

# **CLASSIFICATION NOTES**

**Approval of I.C. Engines**

**July 2016**

**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 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 builder/licensee and IRS's Surveyors.

This document is applicable to any IC engine(s) for which type approval certification is dated on or after 01 July 2016. The "date of application for type approval" is the date of documents accepted by IRS as request for type approval certification of a new engine type or of an engine type that has undergone substantive modifications in respect of the one previously type approved, or for renewal of an expired type approval certificate.

Engines with an existing type approval on 1 July 2016 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 I.C. Engines given in this Classification Notes apply to diesel engines also.

This Classification Note supersedes IRS document "Type Approval Certification Scheme for Machinery Manufactured by Mass Production System".

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# Approval of I.C. Engines

## Section 1

### Documentation

#### 1.1 Scope

This section gives an overview of the type approval and certification process of I.C. Engines. The documents necessary to approve a diesel engine design for conformance to the Rules and for use during manufacture and installation are listed. Further, the document flow between engine designer, IRS Plan Approval Centre, engine builder/licensee and IRS's Surveyors is indicated.

#### 1.2 Definitions

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

#### 1.3 Overview

##### 1.3.1 Approval process

###### 1.3.1.1 Type Approval Certificate

A type approval certificate is to be obtained by the engine designer for each type of engine that is required to be approved. The process details for obtaining a type approval certificate are indicated in 1.4. This process consists of the following:

- drawing and specification approval,
- assessment of conformity of production,
- approval of type testing programme,
- type testing of engines,
- review of the obtained type testing results, and
- evaluation of the manufacturing arrangements,
- issue of a type approval certificate upon satisfactorily meeting the Rule requirements.

###### 1.3.1.2 Engine Certificate

Each diesel engine manufactured for a shipboard application is to have an engine certificate. The certification process details for obtaining the engine certificate are indicated in 1.5. This process consists of the engine builder/ licensee obtaining design approval of the engine application specific documents, submitting a comparison list of the production drawings to the previously approved engine design drawings referenced in 1.3.1.1, forwarding the relevant production drawings and comparison list for the use of the Surveyors at the manufacturing plant and shipyard if necessary, engine testing and upon satisfactorily meeting the Rule requirements, the issuance of an engine certificate.

##### 1.3.2 Document flow for diesel engines

###### 1.3.2.1 Document flow for obtaining a type approval certificate

1.3.2.1.1 For the initial engine type, 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.

1.3.2.1.2 Upon review and approval of the submitted documentation (evidence of approval), it would be returned to the engine designer.

1.3.2.1.3 The engine designer is to arrange for a Surveyor to attend an engine type test and upon satisfactory testing IRS would issue a type approval certificate.

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

### 1.3.2.2 Document flow for engine certificate

1.3.2.2.1 The engine type is to have a type approval certificate. For the first engine of a type, the type approval process and the engine certification process (ECP) may be performed simultaneously.

1.3.2.2.2 Engines to be installed in specific applications may require the engine designer/ licensor to modify the design or performance requirements. The modified drawings are to be forwarded by the engine designer to the engine builder/ licensee to develop production documentation for use in the engine manufacture in accordance with Table 3.

1.3.2.2.3 The engine builder/ licensee is to develop a comparison list of the production documentation to 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 licensee's production drawings/ documents compared to the corresponding licensor's drawings, the licensee is to obtain agreement to such differences from the licensor using the template in Appendix 5.

If the designer acceptance is not confirmed, then the engine is to be regarded as a different engine type and is to be subjected to the complete type approval process by the licensee.

1.3.2.2.4 The engine builder/ licensee is to submit the comparison list and the production documentation to IRS according to the agreed procedure for review/approval.

1.3.2.2.5 IRS would return documentation to the engine builder/ licensee with confirmation that the design has been approved. This documentation is intended to be used by the engine builder/ licensee and their subcontractors and attending Surveyors. As the attending Surveyors may request the engine builder/ licensee or their subcontractors to provide the actual documents indicated in the list, the documents are necessary to be prepared and available for the Surveyors.

1.3.2.2.6 The attending Surveyors, at the engine builder/ licensee/ subcontractors, are to issue product certificates as necessary for components manufactured upon satisfactory inspections and tests.

1.3.2.2.7 The engine builder/ licensee is to assemble the engine and test the engine with a Surveyor present. An engine certificate would be issued by the Surveyor upon satisfactory completion of assembly and tests.

1.3.2.2.8 A representative document flow process for obtaining an engine certificate is indicated in Appendix 2, Figure 2.

### **1.3.3 Approval of diesel engine components**

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

### **1.3.4 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.

## **1.4 Type Approval Process**

The type approval process is to consist of the steps in 1.4.1 to 1.4.4. The document flow for this process is shown in Appendix 2, Figure 1.

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

### **1.4.1 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.

### **1.4.2 Documents for approval or recalculation Table 2**

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

### **1.4.3 Design approval/ appraisal (DA)**

DA's are valid as long as no substantial modifications have been implemented. Where substantial modifications have been made the validity of the DA's may be renewed based on evidence that the design is in conformance with all current Rules and statutory regulations (e.g. SOLAS, MARPOL). See also 1.4.6.

### **1.4.4 Type approval test**

A type approval test is to be carried out in accordance with Section 2 and is to be witnessed by IRS Surveyors.

The manufacturing facility of the engine presented for the type approval test is to be assessed in accordance with Section 3.

### **1.4.5 Type approval certificate**

After the requirements in 1.4.1 through 1.4.4 have been satisfactorily completed, IRS will issue a type approval certificate (TAC).

### **1.4.6 Design modifications**

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

### **1.4.7 Type approval certificate renewals**

A renewal of type approval certificates will be granted upon:

1.4.7.1 Submission of information in either 1.4.7.1.1 or 1.4.7.1.2.

1.4.7.1.1 The submission of modified documents or new documents with substantial modifications replacing former documents compared to the previous submission(s) for DA.

1.4.7.1.2 A declaration that no substantial modifications have been applied/ undertaken since the last DA was issued.

### **1.4.8 Validity of type approval certificate**

The duration of validity of the type approval certificate will be five (05) years. The type approval certificate 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.

### **1.4.9 Document review and approval**

1.4.9.1 The assignment of documents to Table 1 for information does not preclude possible comments by IRS.

1.4.9.2 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.

## **1.5 Certification Process**

The certification process consists of the steps in 1.5.1 to 1.5.5. This process is illustrated in Appendix 2, Figure 2 showing the document flows between the:

- engine designer/ licensor,
- engine builder/ licensee,
- component manufacturers,
- IRS plan approval centre, and
- IRS site offices.

For those cases when a licensor – licensee agreement does NOT apply, an “engine designer” shall be understood as the entity that has the design rights for the engine type or is delegated by the entity having the design rights to modify the design.

The documents listed in Table 3 may be submitted by:

- the engine designer (licensor),
- the manufacturer/ licensee.

### **1.5.1 Document development for production**

Prior to the start of the engine certification process, a design approval is to be obtained as per 1.4.1 through 1.4.3 for each type of engine. Each type of engine is to be provided with a type approval certificate obtained by the engine designer/ licensor prior to the engine builder/ licensee beginning production manufacturing. For the first engine of a type, the type approval process and the certification process may be performed simultaneously.

The engine designer/ licensor is to review the documents listed in Tables 1 and 2 for the application and develop, if necessary, application specific documentation for the use of the engine builder/ licensee in developing engine specific production documents.

If substantive changes have been made, the affected documents are to be resubmitted to IRS as per 1.4.6.

### **1.5.2 Documents to be submitted for inspection and testing**

Table 3 lists the production documents, which are to be submitted by the engine builder/ licensee to IRS following acceptance by the engine designer/ licensor. The Surveyor is to use the information for inspection purposes during manufacture and testing of the engine and its components. See 1.3.2.2.3 through 1.3.2.2.6.

### **1.5.3 Alternative execution**

If there are differences in the technical content on the licensee's production drawings/ documents compared to the corresponding licensor's drawings, the licensee must provide to the IRS plan approval centre a "Confirmation of the licensor's acceptance of licensee's modifications" approved by the licensor and signed by licensee and licensor. Modifications applied by the licensee are to be provided with appropriate quality requirements. Sample format for the same is provided in Appendix 5.

### **1.5.4 Manufacturer approval**

IRS would assess conformity of production with the Society's requirements for production facilities comprising manufacturing facilities and processes, machining tools, quality assurance, testing facilities, etc. (See Section 3). Satisfactory conformance would result in the issue of a Class approval document.

### **1.5.5 Document availability**

In addition to the documents listed in Table 3, the engine builder/ licensee 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.

### **1.5.6 Engine assembly and testing**

Each engine assembly and testing procedure required according to requirements of Cl. 4.13/ Pt. 4, Ch. 4 of IRS Rules and Regulations for Construction and Classification of Steel Ships are to be witnessed by the attending Surveyors, unless an Alternative Certification Scheme (ACS) meeting the requirements of Pt.1, Ch.1, Sec.4 of IRS Rules for Construction and Classification of Steel Ships; is agreed between manufacturer and 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 <sup>1</sup>   |
| 6             | Frame/framebox/gearbox of cast design <sup>2</sup>   |
| 7             | Tie rod  |
| 8             | Connecting rod   |
| 9             | Connecting rod, assembly <sup>3</sup>  |
| 10            | Crosshead, assembly <sup>3</sup>   |
| 11            | Piston rod, assembly <sup>3</sup>  |
| 12            | Piston, assembly <sup>3</sup>  |
| 13            | Cylinder jacket/ block of cast design <sup>2</sup>   |
| 14            | Cylinder cover, assembly <sup>3</sup>  |
| 15            | Cylinder liner   |
| 16            | Counterweights (if not integral with crankshaft), including fastening  |
| 17            | Camshaft drive, assembly <sup>3</sup>  |
| 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 <sup>4</sup>   |
| 25            | FMEA (for engine control system) <sup>5</sup>  |
| 26            | Production specifications for castings and welding (sequence)  |
| 27            | Evidence of quality control system for engine design and in service maintenance  |
| 28            | Quality requirements for engine production   |
| 29            | Type approval certification for environmental tests, control components <sup>6</sup>   |
| <b>Notes:</b> |  |
| 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. The FMEA reports required will not be explicitly approved by IRS. |
| 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".  |

**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 <sup>1,2</sup>  |
| 2              | Thrust bearing bedplate of welded design, with welding details and welding instructions <sup>1</sup>   |
| 3              | Bedplate/oil sump welding drawings <sup>1</sup>  |
| 4              | Frame/framebox/gearbox of welded design, with welding details and instructions <sup>1,2</sup>  |
| 5              | Engine frames, welding drawings <sup>1,2</sup>   |
| 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 <sup>3</sup>   |
|                | 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 <sup>4</sup>   |
| 20             | Construction of accumulators (common rail) (for electronically controlled engine)  |
| 21             | Construction of common accumulators (common rail) (for electronically controlled engine)   |
| 22             | Arrangement and details of the crankcase explosion relief valve ( Pt.4/Ch.4 of the Rules) <sup>5</sup>   |
| 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) <sup>7</sup>  |
| 25             | High pressure parts for fuel oil injection system <sup>6</sup>   |
| 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  |
| <b>Notes :</b> |  |
| 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 <sup>3</sup> ] or more.  |
| 6.             | The documentation to contain specifications for pressures, pipe dimensions and materials.  |
| 7.             | The type test report may be submitted shortly after the conclusion of the type test.   |

| <b>Table 3 : Documentation for the inspection of components and systems</b> |  |
|---|--|
| -   | Special consideration will be given to engines of identical design and application                                       |
| -   | 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 <sup>1</sup> |
| 3   | Bedplate and crankcase of welded design, with welding details and welding instructions <sup>2</sup>                      |
| 4   | Thrust bearing bedplate of welded design, with welding details and welding instructions <sup>2</sup>                     |
| 5   | Frame/frame box/gearbox of welded design, with welding details and instructions <sup>2</sup>                             |
| 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: <sup>3</sup>  |
| 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 <sup>4</sup>   |
| 21  | Construction of accumulators for hydraulic oil and fuel oil  |
| 22  | High pressure parts for fuel oil injection system <sup>5</sup>   |
| 23  | Arrangement and details of the crankcase explosion relief valve (Pt.4/Ch.4 of Rules) <sup>6</sup>                        |
| 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 <sup>7</sup>  |
| 33  | Piston head  |
| 34  | Camshaft drive, assembly <sup>7</sup>  |
| 35  | Flywheel   |
| 36  | Arrangement of foundation (for main engines only)  |
| 37  | Fuel oil injection pump  |

| <b>Table 3 : (Contd.)</b> |  |
|---------------------------|--|
| 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 <sup>8</sup>   |
| 45                        | Test program resulting from FMEA (for engine control system) <sup>9</sup>  |
| 46                        | Production specifications for castings and welding (sequence)  |
| 47                        | Type approval certification for environmental tests, control components <sup>10</sup>  |
| 48                        | Quality requirements for engine production   |
| <b>Notes :</b>            |  |
| 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 <sup>3</sup> ] 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 1.3.2.2.2, Appendix 4 and Appendix 5.   |

### 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   |
| 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 |
| 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  |
| 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  |
| Competent body                         | Organization recognized as having appropriate knowledge and expertise in a specific area   |
| Component                              | Part, member of equipment or system  |

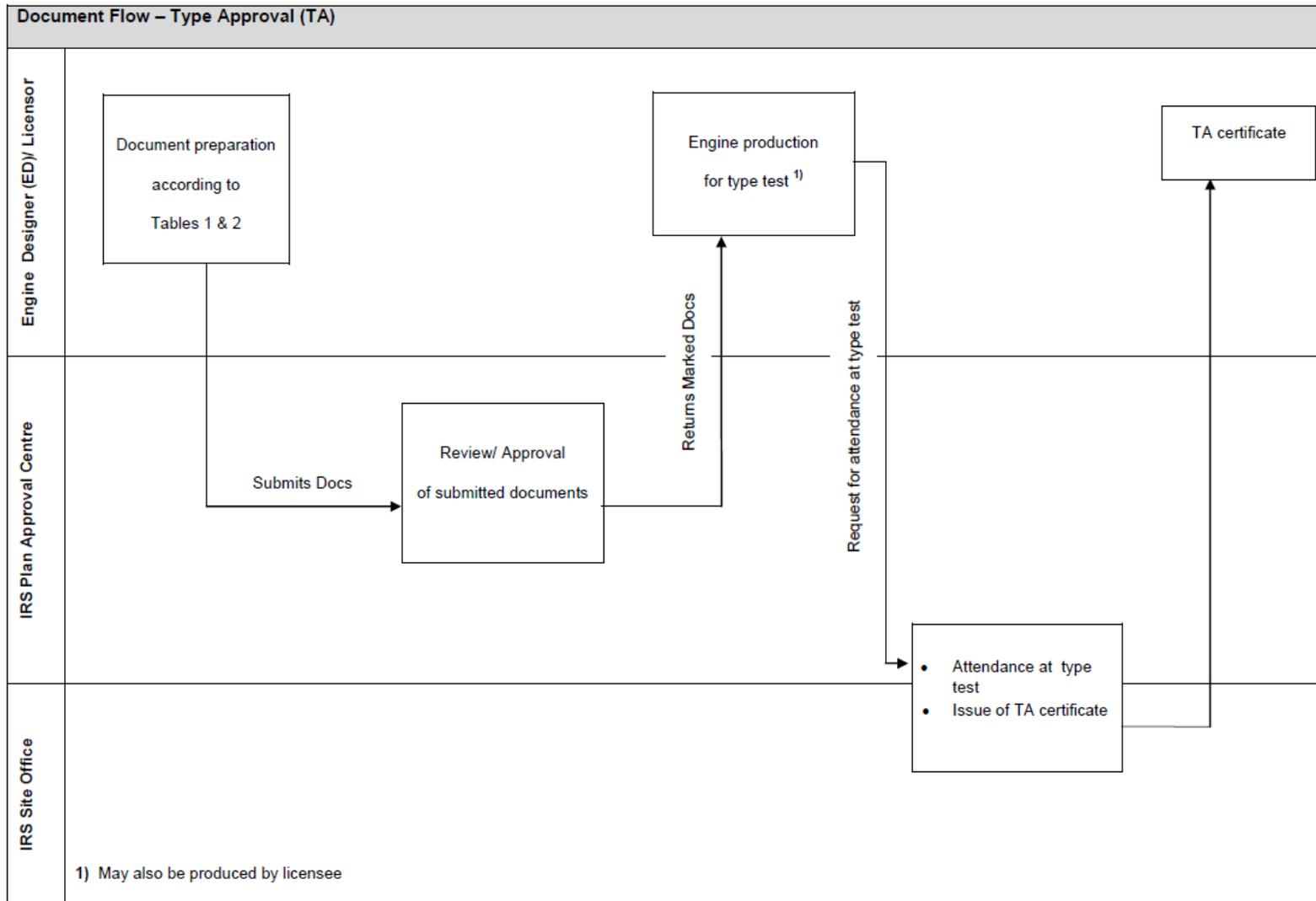
| <b>Term</b>                      | <b>Definition</b>   |
|----------------------------------|---|
| Conformity                       | Where a design, product, process or service demonstrates compliance with its specific requirements                              |
| Contract                         | 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 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                                       |
| 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  |
| 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 |

| <b>Term</b>   | <b>Definition</b>   |
|---|---|
|   | 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   |
| Prototype test  | Investigations on the first or one of the first new engines with regard to optimization, fine tuning of engine parameters and verification of the expected running behaviour  |
| 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 9000 series |
| 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  |
| Information   | Additional technical data or details supplementing the drawings requiring approval  |
| Revision  | Means to record changes in one or more particulars of design drawings or specifications   |
| 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  |
| Supplier  | One who contracts to furnish materials or design, products, service or components to a customer or user   |

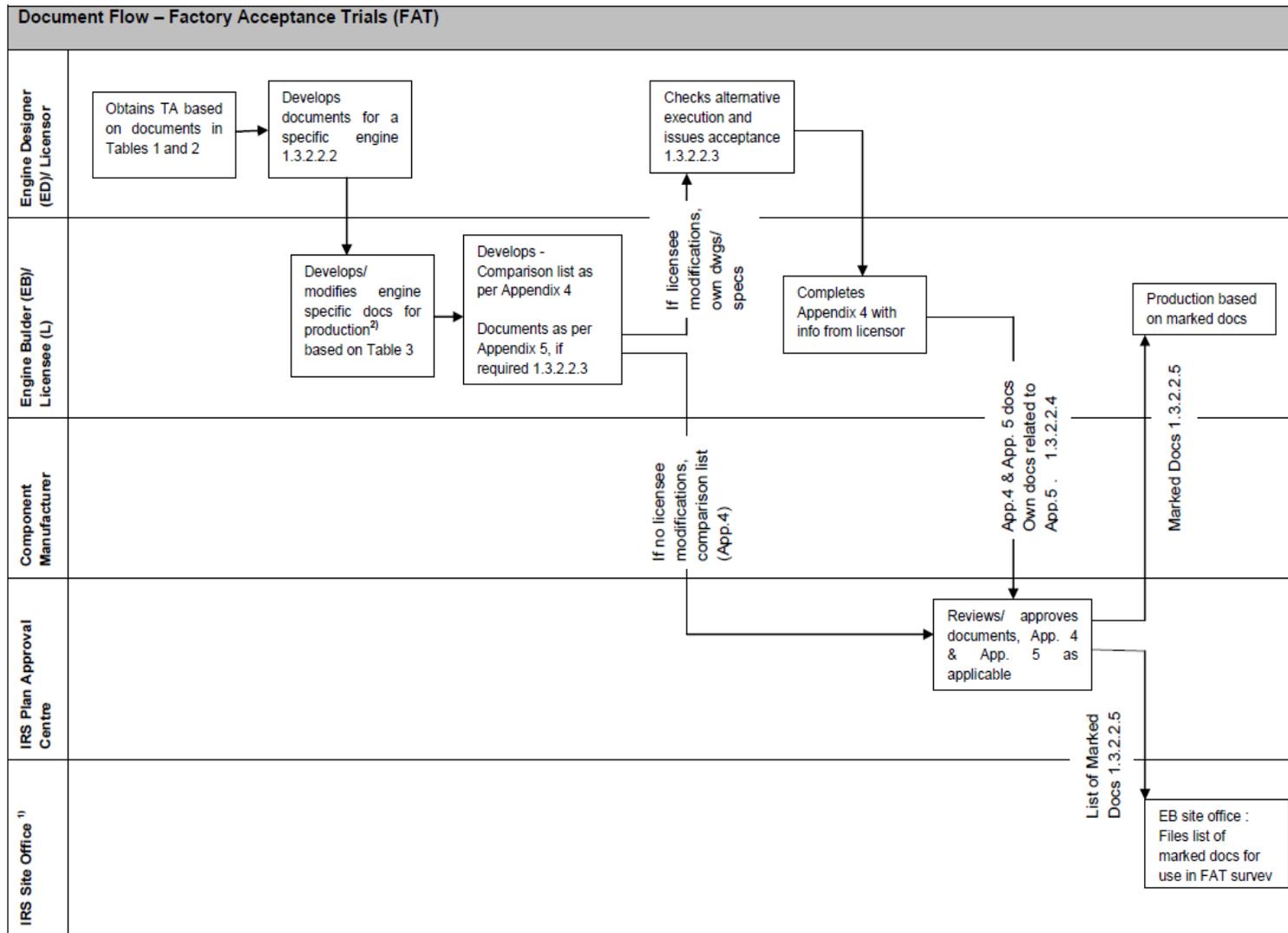
| <b>Term</b>        | <b>Definition</b>   |
|--------------------|---|
| Test               | A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to 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: <ol style="list-style-type: none"> <li data-bbox="624 663 1516 730">1. Evaluation of a design to determine conformance with specifications</li> <li data-bbox="624 763 1516 831">2. Witnessing manufacture and testing of a type of product to determine compliance with the specification</li> <li data-bbox="624 864 1516 965">3. Evaluation of the manufacturing arrangements to confirm that the product can be consistently produced in accordance with the specification</li> </ol> |
| 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.

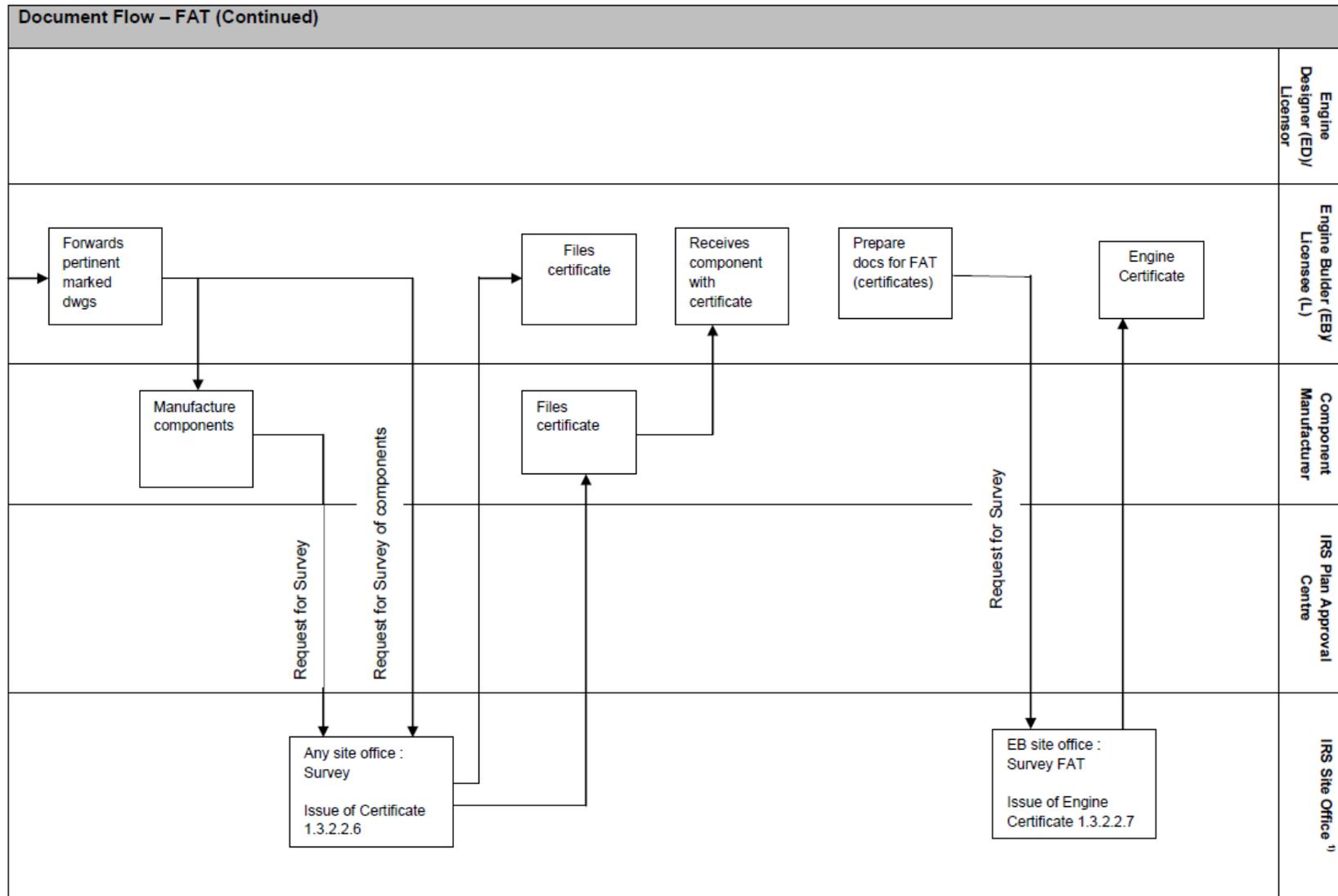


**Figure 1 : Type Approval Document Flow**



1) IRS Site office with responsibility for engine builder and component manufacturer in different locations  
 2) For alternative execution, see 1.5.3

**Figure 2 : Engine certificate document flow**



1) IRS Site office with responsibility for engine builder and component manufacturer in different locations

**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<br><input type="checkbox"/> New Type Approval<br><input type="checkbox"/> Renew Type Approval<br><input type="checkbox"/> Amend Type Approval<br><input type="checkbox"/> Design Evaluation<br><input type="checkbox"/> Update TA Supplement<br><input type="checkbox"/> Other  | <i>Required activities<sup>†</sup></i><br>• DA, TT, CoP<br>• CoP, if design change then amended or new certificate process to be followed<br>• DA & CoP, Further TT if previously approved engine has been substantively modified (as required by Section 2)<br>• 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<br>• Update to Supplement, only for minor changes not affecting the Type Approval Certificate<br>• e.g. National/Statutory Administration requirements i.e. MSC.81(70) 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  |  |  |  |
| <input type="checkbox"/> 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.<br>Only section 3b requires completion. Where changes to other sections are necessary, a new Type Approval Application may be required. |  |  |  |
| Reference number of <i>Internal Combustion Engine Approval Application Form</i> previously submitted and reference number of the Type Approval Certificate.   | <i>(Copy of original application form to be attached to this document)</i>   |  |  |
| 2. Existing documentation   |  |  |  |
| Previous Class Type Approval Certificate No. or related Design Approval No. (if applicable)   |  |  |  |
| Formerly issued documentation for engine<br><i>(E.g. previous type test reports, in-service experience justification reports, etc.)</i>   | Issuing Body:  | Document Type:   | Document No.:  |
| Existing Certification<br><i>(E.g. Manufacturer's quality certification ISO 9001 etc.)</i>  | Issuing Body:  | Document Type:   | Document No.:  |
| 3. Design (mark all that apply)   |  |  |  |
| 3a. Engine Particulars:   |  |  |  |
| Engine Type<br>Manufactured Since <sup>‡</sup> :  | Number of delivered marine engines <sup>‡</sup> :  |  |  |
| Application   | <input type="checkbox"/> Direct drive Propulsion<br>( <input type="checkbox"/> Single engine / <input type="checkbox"/> Multi-engine installation)   | <input type="checkbox"/> Auxiliary<br>( <input type="checkbox"/> Aux. Services / <input type="checkbox"/> Electric Propulsion)                                   | <input type="checkbox"/> Emergency   |
| Mechanical Design   | <input type="checkbox"/> 2-stroke<br><input type="checkbox"/> Cross-head<br>Cylinder bore(mm)  | <input type="checkbox"/> 4-stroke<br><input type="checkbox"/> Trunk-piston<br>Length of piston stroke (mm)   | <input type="checkbox"/> In-line<br><input type="checkbox"/> Vee (V-angle °)<br><input type="checkbox"/> Reversible<br><input type="checkbox"/> Non-reversible<br><input type="checkbox"/> Other ( ) |
| Supercharging   | <input type="checkbox"/> Without supercharging   | <input type="checkbox"/> With supercharging<br><input type="checkbox"/> Without charge air cooling<br><input type="checkbox"/> Constant-pressure charging system | <input type="checkbox"/> With charge air cooling<br><input type="checkbox"/> Pulsating pressure charging system  |
| Valve operation   | <input type="checkbox"/> Cam control<br><input type="checkbox"/> Electronic control  |  |  |
| Fuel Injection  | <input type="checkbox"/> Direct injection<br><input type="checkbox"/> Indirect injection   | <input type="checkbox"/> Cam controlled injection<br><input type="checkbox"/> Electronically controlled injection  |  |

|   |  |  |
|---|--|--|
| Fuel Types <sup>s</sup><br>(Classification according to ISO 8216)   | <input type="checkbox"/> Marine residual fuel<br><input type="checkbox"/> Marine distillate fuel<br><input type="checkbox"/> Marine distillate fuel<br><input type="checkbox"/> Low flashpoint liquid fuel (specify fuel type)<br><input type="checkbox"/> Gas (specify gas type)<br><input type="checkbox"/> Other (specify)<br><input type="checkbox"/> Dual Fuel<br>(specify combinations of fuels to be used simultaneously) | cSt (Max. kinematic viscosity at 50°C)<br>DMA, DMB, DMC<br>DMX |
| <b>3b. Performance Data</b>   |  |  |
| <i>(Related to: Barometric pressure 1,000 mbar; Air temperature 45°C; Relative humidity 60%; Seawater temperature 32°C)</i>   |  |  |
| 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  |  |
| <b>3c. Crankshaft</b>   |  |  |
| Design  | <input type="checkbox"/> Solid <input type="checkbox"/> Semi-built <input type="checkbox"/> Built  |  |
| Method of Manufacture   | <input type="checkbox"/> Cast <input type="checkbox"/> Forged<br><input type="checkbox"/> Slab forged <input type="checkbox"/> Approved die forged <input type="checkbox"/> 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? <input type="checkbox"/> Yes <input type="checkbox"/> No |  |  |
| If yes, state process:  |  |  |
| Crankshaft material specification:  |  |  |
| U.T.S. (N/mm <sup>2</sup> )   | Yield strength (N/mm <sup>2</sup> )  |  |
| Hardness value (Brinell/Vickers)  | Elongation (%)   |  |
| <b>Dimensional Data</b>   |  |  |
| If shrunk on webs, state shrinkage allowance (mm)   | Yield strength of crankweb material (N/mm <sup>2</sup> )   |  |
| Centre of gravity of connecting rod from large end 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 <sup>2</sup> )   | Nominal alternating torsional stress in crank journal (N/mm <sup>2</sup> )   |  |
| Length between centres (Total length)(mm)   |  |  |
| <b>3d. Firing order</b>   |  |  |
|   |  |  |
| 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  |  | <input type="checkbox"/> Fitted   |   | <input type="checkbox"/> Not Fitted   |   |
| Turbocharger oil supply by:  |  | <input type="checkbox"/> Engine lub. oil system                                     |   | <input type="checkbox"/> 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   |  | <input type="checkbox"/> Yes <input type="checkbox"/> No                            |   | Mode of operation:  |   |
| Manufacturer / type, if electronic: /  |  | Type approval certificate No.   |   |   |   |
| 4d. Electronic systems   |  |   |   |   |   |
| Engine control and management system   |  |   |   |   |   |
| <i>Note: use Remarks section to identify when a different engine control system will be used for Type Test</i> |  |   |   |   |   |
| Hardware: Manufacturer & Model: /  |  | Type approval certificate No.   |   |   |   |
| Software: Name & Version: /  |  | Software conformity certificate No.   |   |   |   |
| Additional electronic system 1:  |  | System function:  |   |   |   |
| Manufacturer & type: /   |  | Type approval certificate No.   |   |   |   |
| Additional electronic system 2:  |  | System function:  |   |   |   |
| Manufacturer & type: /   |  | Type approval certificate No.   |   |   |   |
| Additional electronic system 3:  |  | System function:  |   |   |   |
| 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 <input type="checkbox"/> Yes <input type="checkbox"/> No |   | in the starting air manifold <input type="checkbox"/> Yes <input type="checkbox"/> No   |   |
| Crankcase relief valves available  |  | <input type="checkbox"/> Yes <input type="checkbox"/> No                            |   | Manufacturer / type: /  |   |
| Type approval certificate No.  |  |   |   |   |   |
| No. of cyl.  | Total crankcase gross volume incl. attachments (m <sup>3</sup> ) | Type & size (mm) of relief valve  | Relief area per relief valve (mm <sup>2</sup> ) | No. of relief valves  |   |
|  |  | /   |   |   |   |
|  |  | /   |   |   |   |
|  |  | /   |   |   |   |
|  |  | /   |   |   |   |
| Method used for detection of potentially explosive crankcase condition:  |  |   |   |   |   |
| <input type="checkbox"/> Oil mist detector: Manufacturer / type: /   |  | Type approval certificate No.   |   |   |   |
| <input type="checkbox"/> Alternative method: (mark all that apply)   |  | <input type="checkbox"/> crankcase pressure monitoring                              |   | <input type="checkbox"/> bearing temperature monitoring <input type="checkbox"/> other: |   |
|  |  | <input type="checkbox"/> oil splash temperature monitoring                          |   | <input type="checkbox"/> recirculation arrangements                                     |   |
| Cylinder overpressure warning device available   |  | <input type="checkbox"/> Yes <input type="checkbox"/> No                            |   |   |   |
| Type:  |  | Opening pressure (bar):   |   |   |   |
| 4g. Attached ancillary equipment (Mark all that apply)   |  |   |   |   |   |
| Engine driven pumps:   |  |   |   |   |   |
| <input type="checkbox"/> Main lubricating oil pump   |  | <input type="checkbox"/> Sea cooling water pump                                     |   | <input type="checkbox"/> LT-fresh cooling water pump                                    |   |
| <input type="checkbox"/> HT-fresh cooling water pump   |  | <input type="checkbox"/> Fuel oil booster pump                                      |   | <input type="checkbox"/> Hydraulic oil pump <input type="checkbox"/> Other ( )          |   |
| Engine attached motor driven pumps:  |  |   |   |   |   |
| <input type="checkbox"/> Lubricating oil pump  |  | <input type="checkbox"/> Cooling fresh water pump                                   |   | <input type="checkbox"/> Fuel oil booster pump  |   |
| <input type="checkbox"/> Hydraulic oil pump  |  | <input type="checkbox"/> Other ( )  |   |   |   |

|  |   |  |                                    |   |
|--|---|--|------------------------------------|---|
| Engine attached cooler or heater:  |   |  |                                    |   |
| <input type="checkbox"/> Lubricating oil cooler  | <input type="checkbox"/> Lubricating oil heater     | <input type="checkbox"/> Fuel oil valve cooler           |                                    |   |
| <input type="checkbox"/> Hydraulic oil cooler  | <input type="checkbox"/> Cooling fresh water cooler |  |                                    |   |
| Engine attached filter:  |   |  |                                    |   |
| Lubricating oil filter   | <input type="checkbox"/> Single                     | <input type="checkbox"/> Duplex                          | <input type="checkbox"/> Automatic |   |
| Fuel oil filter  | <input type="checkbox"/> Single                     | <input type="checkbox"/> Duplex                          | <input type="checkbox"/> Automatic |   |
| 5. Inclination limits<br><i>(engine operation is safeguarded under the following limits)</i> |   | Athwartships   |                                    | Fore-and-aft  |
|  |   | Static   | Dynamic                            | Static      Dynamic   |
| Main & Auxiliary machinery   | <input type="checkbox"/>                            | 15.0°  | <input type="checkbox"/>           | 22.5° <input type="checkbox"/> 5.0° <input type="checkbox"/> 7.5°   |
| Emergency machinery  | <input type="checkbox"/>                            | 22.5°  | <input type="checkbox"/>           | 22.5° <input type="checkbox"/> 10.0° <input type="checkbox"/> 10.0° |
| Emergency machinery on ships for the carriage of liquefied gas and liquid chemicals          | <input type="checkbox"/>                            | 30.0°  | <input type="checkbox"/>           | 30.0°   |
| 6. Main engine emergency operation   |   |  |                                    |   |
| At failure of one auxiliary blower, engine can be started and operated at partial load       |   | <input type="checkbox"/> Yes <input type="checkbox"/> No |                                    |   |
| At failure of one turbocharger, engine operation can be continued                            |   | <input type="checkbox"/> Yes <input type="checkbox"/> No |                                    |   |
| 7. References: <i>Additional Information Attached to Application</i>                         |   |  |                                    |   |
| 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: \_\_\_\_\_ Signature: \_\_\_\_\_

Company: \_\_\_\_\_

Job Title: \_\_\_\_\_ Stamp: \_\_\_\_\_

Date: \_\_\_\_\_

**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 Licensor's and Licensee's Drawing and Data**

**Licensee:** \_\_\_\_\_

**Licensor:** \_\_\_\_\_

**Licensee Engine No. :** \_\_\_\_\_

**Engine type:** \_\_\_\_\_

| No. | Components or System | Licensor         |          |                                  | Licensee |          | Has Design been modified by Licensee? |    | 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 Licensor | Date of Class Approval or Review of Licensee Dwg. |
| 1   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| 2   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| 3   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| 4   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| 5   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| 6   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| 7   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| 8   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| 9   |                      |                  |          |                                  |          |          |                                       |    |  |   |
| ... |                      |                  |          |                                  |          |          |                                       |    |  |   |

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

**Person in Charge (Licensee):** \_\_\_\_\_

**Printed Name**

**Signature**

**Date:** \_\_\_\_\_

**Appendix 5 Sample Template for Confirmation of the Licensor's Acceptance of Licensee's Modifications**

| <b>Engine Licensee Proposed Alternative to Licensor's Design</b>  |   |   |                                      |
|---|---|---|--------------------------------------|
| <b>Licensee information</b>   |   |   |                                      |
| Licensee:   |   | Ref No.:  |                                      |
| Description:  |   | Info No.:   |                                      |
| Engine type:  |   | Main Section:   |                                      |
| Engine No.:   |   | Plant Id.:  |                                      |
| Design Spec: <input type="checkbox"/> General <input type="checkbox"/> Specific Nos:  |   |   |                                      |
| <i>Licensor design:</i>   | <small>State relevant part or drawing numbers. Insert drawing clips or pictures.<br/>Add any relevant information</small> |   | <i>Licensee Proposed Alternative</i> |
|   |   | For example:  |                                      |
|   |   | <ul style="list-style-type: none"> <li>• Differences in geometry</li> <li>• Differences in the functionality</li> <li>• Material</li> <li>• Hardness</li> <li>• Surface condition</li> <li>• Alternative standard</li> <li>• Licensee production information introduced on the drawing</li> <li>• Weldings or castings</li> <li>• etc.</li> </ul> |                                      |
| Reason:   | Interchangeability w. licensor design   | Non-conformity Report Research, Assessment, Evaluation  | Certified by licensee:               |
| <input type="checkbox"/> Licensee's production<br><input type="checkbox"/> Sub-supplier's production<br><input type="checkbox"/> Cost down<br><input type="checkbox"/> Tools  | <input type="checkbox"/> Yes <input type="checkbox"/> No  | <input type="checkbox"/> NCR <input type="checkbox"/> RAE   | Initials:<br>Date:                   |
| <b>Licensor comments</b>  |   |   |                                      |
| LoAE:   |   | NCR:  | Certified by licensor:               |
| <input type="checkbox"/> Accepted as alternative execution<br><small>(Licensor undertakes responsibility)</small><br><input type="checkbox"/> No objection <input type="checkbox"/> Not acceptable<br><small>(Licensee undertakes responsibility)</small> |   | <input type="checkbox"/> Approved<br><input type="checkbox"/> Conditionally approved<br><input type="checkbox"/> Rejected   | Initials:<br>Date:                   |
| Licensor ref.:  |   |   | Date:                                |
| Licensee ref.:  |   |   | Date:                                |

## Section 2

### Type Testing of I.C. Engines

#### 2.1 General

2.1.1 Type approval of I.C. engine types consists of drawing approval, specification approval, conformity of production, approval of type testing programme, type testing of engines, review of the obtained results, and the issuance of the Type Approval Certificate. The maximum period of validity of a Type Approval Certificate is 5 years. The requirements for drawing approval and specification approval of engines and components are specified in separate Sections, as applicable.

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

*Low-Speed Engines* means diesel engines having a rated speed of less than 300 rpm.

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

*High-Speed Engines* means diesel engines having a rated speed of 1400 rpm or above.

#### 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 Validity

2.3.1 Type testing is required for every new engine type intended for installation onboard ships subject to classification.

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

2.3.3 A type of engine is defined by:

- bore and stroke
- injection method (direct or indirect)
- valve and injection operation (by cams or electronically controlled)
- kind of fuel (liquid, dual-fuel, gaseous)
- 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) <sup>1)</sup>
- cylinder power, speed and cylinder pressures <sup>2)</sup>

Notes:

- 1) One type test will be considered adequate to cover a range of different numbers of cylinders. 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) The engine is type approved up to the tested ratings and pressures (100% corresponding to MCR).

Provided documentary evidence of successful service experience with the classified 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

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

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

## De-rated engine

If an engine has been design approved, and internal testing per Stage A is documented to a rating higher than the one type tested, the Type Approval may be extended to the increased power/mep/rpm upon submission of an Extended Delivery Test Report at:

- 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

## Integration Test

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

## 2.4 Safety Precautions

2.4.1 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.

2.4.2 This applies especially to crankcase explosive conditions protection, but also over-speed protection and any other shut down function.

2.4.3 The inspection for jacketing of high-pressure fuel oil lines and proper screening of pipe connections (as required in 2.8.9 fire measures) is also to be carried out before the test runs.

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

## 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 complete 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:

- overall description of tests performed during stage A. Records are to be kept by the builders QA management for presentation to IRS.
- detailed description of the load and functional tests conducted during stage B.
- inspection results from stage C.

2.5.5 As required in 2.2 the type testing is to substantiate the capability of the design and its suitability for the intended operation. Special testing such as LCF and endurance testing will normally be conducted during stage A.

2.5.6 High speed engines for marine use are normally to be subjected to an endurance test of 100 hours at full load. Omission or simplification of the type test may be considered for the type approval of engines with long service experience from non-marine fields or for the extension of type approval of engines of a well-known type, in excess of the limits given in 2.3.

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

## **2.6 Measurements and recordings**

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

2.6.2 As a minimum, the following engine data are to be measured and recorded:

- Engine r.p.m.
- Torque
- Maximum combustion pressure for each cylinder <sup>1)</sup>
- Mean indicated pressure for each cylinder <sup>1)</sup>
- Charging air pressure and temperature
- Exhaust gas temperature
- Fuel rack position or similar parameter related to engine load
- Turbocharger speed

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

Notes:

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

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

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 and the pertaining operating values are to be recorded. The load conditions to be tested are also to include the testing specified in the applicable type approval programme.

2.7.2 At least the following conditions are to be tested:

- Normal case:

The load points 25%, 50%, 75%, 100% and 110% of the maximum rated power for continuous operation, to be made along the normal (theoretical) propeller curve and at constant speed for propulsion engines (if applicable mode of operation i.e. driving controllable pitch propellers), and at constant speed for engines intended for generator sets including a test at no load and rated speed.

- The limit points of the permissible operating range. These limit points are to be defined by the engine manufacturer.
- For high speed engines, the 100 hr full load test and the low cycle fatigue test apply as required in connection with the design assessment.
- 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 a Surveyor. The achieved results are to be recorded and signed by the attending Surveyor after the type test is completed.

2.8.2 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.

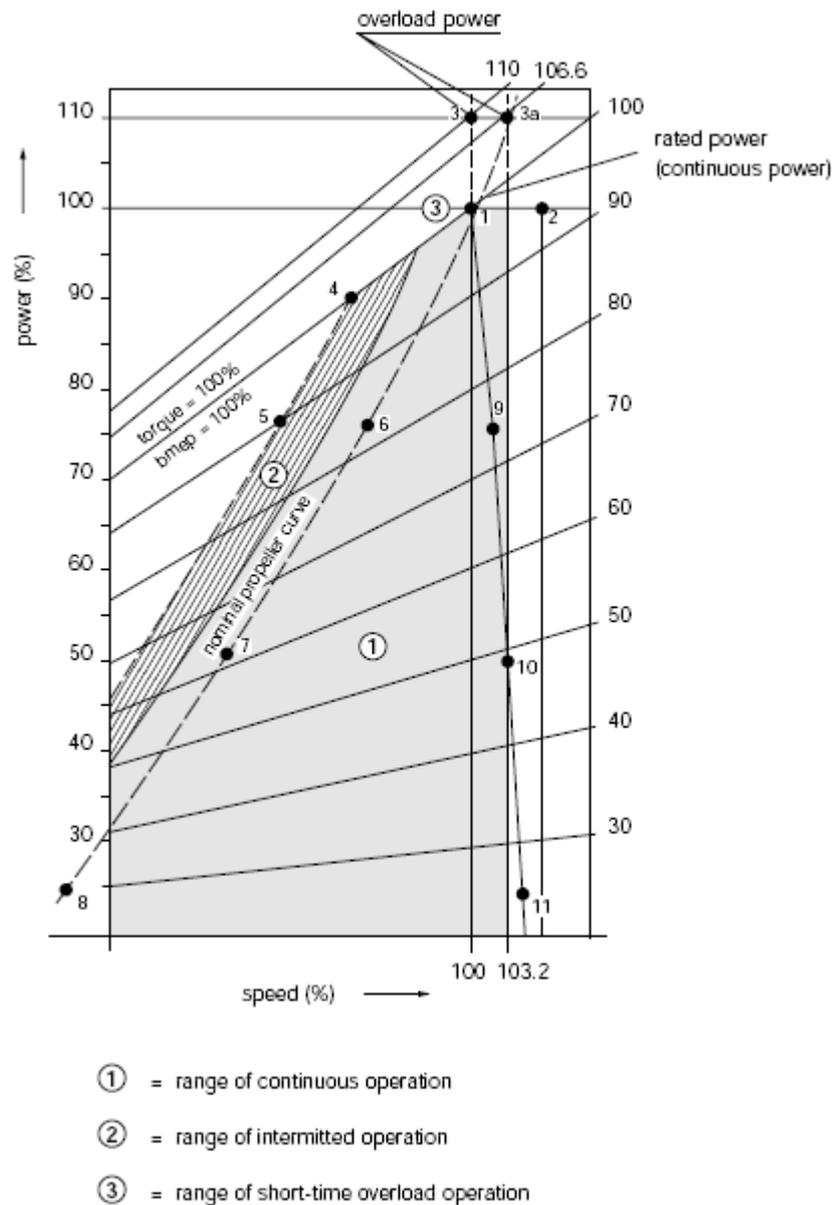
### 2.8.3 Load points

The engine is to be operated according to the power and speed diagram (see Figure 2.8.3). 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.

### 2.8.4 The load points are:

- Rated power (MCR), i.e. 100% output at 100% torque and 100% speed corresponding to load point 1, normally for 2 hours with data collection with an interval of 1 hour. If operation of the engine at limits as defined by its specified alarm system (e.g. at alarm levels of lub oil pressure and inlet temperature) is required, the test should be made here.
- 100% power at maximum permissible speed corresponding to load point 2.
- Maximum permissible torque (at least and normally 110%) at 100% speed corresponding to load at point 3, or maximum permissible power (at least and normally 110%) and 103.2% speed according to the nominal propeller curve corresponding to load point 3a. Load point 3a applies to engines only driving fixed pitch propellers or water jets. Load point 3 applies to all other purposes.  
Load point 3 (or 3a as applicable) is to be replaced with a load that corresponds to the specified overload and duration approved for intermittent use. This applies where such overload rating exceeds 110% 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.
- Minimum permissible speed at 100% torque, corresponding to load point 4.
- Minimum permissible speed at 90% torque corresponding to load point 5. (Applicable to propulsion engines only).
- Part loads e.g. 75%, 50% and 25% of rated power and speed according to nominal propeller curve (i.e. 90.8%, 79.3% and 62.9% speed) corresponding to points 6, 7 and 8 or at constant rated speed setting corresponding to points 9, 10 and 11, depending on the intended application of the engine.
- Crosshead engines not restricted for use with C.P. propellers are to be tested with no load at the associated maximum permissible engine speed.

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



**Figure 2.8.3 Load points**

### 2.8.6 Operation with damaged turbocharger

For 2-stroke propulsion engines, the achievable continuous output is to be determined in the case of turbocharger damage.

Engines intended for single propulsion with a fixed pitch propeller are to be able to run continuously at a speed (r.p.m.) of 40% of full speed along the theoretical propeller curve when one turbocharger is out of operation. (The test can be performed by either by-passing the turbocharger, fixing the turbocharger rotor shaft or removing the rotor.)

### 2.8.7 Functional tests

- Verification of the lowest specified propulsion engine speed according to the nominal propeller curve as specified by the engine designer (even though it works on a water-brake). During this operation, no alarm shall occur.
- 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 a start.
  
- Governor tests: tests for compliance with Pt.4/Ch.4/ Sec.4 of the Rules, are to be carried out.

### 2.8.8 Integration test

For electronically controlled diesel engines, integration tests are to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests is to be agreed with IRS for selected cases based on the FMEA required in Section 1.

### 2.8.9 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 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 certified product itself, or on samples taken from the certified product itself.
- that the inspection and tests were performed in the presence of the Surveyor or in accordance with special agreements, i.e. 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 certified product itself, or on samples taken from the raw material, used for the product to be certified.
- 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 under the following cases:

- the test was witnessed by IRS Surveyor; or
- an Alternative Certification Scheme (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.

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. Manufacturing works is to be equipped 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).

| <b>Table 3.2.2 (a) : Symbols used in Table 3.2.2 (b)</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 |

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.

Table 3.2.2 (b) : Summary of required documentation for engine components

| Part <sup>4), 5), 6), 7)</sup>                      | Material properties <sup>1)</sup> | Non-destructive examination <sup>2)</sup> | Hydraulic testing <sup>3)</sup> | Dimensional inspection, including surface condition | Visual inspection (surveyor)           | Applicable to engines: | Component certificate |
|---|-----------------------------------|---|---------------------------------|---|--|------------------------|-----------------------|
| <b>Welded bedplate</b>                              | W(C+M)                            | W(UT+CD)                                  |                                 |   | fit-up + post-welding                  | All                    | SC                    |
| <b>Bearing transverse girders GS</b>                | W(C+M)                            | W(UT+CD)                                  |                                 |   | X                                      | All                    | SC                    |
| <b>Welded frame box</b>                             | W(C+M)                            | W(UT+CD)                                  |                                 |   | fit-up + post-welding                  | All                    | SC                    |
| <b>Cylinder block GJL</b>                           |                                   |   | W <sup>9)</sup>                 |   |  | CH                     |                       |
| <b>Cylinder block GJS</b>                           |                                   |   | W <sup>9)</sup>                 |   |  | CH                     |                       |
| <b>Welded cylinder frames</b>                       | W(C+M)                            | W(UT+CD)                                  |                                 |   | fit-up + post-welding                  | CH                     | SC                    |
| <b>Engine block GJL</b>                             |                                   |   | W <sup>9)</sup>                 |   |  | >400 kW/cyl            |                       |
| <b>Engine block GJS</b>                             | W(M)                              |   | W <sup>9)</sup>                 |   |  | >400 kW/cyl            |                       |
| <b>Cylinder liner</b>                               | W(C+M)                            |   | W <sup>9)</sup>                 |   |  | D>300mm                |                       |
| <b>Cylinder head GJL</b>                            |                                   |   | W                               |   |  | D>300mm                |                       |
| <b>Cylinder head GJS</b>                            |                                   |   | W                               |   |  | D>300mm                |                       |
| <b>Cylinder head GS</b>                             | W(C+M)                            | W(UT+CD)                                  | W                               |   | X                                      | D>300mm                | SC                    |
| <b>Forged cylinder head</b>                         | W(C+M)                            | W(UT+CD)                                  | W                               |   | X                                      | D>300mm                | SC                    |
| <b>Piston crown GS</b>                              | W(C+M)                            | W(UT+CD)                                  |                                 |   | X                                      | D>400mm                | SC                    |
| <b>Forged piston crown</b>                          | W(C+M)                            | W(UT+CD)                                  |                                 |   | X                                      | D>400mm                | SC                    |
| <b>Crankshaft: made in one piece</b>                | SC(C+M)                           | W(UT+CD)                                  |                                 | W   | Random, of fillets and oil bores       | All                    | SC                    |
| <b>Semi-built crankshaft</b>                        | See below                         | See below                                 |                                 | See below   | See below                              | All                    | SC                    |
| <b>Crank throw</b>                                  | SC(C+M)                           | W(UT+CD)                                  |                                 | W   | Random, of fillets and shrink fittings | All                    |                       |
| <b>Forged main journal and journals with flange</b> | SC(C+M)                           | W(UT+CD)                                  |                                 | W   | Random, of shrink fittings             | All                    |                       |

Table 3.2.2 (b) : (Contd.)

| Part <sup>4), 5), 6), 7)</sup>                                 | Material properties <sup>1)</sup> | Non-destructive examination <sup>2)</sup>                           | Hydraulic testing <sup>3)</sup> | Dimensional inspection, including surface condition | Visual inspection (surveyor)                             | Applicable to engines: | Component certificate |
|--|-----------------------------------|---|---------------------------------|---|--|------------------------|-----------------------|
| Exhaust gas valve cage   |                                   |   | W                               |   |  | CH                     |                       |
| Piston rod, if applicable                                      | SC(C+M)                           | W(UT+CD)<br>CD again after final machining (grinding)               |                                 |   | Random   | D>400mm                | SC                    |
| Cross head   | SC(C+M)                           | W(UT+CD)<br>CD again after final machining (grinding and polishing) |                                 |   | Random   | CH                     | SC                    |
| Connecting rod with cap  | SC(C+M)                           | W(UT+CD)  |                                 | W   | Random, of all surfaces, in particular those shot peened | All                    | SC                    |
| Coupling bolts for crankshaft                                  | SC(C+M)                           | W(UT+CD)  |                                 | W   | Random, of interference fit                              | All                    | SC                    |
| Bolts and studs for main bearings                              | W(C+M)                            | W(UT+CD)  |                                 |   |  | D>300mm                |                       |
| Bolts and studs for cylinder heads                             | W(C+M)                            | W(UT+CD)  |                                 |   |  | D>300mm                |                       |
| Bolts and studs for connecting rods                            | W(C+M)                            | W(UT+CD)  |                                 | TR of thread making                                 |  | D>300mm                |                       |
| Tie rod  | W(C+M)                            | W(UT+CD)  |                                 | TR of thread making                                 | Random   | CH                     | SC                    |
| High pressure fuel injection pump body                         |                                   |   | W<br>TR                         |   |  | D>300mm                |                       |
| High pressure fuel injection valves (only for not autofretted) |                                   |   | W<br>TR                         |   |  | D>300mm                |                       |

Table 3.2.2 (b) : (Contd.)

| Part <sup>4), 5), 6), 7)</sup>  | Material properties <sup>1)</sup> | Non-destructive examination <sup>2)</sup>                         | Hydraulic testing <sup>3)</sup>      | Dimensional inspection, including surface condition | Visual inspection (surveyor) | Applicable to engines:                                  | Component certificate |
|---|-----------------------------------|---|--------------------------------------|---|------------------------------|---|-----------------------|
| High pressure fuel injection pipes including common fuel rail   | W(C+M)                            |   | W for those that are not autofretted |   |                              | D>300mm   |                       |
| High pressure common servo oil system   | W(C+M)                            |   | W                                    |   |                              | D>300mm   |                       |
| Cooler, both sides <sup>8)</sup>  | W(C+M)                            |   | W                                    |   |                              | D>300mm   |                       |
| Accumulator of common rail fuel or servo oil system   | W(C+M)                            |   | W                                    |   |                              | All engines with accumulators with a capacity of >0.5 l |                       |
| Piping, pumps, actuators, etc. for hydraulic drive of valves, if applicable   | W(C+M)                            |   | W                                    |   |                              | >800 kW/cyl   |                       |
| Engine driven pumps (oil, water, fuel, bilge)   |                                   |   | W                                    |   |                              | >800 kW/cyl   |                       |
| Bearings for main, crosshead, and crankpin  | TR(C)                             | TR (UT for full contact between basic material and bearing metal) |                                      | W   |                              | >800 kW/cyl   |                       |
| <b>Notes :</b>  |                                   |   |                                      |   |                              |   |                       |
| 1. Material properties include chemical composition and 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.   |                                   |   |                                      |   |                              |   |                       |

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. For turbochargers, see Section 4.
5. Crankcase safety 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.
6. 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.
7. For Speed governor and over-speed protective devices, see Pt 4/ Ch4/ Sec.4 of the Rules.
8. Charge air coolers need only be tested on the water side.
9. 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.

## 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:  $\leq 1000$  [kW]
- Category B:  $> 1000$  [kW] and  $\leq 2500$  [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<sup>\*)</sup> 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<sup>\*)</sup>.

<sup>\*)</sup> 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, CI 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.

4.3.3.3 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 working temperature.

4.3.2.5 A numerical analysis (simulation) 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 similar to the turbocharger that was used for the reference containment test. In general, totally new designs will call for a new reference containment test.

#### 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 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 at a minimum cites the applicable type approval and the ACS, when ACS applies.
- For category B, a work's certificate; which at 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.

| Pos.  | Monitored Parameters                                | Category of Turbochargers |                  |                     |                  | Notes  |
|---|---|---------------------------|------------------|---------------------|------------------|--|
|   |   | B                         |                  | C                   |                  |  |
|   |   | Alarm                     | Indication       | Alarm               | Indication       |  |
| 1   | Speed   | High <sup>(4)</sup>       | X <sup>(4)</sup> | High <sup>(4)</sup> | X <sup>(4)</sup> |  |
| 2   | Exhaust gas at each turbocharger inlet, temperature | high <sup>(1)</sup>       | X <sup>(1)</sup> | high                | X                | High temp. alarms for each cylinder at engine is acceptable <sup>(2)</sup> |
| 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 <sup>(3)</sup>                         |
| Notes:<br><sup>(1)</sup> 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.<br><sup>(2)</sup> 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.<br><sup>(3)</sup> 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.<br><sup>(4)</sup> 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. |   |                           |                  |                     |                  |  |