Guideline No.M-12(202607)

M-12

GOVERNOR

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Foreword

China Classification Society (hereinafter referred to as CCS) Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at http://www.ccs.org.cn. Your comments or suggestions are welcomed and may be sent to our email addressed service@ccs.org.cn .

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Main changes:

This version has been revised from the original guide as follows:

a) Revised definitions of speed control system and steady-state speed regulation rate;

b) Removed definitions related to transient process of speed regulation, rated power, rated speed, rated operating condition, maximum instantaneous speed, no-load speed, minimum instantaneous speed, and speed under partial load;

c) Revised test classification, measurement of speed fluctuation rate, and method for sudden load application test;

d) Removed unit/batch inspection.

CONTENTS

1 Application 4

2 Basis for approval and inspection 4

3 Terms and definitions 4

4 Plans and documents 7

5 Materials and components 8

6 Technical requirements 8

7 Type test 11

8 Unit/batch inspection 17

GOVERNOR

1 Application

This Guideline applies to the approval and inspection of hydraulic, electronic and electro-hydraulic governors for marine diesel engines and may be provided as a reference for other types of governors such as the injection pump assembly equipped with a mechanical governor and electronic injection device with a speed governing function.

2 Basis for approval and inspection

2.1 CCS Rules for Classification of Sea-Going Steel Ships

2.2 CCS Guideline on Type Approval Test of Electric and Electronic Products

3 Terms and definitions

3.1 For definitions of product inspection, design approval, type approval, prototype test, sample, unit/batch inspection and final inspection, refer to Article 3.1.2, Chapter 3, Part One of *Sea-going Rules*.

3.2 For the purpose of this Guideline, the following definitions apply:

(1) Speed governing system: A device that can automatically adjust the fuel supply according to the load changes to maintain the stable speed of the diesel engine. The speed regulation system mainly consists of sensors, speed regulation controllers, speed regulation actuators and regulating mechanisms, etc.

(2) Speed stability bandwidth υ: the ratio of the difference between the maximum speed n_1 and the minimum speed n_2 measured within a certain time interval (not less than 1 min) to twice the rated speed n_r when the diesel engine operates under the invariable load working condition, which is represented in percentage and calculated by Eq. (1).

$$\upsilon = \frac{n_1 - n_2}{2n_r} \times 100\% \quad \text{..... (1)}$$

Where:

n_1 — measured maximum speed, in rotation per minute (r/min)

n_2 — measured minimum speed, in rotation per minute (r/min)

n_r — rated speed, in rotation per minute (r/min)

(3) Steady state speed regulation δ_{st}: After the diesel engine speed control system is set at the rated operating condition, when the load changes from the rated load to no load or from no load to the rated load (either in one step or in segments), the percentage of the difference between the stable no-load speed and the rated speed to the rated speed is calculated according to formulas (2) and (3).

① Unloading of rated load under the rated working condition:

$$\delta_{st} = \frac{n_i - n_r}{n_r} \times 100\% \quad \text{..... (2)}$$

② Loading of rated load under the no-load condition(either in one step or in segments):

$$\delta_{st} = \frac{n'_r - n_i}{n_r} \times 100\% \quad \text{..... (3)}$$

Where:

n_i — steady no-load speed, in rotation per minute (r/min)

n_r — rated speed, in rotation per minute (r/min)

n_r' — steady speed after loading of rated load, in rotation per minute (r/min)

(4) Transient speed regulation δd: After the diesel engine has been set to a steady-state speed regulation rate, the maximum or minimum speed difference between the speed after a sudden unloading or loading (either in one go or in stages) of the specified load and the stable speed before the load change, as a percentage of the rated speed, is calculated according to formulas (4) to (6).

① Instant unloading of rated load under the rated working condition:

$$\delta_d = \frac{n_{max} - n_r}{n_r} \times 100\% \quad \text{..... (4)}$$

② Instant loading of part load under the no-load condition:

$$\delta_d = \frac{n'_{min} - n_r}{n_r} \times 100\% \quad \text{..... (5)}$$

③ Instant loading of rated load under the part-load condition:

$$\delta_d = \frac{n_{min} - n_L}{n_r} \times 100\% \quad \text{..... (6)}$$

(5) Steady state: After the load changes, the variation in speed eventually falls within the specified speed fluctuation rate υ range. The speed control system remains within this range at all times.

(6) Steady speed: the average speed (r/min) measured within a certain time interval (not less than 1 min) when the speed fluctuates within the specified range of speed stability bandwidth υ in case that the diesel engine is under the invariable load condition.

(7) Speed recovery time τ: the time from instant load and speed changes to speed entry into and stay within the range of permissible speed stability bandwidth α which is calculated by Eq. (7).

$$\alpha = \frac{n'_1 - n'_2}{2n_r} \times 100\% \quad \text{..... (7)}$$

Where:

n'_1 — maximum speed corresponding to permissible speed stability bandwidth α, in rotation per minute (r/min)

n'_2 — minimum speed corresponding to permissible speed stability bandwidth α, in rotation per minute (r/min)

(8) Speed governing characteristic curve: Curve 3 obtained by connecting the arithmetic mean values of two speeds corresponding to a certain power on Curve 1 obtained by fixing the governor control handle (or knob) and slowly reducing the load and on Curve 2 obtained by slowly increasing the load afterwards under the rated working condition at different power levels. (3.2(8)).

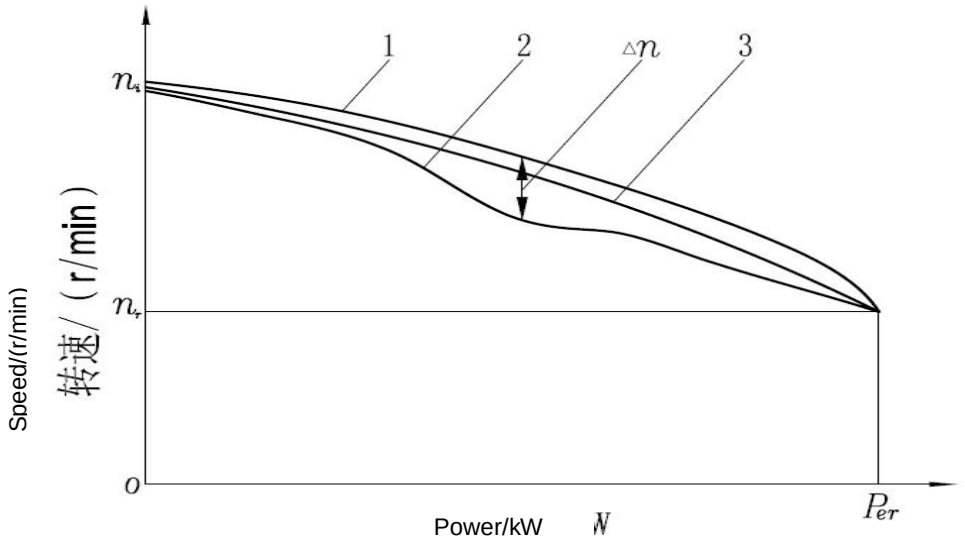

Fig. 3.2(8) Speed governing characteristic curve

(9) Non-sensitivity of speed governing system ε: the ratio of the maximum speed difference Δn absolute value between curve 1 and curve 2 (as shown in Fig. 3.2(8)) to the rated speed nr under a certain power condition, which is represented in percentage and calculated by Eq. (8).

$$\varepsilon = \left| \frac{\triangle n}{n_r} \right| \times 100\% \quad \text{..... (8)}$$

(10) Non-linearity γ of speed governing characteristic curve: the absolute value of the ratio of the maximum speed deviation between the speed governing characteristic curve and the ideal straight line (5) (as shown in Fig. 3.2(10)) to the rated speed nr, which is represented in percentage and calculated by Eq. (9).

$$\left| \frac{n_3 (n_4) - n_i \quad) - n_i}{n_r} \right| \times 100\% \text{..... (9)}$$

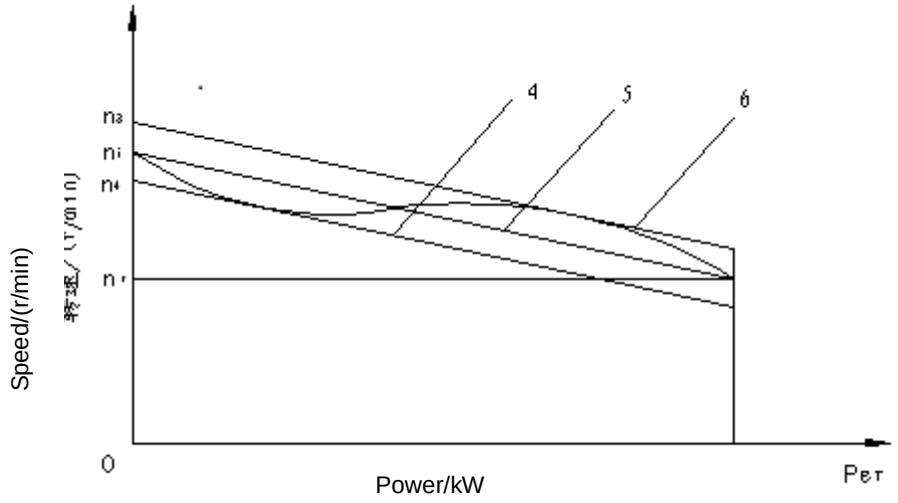

Fig. 3.2(10) Non-linearity of speed governing characteristic curve

The ideal straight line 5 is obtained by connecting two end points (0, n_i) and (P_{er}, n_r) of speed governing characteristic curve. Straight lines 4 and 6 (as shown in Fig. 3) parallel to the ideal straight line 5 and tangent to the speed governing characteristic curve are intersected with the axis n at n_4 and n_3. The maximum deviation is the larger of the differences between n_3/n_4 and n_i.

(11) Difference of load sharing θ When diesel main engines or diesel generator sets operate in parallel, the difference between the load rate of a single unit and the total load rate is taken as the absolute value and expressed as a percentage. It is calculated according to formula (10).

$$\theta = \left| \frac{P_i}{P_{ri}} - \frac{\sum P_i}{\sum P_{ri}} \right| \times 100\% \text{ ..... (10)}$$

Where：

P_i — actual load of the ith set, in kilowatt (kW);

P_{ri} — rated power of the ith set, in kilowatt (kW);

$\sum P_i$ — actual total load at parallel operation for sets, in kilowatt (kW);

$\sum P_{ri}$ — total rated power at parallel operation for sets, in kilowatt (kW)

4 Plans and documents

4.1 The following plans and technical documents are to be submitted to CCS for approval at the time of approval application:

(1) Main product performance specification table; (speed range, working oil pressure, output shaft torque and angle, operating voltage, other electrical parameters, etc.)

(2) Assembly plan or (and) schematic diagram;

(3) Plans of important parts and components;

(4) Type test program.

4.2 The following plans and technical documents are to be submitted to CCS for information at the time of approval application:

(1) Instructions on product use;

(2) Samples of product nameplate, certificate of inspection, etc.

4.3 In addition to the above plans and documents, the following documents are to be submitted by the manufacturer:

(1) Related factory profile (including factory history and current situation) and product production history descriptions which may be attached with the related report and certificate if the product has been subject to special verification or appraisal;

(2) Quality control plan which is to be established for the product within the approved range and submitted to CCS for examination by the manufacturer and is to specify the quality assurance and control methods during product manufacturing in accordance with the technical requirements or standards of the product, include the approved inspection plan and particularly reflect the inspection and test requirements required in the CCS Rules.

5 Materials and components

5.1 The parts that may have a great influence on the performance and reliability of the governor such as spring, flyweight, various matching parts, etc. are to be considered as important.

5.2 The controller and actuator of the electronic governor are to be considered as important.

6 Technical requirements

6.1 The accuracy class and applicable scope of marine diesel engine speed regulation systems are listed in Table 6.1. Special requirements exceeding Class 1 accuracy shall be agreed upon by both suppliers and buyers. If any individual parameter exceeds Class 1 accuracy, the remaining parameters shall comply with Class 1 accuracy specifications.

Precision Grades of Diesel Engine Speed Control Systems **Table 6.1**

Accuracy class	Scope of application
1	Power generation units requiring the highest precision in stable frequency and voltage output
2	Power generation units requiring high-precision stable frequency and voltage output
3	A diesel engine for electric propulsion or multi-unit single propeller systems requiring generator sets with general accuracy, stable frequency, and voltage for parallel operation
4	General direct-drive diesel engine and other applications of diesel engines

6.2 When a diesel engine or diesel generator set experiences sudden load shedding or sudden load addition (single or staged), the instantaneous speed regulation rate δd, steady-state speed regulation rate δst, and speed stabilization time τ must not exceed the values specified in Table 6.2.

Speed Regulation Performance Indicators **Table 6.2**

<table>
<tr><th rowspan="3">Accuracy class</th><th colspan="3">Variation in load</th></tr>
<tr><th>Sudden or gradual discharge: 100% → 0; Sudden or gradual addition: 0 → 100%</th><th colspan="2">Sudden rupture
Segmental abrupt onset</th></tr>
<tr><th>δst/%</th><th>δd/%</th><th>τ/s</th></tr>
<tr><td>1</td><td>2</td><td>5</td><td>2</td></tr>
<tr><td>2</td><td>3</td><td>7</td><td>3</td></tr>
<tr><td>3</td><td>5</td><td>10</td><td>5</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">10</td><td>High-speed machine: 12</td><td>—</td></tr>
<tr><td>Medium-low speed machine: 15</td><td>—</td></tr>
<tr><td colspan="4">For diesel generator sets operating in parallel, the governor must incorporate a mechanism capable of adjusting the steady-state regulation rate, with the values set to be essentially equal. These values are determined through testing by the original equipment manufacturer (OEM) of the generator sets.
Note: When measuring the speed stabilization time τ, a larger value of τ is adopted under segmented sudden acceleration conditions.</td></tr>
</table>

6.3 The rotational speed fluctuation rate υ of the speed regulation system shall not exceed the values specified in Table 3.

Speed Fluctuation Rate **Table 6.3**

Diesel engine operating conditions			**Accuracy class**			
			1	**2**	**3**	**4**
			υ/%			
Diesel engine	RPM Ratio Between No-Load Operation Speed and Rated Speed	≤50%	—	—	1.5	2.5
		>50%	—	—	1.0	2.0
	The ratio of corresponding speed to rated speed when operating according to propulsion characteristics	≤50%	—	—	1.0	2.0
		>50%	—	—	0.7	1.5
Diesel generator sets operate at rated speed		Various loads	0.25	0.4	0.5	—

6.4 The non-sensitivity ε of the speed regulation system shall not exceed the values specified in Table 6.4.

Insensitivity of Speed Control System **Table 6.4**

Accuracy class	**1**	**2**	**3**	**4**
ε/%	0.25	0.35	0.50	—

6.5 For diesel main engines and diesel generator sets operating in parallel, the curvature direction of their speed control system characteristic curves must be consistent, and the non-linearity (γ) of the speed control characteristic curves shall not exceed the limits specified in Table 6.5.

Non-linearity of Speed Control System **Table 6.5**

Accuracy class	**1**	**2**	**3**	**4**
γ/%	0.15δst	0.15δst	0.20δst (Hydraulic Speed Control System) 0.30δst (Mechanical speed control system)	—
Note: The δst in the table represents the actual steady-state modulation rate.				

6.6 For diesel main engines and diesel generator sets operating in parallel, the load distribution difference θ shall not exceed 15%.

6.7 AC generator sets operating in parallel must be equipped with a remote speed control mechanism for synchronous operation and active load distribution/transfer control. The adjustment rate shall operate within the rated speed range of ±0.2% to 1.0% per second, with a speed adjustment range of no less than ±10% of the rated speed. The system shall include a manual-automatic switching device.

6.8 Diesel engines with an output power of no less than 220 kW shall be equipped with independent overspeed protection devices to prevent the maximum rotational speed of the diesel engine from exceeding 120% of the rated speed or the maximum rotational speed of the diesel generator set from exceeding 115% of the rated speed.

7 Type test

7.1 In case of one of the following conditions, the type test is to be carried out:

(1) First approval;

(2) New design or major improvement of governor;

(3) Request by the Surveyor at the time of certificate renewal approval.

7.2 Principles for selection of typical sample:

(1) Respective selection of samples of different types of governors, e.g. hydraulic and electronic governors;

(2) Respective selection of samples of governors for common directly-driven main engines and generator sets;

(3) Selection of one or two types of products as samples for governors with different operating capabilities in the same series.

7.3 Test equipment, apparatus and instrument

The priority is to be given to the type test of the governor together with the matched diesel engine. With the consent of the Surveyor, the type test may be simulated on a special test bench or by matching the governor with other diesel engines. The test bench is to have the capability of measuring the transient speed stability bandwidth, e.g. oscilloscope, etc. The equipment, apparatus and instrument required for the test are to be qualified through calibration, and their precision grade and measurement range are to meet the test requirements.

7.4 Type test of the governor for the main diesel engine

7.4.1 Steady state characteristic test

When the diesel engine is operating under the rated condition and with the throttle fixed, gradually reduce the load slowly, so that the power of the diesel engine decreases from the rated value to zero; then slowly increase the load, so that the power of the diesel engine increases from zero to the rated value. Measure the stable speed and corresponding power before and after the load change. Record the measurement results and draw the speed regulation characteristic curve as shown in Figure 7.4.1; calculate the steady-state regulation rate and the non-linearity of the speed regulation characteristic curve and the sluggishness of the speed regulation system (parallel main engine).

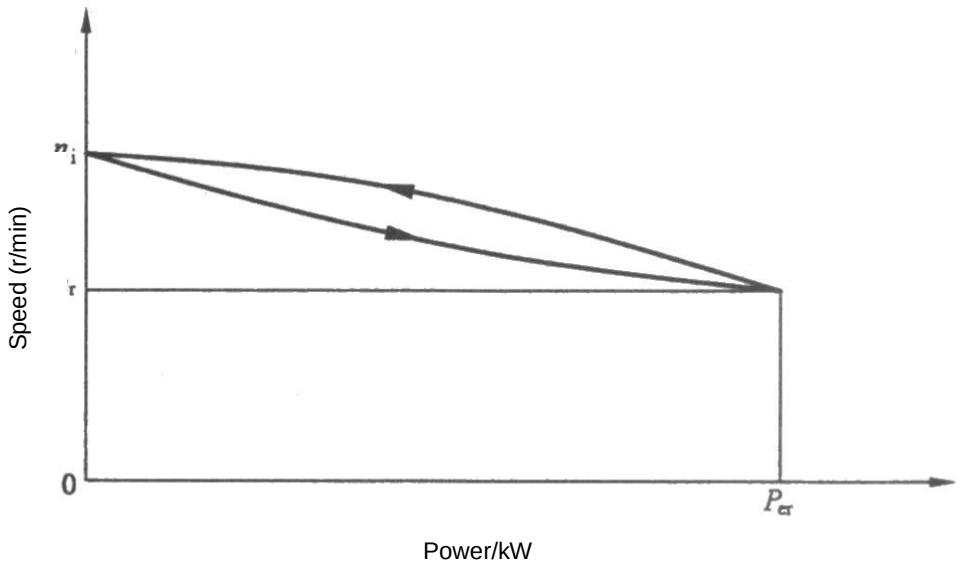

Fig. 7.4.1 Schematic plan diagram of speed governing characteristic curve

7.4.2 Speed stability bandwidth measurement and test

Measure the following items when the diesel engine is under the stable working condition:

(1) Speed stability bandwidth at loads equal to 100%, 75%, 50%, and 25% of rated value and at no-load steady speed according to the propulsion characteristic;

(2) Speed stability bandwidth under the no-load condition and at speeds equal to 100%, 80% and 50% of rated value.

7.4.3 Dynamic characteristic test

Conduct instant unloading of rated load and measure the followings items when the diesel engine is under the rated working condition:

(1) Speed before instant unloading;

(2) Power before instant unloading;

(3) Maximum transient speed at the time of instant unloading;

(4) Speed after instant unloading;

(5) Speed recovery time.

Two methods for instant unloading:

(1) Load consumption system - Cut off the load power supply

(2) Hydraulic dynamometer — A quick-closing valve (such as a butterfly valve or ball valve) should be installed, Close the inlet value as soon as possible and sufficiently open the outlet valve.

7.4.4 Test of overspeed protection device

The diesel engine is equipped with an overspeed protection device. This test should be conducted. During the test, the rotational speed of the diesel engine should not exceed 120% of the rated value. It should meet the requirements in all three consecutive tests.

7.5 Type test of the governor for a single diesel generator set

7.5.1 Inspection and test of adjustable range of steady state speed regulation

Adjust the steady state speed regulation regulating mechanism of the governor to change and test the steady state speed regulation so as to check its adjustable range within which the set is to operate stably.

7.5.2 Steady state characteristic test

When the diesel engine is under the rated working condition, fix at a given rotational speed and take two points within the range of steady state speed regulation for testing. Slowly reduce the

load to decrease the electric power from the rated value to zero; then slowly increase the load to improve the electric power from zero to the rated value (slowly change the load in a single direction). Measure the steady speeds and corresponding powers before and after load changes.

Record the measured results and draw the curve as shown in Fig. 7.4.1; obtain the steady state speed regulation, non-linearity of speed governing characteristic curve and non-sensitivity of speed governing system.

7.5.3 Speed stability bandwidth measurement and test

Adjust the speed to the rated value and measure the speed stability bandwidth under the loads equal to 100%, 75%, 50% and 25% of rated electric power and under the no-load condition (which is allowed to be conducted together with the speed governing characteristic test).

7.5.4 Dynamic characteristic test

Mainly measure the following items for these tests:

(1) Speed before instant unloading;

(2) Electric power before instant unloading;

(3) Maximum transient speed at the time of instant unloading;

(4) Speed after instant unloading;

(5) Electric power after instant loading;

(6) Minimum transient speed at the time of instant loading;

(7) Speed recovery time.

7.5.5 When the diesel generator set is under the rated working condition, conduct instant unloading of rated load and perform instant loading after recovery. Continuously repeat such operation for three times and take their average value as the test result.

7.5.6 Methods for instant loading:

(1) The supercharged diesel engine is to be loaded step by step in two phases: first 0→50% and then 50%→100% after recovery. The highly supercharged four-stroke diesel engine may be loaded in more than two phases (as per the methods in Fig. 7.5.6(1)).

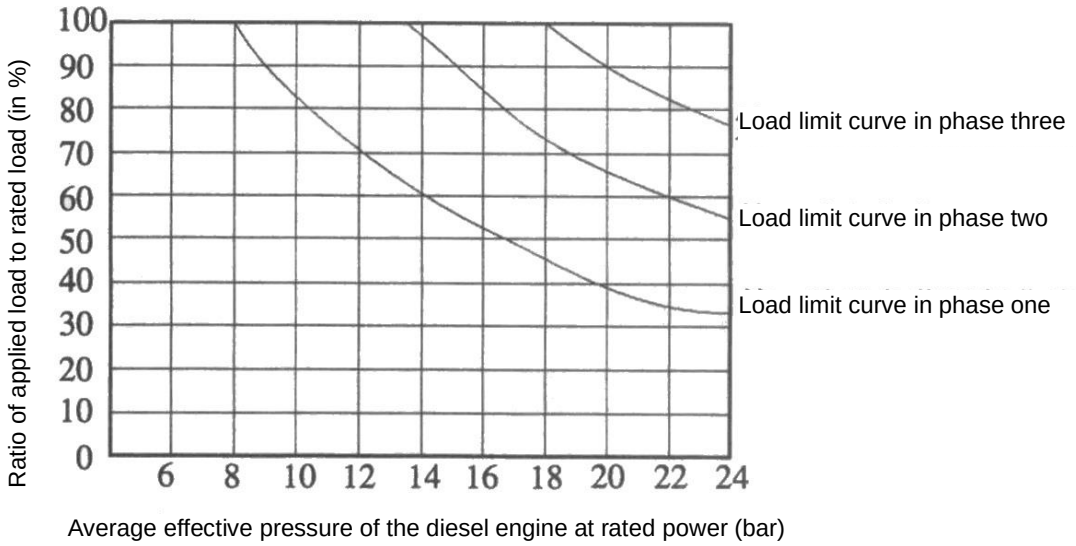

Fig. 7.5.6(1) Loading methods for the speed governing test of the highly supercharged four-stroke diesel engine

(2) The first instant load on the emergency diesel generator set is not to be less than the specified total emergency load.

7.5.7 Inspection and test of the speed remote control mechanism

(1) Sensitivity test: When the diesel generator set is in operation, press the speed remote control button or rotate the remote control knob and observe whether the accelerator and reducer operate normally and whether the diesel engine speed varies uniformly.

(2) Speed regulation measurement and test: When the diesel generator set is in operation, measure the time required for each speed variation by 10% of rated value according to the reading on the tachometer.

7.5.8 Test of overspeed protection device

The diesel engine is equipped with an overspeed protection device. The test should be conducted under no-load conditions. When the engine speed reaches 112% to 115% of the rated speed (not exceeding 115%), the overspeed protection device should act quickly and stop the engine. The speed at which the engine stops should not exceed 115% of the rated speed. This should be successful for three consecutive times.

7.6 Type test of governors for diesel generator sets operating in parallel

The type test of governors for diesel generator sets operating in parallel may be conducted only according to the items in 7.5. The parallel operation test may be performed by reference to the following items when it is necessary in the opinion of the Surveyor or user.

The automatic frequency and load adjuster is not to be used for this test.

7.6.1 Parallel operation inspection and test:

(1) Adjust the steady state speed regulation of each set to be basically the same, load the set in trail operation to 75% ~ 100% of rated electric power and then adjust the speed of the paralleled set to put it into parallel operation.

(2) Transfer the load of the operating set to the paralleled set and then to the original operating set, and observe the load operation stability.

7.6.2 Load sharing and its stability test at parallel operation for sets

(1) Adjust the electric powers of two sets ready for parallel operation to 75% of rated power respectively. Keep the given speed invariable by using the power factor of 0.8 as a reference point, slowly change the total load in a single direction as per the procedure of 75%→100%→75% →50%→20%→50%→75%, measure the parameters of each set, record them and calculate the difference of load sharing at parallel operation for sets.

(2) Continuously operate the set for 1 h under the total load equal to 90% of rated electric power, record the data once every 15 min and check the load sharing stability at parallel operation for sets.

7.6.3 Dynamic stability test

After putting the set into parallel operation, instantly load 30% of the rated electric power of a single set under such an working condition that the total load is equal to 25%~50% of rated electric power and check the dynamic stability at parallel operation for sets.

7.7 In addition to the above performance tests, the following basic tests are to be performed as per the relevant requirements of *Guideline on Type Approval Test of Electrical and Electronic Equipment of CCS* at the time of type test of the electrical parts for electronic and electro-hydraulic governors:

(1) Insulation resistance measurement;

(2) Power supply variation test;

(3) Power supply failure test;

(4) Inclination and swaying test;

(5) Vibration test;

(6) Dry heat test;

(7) Low temperature test;

(8) Electromagnetic compatibility test;

(9) Cyclic damp heat test;

(10) Steady damp heat test;

(11) Voltage withstanding test;

(12) Enclosure protection test.

7.8 In addition to the above speed governing performance tests, the following tests are to be performed where applicable:

(1) Local and remote control test;

(2) Emergency stop efficiency test;

(3) Maximum power piston stroke or output shaft angle inspection;

(4) Working oil pressure stability inspection;

(5) Inspection of working oil pressure at the minimum operating speed;

(6) Inspection of adjustable range of steady state speed regulation;

(7) Tightness test;

(8) Cleanness inspection;

(9) Other tests.

8 Unit/batch inspection

Not applicable.