Lloyd’s Register
Type Approval System
Test Specification Number 4

Type testing for reciprocating internal combustion engines
and associated ancillary equipment

July 2016
**Foreword**

This Specification details the type tests required for reciprocating internal combustion engines operating on liquid, gas or dual fuel for use in marine offshore and industrial applications. Type test specifications are also provided for turbochargers, crankcase explosion relief valves and oil mist detection and alarm systems.

This Specification should be read in conjunction with the Lloyd’s Register (hereinafter referred to as LR) Type Approval Procedure.

The interpretation of this Specification is the sole responsibility, and at the discretion, of LR. Any uncertainty in the meaning of the Specification is to be referred to LR for clarification (typeapprovalenquiries@lr.org).

Failure to comply with these requirements may render the test results unacceptable for the purposes of LR Type Approval.

Note: This test specification No. 4 will be subject to future amendments which will be required to incorporate statutory and other conventions and codes.
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Chapter 1

Type Testing of Reciprocating Internal Combustion Engines and Associated Ancillary Equipment

1. General

1.1 Introduction

1.1.1 This test specification specifies LR’s requirements for the type testing of engines and associated ancillary equipment. It incorporates the International Association of Classification Societies (IACS) requirements concerning the type testing of reciprocating internal combustion engines (hereinafter referred to as engines), operating on liquid, gas or dual fuel.

1.1.2 The requirements of this test specification apply to complete engines including the control system, all ancillary systems and equipment referred to in the Rules that are used for operation of the engine and for which there are Rule requirements. This includes systems for use with different fuel types. The extent of components / items that will need to be tested together with the bare engine will depend on the specific design of the engine, its control system and the fuel(s) used and may include, but not be limited to, the following:

(a) Turbocharger(s)
(b) Crank case explosion relief devices
(c) Oil mist detection and alarm devices
(d) Piping
(e) Electronic monitoring and control system(s) – software and hardware (note that the type test requirements for electrical and control equipment are located in test specification No. 1)
(f) Fuel management system (where dual fuel arrangements are fitted)
(g) Engine driven pumps
(h) Engine mounted filters
(j) Other safety systems necessary for the engine type (may be linked to the fuel(s) used)

1.2 Scope

1.2.1 This Specification covers engines for marine and offshore applications and separates engines into three categories defined by engine operating speed:

(a) Low-Speed Engines - rated speed of less than 300 rpm.
(b) Medium-Speed Engines - rated speed of 300 rpm and above, but less than 1400 rpm.
(c) High-Speed Engines - rated speed of 1400 rpm or above.

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

1.2.3 This applies to:

(a) 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.
(b) 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.
(c) 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.

1.2.4 Engines for emergency use shall be approved in accordance with the general type test requirements (see Chapter 2, Section 1) together with the enhanced requirements for emergency engines (see Chapter 2, Section 2.1).

1.2.5 Engines for auxiliary power generation shall be approved in accordance with the general type test requirements (see Chapter 2, Section 1). The test programme may be modified by agreement with LR.

1.2.6 Lifeboat and rescue boat engines will be approved in accordance with the appropriate IMO requirements (see Chapter 2, Section 2.3). All other engines are to be tested as required by Chapter 2, Section 1, except small engines used for general duties where a simplified approach has been agreed between LR and the manufacturer (see Chapter 2, Section 2.2).

1.2.7 Engines to be approved for industrial applications shall be tested to a procedure agreed with LR.
1.3 Definition of engine type

1.3.1 A range of engines may be considered to be included under the same general type designation as specified by the manufacturer/licensor, provided:
(a) they do not vary in any design detail included in the definition given in 1.3.2 below;
(b) they do not substantially differ in any other design detail, in particular the details of the crankshaft and materials which require approval by LR with respect to the requirements of the LR Rules.

1.3.2 The type of engine, expressed by the manufacturer/licensor’s designation, is defined by:
(a) the bore and stroke;
(b) the method of injection (i.e., direct injection, indirect injection, pilot injection);
(c) the fuel pump and injection system (independent line to fuel oil valve, common rail);
(d) the valve and injection operation (by cams or electronically controlled);
(e) the fuel(s) used (liquid, dual-fuel, gaseous, etc.,);
(f) the working cycle (4-stroke, 2-stroke);
(g) the gas exchange (naturally aspirated, turbocharged, etc.,);
(h) the method of turbocharging (pulsating system, constant pressure system);
(j) the charging air cooling system (with or without intercooler, number of stages);
(k) cylinder arrangement (in-line, vee, etc.,);
(l) cylinder power. speed and cylinder pressures;
(m) the manufacturer and type of governor (and control system if applicable) fitted.

NOTES

1) One type test will cover the whole range of different numbers of cylinders. However, a type test of an in-line engine will not in general cover the V-version. A type test of a V-engine may cover the in-line engines, unless the BMEP is higher and there are significant differences in the crankshaft designs. Items such as axial crankshaft vibration, torsional vibration in camshaft drives, and crankshafts, etc., may vary considerably in the number of cylinders and may influence the choice of engine to be selected for type testing.

2) The engine is approved for the tested rating and pressures (100 per cent corresponding to MCR). Provided documentary evidence of successful service experience with a number of applications with the classified rating of 100 per cent is submitted, an increase (if design approved*) may be permitted without a new type test if the increase of any of the following does not exceed five per cent of the original type tested engine parameters.

Providing maximum power is not increased by more than 10 per cent, 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 of any of the following does not exceed 10 per cent of the original type tested engine parameters

(i) the maximum combustion pressure
(ii) the mean effective pressure
(iii) the rpm.

*Only crankshaft calculation and crankshaft drawings, if modified.

1.3.3 Separate tests may be required for engines of a given range if significant design differences exist within that range to ensure that the engines concerned would not be mutually representative. These tests are to be agreed with LR.

1.3.4 If an engine has been design approved, and internal testing per Stage A (see Chapter 2, 1.2) is documented to a rating higher than the one type tested, the Type Approval may be extended to the increased power/mep/rpm upon submission of an Extended Delivery Test Report at:
(iv) Test at over speed (only if nominal speed has increased)
(v) 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
(vi) 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
(vii) 100% power at maximum permissible speed corresponding to load point 2, ½ hour

1.4 Safety

1.4.1 In the first instance it shall be the responsibility of the provider(s) of the test facility to ensure adequate measures are taken to safeguard all personnel from health and safety risks at all points of observation and means of
access. However, where the manufacturer/licensor has appointed a third party to provide the test facility, he shall be responsible for ensuring that the appointed third party is notified of, and has acknowledged, the following:
(a) Details of personnel invited to witness, or participate otherwise, during the test.
(b) The requirement to ensure the safety of personnel referred to above.

1.4.2 Before any testing 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; its correct functioning is to be verified. This applies especially to crankcase explosion relief valves, overspeed protection and any other safety shutdown function.

1.4.3 Where fitted, inspection of jacketing of high-pressure fuel oil lines and proper screening of pipe and interlock test of turning gear are to be carried out before testing.

1.4.4 Interlock test of turning gear is to be performed when installed.

1.5 Ambient conditions

1.5.1 Ambient conditions at the test site shall be defined by recording the following:
(a) Barometric pressure;
(b) Air temperature;
(c) Relative humidity;
(d) Charge air coolant temperature.

NOTE Items (a), (b) and (c) are to be measured in the non-turbulent air close to the air inlet to the engine.

1.6 Measuring instruments

1.6.1 All measuring instruments shall be calibrated with respect to traceable standards and calibration records shall be kept for review.

1.6.2 Instrumentation used for the measurement of parameters and required for the type testing of the engine is to be independent from the engine control system.

1.7 Definition of powers

1.7.1 Rated Power: The engine brake power declared by the manufacturer/licensor and agreed by LR. This corresponds to the target maximum continuous rating (100 per cent MCR) for the type test. There will also be a corresponding maximum rated engine speed and hence, torque.

1.7.2 Adjusted Power: The engine brake power after adjustment to reference conditions different to the ambient conditions at the test site. It is permissible to use a substitute target (100 per cent MCR) for the type test, such that the adjusted power coincides with the rated power.
(a) Appropriate reference conditions for marine engines may be found in the LR Rules.
(b) An acceptable method for adjusting power to reference conditions is given in ISO 3046/1. Other methods of equivalent accuracy would also be acceptable.

1.7.3 Indicated Power: The power developed in the working cylinders as a result of measured gas pressure acting on the pistons.

1.7.4 Brake Power: The power measured at the driving shaft of the engine.

1.7.5 Rated Output: The output corresponding to that declared by the manufacturer/licensor and agreed by LR, i.e., the actual maximum power which the engine is capable of continuously delivering between the normal maintenance intervals stated by the manufacturer/licensor at the rated speed and under the stated ambient conditions.
Chapter 2

Marine and Offshore Engines

1. Type Testing of Engines

1.1 General requirements for engine testing

1.1.1 Type testing is required for every new engine type intended for installation on board ships subject to classification.

1.1.2 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 LR.

1.1.3 The range of fuels suitable for the engine is to be stated by the manufacturer/licensor. The details of all fuels and mixtures of fuels that are used during the type test are to be recorded and included in the report.

1.1.4 The type testing is divided into three stages as detailed in Sections 1.2 to 1.4.

1.1.5 The complete type testing programme is subject to approval by LR. The extent of the Surveyor’s attendance is to be agreed in each case, but at least during stages B and C. Testing prior to the witnessed type testing (stages B and C) is also considered as a part of the complete type testing programme.

1.1.6 Upon completion of complete type testing (stage A through stage C), a type test report is to be submitted to LR for review. The type test report is to contain:
(a) overall description of tests performed during stage A. Records are to be kept by the builders QA management for presentation to LR;
(b) detailed description of the load and functional tests conducted during stage B;
(c) inspection results from stage C.

1.1.7 In addition to the three stage type testing, an integration test demonstrating that the response of the complete mechanical, hydraulic and electronic system is as predicted shall be carried out for acceptance of any sub-systems (Turbo Charger, Engine Control System, Dual Fuel, Exhaust Gas treatment...) separately approved. The scope of these tests shall be proposed by the designer/licensor taking into account any impact on the engine.

1.1.8 During all testing the ambient conditions shall be recorded (see Chapter 1, 1.5).

1.1.9 As a minimum the following engine data are to be measured and recorded during internal tests and at each load point of the witnessed tests:
(a) External cooling water temperature.
(b) Engine revolutions per minute.
(c) Brake power.
(d) Torque.
(e) Maximum combustion pressure for each cylinder (see Note 1).
(f) Mean indicated pressure for each cylinder (see Note 1).
(g) Exhaust smoke (with an approved smoke meter).
(h) Fuel and lubricating oil pressure and temperature.
(i) Exhaust gas temperature in exhaust manifold and, where facilities are available, from each cylinder.
(j) Fuel rack position or similar parameter related to engine load.
(k) Charging air pressure and temperature
(l) For the turbocharger, where applicable:
   (i) Revolutions per minute.
   (ii) Air temperature and pressures before and after turbo-blower and charge cooler.
   (iii) Exhaust gas temperature and pressures before and after the turbine.
   (iv) Cooling water inlet temperature to the charge air cooler.
(n) All engine parameters that are required for control and monitoring for the intended use (propulsion, auxiliary, emergency).

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.

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

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

1.1.10 The measurements to be included in the test report shall be made when the engine or component under test has reached steady state operating conditions, except when transient conditions are specified.

1.1.11 The engine to be tested is to be selected from the production line and agreed by LR.

1.1.12 During testing, the engine shall be fitted with, and have operational, all ancillary systems and equipment as defined in Chapter 1, 1.1.2. Where these include stand-by units, these shall be in their normal state of readiness.

1.1.13 During testing, no additional measures, other than any required to maintain the engine at a particular operating condition, or those normally required during operation, may be taken.

1.1.14 The test shall proceed, so far as practicable, in a continuous uninterrupted manner with any significant interruption being recorded in the test report. Where a significant defect or malfunction becomes evident, the test shall be stopped and the cause identified, reported to LR and rectified. The test shall then continue after agreement with LR concerning the running period for the rectified part.

1.1.15 New engine or component types or developments of existing types are to be subjected to an agreed programme of type testing to complement the design appraisal and review of documentation. For prototype engines, the duration and programme of tests are to be specially agreed between the manufacturer and LR.

1.1.16 Type tests are to be conducted with the engine control systems operational in the approved configuration. Configuration records are to be reviewed at testing to validate the approval of the control systems and are to be referenced in the type test report.

1.1.17 A type test will be considered to cover engines of a given design for a range of cylinder numbers in a given cylinder arrangement.

1.1.18 For engines that are to be type approved for different purposes (multi-purpose engines), and that have different performances for each purpose, the programme and duration of test will be modified to cover the whole range of the engine performance taking into account the most severe values.

1.1.19 Where engines incorporate electronic control systems, the test programme is to include tests and trials necessary to verify the conclusions of the risk-based analysis required by LR Rules. This is to apply to all electronically controlled engines regardless of the intended function of propulsion, auxiliary or emergency power purpose. The details of how the conclusions of the risk-based analysis have been verified are to be included in the test report.

1.1.20 Where separate items are provided for speed governor and engine control system, the test report is to include details of the manufacturer, type and approval status of each item fitted to the engine under test.

1.1.21 The type testing is to substantiate the capability of the design and its suitability for the intended operation. Special testing such as Low Cycle Fatigue (LCF) and endurance testing will normally be conducted during stage A.

1.1.22 High speed engines for marine use are normally to be subjected to an endurance test of 100 hours at full load. Omission or simplification of the type 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 Chapter 1, 1.3.2.

Propulsion engines for high speed vessels 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.
1.2 Stage A – Internal tests

1.2.1 This Section refers to functional tests carried out by the manufacturer/licensee as part of the engine development, function testing, and collection of measured parameters and records of testing hours. The results of this internal testing are to be presented to LR before starting stage B. The following sub-Sections detail the minimum requirements of this stage.

1.2.2 The engine shall be operated at various load points, sufficient for the manufacturer/licensee to accumulate comprehensive records of operational measured values. The load conditions to be tested are also to include the testing specified in the applicable Type Test programme.

1.2.3 As a minimum the following conditions are to be tested:
   
   (a) Under normal operating conditions, the engine shall be run at the following load points: 25, 50, 75, 100 and 110 per cent of the maximum rated power for continuous operation. The load characteristics should include:

   (i) nominal (theoretical) propeller curve and constant speed for propulsion engines (if applicable to the mode of operation, i.e., driving controllable pitch propellers);
   (ii) constant speed including a test at no load and rated speed (only for engines solely for auxiliary power generation).

   (b) The limit points of the permissible operating range shall be determined (or verified). These limit points shall be specified by the manufacturer/licensor.

   (c) For high speed engines, the 100 hour endurance test and the low cycle fatigue test apply as required in connection with the design assessment. The endurance test is to include the following:

   (i) 80 hours at rated output.
   (ii) 8 hours at 110 per cent overload.
   (iii) 10 hours at varying partial loads (25 per cent, 50 per cent, 75 per cent and 90 per cent of rated output).
   (iv) 2 hours at maximum intermittent loads.

   The required outputs are to be combined together in working cycles for the whole duration within the limits indicated. Omission or simplification of the type test may be considered for extension of approval of engines of a well-known type and for approval of engines with long service experience from non-marine fields.

   (d) Additional specific tests on parts of the engine as required by LR or stipulated by the designer.

1.2.4 Measurements recorded during the test programme shall include, as found relevant, those listed in 1.1.9.

1.3 Stage B – Witnessed testing

1.3.1 This testing is to be carried out in the presence of an LR Surveyor. All achieved results are to be recorded and signed by the Surveyor after completion of the type tests.

1.3.2 The overspeed test is to be carried out and is to demonstrate that the engine operates satisfactorily, and is not damaged, 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.

1.3.3 Load point test: The engine shall be operated under the test conditions according to the load point schedule illustrated in 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 1.1.9. 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.

1.3.4 The load points are:

   (a) Rated power (MCR), i.e., 100 per cent output at 100 per cent torque and 100 per cent speed corresponding to load point 1, normally for 2 hours with data collection with an interval of 1 hour. If operation of the engine at limits as defined by its specified alarm system (e.g., at alarm levels of lub oil pressure and inlet temperature) is required, the test should be made here.

   (b) 100 per cent power at maximum permissible speed (110 per cent of the rated speed) corresponding to load point 2.

   (c) Maximum permissible torque (at least and normally 110 per cent) at 100 per cent speed corresponding to load at point 3, or maximum permissible power (at least and normally 110 per cent) and 103.2 per cent speed according to the nominal propeller curve corresponding to load point 3a. Load point 3a applies to engines only driving fixed pitch propellers or water jets. Load point 3 applies to all other purposes.

   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 per cent of MCR. Where the approved intermittent overload rating is less than 110 per cent of MCR, this overload rating has to replace the load point at 100 per cent of MCR. In such case, the load point at 110 per cent of MCR remains.
(d) Minimum permissible speed at 100 per cent torque corresponding to load point 4.
(e) Minimum permissible speed at 90 per cent torque corresponding to load point 5. (Applicable to propulsion engines only.)
(f) Part loads, e.g., 75 per cent, 50 per cent and 25 per cent of rated power and speed according to nominal propeller curve (i.e., 90.8 per cent, 79.3 per cent and 62.9 per cent speed) corresponding to points 6, 7 and 8 or at constant rated speed setting corresponding to points 9, 10 and 11, depending on the intended application of the engine.
(g) The load on the engine is then to be reduced, without altering the engine controls, to 75 per cent, 50 per cent and 25 per cent MCR. The rate of change of load between points is to be similar to that which would occur in service.
(h) Crosshead engines not restricted for use with C.P. propellers are to be tested with no load at the associated maximum permissible engine speed. During all these load points, engine parameters are to be within the specified and approved values.

NOTES
1) Concerning load points 9, 10 and 11:
   (i) Applicable criteria for governor performance may be found in the LR Rules.
   (ii) Alternative part load values may be chosen where this is appropriate. For example, an engine for alternator drive would be expected to maintain its set point speed at zero load.
2) Where an engine is only intended for alternator drive, no tests need to be carried out below 100 per cent speed.

1.3.5 For crosshead type engines, it shall be demonstrated during the test programme that they can be operated satisfactorily without using mechanically driven cylinder lubricators.
1.3.6 Operation with damaged turbocharger: For 2-stroke propulsion engines, the achievable continuous output is to be determined in the case of turbocharger damage. Engines intended for single propulsion with a fixed pitch propeller are to be able to run continuously at a speed (r.p.m.) of 40 per cent of full speed along the theoretical propeller curve when one turbocharger is out of operation. (The test can be performed by either by-passing the turbocharger, fixing the turbocharger rotor shaft or removing the rotor).

Reference:
MARINE – Test Specification No.4 – 07/16
Reporting date: July 2016
Report by: Global Marine Technical Services
1.3.7 Functional tests are to be carried out to determine or verify the following:
(a) Lowest engine speed according to the nominal propeller curve (during this test, no alarm shall occur).
(b) Starting and, where applicable, reversing to determine minimum air pressure and consumption for a start.
(c) Function and activation point of overspeed and low lubricating oil pressure protection and alarm devices.
(d) Engine running when inclined at $\pm 22.5^\circ$ transversely and $\pm 10^\circ$ longitudinally. If not function-tested, this is to be demonstrated to LR’s satisfaction.
(e) Function of engine governors (compliance with LR Rules and Regulations for the Classification of Ships Part 5, Chapter 2, Section 7)

NOTES
1) Applicable criteria for overspeed protective device performance may be found in LR Rules.
2) For engines driving electric generator sets, additional governor tests may also be carried out to demonstrate compliance with LR Rules.

1.3.8 During the test, samples of the fuel(s) are to be taken from the fuel supply line. These are to be analysed and the following characteristics reported:

For liquid fuels:
(a) Net calorific value.
(b) Density.
(c) Viscosity (with corresponding temperature).
(d) Water content.
(e) Sulphur content.

For Gas fuels:
(a) Net calorific value.
(b) Supply temperature and pressure as applicable.

NOTE
Lubricating oil characteristics are to be verified with respect to those recommended by the engine manufacturer/licensor for normal operation.

1.3.9 Integration test: For electronically controlled engines, integration tests are 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 is to be agreed with LR for selected cases based on the engine control system’s risk-based analysis.

1.3.10 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:
(a) 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.
(b) Proper insulation of hot surfaces is to be verified while running the engine at 100 per cent load, or alternatively at the overload approved for intermittent use. Readings of surface temperatures are to be done by use of Infrared Thermoscaning Equipment. Equivalent measurement equipment may be used when so approved by LR. Readings obtained are to be randomly verified by use of contact thermometers.

1.4 Stage C – Component inspection

1.4.1 Where a specification for crankshaft deflections exists, the crankshaft deflections are to be measured in the condition specified by the designer.

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

1.4.3 For all 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 inspections as follows (engines with long service experience from non-marine fields may have a reduced extent of opening):
(a) Piston removed and dismantled;
(b) Crosshead bearing dismantled;
(c) Guide planes;
(d) Connecting rod bearings (big and small end) dismantled (special attention to serrations and fretting on contact surfaces with the bearing backsides);
(e) Main bearing dismantled
(f) Cylinder liner in the installed condition;
(g) Cylinder head, valves disassembled;
(h) Controlgear, camshaft and crankcase with opened covers. (The engine must be turnable by turning gear for this inspection).

NOTE:
If deemed necessary by the representative of LR, further dismantling of the engine may be required.
For V-engines, the cylinder units are to be selected from both cylinder banks and different crankthrows.
2. **Type Testing of Engines for Specific Applications**

2.1 **Type testing of engines designated for emergency use**

2.1.1 The requirements of this Section apply in addition to the requirements of Section 1.

2.1.2 Engines for emergency power generation are to be tested as a complete unit with generator and other auxiliary components attached.

2.1.3 Cold starting performance is to be tested in accordance with the test regime set out in MSC.81(70), Sections 6.10.2 to 6.10.4 but at a temperature of 0°C.

2.1.4 The stored energy capacity of the automatic starting arrangements is to be tested by repeated starting of the engine. Both the main and auxiliary starting arrangements are to be capable of a minimum of three consecutive starts. (The secondary source of energy must be capable of three starts within 30 minutes).

2.1.5 Emergency engines are to operate with the vessel at an athwart ships inclination of 22,5° and fore-and-aft inclination of 10°. Where facilities are not available to test this, documented design features that ensure correct operation of the engine under these conditions may be accepted by LR on a case-by-case basis. Note that engines may be installed athwart ships as well as fore-and-aft.

2.2 **Type testing of high speed engines used for general duties**

2.2.1 Engines with a cylinder bore of less than 250mm and a power output of 110kW or lower that are to be used for general duties may be permitted to follow a simplified test regime as agreed between LR and the manufacturer. The manufacturer is to submit a test programme for approval, as a minimum this should include, but is not necessarily limited to, the provisions laid out below.

2.2.2 **Engine speed governor test**
   (a) The engine is to be adjusted to 100 per cent of the rated power and 100 per cent of the rated speed and its speed is to be kept stable.
   (b) The load is to be suddenly removed allowing the speed of the engine to rise to the maximum allowed by the governor.
   (c) The speed value at this moment is to be recorded. It should be <1,15 times full speed. Evaluation of the test is to be made.

2.2.3 **Lubricating oil system failure alarm test**
   (a) During the operating of the engine, a short-time failure of the lubricating oil pressure is to be artificially imposed, namely the oil pressure is to be lowered sufficiently to give an alarm.
   (b) The lubricating oil pressure at alarm should be >1,0 bar (15 psi); it is to be recorded and an evaluation is to be made.

2.2.4 **Minimum engine speed test**
   (a) The engine is to be set to a reliable idling speed and run for 5 minutes.
   (b) The idling speed is to be recorded and an evaluation is to be made.

2.2.5 **Engine load test**
   (a) Running tests are to be conducted according to Section 1.3.
   (b) Engine cooling water temperature at inlet to the engine should be adjusted to 27°C (80,6 °F) and the engine run for 30 minutes at full load. The engine should show no signs of overheating.
   (c) During the full load tests, fuel and lubricating oil specifications are to be recorded (to include multiple fuels as applicable).
   (d) Measurements recorded during the test programme shall include, as found relevant, those listed in 1.1.8 and 1.1.9.
   (e) The test result is to be recorded and an evaluation is to be made.

2.3 **Type testing of engines used as lifeboat engines and outboard motors used for rescue boats**

2.3.1 Engines for these purposes may be submitted for approval against the applicable requirements of the IMO test procedure set out in the following Sections of Resolution MSC.81(70).
2.3.2 Lifeboat testing requirements
(a) Operational testing for all lifeboats – IMO Resolution MSC.81(70) Part 1, Section 6.10.
(b) Additional testing for totally enclosed self-righting lifeboats – IMO Resolution MSC.81(70) Part 1, Section 6.10.
(c) Operational testing for outboard rescue boat engines – IMO Resolution MSC.81(70) Part 1, Section 7.7.

2.3.3 EMI
test
(a) The radio communication equipment used in or with lifeboats is to be made operational and adjusted to the fixed communication frequency and frequency channel.
(b) Test of transmitting and receiving dispatches is to be carried out during engine running.
(c) The test result is to be recorded and an evaluation of the test is to be made.

2.3.4 Minimum engine speed test
(a) The engine is to be set to a reliable idling speed and the engine run for 5 minutes. Due allowance should be made for the propeller being submerged.
(b) The idling speed is to be recorded and an evaluation is to be made.

2.3.5 Engine load test. As per 2.2.5 of the test programme for small diesel engines used for general duties.

2.3.6 Additional tests for small diesel engines for totally enclosed lifeboats
(a) Water ingress test.
(b) Water shall be excluded from the engine during capsize and return. Note that water can ingress via the air intake, or crankcase breather, or other opening.

NOTE The tests in 2.3.3 to 2.3.6 are not required by the IMO requirements. However, they are considered to be valued tests. Past test results may be accepted.
Chapter 3

Ancillary Equipment

1. Type testing of turbochargers

1.1 Scope

1.1.1 This test specification is applicable to all category B and C turbochargers unless otherwise agreed with LR. Turbocharger categories are defined in Lloyd’s Register Rules and Regulations for the Classification of Ships, Part 5, Chapter 2, 12.1.2. Those turbochargers that are integral to the engine design should be tested as below in conjunction with the engine type test.

1.1.2 For a generic range of turbochargers the type testing may either be carried out on an engine (for which the turbocharger is foreseen) or in a test rig.

1.1.3 LR reserves the right to limit the duration of validity of approval of a mass produced turbo-charger. LR is to be informed, without delay, of any change in the design of the turbo-charger, in the manufacturing or control processes, in the selection of materials or in the list of subcontractors for main parts.

1.2 Test requirements

1.2.1 A type test is to be carried out on a standard unit taken from the assembly line and is to be witnessed by the Surveyor. The extent of the surveyor’s presence during the various parts of the type tests is to be agreed between LR and the manufacturer. The performance data which may have to be verified are to be made available at the time of the type test.

1.2.2 Turbochargers are to be subjected to at least 500 load cycles at the limits of operation. This test may be waived if the turbocharger together with the engine is subjected to this kind of low cycle testing, see Chapter 2.

1.2.3 The suitability of the turbocharger for such kind of operation is to be preliminarily stated by the manufacturer.

1.2.4 The rotor vibration characteristics shall be measured and recorded in order to identify possible sub-synchronous vibrations and resonances.

1.2.5 The type test is to include a hot gas running test of at least one hour duration at the maximum permissible speed and maximum permissible temperature. Following the test, the turbocharger is to be opened up and examined with focus on possible rubbing and the bearing conditions.

1.2.6 For manufacturers who have facilities for testing the turbocharger unit on an engine for which the turbocharger is intended, substitution of the hot gas running test by a test run of one hour duration at overload (110 per cent of the rated output) may be considered.

1.2.7 Upon application, with details of a historical audit covering previous testing of turbochargers manufactured under an approved quality assurance scheme, consideration will be given to confining the test, outlined in 1.2.4 to a representative sample of turbochargers.

1.2.8 Alternative arrangements to the test specification set out above may be specially considered.

1.3 Disk-Shaft shrinkage fit

1.3.1 For category C turbochargers where the disc is connected to the shaft with an interference fit, calculations are to substantiate safe torque transmission during all relevant operating conditions such as maximum speed, maximum torque and maximum temperature gradient combined with minimum shrinkage amount.

1.4 Containment

1.4.1 In the event of any rotor burst, the turbocharger casing is to fully contain all debris and no part may penetrate the casing of the turbocharger or escape through the air intake. For documentation purposes (test/calculation) the worst case scenario for disk disintegration is to be considered.
1.4.2 For category B and C turbochargers containment is to be demonstrated by testing which is to be fully documented. For approval of a generic range of turbochargers, subject to satisfactory performance, only the largest unit is required to be tested. In any case, it must be demonstrated (e.g., by calculation) that the selected test unit is representative for the whole generic range.

1.4.3 The minimum test speeds for rotor burst testing is to be the same as those required for the overspeed test specified in the Rules and Regulations for the Classification of Ships, Pt 5, Ch 2, 12.3.1., relative to the maximum permissible operating speed, are:
(a) for the compressor: 120%
(b) for the turbine: 140% or the natural burst speed, whichever is lower

1.4.4 Containment tests are to be performed at working temperature.

1.4.5 Calculations using a simulation model and numerical analysis to demonstrate the required containment may be accepted in lieu of the practical containment test, provided that:
(a) The numerical simulation model has been validated and its suitability/accuracy has been proven by direct comparison between calculation results and the practical containment test for a reference application (reference containment test). This test is to be performed at least once by the manufacturer for acceptance of the numerical simulation method in lieu of tests.
(b) The corresponding numerical simulation for the containment is performed for the same speeds as specified for the containment test.
(c) Material properties for high-speed deformations are to be applied in the numeric simulation. The correlation between normal properties and the properties at the pertinent deformation speed are to be substantiated.
(d) The design of the turbocharger regarding geometry and kinematics is similar to the turbocharger that was used for the reference containment test. In general, totally new designs will call for a new reference containment test.
2. Type Testing of Crankcase Explosion Relief Valves

2.1 Scope

2.1.1 This test specification is applicable to all crankcase explosion relief valves intended to be fitted to engines and gear cases except where 2.1.2 applies or otherwise agreed with LR.

2.1.2 The test procedure is only applicable to crankcase explosion relief valves fitted with flame arresters. Where internal oil wetting of a flame arrester is a design feature of an explosion relief valve, alternative testing arrangements that demonstrate compliance with these requirements may be proposed by the manufacturer. The alternative testing arrangements are to be submitted to LR for approval.

2.2 Purpose

2.2.1 The purpose of type testing crankcase explosion relief valves is to:
(a) verify the effectiveness of the flame arrester.
(b) verify that the valve closes after an explosion.
(c) verify that the valve is gas/airtight after an explosion.
(d) establish the level of overpressure protection provided by the valve.

2.3 Test facilities

2.3.1 Test houses carrying out type testing of crankcase explosion relief valves are to meet the following requirements:
(a) The test houses where testing is carried out are to be accredited to a National or International Standard for the testing of explosion protection devices such as ISO/IEC 17025.
(b) The test facilities are to be acceptable to LR.
(c) The test facilities are to be equipped so that they can perform and record explosion testing in accordance with this procedure.
(d) The test facilities are to have equipment for controlling and measuring a methane gas in air concentration within a test vessel to an accuracy of ± 0.1 per cent.
(e) The test facilities are to be capable of effective point located ignition of a methane gas in air mixture.
(f) The pressure measuring equipment is to be capable of measuring the pressure in the test vessel in at least two positions, one at the valve and the other at the test vessel's centre. The measuring arrangements are to be capable of measuring and recording the pressure changes throughout an explosion test at a frequency recognising the speed of events during an explosion. The result of each test is to be documented by video recording and by recording with a heat-sensitive camera.
(g) The test vessel for explosion testing is to have documented dimensions. The dimensions are to be such that the vessel is not pipe-like with the distance between dished ends being not more than 2.5 times the diameter. The internal volume of the test vessel is to include any standpipe arrangements.
(h) The test vessel is to be provided with a flange, located centrally at one end at 90 degrees to the vessel longitudinal axis for mounting the crankcase explosion relief valve. The test vessel is to be arranged in an orientation consistent with how the valve will be installed in service, i.e., in the vertical plane or the horizontal plane.
(j) A circular flat plate is to be provided for fitting between the pressure vessel flange and valve to be tested with the following dimensions:
   (i) Outside diameter of 2 times the outer diameter of the valve top cover.
   (ii) Internal bore having the same internal diameter as the valve to be tested.
(k) The test vessel is to have connections for measuring the methane in air mixture at the top and bottom.
(l) The test vessel is to be provided with a means of fitting an ignition source at a position as specified in 2.4.3.
(m) The test vessel's volume is to be as far as practicable, related to the size and capability of the relief valve to be tested. In general, the volume is to correspond to the LR Rule requirement for the free area of the explosion relief valve to be not less than 115 cm²/m³ of the crankcase gross volume, e.g., the testing of a valve having 1150 cm² of free area, would require a test vessel with a volume of 10 m³.

The following is to apply:
(i) Where the free area of relief valves is greater than 115 cm²/m³ of the crankcase gross volume, the volume of the test vessel is to be consistent with the design ratio.
(ii) In no case is the volume of the test vessel to vary by more than ±15 per cent from the design cm²/m³ volume ratio.
2.4 Explosion test process

2.4.1 All explosion tests to verify the functionality of crankcase explosion relief valves are to be carried out using an air and methane mixture with a volumetric methane concentration of (9.5 ±0.5) per cent. The pressure in the test vessel is to be not less than atmospheric and is not to exceed the opening pressure of the relief valve.

2.4.2 The concentration of methane in the test vessel is to be measured at the top and bottom of the vessel and these concentrations are not to differ by more than 0.5 per cent.

2.4.3 The ignition of the methane and air mixture is to be made at the centreline of the test vessel at a position approximately one third of the height or length of the test vessel opposite to where the valve is mounted.

2.4.4 The ignition is to be made using a maximum 100 joule explosive charge.

2.5 Valves to be tested

2.5.1 The valves used for type testing (including testing specified in 2.5.3) are to be selected from the manufacturer’s normal production line for such valves by the LR Surveyor witnessing the tests.

2.5.2 For approval of a specific valve size, three valves are to be tested in accordance with 2.5.3 and 0. For a series of valves, see 2.3.

2.5.3 The valves selected for type testing are to have been previously tested at the manufacturer’s works to demonstrate that the opening pressure is in accordance with the specification within a tolerance of ± 20 per cent and that the valve is airtight at a pressure below the opening pressure for at least 30 seconds. This test is to verify that the valve is airtight following assembly at the manufacturer’s works and that the valve begins to open at the required pressure demonstrating that the correct spring has been fitted.

2.5.4 The type testing of valves is to recognise the orientation in which they are intended to be installed on the engine or gear case. Three valves of each size are to be tested for each intended installation orientation, i.e., in the vertical and/or horizontal positions.

2.6 Method

2.6.1 The following requirements are to be satisfied at explosion testing:
(a) The explosion testing is to be witnessed by an LR Surveyor.
(b) Where valves are to be installed on an engine or gear case with shielding arrangements to deflect the emission of explosion combustion products, the valves are to be tested with the shielding arrangements fitted.
(c) Successful explosion testing to establish a valve’s functionality is to be carried out as quickly as possible during stable weather conditions.
(d) The pressure rise and decay during all explosion testing are to be recorded.
(e) The external condition of the valves is to be monitored during each test for indication of any flame release by video and heat-sensitive camera.

2.6.2 The explosion testing is to be carried out in three stages for each valve that is required to be approved as being type tested.

2.6.3 Stage 1: Two explosion tests are to be carried out in the test vessel with the circular plate as specified in 2.3.1(j) fitted and the opening in the plate covered by a 0.05 mm thick polythene film. These tests establish a reference pressure level for determination of the capability of a relief valve in terms of pressure rise in the test vessel, see 2.7.1(f).

2.6.4 Stage 2:
(a) Two explosion tests are to be carried out on three different valves of the same size. Each valve is to be mounted in the orientation for which approval is sought i.e., in the vertical or horizontal position with the circular plate described in 2.3.1(j) located between the valve and pressure vessel mounting flange.
(b) The first of the two tests on each valve is to be carried out with a 0.05 mm thick polythene bag, having a minimum diameter of three times the diameter of the circular plate and volume not less than 30 per cent of the test vessel, enclosing the valve and circular plate. Before carrying out the explosion test the polythene bag is to be empty of air. The polythene bag is required to provide a readily visible means of assessing whether there is flame transmission through the relief valve following an explosion. During the test, the explosion pressure will open the valve and some unburned methane/air mixture will be collected in the polythene bag. When the flame reaches the flame arrester and if there is flame transmission through the flame arrester, the methane/air mixture in the bag will be ignited and this will be visible.
Lloyd’s Register Type Approval System

(c) Provided that the first explosion test successfully demonstrated that there was no indication of combustion outside the flame arrester and there are no signs of damage to the flame arrester or valve, a second explosion test without the polythene bag arrangement is to be carried out as quickly as possible after the first test. During the second explosion test, the valve is to be visually monitored for any indication of combustion outside the flame arrester and video records are to be kept for subsequent analysis. The second test is required to demonstrate that the valve can still function in the event of a secondary crankcase explosion.

(d) After each explosion, the test vessel is to be maintained in the closed condition for at least 10 seconds to enable the tightness of the valve to be ascertained. The tightness of the valve can be verified during the test from the pressure/time records or by a separate test after completing the second explosion test.

2.6.5 Stage 3: Carry out two further explosion tests as described in Stage 1. These further tests are required to provide an average baseline value for assessment of pressure rise, recognising that the test vessel’s ambient conditions may have changed during the testing of the explosion relief valves in Stage 2.

2.7 Assessment and records

2.7.1 For the purposes of verifying compliance with the requirements of this Section, the assessment and records of the valves used for explosion testing are to address the following:

(a) The valves to be tested are to have evidence of appraisal/approval by LR, see also 2.5.1.
(b) The designation, dimensions and characteristics of the valves to be tested are to be recorded. This is to include the free area of the valve and of the flame arrester and the amount of valve lift at 0,2 bar.
(c) The test vessel volume is to be determined and recorded.
(d) For acceptance of the functioning of the flame arrester there is not to be any indication of flame or combustion outside the valve during an explosion test.
(e) The pressure rise and decay during an explosion are to be recorded, with indication of the pressure variation showing the maximum overpressure and steady under-pressure in the test vessel during testing. The pressure variation is to be recorded at two points in the test vessel.
(f) The effect of an explosion relief valve in terms of pressure rise following an explosion is ascertained from maximum pressures recorded at the centre of the test vessel during the three stages. The pressure rise within the test vessel due to the installation of a relief valve is the difference between average pressure of the four explosions from Stages 1 and 3 and the average of the first tests on the three valves in Stage 2. The pressure rise is not to exceed the limit specified by the manufacturer.
(g) The valve tightness is to be ascertained by verifying from the records at the time of testing that an under-pressure of at least 0,3 bar is held by the test vessel for at least 10 seconds following an explosion. This test is to verify that the valve has effectively closed and is reasonably gastight following dynamic operation during an explosion.
(h) After each explosion test in Stage 2, the external condition of the flame arrester is to be examined for signs of serious damage and/or deformation that may affect the operation of the valve.
(i) After completing the explosion tests, the valves are to be dismantled and the condition of all components ascertained and documented. In particular, any indication of valve sticking or uneven opening that may affect the operation of the valve is to be noted. Photographic records of the valve condition are to be taken and included in the report.

2.8 Design series qualification

2.8.1 The qualification of quenching devices to prevent the passage of flame can be evaluated for other similar devices of identical type where one device has been tested and found satisfactory.

2.8.2 The quenching ability of a flame arrester depends on the total mass of quenching lamellas/mesh. Provided the materials, thickness of materials, length of lamellas/thickness of mesh layer and the quenching gaps are the same, the same quenching ability can be qualified for different sizes of flame arresters subject to (a) and (b) being satisfied.

\[
\frac{n_1}{n_2} = \sqrt{\frac{S_1}{S_2}}
\]

\[
\frac{A_1}{A_2} = \frac{S_1}{S_2}
\]

where

- \(n_1\) = total depth of flame arrester corresponding to the number of lamellas of size 1 quenching device for a valve with a relief area equal to \(S_1\)
- \(n_2\) = total depth of flame arrester corresponding to the number of lamellas of size 2 quenching device for a valve with a relief area equal to \(S_2\)
- \(A_1\) = free area of quenching device for a valve with a relief area equal to \(S_1\)
- \(A_2\) = free area of quenching device for a valve with a relief area equal to \(S_2\)

Reference:
MARINE – Test Specification No.4 – 07/16
Reporting date: July 2016
Report by: Global Marine Technical Services
2.8.3 The qualification of explosion relief valves of larger sizes than that which has been previously satisfactorily tested in accordance with 2.6 and 2.7 can be evaluated where valves are of identical type and have identical features of construction subject to the following:

(a) The free area of a larger valve does not exceed three times +5 per cent that of the valve that has been satisfactorily tested.

(b) One valve of the largest size, subject to (a), requiring qualification is subject to satisfactory testing required by 2.6.3 and 2.6.4 except that a single valve will be accepted in 2.6.4(a) and the volume of the test vessel is not to be less than one third of the volume required by 2.3.1(m).

(c) The assessment and records are to be in accordance with 2.7, noting that 2.7.1(f) will only be applicable to Stage 2 for a single valve.

2.8.4 The qualification of explosion relief valves of smaller sizes than that which has been previously satisfactorily tested in accordance with 2.6 and 2.7 can be evaluated where valves are of identical type and have identical features of construction subject to the following:

(a) The free area of a smaller valve is not less than one third of that of the valve that has been satisfactorily tested.

(b) One valve of the smallest size, subject to (a), requiring qualification is subject to satisfactory testing required by 2.6.3 and 2.6.4 except that a single valve will be accepted in 2.6.4(a) and the volume of the test vessel is not to be more than the volume required by 2.3.1(m).

(c) The assessment and records are to be in accordance with 2.7, noting that 2.7.1(f) will only be applicable to Stage 2 for a single valve.

2.9 The report

2.9.1 The test house is to deliver a full report that includes the following information and documents:

(a) Test specification.

(b) Details of test pressure vessel and valves tested.

(c) The orientation in which the valve was tested (vertical or horizontal position).

(d) Methane in air concentration for each test.

(e) Ignition source.

(f) Pressure curves for each test.

(g) Video recordings of each valve test.

(h) The assessment and records stated in 2.7.
3. **Type Testing of Crankcase Oil Mist Detection and Alarm Equipment**

3.1 **Scope**

3.1.1 This test specification is applicable to all crankcase oil mist detection and alarm equipment intended to be fitted on engines unless otherwise agreed with LR. Note that the type test requirements for electrical and control equipment are located in test specification No. 1.

3.1.2 This test procedure is also applicable to oil mist detection and alarm arrangements intended for gear cases.

3.2 **Purpose**

3.2.1 The purpose of type testing crankcase oil mist detection and alarm equipment is to verify:

(a) the functionality of the system.

(b) the effectiveness of the oil mist detectors.

(c) the accuracy of oil mist detectors.

(d) the alarm set points.

(e) time delays between oil mist leaving the source and alarm activation.

(f) functional failure detection.

(g) the influence of optical obscuration on detection.

3.3 **Test facilities**

3.3.1 Test houses carrying out type testing of crankcase detection and alarm equipment are to satisfy the following criteria:

(a) A full range of facilities for carrying out the environmental and functionality tests required by this procedure shall be available and be acceptable to LR.

(b) The test house that verifies the functionality of the equipment is to be equipped so that it can control, measure and record oil mist concentration levels in terms of mg/l to an accuracy of ±10 per cent in accordance with this procedure.

(c) When verifying the functionality, test houses are to consider the possible hazards associated with the generation of the oil mist required and take adequate precautions. LR will accept the use of low toxicity, low hazard oils as used in other applications, provided it is demonstrated to have similar properties to SAE 40 monograde mineral oil specification.

3.4 **Equipment testing**

3.4.1 The range of tests is to include the following for the alarm/monitoring panel:

(a) Functional tests described in 3.5.

(b) Electrical power supply failure test.

(c) Power supply variation test.

(d) Dry heat test.

(e) Damp heat test.

(f) Vibration test.

(g) EMC test.

(h) Insulation resistance test.

(i) High voltage test.

(k) Static and dynamic inclinations, if moving parts are contained.

3.4.2 The range of tests is to include the following for the detectors:

(a) Functional tests described in 3.5.

(b) Electrical power supply failure test.

(c) Power supply variation test.

(d) Dry heat test.

(e) Damp heat test.

(f) Vibration test.

(g) EMC test.

(h) Insulation resistance test.

(i) High voltage test.

(k) Static and dynamic inclinations, if moving parts are contained.
3.5 Functional tests

3.5.1 All tests to verify the functionality of crankcase oil mist detection and alarm equipment are to be carried out in accordance with 3.5.2 to 3.5.6 with an oil mist concentration in air, known in terms of mg/l to an accuracy of ±10 per cent.

3.5.2 The concentration of oil mist in the test chamber is to be measured in the top and bottom of the chamber and these concentrations are not to differ by more than 10 per cent. See 3.7.1 (b).

3.5.3 The oil mist monitoring arrangements are to be capable of detecting oil mist in air concentrations of between

(a) 0 per cent and 10 per cent of the lower explosive limit (LEL), which corresponds to an oil mist concentration of approximately 50 mg/l (13 per cent oil-air mixture) or

(b) between 0 and a percentage of weight of oil in air based on the sensor measurement method acceptable to LR and in accordance with 3.5.4.

Note: The LEL corresponds to an oil mist concentration of approximately 50 mg/l (~4.1% weight of oil in air mixture).

3.5.4 The alarm set point for oil mist concentration in air is to provide an alarm at a maximum setting corresponding to not more than 5 per cent of the LEL or approximately 2.5 mg/l.

3.5.5 Where alarm set points can be altered, the means of adjustment and indication of set points are to be verified against the equipment manufacturer’s instructions.

3.5.6 The performance of the oil mist detector in mg/l is to be demonstrated. This is to include the following:

(a) range (oil mist detector)
(b) resolution (oil mist detector)
(c) sensitivity (oil mist detector)

Note:
1) Sensitivity of a measuring system: quotient of the change in an indication of a measuring system and the corresponding change in a value of a quantity being measured.
2) Resolution: smallest change in a quantity being measured that causes a perceptible change in the corresponding indication.

3.5.7 Where oil mist is drawn into a detector via piping arrangements, the time delay between the sample leaving the crankcase and operation of the alarm is to be determined for the longest and shortest lengths of pipes recommended by the manufacturer. The pipe arrangements are to be in accordance with the manufacturer’s instructions/recommendations. Piping is to be arranged to prevent pooling of oil condensate which may cause a blockage of the sampling pipe over time.

3.5.8 Detector equipment that is in contact with the crankcase atmosphere and may be exposed to oil splash and spray from engine lubricating oil is to be tested to demonstrate that openings do not occlude or become blocked under continuous oil splash or spray conditions. Testing is to be in accordance with arrangements proposed by the manufacturer and agreed by LR. The temperature, quantity and angle of impact of the oil to be used is to be declared and their selection justified by the manufacturer.

3.5.9 Detector equipment may be exposed to water vapour from the crankcase atmosphere which may affect the sensitivity of the equipment; it is to be demonstrated that exposure to such conditions will not affect the functional operation of the detector equipment. Where exposure to water vapour and/or water condensation has been identified as a possible source of equipment malfunctioning, testing is to demonstrate that any mitigating arrangements such as heating are effective. Testing is to be in accordance with arrangements proposed by the manufacturer and agreed by LR. This testing is in addition to that required by 3.4.2(e) and is concerned with the effects of condensation caused by the detection equipment being at a lower temperature than the crankcase atmosphere.

3.5.10 The ability of the detector equipment to sense the presence of oil mist may be adversely affected by obscuration of the sensing device(s), such as partial obscuration of a lens. It should be shown that any such degradation is detected and an indication is given.

3.6 Detectors and alarm equipment to be tested

3.6.1 The detectors and alarm equipment selected for the type testing are to be selected from the manufacturer’s normal production line by the LR Surveyor witnessing the tests.

3.6.2 Two detectors are to be tested. One is to be tested in the clean condition and the other in a condition representing the maximum level of lens obscuration specified by the manufacturer.
3.7 Method

3.7.1 Oil mist generation is to satisfy the following:

(a) The ambient temperature in and around the test chamber is to be at the standard atmospheric conditions defined in the Rules and Regulations for the Classification of Ships, Pt 6, Ch 2, 1.9 before any test run is started.

(b) Oil mist is to be generated with suitable equipment using an SAE 40 monograde mineral oil or an equivalent acceptable to LR and supplied to a test chamber. The selection of the oil to be used is to take into consideration risks to health and safety, and the appropriate controls implemented. A low toxicity, low flammability oil of similar viscosity may be used as an alternative. The oil mist produced is to have an average (or arithmetic mean) droplet size not exceeding 5 μm. The oil droplet size is to be checked using the sedimentation method or an equivalent method to a relevant international or national standard. If the sedimentation method is chosen, the test chamber is to have a minimum height of 1m and volume of not less than 1m3. Note: The calculated oil droplet size using the sedimentation method represents the average droplet size.

(c) The oil mist concentrations used are to be ascertained by the gravimetric deterministic method, or an equivalent method acceptable to LR. For this test, the gravimetric deterministic method is a process where the difference in weight of a 0.8 μm pore size membrane filter is ascertained from weighing the filter before and after drawing 1 litre of oil mist through the filter from the oil mist test chamber. The oil mist chamber is to be fitted with a recirculating fan.

(d) Samples of oil mist are to be taken at regular intervals and the results plotted against the oil mist detector output. The oil mist detector is to be located adjacent to where the oil mist samples are drawn off.

(e) The results of a gravimetric analysis are considered invalid and are to be rejected if the resultant calibration curve has an increasing gradient with respect to the oil mist detection reading. This situation occurs when insufficient time has been allowed for the oil mist to become homogeneous. Single results that are more than 10 per cent below the calibration curve are to be rejected. This situation occurs when the integrity of the filter unit has been compromised and not all of the oil is collected on the filter paper.

(f) The filters require to be weighed to a precision of 0.1 mg and the volume of air/oil mist sampled to 10 ml.

3.7.2 Oil mist detection equipment is to be tested in the orientation (vertical, horizontal or inclined) in which it is intended to be installed on an engine or gear case as specified by the equipment manufacturer.

3.7.3 Where sensitivity levels of the oil mist detector can be adjusted, testing is to be carried out at the extreme and mid-point level settings.

3.7.4 After completing the tests, the detection equipment is to be examined and the condition of all components ascertained and documented. Photographic records of the monitoring equipment condition are to be taken and included in the report.

3.8 Assessment

3.8.1 Assessment of oil mist detection equipment after testing is to address the following:

(a) The equipment to be tested is to have evidence of design appraisal/approval by LR.

(b) Details of the detection equipment to be tested are to be recorded and are to include:

(i) name of manufacturer;
(ii) type designation;
(iii) oil mist concentration assessment capability and alarm settings;
(iv) The maximum percentage level of lens obscuration used in 3.6.2.

(c) After completing the tests, the detection equipment is to be examined and the condition of all components ascertained and documented. Photographic records of the monitoring equipment condition are to be taken and included in the report.

3.9 Submission for approval

3.9.1 The following information is to be submitted for acceptance of oil mist detection equipment and alarm arrangements.

3.9.2 Description of oil mist detection equipment and system including alarms.

3.9.3 The test report, prepared by the test house, which is to include the following information and documents:

(a) Test specification.

(b) Details of equipment tested.

(c) Results of tests to include a declaration by the manufacturer of the oil mist detector of its:

(i) Performance, in mg/L;
(ii) Accuracy, of oil mist concentration in air;
(iii) Precision, of oil mist concentration in air;
(iv) Range, of oil mist detector;
(v) Resolution, of oil mist detector;
(vi) Response time, of oil mist detector;
(vii) Sensitivity, of oil mist detector;
(viii) Obscuration of sensor detection, declared as percentage of obscuration. 0% totally clean, 100% totally obscure;
(ix) Detector failure alarm;

3.9.4 Schematic layout of engine oil mist detection arrangements showing location of detectors/sensors and piping arrangements and dimensions.

3.9.5 Maintenance and test manual which is to include the following information:
(a) Intended use of equipment and its operation.
(b) Functionality tests to demonstrate that the equipment is operational and that any faults can be identified and corrective actions notified.
(c) Maintenance routines and spare parts recommendations.
(d) Limit setting and instructions for safe limit levels.
(e) Where necessary, details of configurations in which the equipment is and is not to be used.

3.9.6 The approval of one type of detection equipment may be used to qualify other devices having identical construction details. Proposals are to be submitted for consideration.