# M-11

# MARINE DIESEL ENGINE FUEL INJECTOR

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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:

Deleted the requirements for 5.4.2 non-destructive testing

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# MARINE DIESEL ENGINE FUEL INJECTOR

## 1 Application

This Guideline applies to the type approval and product inspection of the high pressure fuel injector assembly of diesel engine.

## 2 Basis for approval and inspection

2.1 CCS Rules for Classification of Sea-Going Steel Ships

2.2 CCS Rules for Materials and Welding

2.3 Technical Specifications Established by the Low-Speed Diesel Engine Patent Awarded Factory and Approved by CCS

## 3 Terms and definitions

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 Rules*.

## 4 Plans and documents

When applying for the approval or inspection of marine high-pressure fuel injector, the applicant is to submit the following plans and technical documents to CCS for approval and information.

4.1 The following plans and documents are to be submitted for approval:

4.1.1 General plans (longitudinal and transverse section plans);

4.1.2 Plans of main parts and components (injector housing, needle valve assembly, etc. which may be properly added or deleted as the case may be);

4.1.3 Main performance specification table;

4.1.4 List of physicochemical properties of main parts and components;

4.1.5 Technical conditions for inspection and delivery, factory test program and type test program.

4.2 The following plans and documents are to be submitted for information:

4.2.1 Product Operation Instructions and nameplate, certificate of inspection / warranty certificate (templates), etc. (Chinese-English bilingual edition);

4.2.2 Nondestructive test standard (including UT, MT and PT);

4.2.3 Pressure test standard.

**5 Design and technical requirements**

5.1 Material requirements

5.1.1 The fuel injector housing is to be made of forgings or castings. Forgings are to be in accordance with the provisions of Chapter 5, Part One of *CCS Rules for Materials and Welding*, and castings are to be in accordance with the provisions of Chapter 7, Part One of *CCS Rules for Materials and Welding*.

5.1.2 The needle valve assembly is to be made of steels meeting the technical requirements of relevant standards on properties.

5.1.3 When the fuel injector is produced according to the technical specifications established by the diesel engine patent awarded factory, the chemical compositions of the materials of main parts and the mechanical properties after heat treatment are to be in accordance with the provisions of the above-mentioned technical specifications.

5.1.4 The raw materials and the casting and forging blanks are to be purchased generally from the manufacturer approved by CCS.

5.2 Structural requirements

5.2.1 The type-approved fuel injector assembly and its main parts are to be interchangeable.

5.2.2 The size of the interface between the fuel injector and the diesel engine high-pressure fuel pipe assembly or the fuel injection pump assembly is to be as agreed upon between the purchaser and the supplier.

5.3 Requirements on working accuracy

5.3.1 The main dimensional and geometric tolerances of the needle valve assembly are to comply with the requirements of relevant technical standards.

5.3.2 The main surface roughness of the needle valve assembly is to comply with the requirements of relevant technical standards.

5.3.3 In case of any discrepancy on the surface roughness series between the supplier and the designer, the supplier is to comply with the design requirements comparable to those provided in the product plan.

5.4 Nondestructive test

5.4.1 The needle valve and the needle valve body are to be subjected to a magnetic particle test.

~~5.4.2 The pressure-adjusting spring of fuel injector is to be subjected to a nondestructive test~~

5.5 Heat treatment

5.5.1 The heat treatment of fuel injector housing is to comply with the requirements of Chapters 5 and 7, Part One of CCS Rules for Materials and Welding.

5.5.2 The mechanical properties and surface hardness of the needle valve assembly after heat treatment are to comply with the requirements of relevant technical standards.

5.5.3 The internal metallographic structure and case depth of the needle valve assembly after heat treatment are to comply with the requirements of relevant technical standards.

5.6 Pressure test and tightness test

5.6.1 The diametral part and the sealed cone of needle valve assembly are to be subjected to a tightness test.

5.6.2 The high-pressure sealed part of fuel injector is to be subjected to a tightness test.

5.6.3 The cooling channel of cooled fuel injector is to be subjected to a tightness test.

5.6.4 The high-pressure face of fuel injector housing is to be subjected to a pressure test at a test pressure of 1.5 P or P+30 MPa, whichever is the less (P means the maximum working pressure of the tested part). When the fuel injector is produced according to the technical specifications established by the diesel engine patent awarded factory, the pressure test of the pressure face of high pressure fuel pump housing is to be conducted in accordance with such technical specifications.

5.7 Performance requirements

5.7.1 When the light diesel oil and heavy fuel oil with a kinematic viscosity of lower than 380 $mm^2/s$ at 50 ℃ are used, the fuel injector is to function properly. If heavy fuel oil is used, the inlet temperature is to be 130 ℃ ~ 150 ℃.

(1) The valve opening pressure is to be as agreed upon between the purchaser and the supplier; for high and medium speed diesel engines, the valve opening pressure deviation of the same diesel engine is not to be more than ±0.5 MPa.

(2) The flow deviation of the injector nozzle assembly is to be not more than ±7.5%.

(3) The fuel injector is allowed to be grouped by flow, but the flow deviation of each group is not to be more than ± 3%. in case of grouping by flow, the fuel injector of the same flow group is to be provided by the supplier for the same diesel engine.

The flow deviation ratio δ is to be calculated by Formula (1):

$$\delta = \frac{Q_{max}\ (\text{or}\ Q_{min}) - Q_b}{Q_b} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Where:

$\delta$ — percentage of flow deviation (%);

$Q_{max}$— maximum flow in the samples (or in the same group), in mL;

$Q_{min}$— minimum flow in the samples (or in the same group), in mL;

$Q_b$— average flow in the samples (or in the same group), in mL;

5.8 Reliability

The reliability of the fuel injector is to be as agreed upon between the purchaser and the supplier.

**6 Materials and components**

6.1 The materials and components of the product are to be controlled according to relevant requirements of the CCS Rules currently in effect.

6.2 The main parts of the fuel injector assembly are to include injector housing, needle valve assembly, etc.

**7 Type test**

7.1 Selection of typical samples

Generally, one prototype of each series of fuel injector is to be selected for type test for the first approval. The prototype selected is to be inclusive of the series in terms of technical parameters; representative in terms of the structure and manufacturing process, and able to reflect the processing capability and manufacturing level of the factory.

7.2 Test items

Generally, the type tests on the fuel injector are to include the type tests on the needle valve assembly and the fuel injector assembly.

7.2.1 Type test items for needle valve assembly

(1) Sliding test

(2) Diametral tightness test

(3) Cone tightness test

(4) Spray test

(5) Flow test

(6) Cleanliness inspection

(7) Reliability test

7.2.2 Type test items for fuel injector assembly

(1) Valve opening pressure test

(2) Sliding test

(3) Hydraulic test and tightness test

(4) Spray test

(5) Flow test

(6) Cleanliness inspection

(7) Reliability test

7.2.3 Type test items for low-speed diesel engine fuel injector produced according to the technical specifications established by the diesel engine patent awarded factory

The fuel injector assembly of low-speed diesel engine may not be subjected to the flow test. The Hydraulic test should be taken according to approved patent drawings and technical specifications.

7.3 Exemption of the type test items

7.3.1 First approval

All applicable test items described above are to be conducted for the first approval. If the following conditions are met, the manufacturer may submit a written application on exemption of part of test items to CCS, and the Surveyor is to give his/her comments based on the production situation and the product history and usage records of the factory and fax such comments along with the written application of the manufacturer to the Construction Classification Division of the Headquarters. Only after being approved can the test items be exempted:

(1) The manufacturer applying for approval is to provide the test reports of relevant test items recently issued by an authoritative testing agency (such as the General Administration of Quality Supervision, Inspection and Quarantine or the Defense Science and Technology Laboratory);

(2) The test approval applicant is to provide the test reports of relevant test items recently signed by IACS members.

7.4 Type test methods and requirements

7.4.1 Type test methods for needle valve assembly

(1) Sliding test

The parts are cleaned and lubricated with filtered light diesel oil. When the fuel injector nozzle assembly is at an angle of 45 °to the horizontal plane, the needle valve is pulled out for 1/3 of the length of the guide surface from the needle valve body and rotated around its axis to any position. After the needle valve is released, it is to slide down freely by virtue of its dead weight without retardance.

(2) Diametral (the appropriate cylindrical working surface between the needle valve and the valve body) tightness test

The pressure-reducing method is to be used for the diametral tightness test. The kinematic viscosity of test fluid at 20 ℃ is to be 10.2 mm2/s ~ 10.7 mm2/s. when the test fluid is pumped in from the hole at the tail of the need valve of fuel injector nozzle assembly, no leakage is to be present between the sealed end face of needle valve body and the fixture; when the test fluid pressure drops 5 MPa from the pressure 2 MPa lower than the specified valve opening pressure, the test fluid leakage time is not to be less than that of the standard sample.

The diametral tightness of nozzle assembly may be inspected by the mode of fuel delivery from the inlet port of fuel injector, but the following requirements are to be met:

① The nozzle retaining nuts are tightened to the torque specified on the product plan;

② Several times of fuel injection are conducted before each test;

③ The test is conducted with the valve opening pressure of fuel injector adjusted to 2 MPa -3 MPa higher than the specified value.

When the standard tightness sample of the nozzle assembly is used for the comparative test, the viscosity of test fluid and the ambient temperature are not specified, but the sample must be re-calibrated if the ambient temperature variation exceeds 4 ℃ during the test.

Other methods (such as assembly clearance measurement) are allowed to be used for assessing the diametral tightness of the needle valve assembly, but the measuring method is to comply with the requirements of relevant technical standards.

(3) Cone tightness test

Under the fuel pressure 2 MPa lower than the specified valve opening pressure, the head or end face of the needle valve body is subjected to visual inspection for 10 s. No leakage is to be present on the high-pressure sealed part and sealed cone, but a little moist around the nozzle hole is to be permitted.

(4) Spray test

With the valve opening pressure adjusted to the specified value, when the pumped fuel is injected once or twice within 1 s, the spray quality is to meet the following requirements:

① The fuel sprayed through the nozzle hole is to be vaporific with crisp fuel injection sounds; obvious splashing fuel particles visible to the naked eyes, continuous fuel columns and easily identified partial spray unevenness are to be not present;

② No leakage is to be present before and after spray, but a little moist around the nozzle hole is to be permitted. When the diameter of needle valve is greater than 10 mm, fluid concentration around the nozzle hole but without dribbling is permitted;

③ The spray quality may be assessed using the nozzle assembly sample as agreed upon between the purchaser and the supplier.

(5) Flow test

The flow test of nozzle assembly is to be conducted after the tests described above are passed. The test method is to be in accordance with the provisions of product technical document. The flow test of nozzle assembly may be conducted by other methods as agreed upon between the purchaser and the supplier.

(6) Cleanliness inspection

The needle valve assembly is rinsed though a syringe with gasoline which is then contained in a clean vessel, filtered with a 5-μm strainer, dried and weighed. The weight of impurities is the cleanliness of the needle valve assembly. The specific limit value is to be as agreed upon between the purchaser and the supplier.

(7) Reliability test

The evaluation or assessment method for the reliability of nozzle assembly is to be as agreed upon between the purchaser and the supplier.

7.4.2 Type test methods for fuel injector assembly

(1) Test equipment and test fluid:

The test fluid is to use light diesel oil.

The fuel injector test bench is to meet the flowing requirements:

① The range of the pressure gauge is to be 0 MPa ~ 60 MPa and the accuracy class is to be not lower than 1.5;

② The ambient temperature is to be 20 ± 2 ℃; and, if the test is to be conducted under other temperature conditions, the test result is to be compared with that of standard sample;

③ All connections in the high-pressure passages such as pump, gauge, fuel pipe joint, switch and valve on the test bench are to be kept tight. When the test bench is tested with a non-porous process pad, the pressure drop under a fuel pressure of 40 MPa for 3 min is not to exceed 1 MPa.

(2) Valve opening pressure test

With the fuel pumped slowly, the pressure gauge pointer is rising gradually. The displayed pressure value before the pointer indication suddenly decreases at the moment that the fuel injector starts to inject fuel is the valve opening pressure of fuel injector.

(3) Sliding test

With the valve opening pressure of fuel injector adjusted to the specified value, the fluctuation and leakage of need valve are observed when fuel is pumped slowly and steadily at an injection velocity of not more than twice within 3 s.

(4) Hydraulic test and tightness test

The high-pressure face of fuel injector housing is to be subjected to a hydraulic test test at a test pressure of 1.5 P or P+30 MPa, whichever is the less (P means the maximum working pressure of the tested part).

The tightness test of the cooling channel of cooled fuel injector is to be conducted using light diesel oil at a pressure of 1 MPa. The presence of leakage is to be observed within 3 min.

The tightness test of the high-pressure sealed part may be conducted simultaneously with the tightness test of the sealed cone of nozzle assembly, and the test method is the same as that in 7.4.1(3).

(5) Spray test

The test method is the same as that in 7.4.1(4).

(6) Flow test

The flow test of fuel injector is to be carried out after the tests described above are passed.

Comparison with the standard fuel injector is to be used for the flow test of fuel injector, but a fuel injection quantity of not less 50 mL at the specified speed is to be guaranteed during the duration of each measurement.

Other methods as agreed upon between the purchaser and the supplier are allowed to be used for the flow test of fuel injector.

(7) Cleanliness inspection

After the fuel injector is disassembled, the inner cavities of parts are rinsed through a syringe with 120# gasoline which is then contained in a clean vessel, filtered with a 5 μm strainer, dried and weighed. The weight of impurities is the cleanliness of the fuel injector.

(8) Reliability test

The evaluation or assessment method for the reliability of fuel injector is to be as agreed upon between the purchaser and the supplier.

**8 Unit/batch inspection**

For the specific inspection methods for products after type approval, the inspection plan at the time of issuing the type approval certificate by CCS is to be complied with.

8.1 For unit/batch inspection of products produced by the manufacturer B-type-approved by CCS:

8.1.1 Inspection items

(1) The inspection items of fuel injector are to comply with the factory test program approved at the time of type approval but be inclusive of, at a minimum, the following tests:

① Valve opening pressure test

② Hydraulic test and tightness test

③ Spray test

The test methods are the same as that in 7.4.2.

(2) For low-speed diesel engine fuel injector produced according to the technical specifications established by the patent awarded factory, only the hydraulic test of fuel injector housing is to be conducted if only the fuel injector housing is subjected to certified inspection.

8.1.2 The above tests may be carried out independently by the manufacturer with a complete test report to be submitted to the Surveyor for approval;

8.1.3 The sampling quantity taken by the Surveyor is to depend on the quantity declared by the factory for inspection. In principle, for batch-produced products, 2% of the same series but not less than 2 sets may be sampled; for single-piece and small-batch produced products, the sampling quantity may be taken as appropriate but at least one set per model. The sampled products are to be subjected to re-test against the above-mentioned inspection items or on-site test witness at the manufacturer's premises.

8.1.4 When the manufacturer applies for unit/batch inspection each time, the following documents are to be submitted at the same time to the Surveyor for approval:

(1) Inspection of fuel injector assembly: Reports on inspections or tests carried out according to 8.1.1.

(2) Inspection of injector housing of low speed diesel engine:

Hydraulic test report.