Lloyd’s Register
Type Approval System
Test Specification Number 3

Performance Test Specification
for Equipment to be used in Marine Applications:

- Electric Cables
- Circuit-breakers
- Fuses and Fuse Holders
- Fixed Submerged Electrical Equipment

May 2018
**Foreword**

This specification details performance, and where required environmental, testing for electrical products for Marine applications.

This test specification should be read in conjunction with the Lloyd’s Register Type Approval Procedure and, where indicated, the latest Lloyd’s Register Type Approval Test Specification No. 1.

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

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

1.1 **Introduction**

1.1.1 The following requirements provide guidance for the approval of electric cables in accordance with the LR Type Approval Procedure.

1.2 **Submitted information**

1.2.1 The Producer's submission should fully describe each cable under consideration and be submitted in a single package in a clear and logical manner including the following details, as applicable.

(a) Cable type.
(b) Rated operating voltage.
(c) Maximum rated conductor temperature.
(d) Conductor material, form and class.
(e) Cross-section of conductor and number of cores.
(f) Insulation material.
(g) Thickness of insulation.
(h) Material of inner sheath.
(i) Thickness of inner sheath.
(j) Dimensions of metallic armouring wires or tapes.
(k) Material of outer sheath.
(l) Thickness of outer sheath.
(m) Dimensions, materials and construction of core, conductor screens or braids.
(n) Type and construction of inner fillers.
(o) Details of any special properties such as reduced smoke or acid emission.
(p) Details of applicable specifications and standards to which the cables are produced.

1.2.2 The following information, additional to what is listed in 1.2.1, regarding the exact constituents of each polymeric compound used in the product to be type approved shall be submitted:

(a) Base polymer.
(b) Additives to compounds for UV and ozone stabilisation.
(c) Additives for reduced smoke and fire propagation.
(d) Antioxidants.
(e) Cross-linking agent(s).
(f) Mineral or other type of bulk filler(s).
(g) Carbon black content.
(h) Plasticiser(s).
(j) Coupling agent(s) (in the case of polymer blends).

In case the detailed information specified above is not made available, analytical testing is required on polymeric compounds to fingerprint the material. Testing to fingerprint the material can consist of the following:

(k) FTIR (Fourier Transform Infra-Red).
(l) TGA (Thermogravimetric Analysis).
(m) SEM (Scanning Electron Microscopy).

Information regarding materials and codes for any special constituents, such as water blocking tape or mica glass tape for fire survival, are also required, or any other approved technical solution for fire survival.

1.2.3 The Producer's technical brochures and sectional drawings should be submitted.

1.2.4 The approval of cables which incorporate special properties or new materials for which no standards have been published will be the subject of special consideration.

1.2.5 Where National or International Standards are to be quoted on the Certificate, the cable’s technical specification should include all details required to show compliance with the various aspects selected from the standards chosen.
1.3 Testing procedure

1.3.1 Agreed representative samples of the cables shall be subjected to a series of type tests, witnessed by the LR Surveyor, unless carried out at a nationally accredited test establishment. The LR Surveyor is required to visit the place of production to verify that the cables are manufactured and routinely tested to the declared standards. In the event of a range of cables being considered, the samples are chosen to provide a spread across the complete range. An example of this would be:
(a) Largest cross-sectional area/smallest number of cores.
(b) Smallest cross-sectional area/largest number of cores.
(c) Test samples should reflect what is actually being produced at the manufacturing site.

1.3.2 The tests are to include the following:
(a) General visual examination to verify details of construction against the specification.
(b) Dimensional checks to verify the following where applicable:
   (i) Conductor cross-sectional area.
   (ii) Insulation thickness.
   (iii) Sheath thickness.
   (iv) Metallic armouring.
   (v) Overall dimensions.
   (vi) Core or conductor screens or braids.
(c) Determination of conductor resistance.
(d) High voltage endurance test.
(e) Determination of insulation resistance.
(f) Tests to determine performance under fire conditions.
(g) Tests to determine the mechanical characteristics of insulating materials.
(h) Tests to determine the mechanical characteristics of sheathing materials.
(j) Additional tests required to show compliance with the design standards (see 1.2.5).
(k) Additional tests for polar code compliance are to include cold bend, cold impact and cold elongation.*

Note
* Tests for polar code compliance are to be conducted at specified polar service temperature or test temperature as specified for the type of compound in the relevant cable standard, whichever is greater.

1.4 Quality assurance actions

1.4.1 Extracts from manufacturer’s Quality Assurance manual are to be submitted to verify that procedures listed below are in place and followed:
(a) Periodical inspection is to be carried out on compound and extruded materials to ensure the continuation of product quality. See 1.2.2.
(b) Certificates of conformance for each constituent of the insulating compound materials is to be requested periodically from external suppliers for inspection.
(c) A procedure is to be in place to ensure timely communication of any design change to LR for consideration. Medium to long-term impacts of any design changes are to be assessed, preferably using laboratory life prediction techniques, and assessment results are to be presented to LR.
(d) In case there are changes to the design, components or manufacturing processes, the cables are to undergo testing throughout the product range to ensure the continuation of product quality.
(e) Test and manufacturing data is to be appropriately stored and made available to LR upon request.
1.5 **Design and testing standards**

1.5.1 In accordance with the objective to harmonise test specifications with International Standards, cable performance tests will be generally acceptable if compliance with appropriate IEC standards is demonstrated.

1.5.2 All cables to be Type Approved by LR are to be of the flame retardant type. The minimum acceptable is flame retardance tests carried out on single cables in a vertical arrangement. Compliance with IEC 60332-1: Tests on electric cables under fire conditions – Part 1: Tests on a single vertical insulated wire or cable will be acceptable.

1.5.3 **Sample testing requirements.** The manufacturer is to keep records of the total cable lengths produced of each approved cable type since the issue of the certificate or any subsequent extension. Sample testing, as per IEC 60092-350 section 6, is required to be carried out when the total lengths of each approved cable type meet the lengths specified below.

(a) Multi-core cables:
   - A sample every 10 km of each approved type of cable produced.

(b) Single-core cables:
   - A sample every 20 km of each approved type of cable produced.

The sample test reports are to be submitted to LR, in order for the Type Approval certificate to remain valid.

If any sample fails any of the tests, two further samples shall be taken from the same batch and submitted to the same test or tests in which the original sample failed. If both additional samples pass the tests, the type approval certificate shall remain valid. If either of the additional samples fails, the type approval certificate will cease to be valid.

1.5.4 Table 3.1.1 gives a list of some design and testing standards.
### Table 3.1.1 Various cable standards

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60092-350</td>
<td>Electrical installations in ships. Part 350: Shipboard power cables. General construction and test requirements</td>
</tr>
<tr>
<td>IEC 60092-351</td>
<td>Electrical installations in ships. Part 351: Insulating materials for shipboard and mobile and fixed offshore units power, telecommunication and control data cables</td>
</tr>
<tr>
<td>IEC 60092-353</td>
<td>Electrical installations in ships. Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltages 1 kV and 3 kV</td>
</tr>
<tr>
<td>IEC 60092-354</td>
<td>Electrical installations in ships. Part 354: Single - and multi-core power cables with extruded solid insulation for rated voltage 6 kV up to 30 kV</td>
</tr>
<tr>
<td>IEC 60092-359</td>
<td>Electrical installations in ships. Part 359: Sheathing materials for shipboard power and telecommunication cables</td>
</tr>
<tr>
<td>IEC 60092-376</td>
<td>Electrical installations in ships. Part 376: Cables for Control and Instrumentation Circuits 150/250 V (300 V)</td>
</tr>
<tr>
<td>IEC 60331-21</td>
<td>Tests for electric cables under fire conditions – Circuit integrity – Part 21: Procedures and requirements – Cables of rated voltages up to and including 0,6/1,0 kV.</td>
</tr>
<tr>
<td>IEC 60331-23</td>
<td>Tests for electric cables under fire conditions – Circuit integrity – Part 23: Procedures and requirements – Electric data cables</td>
</tr>
<tr>
<td>IEC 60331-25</td>
<td>Tests for electric cables under fire conditions – Circuit integrity – Part 25: Procedures and requirements – Optical fibre cables</td>
</tr>
<tr>
<td>IEC 60332-1-1</td>
<td>Tests on electric and optical fibre cables under fire conditions – Part 1-1: Test for vertical flame propagation for a single insulated wire or cable apparatus</td>
</tr>
<tr>
<td>IEC 60332-1-2</td>
<td>Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable. Procedure for 1 kW pre-mixed flame</td>
</tr>
<tr>
<td>IEC 60332-1-3</td>
<td>Tests on electric and optical fibre cables under fire conditions – Part 1-3: Test for vertical flame propagation for a single insulated wire or cable. Procedure for determination of flaming droplets/particles</td>
</tr>
<tr>
<td>IEC 60332-2-1</td>
<td>Tests on electric and optical fibre cables under fire conditions – Part 2-1: Test for vertical flame propagation for a single small insulated wire or cable apparatus</td>
</tr>
<tr>
<td>IEC 60332-2-2</td>
<td>Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable. Procedure for diffusion flame</td>
</tr>
<tr>
<td>IEC 60332-3-21</td>
<td>Tests on electric cables under fire conditions – Part 3-21: Tests for vertical flame spread of vertically mounted bunched wires or cables – Category AF/R</td>
</tr>
<tr>
<td>IEC 60332-3-22</td>
<td>Tests on electric cables under fire conditions – Part 3-22: Tests for vertical flame spread of vertically mounted bunched wires or cables – Category A</td>
</tr>
<tr>
<td>IEC 60332-3-23</td>
<td>Tests on electric cables under fire conditions – Part 3-23: Tests for vertical flame spread of vertically mounted bunched wires or cables – Category B</td>
</tr>
<tr>
<td>IEC 60332-3-24</td>
<td>Tests on electric cables under fire conditions – Part 3-24: Tests for vertical flame spread of vertically mounted bunched wires or cables – Category C</td>
</tr>
<tr>
<td>IEC 60754-1</td>
<td>Test on gases evolved during combustion of materials from cables – Part 1: Determination of the amount of halogen acid gas</td>
</tr>
<tr>
<td>IEC 60754-2</td>
<td>Test on gases evolved during combustion of electric cables – Part 2: Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity</td>
</tr>
<tr>
<td>IEC 60811-504</td>
<td>Electric and optical fibre cables — Test methods for non-metallic materials Part 504: Mechanical tests — Bending tests at low temperature for insulation and sheaths</td>
</tr>
<tr>
<td>IEC 60811-505</td>
<td>Electric and optical fibre cables — Test methods for non-metallic materials Part 505: Mechanical tests — Elongation at low temperature for insulations and sheaths</td>
</tr>
<tr>
<td>IEC 60811-506</td>
<td>Electric and optical fibre cables — Test methods for non-metallic materials Part 506: Mechanical tests — Impact test at low temperature for insulations and sheaths</td>
</tr>
<tr>
<td>IEC 61034-2</td>
<td>Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements</td>
</tr>
</tbody>
</table>
2. **Circuit-breakers**

2.1 **Introduction**

2.1.1 The following requirements provide guidance for the approval of circuit-breakers in accordance with the LR Type Approval Procedure and the latest LR Type Approval Specification No. 1. The latter is applicable where environmental testing is required.

2.1.2 Approval of circuit-breakers intended for use in marine switchboards may be based upon agreed performance tests. Circuit-breakers intended for other marine applications (where excessive temperature, humidity and vibration may be present) are to satisfy the requirements of Test Specification No. 1 category ENV2 as a minimum.

2.2 **Submitted information**

2.2.1 Request forms and documentation in accordance with the LR Type Approval Procedure should include the following information:
   (a) Circuit-breaker type designation.
   (b) Rated operating voltage.
   (c) Whether ENV rating is required (state ENV category).
   (d) Making and breaking capacity. If circuit-breakers incorporate components, e.g., electronic trip unit, the following is also to be submitted:
   (e) Detailed functional description of the electronic unit and behaviour in case of malfunction.
   (f) In the case of used programmable system (PES) the software quality requirements in LR Type Approval Test Specification No. 1 are to be complied with.

2.2.2 The Producer’s technical brochures and sectional drawings should be submitted.

2.2.3 The approval of circuit-breakers which incorporate special properties or new materials for which no standards have been published will be the subject of special consideration.

2.2.4 Where National or International Standards are to be quoted on the Certificate, the circuit-breaker’s technical specification should include all details required to show compliance with the various aspects selected from the standards chosen.

2.3 **Testing procedures**

2.3.1 The performance tests are to comply fully with the Type Test requirements of:
   (a) IEC 60947-2: Low-voltage switchgear and controlgear – Part 2: circuit-breakers;
   (b) IEC 62271-100: High-voltage switchgear and controlgear – Part 100: High-voltage;
   (c) IEC 62271-200: Annex A Method for testing the metal-enclosed switchgear and control gear under conditions of arcing due to an internal fault.

Or an acceptable and relevant National Standard, amended where necessary for the marine ambient temperature of 45°C and other environmental conditions.
2.4 **Design and testing standards**

2.4.1 Type tests to IEC 60947-2 include the following shown in Table 3.2.1.

<table>
<thead>
<tr>
<th>Table 3.2.1</th>
<th>Type tests to IEC 60947-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>General performance characteristics.</td>
<td></td>
</tr>
<tr>
<td>Rated service short-circuit breaking capacity.</td>
<td></td>
</tr>
<tr>
<td>Rated ultimate short-circuit breaking capacity.</td>
<td></td>
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<tr>
<td>Rated short time withstand current.</td>
<td></td>
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<tr>
<td>Performance of integrally fused circuit-breakers.</td>
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</tr>
<tr>
<td>Combined test sequence.</td>
<td></td>
</tr>
<tr>
<td>Individual pole short-circuit test sequence.</td>
<td></td>
</tr>
</tbody>
</table>

2.4.2 In accordance with the objective to harmonise test specifications with International Standards, circuit-breaker tests will be accepted if compliance with appropriate IEC standards is demonstrated.

2.4.3 Type tests to IEC 62271-100 should be selected in accordance with Table 11 of the standard.

2.4.4 Electronic equipment incorporated into circuit-breakers is to satisfy, as a minimum, the requirements of IEC 60947-2, annex F, or the electromagnetic compatibility tests (EMC) of LR Type Approval Test Specification No. 1. However, the tests cannot be mixed.

3. **Fuses and fuse holders**

3.1 **Introduction**

3.1.1 The following requirements provide guidance for the approval of fuses and fuse holders in accordance with LR Type Approval Procedure and LR Test Specification No. 1.

3.1.2 Approval of fuses for use in marine switchboards may be based upon agreed performance tests. Fuse holders are to satisfy the requirements of LR Type Approval Test Specification No. 1, category ENV2, as a minimum.

3.2 **Submitted information**

3.2.1 Request forms and documentation in accordance with the LR Type Approval Procedure should include the following information:

(a) Fuse type designation.
(b) Carrier type designation (if applicable).
(c) Rated voltage.
(d) Rated current capacity.
(e) Breaking capacity.

3.2.2 The Producer’s technical brochures and sectional drawings should be submitted.

3.2.3 The approval of fuses which incorporate special properties, or new materials for which no standards have been published, will be the subject of special consideration.

3.2.4 Where National or International Standards are to be quoted on the Certificate, the fuse/fuse holder’s technical specification should include all details required to show compliance with the various aspects selected from the standards chosen.

3.3 **Testing procedures**

3.3.1 The performance tests are to comply fully with the type test requirements of IEC 60269-1 and IEC 60282-1 or an acceptable and relevant National Standard, amended where necessary for the marine ambient temperature of 45°C and other environmental conditions.

3.4 **Design and testing standards**
3.4.1 In accordance with the objective to harmonise test specifications with International Standards, fuses and fuse holders will be generally acceptable if compliance with appropriate IEC standards is demonstrated.

3.4.2 Type tests to IEC 60269-1 include the following, as shown in Table 3.3.1.

Table 3.3.1 Type tests to IEC 60269-1

<table>
<thead>
<tr>
<th>Test Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
</tr>
<tr>
<td>Resistance</td>
</tr>
<tr>
<td>Temperature rise</td>
</tr>
<tr>
<td>Power dissipation</td>
</tr>
<tr>
<td>Conventional fusing current</td>
</tr>
<tr>
<td>Rated current</td>
</tr>
<tr>
<td>Time-current characteristics</td>
</tr>
<tr>
<td>Overload</td>
</tr>
<tr>
<td>Conventional cable overload protection</td>
</tr>
<tr>
<td>Indicating device</td>
</tr>
<tr>
<td>Breaking capacity</td>
</tr>
<tr>
<td>Cut off current characteristics</td>
</tr>
<tr>
<td>$I^2t$ characteristics</td>
</tr>
<tr>
<td>Degree of protection</td>
</tr>
<tr>
<td>Resistance to heat</td>
</tr>
<tr>
<td>Non-deterioration of contacts</td>
</tr>
<tr>
<td>Mechanical strength</td>
</tr>
<tr>
<td>Freedom from season cracking</td>
</tr>
<tr>
<td>Resistance to abnormal heat and fire</td>
</tr>
<tr>
<td>Resistance to rusting</td>
</tr>
</tbody>
</table>

When a range of products is to be type approved, normally one of each type is to be tested. Test samples should reflect what is actually being produced at the manufacturing site.

3.4.3 Type tests to IEC 60282-1 include the following, as shown in Table 3.3.2.

Table 3.3.2 Type tests to IEC 60282-1

<table>
<thead>
<tr>
<th>Test Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric tests</td>
</tr>
<tr>
<td>Temperature-rise tests</td>
</tr>
<tr>
<td>Breaking tests for time-current characteristics</td>
</tr>
<tr>
<td>Oil-tightness tests (only for fuses intended to be used in oil)</td>
</tr>
<tr>
<td>Test of strikers</td>
</tr>
</tbody>
</table>
4. Fixed submerged electrical equipment

4.1 Introduction

4.1.1 The following requirements provide guidance for the approval of electrical pressure hull penetrators and subsea cable connectors in accordance with the LR Type Approval Procedure.

4.2 Submitted information

4.2.1 Request forms and documentation in accordance with the Lloyd’s Register Type Approval Procedure should include the following information:

4.2.2 General arrangement drawings showing:
(a) Arrangement of inserts, connectors and general construction.
(b) Section view together with detailed drawing of all parts.
(c) Associated parts list detailing all materials used.

4.2.3 Design specification, covering:
(a) Current and voltage ratings.
(b) Operating depths and ambient temperature limitations.
(c) Wet and dry side pressure ratings.
(d) Intended purpose.

4.2.4 Proposed test specification detailing:
(a) Equipment to be used.
(b) Procedures for type and routine tests.
(c) Pass and fail acceptance criteria.

4.2.5 The Producer’s technical brochures should be submitted.

4.2.6 Where National or International Standards are to be quoted on the certificate, the equipment’s technical specification is to include all details required to show compliance with the various aspects selected from the standards chosen.

4.3 Testing procedure

4.3.1 Test reports are to demonstrate the suitability of equipment in its environment, considering issues such as corrosion during service life, submerged depth of installation and impact on safety of the ship, boat or craft.

4.3.2 For equipment incorporating active electronic equipment, testing is to include radiated and conducted emission tests as per Test Specification No. 1.