Materials and Qualification Procedures for Ships

Book G

Procedure 9-1

Approval of a Works for the Manufacture of Copper Alloy Castings for Propellers

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Approval of a Works for the Manufacture of Copper Alloy Castings for Propellers

1 General Requirements

1.1 The Approval Process

1.1.1 The approval scheme is intended to verify the manufacturer’s capability to provide satisfactory products under effective process, production and inspection controls in accordance with the Rules for the Manufacture, Testing & Certification of Materials Chapter 1.

1.1.2 In order that consideration may be given to approval of a foundry for the manufacture of copper alloy castings for propellers, the process given in Section 2 is to be followed.

1.1.3 Works are to communicate to Surveyors the information which will result in the following reports, each of which is to be submitted to the Materials and NDE Department (MNDE) by the surveyor:

- An initial report giving the information listed in Sections 3 and 4, together with a proposed test programme in accordance with section 5.
- A final report containing the results of approval tests carried out under Sections 5 and 6.

1.1.4 The name of the approved works will appear in Lloyd's Register’s List of Approved Manufacturers of Copper Alloy Castings which is published on Lloyd’s Register’s Class Direct website (www.cdlive.lr.org).
1.2 Scope

1.2.1 The procedure applies to foundries manufacturing propeller and propeller blade castings in copper base alloys. (as included in Chapter 9, Section 1 of LR Rules for Materials)

1.3 Related Rules

1.3.1 Lloyd’s Register’s Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships).

1.3.2 Lloyd’s Register’s Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials).
2 Application for Approval

2.1 Stages of approval

2.1.1 This section sets out the five stages involved in the granting of Lloyd’s Register approval as follows.

(a) Preliminary Review [Stage 1]

The purpose of the preliminary review is to confirm the general capabilities of the works and identify any major non-compliance which will need to be addressed prior to further consideration of the approval process. This review may involve a preliminary assessment visit to the works.

During the course of the review the works shall also demonstrate to the satisfaction of the surveyor that they operate a robust Health & Safety Management System.

Based upon the findings of the preliminary review, the surveyor will issue a report to the company:

- Giving a recommendation that the works approval process proceeds to the next stage (see the Flow Chart below) or
- Giving the reasons why the works is not considered suitable for LR approval at this time.
(b) **Submission of Works Approval Information [Stage 2]**

Following the surveyor’s recommendation to progress with the approval process, the manufacturer will be invited to compile and submit the detailed information requested in Sections 3 and 4 to the local Lloyd’s Register office. The report shall be formatted to follow the sections and sub-sections of this procedure and shall preferably be submitted in electronic format. The report and all supporting documents should be presented in English or annotated in English in an appropriate manner.

Additionally, the manufacturer must submit a proposed test programme in accordance with Section 5.

The local surveyor will review the submitted information from the works and shall conduct an on-site survey during which the contents of the submitted information are verified and any technical or procedural issues related to the approval are resolved.

On satisfactory review of these documents, the surveyor will submit the following to the Materials & NDE Department:

- A short visit report
- The information submitted by the works in accordance with Sections 3 & 4
- A proposed test programme in accordance with Section 5

(c) **Review of Submission by Materials & NDE Department [Stage 3]**

Lloyd’s Register Materials & NDE Department shall review the submitted information before any manufacture and testing commences. Any testing carried out before notification of test plan acceptance by MNDE shall be at the manufacturer’s risk.

Where necessary, clarification will be sought regarding major issues that are discovered during this stage of review of the submitted information.

The outcome of the review will be conveyed to the surveyor and the Materials & NDE Department will confirm the approval test programme and any other actions they require the surveyor to carry out during the surveyor’s attendance at the manufacturer whilst witnessing approval manufacture and testing.

The surveyor will communicate this information to the manufacturer.
(d) **Approval Tests & Survey [Stage 4]**

Following Materials & NDE Department agreement to the test plan, the Works will manufacture the approval test castings. The Lloyd's Register surveyor will arrange to attend the works to survey the manufacture and witness the testing of the approval test products.

In addition, during attendance, the surveyor will follow up on actions requested by the Materials & NDE Department.

The surveyor will appropriately appraise and endorse all test reports which are required by this procedure.

The surveyor will review a manufacturer's report which collates all required information in a clear and concise manner. The format of the report must follow the sections and sub-sections of this procedure and it should preferentially be in electronic form. If the report is found to be satisfactory by the surveyor, it will be endorsed by the manufacturer and verified and stamped by the LR surveyor. It will then be forwarded to the Materials & NDE Department for final review and approval.

(e) **Review of Results [Stage 5]**

The surveyor’s report and endorsed test results will be reviewed by Lloyd’s Register Materials & NDE Department. During this process, points of clarification may be required to be followed up with the surveyor in cooperation with the manufacturer. On satisfactory review the works will be added to Lloyd’s Register’s list of approved manufacturers and a Certificate of Approval will be issued.

(f) Unless otherwise agreed with the MNDE Department, the above stages are to be carried out as five distinct entities. In particular, Stage 3 - test plan approval is required before testing is commenced in order to avoid delays in the approval process.
3 Written information required for the manufacturing capability review

3.1 Product specific information

3.1.1 The manufacturer is to provide the following product related details in writing to the local surveyor:

(a) Types of castings and alloy grades in general production.

(b) The finished weight as dressed (ie after removal of all runners and feeders) of the largest casting which can be manufactured for each generic copper grade.

(c) Largest casting in terms of finished weight after removal of all runners and feeders (as dressed condition) required for approval.

(d) Estimated total annual production of finished castings in each generic copper grade

(e) Types of castings and alloy grades for which approval is required.

(f) Contact details that the manufacturer would like on the published approved list including sales telephone number, fax number, email address and website.

(g) The year of issue of the copy of the Rules for Materials which are held by the Works and the means whereby possible Rule changes are incorporated into company procedures.

(h) The MQPS documents which are used for the approval application, including their revision numbers

(i) Details of the inspection and quality control systems established in the works, including details of the personnel involved

(j) Third party certification held (eg ISO 9001, ISO 14001 and/or ISO 18001, etc), as applicable.

(k) A flow diagram showing all stages of production, testing and inspection points.

(l) An organogram showing the organisational structure shall be submitted.

3.2 Process specific information

3.2.1 The manufacturer is to provide the following process related details in writing to the local surveyor:

(a) Melting facilities; details of the number of individual melting units and for each unit; type and individual single melt capacity.

(b) Details of the origin and storage of raw materials.

(c) Details of melting and refining practices.
(d) Production of moulds and cores; details are required of; the different types of sand systems used; types of moulding and core making systems used; routine daily, weekly, monthly tests carried out on mixed sand and the raw materials for mould and core production; method and frequency of sand mixer calibrations; methods used to determine that moulds and cores are sufficiently cured for casting; application methods and materials used for mould and core coating, including quality control checks.

(e) Melting and charge composition control; details are required of the typical materials used for charge make, and method of calculating / controlling composition; charging practice and control including typical melt out; holding and superheat temperatures.

(f) Casting and pouring practices and controls; details of the types and range of sizes of pouring ladles; method of pouring (manual / automatic); typical casting temperatures used for different casting weights and/or configurations.

(g) Facilities and practices for mechanical testing; details should include the normal practices for manufacture and preparation of mechanical test specimens and the name of the manufacturer, model number or description, manufacturers unique serial number, maximum test capacity and calibration status for each item of mechanical test equipment.

(h) Heat treatment facilities and control; details should include; the number of furnaces used including dimensions, type of fuel used and facilities for temperature measurement and control including positions of thermocouples; details of the methods, frequency, and acceptance parameters of checks carried out to assess the temperature distribution of each furnace; details of how each furnace is loaded including restrictions of volume, mass, number of items, etc; details of the loading temperatures, heating rates, holding times (including how these have been determined) and cooling rates used.

(i) Welding procedures for each type and grade of copper casting material for which approval is required. Each welding procedure submitted for review is to include, as a minimum, the following information:

i) Welding equipment.

ii) Welding process.

iii) Parent metal.

iv) Welding consumables.

v) Type of joint and preparation of the edges to be welded as well as backings.
vi) Thickness of the parent metal.

vii) Welding position.

viii) Welding sequence (number and order of metal depositions).

ix) Welding parameters: amperage and voltage, welding speed.

x) Pre-heating and post weld heat treatment.

xi) Heat input and interpass temperature

(j) Details of any subcontracted activities and particulars relating to the related requirements of the appropriate sections above (eg Section (h) applies to subcontracted heat treatment)
4 Survey of the manufacturing, testing and inspection capabilities

4.1 The local surveyor will carry out a survey of the works and subcontractor as applicable, which will include the manufacturing, inspection and testing processes and procedures. As a minimum, the following manufacturing areas are to be included in the survey, with a view towards verification of the information contained in the manufacturer’s written report (see Section 3 above). If permitted, photographs might be used to support appropriate information.

(a) Raw materials used and their procurement and storage
(b) Manufacture and control of patterns and core boxes
(c) Production of moulds and cores
(d) Methoding practices
(e) Melting facilities
(f) Melting and charge composition and control, including de-oxidation practices.
(g) Chemical analysis equipment and practice
(h) Casting and pouring practices and control
(i) Equipment and procedures for fettling/dressing of castings
(j) Product and test material Identification and control
(k) Heat treatment facilities and controls
(l) Facilities and practices for mechanical testing
(m) Facilities and control procedures for metallographic testing and microstructure control
(n) Facilities and practices for routine castings inspection, including NDE
(o) Manufacture, test or inspection activities or services which are sub-contracted and the controls in place

4.2 Where responses to any questions raised by the survey are not forthcoming from the manufacturer, the reasons for omission must be clearly stated in writing.
4.3 Following review of submitted documentation and its verification through the site survey, the surveyor will issue a report of their findings together with a proposed scope of approval testing based upon the guidance given in Section 5 and Section 6. The surveyor will issue a final recommendation stating their opinion as to whether the works should be considered for the next stage of approval. If the surveyor decides that approval application would not be appropriate at this time, this will be communicated to the works together with the reasons why this decision was made and suggestions as to actions which could be undertaken to improve the application.

If the surveyor deems the approval application to be suitable for progression, the documents listed in 3.1.2 and the proposed test programme will be sent to the Materials & NDE Department for specialist review before testing commences.
5 Approval test programme

5.1 Selection of material

5.1.1 Approval tests are to be carried out on at least three castings taken from current production. Where possible, one of the castings selected for this purpose is to be a propeller with a diameter approaching the maximum which can be manufactured. Approval will be limited to the grades of alloy of the castings submitted.

5.1.2 Approval is based on the dressed weight of castings (after removal of running and feeding systems) and a minimum of one casting shall be at the maximum weight for which approval is required. If the maximum weight is less than 50 tonnes, a justification could be submitted for increasing the maximum weight of approval to a figure of 1.33x the weight of the largest sample casting. This request would be subject to review by the Materials and NDE Dept.

5.1.3 Testing shall be carried out according to Chapter 2 and Chapter 9 of LR Rules for Materials or to an agreed National Standard or proprietary specification. Details of the applicable testing standards shall be submitted.

5.1.4 For each of the proposed test castings, the following shall be provided

i) A sketch showing method of casting with details of the gating and feeding systems, this should clearly show the positions and sizes of pouring basins, down-sprues, runner bars, in-gates, and feeders. Types of feeders used should be detailed, as well as any other aids used in the methoding such as chills or filters. Where computer simulations have been used to assess the methoding used, the results should be submitted together with the name of the software used.

ii) The aim chemical analysis to which the casting is to be made (including tolerances).

iii) Applicable specification. Copies of specifications should be submitted where these are not National/International standards. English copies are preferred although documents annotated in English will be acceptable.

iv) The NDE procedures to be used (as approved by Level III NDE specialist) and proposed test locations for each test casting are to be submitted.

(v) The full details of the proposed heat treatments (full thermal cycle) which is applied to each test casting.
5.1.5 Testing is required to include weld repair procedures for each type and grade of copper casting material for which approval is being sought.

All repairs made to copper castings during manufacture are to be in accordance with the requirements of Ch 9 of the Rules for Materials.

All welders and welding procedures and qualifications in accordance with a recognized National or International Standard. As an alternative to this, a welder may be approved on the basis of past experience provided that qualification tests acceptable to the Surveyor are undertaken satisfactorily for each type and grade of material.

Material to used in qualification tests is to be of a cast and of a size suitable to ensure a reasonable heat distribution and suitable equivalence to practical use

Weld consumables are to be approved types

All tests and examinations are made after any heat treatment has been carried out. For copper alloy castings the weld test sample is to be subjected to a stress relief heat treatment prior to testing.

5.2 Tests, test samples and specimens

5.2.1 The dimensions of separately cast test samples, dimensions of test specimens and mechanical testing procedures are to be in accordance with Ch 2 and Ch 9 of the Rules for Materials or an agreed specification. The test samples are to be taken at the end of the pouring of the castings.

5.2.2 The following tests and examinations are to be carried out, as a minimum, on each casting submitted for approval tests:

(a) Visual examination before and after final machining.

(b) Dye penetrant testing of all surfaces after final machining.

(c) Ultrasonic or radiographic examination, where appropriate, particularly in way of the blade roots.

(d) Mechanical tests in accordance with the requirements of the applicable specification.

(e) Chemical analysis of the propeller including, for the manganese bronze alloys, the value for the calculated zinc equivalent.

(h) Representative photomicrographs of the test material at x100 magnification. This is to be issued in the form of a report giving which gives details of the etchants used and a description of the microstructure shown.

(i) For manganese bronze alloys determination of the proportion of alpha phase present in the structure.
(j) Where castings are made to National, International, or proprietary specifications the results of any additional tests and inspections required by these must be submitted.

5.2.3 For approval of the weld repair process, tests and examinations on the welded assembly are to include the following:

(a) Two cross-weld tensile tests. The minimum tensile strengths are to be: Grades Cu 1 and Cu 2 375 N/mm² Grade Cu 3 500 N/mm² Grade Cu 4 550 N/mm²

(b) Two root bend and two face bend tests. The tests are to be made over a mandrel with a diameter six times the thickness of the test specimen. The bend angles at which cracking commences are to be recorded for information. Photographs of the specimens after test are to be included in the report.

(c) Where the Rules require the cast material to be impact tested, then impact tests should be taken from the weld centreline and heat affected zone and exhibit properties equivalent to that specified for the cast material.

(d) Two macrographs showing the weld, heat affected zone and parent metal and photomicrographs at x100 magnification showing the microstructures of these three regions.
6 Specific approval test results

6.1 General

6.1.1 Following Materials & NDE Department agreement to the test plan, the Works will manufacture approval test castings and stages of manufacture and all approval testing, including weld procedure testing, is to be witnessed by the Lloyd’s Register surveyor.

All test results will be endorsed by the surveyor.

All details listed in Section 6.2 together with the test results will be submitted to the Materials & NDE Department for review.

6.2 Approval test submission

6.2.1 For each casting selected for approval tests, the foundry is to provide the following information:

(a) Information required as indicated in Section 5.1.4.

(b) Results of tests undertaken in accordance with 5.2.2 and 5.2.3

6.2.2 In addition to selecting and witnessing the above tests, surveyors will carry out a careful visual examination of other products in general production and report on the general quality and surface condition.

6.2.3 The surveyor will submit the information requested in Section 6.1-6.2 to Materials & NDE Department together with any additional survey reports that were requested by Materials & NDE Department specialists.

Photographs may be used to support the submitted information.
7  Validity of approval certificate

7.1  Initial approval

7.1.1 On satisfactory review of the submitted approval test report Materials & NDE Department will enter the manufacturer onto the List of Approved Manufacturers and an initial approval certificate will be issued.

7.1.2 The approval will state the approved copper alloy grades and the maximum weight.

7.1.3 The initial approval certificate will have a validity of three years.

7.2  Extension of the scope of approval

7.2.1 Manufacturers who intend to extend their scope of approval will be required to repeat the approval process in Section 2 and the scope of information to be submitted and test program is to be agreed with Materials & NDE Department.

7.3  Re-approval of works

7.3.1 For the validity to be renewed for a further three years the Surveyors should undertake a periodic inspection in accordance with Procedure 1-1. To ensure continuity, this should be carried out within six months of the approval expiry date.

7.3.2 It is a Rule requirement that during material surveys the works will be subject to regular visits to confirm continued compliance with the original approval. The frequency of visits will depend on the frequency of material surveys. Records of these visits will be kept by the surveyors.

7.3.3 Manufacturers that have not produced products under Lloyd's Register survey during the approval period must either conduct new approval tests (according to Sections 5 and 6) or contact Lloyd's Register to agree on any additional requirements to continue approval.

7.3.4 Where a manufacturer physically moves the location of an approved works from the approved location to a new site, the manufacturer will be required to follow the initial approval process in full unless they can present a satisfactory case to the MNDE Dept that this would not be necessary.