M71 Type Testing of Reciprocating Internal Combustion Engines

(Feb 2015) (Corr.1 June 2016) (Rev.1 Apr 2025 Complete revision)

1. General

1.1 The type test is part of the Certification Scheme for reciprocating internal combustion engines (hereafter referred to as the “engine”).

2. Scope

2.1 This UR is associated with IACS UR M87 and contains requirements for type testing of engines and sub-systems.

2.2 This UR describes general type testing requirements for engines. Additional requirements in following UR apply, as applicable:

- M78, Reciprocating Internal Combustion Engines Fuelled by Gases or Low-flashpoint Fuels.

3. Objectives

3.1 The type testing, documented in this UR, is to be arranged to represent typical foreseen service load profiles, as specified by the engine designer, as well as to cover for required margins due to fatigue scatter and reasonably foreseen in-service deterioration.

3.2 This applies to:

- Parts subjected to high cycle fatigue (HCF) such as connecting rods, cams, rollers and spring tuned dampers where higher stresses may be provided by means of elevated injection pressure, cylinder maximum pressure, etc.

- Parts subjected to low cycle fatigue (LCF) such as “hot” parts when load profiles such as idle - full load - idle (with steep ramps) are frequently used.

- Operation of the engine at limits as defined by its specified alarm system, such as running at maximum permissible power with the lowest permissible oil pressure and/or highest permissible oil inlet temperature.

Notes:

1. The requirements of UR M71 are to be uniformly implemented by IACS Societies for engines for which the date of application for type approval certification is dated on or after 1 July 2016.

2. The requirements of Rev.1 of UR M71 are to be uniformly implemented by the IACS Societies for engines for which the date of application for type approval certification is dated on or after 01 January 2027.

3. The “date of application for type approval” is the date of the document accepted by the Classification Society as request for type approval certification of a new engine type or of an engine type that has undergone substantive modifications in respect of the one previously type approved, or for renewal of an expired type approval certificate.

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4. Definitions

4.1 The definitions in UR M87 are applicable.

4.2 For the purposes of this UR, the following definitions apply:

- **Low-Speed Engines**: Diesel engines with a rated speed of less than 300 rpm.
- **Medium-Speed Engines**: Diesel engines with a rated speed of 300 rpm or more but less than 1400 rpm.
- **High-Speed Engines**: Diesel engines with a rated speed of 1400 rpm or more

5. Validity

5.1 A type test carried out for a particular type of engine at any place of manufacture will be accepted for all engines of the same type built by licensees or the licensor, subject to each place of manufacture being found to be acceptable to the Society.

5.2 Cylinder arrangement
One type test will be considered adequate to cover a range of different numbers of cylinders[1)].

Notes:

1) *However, a type test of an in-line engine may not always cover the V-version. Subject to the individual Societies' discretion, separate type tests may be required for the V-version. On the other hand, a type test of a V-engine covers the in-line engines, unless the bmep is higher.*
Items such as axial crankshaft vibration, torsional vibration in camshaft drives, and crankshafts, etc. may vary considerably with the number of cylinders and may influence the choice of engine to be selected for type testing.

5.3 Engine rating

5.3.1 The engine is considered type approved up to the type tested ratings and pressures (100% corresponding to MCR). An increase in engine rating or pressures requires a new type test, with the exception of the cases in 5.3.2 and 5.3.3. The new type test may be performed as an Extended Factory Acceptance Test as described in 5.4 if accepted by the Society.

5.3.2 Provided documentary evidence of successful service experience with the latest approved rating of 100% is submitted, an increase (if design approved*) may be permitted without a new type test if the increase from the type tested engine is within:

- 5% of the maximum combustion pressure, or
- 5% of the mean effective pressure, or
- 5% of the rpm

** Only crankshaft calculation and crankshaft drawings, if modified.*

5.3.3 Providing maximum power is not increased by more than 10%, an increase of maximum approved power may be permitted without a new type test provided engineering analysis and evidence of successful service experience in similar field applications (even if the application is not classified) or documentation of internal testing are submitted if the increase from the type tested engine is within:

- 10% of the maximum combustion pressure, or

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- 10% of the mean effective pressure, or
- 10% of the rpm

5.4 Power increase based on an Extended Factory Acceptance Test.

If an engine has been design approved, and the Stage A internal testing completed and documented to a rating higher than the one type tested, the Type Approval may be extended to the increased power/mep/rpm rating upon submission of an Extended Factory Acceptance Test Report. The report to include the following at the higher rating:

- Test at over speed (only if nominal speed has increased)
- Rated power, i.e. 100% output at 100% torque and 100% speed corresponding to load point 1., 2 measurements with one running hour in between
- Maximum permissible torque (normally 110%) at 100% speed corresponding to load point 3 or maximum permissible power (normally 110%) and speed according to nominal propeller curve corresponding to load point 3a., ½ hour
- 100% power at maximum permissible speed corresponding to load point 2, ½ hour

5.5 Design update

5.5.1 An existing type approval of an engine may be extended according to a design update. A function test may be required to be carried out if a substantial function of the updated component has been changed, added or omitted.

5.5.2 The test program is subject to approval by the Society. The Surveyor's attendance is to be agreed on in each case.

6. Test program

6.1 The type testing is divided into 3 stages:

.1 Stage A - internal tests.
This includes some of the testing made during the engine development, function testing, and collection of measured parameters and records of testing hours. The results of testing required by the Society or stipulated by the designer are to be presented to the Society before starting stage B.

.2 Stage B - witnessed tests.
This is the testing made in the presence of the Classification Society's surveyor.

.3 Stage C - component inspection.
This is the inspection of engine parts to the extent as required by the Society.

6.2 The complete type testing program is subject to approval by the Society. The extent the Surveyor's attendance is to be agreed in each case, but at least during stage B and C.

6.3 Testing prior to the witnessed type testing (stage B and C), is also considered as a part of the complete type testing program.

6.4 Upon completion of all type testing (stages A through C), a type test report is to be submitted to the Society for review. The type test report is to contain:
- statement of conformity of the test engine to approved drawings and specifications.
- overall description of tests performed during stage A. Records are to be kept by the manufacturer's QA management for presentation to the Classification Society.

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-detailed description of the safety functional and load tests as well as the inspection results of fire protective measures conducted during stage B.
-inspection results from stage C.

7. Measurements and recordings

7.1 During all testing the following environmental test conditions are to be recorded:

- Ambient air temperature
- Ambient air pressure
- Ambient humidity

7.2 For each required load point, the following parameters are to be recorded as a minimum:

- Engine speed.
- Power and/or Torque
- Maximum combustion pressure for each cylinder [1)]
- Mean indicated pressure for each cylinder [1)]
- Charging air pressure and temperature
- Exhaust gas temperature before turbine and from each cylinder (to the extent that monitoring is required in M73 and M35/36).
- Turbocharger speed (to the extent that monitoring is required in M73)
- All engine parameters that are required for control and monitoring for the intended use (propulsion, auxiliary, emergency).
- Fuel command/Fuel index or equivalent reading e.g. fuel rack position
- Specific parameters of relevant sub-systems

Notes:

1) For engines where the standard production cylinder heads are not designed for such measurements, a special cylinder head made for this purpose may be used. In such a case, the measurements may be carried out as part of Stage A and are to be properly documented. Where deemed necessary e.g. for dual fuel engines, the measurement of maximum combustion pressure and mean indicated pressure may be carried out by indirect means, provided the reliability of the method is documented.

7.3 All measurements conducted at the various load points are to be carried out at steady state operating conditions.

7.4 Calibration records for the instrumentation used to collect data as listed above are to be presented to - and reviewed by the attending Surveyor.

7.5 Additional measurements may be required in connection with the design assessment.

8. Stage A - internal tests

8.1 During the internal tests, the engine is to be operated at the load points:

- important for the engine designer.
- specified in the applicable type approval test program.
  the pertaining operating value are to be recorded.

8.2 Safety tests
Safey tests according to M71.9.2 are to be carried out.

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8.3 Functional tests
Functional tests according to M71.9.3 are to be carried out.

8.4 Integration tests of sub-systems
Integration tests according to M71.9.4 are to be carried out.

8.5 Load tests
Applicable load points according to M71.9.5 are to be tested and recorded.

8.6 Endurance test for high-speed engines

8.6.1 High-speed engines to be subjected to an endurance test of 100 hours at full load. Omission or simplification of this test may be considered for the type approval of engines with long service experience from non-marine fields or for the extension of type approval of engines of a well-known type, in excess of the limits given in M71.4.

8.6.2 The 100 hours test may include the load tests (see M71.8.5) and the load cycles tests (see M71.8.7), deemed necessary by the engine designer.

8.7 Load cycles for high-speed propulsion engines
High speed propulsion engines that may be used for frequent load changes from idle to full are normally to be tested with at least 500 cycles (idle - full load - idle) using the steepest load ramp that the control system (or operation manual if not automatically controlled) permits. The duration at each end is to be sufficient for reaching stable temperatures of the hot parts.

8.8 Specific tests required by the Society
Specific tests of parts of engine, required by the Society or stipulated by the designer.

9. Stage B - witnessed tests

9.1 The tests listed below are to be carried out in the presence of a Surveyor. The achieved results are to be recorded and signed by the attending Surveyor after the type test is completed. The safety tests in M71.9.2 shall be performed before the other relevant tests in M71.9.2 and M71.9.5.

9.2 Safety tests

9.2.1 Before any test run is carried out, all relevant equipment for the safety of attending personnel is to be made available by the manufacturer/shipyard and is to be operational, and its correct functioning is to be verified.

9.2.2 This applies especially to:

- Crankcase explosion conditions protection
- Over-speed protection

  The over-speed test is to be carried out and is to demonstrate that the engine is not damaged by an actual engine overspeed within the overspeed shutdown system set point. This test may be carried out at the manufacturer’s choice either with or without load during the speed overshoot.

- Other shut down function
- Interlock test of turning gear

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9.3 Functional tests

9.3.1 This applies to:

- Verification of the lowest engine speed (10 minutes), the lowest specified propulsion engine speed according to the nominal propeller curve as specified by the engine designer (even though it works on a water-brake).

During this operation, no alarm shall occur.

The following items are to be measured: rpm, power, T/C rpm, scavenge pressure, dynamometer torque.

- Starting tests, for non-reversible engines and/or starting and reversing tests, for reversible engines, for the purpose of determining the minimum air pressure and the consumption for start.
- Governor tests: tests for compliance with UR M3.1 and M3.2 are to be carried out.

9.3.2 Operation with damaged turbocharger

The achievable engine continuous output is to be determined by the engine designer in the case of turbocharger damage for all single main propulsion engine. The test shall be performed with one turbocharger out of operation.

Engines intended for fixed pitch propeller applications are to be able to run continuously at a speed of 40% of full speed along the theoretical propeller curve (6.4 % power).

Engines only intended for controllable pitch propeller application are to be able to run continuously at a power of 6.4%. The engine speed shall be at the lower limit of the intended operation field according to the designer’s specification.

9.4 Integration tests of sub-systems

Integration tests for acceptance of sub-systems are to be carried out to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes.

The scope of these tests shall be proposed by the designer taking into account of multiple operation mode of engine, FMEA reports, and the impact of the test on engine, and is to be agreed by the Society.

Note: The integration test requirements of sub-system may be developed individually by the Society.

9.5 Load tests

9.5.1 The engine is to be operated according to the power and speed diagram (see Figure 1). The data to be measured and recorded when testing the engine at the various load points have to include all engine parameters listed in M71.6. The operating time per load point depends on the engine size (achievement of steady state condition) and on the time for collection of the operating values. Normally, an operating time of 0.5 hour can be assumed per load point, however sufficient time should be allowed for visual inspection by the Surveyor from the Classification Society.

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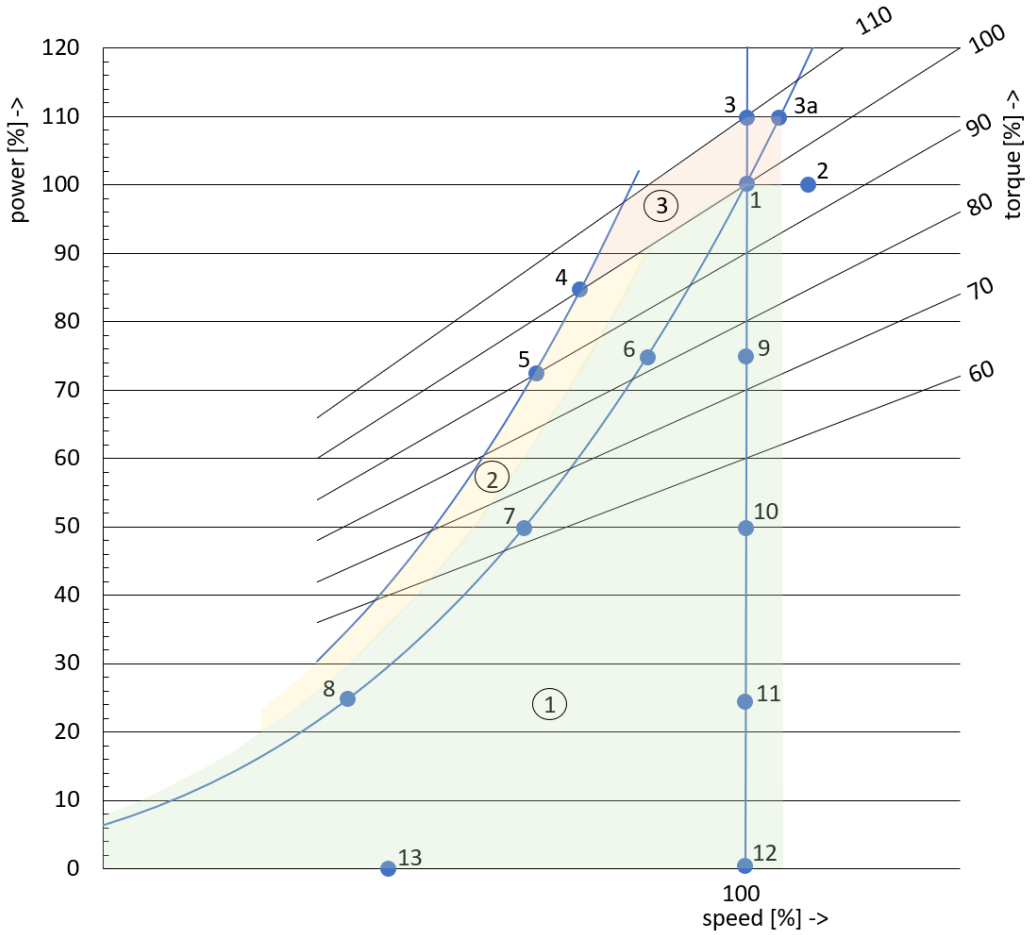
9.5.2 The load points are:



① range of continuous operation
② range of intermitted operation
③ range of short-time overload operation

Figure 1, Load points

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Load point [3]	Power [%]	Speed [%]	Torque [%]	Remarks	Time [h] [4]
1	100	100		MCR, 2 measurements with an interval of 1 hour	2
2	100	maximum permissible [2]			0.5
3 3a	110 110	100 103.2		maximum permissible torque [1] for constant speed applications or for propeller curve applications	0.5 0.5
4		minimum permissible [2]	100		0.5
5		minimum permissible [2]	90	For propeller curve applications	0.5
6	75	90.8		part load, nominal propeller curve	0.5
7	50	79.3		part load, nominal propeller curve	0.5
8	25	62.9		part load, nominal propeller curve	0.5
9	75	100		part load, constant rated speed	0.5
10	50	100		part load, constant rated speed	0.5
11	25	100		part load, constant rated speed	0.5
12	no load	100		engines for generator applications, only	0.5
13	no load	maximum permissible [2]		crosshead engines intended for controllable pitch propellers, only	0.5

Table 1 Load points

Note:

[1] *Load point 3 (or 3a as applicable) is to be replaced with a load that corresponds to the specified overload and duration approved for intermittent use. This applies where such overload rating exceeds 110% of MCR. Where the approved intermittent overload rating is less than 110% of MCR, subject overload rating has to replace the load point at 100% of MCR. In such case the load point at 110% of MCR remains.*

[2] *Permissible speed to be defined by the engine designer.*

[3] *Load points not applicable for the intended application may be omitted.*

[4] *See 9.5.1*

9.5.3 Sub-systems shall be in operation during the load test as intendent by the designer. If the operation of the sub-system or equipping the engine with the sub-system is optional

- all load points are to be tested without the sub-system in operation and
- one load point (0.5 h) is to be tested with the sub-system in operation. The load point shall be the highest possible load at corresponding speed using the sub-system or 100% load (load point 1) whichever is lower.
- part load points with the sub-system in operation if considered necessary.

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9.5.4 During all load points, engine parameters are to be within the specified and approved values.

9.6 Inspection of the Fire protection measures

Verification of compliance with requirements for jacketing of high-pressure fuel oil lines, screening of pipe connections in piping containing flammable liquids and insulation of hot surfaces:

- The engine is to be inspected for jacketing of high-pressure fuel oil lines, including the system for the detection of leakage, and proper screening of pipe connections in piping containing flammable liquids.

- Proper insulation of hot surfaces is to be verified while running the engine at 100% load, alternatively at the overload approved for intermittent use. Readings of surface temperatures are to be done by use of infrared thermos-scanning equipment.

Equivalent measurement equipment may be used when so approved by the Society. Readings obtained are to be randomly verified by use of contact thermometers.

10. Stage C - Opening up for Inspections

10.1 The crankshaft deflections are to be measured in the specified (by designer) condition (except for engines where no specification exists).

10.2 High speed engines for marine use are normally to be stripped down for a complete inspection after the type test.

10.3 For all the other engines, after the test run the components of one cylinder for in-line engines and two cylinders for V-engines are to be presented for inspection as follows (engines with long service experience from non-marine fields can have a reduced extent of opening):

- piston removed and dismantled

- crosshead bearing dismantled

- guide planes

- connecting rod bearings (big and small end) dismantled (special attention to serrations and fretting on contact surfaces with the bearing backsides)

- main bearing dismantled

- cylinder liner in the installed condition

- cylinder head, valves disassembled

- cam drive gear or chain, camshaft and crankcase with opened covers. (The engine must be turnable by turning gear for this inspection.)

10.4 For V-engines, the cylinder units are to be selected from both cylinder banks and different crank throws.

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10.5 Components of relevant sub-systems are to be inspected as agreed with the Society or stipulated by the engine designer when approved by society and may imply some dismantling.

10.6 If deemed necessary by the surveyor, further dismantling of the engine may be required.

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