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CLASSIFICATION NOTES:

# APPROVAL OF RECIPROCATING I.C. ENGINES

MARCH 2026

# CLASSIFICATION NOTES

## Approval of Reciprocating I.C. Engines

## March 2026

**Foreword**

This Classification Note is prepared in order to provide a single document of reference to all concerned for all activities / procedures involved in approval of Reciprocating I.C. Engines and their components including Turbochargers. The various Sections and Appendices also provide a generic flow of documents between engine designer, IRS Plan Approval Centre, engine manufacturer and IRS's Surveyors.

This document is applicable to any Reciprocating IC engine(s) for which type approval certification is dated on or after 01 January 2027. The "date of application for type approval" is the date of documents accepted by IRS as a 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.

Engines with an existing type approval on 1 January 2027 are not required to be re- type-approved. Engine certification for these engines will be carried out accepting the existing type approval and related submitted documentation in place of that required by this Classification Notes until the existing type approval expires or the engine type has undergone substantive modifications at which point the type approval is to be renewed in accordance with this Classification Notes.

Requirements for Factory Acceptance Trials and Shipboard Trials of I.C. Engines are indicated in the Rules for Construction and Classification of Steel Ships.

The requirements for Reciprocating I.C. Engines given in this Classification Notes apply to diesel engines also.

Section 5 of this Classification Note addresses the type approval requirements of reciprocating internal combustion engines supplied with gases or low flash point fuels. Such engines can be either dual fuel engines or gas fuel only engines.

This edition of the Classification Note supersedes "*Approval of I.C Engines - July 2024"*

# CLASSIFICATION NOTES

## Approval of Reciprocating I.C Engines

## March 2026

## TABLE 1 – AMENDMENTS INCORPORATED IN THIS EDITION

| Section or Clause | Subject/ Amendments |
|---|---|
| **Section 1: Documentation and Certification Scheme**<br><br>*The amendments are applicable to engines for which the date of an application for type approval certification is dated on or after 1 January 2027.* | |
| Section 1 | Section 1 is completely revised to specify requirements for document approval related to type approval, product certification, and approval of sub-systems and to include requirements for certification scheme of I.C Engines. |
| **Section 2: Type Testing of Reciprocating I.C. Engines**<br><br>*The amendments are applicable to engines for which the date of an application for type approval certification is dated on or after 1 January 2027.* | |
| Section 2 | Section 2 is completely revised to better clarify requirements for type testing of I.C Engines including test programme, internal tests, witnessed tests and load points. |
| **Section 3: Certification of Engine Components**<br><br>*The amendments are applicable to engines:*<br>*i) for which the application date for type approval certification is on or after 1 January 2027;*<br>*ii) fitted on ships contracted for construction on or after 1 January 2027.* | |
| Table 3.2.4, Footnote 3) | Amended to clarify that for double-wall gas piping, the outer pipe is to be pressure tested at design pressure for ventilated systems and at 1.5 times design pressure for pressurised systems. |
| **Section 5: Dual Fuel and Gas Fuel Engines**<br><br>*The amendments are applicable to engines:*<br>*i) for which the application date for type approval certification is on or after 1 January 2027;*<br>*ii) fitted on ships contracted for construction on or after 1 January 2027.* | |
| Section 5 | Section 5 is revised to better clarify requirements for approval of dual fuel and gas fuel engines and to include requirements for engine safety concept. |
| Section 6 (deleted) | Section 6 is deleted since subject requirements are now covered in Section 5. |

# Approval of Reciprocating I.C. Engines

## March 2026

## Contents

## Section

# Section 1

# Documentation and Certification Scheme

## 1.1 Documentation

### 1.1.1 Scope and Objectives

1.1.1.1 This section covers the following:

.1 an overview of the type approval and certification process of Reciprocating I.C. Engines (hereafter referred to as the “engine”) and contains the requirements for the approval of drawings and specifications for engines and sub-systems.

.2 description of the general requirements for the approval of drawings and specifications. Further, requirements for reciprocating engines fueled by Gases or Low-flashpoint Fuels (refer Section 5 and Main Rules Part 4, Chapter 4, Section 4.13) apply, as applicable.

.3 specification of the following items:

- The documentation to be submitted for type approval or design evaluation of an engine design;

- The documentation to be submitted for use during manufacturing and installation;

- The documentation flow required between engine designer, IRS, engine manufacturer, and IRS’s Surveyors; and

- Documentation required for approval of sub-systems.

### 1.1.2 Definitions

Definitions relating to approval of engines are given in Appendix 1.

### 1.1.3 Documents required for Type Approval or Design Evaluation Certificate

1.1.3.1 Document flow

1.1.3.1.1 For the initial type approval of an engine, the engine designer is to prepare the documentation in accordance with requirements in Tables 1 and 2 and forward to IRS, according to the agreed procedure for review.

1.1.3.1.2 Upon review and approval of the submitted documentation, evidence of approval (including approval documents, stamped drawings) is returned to the engine designer.

1.1.3.1.3 A representative document flow process for obtaining a type approval certificate is shown in Appendix 2, Figure 1.

1.1.3.2 Documentation to be submitted

The documentation, as far as applicable to the type of engine, which is to be submitted by the engine designer/licensor to IRS is listed in Tables 1 and 2.

1.1.3.2.1 Documents for information Table 1

Table 1 lists basic descriptive information to provide IRS an overview of the engine’s design, engine characteristics and performance. Additionally, there are requirements related to auxiliary systems for the engine’s design including installation arrangements, list of capacities, technical specifications and requirements, along with information needed for maintenance and operation of the engine.

1.1.3.2.2 Documents for approval Table 2

Table 2 lists the documents and drawings, which are to be approved by IRS.

1.1.3.2.3 The assignment of documents for information (Table 1) does not preclude possible comments by IRS.

1.1.3.2.4 Where considered necessary, IRS may request further documents to be submitted. This may include details or evidence of existing type approval or proposals for a type testing programme in accordance with Section 2.

1.1.3.3 Submission format of documentation

IRS determines the documentation format - electronic or paper. If submitted in paper format, the number of copies is specified by IRS.

1.1.3.4 Design modifications

After IRS has approved the engine type for the first time, only the documents listed in the tables that have undergone substantive changes need to be resubmitted for consideration by IRS.

### 1.1.4 Documents required for Product Certificate

When the engine's design has been approved in the type approval process without any design modifications, the following procedures may be omitted. Upon request by the Surveyor in charge of inspections, the documents in Table 3 are to be available during the inspection process. For engines with substantive modifications, the documents are to be resubmitted for approval in accordance with 1.1.3.4.

Note: When a licensor-licensee and joint venture agreement is in place, the terms 'engine designer' and 'engine manufacturer' may refer to the 'licensor' and 'licensee,' respectively. If the engine designer and manufacturer belong to the same company, they can be regarded as the design and manufacturing departments of that company.

#### 1.1.4.1 Document flow for engine certificate

1.1.4.1.1 For engines to be installed in specific applications, the engine designer may need to modify the design or performance requirements. The modified drawings are then forwarded by the engine designer to the engine manufacturer to develop production documentation for use in the engine manufacturing in accordance with Table 3.

1.1.4.1.2 For engines to be installed in specific applications, the engine manufacturer may modify the design and performance requirements or prepare their own production documentation. The engine manufacturer is to develop a comparison list of the production documentation against the documentation listed in Tables 1 and 2. An example comparison list is provided in Appendix 4. If there are differences in the technical content on the manufacturer's production drawings/ documents compared to the corresponding designer's drawings, the manufacturer is to obtain agreement on such differences from the designer using the template in Appendix 5.

1.1.4.1.3 The engine manufacturer submits the comparison list and the production documentation to IRS according to the agreed procedure for review and approval.

1.1.4.1.4 IRS returns evidence of approval to the engine manufacturer. This documentation is intended for use by the engine manufacturer, their subcontractors and the attending Surveyors. As the attending Surveyors may request the engine manufacturer or their subcontractors to provide the actual documents indicated in the list, it is necessary for these documents to be prepared and available for the Surveyors.

1.1.4.1.5 A representative document flow process for obtaining an engine certificate is shown in Appendix 2, Figure 2, illustrating the document flows between the:

- engine designer,
- engine manufacturers,
- component manufacturers, and
- IRS

1.1.4.1.6 The documents listed in Table 3 may be submitted by:

- the engine designer,
- the engine manufacturer.

**1.1.4.2 Documents to be submitted for inspection and testing**

1.1.4.2.1 Prior to the start of the engine certification process, drawings approval is to be obtained.

The engine designer reviews the documents listed in Tables 1 and 2 for the application and develops, if necessary, application specific documentation for the use of the engine manufacturer in developing engine specific production documents.

If substantive changes have been made, the affected documents are to be resubmitted to IRS as per 1.1.3.4.

1.1.4.2.2 Table 3 lists the production documents, which are to be submitted by the engine manufacturer to IRS following acceptance by the engine designer. The Surveyor uses the information for inspection purposes during manufacture and testing of the engine and its components. See 1.1.4.1.2 to 1.1.4.1.4.

In addition to the documents listed in Table 3, the engine manufacturer is to be able to provide to the Surveyor performing the inspection upon request the relevant detail drawings, production quality control specifications and acceptance criteria. These documents are for supplemental purposes to the survey only.

1.1.4.2.3 Alteration execution

If there are differences in the technical content of the manufacturer's production drawings/documents compared to the corresponding designer's drawings, the manufacturer is to provide IRS with a "Confirmation of the Designer's Acceptance of Manufacturer's Modifications" approved by the designer and signed by both the manufacturer and the designer responsible for the type approval. Modifications made by the manufacturer must adhere to the appropriate quality requirements. See Appendix 5 for a sample format.

**1.1.4.3 Submission format of documentation**

IRS would determine the documentation format: electronic or paper, based on prior agreement. If documentation is to be submitted in paper format, the number of copies would be indicated by IRS.

**1.1.5 Documentation required for approval of sub-systems**

1.1.5.1 Unless otherwise specified in other Sections of this Classification Notes or the Rules (due to the diversity of possible sub-systems), the following documents are typically to be submitted for information, in addition to the documents listed in Tables 1, 2, and 3:

- Product specification and/or references to design standards, regulations, etc.
- Description of the function and safety aspects of the sub-system.
- Relevant design drawings with specified materials, catalogues, data sheets, calculations, functional descriptions, component lists where necessary, and marking of the product.
- Proposed field of application and operational limitations.
- Risk assessment (FMEA or Qualitative Failure Analysis), when applicable.
- Test program, including a design verification test on a typical engine to demonstrate that the performance provisions of the specified standard(s) are fulfilled and that failure modes identified in the risk assessment are verified.

- Certificates and reports for relevant tests previously obtained.
- Quality specification of the manufacturer, where necessary.
- Any other information that IRS considers necessary.

1.1.5.2 If the sub-system is either already certified for the relevant engine type or type approved by IRS or has been applied and approved for another engine type, the documents normally required for submission in 1.1.5.1 can then be omitted at the discretion of IRS, unless there are modifications.

**1.1.6 Approval and Issuance of Approval Letter**

Upon completion of the design approval/ review, and once the requirements in this Section and the related rules of IRS have been satisfactorily met, a design approval document (an approval letter or certificate with an approved drawing list) may be issued at the discretion of IRS.

In the case of modifications to an existing type approval, a design approval document may also be issued in lieu of reissuing the existing type approval certificate at the discretion of IRS.

| Table 1 : Documentation to be submitted for information, as applicable | |
|---|---|
| **No.** | **Item** |
| 1 | Engine particulars (e.g. Data sheet with general engine information (see Appendix 3), Project Guide, Marine Installation Manual) |
| 2 | Engine cross section |
| 3 | Engine longitudinal section |
| 4 | Bedplate and crankcase of cast design |
| 5 | Thrust bearing assembly[1] |
| 6 | Frame/framebox/gearbox of cast design[2] |
| 7 | Tie rod |
| 8 | Connecting rod |
| 9 | Connecting rod, assembly[3] |
| 10 | Crosshead, assembly[3] |
| 11 | Piston rod, assembly[3] |
| 12 | Piston, assembly[3] |
| 13 | Cylinder jacket/ block of cast design[2] |
| 14 | Cylinder cover, assembly[3] |
| 15 | Cylinder liner |
| 16 | Counterweights (if not integral with crankshaft), including fastening |
| 17 | Camshaft drive, assembly[3] |
| 18 | Flywheel |
| 19 | Fuel oil injection pump |
| 20 | Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly |
| | For electronically controlled engines, construction and arrangement of: |
| 21 | Control valves |
| 22 | High-pressure pumps |
| 23 | Drive for high pressure pumps |
| 24 | Operation and service manuals[4] |
| 25 | FMEA (for engine control system)[5] |
| 26 | Production specifications for castings and welding (sequence)[7] |
| 27 | Evidence of quality control system for engine design and in service maintenance[7] |
| 28 | Quality requirements for engine production[7] |
| 29 | Type approval certification for environmental tests, control components[6,7] |
| 30 | Any other information and documents that IRS considers necessary for sub-system (refer 1.1.5.1). |

**Notes**:

1. If integral with engine and not integrated in the bedplate.
2. Only for one cylinder or one cylinder configuration.
3. Including identification (e.g. drawing number) of components.
4. Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
5. Where engines rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves, a failure mode and effects analysis (FMEA) is to be submitted to demonstrate that failure of the control system will not result in the operation of the engine being degraded beyond acceptable performance criteria for the engine.
6. Tests are to demonstrate the ability of the control, protection and safety equipment to function as intended under the specified testing conditions per Classification Note “Type Approval of Electrical Equipment used for Control, Protection, Safety and Internal Communication Systems for Use in Ships”.
7. No. 26, 27, 28, and 29 may be common to different engine types and reviewed only once by IRS accordingly.

| Table 2 : Documentation to be submitted for approval, as applicable | |
|---|---|
| **No.** | **Item** |
| 1 | Bedplate and crankcase of welded design, with welding details and welding instructions[1,2] |
| 2 | Thrust bearing bedplate of welded design, with welding details and welding instructions[1] |
| 3 | Bedplate/oil sump welding drawings[1] |
| 4 | Frame/framebox/gearbox of welded design, with welding details and instructions[1,2] |
| 5 | Engine frames, welding drawings[1,2] |
| 6 | Crankshaft, details, each cylinder No. |
| 7 | Crankshaft, assembly, each cylinder No. |
| 8 | Crankshaft calculations (for each cylinder configuration) according to the attached data sheet and Classification Note : “Calculation of Crankshafts for I.C. Engines”. |
| 9 | Thrust shaft or intermediate shaft (if integral with engine) |
| 10 | Shaft coupling bolts |
| 11 | Material specifications of main parts with information on non-destructive material tests and pressure tests[3] |
| | Schematic layout or other equivalent documents on the engine of: |
| 12 | Starting air system |
| 13 | Fuel oil system |
| 14 | Lubricating oil system |
| 15 | Cooling water system |
| 16 | Hydraulic system |
| 17 | Hydraulic system (for valve lift) |
| 18 | Engine control and safety system |
| 19 | Shielding of high pressure fuel pipes, assembly[4] |
| 20 | Construction of accumulators (for electronically controlled engine) |
| 21 | Construction of common accumulators (for electronically controlled engine) |
| 22 | Arrangement and details of the crankcase explosion relief valve ( Pt.4/Ch.4 of the Rules)[5] |
| 23 | Calculation results for crankcase explosion relief valves (Pt.4/Ch.4 of the Rules) |
| 24 | Details of the type test program and the type test report[7] |
| 25 | High pressure parts for fuel oil injection system[6] |
| 26 | Oil mist detection and/or alternative alarm arrangements (Pt.4/Ch.4 of Rules) |
| 27 | Details of mechanical joints of piping systems (Pt.4/ Ch.2 of Rules) |
| 28 | Documentation verifying compliance with inclination limits (Pt.4/ Ch.1 of the Rules) |
| 29 | Documents as required in Pt.4/ Ch.7 of the Rules, as applicable |

**Notes** :

1. For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
2. For each cylinder for which dimensions and details differ.
3. For comparison with IRS requirements for material, NDT and pressure testing as applicable.
4. All engines.
5. Only for engines of a cylinder diameter of 200 [mm] or more or a crankcase volume of 0.6 [$m^3$] or more.
6. The documentation to contain specifications for pressures, pipe dimensions and materials.
7. The type test program may be submitted for approval before type test, and the type test report may be submitted shortly after the conclusion of the type test.

| Table 3 : Documentation for the inspection of components and systems | |
|---|---|
| - | Special consideration will be given to engines of identical design and application<br><br>- For engine applications refer to Section 3 (Certification of Engine Components) |
| **No.** | **Item** |
| 1 | Engine particulars as per data sheet in Appendix 3 |
| 2 | Material specifications of main parts with information on non-destructive material tests and pressure tests[1] |
| 3 | Bedplate and crankcase of welded design, with welding details and welding instructions[2] |
| 4 | Thrust bearing bedplate of welded design, with welding details and welding instructions[2] |
| 5 | Frame/frame box/gearbox of welded design, with welding details and instructions[2] |
| 6 | Crankshaft, assembly and details |
| 7 | Thrust shaft or intermediate shaft (if integral with engine) |
| 8 | Shaft coupling bolts |
| 9 | Bolts and studs for main bearings |
| 10 | Bolts and studs for cylinder heads and exhaust valve (two stroke design) |
| 11 | Bolts and studs for connecting rods |
| 12 | Tie rods |
| | Schematic layout or other equivalent documents on the engine of:[3] |
| 13 | Starting air system |
| 14 | Fuel oil system |
| 15 | Lubricating oil system |
| 16 | Cooling water system |
| 17 | Hydraulic system |
| 18 | Hydraulic system (for valve lift) |
| 19 | Engine control and safety system |
| 20 | Shielding of high pressure fuel pipes, assembly[4] |
| 21 | Construction of accumulators for hydraulic oil and fuel oil |
| 22 | High pressure parts for fuel oil injection system[5] |
| 23 | Arrangement and details of the crankcase explosion relief valve (Pt.4/Ch.4 of Rules)[6] |
| 24 | Oil mist detection and/or alternative alarm arrangements (see Pt.4/Ch.4 of Rules) |
| 25 | Cylinder head |
| 26 | Cylinder block, engine block |
| 27 | Cylinder liner |
| 28 | Counterweights (if not integral with crankshaft), including fastening |
| 29 | Connecting rod with cap |
| 30 | Crosshead |
| 31 | Piston rod |
| 32 | Piston, assembly[7] |
| 33 | Piston head |
| 34 | Camshaft drive, assembly[7] |
| 35 | Flywheel |
| 36 | Arrangement of foundation (for main engines only) |
| 37 | Fuel oil injection pump |

| **Table 3 : (Contd.)** | |
|---|---|
| 38 | Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly |
| 39 | Construction and arrangement of dampers |
| | For electronically controlled engines, assembly drawings or arrangements of: |
| 40 | Control valves |
| 41 | High-pressure pumps |
| 42 | Drive for high pressure pumps |
| 43 | Valve bodies, if applicable |
| 44 | Operation and service manuals[8] |
| 45 | Test program resulting from FMEA (for engine control system)[9] |
| 46 | Production specifications for castings and welding (sequence) |
| 47 | Type approval certification for environmental tests, control components[10] |
| 48 | Quality requirements for engine production |

**Notes** :

1. For comparison with IRS requirements for material, NDT and pressure testing as applicable.
2. For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.
3. Details of the system so far as supplied by the engine manufacturer such as: main dimensions, operating media and maximum working pressures.
4. All engines.
5. The documentation to contain specifications for pressures, pipe dimensions and materials.
6. Only for engines of a cylinder diameter of 200 [mm] or more or a crankcase volume of 0.6 [$m^3$] or more.
7. Including identification (e.g. drawing number) of components.
8. Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.
9. Required for engines that rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves.
10. Documents modified for a specific application are to be submitted to IRS for information or approval, as applicable. See 1.1.4.1.1, Appendix 4 and Appendix 5.

### 1.2 Certification Scheme for Reciprocating I.C. Engines

#### 1.2.1 General

1.2.1.1 An engine product certificate is required for each Reciprocating I.C. Engine (hereinafter referred to as “engine”) for shipboard applications for propulsion, electrical power generation or other auxiliary purposes including emergency generators.

1.2.1.2 The Engine Certification Scheme is a certification process based on engine type approval, (including drawings and specifications approval, type test and manufacturer assessment) and, issuance of a product certificate for each individual engine, upon satisfactory components inspection, assembly inspection and factory acceptance test.

1.2.1.3 As an alternative, an engine may be individually certified, provided that the individual engine is subjected to a similar process, including drawing approval as per 1.1, a Type test as per Section 2 and a Factory acceptance test as per Part 4, Chapter 4, Section 4, 4.11 of the *Rules and Regulations for the Construction and Classification of Steel Ships* (hereinafter referred to as Main Rules).

**1.2.2 Scope**

1.2.2.1 This subsection outlines the process and associated requirements for the certification of engines.

1.2.2.2 The following referenced associated requirements give further details concerning the different steps in the engine certification process:

- Ambient reference conditions – Main Rules, Part 4, Chapter 1
- Documents for the Approval of Reciprocating Internal Combustion Engines – 1.1
- Type Testing of Reciprocating Internal Combustion Engines – Section 2
- Certification of Engine Components – Section 3
- Factory Acceptance Test of Reciprocating Internal Combustion Engines – Main Rules, Part 4, Chapter 4, Section 4, 4.11.
- Shipboard Trials of Reciprocating Internal Combustion Engines – Main Rules, Part 4, Chapter 4, Section 4, 4.12.
- Reciprocating Internal Combustion Engines Fuelled by Natural Gas – Section 5 and Part 4, Chapter 4, Section 4, 4.13 of the Main Rules.
- Alternative Certification Scheme (ACS) – Main Rules, Part 4, Chapter 1, Section 4.

**1.2.3 Approval and certification process**

1.2.3.1 The type approval and individual engine certification process consists of different stages and pathways, as shown in Figure 1.2.3.1.

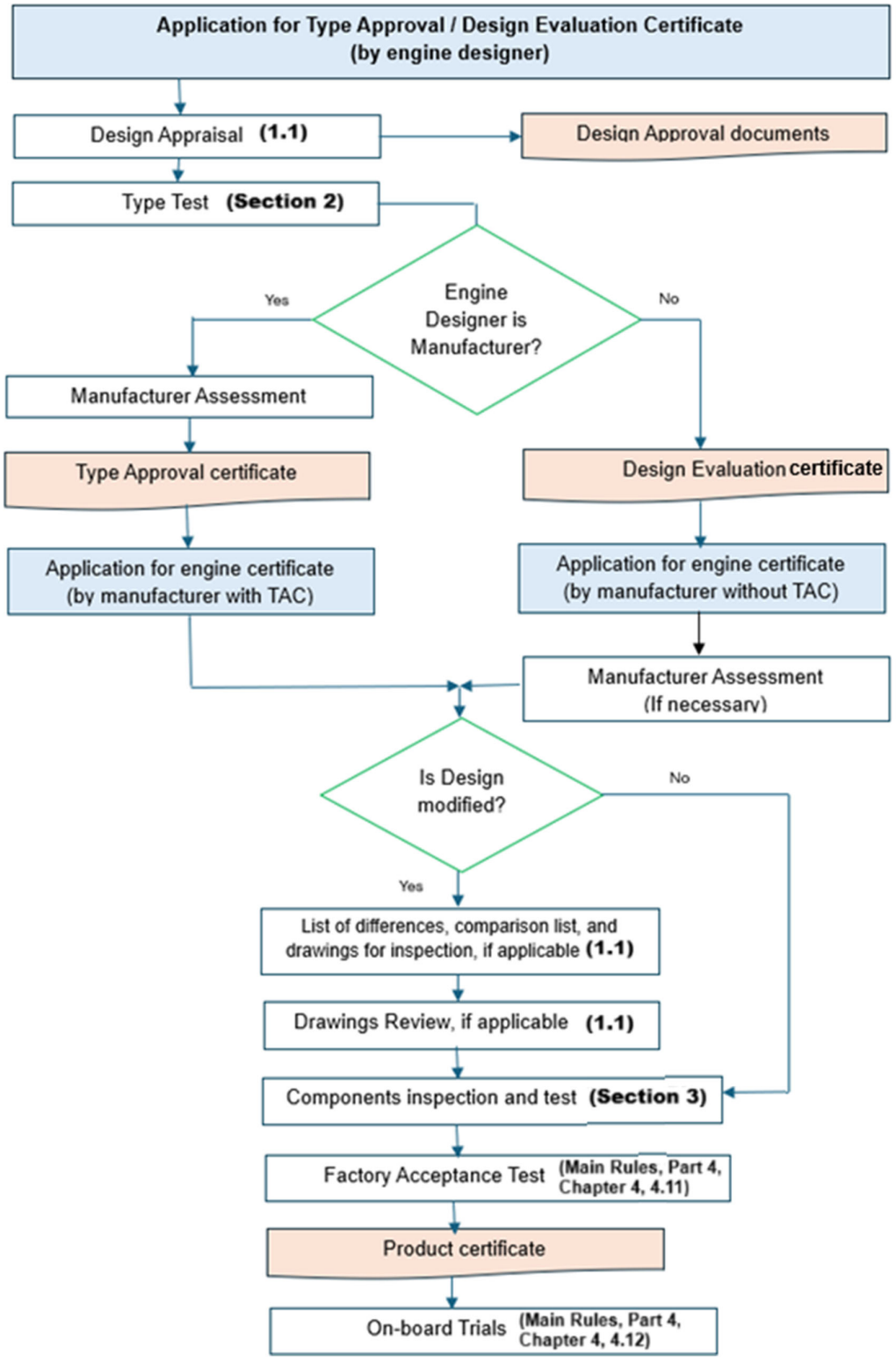



**Figure 1.2.3.1 :Type approval and individual engine certification process**

### 1.2.4 Type approval

#### 1.2.4.1 Principles of type approval

1.2.4.1.1 The type approval of engines is a certification process based on a design appraisal and type testing of the engine type together with a manufacturer assessment including quality assurance system assessment.

This process consists of:

- drawing and specification approval according to 1.1;
- type testing of engines according to Section 2;
- evaluation of the manufacturing arrangements for assessment of conformity of production and certification of components, according to Section 3 and Part 4, Chapter 1, Section 4 of the Main Rules as applicable; and
- issuance of a Type Approval certificate.

#### 1.2.4.2 The scope of type approval

1.2.4.2.1 An engine type is defined by:

- Bore and stroke
- Injection method (direct or indirect)
- Valve and injection operation (by cams or electronically controlled)
- Further type characteristics for dual-fuel and gas engines are given in Section 5, 5.6.2.
- Working cycle (4-stroke, 2-stroke)
- Turbo charging system (pulsating or constant pressure)
- The charging air cooling system (e.g. with or without intercooler)
- Cylinder arrangement (in-line or V)

Engines with the same type characteristics as defined above can be included in the same engine type for a type approval.

Note that where the same engine type (as defined) is capable of using different fuels, its suitability shall be demonstrated by integration testing for each new fuel type.

Additionally, if an engine has varying parameters, new functions, or alternative sub-systems beyond those listed above, it may still be defined as the same engine type, but an extended approval is required in accordance with 1.2.4.2.2 to 1.2.4.2.3 and Appendix 6.

1.2.4.2.2 There are further possible scopes to a type approval, which may occur depending on circumstances, such as:

Extension of the scope of a Type approval, to include e.g. (list not exhaustive):

- New place of production
- Alternative sub-systems
- Alternative or additional duty cycle or applications
- Additional or extended ratings

1.2.4.2.3 Engine rating

1) The engine is type approved up to the rating considered in the design approval and Type test according to Section 2(whichever is the lower, in case of differences).

2) Approval of increased rating is subject to review of design approval and a Type test, except in the cases detailed in Section 2, 2.4.3.

**1.2.4.3 Design Approval**

.1 Design approval is based on evidence that the design is in conformance with all current Rules and statutory regulations (e.g. SOLAS, MARPOL), and it is valid as long as no substantial modifications have been implemented. The details of drawings and specification approval are given in 1.1.

.2 After IRS has approved the engine type for the first time, documents as listed in 1.1, which have undergone substantive changes, have to be resubmitted for consideration by IRS (see also 1.2.4.8).

**1.2.4.4 Type approval test**

.1 A type approval test is to be carried out in accordance with Section 2, under the attendance of Surveyor.

.2 The type testing program is to be approved by IRS, and the conformity of the engine presented for type approval test is also to be assessed.

**1.2.4.5 Manufacturer assessment**

.1 IRS will assess production facilities comprising manufacturing facilities and processes, machining tools, quality assurance, testing facilities, etc. See Section 3 and Part 4, Chapter 1, Section 4 of the Main Rules as applicable.

**1.2.4.6 Type approval certificate**

.1 After the requirements in 1.2.4.3 through 1.2.4.5 have been satisfactorily completed, IRS may issue a type approval certificate (TAC) to the engine designer.

.2 When applicable, the authorized engine manufacturers approved in 1.2.4.5 or 1.2.5.2 may be listed in the notes of type approval certificate at the request of the applicant.

**1.2.4.7 Design evaluation certificate**

.1 Where the issuance of a design evaluation certificate is part of the certification process of IRS, a design evaluation certificate may be issued instead of a Type Approval certificate, with the engine designer as applicant, in the case manufacturer assessment in 1.2.4.5 cannot be carried out, but the requirements in 1.2.4.3 and 1.2.4.4 have been satisfactorily completed.

**1.2.4.8 Validity of type approval and Design evaluation certificates**

.1 The maximum period of validity of a Type Approval Certificate or a Design evaluation certificate, where issued by IRS is 5 years. IRS reserves the right to further limit the duration of validity.

.2 The type approval certificate or Design evaluation certificate, where issued by IRS will be invalid if there are substantial modifications in the design, in the manufacturing or control processes or in the characteristics of the materials unless approved in advance by IRS.

**1.2.4.9 Renewal of type approval or design evaluation certificate**

A renewal of Type approval certificate or Design evaluation certificate, where issued by IRS will be granted upon:

1.2.4.9.1 Submission of information in either a) or b),

a) modified documents or new documents with substantial modifications replacing former documents compared to the previous submission(s) for design appraisal, or

b) a declaration that no substantial modifications have been applied since the last design appraisal issued.

1.2.4.9.2 An assessment to verify, in either above case a) or b), that the applicable requirements have not changed, and the product also complies with applicable requirements.

**1.2.4.10 Extension of the scope of a Type approval certificate or Design evaluation certificate and Approval of sub-systems**

1.2.4.10.1 The scope of a type approval certificate or a design evaluation certificate, where issued by IRS may be extended by the issue of a new certificate or an extension document.

1.2.4.10.2 Approval of engine components and sub-system

The design of components and sub-system which are covered by the type approval certificate or by a design evaluation of the relevant engine type is regarded as approved whether manufactured by the engine manufacturer or sub-supplied. For some components or sub-system of subcontractor's design, necessary approvals are to be obtained by the relevant suppliers (e.g. exhaust gas turbochargers, charge air coolers, etc.).

In case the extension is requested to allow the incorporation of an additional or alternative sub-system, the requirements in Appendix 6 apply. As an alternative, the complete engine incorporating additional or alternative sub-system may be subjected to the complete Type approval process, in which case Appendix 6 is not applicable.

**1.2.5 Individual engine certification**

The individual engine certification is based on a valid type approval certificate or a valid design evaluation certificate. For the first engine of a type, the type approval process and the individual engine certification process may be performed simultaneously.

**1.2.5.1 Documents for individual engine certification**

Prior to the start of the individual engine certification process, a design approval is to be obtained according to the procedure given in 1.1.

Where the engines were design approved in type approval process without any modification, document approval for individual engine can be waived.

**1.2.5.2 Manufacturer assessment**

To verify the arrangements intended to ensure the conformity of production, a manufacturer assessment according to 1.2.4.5 is to be carried out by IRS, except when the manufacturer arrangement was already addressed for issuance of the type approval certificate or were assessed satisfactorily before.

**1.2.5.3 Inspection of engine components and sub-system**

The attending Surveyors will inspect and witness the test of engine components according to the requirements in Section 3, and issue product certificates as necessary upon satisfactory inspections and tests.
Where applicable, inspection for sub-system may also be required according to rules of IRS or quality specification accepted by IRS.

**1.2.5.4 Engine assembly and test**

Each engine assembly and testing procedure required according to relevant requirements is to be witnessed by IRS, except when otherwise allowed by an Alternative Certification Scheme meeting the requirements of Part 4, Chapter 1, Section 4 of the Main Rules, in which case the relevant records are to be reviewed.

The details of Factory acceptance test are given in Part 4, Chapter 4, Section 4, 4.11 of the Main Rules.

**1.2.5.5 Certification**

The Surveyor will issue a product certificate for the engine upon satisfactory outcome of previous steps and review of inspection and test records.

**1.2.5.6 Shipboard trials**

Irrespective of contractual arrangements, shipboard trials are regarded as part of the engine certification process to verify quality and conformity after installation on board, even if a product certificate was already issued.

This process consists of:

- testing the engine when installed on board and connected to ancillary equipment, according to Part 4, Chapter 4, Section 4, 4.12 of the Main Rules.

Note: Depending on the contractual arrangement between the manufacturer and shipyard/shipowner, the responsibility for shipboard trials may lie on either party.

**Appendix 1 - Definitions**

| Term | Definition |
|---|---|
| Acceptance criteria | A set of values or criteria which a design, product, service or process is required to conform with, in order to be considered in compliance |
| Acceptance test | Test carried out as an overall check of the manufacturing quality and to establish that the contractual commitments have been fulfilled |
| Accepted | Status of a design, product, service or process, which has been found to conform to specific acceptance criteria |
| Alternative Certification Scheme (ACS) | A system, by which IRS evaluates a manufacturer's quality assurance and quality control arrangements for compliance with Rule requirements, then authorizes a manufacturer to undertake and witness testing normally required to be done in the presence of a Surveyor. The Alternative Certification Scheme as followed by IRS is detailed in Pt.1, Ch. 1, Sec. 4 of the IRS Rules for Construction and Classification of Steel Ships |
| Ancillary Equipment | An auxiliary equipment or a system outside the engine which is located in engine room or in separate space outside engine room |
| Appraisal | Evaluation by a competent body |
| Approval | The granting of permission for a design, product, service or process to be used for a stated purpose under specific conditions based upon a satisfactory appraisal |
| Assembly | Equipment or a system made up of components or parts |
| Assess | Determine the degree of conformity of a design, product, service, process, system or organization with identified specifications, Rules, standards or other normative documents |
| Assessment of Conformity of Production | Assessment of quality assurance, manufacturing facilities and processes and testing facilities, to confirm the manufacturer's capability to repeatedly produce the complete engine in accordance with the approved and type tested design |
| Audit | Planned systematic and independent examination to determine whether the activities are documented, the documented activities are implemented, and the results meet the stated objectives |
| Auditor | Individual who has the qualifications and experience to perform audits |
| Certificate | A formal document attesting to the compliance of a design, product, service or process with acceptance criteria |
| Certification | A procedure whereby a design, product, service or process is approved in accordance with acceptance criteria |
| Class | Short for Classification Society (here IRS) |
| Class approval | Approved by a Classification Society (here IRS) |
| Classification | Specific type of certification, which relates to the Rules of IRS |

| Term | Definition |
|---|---|
| Competent body | Organization recognized as having appropriate knowledge and expertise in a specific area |
| Component | Part, member of equipment or system |
| Conformity | Where a design, product, process or service demonstrates compliance with its specific requirements |
| Contract | Agreement between two or more parties relating to the scope of service |
| Contractor | see Supplier |
| Customer | Party who purchases or receives goods or services from another |
| Design | All relevant plans, documents, calculations described in the performance, installation and manufacturing of a product |
| Design analysis | Investigative methodology selectively used to assess the design |
| Design appraisal | Evaluation of all relevant plans, calculations and documents related to the design |
| Design approval | The granting of permission for the design of a product, service or process upon a satisfactory design appraisal |
| Design evaluation certificate | Design evaluation certificate is a certificate that may be issued by IRS, depending on its certification process, upon satisfactory completion of design appraisal and type testing. |
| Designer/Engine designer | The entity that has the design rights for the (engine type/product) or is delegated by the entity having the design rights to modify the design. When a licensor-licensee agreement is applied, it could be regarded as the “licensor” |
| Design review | Part of the appraisal process to evaluate specific aspects of the design |
| Drawings approval/ plan approval | Part of the design approval process which relates to the evaluation of drawings and plans |
| Engine | Reciprocating internal combustion engine |
| Equipment | Part of a system assembled from components |
| Equivalent | An acceptable, no less effective alternative to specified criteria |
| Evaluation | Systematic examination of the extent to which a design, product, service or process satisfies specific criteria |
| Examination | Assessment by a competent person to determine compliance with requirements |
| Extended Factory Acceptance Test | Factory acceptance test with additional test items for the purpose of extension of a type approval |

| Term | Definition |
|---|---|
| Extension of a type approval | Extension of a type approval means issuance of a type approval certificate with inclusion of new features in respect of a previously issued certificate for the same equipment |
| Factory acceptance test | A technical operation that consists of the determination of one or more characteristics or performance of a given product or equipment, according to a specified procedure |
| Information | Additional technical data or details supplementing the drawings requiring approval |
| Inspection | Examination of a design, product service or process by an Inspector |
| Inspection plan | List of tasks of inspection to be performed by the Inspector |
| Installation | The assembling and final placement of components, equipment and subsystems to permit operation of the system |
| Manufacturer | Party responsible for the manufacturing and quality of the product |
| Manufacturing process | Systematic series of actions directed towards manufacturing a product |
| Manufacturing process approval | Approval of the manufacturing process adopted by the manufacturer during production of a specific product |
| Material | Goods supplied by one manufacturer to another manufacturer that will require further forming or manufacturing before becoming a new product |
| Modification | A limited change that does not affect the current approval |
| Modification notice | Information about a design modification with new modification index or new drawing number replacing the earlier drawing |
| Performance test | Technical operation where a specific performance characteristic is determined |
| Producer | See manufacturer |
| Product | Result of the manufacturing process |
| Quality assurance | All the planned and systematic activities implemented within the quality system, and demonstrated as needed to provide adequate confidence that an entity will fulfill requirements for quality. Refer to ISO 9001:2015 |
| Regulation | Rule or order issued by an executive authority or regulatory agency of a government and having the force of law |
| Repair | Restore to original or near original condition from the results of wear and tear or damages for a product or system in service |
| Requirement | Specified characteristics used for evaluation purposes |
| Revision | Means to record changes in one or more particulars of design drawings or specifications |

| Term | Definition |
|---|---|
| Rules | For the purpose of this document, Rules means IRS Rules for Construction and Classification of Steel Ships |
| Specification | Technical data or particulars which are used to establish the suitability of materials, products, components or systems for their intended use |
| Substantive modifications or major modifications or major changes | Design modifications, which lead to alterations in the stress levels, operational behaviour, fatigue life or an effect on other components or characteristics of importance such as emissions |
| Subsupplier/subcontractor | One who contracts to supply material to another supplier |
| Sub-systems | Assembly of components belonging to engine, intended to achieve a defined function which may affect the engine performance |
| Supplier | One who contracts to furnish materials or design, products, service or components to a customer or user |
| Test | A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. A technical operation to determine if one or more characteristic(s) or performance of a product, process or service satisfies specific requirements |
| Traceability | Ability to follow back through the design and manufacturing process to the origin |
| Type approval | The establishment of the acceptability of a product through the systematic:<br>1. Evaluation of a design to determine conformance with specifications<br>2. Witnessing manufacture and testing of a type of product to determine compliance with the specification<br>3. Evaluation of the manufacturing arrangements to confirm that the product can be consistently produced in accordance with the specification |
| Type approval certificate | Type Approval Certificate is a certificate issued by IRS upon satisfactory completion of design approval, assessment of Conformity of Production and Type test of the complete engine |
| Type approval test | Last step of the type approval procedure. Test program in accordance with Section 2 |
| Witness | Individual physically present at a test and being able to record and give evidence about its outcome |

## Appendix 2 - Representative Document Flow Diagrams

The document flow diagrams in this Appendix are provided as an aid to all parties involved in the engine certification process as to their roles and responsibilities. Variations in the document flow may vary in response to unique issues with regard to various factors related to location, availability of components and surveys. In any case, the text in the Classification Note takes precedence over these flow diagrams.

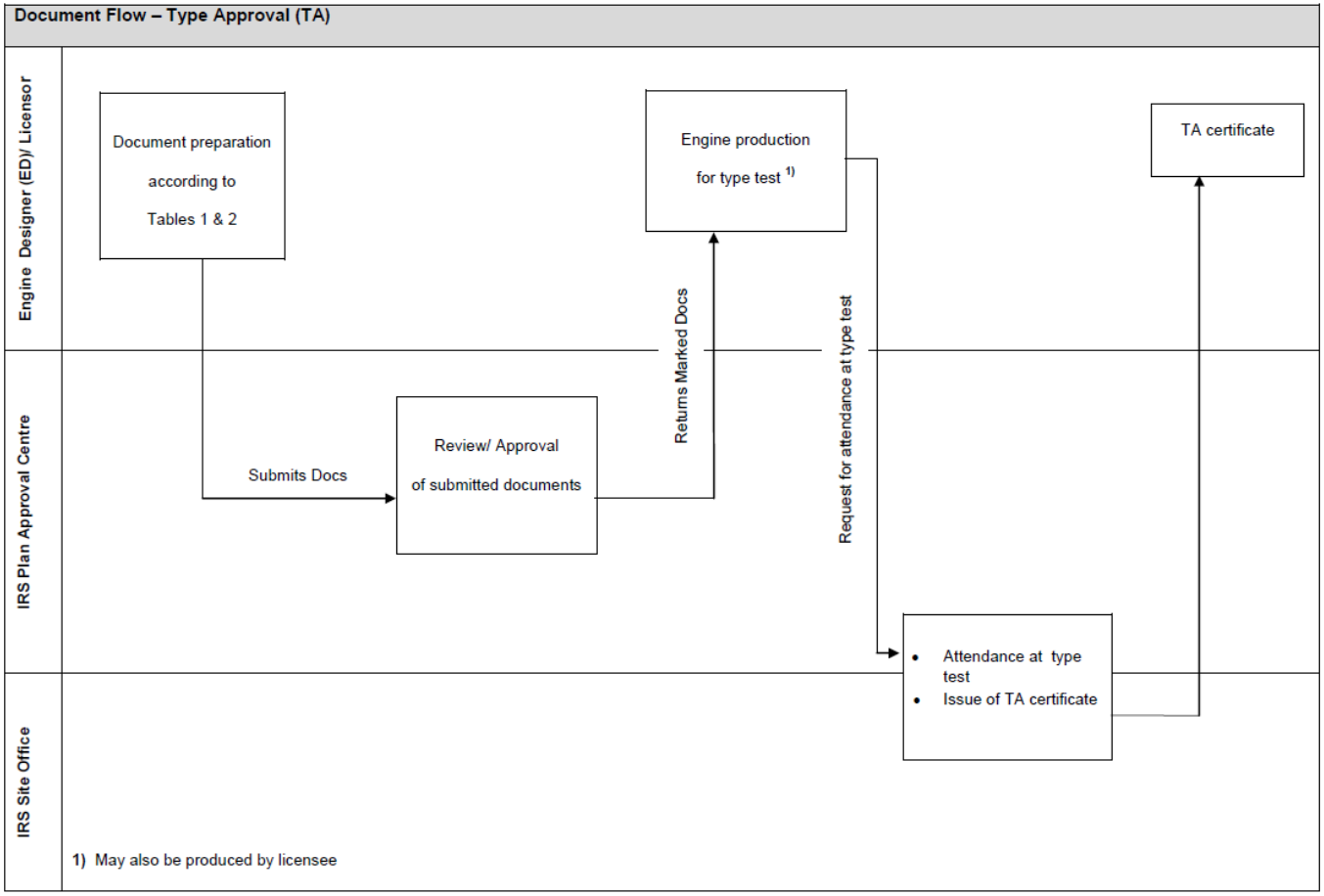



**Figure 1 : Type Approval Document Flow**

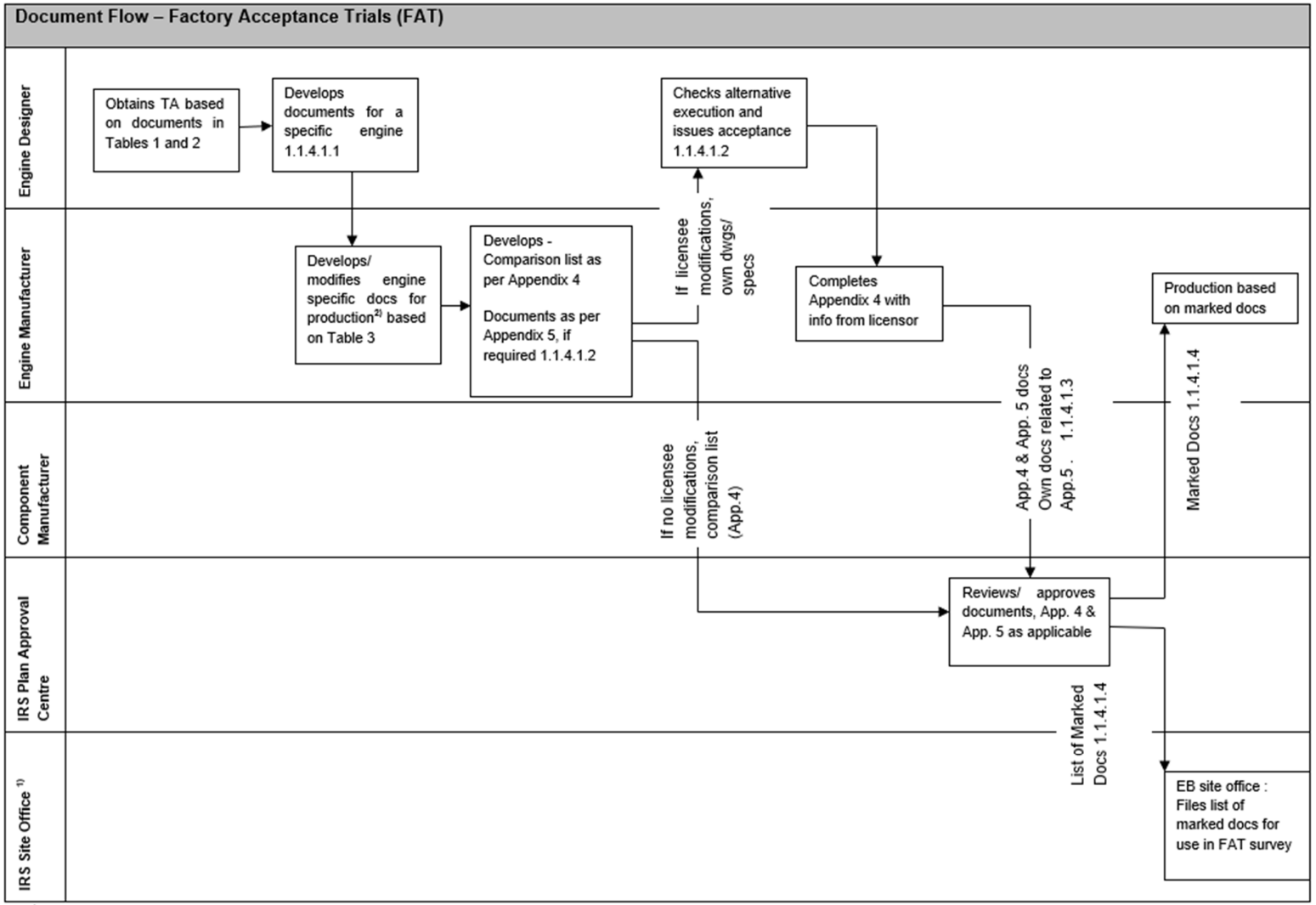



**Figure 2 : Engine certificate document flow**

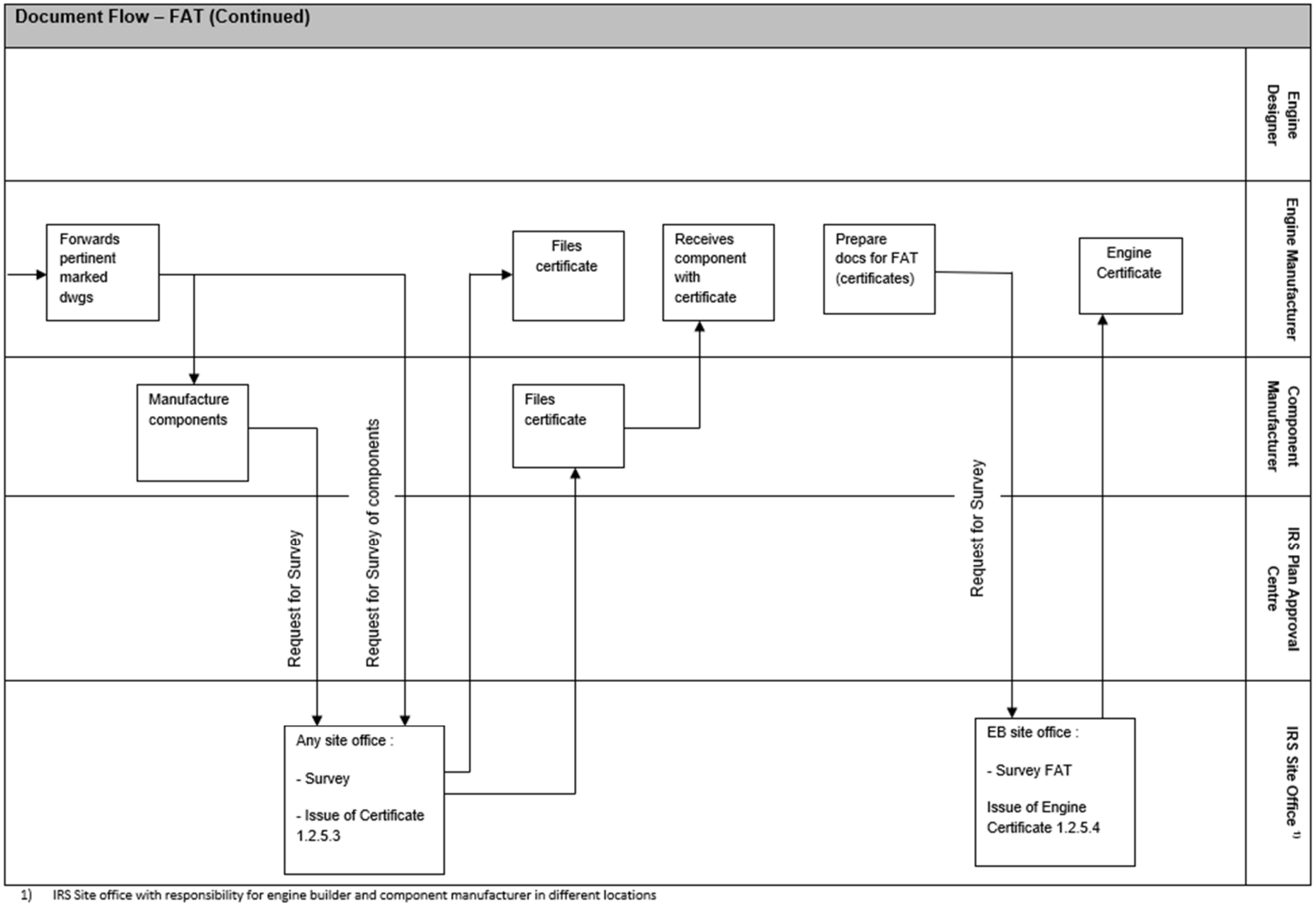



**Figure 2 Engine certificate document flow (continued)**

**Appendix - 3 - Internal Combustion Engine Approval Application Form and Data Sheet**

| Class Application number (if applicable): | Engine Manufacturer's Application Identification Number: |
|---|---|

| General Data | |
|---|---|
| Engine Designer:<br>Contact Person:<br>Address: | Engine Manufacturer(s), Licensee(s) and/or Manufacturing Sites* Name<br>Country |

| 1. Document purpose *(select options from either 1a or 1b)* | |
|---|---|
| 1a. Type Approval Application | |
| Service Requested | *Required activities*† |
| ☐ New Type Approval | • *DA, TT, CoP* |
| ☐ Renew Type Approval | • *CoP, if design change then amended or new certificate process to be followed* |
| ☐ Amend Type Approval | • *DA & CoP, Further TT if previously approved engine has been substantively modified (as required by Section 2)* |
| ☐ Design Evaluation | • *DA, TT, applicable where designer does not have production facilities, Type Approval to be granted to specific production facility once associated CoP has been completed* |
| ☐ Update TA Supplement | • *Update to Supplement, only for minor changes not affecting the Type Approval Certificate* |
| ☐ Other | • *e.g. National/Statutory Administration requirements i.e. MSC.81(70), as amended, for emergency engines* |
| For TA Cert amendments or Supplement updates, details of what is to be changed: | |
| For 'Other', Details of the requirements to be considered: | |
| 1b. Addendum for Individual Engine FAT and Certification | |
| ☐ Individual engine requiring FAT and Certification, only where the performance data for the engine being certified differs from the details provided on the original Type Approval Application. Only section 3b requires completion. Where changes to other sections are necessary, a new Type Approval Application may be required. | |
| Reference number of *Internal Combustion Engine Approval Application Form* previously submitted and reference number of the Type Approval Certificate. | *(Copy of original application form to be attached to this document)* |

| 2. Existing documentation | | | |
|---|---|---|---|
| Previous Class Type Approval Certificate No. or related Design Approval No. *(if applicable)* | | | |
| Formerly issued documentation for engine *(E.g. previous type test reports, in-service experience justification reports, etc.)* | Issuing Body: | Document Type: | Document No.: |
| | | | |

| Existing Certification *(E.g. Manufacturer's quality certification ISO 9001:2015 etc.)* | Issuing Body: | Document Type: | Document No.: |
|---|---|---|---|
| | | | |

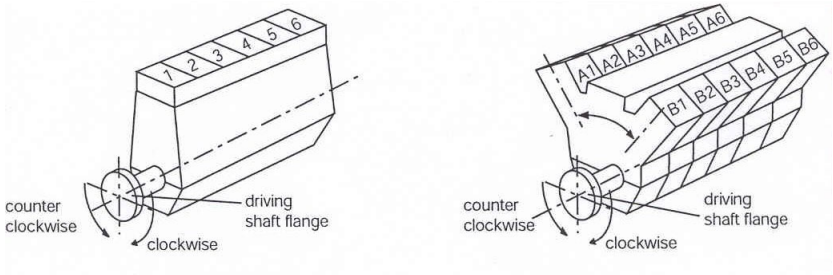
| 3. Design *(mark all that apply)* | | | |
|---|---|---|---|
| 3a. Engine Particulars: | | | |
| Engine Type<br>Manufactured Since‡: | | Number of delivered marine engines‡: | |
| Application | ☐ Direct drive Propulsion (☐ Single engine / ☐ Multi-engine installation) | ☐ Auxiliary (☐ Aux. Services / ☐ Electric Propulsion) | ☐ Emergency |
| Mechanical Design | ☐ 2-stroke ☐ 4-stroke ☐ In-line ☐ Vee (V-angle °) ☐ Other ( )<br>☐ Cross-head ☐ Trunk-piston ☐ Reversible ☐ Non-reversible<br>Cylinder bore(mm) Length of piston stroke (mm) | | |
| Supercharging | ☐ Without supercharging ☐ With supercharging<br>☐ Without charge air cooling ☐ With charge air cooling<br>☐ Constant-pressure charging system ☐ Pulsating pressure charging system | | |
| Valve operation | ☐ Cam control ☐ Electronic control | | |
| Fuel Injection | ☐ Direct injection ☐ Indirect injection | ☐ Cam controlled injection | ☐ Electronically controlled injection |
| Fuel Types§ (Classification according to ISO 8216-1:2017) | ☐ Marine residual fuel cSt (Max. kinematic viscosity at 50°C)<br>☐ Marine distillate fuel DMA, DMB, DMC<br>☐ Marine distillate fuel DMX<br>☐ Low flashpoint liquid fuel (specify fuel type)<br>☐ Gas (specify gas type)<br>☐ Other (specify)<br>☐ Dual Fuel (specify combinations of fuels to be used simultaneously) | | |

| 3b. Performance Data *(Related to: Barometric pressure 1,000 mbar; Air temperature 45°C; Relative humidity 60%; Seawater temperature 32°C)* | |
|---|---|
| Model reference No. (if applicable) | |
| Max. continuous rating | kW/cyl |
| Rated speed | 1/min |
| Mean indicated pressure | MPa |
| Mean effective pressure | MPa |
| Max. firing pressure | MPa |
| Charge air pressure | MPa |
| Compression ratio | - |
| Mean piston speed | m/s |

| 3c. Crankshaft | | | | |
|---|---|---|---|---|
| Design | ☐ Solid | ☐ Semi-built | ☐ Built | |
| Method of Manufacture | ☐ Cast | ☐ Forged<br>☐ Slab forged | ☐ Approved die forged | ☐ Continuous grain flow process |
| State approved forge/works name: | | | | |
| Is the crankshaft hardened by an approved process which includes the fillet radii of crankpins and journals?<br>If yes, state process: | | | | ☐ Yes ☐ No |
| Crankshaft material specification:<br>U.T.S. (N/mm$^2$)<br>Hardness value (Brinell/Vickers) | | Yield strength (N/mm$^2$)<br>Elongation (%) | | |

| Dimensional Data | |
|---|---|
| If shrunk on webs, state shrinkage allowance (mm) | Yield strength of crankweb material (N/mm$^2$) |
| Centre of gravity of connecting rod from large en centre (mm) | Radius of gyration of connecting rod (mm) |
| Mass of each crankweb (kg) | Centre of gravity of web from journal axis (mm) |
| Mass of each counterweight (kg) | Centre of gravity of each counterweight from journal axis (mm) |
| Axial length of main bearing (mm) | Main bearing working clearance (mm) |
| Mass of flywheel at driving end (kg) | Mass of flywheel at opposite end (kg) |
| Nominal alternating torsional stress in crankpin (N/mm$^2$) | Nominal alternating torsional stress in crank jour (N/mm$^2$) |
| Length between centres (Total length)(mm) | |

3d. Firing order




*State numbering system of cylinders from left to right as per above diagrams ( as applicable)*

| Number of cylinders | Clockwise firing order | Counter-clockwise firing order |
|---|---|---|
| | | |

| 4. Engine Ancillary Systems | | | | | |
|---|---|---|---|---|---|
| 4a. Turbochargers ☐Fitted ☐Not Fitted | | | | | |
| Turbocharger oil supply by: ☐Engine lub. oil system ☐TC internal lub. oil system | | | | | |
| No. of cylinders | No. of aux blowers | No. of charge air coolers | No. of TC | TC manufacturer & type | TC type approval certificate No. |
| | | | | / / / / / / | |

| 4b. Speed governor | | | |
|---|---|---|---|
| Engine application (Main/Aux/Emergency) | Manufacturer / type | Mode of operation | Type approval cert. No. (if electric / electronic gov.) |
| | / / / | | |

| 4c. Overspeed protection |
|---|
| Independent overspeed protection available ☐ Yes ☐ No Mode of operation: |
| Manufacturer / type, if electronic: / Type approval certificate No. |

| 4d. Electronic systems |
|---|
| Engine control and management system<br>*Note: use Remarks section to identify when a different engine control system will be used for Type Test*<br>Hardware: Manufacturer & Model: / Type approval certificate No.<br>Software: Name & Version: / Software conformity certificate No. |
| Additional electronic system 1: System function:<br>Manufacturer & type: / Type approval certificate No. |
| Additional electronic system 2: System function:<br>Manufacturer & type: / Type approval certificate No. |
| Additional electronic system 3: System function:<br>Manufacturer & type: / Type approval certificate No. |

| 4e. Starting System |
|---|
| Type: |

| 4f. Safety devices/functions |
|---|
| A flame arrestor or a bursting disk is installed in the starting air system: before each starting valve ☐ Yes ☐ No<br>in the starting air manifold ☐ Yes ☐ No |
| Crankcase relief valves available ☐ Yes ☐ No Manufacturer / type: /<br>Type approval certificate No. |

| No. of cyl. | Total crankcase gross volume incl. attachments ($m^3$) | Type & size (mm) of relief valve | Relief area per relief valve ($mm^2$) | No. of relief valves |
|---|---|---|---|---|
| | | / / / / | | |

| | | | | |
|---|---|---|---|---|
| Method used for detection of potentially explosive crankcase condition:<br>☐ Oil mist detector: Manufacturer / type:<br>/ Type approval certificate No. | | | | |
| ☐ Alternative method:<br>*(mark all that apply)* | ☐ crankcase pressure monitoring<br>☐ oil splash temperature monitoring | ☐ bearing temperature monitoring<br>☐ recirculation arrangements | ☐ other: | |
| Cylinder overpressure warning device available ☐ Yes ☐ No<br>Type: Opening pressure (bar): | | | | |
| 4g Sub-systems | | | | |
| Description of sub-systems<br>☐Electronical engine control system<br>☐Fuel injection/admission system<br>☐EGR (exhaust gas recirculation) system<br>☐Others | | | | |
| 4h. Attached ancillary equipment*(Mark all that apply)* | | | | |
| Engine driven pumps:<br>☐ Main lubricating oil pump<br>☐ HT-fresh cooling water pump | ☐ Sea cooling water pump<br>☐ Fuel oil booster pump | ☐ LT-fresh cooling water pump<br>☐ Hydraulic oil pump | ☐ Other ( ) | |
| Engine attached motor driven pumps:<br>☐ Lubricating oil pump<br>☐ Hydraulic oil pump | ☐ Cooling fresh water pump<br>☐ Other ( ) | ☐ Fuel oil booster pump | | |
| Engine attached cooler or heater:<br>☐ Lubricating oil cooler<br>☐ Hydraulic oil cooler | ☐ Lubricating oil heater<br>☐ Cooling fresh water cooler | ☐ Fuel oil valve cooler | | |
| Engine attached filter:<br>Lubricating oil filter ☐ Single ☐ Duplex ☐ Automatic<br>Fuel oil filter ☐ Single ☐ Duplex ☐ Automatic | | | | |

| 5. Inclination limits *(engine operation is safeguarded under the following limits)* | Athwartships Static | Athwartships Dynamic | Fore-and-aft Static | Fore-and-aft Dynamic |
|---|---|---|---|---|
| Main & Auxiliary machinery | ☐ 15.0° | ☐ 22.5° | ☐ 5.0° | ☐ 7.5° |
| Emergency machinery | ☐ 22.5° | ☐ 22.5° | ☐ 10.0° | ☐ 10.0° |
| Emergency machinery on ships for the carriage of liquefied gas and liquid chemicals | ☐ 30.0° | ☐ 30.0° | | |

| 6. Main engine emergency operation | |
|---|---|
| At failure of one auxiliary blower, engine can be started and operated at partial load | ☐ Yes ☐ No |
| At failure of one turbocharger, engine operation can be continued | ☐ Yes ☐ No |

| 7. References: *Additional Information Attached to Application* | |
|---|---|
| Document Name/Number | Summary of information contained in document |
| | |

| 8. Further Remarks: |
| --- |
| |

* All parties that affect the final complete engine (e.g. manufacture, modify, adjust) are to be listed. All sites where such work is carried out may be required to complete CoP assessment.

† DA = Design Appraisal, TT = Type Test, CoP = Assessment of Conformity of Production. See 'Definitions' at the end of this application form for more information.

‡ Only in case of TA Extension.

§ See 'Definitions' at the end of this application form for more information.

Completed By:

Company:

Job Title:

Date:

Signatur _____

Stamp:

Definitions:

**Design Appraisal**: Evaluation of all relevant plans, calculations and documents related to the design to determine compliance with IRS' technical requirements. This includes requirements for all associated ancillary equipment and systems essential for the safe operation of the engine i.e. the Complete Engine. The Design Appraisal is recorded on a Supplement to the Type Approval Certificate.

**Type Testing** requires satisfactory completion of testing of the Complete Engine against the requirements of the Classification Societies' applicable engine Type Testing programme (based on minimum requirements of Section 2). Type testing is only applicable to the first in series; all engines are to complete factory acceptance and shipboard trials as defined by Section 5.

**Design Evaluation Certification** may be granted upon satisfactory completion of Design Appraisal and Type Testing.

**Assessment of Conformity of Production** means the assessment of quality assurance, manufacturing facilities and processes and testing facilities, to confirm the manufacturer's capability to repeatedly produce the complete engine in accordance with the approved and type tested design.

**Type Approval Certification** will be granted upon satisfactory completion of Design Appraisal, Type Testing and assessment of Conformity of Production of the complete engine. The Type Approval Certificate will incorporate outputs from the Design Appraisal, the Type Test and the Assessment of Conformity of Production.

**Complete Engine** includes the control system and all ancillary systems and equipment referred to in the Rules that are used for safe operation of the engine and for which there are rule requirements, this includes systems allowing the use of different fuel types. The exact list of components/items that will need to be tested in together with the bare engine will depend on the specific design of the engine, its control system and the fuel(s) used but may include, but are not limited to, the following:

(a) Turbocharger(s)
(b) Crankcase explosion relief devices
(c) Oil mist detection and alarm devices
(d) Piping
(e) Electronic monitoring and control system(s) – software and hardware
(f) Fuel management system (where dual fuel arrangements are fitted)
(g) Engine driven pumps
(h) Engine mounted filters

**Fuel Types**: All fuels that the engine is designed to operate with are to be identified on the application form as this may have impact on the requirements that are applicable for Design Appraisal and the scope of the tests required for Type Testing. Where the engine is to operate in a Dual Fuel mode, the combinations of fuel types are to be detailed. E.g. Natural Gas + DMA, Natural Gas + Marine Residual Fuel, the specific details of each fuel are to be provided as indicated in the relevant rows of the Fuel Types part of section 3a of this form.

**Appendix 4 - Tabular Listing of Designer's and Manufacturer's Drawing and Data**

**Manufacturer:**_____ **Designer:**_____
**Engine No. :**_____ **Engine type:**_____

| No. | Components or System | Designer | | | Manufacturer | | Has Design been modified by Manufacturer ? | | If Yes, indicate following information | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Dwg. No. & Title | Rev. No. | Date of Class Approval or Review | Dwg. No. | Rev. No. | Yes | No | Identification of Alternative approved by Designer | Date of Class Approval or Review of Manufacturer Dwg. |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 ... | | | | | | | | | | |

**I attest the above information to be correct and accurate.**

**Person in Charge (Manufacturer):** _____ _____
**Printed Name** **Signature**

**Date:**_____

Note: When a licensor-licensee agreement is applied, the "designer" and "manufacturer" could be regarded as the "licensor" and "licensee".

**Appendix 5 Sample Template for Confirmation of the Designer's Acceptance of Manufacturer's Modifications**

<table>
<tr><td colspan="5">Engine Manufacturer Proposed Alternative to Designer's Design</td></tr>
<tr><td colspan="5">Manufacturer information</td></tr>
<tr><td>Designer:</td><td colspan="2"></td><td>Ref No.:</td><td></td></tr>
<tr><td>Description:</td><td colspan="2"></td><td>Info No.:</td><td></td></tr>
<tr><td>Engine type:</td><td colspan="2"></td><td>Main Section:</td><td></td></tr>
<tr><td>Engine No.:</td><td colspan="2"></td><td>Plant Id.:</td><td></td></tr>
<tr><td colspan="5">Design Spec: ☐ General ☐ Specific Nos:</td></tr>
<tr><td>Design:</td><td colspan="2">State relevant part or drawing. numbers. Insert drawing clips or pictures.<br>Add any relevant information</td><td colspan="2">Manufacturer Proposed Alternative</td></tr>
<tr><td colspan="2"></td><td colspan="3">For example:<br><br>• Differences in geometry<br>• Differences in the functionality<br>• Material<br>• Hardness<br>• Surface condition<br>• Alternative standard<br>• Manufacturer production information introduced on the drawing<br>• Weldings or castings<br>• etc.</td></tr>
<tr><td colspan="2">Reason:<br>☐ Manufacturer's production<br>☐ Sub-supplier's production<br>☐ Cost down<br>☐ Tools</td><td>Interchangeability w. design<br><br>☐ Yes ☐ No</td><td>Non-conformity Report Research, Assessment, Evaluation<br><br>☐ NCR ☐ RAE</td><td>Certified by manufacturer:<br>Initials:<br>Date:</td></tr>
<tr><td colspan="5">Licensor comments</td></tr>
<tr><td colspan="2">LoAE:<br>☐ Accepted as alternative execution<br>(Designer undertakes responsibility)<br>☐ No objection ☐ Not acceptable<br>(Manufacturer undertakes responsibility)</td><td colspan="2">NCR:<br>☐ Approved<br>☐ Conditionally approved<br>☐ Rejected</td><td>Certified by designer:<br>Initials:<br>Date:</td></tr>
<tr><td>Designer ref.:</td><td colspan="3"></td><td>Date:</td></tr>
<tr><td>Manufacturer ref.:</td><td colspan="3"></td><td>Date:</td></tr>
</table>

## APPENDIX 6 - Extension of the scope of an Engine type approval and approval of sub-systems

### 1 Definitions and concepts

Sub-system can be an assembly of components belonging to an engine, intended to achieve a defined function and engine performance (output, emission behaviour, availability etc.).

The sub-system can be separately approved before integration in the engine, if required by IRS or on a voluntary basis. Using this modular system may simplify the certification process, design approval and testing. It does not affect the definition of the engine type.

- IRS will evaluate whether an assembly of components is to be considered as a sub-system or as an integral part of the engine, and in the latter will require a Type approval to be obtained. Examples of sub-systems are electronic engine control system, turbocharger, etc.

- The engine designer can also choose type approval for the sub-system voluntarily, when they deem it is helpful to get an Extension of the scope of engine type approval. Examples of such sub-systems are fuel injection/admission system, exhaust gas recirculation system, exhaust gas treatment system, etc.

Basic engine parts are not to be regarded as sub-systems, examples of such parts are crankshafts, con-rods, pistons, camshafts, intake and exhaust valve actuating systems, etc.

### 2 Extension of the scope of a Type approval of engine

#### 2.1 Certification process of extended type approval using sub-system concept

In case an extension of the scope of an engine type approval is requested, to allow the incorporation of additional or alternative sub-systems, the process in Figure 2.1 is to be applied as an alternative to a complete type approval process.

#### 2.2 Drawings approval

Drawings of sub-system and engines are to be reviewed by IRS. For details see 1.1.7.

#### 2.3 Integration test

The engine is to be subjected to an integration test in the presence of the Surveyor to verify the response of the complete mechanical, hydraulic and electronic systems is as predicted for the engine manufacturer defined operational modes and based on the required FMEA in Section 2.
This may take the form of an extended Factory Acceptance test.
On completion of test, a report is to be issued, identified by number and date which accurately, clearly and unambiguously presents the test results and all other relevant information.

#### 2.4 Certificate of extended approval

An extended approval certificate may also be issued at the discretion of IRS, taking into consideration of the engine defining parameters in 1.2.4.2.1 and individual rules or standards for specific sub-systems. The extended type approval recognition may take the form of any of the following,

- New type approval certificate (for new engine type according to 1.2.4.2.1), or
- Extended engine type approval certificate, or
- Extended Design evaluation certificate, or
- Certificate of extension of a Type approval or Design evaluation certificate.

### 3 Type approval of Sub-system

The type approval of sub-system is to be subjected to:

**3.1 Drawing and specification approval**

The application and submitted documents must contain sufficient information to allow the product to be assessed against the design criteria (see 1.1.7 for details).

**3.2 Type testing in the presence of a surveyor**

3.2.1 The aim of the inspection and testing is to:

- Examine and test the material and workmanship and confirm that the equipment has been manufactured and tested in accordance with the rules, the applicable specified design codes, national and international standards, manufacturer's specification in so far as they are applicable;
- Demonstrate that the product is able to perform its specified function
- Establish the performance characteristics of the product / component, where applicable.

3.2.2 Type testing requirements for specific sub-system are determined by IRS, taking into consideration the following factors,

- The relevant requirements of IRS Rules.
- Product specification and/or reference to design codes, standards, regulations etc.
- Relevant design drawings with materials specified, catalogues, data sheets calculations, functional description.
- Tests required by FMEA, when applicable.
- The type approval tests are adequate to demonstrate that the safety, function and performance provisions of the specified standard(s) can be fulfilled;

On completion of test, a report is to be issued, identified by number and date which accurately, clearly and unambiguously presents the test results and all other relevant information.

3.2.3 IRS may accept a design analysis instead of type testing, where:

- there is evidence, in the form of performance measurements from similar products, to validate the findings of the analysis, and
- the analysis method is recognized by IRS and is well established; and
- it is mutually agreed that type approval tests cannot be performed or are inappropriate.

**3.3 Issue of Type Approval Certificate for sub-systems**

A type approval certificate may be issued upon satisfactory design approval, type testing in the presence of Surveyor, and a manufacturer assessment.

Note: For detail type approval process, please refer to 1.2.4.

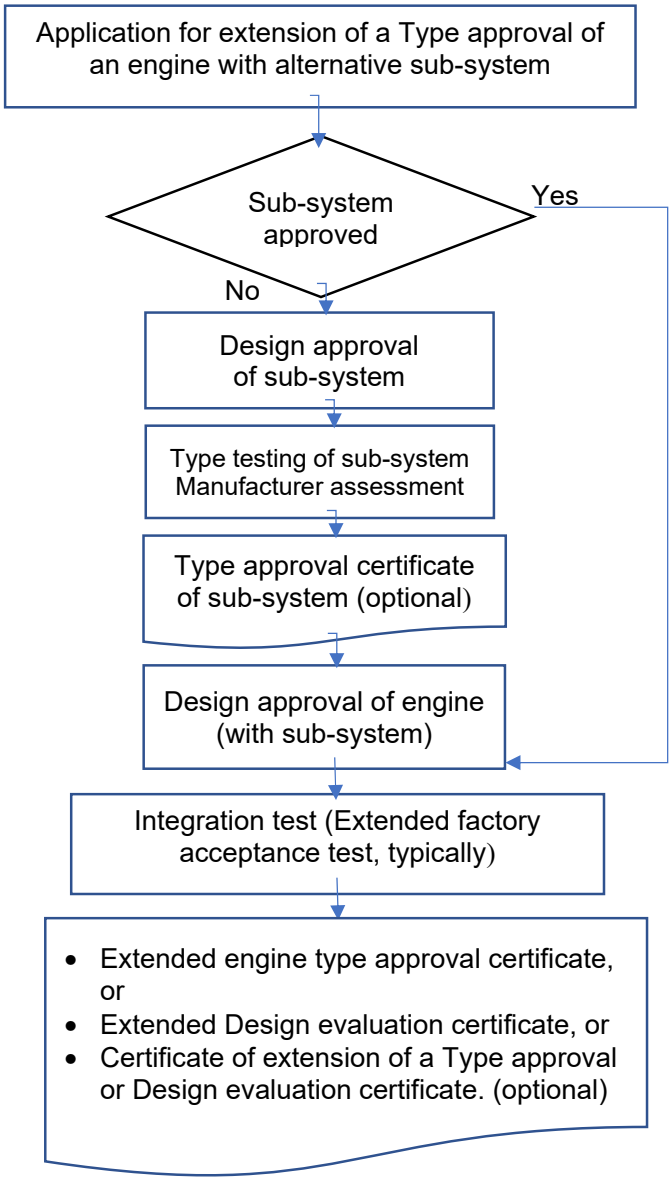



**Figure 2.1 : Certification process of extended type approval using sub-system concept**

# Section 2

# Type Testing of Reciprocating I.C. Engines

## 2.1 General

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

## 2.2 Objectives

2.2.1 The type testing, documented in this Section, 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.

2.2.2 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.

## 2.3 Definitions

2.3.1 The definitions in Appendix 1 are applicable

2.3.2 For the purpose of this Section, the following definitions apply:

Low-Speed Engines means I.C. Engines having a rated speed of less than 300 rpm.

Medium-Speed Engines means I.C Engines having a rated speed of 300 rpm and above, but less than 1400 rpm.

High-Speed Engines means I.C Engines having a rated speed of 1400 rpm or above.

## 2.4 Validity

2.4.1 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 manufacturer or the designer, subject to each place of manufacture being found to be acceptable to IRS.

2.4.2 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. Separate type tests may be required for the V-version, depending on case-to-case basis. 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.

2.4.3 Engine rating

2.4.3.1 The engine is type approved up to the 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 2.4.3.2 and 2.4.3.3. The new type test may be performed as an Extended Factory Acceptance Test as described in 2.4.4 if accepted by IRS.

2.4.3.2 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.

2.4.3.3 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
- 10% of the mean effective pressure, or
- 10% of the rpm

2.4.4 Power increase based on an Extended Factory Acceptance Test

If an engine has been design approved, and internal testing per Stage A is 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.

2.4.5 Design update

2.4.5.1 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.

2.4.5.2 The test program is subject to approval by IRS. The Surveyor’s attendance is to be agreed on in each case.

### 2.5 Test programme

2.5.1 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 IRS or stipulated by the designer are to be presented to IRS before starting stage B.

.2 Stage B - witnessed tests.
This is the testing made in the presence of attending Surveyors.

.3 Stage C - component inspection.
This is the inspection of engine parts to the extent as required on case-to-case basis.

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

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

2.5.4 Upon completion of all type testing (stage A through C), a type test report is to be submitted to IRS 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 IRS.

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

- inspection results from stage C.

### 2.6 Measurements and recordings

2.6.1 During all testing the ambient environmental test conditions (air temperature, air pressure and humidity) are to be recorded.

2.6.2 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 Section 4 and Part 5, Chapter 22 of the Main Rules)

- Fuel command/Fuel index or equivalent reading e.g. fuel rack position

- Turbocharger speed(to the extent that monitoring is required in Section 4)

- All engine parameters that are required for control and monitoring for the intended use (propulsion, auxiliary, emergency)

- 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.

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

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

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

### 2.7 Stage A - internal tests

2.7.1 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 values are to be recorded.

2.7.2 Safety tests

Safety tests according to 2.8.2 are to be carried out.

2.7.3 Functional tests

Functional tests according to 2.8.3 are to be carried out.

2.7.4 Integration tests of sub-systems

Integration tests according to 2.8.4 are to be carried out.

2.7.5 Load tests

Applicable load points according to 2.8.5 are to be tested and recorded.

2.7.6 Endurance test for high-speed engines

2.7.6.1 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 2.4.3.

2.7.6.2 The 100 hours test may include the load tests (see 2.7.5) and the load cycles tests (see 2.7.7), deemed necessary by the engine designer.

2.7.7 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.

2.7.8 Specific tests required by IRS

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

**2.8 Stage B - witnessed tests**

2.8.1 The tests listed below are to be carried out in the presence of Surveyor. The achieved results are to be recorded and signed by the attending Surveyor after the type test is completed. The safety tests in 2.8.2 are to be performed before the other relevant tests in 2.8.2 and 2.8.5.

2.8.2 Safety tests

2.8.2.1 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.

2.8.2.2 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

2.8.3 Functional tests

2.8.3.1 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 is to 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 Part 4, Chapter 4, Section 4, 4.7 of the Main Rules are to be carried out.

2.8.3.2 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 engines. The test is to 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 is to be at the lower limit of the intended operation field according to the designer's specification.

2.8.4 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 is to 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 IRS.

Note: The integration test requirements of sub-system may be specified by IRS.

2.8.5 Load tests

2.8.5.1 The engine is to be operated according to the power and speed diagram (see Figure 2.8.5 and Table 2.8.5). The data to be measured and recorded when testing the engine at the various load points have to include all engine parameters listed in 2.6. 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.

2.8.5.2 Sub-systems are to be in operation during the load test as intended 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 is to 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.

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

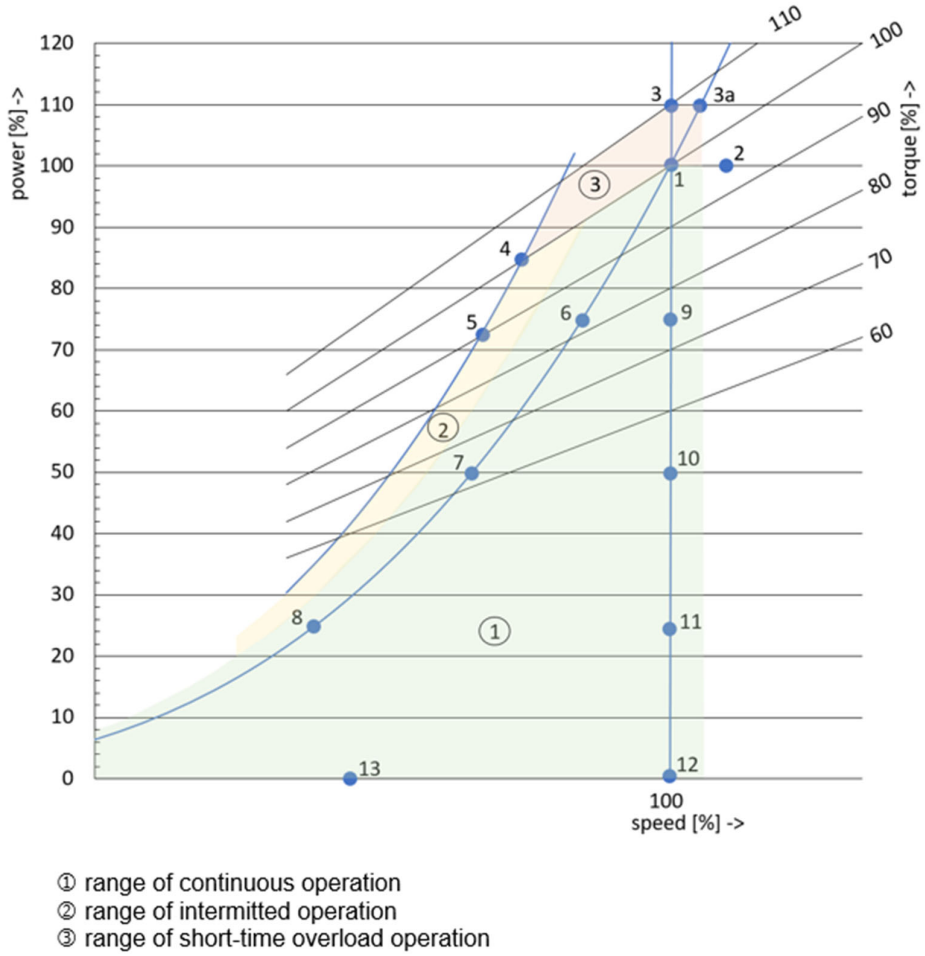



**Fig.2.8.5 : Load points**

| Table 2.8.5 : Load Points | | | | | |
|---|---|---|---|---|---|
| **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<br>3a | 110<br>110 | 100<br>103.2 | | maximum permissible torque [1]<br>for constant speed applications or<br>for propeller curve applications | 0.5<br>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 |

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 2.8.5.1

2.8.6 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 Thermoscanning Equipment. Equivalent measurement equipment

may be used when so approved by IRS. Readings obtained are to be randomly verified by use of contact thermometers.

### 2.9 Stage C - Opening up for Inspections

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

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

2.9.3 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.)

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

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

2.9.6 If deemed necessary by the Surveyor, further dismantling of the engine may be required.

# Section 3

# Certification of Engine Components

## 3.1 General

3.1.1 The engine manufacturer is to have a quality control system that is suitable for the actual engine types to be certified by IRS. The quality control system is also to apply to any sub-suppliers. IRS reserves the right to review the system or parts thereof. Materials and components are to be produced in compliance with all the applicable production and quality instructions specified by the engine manufacturer. IRS requires that certain parts are verified and documented by means of Society Certificate (SC), Work Certificate (W) or Test Report (TR).

3.1.2 Society Certificate (SC)

This is a document issued by IRS stating:

- conformity with Rule requirements.
- that the tests and inspections have been carried out on the finished certified component itself, or on samples taken from earlier stages in the production of the component, when applicable.
- that the inspection and tests were performed in the presence of the Surveyor or in accordance with special agreements, i.e. Alternative Certification Scheme (ACS).

3.1.3 Work's Certificate (W)

This is a document signed by the manufacturer stating:

- conformity with requirements.
- that the tests and inspections have been carried out on the finished certified component itself, or on samples taken from earlier stages in the production of the component, when applicable.
- that the tests were witnessed and signed by a qualified representative of the applicable department of the manufacturer.

A Work's Certificate may be considered equivalent to a Society Certificate and endorsed by IRS if:

- the test was witnessed by IRS Surveyor; or
- an ACS agreement is in place between IRS and the manufacturer or material supplier; or
- the Work's certificate is supported by tests carried out by an accredited third party that is accepted by IRS and independent from the manufacturer and/or material supplier.

3.1.4 Test Report (TR)

This is a document signed by the manufacturer stating:

- conformity with requirements.
- that the tests and inspections have been carried out on samples from the current production batch.

3.1.5 The documents above are used for product documentation as well as for documentation of single inspections such as crack detection, dimensional check, etc. If agreed to by IRS, the documentation of single tests and inspections may also be arranged by filling in results on a control sheet following the component through the production.

3.1.6 The Surveyor is to review the TR and W for compliance with the agreed or approved specifications. SC means that the Surveyor also witnesses the testing, batch or individual, unless an ACS provides other arrangements.

3.1.7 The manufacturer is not exempted from responsibility for any relevant tests and inspections of those parts for which documentation is not explicitly requested by IRS. The manufacturing process and equipment is to be set up and maintained in such a way that all materials and components can be consistently produced to the required standard. This includes production and assembly lines, machining units, special tools and devices, assembly and testing rigs as well as all lifting and transportation devices.

### 3.2 Parts to be documented

3.2.1 The extent of parts to be documented depends on the type of engine, engine size and criticality of the part.

3.2.2 Symbols used are listed in Table 3.2.2 (a). A summary of the required documentation for the engine components is listed in Table 3.2.2 (b).

3.2.3 Components and materials not specified in Table 3.2.2(b), will be specially considered based upon full details being submitted by manufacturer and reviewed.

3.2.4 In addition to those components specified in 3.2.2, the engine components listed in Table 3.2.4 for reciprocating internal combustion engines fuelled by natural gas are to be documented.

**Table 3.2.2 (a) : Symbols used in Table 3.2.2 (b)**

| Symbol | Description |
|---|---|
| C | chemical composition |
| CD | crack detection by MPI or DP |
| CH | crosshead engines |
| D | cylinder bore diameter (mm) |
| GJL | gray cast iron |
| GJS | spheroidal graphite cast iron |
| GS | cast steel |
| M | mechanical properties |
| SC | society certificate |
| TR | test report |
| UT | ultrasonic testing |
| W | work certificate |
| X | visual examination of accessible surfaces by the Surveyor |

| Table 3.2.2 (b) : Summary of required documentation for engine components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **Part [4), 5), 6), 7),8)]** | **Material properties [1)]** | **Non-destructive examination [2)]** | **Hydraulic testing [3)]** | **Dimensional inspection, including surface condition** | **Visual inspection (surveyor)** | **Applicable to engines:** | **Component certificate** |
| **1** | **Welded bedplate** | W(C+M) | W(UT+CD) | | | fit-up + post-welding | All | SC |
| **2** | **Bearing transverse girders GS** | W(C+M) | W(UT+CD) | | | X | All | SC |
| **3** | **Welded frame box** | W(C+M) | W(UT+CD) | | | fit-up + post-welding | All | SC |
| **4** | **Cylinder block GJL** | | | W[10)] | | | >400 kW/cyl | |
| **5** | **Cylinder block GJS** | | | W[10)] | | | >400 kW/cyl | |
| **6** | **Welded cylinder frames** | W(C+M) | W(UT+CD) | | | fit-up + post-welding | CH | SC |
| **7** | **Engine block GJL** | | | W[10)] | | | >400 kW/cyl | |
| **8** | **Engine block GJS** | W(M) | | W[10)] | | | >400 kW/cyl | |
| **9** | **Cylinder liner** | W(C+M) | | W[10)] | | | D>300mm | |
| **10** | **Cylinder head GJL** | | | W | | | D>300mm | |
| **11** | **Cylinder head GJS** | | | W | | | D>300mm | |
| **12** | **Cylinder head GS** | W(C+M) | W(UT+CD) | W | | X | D>300mm | SC |
| **13** | **Forged cylinder head** | W(C+M) | W(UT+CD) | W | | X | D>300mm | SC |
| **14** | **Piston crown GS** | W(C+M) | W(UT+CD) | | | X | D>400mm | SC |
| **15** | **Forged piston crown** | W(C+M) | W(UT+CD) | | | X | D>400mm | SC |
| **16** | **Crankshaft: made in one piece** | SC(C+M) | W(UT+CD) | | W | Random, of fillets and oil bores | All | SC |

**Table 3.2.2 (b) : (Contd.)**

| Item | Part [4), 5), 6), 7),8)] | Material properties [1)] | Non-destructive examination [2)] | Hydraulic testing [3)] | Dimensional inspection, including surface condition | Visual inspection (surveyor) | Applicable to engines: | Component certificate |
|---|---|---|---|---|---|---|---|---|
| **17** | **Semi-built Crankshaft(Crankthrow, forged main journal and journals with flange)** | SC(C+M) | W(UT+CD) | | W | Random, of fillet and shrink fittings | All | SC |
| **18** | **Exhaust gas valve cage** | | | W | | | CH | |
| **19** | **Piston rod** | SC(C+M) | W(UT+CD) | | | Random | D>400mm CH | SC |
| **20** | **Cross head** | SC(C+M) | W(UT+CD) | | | Random | CH | SC |
| **21** | **Connecting rod with cap** | SC(C+M) | W(UT+CD) | | W | Random, of all surfaces, in particular those shot peened | All | SC |
| **22** | **Coupling bolts for crankshaft** | SC(C+M) | W(UT+CD) | | W | Random, of interference fit | All | SC |
| **23** | **Bolts and studs for main bearings** | W(C+M) | W(UT+CD) | | | | D>300mm | |
| **24** | **Bolts and studs for cylinder heads** | W(C+M) | W(UT+CD) | | | | D>300mm | |
| **25** | **Bolts and studs for connecting rods** | W(C+M) | W(UT+CD) | | TR of thread making | | D>300mm | |
| **26** | **Tie rod** | W(C+M) | W(UT+CD) | | TR of thread making | Random | CH | SC |

**Table 3.2.2 (b) : (Contd.)**

| Item | Part [4), 5), 6), 7),8)] | Material properties [1)] | Non-destructive examination [2)] | Hydraulic testing [3)] | Dimensional inspection, including surface condition | Visual inspection (surveyor) | Applicable to engines: | Component certificate |
|---|---|---|---|---|---|---|---|---|
| **27** | **High pressure fuel injection pump body** | W(C+M) | | W | | | D>300mm | |
| | | W(C+M) | | TR | | | D≤300mm | |
| **28** | **High pressure fuel injection valves (only for those not autofretted)** | | | W | | | D>300mm | |
| | | | | TR | | | D≤300mm | |
| **29** | **High pressure fuel injection pipes including common fuel rail** | W(C+M) | | W for those that are not autofretted | | | D>300mm | |
| | | W(C+M) | | TR for those that are not autofretted | | | D≤300mm | |
| **30** | **High pressure common servo oil system** | W(C+M) | | W | | | D>300mm | |
| | | W(C+M) | | TR | | | D≤300mm | |
| **31** | **Cooler, both sides[9)]** | W(C+M) | | W | | | D>300mm | |

**Table 3.2.2 (b) : (Contd.)**

| Item | Part [4), 5), 6), 7),8)] | Material properties [1)] | Non-destructive examination [2)] | Hydraulic testing [3)] | Dimensional inspection, including surface condition | Visual inspection (surveyor) | Applicable to engines: | Component certificate |
|---|---|---|---|---|---|---|---|---|
| **32** | **Accumulator** | W(C+M) | | W | | | All engines with accumulators with a capacity of >0.5 l | |
| **33** | **Piping, pumps, actuators, etc. for hydraulic drive of valves, if applicable** | W(C+M) | | W | | | >800 kW/cyl | |
| **34** | **Engine driven pumps (oil, water, fuel, bilge) other than pumps referred to in item 27 and 33** | | | W | | | >800 kW/cyl | |
| **35** | **Bearings for main, crosshead, and crankpin** | TR(C) | TR (UT for full contact between base material and bearing metal) | | W | | >800 kW/cyl | |

**Table 3.2.2 (b) : (Contd.)**

**Notes** :

1. Material properties include:
   - chemical composition;
   - mechanical properties, and also;
   - surface treatment such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force).

2. Non-destructive examination means e.g. ultrasonic testing, crack detection by MPI or DP. When certain NDE method on the finished component is impractical (for example UT for items 12/13), the NDE method can be performed at earlier appropriate stages in the production of the component, see 3.1.2.

3. Hydraulic testing is applied on the water/oil side of the component. Items are to be tested by hydraulic pressure at the pressure equal to 1.5 times the maximum working pressure. High pressure parts of the fuel injection system are to be tested by hydraulic pressure at the pressure equal to 1.5 maximum working pressure or maximum working pressure plus 300 bar, whichever is the less. Where design or testing features may require modification of these test requirements, special consideration may be given.

4. Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this Table apply except where alternative requirements are explicitly given elsewhere in the Rules.

5. For turbochargers, see Section 4.

6. Crankcase explosion relief valves are to be type tested in accordance with Classification Note: “Type testing procedure for Crankcase Explosion Relief Valves” and documented according to Pt.4/Ch.4 of the Rules.

7. Oil mist detection systems are to be type tested in accordance with Classification Note: “Type testing procedure for Crankcase Oil Mist Detection and Alarm Equipment” and documented according to Pt.4/Ch.4 of the Rules.

8. For speed governor and over-speed protective devices, see Pt 4/ Ch4/ Sec.4 of the Rules.

9. Charge air coolers need only be tested on the water side.

10. Hydraulic testing is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

**Table 3.2.4 : Required documentation for engine components of reciprocating internal combustion engines fuelled by natural gas**

| Part | Material properties | Non-destructive examination | Pressure testing | Visual inspection of welds | Component certificate |
|---|---|---|---|---|---|
| Gas pipe Low-pressure double walled | W(C+M) | W 2), 6) | W 4) | X | |
| Single walled Gas pipes | W(C+M) | W 1) | W 4) | X | SC |
| High-pressure gas pipes | W(C+M) | W 1) | W 4) | X | SC |
| Secondary enclosure for gas pipes | W(C+M) | W 2) | W 3) | X | |
| Gas pipe Low-pressure, Flanges* | W(C+M) | W 2), 6) | | X | |
| Gas pipe High-pressure, Flanges* | W(C+M) | W 1) | | X | SC |
| Gas pipe Low-pressure, Fittings and other components | W(C+M) | | W 4) | X | |
| Gas pipe High-pressure, Fittings and other components | W(C+M) | | W 4) | X | SC |
| Gas pipe Low-pressure Bodies of valves, 7) | W(C+M) | | W 4) | | |
| Gas pipe High-pressure Bodies of valves | W(C+M) | | W 4) | | SC |
| Gas venting pipes and flanges*, build up pressure less than 5.0bar | TR(C+M) | W 2) | W 4) | X | |
| Gas venting pipes and flanges*, build up pressure at 5.0bar or more with secondary enclosure | TR(C+M) | W 2) | W 4) | X | |
| Gas venting pipes and flanges*, build up pressure at 5.0bar or more | W(C+M) | W 1) | W 4) | X | SC |
| Gas venting pipes Secondary enclosure | | | W 5) | X | |

**Footnotes:**

1) 100 % radiographic or ultrasonic inspection of all butt-welded joints (Pt.5, Ch.35, Sec.15, 16.6.3.1)
2) 10 % radiographic or ultrasonic inspection of butt-welded joints (Pt.5, Ch.35, Sec.16, 16.6.3.4)
3) In ventilated double wall piping systems the outer pipe is to be pressure tested at the design pressure calculated in accordance with part 5, Chapter 35, Section 9, 9.8.1 or 9.8.2 of the Main Rules. . In pressurized double wall piping systems the outer pipe or duct is to be pressure tested at 1.5 x the design pressure of the outer pipe or duct. Refer to Part 4, Chapter 4, Section 4, 4.13.4.3.1.
4) Pressure test at 1.5 x design pressure
5) Leak test.
6) If inside diameter > 75 mm or wall thickness > 10 mm: 100 % radiographic or ultrasonic inspection of all butt-welded joints (Pt.5, Ch.35, Sec.16, 16.6.3.1)
7) If nominal diameter > 25 mm

(*) “Flanges” limited to the final connection to the engine.

# Section 4

# Turbochargers

## 4.1 Scope

4.1.1 These requirements are applicable for turbochargers with regard to design approval, type testing and certification and their matching on engines.

Turbochargers are to be type approved, either separately or as a part of an engine. The requirements are written for exhaust gas driven turbochargers, but apply in principle also for engine driven chargers.

4.1.2 The requirements escalate with the size of the turbochargers. The parameter for size is the engine power (at MCR) supplied by a group of cylinders served by the actual turbocharger, (e.g. for a V-engine with one turbocharger for each bank the size is half of the total engine power).

4.1.3 Turbochargers are categorised in three groups depending on served power by cylinder groups with:

- Category A: ≤ 1000 [kW]
- Category B: > 1000 [kW] and ≤ 2500 [kW]
- Category C: > 2500 [kW

## 4.2 Documentation to be submitted

4.2.1 Category A:

On request

- Containment test report.
- Cross sectional drawing with principal dimensions and names of components.
- Test program.

4.2.2 Category B and C:

- Cross sectional drawing with principal dimensions and materials of housing components for containment evaluation.
- Documentation of containment in the event of disc fracture, see 4.3.2.
- Operational data and limitations as:
- Maximum permissible operating speed (rpm)
  - Alarm level for over-speed
  - Maximum permissible exhaust gas temperature before turbine
  - Alarm level for exhaust gas temperature before turbine
  - Minimum lubrication oil inlet pressure
  - Lubrication oil inlet pressure low alarm set point

- Maximum lubrication oil outlet temperature
- Lubrication oil outlet temperature high alarm set point
- Maximum permissible vibration levels, i.e. self- and externally generated vibration

(Alarm levels may be equal to permissible limits but shall not be reached when operating the engine at 110% power or at any approved intermittent overload beyond the 110%.)

- Arrangement of lubrication system, all variants within a range.
- Type test reports.
- Test program.

4.2.3 Category C:

- Drawings of the housing and rotating parts including details of blade fixing.
- Material specifications (chemical composition and mechanical properties) of all parts mentioned above.
- Welding details and welding procedure of above mentioned parts, if applicable.
- Documentation*) of safe torque transmission when the disc is connected to the shaft by an interference fit, see 4.3.3.
- Information on expected lifespan, considering creep, low cycle fatigue and high cycle fatigue.
- Operation and maintenance manuals*).

*) Applicable to two sizes in a generic range of turbochargers.

**4.3 Design requirements and corresponding type testing**

4.3.1 General

4.3.1.1 The turbochargers are to be designed to operate under conditions given in Part 4, Chapter 1, Cl 1.7 of IRS Rules and Regulations for the Construction and Classification of Steel Ships. The component lifetime and the alarm level for speed are to be based on 45°C air inlet temperature.

4.3.1.2 The air inlet of turbochargers is to be fitted with a filter.

4.3.2 Containment

4.3.2.1 Turbochargers are to fulfill containment in the event of a rotor burst. This means that at a rotor burst no part may penetrate the casing of the turbocharger or escape through the air intake. For documentation purposes (test/calculation), it is to be assumed that the discs disintegrate in the worst possible way.

4.3.2.2 For category B and C, containment is to be documented by testing. Fulfillment of this requirement can be awarded to a generic range of turbochargers based on testing of one specific unit. Testing of a large unit is preferred as this is considered conservative for all smaller units in the generic range. In any case, it is to be documented (e.g. by calculation) that the selected test unit really is representative for the whole generic range.

4.3.2.3 The minimum test speeds, relative to the maximum permissible operating speed, are:

- For the compressor: 120%.
- For the turbine: 140% or the natural burst speed, whichever is lower.

4.3.2.4 Containment tests are to be performed at a temperature which is not lower than the maximum allowable temperature of the turbocharger to be specified by the manufacturer.

4.3.2.5 Manufacturers are to determine whether cases more critical than those defined in 4.3.2.3. and 4.3.2.4 exist with respect to containment safety. Where such a case is identified, evidence of containment safety shall also be provided for that case.

4.3.2.6 A numerical analysis simulation such as Finite Element Method (FEM) of sufficient containment integrity of the casing based on calculations by means of a simulation model may be accepted in lieu of the practical containment test, provided that:

- The numerical simulation model has been tested 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.

- The corresponding numerical simulation for the containment is performed for the same speeds as specified for the containment test.

- 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.

- The design of the turbocharger regarding geometry and kinematics is to be similar to the turbocharger that was used for the reference containment test.

4.3.2.7 In cases where a totally new design[1]) is adopted for a turbocharger for which an application for type approval certification has been requested, new reference containment tests are to be performed.

**Note 1**: A totally new design means the principal differences between a new turbocharger and previous ones are related to geometry and kinematics. The turbochargers are to be regarded as having a totally new design if the structure and/or material of the turbocharger casings are changed, or any of, but not limited to, the following items are changed from the previous design:

- Maximum permissible exhaust gas temperature
- Number of bearings
- Number of turbine blades
- Number of turbine wheels and/or compressor wheels
- Direction of inlet air and/or exhaust gas (e.g., axial flow orientation, radial flow orientation)
- Type of the turbocharger drive (e.g., axial turbine type, radial turbine type, mixed flow turbine type)

4.3.3 Disc-shaft shrinkage fit

4.3.3.1 Applicable to Category C

4.3.3.2 In cases where the disc is connected to the shaft with 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.

4.3.4 Type testing

4.3.4.1 Applicable to Categories B and C

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

4.3.4.3 Turbochargers for the low, medium, and high-speed engines 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 Section 2.

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

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

4.3.4.6 The type test is to be completed by a hot running test at maximum permissible speed combined with maximum permissible temperature for at least one hour. After this test, the turbocharger is to be opened for examination, with focus on possible rubbing and the bearing conditions.

4.3.4.7 The extent of the surveyor's presence during the various parts of the type tests would be subject to agreement between the manufacturer and IRS.

**4.4 Certification**

4.4.1 The manufacturer is to adhere to a quality system designed to ensure that the designer's specifications are met, and that manufacturing is in accordance with the approved drawings.

4.4.2 For category C, this is to be verified by means of periodic product audits of an Alternative Certification Scheme (ACS), as detailed in Pt.1, Ch.1, Sec.1 of the Rules for Construction and Classification of Steel Ships.

4.4.3 These audits are to focus on:

- Chemical composition of material for the rotating parts.
- Mechanical properties of the material of a representative specimen for the rotating parts and the casing.
- UT and crack detection of rotating parts.
- Dimensional inspection of rotating parts.
- Rotor balancing.
- Hydraulic testing of cooling spaces to 4 bars or 1.5 times maximum working pressure, whichever is higher.
- Overspeed test of all compressor wheels for duration of 3 minutes at either 20% above alarm level speed at room temperature or 10% above alarm level speed at 45°C inlet temperature when tested in the actual housing with the corresponding pressure ratio. The over-speed test may be waived for forged wheels that are individually controlled by an approved non-destructive method.

4.4.4 Turbochargers are to be delivered with:

- For category C, an IRS certificate; which -as a minimum cites the applicable type approval and the ACS, when ACS applies.
- For category B, a work's certificate; which -as a minimum cites the applicable type approval, which includes production assessment.

4.4.5 The same applies to replacement of rotating parts and casing.

4.4.6 Alternatively to the above periodic product audits, individual certification of a turbocharger and its parts would be subject to agreement between the manufacturer and IRS. However, such individual certification of category C turbocharger and its parts is also to be based on test requirements specified in the above mentioned bullet points.

### 4.5 Alarms & Monitoring

4.5.1 For all turbochargers of Categories B and C, indications and alarms as listed in the table below are required to be provided.

4.5.2 Indications may be provided at either local or remote locations.

**Table 4.5.1 : Indications and Alarms**

| Pos. | Monitored Parameters | Category of Turbochargers | | | | Notes |
|---|---|---|---|---|---|---|
| | | B | | C | | |
| | | Alarm | Indication | Alarm | Indication | |
| 1 | Speed | High (4) | X (4) | High (4) | X (4) | |
| 2 | Exhaust gas at each turbocharger inlet, temperature | high (1) | X (1) | high | X | High temp. alarms for each cylinder at engine is acceptable (2) |
| 3 | Lub. oil at turbocharger outlet, temperature | | | high | X | If not forced system, oil temperature near bearings |
| 4 | Lub. oil at turbocharger inlet, pressure | low | X | low | X | Only for forced lubrication systems (3) |

Notes:

(1) For Category B turbochargers, the exhaust gas temperature may be alternatively monitored at the turbocharger outlet, provided that the alarm level is set to a safe level for the turbine and that correlation between inlet and outlet temperatures is substantiated.

(2) Alarm and indication of the exhaust gas temperature at turbocharger inlet may be waived if alarm and indication for individual exhaust gas temperature is provided for each cylinder and the alarm level is set to a value safe for the turbocharger.

(3) Separate sensors are to be provided if the lubrication oil system of the turbocharger is not integrated with the lubrication oil system of the diesel engine or if it is separated by a throttle or pressure reduction valve from the diesel engine lubrication oil system.

(4) On turbocharging systems where turbochargers are activated sequentially, speed monitoring is not required for the turbocharger(s) being activated last in the sequence, provided all turbochargers share the same intake air filter and they are not fitted with waste gates.

# Section 5

# Dual Fuel and Gas Fuel Engines

## 5.1 Scope

5.1.1 Types of Engines

5.1.1.1 The following requirements are applicable to marine reciprocating internal combustion engines supplied with gases or low-flashpoint fuels. Engines can be either dual fuel (hereinafter referred to as DF engines) or gas fuel only engines (hereinafter referred to as GF engines), or any variations thereof including fuel sharing (variable fuel oil / gas ratio) capability.

5.1.1.2 The fuels covered by this section include the following fossil, bio or synthetic variants of:

- Natural gas (predominantly methane)
- Ethane
- LPG (predominantly mixes of propane and butane)
- Methyl/ethyl alcohols (methanol/ethanol)

## 5.2 Documents and drawings to be submitted

5.2.1 In addition to the documents in Section 1.1, the following documents are to be submitted for the approval of DF and GF engines:

**Table 5.2.1: Documents and drawings to be submitted for approval of DF and GF engines**

| No. | Item |
|---|---|
| 1 | Schematic layout or other equivalent documents of gas system on the engine |
| 2 | Gas piping system, assembly and details (including double-walled arrangement where applicable)[3] |
| 3 | Parts for gas admission system, assembly and details (including sealing systems where applicable)[3] |
| 4 | Arrangement of explosion relief valves (crankcase[1], charge air manifold, exhaust gas manifold and exhaust gas system on the engine) as applicable |
| 5 | List of certified safe equipment and evidence of relevant certification |
| 6 | Safety concept[4] |
| 7 | Report of the risk analysis[2] (for information) |
| 8 | Gas specification(s) (for information) |
| | |
| **Documents and drawings to be submitted for the approval of DF engine** | |
| 9 | Schematic layout or other equivalent documents of pilot fuel systems |
| 10 | Shielding of high pressure fuel pipes for pilot fuel system, assembly |
| 11 | High pressure parts for pilot fuel oil injection system[3] |
| | |
| **Documents and drawings to be submitted for the approval of GF engine** | |
| 12 | Schematic layout or other equivalent documents of the ignition system |
| | |

**Notes** :

1. If required by Section 1.1, also refer Pt.4, Ch.4, 4.13.4.6 of the *Rules and Regulations for the Construction and Classification of Steel Ships.*

| |
|---|
| 2. See 5.3<br>3. The documentation to contain specification of design pressures, working pressure, pipe dimensions and materials.<br>4 See 5.4. |

5.2.2 IRS may request further documents/ drawings to be submitted, where considered necessary.

**5.3 Risk Analysis**

5.3.1 Scope of the risk analysis

5.3.1.1 The risk analysis is to address:

- a failure or malfunction of any system or component involved in the gas operation of the engine
- a gas leakage downstream of the double block and bleed valves (for methyl/ethyl alcohol fuels downstream of the remote operated shut-off valve required by 9.6.5 of IRS Guidelines on Methanol Fueled Vessels)
- the safety of the engine in case of emergency shutdown or blackout, when running on gas
- the inter-actions between the gas fuel system and the engine.

**Note**: With regard to the scope of the risk analysis it is to be noted that failures in systems external to the engine, such as gas storage or gas supply systems, may require action from the engine control and monitoring system in the event of an alarm or fault condition. Conversely failures in these external systems may, from the vessel perspective, require additional safety actions from those required by the engine limited risk analysis required by this Section. Such actions are to be detailed in the engine safety concept.

5.3.2 Form of the risk analysis

5.3.2.1 The risk analysis is to be carried out in accordance with IEC 31010:2019: Risk management - Risk assessment techniques, or other recognized standards.

5.3.2 The required analysis is to be based on the single failure concept, which means that only one failure needs to be considered at the same time. Both detectable and non-detectable failures are to be considered. Consequences failures, i.e. failures of any component directly caused by a single failure of another component, are also to be considered.

5.3.3 Procedure for the risk analysis

5.3.3.1 The risk analysis is to:

a) Identify all the possible failures in the concerned equipment and systems which could lead to:

(i) the presence of gas in components or locations not designed for such purpose, and/or

(ii) ignition, fire, explosion or toxic release (for methanol engines).

b) Evaluate the consequences (also refer Pt.4, Ch.4, 4.13.4.1.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*)

c) Where necessary, identify the failure detection method

d) Where the risk cannot be eliminated, identify the corrective measures:

(i) in the system design, such as:

- redundancies
- safety devices, monitoring or alarm provisions which permit restricted operation of the system

(ii) in the system operation, such as:

- initiation of the redundancy
- activation of an alternative mode of operation.

5.3.3.2 The results of the risk analysis are to be documented.

5.3.4 Equipment and systems to be analyzed

5.3.4.1 The risk analysis required for engines is to cover at least the following aspects:

a) failure of the gas-related systems or components, in particular:

- gas piping and its enclosure, where provided
- gas admission valves and sealing systems, as applicable

(**Note**: Failures of the gas supply components not located directly on the engine, such as block-and-bleed valves and other components of the gas supply system, are not to be considered in the analysis, unless within the scope of supply, or specification, of the engine designer and are integral to the engine safety concept.)

b) failure of the ignition system (pilot fuel injection, spark plugs, glow plugs)

c) failure of the air to fuel ratio control system (charge air by-pass, gas pressure control valve, etc.)

d) for engines where gas is supplied upstream of the turbocharger compressor, failure of a component likely to result in a source of ignition (hot spots)

e) failure of the gas combustion or abnormal combustion (misfiring, knocking)

f) failure of the engine monitoring, control and safety systems

**Note**: Where engines incorporate electronic control systems, a failure mode and effects analysis (FMEA) is to be carried out in accordance with Footnote 5 of Table 1 in Section 1.1.

g) presence of gas in engine components (e.g. air inlet manifold or scavenge space and exhaust manifold) and in the external systems connected to the engines (e.g. exhaust duct, cooling water system, hydraulic oil system, etc.).

h) changes of operating modes for DF engines.

i) hazard potential for crankcase fuel gas accumulation, for trunk-piston engines, refer to Pt. 5, Ch. 35, Sec. 10, 10.3.1.2 and Pt.4, Ch.4, Sec.4, 4.6 of the *Rules and Regulations for the Construction and Classification of Steel Ships.*

j) risk of crankcase explosion in connection with active crankcase ventilation which produces a flow of external air into the crankcase, (see Pt.4, Ch.4, Sec.4, 4.6 of the *Rules and Regulations for the Construction and Classification of Steel Ships*).

**5.4 Safety concept**

5.4.1 Scope and general content of the safety concept

.1 The safety concept is to describe the DF or GF arrangements of the engine and how the risks of using the gas or low-flashpoint fuel are mitigated, including any specific instructions to be included in the maintenance and operation manuals.

.2 The document is to identify the safety philosophy of the engine design and describe how the risks associated with the fuel are controlled under reasonably foreseeable abnormal conditions as well as possible failure scenarios and their control measures.

.3 To support understanding of the safety philosophy, the document is to describe the established safety concepts, including, but not limited to:

- combustion control;
- operating modes;
- double barriers including ventilation air requirements;
- gas leakage detection;
- sealing systems;
- safety valve arrangements;
- fuel supply system purging and draining philosophy;
- crankcase venting arrangements;
- crankcase or piston underside space monitoring of gas accumulation;
- electrical equipment specifications including the necessity of using certified safe equipment;
- required monitoring, control and safety actions related to fuel supply systems, covering double block and bleed and master gas valve actions;
- fuel supply system specifications and engine control and safety system interaction;
- nitrogen purging and venting systems;
- fuel return/vent treatment equipment;
- off-engine exhaust system explosion relief devices;
- off-engine exhaust system fan purging; and
- auxiliary system specifications and monitoring.

5.4.2 Additional content of the safety concept

.1 The results of the risk analysis, see 5.3, are to be reflected in the safety concept.

.2 A detailed evaluation regarding the hazard potential of overpressure in crankcases, air inlet manifolds, scavenge spaces and exhaust systems, including potential of injury from a possible explosion and/or toxic release, and including how crankcase overpressure or fault condition is to be monitored, is to be carried out and reflected in the safety concept of the engine. Refer to Part 4, Chapter 4, Section 4, 4.13.4.5.

.3 Information regarding the crankcase ventilation and monitoring arrangements. Refer to Part 4, Chapter 4, Section 4, 4.13.4.6.3.

.4 Details regarding any single cylinder cut off functionality in gas mode operation. Refer to Part 4, Chapter 4, Section 4, 4,13.4.8 and 4.13.5.2.1.

.5 As applicable, information regarding potential gas leaks from pre-mixed engines. The safety concept is to consider the need for flame arresters before each cylinder. Refer to Part 4, Chapter 4, Section 4, 4.13.5.3.1.

.6 As applicable, information regarding possible gas accumulation in scavenge spaces and/or failure of piston rod stuffing box. Refer to Part 4, Chapter 4, Section 4, 4.13.5.4.

.7 The safety concept is to clearly identify the equipment that is part of the engine and fuel supply safety philosophy but is not within the scope of supply, or boundary, of the base engine. The equipment may be installed by (and are the responsibility of) third parties or integrators such as ship designers and shipyards. Exhaust system explosion relief valves and auxiliary system gas detection are examples.

.8 Actions required of, or affecting, the engine control and monitoring system from equipment outside of the base engine, such as fuel gas storage or fuel gas supply systems, are to be detailed in the engine safety concept.

.9 The safety concept is to demonstrate how the requirements of this Section and the additional requirements of the Part 5, Chapter 4 and Chapter 35 of the Main Rules are complied with, including how any applicable goals and functional requirements are satisfied. Where deviations or alternatives from the prescribed requirements exist, or conflicts exist between the Part 5, Chapter 4 and Chapter 35 of the Main Rules requirements, the arrangements are to be justified by the safety concept.

Note: Deviations from the statutory requirements are to be agreed with the flag Administration on a case-by-case basis.

**5.5 Design Requirements**

5.5.1 General Principles

.1 The manufacturer is to declare the allowable gas composition limits for the engine and, as applicable, the minimum and maximum methane number.

.2 Components containing or likely to contain gas are to be designed to:

a) minimize the risk of fire and explosion so as to demonstrate an appropriate level of safety commensurate with that of an oil-fueled engine;

b) mitigate the consequences of a possible explosion to a level providing a tolerable degree of residual risk, due to the strength of the component(s) or the fitting of suitable explosion relief devices of an approved type.

The strength of the component(s) of arrangement of explosion relief devices are to be documented (e.g., as part of the safety concept/ risk analysis) or otherwise demonstrated to be sufficient for a worst-case explosion.

Also refer to Pt. 5, Ch. 35, Sec. 10, 10.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

.3. Discharge from explosion relief devices is to prevent the passage of flame to the machinery space and be arranged such that the discharge does not endanger personnel or damage other engine components or systems. For methanol engines, where discharges may pose a risk due to toxicity, such releases are to be documented by the safety concept and considered by the risk analysis.

5.5.2 Specific design requirements for gas piping, charge air system, exhaust system, inerting of engine crankcase, gas ignition, control, monitoring and alarms etc. may be referred in Pt.4, Ch. 4, Sec. 4, 4.14 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

**5.6 Type Testing**

5.6.1 Type approval of DF and GF engines is to be carried out in accordance with Section 2, taking into account the additional requirements below:

5.6.2 Type of engine

.1 In addition to the criteria given in Section 1, 1.2.4.2.1, the type of engine is defined by the following:

- gas admission method (cylinder injection after compression stroke, cylinder individual injection before compression stroke or pre-mixed)
- gas admission valve operation (mechanical or electronically controlled)
- ignition system (pilot injection, spark ignition, glow plug or gas self-ignition)
- ignition system (mechanical or electronically controlled)

**Note:** Cylinder-individual injection before compression stroke may be port injection into the air inlet channel before the cylinder inlet valve, injection into the cylinder before or during compression stroke, or similar arrangements.

5.6.3 Safety Precautions

In addition to the safety precautions indicated in Section 2, 2.8.2, measures to verify that gas fuel piping on engine is gas tight are to be carried out prior to start-up of the engine.

5.6.4 Test programme

.1 The type testing of the engine is to be carried out in accordance with Section 2, 2.5, taking into account the additional requirements of this Section.

.2 The influence of the methane number and LHV of the fuel gas is not required to be verified during the Stage B type tests. It is however to be justified by the engine designer through internal Stage A tests or calculations and documented in the type approval test report.

5.6.5 Measurements and records

.1 In addition to the measurements and records required in Section 2, 2.6, the following engine data are to be measured and recorded:

- Each fuel index for gas and diesel as applicable (or equivalent reading)
- Gas pressure and temperature at the inlet of the gas manifold
- Pilot fuel temperature and pressure (supply or common rail as appropriate)
- Gas concentration in the crankcase

**Note:** The gas concentration in the crankcase should normally be measured inside the crankcase or at the crankcase outlet (crankcase vent pipe). Gas concentration measurements may be carried out as part of Stage A if the method and the results are properly documented.

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

5.6.6 Stage A – Internal Tests

.1 In addition to tests required in Section 2, 2.7, the following conditions are to be tested:

- DF engines are to run the load points defined in Section 2, 2.7 in both fuel oil and gas modes (with and without pilot fuel injection in service) as found applicable for the engine type.
- For DF engines with variable fuel oil / gas ratio, the load tests are to be carried out at different ratios between the minimum and the maximum allowable values.
- For DF engines, switch over between fuel oil and gas modes are to be tested at different loads.
- The influence of the methane number and LHV of the gas on the engine's maximum continuous power available in gas mode is to be verified and documented in the type approval test report.

5.6.7 Stage B – Witnessed Tests

5.6.7.1 General

a) Gas engine testing is to be carried out in accordance with the different tests specified in Section 2, 2.8, as applicable.

b) In case of DF engine:

i) all tests are to be run in both oil and gas modes that apply for the engine type as defined by the engine designer. The load tests are to be carried out in fuel oil mode and in gas mode at the different percentages of the engine's applicable MCR.

ii) The independent overspeed protection device has to be tested in fuel oil mode (Section 2, 2.8.2.2).

iii) The operation with damaged turbocharger test required by 2.8.3.2 need only be verified in fuel oil mode.

iv) For engines with variable fuel oil / gas ratio, selected load tests are to be carried out at different ratios between the minimum and the maximum allowable value. The most relevant and critical loads and ratios are to be selected for the test and agreed with IRS before testing.

v) The maximum continuous power available in gas mode (refer Pt.4, Ch.4, Sec.4, 4.13.5.1 of the *Rules and Regulations for the Construction and Classification of Steel Ships*) is to be demonstrated.

vi)) Overload testing is not required in gas mode for DF engines, provided that the engine is designed for automatic changeover to fuel oil mode in case of overload.

Note: Those engines that are designed to operate in gas mode under overload conditions are to be tested at overload condition in gas mode.

5.6.7.2 Functional Tests

.1 In addition to the functional tests required in Section 2, 2.8.3.1, the following tests are to be carried out:

- For DF engines, the lowest specified speed is to be verified in fuel oil mode and gas mode.

- For DF engines, switch over between gas and fuel oil modes are to be tested at different loads.

- For DF engines, verification of automatic changeover to fuel oil mode when the load demand exceeds the maximum continuous power available in gas mode and when load demand leaves the gas mode operation range (refer Pt.4, Ch.4, Sec.4, 4.13.5.1 of the *Rules and Regulations for the Construction and Classification of Steel Ships*)

- As applicable, the gas mode cylinder cut off functionality is to be demonstrated.

- The efficiency of the ventilation arrangement or other approved method of safety (such as inert gas system) of the double walled gas piping system is to be verified.

.2 Engines intended to produce electrical power are to be tested as follows:

- Capability to take sudden load and loss of load in accordance with the provisions of Pt. 4, Ch. 4, 4.7.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*).

- For GF and premixed engines, the influences of LHV, methane number and ambient conditions on the dynamic load response test results are to be theoretically determined and specified in the test report. Referring to the limitations as specified in 5.4.1.2, the margin for satisfying dynamic load response is to be determined.

**Note**:

1. For DF engines, automatic switchover to oil fuel during the test is acceptable.

2. Application of electrical load in more than 2 load steps can be permitted in the conditions specified in Pt. 4, Ch. 4, 4.7.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

5.6.7.3 Integration Tests

.1 GF and DF engines are to undergo integration tests to verify that the response of the complete mechanical, hydraulic and electronic engine system is as predicted for all intended operational modes. The scope of these tests is to be agreed with IRS for selected cases based on the required safety concept, risk analysis and FMEA (see 5.3 and 5.4), and is to at least include the following incidents:

- Failure of ignition (spark ignition or pilot injection systems), both for one-cylinder unit and common system failure

- Failure of a gas admission valve

- Failure of the combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.)

- Abnormal gas pressure

- Abnormal gas temperature

Note: The above tests, as required under 5.6.7.3 for integration tests, may be carried out using simulation or other alternative methods, subject to special consideration by IRS.

5.6.8 Stage C – Component Inspection

.1 Component inspection is to be carried out in accordance with the provisions of Section 2, 2.9. The components to be inspected after the test run are to also include the following:

- gas admission valve including pre-chamber, as applicable
- spark igniter (for GF engines)
- pilot fuel injection valve (for DF engines)

5.6.9 Engine type approval certificate

For DF engines, the maximum continuous power available in gas mode is to be specified on the type approval certificate in addition to the maximum continuous rating in fuel oil mode if differing.

**5.7 Factory Acceptance Trials**

5.7.1 Requirements for factory acceptance trials of DF and GF engines are indicated in Pt.4, Ch. 4, Sec. 4, 4.13.6.2 of the *Rules and Regulations for the Construction and Classification of Steel Ships*.

**5.8 Shipboard Trials**

5.8.1 Requirements for shipboard trials of DF and GF engines are indicated in Pt.4, Ch. 4, Sec. 4, 4.13.6.3 of the *Rules and Regulations for the Construction and Classification of Steel Ships.*

**End of Classification Notes**