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Reliability test methods for motor vehicle engines

汽车发动机可靠性试验方法

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Table of Contents

Reliability test methods for motor vehicle engines

1 Scope

This document specifies the general reliability test methods and reliability assessment methods for motor vehicle engine bench test.

This document applies to M and N category motor vehicle engines, which are reciprocating, rotary type, excluding free piston type.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the version corresponding to that date is applicable to this document; for undated references, the latest version (including all amendments) is applicable to this document.

GB/T 1883.1, Reciprocating internal combustion engines - Vocabulary - Part 1: Terms for engine design and operation

GB/T 15089, Classification of power-driven vehicles and trailers

GB/T 17754, Tribology terminology

GB/T 18297, Performance test code for road vehicle engines

3 Terms and definitions

For the purpose of this document, terms and definitions given in GB/T 15089, GB/T 1883.1, GB/T 17754 and GB/T 18297, as well as the following apply.

3.1

rated speed

The engine speed at rated power.

Note: The rated power is specified by the manufacturer, and the rated speed is generally lower than the maximum power speed under full load.

3.2

speed of maximum net torque

n_M

By GB/T 18297, the speed at which the engine with a full set of vehicle accessories outputs the maximum effective torque.

3.3

rated net power

By GB/T 18297, the corrected effective power output of the engine with a full set of vehicle accessories at rated speed and full load.

4 Test engine

The three test engines (numbered A, B, and C) shall comply with the product technical standards of the engine manufacturer.

5 General test requirements

The accuracy of the instruments used in the test, the measurement locations and the calculation of the test data shall be in accordance with the provisions of GB/T 18297.

6 Control of general test conditions

6.1 Air intake status

It is recommended to control the air intake temperature within the range of 25 ℃ ± 10 ℃.

6.2 Fuel

The fuel designation shall be in accordance with the regulations of the engine manufacturer. The gasoline temperature shall be controlled at 25 ℃ ± 5 ℃; the diesel temperature shall be controlled at 40 ℃ ± 5 ℃; the temperature of other fuels shall be controlled in accordance with the regulations of the engine manufacturer.

Fuel pressure shall be controlled in accordance with the engine manufacturer's regulations.

6.3 Engine oil

The engine oil designation shall be in accordance with the regulations of the engine manufacturer. The engine oil temperature shall not exceed the permissible temperature specified by the engine manufacturer, otherwise a forced cooling device shall be used.

6.4 Coolant

Use the coolant specified by the engine manufacturer. The coolant outlet temperature shall be controlled at 95 ℃ ± 3 ℃ or the temperature specified by the engine manufacturer; during the hot and cold shock test, the coolant temperature shall be controlled according to the provisions of Table 5.

7 Adjustment of engine accessories and systems during the test

7.1 Air intake system

Use a standard vehicle intake system or an equivalent laboratory intake system (under full speed and full load conditions, the resistance difference with the standard intake system is within ±5%). The intake temperature after intercooling of a supercharged intercooled engine shall meet the product technical standard requirements of the engine manufacturer, and the resistance of the intercooler or intercooler simulator under full speed and full load conditions of the engine shall be equivalent to that of the vehicle intercooler.

7.2 Exhaust system

Use a standard exhaust system installed on the vehicle or a laboratory exhaust system with equal resistance (under full speed and full load conditions, the back pressure difference with the standard exhaust system is within the range of ±2 kPa).

7.3 Cooling system

According to the technical requirements of the engine manufacturer, the maximum power fan for the vehicle is selected (for the clutch fan, the clutch shall be locked to achieve the effect of direct connection to the fan), and an external blower can be used to blow the engine. The vehicle cooling system components or other equivalent components shall be installed, and the cooling system pressure, radiator resistance and coolant flow value shall meet the product technical standards of the vehicle and engine manufacturer. The thermostat shall be set to the fully open position.

7.4 Ignition system

The ignition angular advance of the spark-ignition engine shall be in accordance with the regulations of the engine manufacturer.

7.5 Power generation system

The vehicle-mounted generator, voltage regulator and battery (if any, fully charged) etc. shall be installed and in working condition.

7.6 Accessory system

Test the net power (or total power), piston leakage and oil consumption in accordance with the provisions of GB/T 18297, and select test conditions in accordance with the provisions of the engine manufacturer.

8.4 Reliability test

Proceed as per Chapter 9.

8.5 Performance retest

Repeat 8.3.

8.6 Disassembly and inspection

Dismantle and inspect engine A, engine B and engine C:

a) Detect the attenuation of the tightening torque decrement of fasteners (such as bolts, nuts, etc.), that is, when the fasteners are re-tightened, the difference between the torque at which the fasteners start to rotate and the tightening torque before the test is the torque decrement;

b) Dismantle, inspect and analyze performance-related assembly parts according to the control requirements of the engine manufacturer;

c) Take local clear photos of the surface of the main friction pairs, which includes the journal, bearing, cylinder barrel (hole) (the reversal point of the upper and lower dead points of a ring), piston (skirt), piston ring, cam, tappet, rocker arm, valve, valve seat, etc.;

d) Take magnified photos of the overall appearance of the failed parts, the fracture surface and the cracks;

e) Take photos of the upper and lower surfaces of the piston top, the spark plug ceramic body and electrode, and the injector;

f) Take photos of the deposits, sludge and paint films on the oil pan, cover, cylinder head upper surface, piston and cam surfaces;

g) Take photos of leaking seals such as cylinder gaskets, intake and exhaust pipe gaskets, exhaust pipes and oil seals.

The parts referred to in e), f) and g) shall not be cleaned before taking photos, and instructions shall be provided under each photo.

8.7 Precision measurement after testing

Repeat 8.1.

10.2.1 Apply data acquisition and control system; set alarm or shutdown limit at each step; monitor the main monitoring parameters of the test throughout the whole process. The recommended value of alarm limit is ±5% of normal stable operation condition, and the recommended value of shutdown limit is ±10% of normal stable operation condition.

10.2.2 The alarm and shutdown functions shall be operational when the engine is running.

10.2.3 If an alarm or emergency shutdown occurs, handle and maintain it. If it is an engine failure, it will be counted as a failure shutdown. Record the operating time, cause and handling of the shutdown.

10.2.4 Monitor the abnormal noises from the engine's moving parts (such as the crank-connecting rod mechanism and valve mechanism, etc.) and take measures when necessary.

10.2.5 Record engine speed, torque, power, fuel consumption, oil pressure and temperature and other parameters in a timely manner every hour.

10.3 Inspection and maintenance every 20 h ~ 30 h

10.3.1 Check the engine for inward and outward oil, water and air leakage, such as cracks in the exhaust pipe, air leakage at the flange connection, oil emulsification and gas leakage into the cooling system caused by cylinder gasket seal failure, etc. Keep the engine and its surroundings clean so that leaks can be discovered in time.

10.3.2 Inspect the engine and test equipment, and check the fasteners, connectors and pipelines, especially hoses; check the belt tension.

10.3.3 Check all fluid levels and, if necessary, the engine oil consumption.

10.4 Regular inspection and maintenance (according to the time interval specified by the engine manufacturer)

10.4.1 Check the oil level of the engine oil. If necessary, take oil samples at the time interval specified by the engine manufacturer to measure the viscosity, percentage of insoluble matter, total acidity, total alkalinity, metal element content, grinding morphology, etc.

10.4.2 Measure valve clearance (if applicable) and determine whether to adjust according to the manufacturer's regulations.

10.4.3 Replace the spark plug; check the injector opening pressure, spray and dripping, etc.

10.4.4 Replace the engine oil and oil filter.

10.5 Replacing the air filter and fuel filter elements

Replace the air filter and fuel filter elements at the appropriate time according to the engine manufacturer's regulations.

10.6 Reliability test final inspection

Take an oil sample and measure the oil consumption, cylinder compression pressure, valve clearance (if applicable) and valve depression (the routine inspection and final inspection can be performed together when the time is close).

11 Test result evaluation

11.1 Running time

Based on the actual engine operation duration (h), the parts replaced during operation and their time (h), carry out assessment in accordance with A.1.1.

11.2 Performance stability

11.2.1 Compare the performance curves and main parameters of the initial test (according to 8.3) and the retest (according to 8.5). Evaluate according to the limits of A.1.3, A.1.4 and A.1.5.

11.2.2 Draw the relationship curve between the corrected maximum net torque, corrected maximum net power, rated net power and running duration (h) recorded in 10.2 during the reliability test, and analyze the performance change trend of the reliability test.

11.3 Damage to parts

Record the operating time (h) and maintenance operation conditions of fault shutdown, loose fasteners, seal failure, rubber aging, blockage, deformation, cracks, fractures, and component damage; provide photos of damaged parts, cracks, fractures, and leakage marks; use precise measurement data to analyze deformation. The evaluation of components shall be carried out according to A.2.

11.4 Wear of components

11.4.1 Based on the analysis results of the engine oil sample, determine the wear of components and the quality of the engine oil.

11.4.2 Organize the precise measurement data, and determine the wear amount of the main friction pair in 8.6c).

11.4.3 Distinguish the forms of wear on components; determine the severity of wear; provide photos of wear; make assessments according to A.2.3.

11.4.4 Describe the contact conditions of the friction pair surfaces and provide photos; evaluate according to A.2.4.

11.5 Deposits on the surface of parts

Describe the status of the deposits on the surface of the parts and provide photos; evaluate according to A.2.5.

12 Test report

The test report shall at least include the following contents.

a) Introduction: Explain the origin of the test task.

b) Purpose.

c) Test object: The technical parameters of the test engine shall be filled in according to the contents of the "Main parameters table of ignition engine" or "Main parameters table of compression ignition engine" in GB/T 18297, and attached with graphics, photos and necessary explanations.

d) Test equipment and instruments: The name, manufacturer, model, accuracy, calibration date and measuring location of the main equipment and instruments shall be stated.

e) Test conditions, accessories of the test engine, adjustment and test procedures of each system: indicating the test standard and its number, and explaining any differences from the standard.

f) Test results: Process the original test data and express them with curves as far as possible; tabulate important data; compile according to the requirements of Chapter 11.

g) Conclusion: Based on the test results and the evaluation method in Appendix A, make a pass or fail conclusion on the reliability of the engine; for engines that fail, suggestions for improvement and additional testing shall be made. Pass conditions:

1) Whole machine: If the requirements are met according to A.1 and there is no damage (crack or breakage) to the parts related to the engine's safety, regulations, environmental protection, etc., then the whole machine is judged to have passed; otherwise, it is judged to have failed;

2) Parts: Evaluate with reference to the provisions of A.2. Those that meet the requirements of Category A and Category B in Table A.1 ~ Table A.5 are considered to have passed; those that meet the requirements of Category D in Table A.1 ~ Table A.5 are considered to have failed; those that meet the

Appendix A

(Normative)

Reliability assessment methods for motor vehicle engines

A.1 Whole machine assessment

A.1.1 In order to provide a consistent assessment basis for engine reliability, a small number of parts may be replaced without major structural damage, and the assessment shall be conducted only when the operating duration (h) reaches the requirements of Table 1. If the replaced parts do not reach the designed life during the test, the reliability of the parts is unqualified.

A.1.2 The engine shall not leak oil or water inward or outward; air shall not penetrate into the engine negative pressure system; there shall be no gas in the engine that leaks into the oil or water channels, or oil and water mixing, etc.

A.1.3 During operation, the decrease in the corrected maximum net torque, corrected maximum net power and rated net power shall not exceed 5% of the initial value.

A.1.4 The oil/fuel consumption ratio at rated speed and full load shall not exceed 0.2%.

A.1.5 The maximum piston leakage (B_{max}) of a four-stroke engine at full load shall not exceed the limit (B_L). The leakage limit is calculated according to Formula (A.1):

$$B_L = CV_t = CV_H \times \left(\frac{n_r}{2}\right) \times r_r \times \left(\frac{298}{273 + T_m}\right) \quad \cdots\cdots\cdots\cdots\cdots\cdots (A.1)$$

Where:

C – coefficient (0.8% for compression ignition engine and 0.6% for spark ignition engine);

V_t – the theoretical intake volume of a four-stroke engine at rated speed under standard conditions, in liters per minute (L/min), i.e., the charging coefficient = 1;

V_H – engine displacement, in liters (L);

n_r – rated speed, in revolutions per minute (r/min);

r_r – pressure ratio of the booster at rated speed and full load, that is, the ratio of the compressor outlet absolute pressure P_0 to the compressor inlet absolute pressure P_i ($r_r=P_0/P_i$), for non-boosted compressors, $r_r=1$;

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