

Lloyd's Register Type Approval System Test Specification Number 1

Performance and Environmental Test Specification
for the following Environmentally
Tested Products used in Marine Applications:

- Electrical Equipment
- Control and Monitoring Equipment
- Instrumentation and Internal Communication Equipment
- Programmable Electronic Systems

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Foreword

This Specification details performance and environmental testing required for products to be used in Marine applications; these cover:

- Electrical equipment
- Control and monitoring equipment
- Instrumentation and internal communication equipment
- Programmable electronic systems

This Test Specification should be read in conjunction with the Lloyd's Register Type Approval Procedure.

Failure to comply with this requirement may render the test results unacceptable for the purposes of Lloyd's Register Type Approval.

The introduction specifies the various categories of approval available for differing environmental conditions, together with applicable tests in tabular form.

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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Appendix 1 General acceptance criteria applicable to LR Test Specification No.1

1. Introduction

1.1 General

1.1.1 This specification applies to Lloyd's Register (hereinafter referred to as LR) Type Approval of electrical, control, safety system, instrumentation, internal communication, and programmable electronic systems for use in the marine environment.

1.1.2 Navigation and radio equipment is to be tested in accordance with the test conditions specified in IEC 60945: Marine navigational and radio communication equipment and systems – General requirements, methods of testing and required test results.

1.1.3 Reference is to be made to the LR Type Approval procedure which contains details of the required product documentation and should include, where applicable:

- (a) Circuit diagrams of all system modules to circuit board level with parts lists.
- (b) A 'Master list' showing all the submitted drawings with the following headings:
 - (i) Title.
 - (ii) Type designation.
 - (iii) Drawing number, date and revision mark.
 - (iv) Functional description.
- (c) For products that include programmable electronic systems, the following documents are to be submitted:
 - (i) System functional description.
 - (ii) Details of hardware configuration in the form of a system block diagram, including input/output schedules.
 - (iii) Software quality plans, including applicable procedures.
 - (iv) Factory acceptance integration and sea trial tests for hardware and software.
 - (v) Details of data storage arrangements.

1.1.4 Type Approval of composite products containing mechanical, electrical and control components will be based on performance and environmental tests agreed between LR and the manufacturer. Assessment of safety systems fitted to such units will be carried out.

1.1.5 Separate type approval certificates are not issued for individual components on the basis of tests carried out on a composite product or system. The inclusion of a component in a certificate of a system does not imply type approval of the component as an individual product.

1.1.6 Where type approval of products that include programmable electronic systems is considered, the hardware is to be tested to satisfy the appropriate environmental category for the equipment's intended installation location where known. Additionally, the life cycle activities for the development of the systems software are to be examined to satisfy the requirements of Section 31.

1.1.7 Where type approval of programmable electronic systems that implement emergency trip, emergency stop, safety-critical functionality or provide essential services without alternative means of operation is considered, the software is to satisfy the requirements of LR's Software Conformity Assessment System – Assessment Module GEN1.

1.1.8 Approval can be given for one or more of the following environmental categories given in Table 1.1.1.

Table 1.1.1 Environmental Categories (ENV)

| Category | Description | Ambient temperature range |
|----------|--|-----------------------------|
| ENV1 | Controlled environments | to Producer's specification |
| ENV2 | Enclosed spaces subject to temperature, humidity and vibration | +5°C to +55°C |
| ENV3 | Enclosed spaces subject to generated heat from other equipment | +5°C to +70°C |
| ENV4 | Mounted on reciprocating machinery | +5°C to +55°C |
| ENV5 | Open decks | -25°C* to +70°C |

* For polar code compliance for an ambient temperature range lower than -25°C for ENV5 category, the agreed Polar Service Temperature (PST) is to be specified by the equipment manufacturer.

1.1.9 Basic tests applicable for each environmental category are given in Table 1.1.2.

1.1.10 The severities detailed in this test specification are to be maintained for the environmental categories specified in Table 1.1.2. Where an IEC standard/publication is specified at the end of an individual test requirement, further detailed information on that test procedure may be obtained from that publication. The latest additions and amendments of the standards apply.

1.1.11 Additional tests required for specific products are given in Section 32.

Table 1.1.2 Basic ENV tests

| Test | Environmental Category | | | | |
|--|------------------------|------|------|------|------|
| | ENV1 | ENV2 | ENV3 | ENV4 | ENV5 |
| Visual inspection | X | X | X | X | X |
| Performance | X | X | X | X | X |
| Pressure | X | X | X | X | X |
| Insulation resistance | X | X | X | X | X |
| Power supply variation | X | X | X | X | X |
| Power supply failure | X | X | X | X | X |
| Inclination | X | X | X | X | X |
| Vibration: Test 1 | X | X | X | | X |
| Vibration: Test 2 | | | | X | |
| Humidity: Test 1 | | X | X | X | X |
| Humidity: Test 2 | X | | | | |
| Salt mist | | | | | X |
| Dry heat | | | X | | X |
| Low temperature | X | X | X | X | X |
| High voltage | X | X | X | X | X |
| Enclosure | | | | | X |
| Electromagnetic compatibility tests for equipment incorporating active electronic components | X | X | X | X | X |

1.1.12 Special features:

- (a) Special features will be indicated on the Certificate and in the List of Type Approved Products.
- (b) Where the Producer's published environmental specification exceeds those required by this specification, agreed tests shall be carried out to prove the claims.
- (c) Where type approval of products that include programmable electronic systems is considered, the life cycle activities for the development of the systems software are to be examined to satisfy the requirements of Section 31.

2. Testing procedures

2.1 General

2.1.1 Relevant tests for Table 1.1.2 are defined in Sections 4 to 28, with additional tests in Section 32.

2.1.2 General acceptance criteria applicable for each test are given in Appendix 1. Product-specific acceptance criteria based on the above should be included in the test report.

2.1.3 A test programme should be submitted allowing sufficient time for LR to comment before testing commences. It should contain:

- (a) Identity of the test establishment and any accreditation for the specific tests.
- (b) The proposed equipment to be tested and a technical explanation to justify that they are representative of the range of products to be type approved. The 'Equipment Under Test' (EUT) should be specified by full type designation to system module/circuit board level, as applicable. When relevant, the installed software versions are to be identified.
- (c) A block diagram showing the proposed configuration of the EUT (if applicable).
- (d) The proposed tests demonstrating compliance with the relevant test specification(s) and specified standards.
- (e) A detailed performance test specification for demonstrating compliance with the firm's published technical specification (accuracy, repeatability where applicable, functional operation, etc.).
- (f) Any certificates and reports for relevant tests previously obtained for the product.
- (g) A copy of the specified standard(s) where necessary.

2.1.4 On completion of tests, a report shall be issued which presents accurately and clearly the test results and all other relevant information. The report shall be identified and dated with all pages numbered. It shall clearly show the name and address of the test establishment and those of the client. The English language should be used.

2.1.5 The contents and format should conform with internationally accepted practice and comply with ISO/IEC 17025 or equivalent standard. The contents of the test report shall include the following minimum information:

- (a) Type designation(s) and serial number(s) of the equipment tested. All system modules to circuit board level (if appropriate) are to be identified as above. When relevant, the installed software versions are to be identified.
- (b) A block-diagram or sketch of the test configuration showing interconnections of any system modules.
- (c) The quantity of products tested (if appropriate).
- (d) Date of receipt of the test item and the date of the individual tests.
- (e) Identification of the test specification by number, revision and date.
- (f) Identification of individual tests and brief description of the test methods highlighting any non-standard features/procedures.
- (g) Ambient environmental conditions.
- (h) Details of the test equipment and measuring equipment, serial numbers and dates of calibration.
- (j) Quantitative measured results where appropriate with a statement of measurement uncertainty.
- (k) Measurements, examinations and derived results supported by chart recordings, sketches, photographs, graphs, etc., (e.g., chart recording of vibration tests with sketches showing the positions of accelerometers).
- (l) Specification of the acceptance criteria – definition of success. See Appendix 1.
- (m) Test results. Tabulated numerical values against specified values where appropriate.
- (n) Conclusions with description of any failures, remedies and modifications.

2.1.6 The test report shall be signed by the test engineer(s) and the authorised representative of the test establishment approving the results.

2.1.7 Where the test establishment does not carry any national accreditation for the particular tests undertaken, the report shall be verified and endorsed by the LR Surveyor or agreed independent representative witnessing the tests.

3. General

3.1 General

3.1.1 Test area ambient conditions are to be maintained within the standard range of atmospheric conditions as follows:

- (a) Temperature: 25°C ± 10°C.
- (b) Relative humidity: 60 per cent (allowable deviation during test ±30 per cent).
- (c) Air pressure: 90 kPa ± 10 kPa.

3.1.2 All measuring instruments shall be calibrated with respect to traceable secondary standards.

3.1.3 Temperature changes required in the various tests are to be undertaken at approximately 1°C per minute unless specified otherwise.

3.1.4 During the tests, the EUT (excepting quiescent units) shall be maintained in its normal operative condition with power applied.

3.1.5 Satisfactory operation of the product shall be demonstrated both during and after each test. In all cases, accuracy shall be maintained within specified limits and there shall be no visible deterioration of the product (see also Appendix 1).

3.1.6 Where accuracy is the essence of performance (e.g., transducers, measurement systems) compliance with the manufacturer's published specification and any specified standards should be demonstrated during the performance test and under the relevant environmental tests.

3.1.7 Testing should follow the sequence as set out in the Sections following unless otherwise agreed.

4. Visual inspection

4.1 General

4.1.1 Products shall be examined for workmanship and for conformity with drawings and design data, and LR Rules.

5. Performance test

5.1 General

5.1.1 Performance tests shall be carried out in accordance with specified standards and the producer's specification. The performance test specification shall be submitted to LR for agreement prior to testing. The performance test is to demonstrate compliance with the relevant LR Rules applicable to the product.

5.1.2 The performance test programme and software is to be suitable for executing all normal functions of the EUT. While the use of special test programs is encouraged they are acceptable only if it can be shown that the EUT is fully operational, see also 3.1.6.

5.1.3 The performance test for products that utilise programmable electronic systems is to demonstrate that the specified functions are provided in a safe, stable and repeatable manner under all operating conditions, including emergency conditions. Response times are to be adequate for all functions, taking into account both normal and abnormal operating conditions. For all aspects of system performance, compliance with the relevant LR Rule requirements is to be demonstrated.

6. Pressure test

6.1 General

6.1.1 Sensors, instruments and control devices that are in contact with process fluid shall have their pressure parts tested to twice the maximum working pressure.

6.1.2 For hydraulically or pneumatically operated systems, the following shall apply:

- (a) Design temperature $\leq 300^{\circ}\text{C}$ internal test pressure 1,5 times product design pressure.
- (b) Design temperature $> 300^{\circ}\text{C}$ internal test pressure 2,0 times product design pressure.

7. Insulation resistance test

7.1 General

7.1.1 Insulation resistance tests shall be carried out on electrical products before and after the high voltage test, humidity test, low temperature test and salt mist test. The test voltage and insulation resistance shall be as given in Table 1.7.1.

Table 1.7.1 Insulation resistance test

| Rated supply voltage | Test voltage (d.c.) | Minimum insulation resistance | |
|----------------------|------------------------------------|-------------------------------|---------------|
| | | Before test | After test |
| Up to 65 V | 2 × supply voltage minimum 24 V | 10 M Ω | 1 M Ω |
| Over 65 V | 500 V | 100 M Ω | 10 M Ω |

7.1.2 The insulation resistance test shall be applied between all circuits and earth and between the supply terminals where appropriate. Certain components, such as filters, surge arrestors, variable resistors, etc., may be required to be disconnected for this test.

7.1.3 Reference standard IEC 60092-504 Section 5.

8. Power supply variation test

8.1 Electrical mains supply

8.1.1 Each combination of voltage and frequency variation as given in Table 1.8.1.

Table 1.8.1 Power supply variation

| AC supply | | |
|------------------------------|--------------------------------------|--------------------------------------|
| Combination no. | Voltage variation (permanent) % | Frequency variation (permanent) % |
| 1 | +6 | +5 |
| 2 | +6 | -5 |
| 3 | -10 | +5 |
| 4 | -10 | -5 |
| | Voltage transient % (duration 1,5 s) | Frequency transient % (duration 5 s) |
| 5 | +20 | +10 |
| 6 | -20 | -10 |
| DC supply | | |
| Voltage tolerance continuous | | ±10% |
| Voltage cyclic variation | | 5% |
| Voltage ripple | | 10% |

8.2 Electrical battery supply

8.2.1 With voltage variation of +30 per cent to -25 per cent of the nominal voltage for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device.

8.2.2 With voltage variation of +20 per cent to -25 per cent for equipment not connected to the battery during charging.

8.2.3 Reference standards IEC 60092-504 and Pt 6, Ch 2,1.7.4 of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships).

8.3 Hydraulic or pneumatic supplies

8.3.1 With a supply pressure deviation of ± 20 per cent. Each supply pressure deviation is to be applied for 15 minutes to ensure that equilibrium is attained before carrying out the operational test.

9. Power supply failure test

9.1 General

9.1.1 Products are to be subjected to a power supply failure test as indicated in Table 1.9.1.

Table 1.9.1 Power supply failure

| | |
|--------------------------------|----------------|
| Duration of Interruption | 30 s (minimum) |
| Interval between interruptions | 1,5 minutes |
| Number of interruptions | 3 |

9.1.2 The specified response of the equipment is to be confirmed on loss of power and subsequent re-start.

9.1.3 The time of 1,5 minutes may be exceeded if the equipment under test needs a longer time for start-up such as to execute a booting sequence. Where a booting sequence is required, an additional power supply interruption is to be conducted during the booting sequence.

9.1.4 There is to be no corruption of programme or data held in programmable electronic systems.

9.1.5 Reference standard IEC 60092-504 Section 4b and IEC 6100-4-11.

10. Inclination test – Static

10.1 General

10.1.1 Tests are only normally required for equipment containing moving parts.

10.1.2 The product shall be:

- (a) Inclined to the vertical at an angle of at least 22,5°.
- (b) Inclined to at least 22,5° on the other side of the vertical and in the same plane as in (a).
- (c) Inclined to the vertical at an angle of at least 22,5° in a plane at right angles to that used in (a).
- (d) Inclined to be at least 22,5° on the other side of the vertical and in the same plane as in (c).

10.1.3 The period of testing in each position should be sufficient to evaluate fully the behaviour of the equipment.

10.1.4 Reference standard IEC 60092-504 Section 11a.

11. Inclination test – Dynamic

11.1 General

11.1.1 Tests are normally only required for equipment containing moving parts.

11.1.2 Using the directions defined in 10.1.2, the equipment is to be rolled to an angle of 22,5° each side of the vertical with a period of 10 seconds.

11.1.3 The test in each direction is carried out for a minimum of 15 minutes.

11.1.4 On ships for the carriage of liquefied gases and chemicals, the emergency power supply is to remain operational with the ship flooded up to a maximum final athwart ship inclination of 30°.

11.1.5 Reference standard IEC 60092-504 Section 5.

12. Vibration test 1

12.1 General

12.1.1 The product shall be mounted on the vibration table through its normal points of attachment, and in its normal orientation with respect to the vertical. Where the product may be supplied with anti-vibration mountings, these are to be specified and fitted during the tests.

12.1.2 Testing shall be carried out in three mutually perpendicular directions, where one of which shall be vertical in respect to the normal orientation of the product.

12.1.3 Testing shall be carried out with varying frequency, displacement and acceleration in accordance with Table 1.12.1 at a rate sufficiently low to permit the detection of resonance in each direction.

Table 1.12.1 Vibration test 1

| Frequency range | Displacement | Acceleration |
|-------------------------|--------------|--------------------------------|
| 2_{-0}^{+3} – 13,2 Hz | ±1,0 mm | |
| 13,2 – 100 Hz | | ±0,7 g (6,9 ms ⁻²) |

12.1.4 During each resonance search the following is noted:

- (a) Amplification factors 'Q' are measured and recorded where $Q \geq 2$.
- (b) The position of the accelerometers shall be indicated diagrammatically within the test report.
- (c) An amplification factor $Q \leq 5$ is considered acceptable if the equipment performs satisfactorily during the 90-minute endurance test at the particular resonance frequency.

12.1.5 At each resonant frequency, where an amplification factor of 2 or above is recorded, an endurance vibration test shall be carried out for a minimum of 90 minutes in accordance with Table 1.12.1 in the direction where resonance occurs. The test equipment shall be controlled to follow any shift of the resonance frequency during the test. An operational test of the equipment under test is to be conducted during each vibration endurance test.

12.1.6 The product shall be endurance tested at the 30 Hz frequency with an acceleration of ±0,7g for a minimum of 90 minutes in each mutually perpendicular direction. This test need not be performed in directions tested under 12.1.5. A functional test of the equipment under test is to be conducted during each vibration endurance test.

12.1.7 Reference standard IEC 60068-2-6 Test Fc. For equipment intended for use under extreme vibration conditions, see the additional test of sub-Section 32.2 in this Specification.

13. Vibration test 2

13.1 General

13.1.1 The product shall be mounted on the vibration table through its normal points of attachment, and in its normal orientation with respect to the vertical. Where the product may be supplied with anti-vibration mountings, these are to be specified and fitted during the tests.

13.1.2 Testing shall be carried out in three mutually perpendicular directions where one of which shall be vertical in respect to the normal orientation of the product.

13.1.3 Testing shall be carried out with varying frequency, displacement and acceleration in accordance with Table 1.13.1 at a rate sufficiently low to permit the detection of resonance. In principle, products undergoing this test should not resonate in the specified frequency band.

Table 1.13.1 Vibration test 2

| Frequency range | Displacement | Acceleration |
|----------------------|--------------|-------------------------------|
| 2_{-0}^{+3} –25 Hz | ±1,6 mm | |
| 25–100 Hz | | ±4,0 g (39 ms ⁻²) |

13.1.4 Should, however, resonance occur, the following is noted:

- (a) Amplification factors 'Q' are measured and recorded where $Q \geq 2$.
- (b) The position of the accelerometers shall be indicated diagrammatically within the test report.
- (c) Any resonance with amplification greater than 5 is not acceptable.

13.1.5 At each resonant frequency, where an amplification factor 2 or above is recorded, an endurance vibration test shall be carried out for a minimum of 90 minutes in accordance with Table 1.13.1 in the direction where resonance occurs. The test equipment shall be controlled to follow any shift of the resonance frequency during the test. An operational test of the equipment under test is to be conducted during each vibration endurance test.

13.1.6 The product shall be endurance tested for a minimum of 90 minutes in each mutually perpendicular direction at the frequency 30 Hz with an acceleration of ± 4,0 g. This test need not be performed in the directions tested under 13.1.5. An operational test of the equipment under test is to be conducted during each vibration endurance test.

13.1.7 Reference standard IEC 60068-2-6 Test Fc. For equipment intended for use under extreme vibration conditions, see the additional test of sub-Section 32.2.

14. Humidity test 1 – Cyclic

14.1 General

14.1.1 Refer to insulation resistance test, Section 7.

14.1.2 Where a product is normally supplied with heaters or devices to prevent condensation, they may be used during the test.

14.1.3 The test parameters are to be as follows, configured in accordance with the limits and tolerances as defined in the reference specification:

- (a) Temperature: 55°C.
- (b) Humidity: 95 per cent.
- (c) Duration: 2 cycles of (12 +12) hours' duration.

14.1.4 Two operational tests shall be carried out during the periods indicated in Fig. 1.14.1.

14.1.5 A performance test shall be carried out during the period indicated in Fig. 1.14.1. Surface moisture may be removed by hand prior to this test.

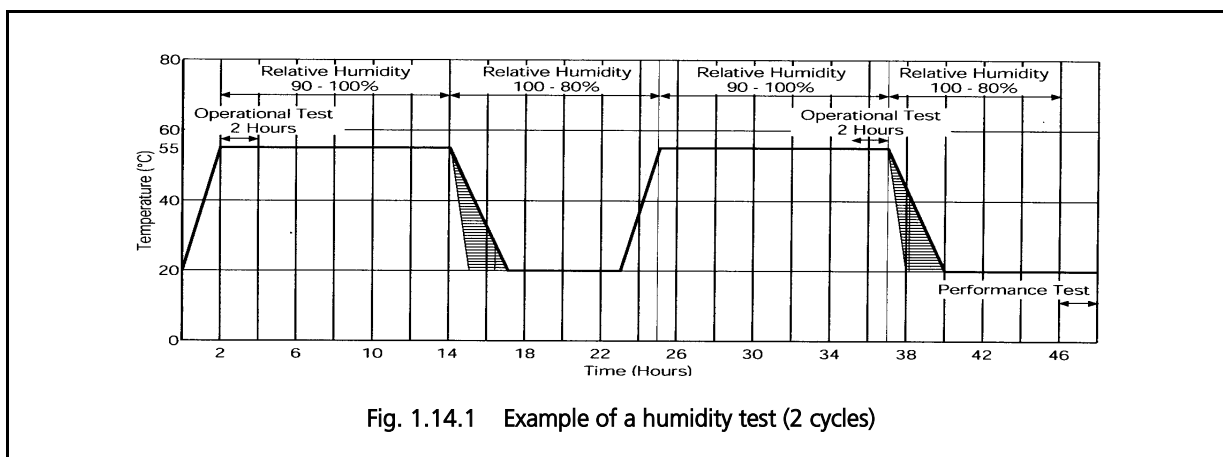


Fig. 1.14.1 Example of a humidity test (2 cycles)

14.1.6 On completion of the performance test there shall be no visible deterioration of the product.

14.1.7 Reference standard IEC 60068-2-30, Test Db.

15. Humidity Test 2 – Steady state

15.1 General

15.1.1 Refer to insulation resistance test, Section 7.

15.1.2 Where a product is normally supplied with heaters or devices to prevent condensation, these may be used during the test.

15.1.3 The test chamber parameters are configured as follows:

- (a) Temperature raised from an initial 20°C to the specified maximum operating temperature for the product $\pm 2^\circ\text{C}$ within a period of two hours.
- (b) This temperature shall be maintained at the maximum relative humidity as specified for the product ± 5 per cent.
- (c) The product shall be kept under these conditions for a period of not less than 96 hours, following which temperature shall be reduced to 20°C within a period of between one and two hours.
- (d) The product shall then be exposed to laboratory conditions.

15.1.4 Operational tests shall be carried out during the first hour, at 50 hours ± 2 hours, and the last 2 hours at the specified test conditions.

15.1.5 A performance test shall be carried out 4 to 6 hours after exposure to laboratory conditions.

15.1.6 On completion of the performance test there is to be no visible deterioration of the product.

15.1.7 Reference standard IEC 60068-2-78, Test Cab.

16. Salt mist test

16.1 General

16.1.1 Refer to insulation resistance test, Section 7.

16.1.2 The salt solution shall be prepared by dissolving the compounds listed below in distilled water and making up the volume of the solution to one litre. The quantities of the salts in the solution are to be within 10 per cent of those shown in Table 1.16.1. A solution prepared to the IEC standard would be acceptable as an alternative.

Table 1.16.1 Salt mist solution

| | | |
|--------------------|--------------------|------------|
| Sodium chloride | NaCl | 26,5 grams |
| Magnesium chloride | MgCl ₂ | 2,4 grams |
| Magnesium sulphate | MgSo ₄ | 3,3 grams |
| Calcium chloride | CaCl ₂ | 1,1 grams |
| Potassium chloride | KCl | 0,73 grams |
| Sodium bicarbonate | NaHCo ₃ | 0,20 grams |
| Sodium bromide | NaBr | 0,28 grams |

16.1.3 The test chamber parameters are configured as follows:

- (a) The salt mist conditions are to be maintained in all parts of the exposure zone in which a clean collecting receptacle with a horizontal collecting area of 80 cm², placed at any point in the exposure zone, shall collect between 1,0 ml and 2,0 ml of solution per hour, averaged over the collecting period. A minimum of two receptacles are to be used, that are to be placed such that they are not shielded by the specimen and so that no condensate from any source shall be collected. When calibrating the spray rate of the chamber, a minimum spray period of 8 hours should be used, for accurate measurement purposes.
To avoid contamination, salt solution dripping from the walls and ceiling of the test chamber and from the product shall not be recycled for re-spraying.
- (c) The spraying shall continue for 2 hours, after which the product is to be maintained as follows:
 - (i) Temperature: 40°C ±2°C.
 - (ii) Relative humidity: 90 per cent to 95 per cent.
 - (iii) Duration: 7 days.
- (d) This procedure shall be repeated four times in succession, following which the test chamber temperature and humidity shall be reduced to ambient conditions.

16.1.4 On completion of exposure, an insulation resistance test shall be carried out four to six hours after recovery, and the product examined to ensure that any deterioration or corrosion is superficial in nature.

16.1.5 Reference standard IEC 60068-2-52 Test Kb severity 1.

17. Dry Heat Test

17.1 General

17.1.1 The test chamber parameters are configured as follows:

- (a) Temperature: Raised from the initial ambient temperature to 70°C and maintained within ±2°C (see 3.1.3).
- (b) Relative Humidity: Monitored during heating process not to exceed 50 per cent at 35°C (equivalent to 9 per cent at 70°C).
- (c) Duration (at 70°C): 16 hours.
- (d) Temperature is then reduced to ambient temperature.

17.1.2 Satisfactory operation of the product shall be demonstrated during the last hour at test temperature.

17.2 Heat-dissipating products normally cooled by convection

17.2.1 The test chamber should be adequately sized to allow the product to stabilise.

17.2.2 The test temperature is measured at such a distance from the product that the effect of dissipation is negligible.

17.2.3 Reference standard IEC 60068-2-2 Tests Bb for non heat-dissipating products and Bd for heat-dissipating products.

Note

For any specified operating temperature over 55°C other than for ENV3 and ENV5 categories, the dry heat test is to be conducted at the agreed test temperature.

18. Low temperature test

18.1 General

18.1.1 Refer to insulation resistance test, Section 7.

18.1.2 The test chamber parameters are configured as follows:

- (a) Temperature: Lowered from the initial ambient temperature to +5°C for environmental categories ENV 1 to 4 inclusive and for environmental category ENV 5 to –25°C and maintained within ±2°C (see 3.1.3).
- (b) Duration (at +5°C or –25°C): 16 hours.
- (c) Temperature shall then be raised to ambient temperature.

18.1.3 Satisfactory operation of the product shall be demonstrated during the last hour at test temperature.

18.1.4 Reference standard IEC 60068-2-1 Tests Ab for non heat-dissipating products and Ad for heat-dissipating products.

Notes

For any specified temperature under 5°C other than for ENV5 category, the low temperature test is to be conducted at the agreed test temperature.

For polar code compliance for any specified temperature under -25°C for ENV5 category, the low temperature test is to be conducted at the agreed Polar Service Temperature (PST).

19. High voltage test

19.1 General

19.1.1 Refer to insulation resistance test, Section 7.

19.1.2 A high voltage (dielectric) test shall be carried out at power frequencies (50 or 60 Hz) as appropriate and at a test voltage as given in Table 1.19.1.

19.1.3 Separate circuits shall be tested against each other, and all circuits shall be tested against earth. Contact pieces shall be tested across their open points of contact.

19.1.4 Printed circuits with electronic components which could be subject to damage may be removed prior to the test. The test voltage should be applied between the power supply terminals strapped together and earth (enclosure).

19.1.5 Period of application of test voltage to be 1 minute.

19.1.6 Reference Pt 6, Ch 2,21.1 of the Rules for Ships.

Table 1.19.1 Test voltage

| Rated voltage, U_n V | Test voltage a.c. (r.m.s.), V |
|--------------------------|-------------------------------|
| $U_n \leq 60$ | 500 |
| $60 < U_n \leq 1000$ | $2 \times U_n + 1000$ |
| $1000 < U_n \leq 2500$ | 6500 |
| $2500 < U_n \leq 3500$ | 10000 |
| $3500 < U_n \leq 7200$ | 20000 |
| $7200 < U_n \leq 12000$ | 28000 |
| $12000 < U_n \leq 15000$ | 38000 |

20. Enclosure test

20.1 General

20.1.1 Tests are to be carried out in accordance with IEC 60529 – Degrees of protection provided by enclosures (IP code) or an acceptable National Standard.

20.1.2 For category ENV5, a minimum enclosure notation of IP56 is required to protect against:

- (a) Ingress of dust in sufficient quantity to interfere with satisfactory operation of the product.
- (b) Water from heavy seas or water projected in powerful jets entering the enclosure in harmful quantities.

20.1.3 Where alternative enclosure notations are specified, see 32.1.

21.

21. Electromagnetic immunity tests for equipment incorporating active electronic components

21.1 General

21.1.1 Electronic products shall be subjected to the specified electromagnetic interference tests for:

- (a) Immunity to conducted low frequency interference.
- (b) Immunity to conducted high frequency interference.
- (c) Immunity to radiated radio frequency fields.
- (d) immunity to fast, low energy transients - bursts (on power, control and signal lines).
- (e) immunity to slow high energy transients (surges).
- (f) Immunity to electrostatic discharge (ESD).

21.1.2 The documentation of the test conditions, test equipment, configuration of the test set-up and test specimens as well as the presentation of the results should be sufficient to enable the tests to be repeated at a future date with similar results, should this be required.

22. Immunity to conducted low frequency interference

22.1 A.C. powered equipment

22.1.1 Low order supply harmonics are to be simulated by applying a sinusoidal RMS voltage configured as follows:

- (a) Amplitude/frequency range: 10 per cent of the nominal power supply up to the 15th harmonic of the supply frequency reducing to 1 per cent at the 100th harmonic, then maintained at this level to the 200th harmonic, as shown in Fig. 1.22.1.
- (b) Applied power: A maximum of 2,0 W to the supply lines, when the impedance is too low to maintain a signal level of 3V RMS.

22.1.2 The appropriate signal level shall be maintained from the 1st to the 200th harmonics of the supply frequency, being superimposed on the power supply lines to the equipment. The frequency shall be adjusted through the specified frequency range at a rate sufficiently low to detect any malfunction of the product under test.

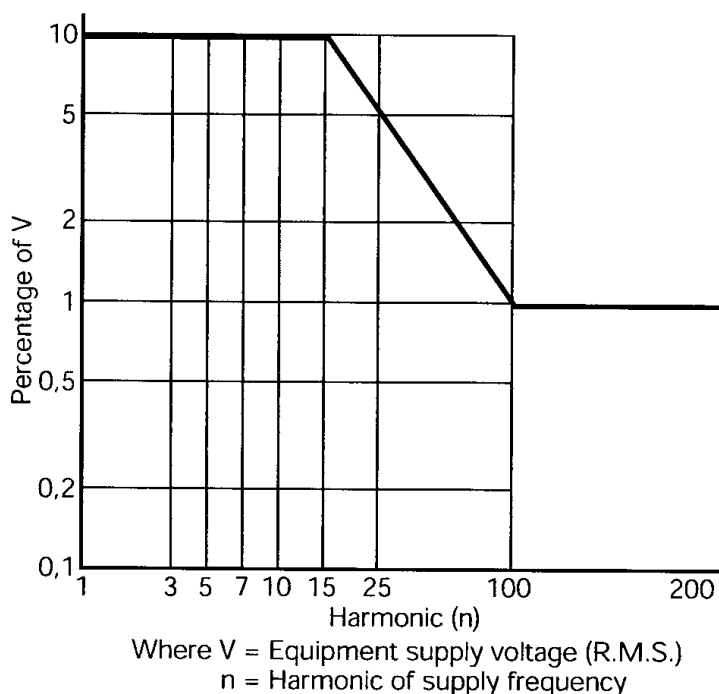


Fig. 1.22.1 Harmonic/test voltage for conducted low frequency interference

22.2 D.C. powered equipment

22.2.1 A sinusoidal RMS voltage is to be superimposed on the power supply lines and configured as follows:

- (a) Amplitude/frequency range: 10 per cent of the nominal supply voltage over the range 50 Hz to 10 kHz.
- (b) Applied power: A maximum of 2,0 W to the supply lines, when the impedance is too low to maintain a signal level of 3V RMS.

22.2.2 The signal level shall be maintained as the frequency is adjusted through the specified frequency range at a rate sufficiently low to detect any malfunction of the product under test.

22.2.3 Reference standard IEC 60533.

23. Immunity to conducted radio interference

23.1 General

23.1.1 The test shall be carried out as described in IEC 61000-4-6 with the test parameters given below and applied to:

- (a) AC power lines.
- (b) DC power lines.
- (c) Signal/control lines.
- (d) I/O ports.

23.1.2 The disturbing signal supplied by the specified generator shall be applied by direct injection using the coupling/decoupling network (CDN) specifications given in the standard referenced in 23.1.1. The test shall be performed by connecting the generator to each CDN in turn while the other CDNs are terminated by 50Ω load resistors. The test disturbance level shall be set for each CDN with the generator connected and the EUT replaced by a 150Ω resistor. If the use of CDNs is not possible, alternative clamp injection as described in the standard may be applied.

23.1.3 Test parameters:

- (a) Frequency range: 150 kHz-80 MHz
- (b) Amplitude: 3V rms
- (c) Modulation: 80 per cent ±5 per cent at 1000 Hz ±10 per cent; or 400 Hz ±10 per cent where an input signal at a modulation frequency of 1000 Hz is necessary.
- (d) Frequency sweep: Not exceeding $1,5 \times 10^{-3}$ decades per second, or 1 per cent per second.

For bridge and deck mounted equipment only (in accordance with IEC 60945)

- (e) Amplitude: 10V rms; at
- (f) Spot frequencies: 2, 3, 4, 6,2, 8,2, 12,6, 16,5 18,8, 22 and 25 MHz
- (g) Modulation: 80 per cent ±10 per cent at 1000 Hz ±10 per cent; or 400 Hz ±10 per cent where an input signal at a modulation frequency of 1000 Hz is necessary.

24. Immunity to radiated radio frequency fields

24.1 General

24.1.1 The test shall be carried out as described in IEC 61000-4-3, severity level 3, with the test parameters given below.

24.1.2 The EUT shall be tested in a:

- (a) Suitably shielded test facility.
- (b) Anechoic chamber.
- (c) TEM cell appropriate for the size of the EUT.

24.1.3 The uniform test area shall be calibrated prior to placing the EUT in position and the same power output shall be applied during the tests.

24.1.4 The EUT shall be housed in the enclosure shown in the manufacturer's published specification or be tested in open rack configuration.

24.1.5 All modules of the EUT shall be interconnected with the type of cables specified by the manufacturer or if not specified, with parallel unscreened conductors and be left exposed for a distance of 1m from the EUT.

- 24.1.6 The configuration of the EUT shall be accurately recorded in the test report.
- 24.1.7 The test shall be carried out with the generating antenna facing each of the four sides of the EUT in turn.
- 24.1.8 The equipment shall be continuously operated, including data transfer between each module.
- 24.1.9 The frequency scan shall be slow enough to detect any malfunctioning.
- 24.1.10 Sensitive frequencies (e.g., clock frequencies, and harmonics) shall be analysed separately.
- 24.1.11 Test parameters:
- (a) Frequency range: 80 MHz – 2 GHz
 - (b) Modulation: 80 per cent \pm 10 per cent at 1000 Hz \pm 10 per cent; or 400 Hz \pm 10 per cent where an input signal at a modulation frequency of 1000 Hz is necessary.
 - (c) Field strength: 10 V/m
 - (d) Frequency sweep: Not exceeding $1,5 \times 10^{-3}$ decades per second, or 1 per cent per second.

25. Immunity to fast low-energy transients (bursts)

25.1 General

25.1.1 The test shall be carried out as described in standard IEC 61000-4-4, severity level 3, using the specified interference generator, with test parameters as given in 25.1.4.

25.1.2 All input/output lines of the EUT shall be connected to appropriate devices. The type of cabling shall be as specified in the manufacturer's data sheets.

25.1.3 The test signal shall be applied to AC & DC power and control/signal lines using the following coupling methods:

- (a) Coupling/decoupling network for a.c./d.c. mains supply port.
- (b) Capacitive coupling clamp.

25.1.4 Test parameters:

- (a) Single pulse rise time: 5 ns (between 10 per cent and 90 per cent value).
- (b) Single pulse width: 50 ns (50 per cent value).
- (c) Wave shape of the pulse output into 50 Ω amplitude (peak):
 - 2 kV line/earth, power lines
 - 1 kV line/earth, control and signal lines.
- (d) Pulse repetition rate: 5 kHz at 1 kV and at 2 kV.
- (e) Application: 15 ms bursts in every 300 ms.
- (f) Duration/polarity: 5 minutes for positive and negative polarity pulses.

26. Immunity to slow high-energy transients (surges)

26.1 General

26.1.1 The test shall be carried out as described in the standard IEC 61000-4-5, severity level 2, using the specified 1,2/5 μ s – 8/20 μ s combination wave pulse generator with test parameters given below.

26.1.2 All input/output lines of the EUT shall be connected to appropriate devices. The test signal shall be applied to AC and DC power lines using the coupling method specified in IEC 61000-4-5.

26.1.3 Test parameters:

- (a) Pulse rise time: 1,2 μ s (between 30 per cent and 90 per cent value).
- (b) Pulse width: 50 μ s (50 per cent value).
- (c) Amplitude (peak): 1 kV line/earth, 0,5 kV line/line.
- (d) Repetition rate: \geq 1 pulse/min.
- (e) No. of pulses: 5 positive and negative polarity pulses.
- (f) Application: Continuous.

27. Immunity to electrostatic discharge (ESD)

27.1 General

27.1.1 The test shall be carried out in accordance with IEC 61000-4-2, severity level 3, using the specified ESD generator and test parameters as given in 27.1.7.

27.1.2 The equipment shall be placed on, but insulated from, a metal ground plate extending at least 0,5 m beyond the perimeter of the EUT. Discharges from the ESD generator as described in IEC 61000-4-2 held perpendicular to the surface shall be applied only to points accessible to the operator in normal use.

27.1.3 Preliminary tests may be made:

- (a) At a rate of 20 discharges per second.
- (b) At each position tested 10 discharges should be applied, with both +ve and -ve polarity with at least 1 second intervals between discharges.

27.1.4 Contact discharges shall be applied to conducting surfaces, and air discharges only to areas declared insulating by the manufacturer, in order to simulate discharges on objects placed or installed near the EUT.

27.1.5 10 single contact discharges per polarity shall be applied to positions on the ground plane around and at a distance from the EUT. In addition, at least 10 single discharges (in the most sensitive polarity) shall be applied to the centre of one edge of a vertical coupling plane of dimension 0,5 x 0,5 m placed parallel to and at 0,1 m distance from the EUT.

27.1.6 Discharges shall be applied with this coupling plane in sufficient different positions so that all four faces of the EUT are sufficiently illuminated.

27.1.7 Test parameters:

- (a) Output voltage: Contact discharge 6 kV
Air discharge 8 kV
- (b) Pulse interval: 1 second
- (c) No. of pulses: 10 for positive and negative polarity pulses.

28. Electromagnetic emission tests for equipment incorporating active electronic components

28.1 General

28.1.1 Electronic products intended for use on the bridge, deck and general power distribution zones shall be subjected to the following specified electromagnetic tests for:

- (a) Radiated emissions.
- (b) Conducted emissions.

28.1.2 The documentation of the test conditions, test equipment, configuration of the test set-up and test specimens as well as the presentation of the results should be sufficient to enable the tests to be repeated at a future date with similar results, should this be required.

29. Radiated emissions

29.1 General

29.1.1 The test shall generally be carried out as described in CISPR 16-1-4 utilising equipment specified in CISPR 16-1-1 with the test parameters as given in Table 1.29.1 (equipment on the bridge and deck zone) and Table 1.29.2 (equipment in general power distribution zones).

29.1.2 To establish the maximum emission levels, the tests should be carried out with the EUT in varying orientations relative to the antenna and the latter's elevation varied. The same applies to the positioning of cables.

29.1.3 Test parameters:

Table 1.29.1 Equipment on the bridge and deck zone

| Frequency range | Limits (quasi peak) |
|---------------------|---------------------|
| 0,15–0,3 MHz | 80–52 dB μ V/m |
| 0,3–30 MHz | 52–34 dB μ V/m |
| 30–2000 MHz | 54 dB μ V/m |
| Except: 156–165 MHz | 24 dB μ V/m |

Table 1.29.2 Equipment in general power distribution zones

| Frequency range | Limits (quasi peak) |
|---------------------|---------------------|
| 0,15–30 MHz | 80–50 dB μ V/m |
| 30–100 MHz | 60–54 dB μ V/m |
| 100–2000MHz | 54 dB μ V/m |
| Except: 156–165 MHz | 24 dB μ V/m |

30. Conducted emissions

30.1 General

30.1.1 The test shall generally be carried out as described in CISPR 16-1-2 utilising equipment specified in CISPR 16-1-1 with the test parameters as given in Table 1.30.1 (equipment on the bridge and deck zone) and Table 1.30.2 (equipment in general power distribution zones).

Table 1.30.1 Equipment on the bridge and deck zone

| Frequency range | Limits (quasi peak) |
|-----------------|---------------------|
| 10-150kHz | 96-50 dB μ V |
| 150-350 kHz | 60-50 dB μ V |
| 350 kHz-30 MHz | 50 dB μ V |

Table 1.30.2 Equipment in general power distribution zones

| Frequency range | Limits (quasi peak) |
|-----------------|---------------------|
| 10-150 kHz | 120- 69 dB μ V |
| 150-500 kHz | 79 dB μ V |
| 0,5-30 MHz | 73 dB μ V |

31. Examination of software for type approval of products that include programmable electronic systems

31.1 General

31.1.1 For Type Approval of products that include the use of programmable electronic systems, the software is to comply with the requirements of LR's Rules for Ships and/or other LR Rules as applicable.

31.1.2 Refer to sub-Section 1.1.7 for systems that implement emergency trip, emergency stop, safety critical functionality or provide essential services without alternative means of operation.

31.1.3 Functional testing of software is to demonstrate functionality required by the relevant LR Rules applicable to the product and may form part of the performance test specified under Section 5.

31.2 Tests

31.2.1 All tests shall be documented. The documentation shall include a description of the methods of test, required test results and test results including tests performed by other suppliers of embedded or interconnected systems.

31.2.2 Software modules are to be tested prior to being installed in the associated hardware.

31.2.3 Application software is to be fully tested prior to being installed on board.

31.3 System testing

31.3.1 Testing shall be performed in full on the system comprising actual hardware components, software modules and application software, in accordance with an approved test program.

31.3.2 System tests and visual examination shall verify that the system fulfils its functional specification.

31.3.3 Failures are to be simulated as realistically as possible. Alarm and safety limits are to be checked, preferably by exceeding the specified limits of monitored parameters.

31.3.4 It is to be verified that the system functions as intended under normal and abnormal operating conditions.

32. Additional tests

32.1 Enclosure test

32.1.1 Where the manufacturer states a degree of protection from dust and water by means of an enclosure other than IP56 for category ENV5, the appropriate tests shall be carried out in accordance with IEC 60529 or an acceptable National Standard for the specified enclosure notation.

32.2 Extreme vibration

32.2.1 Where products are intended for use under extreme vibration conditions, in addition to the tests of Sections 12 or 13 of this specification, the product may be subjected to a vibration test with conditions as follows:

- (a) Frequency range: 40 Hz to 2000 Hz
- (b) Acceleration: ± 10 g
- (d) Endurance duration: 90 min
- (e) Test specification: IEC 60068-2-6.

32.3 Explosion protection tests

32.3.1 Where the product is specified as suitable for use in potentially hazardous areas, certification for such use by an accredited testing authority is required.

32.4 Further tests

32.4.1 Further tests may be required for specific products and these are to be agreed with LR. Such tests will be based on National or International Standards where available. Examples of such tests are:

- (a) Endurance tests.
- (b) Free-fall tests for portable equipment.
- (c) Shock test (e.g., low-level lighting systems).
- (d) Ultraviolet tests for plastic materials exposed to sunlight.
- (e) Flame retardance tests (products with significant plastics content combustible material content): IEC 60695-2-11 and IEC 60695-11-5 or equivalent.

Appendix 1

General acceptance criteria applicable to LR Test Specification No. 1

Performance Criterion A: (For continuous phenomena): The Equipment Under Test (EUT) shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed as defined in the technical specification published by the manufacturer.

Performance Criterion B: (For transient phenomena): The EUT shall continue to operate as intended after the tests. No degradation of performance or loss of function is allowed as defined in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance, which is self-recoverable, is, however, allowed but no change of actual operating state or stored data is allowed.

Performance Criterion C: (For interruption of operation): Temporary degradation or loss of function or performance is allowed during and after the test provided function is self-recoverable, or can be restored by the operation of the controls as defined in the technical specification published by the manufacturer. No corruption or loss of stored data is allowed.

Performance Criterion A applies to the following tests:

- Performance Section 5
- Power supply variation Section 8
- Inclination Section 10 and Section 11
- Vibration Section 12 and Section 13
- Humidity Section 14 and Section 15
- Dry Heat Section 17
- Low Temperature Section 18
- Enclosure Section 20
- Immunity to conducted low frequency interference Section 22
- Immunity to conducted radio interference Section 23
- Immunity to radiated radio frequency fields Section 24

Performance Criterion B applies to the following tests:

- Pressure Section 6
- Power supply transient variation Section 8
- Salt mist Section 16
- High voltage Section 19
- Immunity to bursts Section 25
- Immunity to surges Section 26
- Immunity to electrostatic discharge Section 27

Performance Criterion C applies to the following test:

- Power supply failure Section 9

The above acceptance criteria should be applied in conjunction with specific performance requirements based on the manufacturer's technical product specification and any specified product standard.

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