44	551	102	101	30	28.5	28.6	27.3	41.0	756.00	52	7.00	0.11	276	66
	4:00	22.53	22.42	22.47	552	103	101	30	28.5	28.8	27.8	41.0	756.00	52	7.00	0.11	277	67
	5:00	22.62	22.56	22.56	549	104	101	30	28.5	28.8	27.6	41.0	756.00	52	7.00	0.11	278	68
90 %	5:15	24.64	24.72	24.68	508	104	98	30	28.5	28.8	27.9	40.4	756.00	52	7.00	0.089		
	5:30	24.85	24.76	24.75	507	104	98	31	28.5	28.8	27.9	40.4	756.00	52	7.00	0.089		
	5:45	24.65	24.75	24.68	508	103	98	30	28.5	28.7	27.6	40.4	756.00	52	7.00	0.089		
	6:00	24.75	24.41	24.55	509	103	98	30	28.5	28.7	27.6	40.4	756.00	52	7.00	0.089	279	69
80 %	6:15	26.25	26.28	26.21	480	102	97	30	28.5	28.6	27.6	40.4	756.20	52	7.00	0.065		
	6:30	26.35	26.24	26.18	480	102	97	30	28.5	28.6	27.6	40.4	756.20	52	7.00	0.065		
	6:45	26.21	26.22	26.25	483	102	96	30	28.5	28.6	27.4	40.4	756.20	52	7.00	0.065		
	7:00	26.47	26.49	25.52	483	102	96	31	28.5	28.7	27.4	40.4	756.20	52	7.00	0.065	280	70

ตารางที่ ง-20 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 280-295

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.67	22.66	22.75	550	101	100	31	31.0	30.8	28.4	40.2	755.50	52	7.00	0.111		
	17:00	22.37	22.28	22.44	552	101	98	31	31.0	30.6	28.2	40.2	755.50	52	7.00	0.103	281	71
	18:00	22.69	22.57	22.55	548	103	99	31	30.8	30.2	28.2	40.2	755.50	52	7.00	0.111	282	72
	19:00	22.47	22.44	22.42	546	103	100	32	30.0	30.0	28.0	40.2	755.15	52	7.00	0.111	283	73
90 %	19:15	24.45	24.46	24.48	505	103	98	32	30.0	29.8	28.0	40.0	755.25	52	7.00	0.089		
	19:30	24.48	24.41	24.44	506	102	98	32	30.0	29.7	28.0	40.0	755.40	52	7.00	0.089		
	19:45	24.53	24.47	24.47	507	102	96	31	30.0	29.9	28.2	40.0	755.80	52	7.00	0.089		
	20:00	24.52	24.53	24.48	505	104	97	31	29.5	29.9	28.4	40.0	755.80	52	7.00	0.089	284	74
80 %	20:15	26.21	26.24	26.23	484	100	97	31	29.5	29.8	28.4	36.4	756.00	52	7.00	0.065		
	20:30	26.28	26.25	26.30	483	100	97	31	29.5	29.8	28.4	36.4	756.00	52	7.00	0.065		
	20:45	26.38	26.27	26.31	481	100	96	31	29.5	29.6	28.4	36.4	756.20	52	7.00	0.065		
	21:00	26.41	26.38	26.37	481	99	96	31	29.5	29.6	28.4	36.4	756.20	52	7.00	0.065	285	75
Full	21:15	22.50	22.47	22.53	545	101	99	31	29.5	29.6	28.4	37.2	756.20	52	7.00	0.108		
	22:00	22.41	22.39	22.61	539	102	101	31	29.0	29.4	28.4	37.2	756.60	52	7.00	0.109	286	76
	23:00	22.50	22.59	22.62	537	103	101	31	28.8	29.0	28.4	37.2	756.95	52	7.00	0.109	287	77
	0:00	22.61	22.68	22.73	546	105	102	30	28.8	28.9	28.3	37.2	756.80	52	7.00	0.109	288	78

ตารางที่ ง-20 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 280-295 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.87	24.85	24.84	503	101	98	31	28.8	28.7	27.6	37.4	756.60	52	7.00	0.089		
	0:30	24.41	24.47	24.45	504	101	98	31	28.8	28.7	27.6	37.4	756.50	52	7.00	0.089		
	0:45	24.37	24.38	24.32	504	101	98	31	28.8	28.7	27.4	37.4	756.50	52	7.00	0.089		
	1:00	24.28	24.25	24.21	506	101	98	31	28.8	28.7	27.4	37.4	756.50	52	7.00	0.089	289	79
80 %	1:15	26.06	26.04	26.03	482	102	97	30	28.8	28.6	27.7	37.4	755.75	52	7.00	0.065		
	1:30	26.13	26.13	26.19	482	102	97	30	28.8	28.6	27.7	37.4	755.75	52	7.00	0.065		
	1:45	26.15	26.11	26.08	481	101	96	30	28.8	28.4	27.6	37.4	755.70	52	7.00	0.065		
	2:00	26.22	26.19	26.18	481	100	96	30	28.8	28.4	27.6	37.4	755.70	52	7.00	0.065	290	80
Full	2:15	22.84	22.91	23.01	546	102	100	30	28.2	28.5	27.4	37.4	755.50	52	7.00	0.11		
	3:00	22.25	22.22	22.18	546	102	100	30	28.2	28.5	27.4	37.4	755.40	52	7.00	0.11	291	81
	4:00	22.12	22.10	22.11	543	103	101	30	28.0	28.4	27.6	37.4	756.00	52	7.00	0.11	292	82
	5:00	22.26	22.25	22.29	544	102	101	30	28.0	28.4	27.6	37.4	755.90	52	7.00	0.11	293	83
90 %	5:15	24.03	24.03	24.08	508	102	100	30	28.0	28.4	27.6	37.2	755.90	52	7.00	0.089		
	5:30	24.28	24.32	24.26	508	102	100	30	28.0	28.4	27.6	37.2	755.90	52	7.00	0.089		
	5:45	24.12	24.12	24.16	506	102	99	30	28.0	28.4	27.6	37.2	755.90	52	7.00	0.089		
	6:00	24.44	24.39	24.40	506	102	99	30	28.0	28.4	27.6	37.2	755.90	52	7.00	0.089	294	84
80 %	6:15	26.09	26.15	26.11	483	101	97	30	28.0	28.4	27.4	37.0	756.75	52	7.00	0.065		
	6:30	26.25	26.34	26.36	483	101	97	30	28.0	28.4	27.4	37.0	756.75	52	7.00	0.065		
	6:45	26.02	26.10	26.10	488	100	96	30	28.0	28.4	27.6	37.0	757.00	52	7.00	0.065		
	7:00	26.38	26.34	26.40	487	100	96	30	28.0	28.4	27.6	37.0	757.00	52	7.00	0.065	295	85

ตารางที่ ง-21 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 295-310

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	22.46	22.54	22.38	553	102	101	32	32.0	31.6	29.6	38.0	755.50	52	7.00	0.111		
	17:00	22.52	22.50	22.58	554	105	101	32	31.5	31.0	29.2	38.0	755.50	52	7.00	0.111	296	86
	18:00	22.59	22.67	22.54	552	105	101	32	30.5	30.8	28.6	38.0	755.80	52	7.00	0.111	297	87
	19:00	22.50	22.65	22.62	550	104	102	32	29.5	29.8	28.2	38.0	756.00	52	7.00	0.111	298	88
90 %	19:15	24.16	24.34	24.26	502	104	100	32	29.5	29.8	28.2	38.6	756.20	52	7.00	0.089		
	19:30	24.32	24.31	24.38	502	104	99	32	30.0	29.8	28.4	38.6	756.25	52	7.00	0.089		
	19:45	24.25	24.38	24.30	501	103	99	32	30.0	30.0	28.6	38.6	756.50	52	7.00	0.089		
	20:00	24.20	24.18	24.22	500	102	98	32	30.0	30.1	28.8	38.6	756.50	52	7.00	0.089	299	89
80 %	20:15	26.17	26.13	26.14	483	102	100	31	30.0	30.0	28.8	38.6	756.80	52	7.00	0.065		
	20:30	26.18	26.15	26.17	483	102	99	31	29.5	29.8	28.8	38.6	756.80	52	7.00	0.065		
	20:45	26.10	26.14	26.11	482	101	98	31	29.5	29.6	28.7	38.6	757.00	52	7.00	0.065		
	21:00	26.15	26.12	26.11	482	100	97	31	29.5	29.6	28.7	38.6	757.00	52	7.00	0.065	300	90
Full	21:15	22.74	22.87	22.77	550	105	102	31	29.2	29.6	28.5	38.4	757.20	52	7.00	0.108		
	22:00	22.59	22.56	22.67	549	105	103	31	29.0	29.4	28.2	38.4	757.45	52	7.00	0.108	301	91
	23:00	22.86	22.70	22.86	547	104	102	31	28.8	29.1	27.6	38.4	757.45	52	7.00	0.108	302	92
	0:00	22.87	22.82	22.85	547	103	102	31	28.5	29.1	27.6	38.4	757.25	52	7.00	0.108	303	93

ตารางที่ ง-21 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 295-310 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.21	24.18	24.26	505	103	100	31	28.5	29.0	27.6	38.3	757.00	52	7.00	0.089		
	0:30	24.16	24.32	24.28	505	103	100	31	28.5	29.0	27.8	38.3	757.00	52	7.00	0.089		
	0:45	24.25	24.36	24.31	504	102	100	30	28.5	28.8	27.8	38.3	756.80	52	7.00	0.089		
	1:00	24.41	24.34	24.32	503	102	99	30	28.5	28.8	27.8	38.3	756.80	52	7.00	0.089	304	94
80 %	1:15	26.38	26.41	26.34	478	101	97	30	28.5	28.8	27.8	38.2	756.80	52	7.00	0.065		
	1:30	26.42	26.35	26.31	478	101	97	30	28.5	28.8	27.8	38.2	756.80	52	7.00	0.065		
	1:45	26.45	26.48	26.37	477	100	97	30	28.5	28.6	27.8	38.2	756.75	52	7.00	0.065		
	2:00	26.35	26.33	26.49	477	100	96	30	28.5	28.6	27.8	38.2	756.75	52	7.00	0.065	305	95
Full	2:15	22.78	22.85	22.77	547	106	102	30	28.5	28.6	27.8	38.0	756.50	52	7.00	0.109		
	3:00	22.82	22.67	22.69	548	106	101	30	28.5	28.6	27.8	38.0	756.25	52	7.00	0.109	306	96
	4:00	22.87	22.85	22.97	548	105	101	30	28.2	28.4	27.6	38.0	756.30	52	7.00	0.109	307	97
	5:00	22.87	22.93	22.91	545	103	101	30	28.2	28.4	27.9	38.0	756.85	52	7.00	0.109	308	98
90 %	5:15	24.66	24.59	24.57	507	103	100	30	28.2	28.4	27.7	37.9	756.85	52	7.00	0.089		
	5:30	24.36	24.41	24.38	505	102	100	31	28.2	28.5	27.7	37.9	756.85	52	7.00	0.089		
	5:45	24.35	24.42	24.48	505	102	99	31	28.2	28.5	27.7	37.9	756.85	52	7.00	0.089		
	6:00	24.26	24.22	24.26	503	101	100	31	28.2	28.4	27.6	37.9	756.80	52	7.00	0.089	309	99
80 %	6:15	26.38	26.25	26.31	485	100	99	31	28.0	28.4	27.6	37.9	756.50	52	7.00	0.065		
	6:30	26.42	26.41	26.39	485	101	99	31	28.0	28.4	27.6	37.9	756.50	52	7.00	0.065		
	6:45	26.39	26.34	26.33	486	100	99	31	28.0	28.4	27.6	37.9	756.50	52	7.00	0.065		
	7:00	26.25	26.29	26.27	486	100	100	31	28.0	28.4	27.6	37.9	756.50	52	7.00	0.065	310	100

ตารางที่ ง-22 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 310-320

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
Full	16:15	23.88	23.91	23.96	539	101	100	32	31.2	31.6	30.4	42.10	755.25	52	7.00	0.107		
	17:00	24.62	24.70	24.60	530	103	99	32	31.2	31.6	30.0	43.00	755.25	52	7.00	0.090	311	101
	18:00	22.81	22.69	23.00	538	101	101	33	31.0	31.4	29.8	43.50	755.25	52	7.00	0.104	312	102
	19:00	22.63	23.08	23.09	542	102	99	32	30.2	30.8	29.2	44.00	755.25	52	7.00	0.094	313	103
90 %	19:15	24.47	24.52	24.43	505	101	98	32	30.0	30.6	29.0	44.00	755.50	52	7.00	0.089		
	19:30	24.16	24.28	24.19	503	101	98	31	29.5	30.2	28.8	44.00	756.00	52	7.00	0.089		
	19:45	24.22	24.34	24.34	503	100	98	31	29.0	29.8	28.6	44.00	756.00	52	7.00	0.089		
	20:00	24.54	24.56	24.69	503	100	98	31	29.0	29.8	28.6	44.00	756.00	52	7.00	0.089	314	104
80 %	20:15	26.07	26.06	26.10	480	99	97	31	29.0	29.6	28.4	43.50	756.00	52	7.00	0.065		
	20:30	26.14	26.08	26.12	478	98	96	31	29.0	29.6	28.4	43.50	756.50	52	7.00	0.065		
	20:45	26.15	26.11	26.16	480	97	96	31	29.0	29.4	28.3	43.50	756.50	52	7.00	0.065		
	21:00	26.04	26.12	26.08	478	97	95	31	29.0	29.4	28.3	43.50	756.50	52	7.00	0.065	315	105
Full	21:15	23.87	23.96	24.12	546	102	100	31	29.0	29.4	28.3	43.10	756.50	52	7.00	0.107		
	22:00	23.95	23.72	24.06	546	104	101	31	29.0	29.4	28.3	43.10	756.50	52	7.00	0.107	316	106
	23:00	24.03	23.88	23.89	546	102	100	31	29.0	29.2	28.1	43.10	756.75	52	7.00	0.107	317	107
	0:00	23.88	23.73	24.03	542	103	100	31	29.0	29.1	28.6	43.10	756.90	52	7.00	0.107	318	108

ตารางที่ ง-22 แสดงข้อมูลระหว่างการทดสอบความทนทานชั่วโมงที่ 310-320 (ต่อ)

Load	Time	FC (sec/20cc.)			temp (°C)							P.		pump			working hrs.	
		T1	T2	T3	Exh (°C)	Oil (°C)	Wat (°C)	Air (°C)	amb (°C)	D.B (°C)	W.B (°C)	airbox (mmH_2O)	atm (mmHg)	Pdis (Psi)	Psuc (in Hg)	Hweir (Ft.)	engine	oil
90 %	0:15	24.63	24.59	24.81	523	103	98	31	29.0	29.1	28.6	43.5	756.9	53	7.00	0.089		
	0:30	24.52	24.78	24.46	523	103	98	31	29.0	29.1	28.6	43.5	756.5	52	7.00	0.089		
	0:45	24.58	24.65	24.76	521	103	98	31	29.0	29.1	28.6	43.5	756.5	52	7.00	0.089		
	1:00	24.60	24.75	24.62	520	102	97	31	29.0	29.1	28.6	43.5	756	52	7.00	0.089	319	109
80 %	1:15	25.25	25.75	25.59	504	101	97	31	29.0	29.1	28.6	43.5	756	52	7.00	0.065		
	1:30	25.32	25.43	25.37	506	101	98	31	29.0	29.1	28.6	43.5	756	52	7.00	0.065		
	1:45	25.45	25.32	25.29	505	101	98	31	29.0	29.1	28.6	43.5	756	52	7.00	0.065		
	2:00	25.12	25.13	25.19	507	101	98	31	29.0	29.1	28.6	43.5	756	52	7.00	0.065	320	110

ภาคผนวก จ

ข้อมูลผลการวิเคราะห์น้ำมันหล่อลื่น

รูปที่ จ-1 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นใหม่
ยี่ห้อ ช้าง มาตรฐาน SAE 40 API CF

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Page 1 of 2

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 8030 914

Lube System Capacity :

Unit ID Number : New Oil CHANG SAE40 API CF
Unit Type : NEW OIL
Unit Make :
Unit Model :
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location :

Overall Condition Rating

Wear Condition	Oil Condition	Contamination
	NORMAL	NORMAL

Recommendations and Notes

All tests appear normal for this type of new oil.

AS / Andy Sitton

Condition History	Test Method	Result	Current Sample Wear	Current Sample Oil	Current Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.	Wear	Oil	Cont.
			N	N		N	N		N		N
FocusLab ID			73080			70941			54326		
Date sampled			04-Apr-07			18-Jan-07			26-Feb-06		
Hours on Oil			Not Available			Not Available			Not Available		
Hours on Unit			Not Available			Not Available			Not Available		
Bottle ID			862026			861992			815201		
Wear Condition											
Wear Element	Method	Unit	RDE fine	RFS coarse		RDE fine	RFS coarse		RDE fine	RFS coarse	
Iron	D-6595	PPM	0.6			1.1			0.6		
Chromium	D-6595	PPM	0.0			0.0			0.0		
Lead	D-6595	PPM	1.0			0.8			0.6		
Copper	D-6595	PPM	0.1			0.1			0.1		
Tin	D-6595	PPM	0.0			0.0			0.2		
Aluminum	D-6595	PPM	0.7			0.5			0.9		
Nickel	D-6595	PPM	0.3			0.0			0.1		
Silver	D-6595	PPM	0.0			0.0			0.0		
Molybdenum	D-6595	PPM	66.6			66.4			66.8		
Titanium	D-6595	PPM	0.0			0.0			0.0		
Oil Condition											
Viscosity @ 40 °C	D-445	cSt	151.2			149.7					
Viscosity @ 100 °C	D-445	cSt	14.7			14.7			14.6		
Oxidation	FTIR	Abs	4.9			6.4			6.7		
Nitration	FTIR	Abs	4.5			5.5			5.5		
TAN	D-974	mg KOH/g									
TBN	D-4739	mg KOH/g	8.7			7.0			10.3		
Contamination											
Water	FTIR	% (Wt.)	0.052			0.063			0.027		
Fuel	SAW	% (Wt.)	0.00			0.00			0.00		
Glycol	FTIR	Abs	0			0			0		
Soot	FTIR	% (Wt.)	0.00			0.00			0.00		
Sodium	D-6595	PPM	2			2			2		
Silicon	D-6595	PPM	12.3			13.7			15.9		
Additive Element											
Boron	D-6595	PPM	1			1			0		
Magnesium	D-6595	PPM	12			13			11		
Calcium	D-6595	PPM	2398			2724			2539		
Barium	D-6595	PPM	0			0			0		
Phosphorus	D-6595	PPM	719			694			784		
Zinc	D-6595	PPM	844			900			863		
Additional Test											
Flash Point	D-3828	°C									
Viscosity Index	D-2270										
Other											

Alarm Limit Range
Limit Name (Equipment / Oil) :
New Oil for Baseline Purposes

RDE fine / RFS coarse
New Oil | U-Caution | L-Action | U-Caution | L-Action

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or (N) : NORMAL . C or ▲ : CAUTION (first level warning limit) . A or ■ : ACTION required (second level warning limit)
U-Caution : Upper CAUTION Level L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level L-Action : Lower ACTION required Level
First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level
Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-2 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ -20 ถึง 0

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

Wear Condition	Oil Condition	Contamination
NORMAL	NORMAL	NORMAL

Recommendations and Notes

Note some test values are near to the Alarm Limits, or slightly over the Alarm Limits, but are not considered serious at this time.
All other wear tests and oil condition tests appear satisfactory, and the oil was still serviceable at the time of sampling.
Continue routine sampling interval.

AS / Andy Sitton

Condition History	Test Method	Result	Current Sample Wear	Current Sample Oil	Current Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.
			N	N	N	▲	N	▲	▲	N	▲
FocusLab ID			70940			70939			70938		
Date sampled			19-Feb-07			19-Feb-07			18-Feb-07		
Hours on Oil			0			20			0		
Hours on Unit			0			0			- 20		
Bottle ID			861995			861994			861993		
Wear Condition											
Wear Element	Method	Unit	RDE fine	RFS coarse		RDE fine	RFS coarse		RDE fine	RFS coarse	
Iron	D-6595	PPM	3.4	21.6		42.1 A	122.5 A		4.7	83.3 A	
Chromium	D-6595	PPM	0.0	2.2 C		2.3 A	5.2 A		0.2	3.3 A	
Lead	D-6595	PPM	0.8	10.3 C		3.4	1.2		1.9	13.0 C	
Copper	D-6595	PPM	0.2	0.3		5.8	2.7		0.7	5.5	
Tin	D-6595	PPM	0.0	12.2 A		0.0	11.3 C		0.0	13.4 A	
Aluminum	D-6595	PPM	0.9	11.8 A		7.2 A	23.5 A		1.5	21.5 A	
Nickel	D-6595	PPM	0.1	2.5		0.0	0.0		0.0	2.5	
Silver	D-6595	PPM	0.0	0.1		0.0	0.0		0.0	0.1	
Molybdenum	D-6595	PPM	59.3	13.9		63.3	29.5		57.9	18.7	
Titanium	D-6595	PPM	0.0	1.2		0.0	0.9		0.0	1.6	
Oil Condition											
Viscosity @ 40 °C	D-445	cSt	148.3			150.9			148.6		
Viscosity @ 100 °C	D-445	cSt	14.6			14.9			14.6		
Oxidation	FTIR	Abs	6.3			5.4			6.3		
Nitration	FTIR	Abs	5.5			5.5			5.6		
TAN	D-974	mg KOH/g									
TBN	D-4739	mg KOH/g	6.6			6.9			6.5		
Contamination											
Water	FTIR	% (Wt.)	0.065			0.034			0.077		
Fuel	SAW	% (Wt.)	0.10			0.10			0.10		
Glycol	FTIR	Abs	0			0			0		
Soot	FTIR	% (Wt.)	0.00			0.48			0.00		
Sodium	D-6595	PPM	2			5			2		
Silicon	D-6595	PPM	14.6	7.9		20.7 C	15.0 C		13.8	24.0 A	
Additive Element											
Boron	D-6595	PPM	1			0			1		
Magnesium	D-6595	PPM	12			12			12		
Calcium	D-6595	PPM	2574			2701			2455		
Barium	D-6595	PPM	0			1			9		
Phosphorus	D-6595	PPM	647			671			711		
Zinc	D-6595	PPM	871	146		867	385		802	178	
Additional Test											
Flash Point	D-3828	°C									
Viscosity Index	D-2270		97			98			97		
Other											

Alarm Limit Range

Limit Name (Equipment / Oil) :
Engine Diesel General SAE 40

New Oil	RDE fine U-Caution	RDE fine L-Caution	RFS coarse U-Caution	RFS coarse L-Caution
	>25	>40	>35	>55
	>1	>2	>2	>3
	>8	>13	>9	>15
	>15	>25	>20	>34
	>3	>6	>7	>12
	>4	>6	>6	>9
	>1	>2	>3	>4

New Oil	L-Caution	U-Caution	
148.9	<127	<134	>164
			>14
			>11
	<2	<3.8	

New Oil	U-Caution	
	>0.1	>0.3
	>3	>5
	>2.1	>5.1

New Oil	RDE fine U-Caution	RDE fine L-Caution	RFS coarse U-Caution	RFS coarse L-Caution
	>15	>25	>15	>20

New Oil	L-Caution	U-Caution	

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or (N) : NORMAL , C or ▲ : CAUTION (first level warning limit) , A or ■ : ACTION required (second level warning limit)
U-Caution : Upper CAUTION Level L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level L-Action : Lower ACTION required Level
First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level
Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 6600-3 Fax : (662) 361 6567
Email : focuslab@focuslab.co.th

FL-6.1

รูปที่ จ-2 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ -20 ถึง 0 (ต่อ)

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

Wear Condition	Oil Condition	Contamination
NORMAL	NORMAL	NORMAL

	Current Sample	Previous Sample	
FocusLab ID	70940	70939	70938
Date sampled	19-Feb-07	19-Feb-07	18-Feb-07
Hours on Oil	0	20	0
Hours on Unit	0	0	- 20
Bottle ID	861995	861994	861993
Volume of Sample Used	0.10 ml	0.10 ml	0.10 ml

Ferrographic Analysis

Typical Normal Ferrogram

Image of Wear & Contaminant Magnification 40X

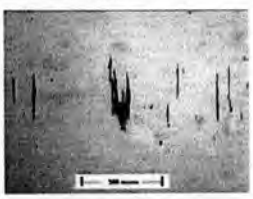


Image of Wear & Contaminant Magnification 100X

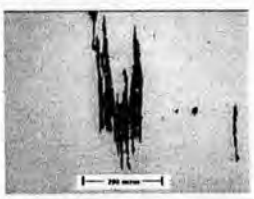


Image of Wear & Contaminant Magnification 400X

Wear & Contaminants Particles	%Rating	Size (Micron	Particle Type	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle
Normal Rubbing Wear	60	3-5	F	40	3-5	F	50	3-5	F			
Fatique Wear	30	20-40	F	50	20-50	F	40	20-50	F			
Fatique Sphere												
Sliding Wear												
Cutting Wear							10	10-20	F			
Black Oxides	10	10-20	F									
Red Oxides												
Corrosive Wear												
Dirt and Dust				10	20-40	C						

Recommendations and Notes

Fatigue wear appears to be one of the major abnormal wear mode in progress.

Black oxides in ferrogram can indicate insufficient lubrication. Possible reasons/sources; improper oil type, improper grade of oil, poor lubricant film strength, poor lubricant circulation, blocked oil passages, equipment overloading or overheating.

%Rating : Percent area covered by wear debris particles or contaminant particles
Size : Size in micron (0.001 mm) unit of wear debris particles or contaminant particles
F : Ferrous Wear Particle, N : Non-ferrous Wear Particle, C : Contaminant Particle

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

FL-6.1

รูปที่ จ-3 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 10 ถึง 50

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

Wear Condition	Oil Condition	Contamination
ACTION	CAUTION	ACTION

Recommendations and Notes

Dirt (silicon) is present and resulting in abrasive wear.
Recommend check to determine how dirt is entering the system and correct the problem to prevent further dirt entry.
Note high soot level. This may be related to the dirt problem, indicating a a blocked or plugged air filter.

AS / Andy Sitton

Condition History	Test Method	Result	Current Sample Wear	Current Sample Oil	Current Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.	Wear	Oil	Cont.
			■	C	■	C	N	C	C	N	C
FocusLab ID			71201			71084			71083		
Date sampled			23-Feb-07			21-Feb-07			20-Feb-07		
Hours on Oil			50			25			10		
Hours on Unit			50			25			10		
Bottle ID			861998			861997			861996		
Wear Condition											
Wear Element	Method	Unit	RDE fine	RFS coarse		RDE fine	RFS coarse		RDE fine	RFS coarse	
Iron	D-6595	PPM	244.9 A	779.3 A		207.1 A	152.7 A		80.5 A	242.5 A	
Chromium	D-6595	PPM	14.0 A	25.9 A		12.3 A	8.0 A		6.3 A	11.9 A	
Lead	D-6595	PPM	1.5	10.3 C		1.9	4.9		1.8	17.6 A	
Copper	D-6595	PPM	4.2	2.6		3.6	1.3		2.0	1.5	
Tin	D-6595	PPM	0.0	17.0 A		0.0	5.3		0.0	27.2 A	
Aluminum	D-6595	PPM	34.4 A	76.4 A		29.9 A	23.4 A		14.9 A	31.6 A	
Nickel	D-6595	PPM	2.3 A	5.6 A		1.3 C	0.0		0.6	4.3 A	
Silver	D-6595	PPM	0.0	0.1		0.0	0.0		0.0	0.2	
Molybdenum	D-6595	PPM	63.6	46.2		66.4	26.7		63.0	37.9	
Titanium	D-6595	PPM	0.0	2.1		0.0	0.0		0.0	1.9	
Oil Condition											
Viscosity @ 40 °C	D-445	cSt	172.7			159.2			153.8		
Viscosity @ 100 °C	D-445	cSt	17.2 A			15.7			15.0		
Oxidation	FTIR	Abs	8.4			5.5			4.6		
Nitration	FTIR	Abs	9.6			6.1			5.0		
TAN	D-974	mg KOH/g									
TBN	D-4739	mg KOH/g	6.3			6.9			6.9		
Contamination											
Water	FTIR	% (Wt.)	0.251 C			0.047			0.039		
Fuel	SAW	% (Wt.)	0.40			1.20			1.10		
Glycol	FTIR	Abs	0			0			0		
Soot	FTIR	% (Wt.)	2.66 C			1.56			0.53		
Sodium	D-6595	PPM	13			11			6		
Silicon	D-6595	PPM	53.2 A	119.4 A		53.3 A	40.8 A		31.8 A	55.7 A	
Additive Element											
Boron	D-6595	PPM	1			1			1		
Magnesium	D-6595	PPM	15			15			14		
Calcium	D-6595	PPM	2654			2665			2635		
Barium	D-6595	PPM	15			13			0		
Phosphorus	D-6595	PPM	664			680			647		
Zinc	D-6595	PPM	748	629		816	427		863	618	
Additional Test											
Flash Point	D-3828	°C									
Viscosity Index	D-2270		107			100			97		
Other											

Alarm Limit Range

Limit Name (Equipment / Oil) :
Engine Diesel General SAE 40

	RDE fine		RFS coarse	
New Oil	U-Caution	U-Action	U-Caution	U-Action
	>25	>40	>35	>55
	>1	>2	>2	>3
	>8	>13	>9	>15
	>16	>25	>20	>34
	>3	>6	>7	>12
	>4	>6	>6	>9
	>1	>2	>3	>4

New Oil	L-Action	L-Caution	U-Caution	U-Action
14.9	<12.7	<13.4	>16.4	>17.1
			>14	>19
			>11	>14

New Oil			U-Caution	U-Action
	<2	<3.8		
			>0.1	>0.3
			>3	>5
			>2.1	>5.1

	RDE fine		RFS coarse	
New Oil				
	>15	>25	>15	>20

New Oil	L-Action	L-Caution	U-Caution	U-Action

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or N : NORMAL , C or C : CAUTION (first level warning limit) , A or ■ : ACTION required (second level warning limit)

U-Caution : Upper CAUTION Level — L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level — L-Action : Lower ACTION required Level

First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level

Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8587
Email : focuslab@focuslab.co.th

รูปที่ จ-3 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 10 ถึง 50 (ต่อ)

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

	Current Sample	Previous Sample	
FocusLab ID	71201	71084	71083
Date sampled	23-Feb-07	21-Feb-07	20-Feb-07
Hours on Oil	50	25	10
Hours on Unit	50	25	10
Bottle ID	861998	861997	861996
Volume of Sample Used	0.10 ml	0.10 ml	0.10 ml

Ferrographic Analysis

Typical Normal Ferrogram

Image of Wear & Contaminant Magnification 40X

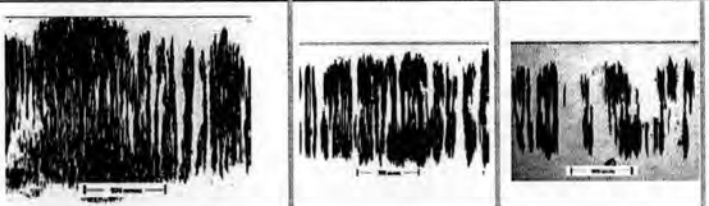


Image of Wear & Contaminant Magnification 100X

Image of Wear & Contaminant Magnification 400X

Wear & Contaminants Particles	%Rating	Size (Micron	Particle Type	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle
Normal Rubbing Wear	30	3-5	F	35	3-5	F	50	3-5	F			
Fatigue Wear	50	20-40	F	50	20-40	F	30	20-50	F			
Fatigue Sphere												
Sliding Wear												
Cutting Wear												
Black Oxides	10	10-20	F	10	5-20	F	10	10-20	F			
Red Oxides												
Corrosive Wear												
Dirt and Dust	10	10-20	C	5	10-20	C	10	10-20	C			

Recommendations and Notes

Fatigue wear appears to be one of the major abnormal wear mode in progress.
Fatigue particles found in the ferrogram may be an indication of the dirt related fatigue wear.
Black oxides in ferrogram can indicate insufficient lubrication. Possible reasons/sources; improper oil type, improper grade of oil, poor lubricant film strength, poor lubricant circulation, blocked oil passages, equipment overloading or overheating.
Note the dirt particles detected in ferrogram.

%Rating : Percent area covered by wear debris particles or contaminant particles
Size : Size in micron (0.001 mm) unit of wear debris particles or contaminant particles
F : Ferrous Wear Particle, N : Non-ferrous Wear Particle, C : Contaminant Particle

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 6600-3 Fax : (662) 361 6567
Email : focuslab@focuslab.co.th

รูปที่ จ-4 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 75 ถึง 100

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

Recommendations and Notes

Minor amount of dirt and abrasive wear noted.
Recommend check to determine how dirt is entering the system and correct the problem to prevent further dirt entry.

AS / Andy Sitton

Condition History	Test Method	Result	Current Sample Wear (N)	Current Sample Oil (N)	Current Sample Cont.	Previous Sample Wear (N)	Previous Sample Oil (N)	Previous Sample Cont.	Previous Sample 2 Wear	Previous Sample 2 Oil (C)	Previous Sample 2 Cont.
FocusLab ID			71259			71258			71202		
Date sampled			26-Feb-07			26-Feb-07			24-Feb-07		
Hours on Oil			0			100			75		
Hours on Unit			100			100			75		
Bottle ID			862001			862000			861999		
Wear Condition											
Wear Element	Method	Unit	RDE fine	RFS coarse		RDE fine	RFS coarse		RDE fine	RFS coarse	
Iron	D-6595	PPM	7.1	13.8		298.5 A	872.7 A		279.9 A	315.2 A	
Chromium	D-6595	PPM	0.4	1.2		16.4 A	25.3 A		15.9 A	13.2 A	
Lead	D-6595	PPM	1.6	2.2		2.3	14.4 C		2.5	0.0	
Copper	D-6595	PPM	0.2	0.2		6.1	3.9		5.5	1.4	
Tin	D-6595	PPM	0.0	6.3		0.0	25.2 A		0.0	3.6	
Aluminum	D-6595	PPM	1.5	8.1 C		40.8 A	76.6 A		38.5 A	37.9 A	
Nickel	D-6595	PPM	0.4	1.5		3.4 A	7.7 A		2.9 A	0.2	
Silver	D-6595	PPM	0.0	0.0		0.0	0.1		0.0	0.0	
Molybdenum	D-6595	PPM	67.1	13.0		68.8	70.3		67.7	22.7	
Titanium	D-6595	PPM	0.0	0.8		0.0	2.4		0.0	0.3	
Oil Condition											
Viscosity @ 40 °C	D-445	cSt	145.6			213.8			191.5		
Viscosity @ 100 °C	D-445	cSt	14.8			25.3 A			21.4 A		
Oxidation	FTIR	Abs	6.2			12.5			10.2		
Nitration	FTIR	Abs	5.5			11.6 C			11.5 C		
TAN	D-974	mg KOH/g									
TBN	D-4739	mg KOH/g	7.0			6.1			5.8		
Contamination											
Water	FTIR	% (Wt.)	0.064			1.372 A			0.604 A		
Fuel	SAW	% (Wt.)	0.40			1.70			0.40		
Glycol	FTIR	Abs	0			0			0		
Soot	FTIR	% (Wt.)	0.02			5.18 A			3.91 C		
Sodium	D-6595	PPM	2			15			14		
Silicon	D-6595	PPM	13.8	36.2 A		58.5 A	112.6 A		57.2 A	56.2 A	
Additive Element											
Boron	D-6595	PPM	1			1			1		
Magnesium	D-6595	PPM	13			15			15		
Calcium	D-6595	PPM	2656			2623			2726		
Barium	D-6595	PPM	2			17			14		
Phosphorus	D-6595	PPM	729			718			682		
Zinc	D-6595	PPM	887	187		748	989		753	396	
Additional Test											
Flash Point	D-3828	°C									
Viscosity Index	D-2270		101			150			133		
Other											

Alarm Limit Range

Limit Name (Equipment / Oil) :
Engine Diesel General SAE 40

	RDE fine U-Caution	RDE fine U-Action	RFS coarse U-Caution	RFS coarse U-Action
New Oil	>26	>40	>35	>55
	>1	>2	>2	>3
	>8	>13	>9	>15
	>15	>25	>20	>34
	>2	>6	>7	>12
	>4	>6	>6	>8
	>1	>2	>3	>4

	L-Action	L-Caution	U-Caution	U-Action
New Oil	14.9	<12.7	<13.4	>16.4
			>14	>19
			>11	>14

		U-Caution	U-Action
New Oil	<2		
		>0.1	>0.3
		>3	>5
		>2.1	>5.1

	RDE fine U-Caution	RDE fine U-Action	RFS coarse U-Caution	RFS coarse U-Action
New Oil	>15	>25	>15	>20

	L-Action	L-Caution	U-Caution	U-Action
New Oil				

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or (N) : NORMAL , C or (C) : CAUTION (first level warning limit) , A or ■ : ACTION required (second level warning limit)
U-Caution : Upper CAUTION Level L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level L-Action : Lower ACTION required Level
First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level
Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8587
Email : focuslab@focuslab.co.th

รูปที่ จ-4 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 75 ถึง 100 (ต่อ)

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

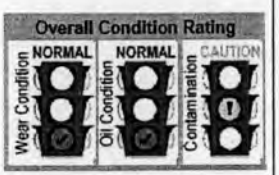
Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating



	Current Sample	Previous Sample	
FocusLab ID	71259	71258	71202
Date sampled	26-Feb-07	26-Feb-07	24-Feb-07
Hours on Oil	0	100	75
Hours on Unit	100	100	75
Bottle ID	862001	862000	861999
Volume of Sample Used	0.10 ml	0.10 ml	0.10 ml

Ferrographic Analysis

Typical Normal Ferrogram

Image of Wear & Contaminant Magnification 40X

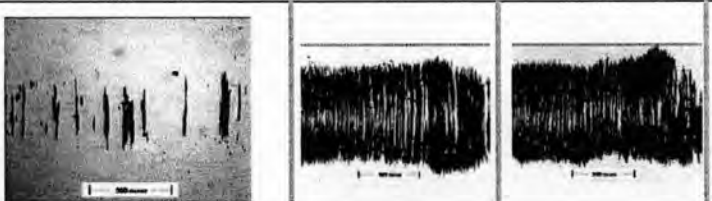


Image of Wear & Contaminant Magnification 100X

Image of Wear & Contaminant Magnification 400X

Wear & Contaminants Particles	%Rating	Size (Micron	Particle Type	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle
Normal Rubbing Wear	30	3-5	F	40	3-5	F	20	3-5	F			
Fatique Wear	60	20-80	F	40	20-40	F	60	20-40	F			
Fatique Sphere												
Sliding Wear												
Cutting Wear												
Black Oxides	10	5-15	F	5	5-15	F	10	5-15	F			
Red Oxides												
Corrosive Wear												
Dirt and Dust				15	10-20	C	10	10-20	C			

Recommendations and Notes

Fatigue wear appears to be one of the major abnormal wear mode in progress.

Black oxides in ferrogram can indicate insufficient lubrication. Possible reasons/sources; improper oil type, improper grade of oil, poor lubricant film strength, poor lubricant circulation, blocked oil passages, equipment overloading or overheating.

%Rating : Percent area covered by wear debris particles or contaminant particles
Size : Size in micron (0.001 mm) unit of wear debris particles or contaminant particles
F : Ferrous Wear Particle, N : Non-ferrous Wear Particle, C : Contaminant Particle

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-5 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 110 ถึง 150

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

Wear Condition	Oil Condition	Contamination
ACTION	CAUTION	ACTION

Recommendations and Notes

Dirt (silicon) is present and resulting in abrasive wear.
Recommend check to determine how dirt is entering the system and correct the problem to prevent further dirt entry.

AS / Andy Sitton

Condition History	Test Method	Result	Current Sample Wear	Current Sample Oil	Current Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.	Previous Sample 2 Wear	Previous Sample 2 Oil	Previous Sample 2 Cont.
			■	C	■	C	N	C	C	N	C
FocusLab ID			71471			71287			71260		
Date sampled			02-Mar-07			28-Feb-07			27-Feb-07		
Hours on Oil			50			25			10		
Hours on Unit			150			125			110		
Bottle ID			862004			862003			862002		
Wear Condition											
Wear Element	Method	Unit	RDE fine	RFS coarse		RDE fine	RFS coarse		RDE fine	RFS coarse	
Iron	D-6595	ppm	97.3 A	125.1 A		66.2 A	59.7 A		46.0 A	145.3 A	
Chromium	D-6595	ppm	9.0 A	7.9 A		5.9 A	5.5 A		3.4 A	8.7 A	
Lead	D-6595	ppm	1.5	0.0		1.2	1.5		1.4	3.2	
Copper	D-6595	ppm	1.8	0.7		1.2	0.5		0.8	0.9	
Tin	D-6595	ppm	0.0	3.5		0.0	10.2 C		0.0	20.2 A	
Aluminum	D-6595	ppm	18.6 A	21.1 A		11.0 A	14.8 A		6.2 A	22.5 A	
Nickel	D-6595	ppm	1.8 C	0.0		1.1 C	0.2		0.9	2.6	
Silver	D-6595	ppm	0.0	0.0		0.0	0.1		0.0	0.1	
Molybdenum	D-6595	ppm	59.8	25.8		64.3	23.8		61.0	39.9	
Titanium	D-6595	ppm	0.0	0.0		0.0	0.9		0.0	1.4	
Oil Condition											
Viscosity @ 40 °C	D-445	cSt	171.3			159.6			152.2		
Viscosity @ 100 °C	D-445	cSt	17.8 A			15.7			15.1		
Oxidation	FTIR	Abs	8.4			6.4			5.1		
Nitration	FTIR	Abs	8.6			6.6			5.5		
TAN	D-974	mg KOH/g									
TBN	D-4739	mg KOH/g	6.3			6.6			6.9		
Contamination											
Water	FTIR	% (Wt.)	0.159 C			0.040			0.040		
Fuel	SAW	% (Wt.)	1.60			1.60			0.60		
Glycol	FTIR	Abs	0			0			0		
Soot	FTIR	% (Wt.)	2.77 C			1.55			0.68		
Sodium	D-6595	ppm	8			5			4		
Silicon	D-6595	ppm	31.1 A	28.2 A		25.7 A	16.7 C		22.1 C	30.1 A	
Additive Element											
Boron	D-6595	ppm	1			1			1		
Magnesium	D-6595	ppm	12			12			13		
Calcium	D-6595	ppm	2772			2669			2661		
Barium	D-6595	ppm	0			0			0		
Phosphorus	D-6595	ppm	577			638			678		
Zinc	D-6595	ppm	722	418		818	388		829	651	
Additional Test											
Flash Point	D-3828	°C									
Viscosity Index	D-2270		114			101			99		
Other											

Alarm Limit Range

Limit Name (Equipment / Oil) :
Engine Diesel General SAE 40

	RDE fine U-Caution	RDE fine U-Action	RFS coarse U-Caution	RFS coarse U-Action
New Oil				
	>25	>40	>35	>55
	>1	>2	>2	>3
	>8	>13	>9	>15
	>16	>25	>20	>34
	>3	>6	>7	>12
	>4	>6	>6	>9
	>1	>2	>3	>4

	L-Action	L-Caution	U-Caution	U-Action
New Oil				
14.9	<12.7	<13.4	>16.4	>17.1
			>14	>19
			>11	>14
	<2	<3.8		

	U-Caution	U-Action
New Oil		
	>0.1	>0.3
	>3	>5
	>2.1	>5.1

	RDE fine U-Caution	RDE fine U-Action	RFS coarse U-Caution	RFS coarse U-Action
New Oil				
	>15	>25	>15	>20

	L-Action	L-Caution	U-Caution	U-Action
New Oil				

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or N : NORMAL , C or ▲ : CAUTION (first level warning limit) , A or ■ : ACTION required (second level warning limit)

U-Caution : Upper CAUTION Level L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level L-Action : Lower ACTION required Level

First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level

Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-5 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 110 ถึง 150 (ต่อ)

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

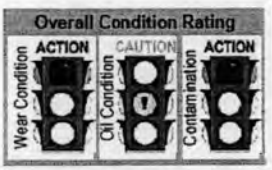
Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating



	Current Sample	Previous Sample	
FocusLab ID	71471	71287	71260
Date sampled	02-Mar-07	28-Feb-07	27-Feb-07
Hours on Oil	50	25	10
Hours on Unit	150	125	110
Bottle ID	862004	862003	862002
Volume of Sample Used	0.10 ml	0.10 ml	0.10 ml

Ferrographic Analysis

Typical Normal Ferrogram

Image of Wear & Contaminant Magnification 40X

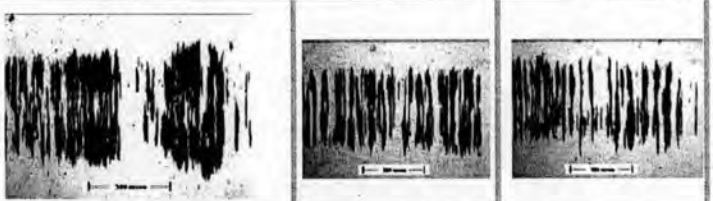


Image of Wear & Contaminant Magnification 100X

Image of Wear & Contaminant Magnification 400X

Wear & Contaminants Particles	%Rating	Size (Micron	Particle Type	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle
Normal Rubbing Wear	30	3-5	F	30	3-5	F	55	3-5	F			
Fatique Wear	50	20-40	F	40	20-40	F	30	10-40	F			
Fatique Sphere												
Sliding Wear												
Cutting Wear												
Black Oxides	10	5-15	F	10	5-15	F	10	5-15	F			
Red Oxides												
Corrosive Wear												
Dirt and Dust	10	5-10	C	10	5-10	C	5	5-10	C			

Recommendations and Notes

Fatigue wear appears to be one of the major abnormal wear mode in progress.

Black oxides in ferrogram can indicate insufficient lubrication. Possible reasons/sources; improper oil type, improper grade of oil, poor lubricant film strength, poor lubricant circulation, blocked oil passages, equipment overloading or overheating.

Note the dirt particles detected in ferrogram.

%Rating : Percent area covered by wear debris particles or contaminant particles
Size : Size in micron (0.001 mm) unit of wear debris particles or contaminant particles
F : Ferrous Wear Particle, N : Non-ferrous Wear Particle, C : Contaminant Particle

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-6 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 175 ถึง 210

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

Wear Condition	Oil Condition	Contamination
ACTION	ACTION	ACTION

Recommendations and Notes

Dirt (silicon) is present and resulting in abrasive wear.
Recommend check to determine how dirt is entering the system and correct the problem to prevent further dirt entry.
Note high soot level. This may be related to the dirt problem, indicating a a blocked or plugged air filter.

AS / Andy Sitton

Condition History			Current Sample			Previous Sample						Alarm Limit Range
			Wear	Oil	Cont.	Wear	Oil	Cont.	Wear	Oil	Cont.	Limit Name (Equipment / Oil) : Engine Diesel General SAE 40
			■	■	■	■	N	■	■	C	■	
FocusLab ID	Test Method	Result	71553			71504			71472			
Date sampled			06-Mar-07			05-Mar-07			03-Mar-07			
Hours on Oil			110			100			75			
Hours on Unit			210			200			175			
Bottle ID			862007			862006			862005			

Wear Condition									New Oil	RDE fine		RFS coarse	
Wear Element	Method	Unit	RDE fine	RFS coarse	RDE fine	RFS coarse	RDE fine	RFS coarse		U-Caution	U-Action	U-Caution	U-Action
Iron	D-6595	PPM	195.9 A	204.6 A	175.8 A	210.6 A	143.3 A	114.1 A		>25	>40	>35	>55
Chromium	D-6595	PPM	13.4 A	12.1 A	12.1 A	12.8 A	11.1 A	7.0 A		>1	>2	>2	>3
Lead	D-6595	PPM	1.9	0.0	1.6	6.0	0.8	0.0		>8	>13	>8	>15
Copper	D-6595	PPM	2.8	1.2	2.5	1.2	2.3	0.7		>15	>25	>20	>34
Tin	D-6595	PPM	0.0	3.1	0.0	15.5 A	0.0	0.7		>3	>6	>7	>12
Aluminum	D-6595	PPM	33.0 A	31.4 A	30.5 A	35.3 A	25.4 A	19.4 A		>4	>6	>6	>9
Nickel	D-6595	PPM	2.9 A	0.0	2.7 A	3.7 C	2.3 A	0.0		>1	>2	>3	>4
Silver	D-6595	PPM	0.0	0.0	0.0	0.1	0.0	0.0					
Molybdenum	D-6595	PPM	74.0	29.4	67.0	39.2	63.6	22.9					
Titanium	D-6595	PPM	0.0	0.0	0.0	1.5	0.0	0.0					

Oil Condition									New Oil	L-Action	L-Caution	U-Caution	U-Action
Viscosity @ 40 °C	D-445	cSt	181.7		183.2		185.5						
Viscosity @ 100 °C	D-445	cSt	17.5 A		17.8 A		20.2 A		14.9	<12.7	<13.4	>16.4	>17.1
Oxidation	FTIR	Abs	10.1		11.2		9.5					>14	>19
Nitration	FTIR	Abs	9.5		9.7		9.4					>11	>14
TAN	D-974	mg KOH/g								<2	<3.8		
TBN	D-4739	mg KOH/g	5.5		5.6		5.9						

Contamination									New Oil			U-Caution	U-Action
Water	FTIR	% (Wt.)	0.038		0.067		0.401 A					>0.1	>0.3
Fuel	SAW	% (Wt.)	1.20		1.00		1.50					>3	>5
Glycol	FTIR	Abs	0		0		0						
Soot	FTIR	% (Wt.)	3.63 C		3.73 C		3.56 C					>2.1	>5.1
Sodium	D-6595	PPM	10		10		10			RDE fine		RFS coarse	
Silicon	D-6595	PPM	46.1 A	43.7 A	41.3 A	49.6 A	35.5 A	24.4 A		>15	>25	>15	>20
Additive Element									New Oil				
Boron	D-6595	PPM	1		1		1						
Magnesium	D-6595	PPM	16		15		13						
Calcium	D-6595	PPM	2849		2847		2778						
Barium	D-6595	PPM	6		0		0						
Phosphorus	D-6595	PPM	712		778		558						
Zinc	D-6595	PPM	836	544	746	555	763	376					

Additional Test									New Oil	L-Action	L-Caution	U-Caution	U-Action
Flash Point	D-3828	°C											
Viscosity Index	D-2270		104		106		122						
Other													

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or (N) : NORMAL , C or (C) : CAUTION (first level warning limit) , A or ■ : ACTION required (second level warning limit)
U-Caution : Upper CAUTION Level L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level L-Action : Lower ACTION required Level
First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level
Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-6 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 175 ถึง 210 (ต่อ)

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

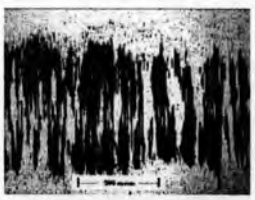
Wear Condition	Oil Condition	Contamination
ACTION	ACTION	ACTION

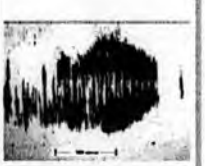
	Current Sample	Previous Sample	
FocusLab ID	71553	71504	71472
Date sampled	06-Mar-07	05-Mar-07	03-Mar-07
Hours on Oil	110	100	75
Hours on Unit	210	200	175
Bottle ID	862007	862006	862005
Volume of Sample Used	3.00 ml	0.10 ml	0.10 ml

Ferrographic Analysis

Typical Normal Ferrogram

Image of Wear & Contaminant Magnification 40X





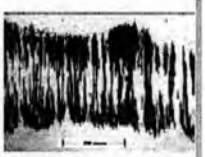


Image of Wear & Contaminant Magnification 100X

Image of Wear & Contaminant Magnification 400X

Wear & Contaminants Particles	%Rating	Size (Micron	Particle Type	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle
Normal Rubbing Wear	60	3-5	F	50	3-5	F	65	3-5	F			
Fatigue Wear	30	20-40	F	30	20-80	F	20	20-50	F			
Fatigue Sphere												
Sliding Wear	10	50	F									
Cutting Wear												
Black Oxides							5	5-10	F			
Red Oxides												
Corrosive Wear												
Dirt and Dust				20	20-40	C	10	10-20	C			

Recommendations and Notes

Sliding wear noted in ferrogram.
Fatigue wear appears to be one of the major abnormal wear mode in progress.

%Rating : Percent area covered by wear debris particles or contaminant particles
Size : Size in micron (0.001 mm) unit of wear debris particles or contaminant particles
F : Ferrous Wear Particle, N : Non-ferrous Wear Particle, C : Contaminant Particle

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-7 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 210 ถึง 235

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

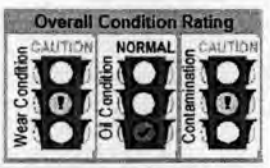
Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating



Recommendations and Notes

Dirt (silicon) is present and resulting in abrasive wear.
Recommend check to determine how dirt is entering the system and correct the problem to prevent further dirt entry.

AS / Andy Sitton

Condition History	Test Method	Result	Current Sample Wear	Current Sample Oil	Current Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.	Wear	Oil	Cont.
			C	N	C	N	N	N	N	N	N
FocusLab ID			71649			71555			71554		
Date sampled			07-Mar-07			06-Mar-07			06-Mar-07		
Hours on Oil			25			10			0		
Hours on Unit			235			220			210		
Bottle ID			862010			862009			862008		
Wear Condition											
Wear Element	Method	Unit	RDE fine	RFS coarse		RDE fine	RFS coarse		RDE fine	RFS coarse	
Iron	D-6595	PPM	43.9 A	54.7		24.8	9.5		3.1	3.5	
Chromium	D-6595	PPM	4.1 A	5.2		1.9 C	0.0		0.2	0.0	
Lead	D-6595	PPM	0.0	0.0		1.2	0.0		0.6	0.0	
Copper	D-6595	PPM	0.8	0.4		0.4	0.0		0.1	0.0	
Tin	D-6595	PPM	0.0	7.7		0.0	0.0		0.0	0.0	
Aluminum	D-6595	PPM	9.2 A	16.0		4.3 C	0.0		1.2	0.0	
Nickel	D-6595	PPM	0.4	0.0		0.1	0.0		0.0	0.0	
Silver	D-6595	PPM	0.0	0.0		0.0	0.0		0.0	0.0	
Molybdenum	D-6595	PPM	62.8	25.9		63.5	11.5		66.6	8.1	
Titanium	D-6595	PPM	0.0	0.2		0.0	0.0		0.0	0.0	
Oil Condition											
Viscosity @ 40 °C	D-445	cSt	152.3			148.2			149.9		
Viscosity @ 100 °C	D-445	cSt	15.0			14.8			14.7		
Oxidation	FTIR	Abs	6.4			6.3			6.3		
Nitration	FTIR	Abs	6.6			5.7			5.6		
TAN	D-974	mg KOH/g									
TBN	D-4739	mg KOH/g	6.6			8.0			8.4		
Contamination											
Water	FTIR	% (Wt.)	0.069			0.026			0.054		
Fuel	SAW	% (Wt.)	1.60			1.40			0.10		
Glycol	FTIR	Abs	0			0			0		
Soot	FTIR	% (Wt.)	0.75			0.25			0.00		
Sodium	D-6595	PPM	5			3			2		
Silicon	D-6595	PPM	20.3 C	19.8		17.2 C	6.4		14.5	11.1	
Additive Element											
Boron	D-6595	PPM	1			1			1		
Magnesium	D-6595	PPM	12			13			13		
Calcium	D-6595	PPM	2674			2627			2632		
Barium	D-6595	PPM	0			0			0		
Phosphorus	D-6595	PPM	634			651			660		
Zinc	D-6595	PPM	844	445		875	238		911	146	
Additional Test											
Flash Point	D-3828	°C									
Viscosity Index	D-2270		98			99			96		
Other											

Alarm Limit Range

Limit Name (Equipment / Oil) :
Engine Diesel General SAE 40

	RDE fine U-Caution	RDE fine U-Action	RFS coarse U-Caution	RFS coarse U-Action
	>25	>40	>35	>55
	>1	>2	>2	>3
	>9	>13	>9	>15
	>18	>25	>20	>34
	>3	>6	>7	>12
	>4	>6	>6	>9
	>1	>2	>3	>4

New Oil	L-Action	L-Caution	U-Caution	U-Action
14.9	<12.7	<12.4	>16.4	>17.1
			>14	>19
			>11	>14
	<2	<3.8		

New Oil	U-Caution	U-Action
	>0.1	>0.3
	>3	>5
	>2.1	>5.1

	RDE fine		RFS coarse	
New Oil	>15	>25	>15	>20

New Oil	L-Action	L-Caution	U-Caution	U-Action

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or (N) : NORMAL , C or (C) : CAUTION (first level warning limit) , A or ■ : ACTION required (second level warning limit)
U-Caution : Upper CAUTION Level L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level L-Action : Lower ACTION required Level
First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level
Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-7 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 210 ถึง 235 (ต่อ)

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

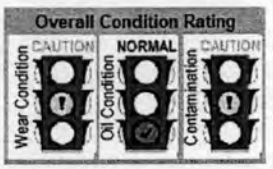
Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating



	Current Sample	Previous Sample	
FocusLab ID	71649	71555	71554
Date sampled	07-Mar-07	06-Mar-07	06-Mar-07
Hours on Oil	25	10	0
Hours on Unit	235	220	210
Bottle ID	862010	862009	862008
Volume of Sample Used	0.10 ml	0.10 ml	0.10 ml

Ferrographic Analysis

Typical Normal Ferrogram

Image of Wear & Contaminant Magnification 40X

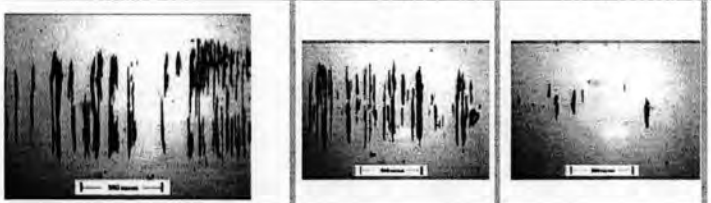


Image of Wear & Contaminant Magnification 100X

Image of Wear & Contaminant Magnification 400X

Wear & Contaminants Particles	%Rating	Size (Micron	Particle Type	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle
Normal Rubbing Wear	80	3-5	F	70	3-5	F	80	3-5	F			
Fatigue Wear	10	10-20	F	15	10-30	F	10	20-50	F			
Fatigue Sphere												
Sliding Wear												
Cutting Wear												
Black Oxides	10	5-10	F	10	5-20	F	10	5-10	F			
Red Oxides												
Corrosive Wear												
Dirt and Dust				5	20-50	C						

Recommendations and Notes

Majority of ferrous particles consist of the normal rubbing wear shape.
Fatigue particles found in the ferrogram.
Black oxides noted in ferrogram.

%Rating : Percent area covered by wear debris particles or contaminant particles
Size : Size in micron (0.001 mm) unit of wear debris particles or contaminant particles
F : Ferrous Wear Particle, **N** : Non-ferrous Wear Particle, **C** : Contaminant Particle

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-8 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 260 ถึง 310

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

Recommendations and Notes

Dirt (silicon) is present and resulting in abrasive wear.
Recommend check to determine how dirt is entering the system and correct the problem to prevent further dirt entry.
Note high soot level. This may be related to the dirt problem, indicating a a blocked or plugged air filter.

AS / Andy Sitton

Condition History	Test Method	Result	Current Sample Wear	Current Sample Oil	Current Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.
			■	C	■	C	N	C	C	N	C
FocusLab ID			71922			71815			71814		
Date sampled			12-Mar-07			11-Mar-07			09-Mar-07		
Hours on Oil			100			75			50		
Hours on Unit			310			285			260		
Bottle ID			862013			862012			862011		
Wear Condition											
Wear Element	Method	Unit	RDE fine	RFS coarse		RDE fine	RFS coarse		RDE fine	RFS coarse	
Iron	D-6595	PPM	154.6 A	185.7 A		119.4 A	74.3 A		79.7 A	55.4 A	
Chromium	D-6595	PPM	12.2 A	14.3 A		10.1 A	5.9 A		7.2 A	4.1 A	
Lead	D-6595	PPM	0.5	0.0		0.8	0.0		1.4	0.0	
Copper	D-6595	PPM	2.1	1.2		1.7	0.5		1.3	0.3	
Tin	D-6595	PPM	0.0	11.7 C		0.0	0.0		0.0	0.0	
Aluminum	D-6595	PPM	31.7 A	37.7 A		25.0 A	17.4 A		17.5 A	15.5 A	
Nickel	D-6595	PPM	2.6 A	1.2		1.7 C	0.0		1.4 C	0.0	
Silver	D-6595	PPM	0.0	0.0		0.0	0.0		0.0	0.0	
Molybdenum	D-6595	PPM	81.0	42.7		75.7	22.6		71.2	19.0	
Titanium	D-6595	PPM	0.0	0.8		0.0	0.0		0.0	0.0	
Oil Condition											
Viscosity @ 40 ℃	D-445	cSt	171.5			162.8			159.4		
Viscosity @ 100 ℃	D-445	cSt	16.7 C			15.7			15.6		
Oxidation	FTIR	Abs	7.6			6.6			6.3		
Nitration	FTIR	Abs	7.9			7.3			6.8		
TAN	D-974	mg KOH/g									
TBN	D-4739	mg KOH/g	6.3			6.3			6.6		
Contamination											
Water	FTIR	% (Wt.)	0.109 C			0.054			0.033		
Fuel	SAW	% (Wt.)	1.90			2.10			2.20		
Glycol	FTIR	Abs	0			0			0		
Soot	FTIR	% (Wt.)	2.29 C			1.76			1.34		
Sodium	D-6595	PPM	10			8			6		
Silicon	D-6595	PPM	43.8 A	47.1 A		39.4 A	21.5 A		28.7 A	17.4 C	
Additive Element											
Boron	D-6595	PPM	1			1			1		
Magnesium	D-6595	PPM	17			16			14		
Calcium	D-6595	PPM	2977			3029			2869		
Barium	D-6595	PPM	1			12			5		
Phosphorus	D-6595	PPM	677			792			735		
Zinc	D-6595	PPM	845	605		862	339		877	282	
Additional Test											
Flash Point	D-3828	°C									
Viscosity Index	D-2270		103			99			99		
Other											

Alarm Limit Range

Limit Name (Equipment / Oil) :
Engine Diesel General SAE 40

	RDE fine U-Caution	RDE fine U-Action	RFS coarse U-Caution	RFS coarse U-Action
New Oil				
	>26	>40	>35	>55
	>1	>2	>2	>3
	>8	>13	>9	>15
	>15	>25	>20	>34
	>3	>6	>7	>12
	>4	>6	>6	>9
	>1	>2	>3	>4

	New Oil	L-Action	L-Caution	U-Caution	U-Action
	14.9	<12.7	<13.4	>18.4	>17.1
				>14	>19
				>11	>14
		<2	<3.8		

	New Oil	U-Caution	U-Action
		>0.1	>0.3
		>3	>5
		>2.1	>5.1

	RDE fine U-Caution	RDE fine U-Action	RFS coarse U-Caution	RFS coarse U-Action
	>15	>25	>15	>20

	New Oil	L-Action	L-Caution	U-Caution	U-Action

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or N : NORMAL , C or ■ : CAUTION (first level warning limit) , A or ■ : ACTION required (second level warning limit)
U-Caution : Upper CAUTION Level L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level L-Action : Lower ACTION required Level
First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level
Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-8 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 260 ถึง 310 (ต่อ)

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

	Current Sample	Previous Sample	
FocusLab ID	71922	71815	71814
Date sampled	12-Mar-07	11-Mar-07	09-Mar-07
Hours on Oil	100	75	50
Hours on Unit	310	285	260
Bottle ID	862013	862012	862011
Volume of Sample Used	0.10 ml	0.10 ml	0.10 ml

Ferrographic Analysis

Typical Normal Ferrogram

Image of Wear & Contaminant Magnification 40X

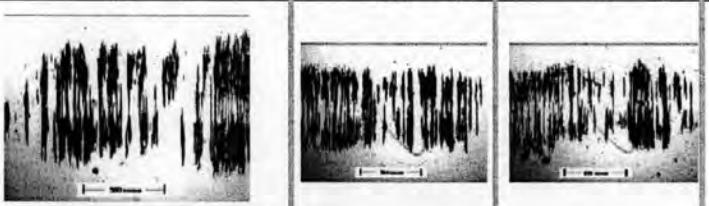


Image of Wear & Contaminant Magnification 100X

Image of Wear & Contaminant Magnification 400X

Wear & Contaminants Particles	%Rating	Size (Micron	Particle Type	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle
Normal Rubbing Wear	60	3-5	F	50	3-5	F	55	3-5	F			
Fatigue Wear	25	10-20	F	40	10-20	F	30	20-30	F			
Fatigue Sphere												
Sliding Wear												
Cutting Wear												
Black Oxides	5	5-10	F	5	5-10	F	10	5-20	F			
Red Oxides												
Corrosive Wear												
Dirt and Dust	10	20-50	C	5	10-20	C	5	10-20	C			

Recommendations and Notes

Majority of ferrous particles consist of the normal rubbing wear shape.
Fatigue particles found in the ferrogram may be an indication of the dirt related fatigue wear.
Black oxides noted in ferrogram.
Note the dirt particles detected in ferrogram.

%Rating : Percent area covered by wear debris particles or contaminant particles
Size : Size in micron (0.001 mm) unit of wear debris particles or contaminant particles
F : Ferrous Wear Particle, **N** : Non-ferrous Wear Particle, **C** : Contaminant Particle

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-9 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 310 ถึง 320

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909
Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

Recommendations and Notes

Dirt (silicon) is present and resulting in abrasive wear.
Recommend check to determine how dirt is entering the system and correct the problem to prevent further dirt entry.

AS / Andy Sitton

Condition History	Test Method	Result	Current Sample Wear	Current Sample Oil	Current Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.	Previous Sample Wear	Previous Sample Oil	Previous Sample Cont.
			■	C	■	■	C	■	C	N	C
FocusLab ID			71986			71922			71815		
Date sampled			13-Mar-07			12-Mar-07			11-Mar-07		
Hours on Oil			110			100			75		
Hours on Unit			320			310			285		
Bottle ID			862014			862013			862012		
Wear Condition											
Wear Element	Method	Unit	RDE fine	RFS coarse		RDE fine	RFS coarse		RDE fine	RFS coarse	
Iron	D-6595	PPM	166.0 A	135.1 A		154.6 A	185.7 A		119.4 A	74.3 A	
Chromium	D-6595	PPM	12.5 A	10.4 A		12.2 A	14.3 A		10.1 A	5.9 A	
Lead	D-6595	PPM	1.2	0.0		0.5	0.0		0.8	0.0	
Copper	D-6595	PPM	2.1	0.7		2.1	1.2		1.7	0.5	
Tin	D-6595	PPM	0.0	0.0		0.0	11.7 C		0.0	0.0	
Aluminum	D-6595	PPM	33.7 A	27.7 A		31.7 A	37.7 A		25.0 A	17.4 A	
Nickel	D-6595	PPM	3.0 A	0.0		2.6 A	1.2		1.7 C	0.0	
Silver	D-6595	PPM	0.0	0.0		0.0	0.0		0.0	0.0	
Molybdenum	D-6595	PPM	79.6	25.6		81.0	42.7		75.7	22.6	
Titanium	D-6595	PPM	0.0	0.0		0.0	0.8		0.0	0.0	
Oil Condition											
Viscosity @ 40 °C	D-445	cSt	170.3			171.5			162.8		
Viscosity @ 100 °C	D-445	cSt	16.7 C			16.7 C			15.7		
Oxidation	FTIR	Abs	8.5			7.6			6.6		
Nitration	FTIR	Abs	8.1			7.9			7.3		
TAN	D-974	mg KOH/g									
TBN	D-4739	mg KOH/g	6.1			6.3			6.3		
Contamination											
Water	FTIR	% (Wt.)	0.108			0.109 C			0.054		
Fuel	SAW	% (Wt.)	0.00			1.90			2.10		
Glycol	FTIR	Abs	0			0			0		
Soot	FTIR	% (Wt.)	2.02			2.29 C			1.76		
Sodium	D-6595	PPM	9			10			8		
Silicon	D-6595	PPM	46.6 A	33.2 A		43.8 A	47.1 A		39.4 A	21.5 A	
Additive Element											
Boron	D-6595	PPM	1			1			1		
Magnesium	D-6595	PPM	17			17			16		
Calcium	D-6595	PPM	2861			2977			3029		
Barium	D-6595	PPM	11			1			12		
Phosphorus	D-6595	PPM	745			677			792		
Zinc	D-6595	PPM	844	424		845	605		862	339	
Additional Test											
Flash Point	D-3828	°C									
Viscosity Index	D-2270		104			103			99		
Other											

Alarm Limit Range

Limit Name (Equipment / Oil) :
Engine Diesel General SAE 40

	RDE fine		RFS coarse	
New Oil	U-Caution	U-Action	U-Caution	U-Action
	>26	>40	>25	>56
	>1	>2	>2	>3
	>8	>13	>9	>15
	>16	>25	>20	>34
	>5	>6	>7	>12
	>4	>6	>6	>9
	>1	>2	>3	>4

New Oil	L-Action	L-Caution	U-Caution	U-Action
14.9	<12.7	<13.4	>16.4	>17.1
			>14	>19
			>11	>14
	<2	<2.8		

New Oil			U-Caution	U-Action
			>0.1	>0.3
			>3	>5
			>2.1	>5.1

	RDE fine		RFS coarse	
New Oil				
	>15	>25	>15	>20

New Oil	L-Action	L-Caution	U-Caution	U-Action

Note: Alarm Limits are variable and dependent upon dataset size and to be used as general guideline.
No Sign or (N) : NORMAL , C or C : CAUTION (first level warning limit) , A or ■ : ACTION required (second level warning limit)

U-Caution : Upper CAUTION Level L-Caution : Lower CAUTION Level
U-Action : Upper ACTION required Level L-Action : Lower ACTION required Level

First level warning limit in Upper level and/or Lower level
Second level warning limit in Upper level and/or Lower level

Accuracy of interpretation and recommendation are based on representatives sample and information supplied.
No warranty is expressed or implied for this report.

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 8600-3 Fax : (662) 361 8567
Email : focuslab@focuslab.co.th

รูปที่ จ-9 แสดงใบรายงานผลการทดสอบน้ำมันหล่อลื่นจากเครื่องยนต์ที่ใช้น้ำมันดีเซลทางเลือก ชั่วโมงการทำงานที่ 310 ถึง 320 (ต่อ)

FOCUS LABORATORIES LTD.

LubeCheck™ - Oil Analysis for Predictive Maintenance

Customer Code : 18004
Customer Name : ICE R&D LAB
Address : Faculty of Engineering
Chulalongkorn University
Bangkok

Test code : 804 904 909

Lube System Capacity : 2.8 Liters

Unit ID Number : RT 120 011663
Unit Type : Engine Diesel
Unit Make : KUBOTA
Unit Model : RT 120
Oil type / Viscosity : CHANG SAE40 API CF
Site Name : IK & Fuel Oil Project
Location : Dipstick

Overall Condition Rating

	Current Sample	Previous Sample	
FocusLab ID	71986	71922	71815
Date sampled	13-Mar-07	12-Mar-07	11-Mar-07
Hours on Oil	110	100	75
Hours on Unit	320	310	285
Bottle ID	862014	862013	862012
Volume of Sample Used	0.10 ml	0.10 ml	0.10 ml

Ferrographic Analysis

Typical Normal Ferrogram

Image of Wear & Contaminant Magnification 40X

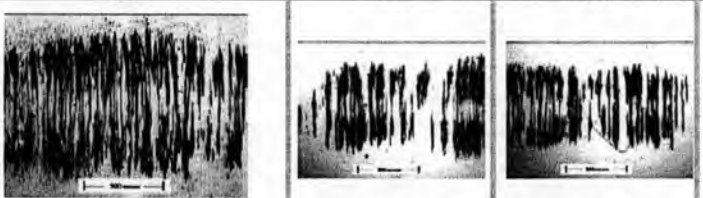


Image of Wear & Contaminant Magnification 100X

Image of Wear & Contaminant Magnification 400X

Wear & Contaminants Particles	%Rating	Size (Micron	Particle Type	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle	%Rating	Size (Micron	Particle
Normal Rubbing Wear	70	3-5	F	60	3-5	F	50	3-5	F			
Fatique Wear				25	10-20	F	40	10-20	F			
Fatique Sphere												
Sliding Wear												
Cutting Wear												
Black Oxides				5	5-10	F	5	5-10	F			
Red Oxides												
Corrosive Wear												
Dirt and Dust	20	50-75	C	10	20-50	C	5	10-20	C			
Copper	10	5-10	N									

Recommendations and Notes

Note the dirt particles detected in ferrogram.

%Rating : Percent area covered by wear debris particles or contaminant particles
Size : Size in micron (0.001 mm) unit of wear debris particles or contaminant particles
F : Ferrous Wear Particle, N : Non-ferrous Wear Particle, C : Contaminant Particle

9 Fl., Thosapol Land 4 Bldg., 947/39 Bangna-Trad Rd., KM.3, Bangna, Bangkok 10260, Thailand
http://www.focuslab.co.th
Tel : (662) 361 6600-3 Fax : (662) 361 6567
Email : focuslab@focuslab.co.th

ประวัติผู้เขียนวิทยานิพนธ์

นายสุวัช คำแฝด เกิดเมื่อวันที่ 4 เดือน กรกฎาคม พุทธศักราช 2524 ที่ โรงพยาบาลพระนั่งเกล้า จังหวัดนนทบุรี สำเร็จการศึกษาปริญญาวิศวกรรมศาสตร์บัณฑิต ภาควิชาวิศวกรรมเครื่องกล คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์ เมื่อปีการศึกษา 2545 เข้าศึกษาต่อในหลักสูตรวิศวกรรมศาสตร์มหาบัณฑิต ภาควิชาวิศวกรรมเครื่องกล คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย เมื่อปีการศึกษา 2546