concerning ELECTRICAL INSTALLATIONS

IACS Req. 2010

CONTENTS

E1 (1975) Governing characteristics of generator prime movers

see revised M 3.2

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E2 Deleted (December 1996)

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E3 Deleted (December 1996)

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E4 Earthing of non-current-carrying parts

(1978)

Deleted in June 2000.

E5 Voltage and frequency variations

(1979) (Rev.1 Sept. 2005)

1. All electrical appliances supplied from the main or emergency systems are to be so designed and manufactured that they are capable of operating satisfactorily under the normally occurring variations in voltage and frequency.

2. Unless otherwise stated in the national or international standards, all equipment should operate satisfactorily with the variations from its rated value shown in the Tables 1 to 3 on the following conditions.

(a) For alternative current components, voltage and frequency variations shown in the Table 1 are to be assumed.

(b) For direct current components supplied by d.c. generators or converted by rectifiers, voltage variations shown in the Table 2 are to be assumed.

(c) For direct current components supplied by electrical batteries, voltage variations shown in the Table 3 are to be assumed.

3. Any special system, e.g. electronic circuits, whose function cannot operate satisfactorily within the limits shown in the Table should not be supplied directly from the system but by alternative means, e.g. through stabilized supply.

Table 1: Voltage and frequency variations for a.c. distribution systems

Quantity in Operation	Variations	
	Permanent	Transient
Frequency	±5%	±10% (5 sec)
Voltage	+6%, -10%	±20% (1.5 sec)

Table 2: Voltage variations for d.c distribution systems

Parameters	Variations
Voltage tolerance (continuous)	±10%
Voltage cyclic variation deviation	5%
Voltage ripple (a.c. r.m.s. over steady d.c. voltage)	10%

Table 3: Voltage variations for battery systems

Systems	Variations
Components connected to the battery during charging (see Note)	+30%, -25%
Components not connected to the battery during charging	+20%, -25%
Note: Different voltage variations as determined by the charging/discharging characteristics, including ripple voltage from the charging device, may be considered.	

END

E6 Deleted

END

E7 Cables

(1975) (Rev. 1 1990) (Rev.2 June 2000) (Rev.3 May 2006)

1 Cables are to be of a type approved by the Classification Society.

2 Cables manufactured in accordance with the relevant recommendations of IEC Publication 60092-350, 60092-351, 60092-352, 60092-353, 60092-354, 60092-359, 60092-373, 60092-374, 60092-375 and 60092-376 will be accepted by the Classification Society provided that they are tested to its satisfaction.

3 Cables manufactured and tested to standards other than those specified in 2 will be accepted provided they are in accordance with an acceptable and relevant international or national standard.

END

E8 Starting arrangements of internal combustion engines

(1977)
(Rev.1 1996)
(Corr. Aug 2000)

Deleted in Dec 2003

(E8 has been merged with UR M49 to form a new UR M61 (Dec 2003))

E9 (1988) Earthing and bonding of cargo tanks/ process plant/piping systems for the control of static electricity

E9.1 The hazard of an incentive discharge due to the build-up of static electricity resulting from the flow of liquids/gases/vapours can be avoided if the resistance between the cargo tanks/process plant/piping systems and the hull of the ship is not greater than 10^6 ohm.

E9.2 This value of resistance will be readily achieved without the use of bonding straps where cargo tanks/process plant/piping systems are directly or via their supports, either welded or bolted to the hull of the ship.

E9.3 Bonding straps are required for cargo tanks/process plant/piping systems which are not permanently connected to the hull of the ship, e.g.

a) independent cargo tanks;
b) cargo tanks/piping systems which are electrically separated from the hull of the ship;
c) pipe connections arranged for the removal of spool pieces.

E9.4 Where bonding straps are required, they should be:

a) clearly visible so that any shortcomings can be clearly detected;
b) designed and sited so that they are protected against mechanical damage and that they are not affected by high resistivity contamination e.g. corrosive products or paint;
c) easy to install and replace.

E9.5 Checks should be made on the resistance to earth during construction of the ship and at subsequent major surveys, supplemented by visual inspection during annual surveys.

E10 Test Specification for Type Approval

(1991)
(Rev.1 1993)
(Rev.2 1997)
(Rev.2.1 July 1999)
(Rev.3 May 2001)
(Corr.1 July 2003)
(Rev.4 May 2004)
(Rev.5 Dec 2006)

E10.1 General

This Test specification is applicable, but not confined, to all equipment used for*:

- control, protection and safety;
- internal communication.

E10.2 Testing

These tests are to demonstrate the ability of the equipment to function as intended under the specified testing conditions.

The extent of the testing (i.e. the selection and sequence of carrying out tests and number of pieces to be tested) is to be determined upon examination and evaluation of the equipment or component subject to testing giving due regard to its intended usage.

Equipment is to be tested in its normal position if otherwise not specified in the test specification.

Relevant tests are as listed in the Table.

E10.3 Navigational and Radio Equipment

Test conditions as specified in IEC 60945 (Marine navigational and radiocommunication equipment and systems - General requirements, Methods of testing and required test results) are to be applied for the above mentioned equipment.

Note: * These test requirements are harmonised with IEC 60092-504 “Electrical Installations in Ships - Part 504: Special features - Control and Instrumentation” and IEC 60533 “Electrical and electronic installations in ships - electromagnetic compatibility”. Electrical and electronic equipment on board ships, required neither by classification rules nor by International Conventions, liable to cause eletromagnetic disturbance shall be of type which fulfill the test requirements of test specification items 19 and 20.

Note: Rev.5 of this UR is to be uniformly implemented by IACS Societies from 1 January 2008.

E10
(cont'd)

Type testing condition for equipment covered by E10.1

<table>
<tr><th>NO.</th><th>TEST</th><th>PROCEDURE ACC. TO:*</th><th>TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td>1.</td><td>Visual inspection</td><td>-</td><td>-</td><td>- conformance to drawings, design data</td></tr>
<tr><td>2.</td><td>Performance test</td><td>Manufacturer performance test programme based upon specification and relevant Rule requirements.</td><td>- standard atmosphere conditions
- temperature: 25°C ± 10°C
- relative humidity: 60% ± 30%
- air pressure: 96 KPa ± 10KPa</td><td>- confirmation that operation is in accordance with the requirements specified for particular system or equipment;
- checking of self-monitoring features;
- checking of specified protection against an access to the memory;
- checking against effect of unerroneous use of control elements in the case of computer systems.</td></tr>
<tr><td>3.</td><td>External power supply failure</td><td>-</td><td>- 3 interruptions during 5 minutes;
- switching-off time 30 s each case</td><td rowspan="2">- The time of 5 minutes may be exceeded if the equipment under test needs a longer time for start up, e.g. booting sequence
- For equipment which requires booting, one additional power supply interruption during booting to be performed
Verification of:
- equipment behaviour upon loss and restoration of supply;
- possible corruption of programme or data held in programmable electronic systems, where applicable.</td></tr>
<tr><td>4.</td><td>Power supply variations
a) electric</td><td>-</td><td>AC SUPPLY
<table>
<tr><th>Combination</th><th>Voltage variation permanent %</th><th>Frequency variation permanent %</th></tr>
<tr><td>1
2
3
4</td><td>+6
+6
-10
-10</td><td>+5
-5
-5
+5</td></tr>
<tr><td></td><td>voltage transient 1,5 s %</td><td>frequency transient 5 s %</td></tr>
<tr><td>5
6</td><td>+20
-20</td><td>+10
-10</td></tr>
</table></td></tr>
</table>

*Note:
indicates the testing procedure which is normally to be applied. However, equivalent testing procedure may be accepted by the individual Society provided that the Unified Requirements stated in the other columns are fulfilled.

E10
(cont'd)

NO.	TEST	PROCEDURE ACC. TO:*	TEST PARAMETERS	OTHER INFORMATION
	b) pneumatic and hydraulic		DC SUPPLY Voltage tolerance continuous: ±10% Voltage cyclic variation: 5% Voltage ripple: 10% Electric battery supply: - +30% to –25% for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device; - +20% to –25% for equipment not connected to the battery during charging. Pressure: ±20% Duration: 15 minutes	
5.	Dry heat	IEC Publication 60068-2-2	Temperature: 55° ± 2°C Duration: 16 hours or Temperature: 70°C ± 2°C Duration: 2 hours (see note 1)	- equipment operating during conditioning and testing; - functional test during the last hour at the test temperature.
6.	Damp heat	IEC Publication 60068-2-30 test D_b	Temperature: 55°C Humidity: 95% Duration: 2 cycles 2 x (12 +12 hours)	- measurement of insulation resistance before test; - equipment operating during the complete first cycle and switched off during second cycle except for functional test; - functional test during the first 2 hours of the first cycle at the test temperature and during the last 2 hours of the second cycle at the test temperature; - recovery at standard atmosphere conditions; - insulation resistance measurements and performance test.

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(cont'd)

NO.	TEST	PROCEDURE ACC. TO:*	TEST PARAMETERS	OTHER INFORMATION
7.	Vibration	IEC Publication 60068-2-6 Test F_c	2^{+3}_{-0} Hz to 13.2 Hz – amplitude ±1mm 13.2 Hz to 100 Hz – acceleration ± 0.7 g. For severe vibration conditions such as, e.g. on diesel engines, air compressors, etc.: 2.0 Hz to 25 Hz – amplitude ±1.6 mm 25.0 Hz to 100 Hz – acceleration ± 4.0 g. Note: More severe conditions may exist for example on exhaust manifolds of diesel engines especially for medium and high speed engines. Values may be required to be in these cases 40 Hz to 2000 Hz - acceleration ± 10.0g at 600°C, duration 90 min.	- duration in case of no resonance condition 90 minutes at 30 Hz; - duration at each resonance frequency at which Q≥ 2 is recorded - 90 minutes; - during the vibration test, functional tests are to be carried out; - tests to be carried out in three mutually perpendicular planes; - it is recommended as guidance that Q does not exceed 5. - where sweep test is to be carried out instead of the discrete frequency test and a number of resonant frequencies is detected close to each other, duration of the test is to be 120 min. Sweep over a restricted frequency range between 0.8 and 1.2 times the critical frequencies can be used where appropriate. Note: Critical frequency is a frequency at which the equipment being tested may exhibit: - malfunction and/or performance deterioration - mechanical resonances and/or other response effects occur, e.g. chatter

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NO.	TEST	PROCEDURE ACC. TO:*	TEST PARAMETERS	OTHER INFORMATION
8.	Inclination	Publication IEC 60092-504	Static 22.5°	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 plane at right angles to that used in (a), d) inclined to at least 22.5° on the other side of the vertical and in the same plane as in (c). Note: The period of testing in each position should be sufficient to fully evaluate the behaviour of the equipment.
			Dynamic 22.5°	Using the directions defined in a) to d) above, the equipment is to be rolled to an angle of 22.5° each side of the vertical with a period of 10 seconds. The test in each direction is to be carried out for not less than 15 minutes. On ships for the carriage of liquified 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°. Note: These inclination tests are normally not required for equipment with no moving parts.

E10
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<table>
<tr><th>NO.</th><th>TEST</th><th>PROCEDURE ACC. TO:*</th><th>TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td>9.</td><td>Insulation resistance</td><td colspan="2"><table>
<tr><th rowspan="2">Rated supply voltage Un (V)</th><th rowspan="2">Test voltage Un (V)</th><th colspan="2">Min. insulation resistance</th></tr>
<tr><th>before test M ohms</th><th>after test M ohms</th></tr>
<tr><td>Un ≤ 65</td><td>2 x Un min. 24V</td><td>10</td><td>1,0</td></tr>
<tr><td>Un > 65</td><td>500</td><td>100</td><td>10</td></tr>
</table></td><td>- For high voltage equipment, reference is made to UR E11.
- insulation resistance test is to be carried out before and after: damp heat test, cold test, salt mist test and high voltage test;
- between all phases and earth; and where appropriate, between the phases.
Note: Certain components e.g. for EMC protection may be required to be disconnected for this test.</td></tr>
<tr><td>10.</td><td>High voltage</td><td colspan="2"><table>
<tr><th>Rated voltage Un (V)</th><th>Test voltage (A.C. voltage 50 or 60Hz) (V)</th></tr>
<tr><td>Up to 65</td><td>2 x Un + 500</td></tr>
<tr><td>66 to 250</td><td>1500</td></tr>
<tr><td>251 to 500</td><td>2000</td></tr>
<tr><td>501 to 690</td><td>2500</td></tr>
</table></td><td>- For high voltage equipment, reference is made to UR E11.
- separate circuits are to be tested against each each other and all circuits connected with each other tested against earth;
- printed circuits with electronic components may be removed during the test;
- period of application of the test voltage: 1 minute</td></tr>
<tr><td>11.</td><td>Cold</td><td>IEC Publication 60068-2-1</td><td>Temperature: +5°C ± 3°C
Duration: 2 hours
or
Temperature: –25°C ± 3°C
Duration: 2 hours
(see note 2)</td><td>- initial measurement of insulation resistance;
- equipment not operating during conditioning and testing except for functional test;
- functional test during the last hour at the test temperature;
- insulation resistance measurement and the functional test after recovery</td></tr>
</table>

E10
(cont'd)

NO.	TEST	PROCEDURE ACC. TO:*	TEST PARAMETERS	OTHER INFORMATION
12.	Salt mist	IEC Publication 60068-2-52 Test Kb	Four spraying periods with a storage of 7 days after each.	- initial measurement of insulation resistance and initial functional test; - equipment not operating during conditioning; - functional test on the 7th day of each storage period; - insulation resistance measurement and performance test 4 to 6h after recovery. (see Note 3)
13.	Electrostatic discharge	IEC 61000-4-2	Contact discharge: 6kV Air discharge: 8kV Interval between single discharges: 1 sec. No. of pulses: 10 per polarity According to level 3 severity standard.	- to simulate electrostatic discharge as may occur when persons touch the appliance; - the test is to be confined to the points and surfaces that can normally be reached by the operator; - Performance Criterion B (See Note 4).
14.	Electromagnetic field	IEC 61000-4-3	Frequency range: 80 MHz to 2 GHz Modulation**: 80% AM at 1000Hz Field strength: 10V/m Frequency sweep rate: $\leq 1.5 \times 10^{-3}$ decades/s (or 1%/3 sec) According to level 3 severity standard.	- to simulate electromagnetic fields radiated by different transmitters; - the test is to be confined to the appliances exposed to direct radiation by transmitters at their place of installation. - Performance criterion A (See Note 5) **If for tests of equipment an input signal with a modulation frequency of 1000 Hz is necessary a modulation frequency of 400 Hz may be chosen.

E10
(cont'd)

NO.	TEST	PROCEDURE ACC. TO:*	TEST PARAMETERS	OTHER INFORMATION
15.	Conducted low Frequency		AC: Frequency range: rated frequency to 200th harmonic; Test voltage (rms): 10% of supply to 15th harmonic reducing to 1% at 100th harmonic and maintain this level to the 200th harmonic, min 3 V r.m.s, max 2 W. DC: Frequency range: 50 Hz - 10 kHz; Test voltage (rms): 10% of supply max. 2 W	- to stimulate distortions in the power supply system generated for instance, by electronic consumers and coupled in as harmonics; - performance criterion A (see Note 5). - See figure - "Test set-up"
16.	Conducted Radio Frequency	IEC 61000-4-6	AC, DC, I/O ports and signal/control lines: Frequency range: 150 kHz - 80 MHz Amplitude: 3 V rms (See Note 6) Modulation ***: 80% AM at 1000 Hz Frequency sweep range: ≤ 1.5 x 10^{-3} decades/s (or 1%/3sec.) According to level 2 severity standard	- Equipment design and the choice of materials is to stimulate electromagnetic fields coupled as high frequency into the test specimen via the connecting lines. - performance criterion A (see Note 5). *** If for tests of equipment an input signal with a modulation frequency of 1000 Hz is necessary a modulation frequency of 400 Hz may be chosen.
17.	Burst/Fast Transients	IEC 61000-4-4	Single pulse time: 5 ns (between 10% and 90% value) Single pulse width: 50 ns (50% value) Amplitude (peak): 2kV line on power supply port/earth; 1kV on I/O data control and communication ports (coupling clamp) Pulse period: 300 ms; Burst duration: 15 ms; Duration/polarity: 5 min According to level 3 severity standard.	- arcs generated when actuating electrical contacts; - interface effect occurring on the power supply, as well as at the external wiring of the test specimen; - performance criterion B (see Note 4).

E10
(cont'd)

<table>
<tr><th>NO.</th><th>TEST</th><th>PROCEDURE ACC. TO:*</th><th>TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td>18.</td><td>Surge/voltage</td><td>IEC 61000-4-5</td><td>Pulse rise time: 1.2 µVs (between 10% and 90% value)
Pulse width: 50 µVs (50% value)
Amplitude (peak): 1kV line/earth;
0.5kV line/line
Repetition rate: ≥ 1 pulse/min
No of pulses: 5 per polarity
Application: continuous
According to level 2 severity standard.</td><td>- interference generated for instance, by switching "ON" or "OFF" high power inductive consumers;

- test procedure in accordance with figure 10 of the standard for equipment where power and signal lines are identical;

- performance criterion B (see Note 4).</td></tr>
<tr><td>19.</td><td>Radiated Emission</td><td>CISPR 16-1, 16-2</td><td>For equipment installed in the bridge and deck zone.

<table><tr><th>Frequency range:</th><th>Limits:</th></tr><tr><td>0.15 - 0.3 MHz</td><td>80 - 52 dBµV/m</td></tr><tr><td>0.3 - 30 MHz</td><td>50 - 34 dBµV/m</td></tr><tr><td>30 - 2000 MHz</td><td>54 dBµV/m</td></tr><tr><td>except for:</td><td></td></tr><tr><td>156 -165 MHz</td><td>24 dBµV/m</td></tr></table>
For equipment installed in the general power distribution zone.

<table><tr><th>Frequency range:</th><th>Limits:</th></tr><tr><td>0.15 - 30 MHz</td><td>80 - 50 dBµV/m</td></tr><tr><td>30 - 100 MHz</td><td>60 - 54 dBµV/m</td></tr><tr><td>100 - 2000 MHz</td><td>54 dBµV/m</td></tr><tr><td>except for:</td><td></td></tr><tr><td>156 - 165 MHz</td><td>24 dBµV/m</td></tr></table></td><td>- procedure in accordance with the standard but distance 3 m between equipment and antenna</td></tr>
</table>

E10
(cont'd)

<table>
<tr><th>NO.</th><th>TEST</th><th>PROCEDURE ACC. TO:*</th><th>TEST PARAMETERS</th><th>OTHER INFORMATION</th></tr>
<tr><td>20.</td><td>Conducted Emission</td><td>CISPR 16-1, 16-2</td><td>For equipment installed in the bridge and deck zone.

<table><tr><td>Frequency range:</td><td>Limits:</td></tr><tr><td>10 - 150 kHz
150 - 350 kHz
350 kHz - 30 MHz</td><td>96 - 50 dBµV
60 - 50 dBµV
50 dBµV</td></tr></table>
For equipment installed in the general power distribution zone.

<table><tr><td>Frequency range:</td><td>Limits:</td></tr><tr><td>10 - 150 kHz
150 - 500 kHz
0.5 - 30 MHz</td><td>120 - 69 dBµV
79 dBµV
73 dBµV</td></tr></table></td><td></td></tr>
<tr><td>21.</td><td>Flame retardant</td><td>IEC 60092-101 or
IEC 60695-11-5</td><td>Flame application: 5 times 15 s each.
Interval between each application:
15s or 1 time 30s.

Test criteria based upon application.

The test is performed with the EUT or housing of the EUT applying needle-flame test method.</td><td>- the burnt out or damaged part of the specimen by not more than 60 mm long.
- no flame, no incandescence or
- in the event of a flame or incandescence being present, it shall extinguish itself within 30 s of the removal of the needle flame without full combustion of the test specimen.
- any dripping material shall extinguish itself in such a way as not to ignite a wrapping tissue. The drip height is 200 mm ± 5 mm.</td></tr>
</table>

E10
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Notes:

1. Equipment to be mounted in consoles, housing etc. together with other equipment are to be tested with 70°C.

2. For equipment installed in non-weather protected locations or cold locations test is to be carried out at –25°C.

3. Salt mist test is to be carried out for equipment installed in weather exposed areas.

4. 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.

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

6. For equipment installed on the bridge and deck zone, the test levels shall be increased to 10V rms for spot frequencies in accordance with IEC 60945 at 2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22, 25 MHz.

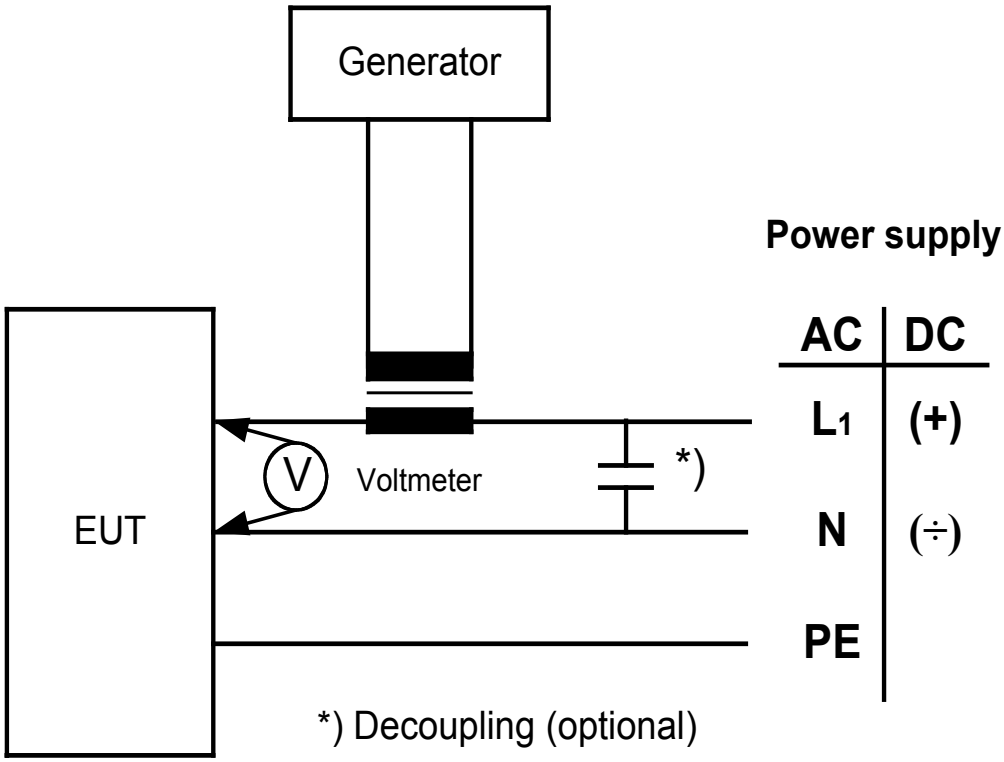

Figure - Test Set-up – Conducted Low Frequency Test

End

E11 Unified requirements for systems with voltages above 1 kV up to 15 kV

1991 (Rev. 1 May 2001) (Rev.2 July 2003)

1. General

1.1 Field of application

The following requirements apply to a.c. three-phase systems with nominal voltage exceeding 1kV, the nominal voltage is the voltage between phases.

If not otherwise stated herein, construction and installation applicable to low voltage equipment generally apply to high voltage equipment.

1.2 Nominal system voltage

The nominal system voltage is not to exceed 15 kV.

Note: Where necessary for special application, higher voltages may be accepted by the Society.

1.3 High-voltage, low-voltage segregation

Equipment with voltage above about 1 kV is not to be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

2 System Design

2.1 Distribution

2.1.1 Network configuration for continuity of ship services

It is to be possible to split the main switchboard into at least two independent sections, by means of at least one circuit breaker or other suitable disconnecting devices, each supplied by at least one generator. If two separate switchboards are provided and interconnected with cables, a circuit breaker is to be provided at each end of the cable.

Services which are duplicated are to be divided between the sections.

2.1.2 Earthed neutral systems

In case of earth fault, the current is not to be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault.

It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energised mode. Electrical equipment in directly earthed neutral or other neutral earthed systems is to withstand the current due to a single phase fault against earth for the time necessary to trip the protection device.

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2.1.3 Neutral disconnection

Means of disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance and for insulation resistance measurement.

2.1. 4 Hull connection of earthing impedance

All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the earth connections do not interfere with radio, radar, communication and control equipment circuits.

2.1. 5 Divided systems
In the systems with neutral earthed, connection of the neutral to the hull is to be provided for each section.

2.2 Degrees of protection

2.2.1 General

Each part of the electrical installation is to be provided with a degree of protection appropriate to the location, as a minimum the requirements of IEC Publication 60092-201.

2.2.2 Rotating machines

The degree of protection of enclosures of rotating electrical machines is to be at least IP 23. The degree of protection of terminals is to be at least IP44.

For motors installed in spaces accessible to unqualified personnel, a degree of protection against approaching or contact with live or moving parts of at least IP4X is required.

2.2.3 Transformers

The degree of protection of enclosures of transformers is to be at least IP23

For transformers installed in spaces accessible to unqualified personnel a degree of protection of at least IP4X is required.

For transformers not contained in enclosures, *see* para 7.1.

2.2.4 Switchgear, controlgear assemblies and converters

The degree of protection of metal enclosed switchgear, controlgear assemblies and static convertors is to be at least IP32. For switchgear, control gear assemblies and static converters installed in spaces accessible to unqualified personnel, a degree of protection of at least IP4X is required.

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2.3 Insulation

2.3.1 Air clearance

In general, for Non Type Tested equipment phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts are to be not less than those specified in Table 2.3.1.

Table 2.3.1

Nominal Voltage (kV)	Minimum air clearance (mm)
3 (3.3)	55
6 (6.6)	90
10 (11)	120
15	160

Intermediate values may be accepted for nominal voltages provided that the next higher air clearance is observed.

In the case of smaller distances, appropriate voltage impulse test must be applied.

2.3.2 Creepage distances

Creepage distances between live parts and between live parts and earthed metal parts for standard components are to be in accordance with relevant IEC Publications for the nominal voltage of the system, the nature of the insultation material and the transient overvoltage developed by switch and fault conditions.

For non-standardised parts within the busbar section of a switchgear assembly, the minimum creepage distance is to be at least 25 mm/kV and behind current limiting devices, 16mm/kV.

2.4 Protection

2.4.1 Faults on the generator side of circuit breaker

Protective devices are to be provided against phase-to-phase faults in the cables connecting the generators to the main switchboard and against interwinding faults within the generators. The protective devices are to trip the generator circuit breaker and to automatically de-excite the generator.

In distribution systems with a neutral earthed, phase to earth faults are also to be treated as above.

2.4.2 Faults to earth

Any earth fault in the system is to be indicated by means of a visual and audible alarm. In low impedance or direct earthed systems provision is to be made to automatic disconnect the faulty circuits. In high impedance earthed systems, where outgoing feeders will not be isolated in case of an earth fault, the insulation of the equipment is to be designed for the phase to phase voltage.

Note: Earthing factor is defined as the ratio between the phase to earth voltage of the health phase and the phase to phase voltage. This factor may vary between (1/sqrt 3) and 1.

A system is defined effectively earthed (low impedance) when this factor is lower than 0.8. A system is defined non-effectively earthed (high impedance) when this factor is higher than 0.8.

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2.4.3 Power transformers

Power transformers are to be provided with overload and short circuit protection. When transformers are connected in parallel, tripping of the protective devices at the primary side has to automatically trip the switch connected at the secondary side.

2.4.4 Voltage transformers for control and instrumentation

Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

2.4.5 Fuses

Fuses are not to be used for overload protection.

2.4.6 Low voltage systems

Lower voltage systems supplied through transformers from high voltage systems are to be protected against overvoltages. This may be achieved by:

i) direct earthing of the lower voltage system
ii) appropriate neutral voltage limiters
iii) earthed screen between the primary and secondary windings of transformers.

3. Rotating machinery

3.1 Stator windings of generators

Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

3.2 Temperature detectors

Rotating machinery is to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit.

If embedded temperature detectors are used, means are to be provided to protect the circuit against overvoltage.

3. 3 Tests

In addition to the tests normally required for rotating machinery, a high frequency high voltage test in accordance with IEC Publication 60034-15 is to be carried out on the individual coils in order todemonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

E11

cont d

4. Power Transformers

4.1 General

Dry type transformers have to comply with IEC Publication 60726. Liquid cooled transformers have to comply with IEC Publication 60076. Oil immersed transformers are to be provided with the following alarms and protections:

- liquid level (Low) - alarm
- liquid temperature (High) - alarm
- liquid level (Low) - trip or load reduction
- liquid temperature (High) - trip or load reduction
- gas pressure relay (High) - trip

5. Cables

5.1 General

Cables are to be constructed in accordance with the I.E.C Publication 60092-353 and 60092-354 or other equivalent Standard.

6. Switchgear and controlgear assemblies

6.1 General

Switchgear and controlgear assemblies are to be constructed according to the I.E.C Publication 60298 and the following additional requirements.

6.2 Construction

6.2.1 Mechanical construction

Switchgear is to be of metal — enclosed type in accordance with I.E.C Publication 60298 or of the insulation — enclosed type in accordance with the I.E.C Publication 60466.

6.2.2 Locking facilities

Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers and switches and fixed disconnectors is to be possible.

Withdrawable circuit breakers are to be located in the service position so that there is no relative motion between fixed and moving portions.

6.2.3 Shutters

The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawable position the live contacts are automatically covered.

6.2.4 Earthing and short-circuiting

For maintenance purposes an adequate number of earthing and short-circuiting devices is to be provided to enable circuits to be worked upon with safety.

6.3 Auxiliary systems

6.3.1 Source and capacity of supply

If electrical energy and/or physical energy is required for the operation of circuit breakers and switches, a stored supply of such energy is to be provided for at least two operations of all the components. ▶

E11
cont d

However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources. This does not preclude shunt tripping provided that alarms are activated upon lack of continuity in the release circuits and power supply failures.

6.3.2 Number of external supply sources

When external source of supply is necessary for auxiliary circuits, at least two external sources of supply are to be provided and so arranged that a failure or loss of one source will not cause the loss of more than one generator set and/or set of essential services.
Where necessary one source of supply is to be from the emergency source of electrical power for the start up from dead ship condition.

6.4 High voltage test

A power-frequency voltage test is to be carried out on any switchgear and controlgear assemblies. The test procedure and voltages are to be according to the IEC Publication 60298.

7. Installation

7.1 Electrical equipment

Where equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down.

At the entrance of the spaces where high-voltage electrical equipment is installed, a suitable marking is to be placed which indicates danger of high-voltage. As regard the high-voltage electrical equipment installed out-side a.m. spaces, the similar marking is to be provided.

7.2 Cables

7.2.1 Runs of cables

In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

7.2.2 Segregation

High voltage cables are to be segregated from cables operating at different voltage ratings each other; in particular, they are not to be run in the same cable bunch, nor in the same ducts or pipes, or, in the same box.

Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage side in 2.3.1. However, high voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV and less.

7.2.3 Installation arrangements

High voltage cables, in general, are to be installed on carrier plating when they are provided with a continuous metallic sheath or armour which is effectively bonded to earth; otherwise they are to be installed for their entire length in metallic castings effectively bonded to earth.

▶

E11
cont'd

7.2.4 Terminations

Terminations in all conductors of high voltage cables are to be, as far as practicable, effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials.
High voltage cables of the radial field type, i.e. having a conductive layer to control the electric field within the insulation, are to have terminations which provide electric stress control.

Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e. tapes, wires etc).

7.2.5 Marking

High voltage cables are to be readily identifiable by suitable marking.

7.2.6 Test after installation

Before a new high voltage cable installation, or an addition to an existing installation, is put into service a voltage withstand test is to be satisfactorily carried out on each completed cable and its accessories.

The test is to be carried out after an insulation resistance test.

When a d.c. voltage withstand test is carried out, the voltage is to be not less than:

- 1.6 (2.5 Uo + 2kV) for cables of rated voltage (Uo) up to and including 3.6 kV, or
- 4.2 Uo for higher rated voltages

where Uo is the rated power frequency voltage between conductor and earth or metallic screen, for which the cable is designed.

The test voltage is to be maintained for a minimum of 15 minutes.

After completion of the test the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge.

An insultation resistance test is then repeated.

Alternatively, an a.c. voltage withstand test may be carried out upon advice from high voltage cable manufacturer at a voltage not less than normal operating voltage of the cable and it is to be maintained for a minimum of 24 hours.

Note: Tests according to those specific in IEC Publication 60502 will be considered adequate too.

E12 Electrical Equipment allowed in paint stores and in the enclosed spaces leading to paint stores

E12 (1994) (Corr. 1997) (Rev.1 May 2001)

1. Electrical equipment is to be installed in paint stores and in ventilation ducts serving such spaces only when it is essential for operational services.

   Certified safe type equipment of the following type is acceptable ;

   a. intrinsically safe Exi
   b. flameproof Exd
   c. pressurised Exp
   d. increased safety Exe
   e. special protection Exs

   Cables (through-runs or terminating cables) of armoured type or installed in metallic conduits are to be used.

2. The minimum requirements for the certified safe type equipment are as follows:

   - explosion group II B
   - temperature class T3

3. Switches, protective devices, motor control gear of electrical equipment installed in a paint store are to interrupt all poles or phases and preferably are to be located in non-hazardous space.

4. In the areas on open deck within 1m of inlet and exhaust ventilation openings or within 3 m of exhaust mechanical ventilation outlets, the following electrical equipment may be installed:

   - electrical equipment with the type of protection as permitted in paint stores or
   - equipment of protection class Exn or
   - appliances which do not generate arcs in service asnd whose surface does not reach unacceptably high temperature or
   - appliances with simplified pressurised enclosures or vapour-proof enclosures (minimum class of protection IP55) whose surface does not reach unacceptably high temperature
   - cables as specified in clause 1.

5. The enclosed spaces giving access to the paint store may be considered as non-hazardous, provided that :

   - the door to the paint store is a gastight door with self-closing devices without holding back arrangements,
   - the paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area,
   - warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

Note:

The paint stores and inlet and exhaust ventilation ducts under Clause 1 are classified as Zone-1-and areas on open deck under Clause 4 as Zone 2, as defined in IEC standard 60092-502, Electrical Installation in ships-part 502: Tankers-special features.

A watertight door may be considered as being gastight.

◀◀

E13 Test requirements for Rotating Machines

(1996) (Rev.1 May 2001) (Corr. 1 May 2004)

1. GENERAL

All machines are to be tested by the manufacturer.

Manufacturer s test records are to be provided for machines for essential services, for other machines they are to be available upon request.

All tests are to be carried out according to IEC Publication 60092-301.

All machines of 100kW and over, intended for essential services, are to be surveyed by the Society during test and, if appropriate, during manufacturing.

Note: An alternative survey scheme may be agreed by the Society with the manufacturer whereby attendance of the Surveyor will not be required as required above.

2. SHAFT MATERIAL

Shaft material for electric propulsion motors and for main engine driven generators where the shaft is part of the propulsion shafting is to be certified by the Society.

Shaft material for other machines is to be in accordance with recognised international or national standard.

E13

cont d

3 TESTS

Type tests are to be carried out on a prototype machine or on the first of a batch of machines, and routine tests carried out on subsequent machines in accordance with Table 1.

Note: Test requirements may differ for shaft generators, special purpose machines and machines of novel construction.

Table 1

No	Tests	A.C. Generators		Motors	
		Type test [1)]	Routine test [2)]	Type test [1)]	Routine test [2)]
1.	Examination of the technical documentation, as appropriate and visual inspection	x	x	x	x
2.	Insulation resistance measurement	x	x	x	x
3.	Winding resistance measurement	x	x	x	x
4.	Verification of the voltage regulation system	x	x[3)]		
5.	Rated load test and temperature rise measurements	x		x	
6.	Overload / overcurrent test	x	x[4)]	x	x[4)]
7.	Verification of steady short circuit conditions [5)]	x			
8.	Overspeed test	x	x	x [6)]	x [6)]
9.	Dielectric strength test	x	x	x	x
10.	No-load test	x	x	x	x
11.	Verification of degree of protection	x		x	
12.	Verification of bearings	x	x	x	x

[1)] Type tests on prototype machine or tests on at least the first batch of machines.

[2)] The report of machines routine tested is to contain the manufacturer s serial number of the machine which has been type tested and the test result.

[3)] Only functional test of voltage regulator system.

[4)] Only applicable for machine of essential services rated above 100kW.

[5)] Verification of steady short circuit condition applies to synchronous generators only.

[6)] Not applicable for squirrel cage motors.

E13
cont d

4 DESCRIPTION OF THE TEST

4.1 Examination of the technical documentation, as appropriate and visual inspection

4.1.1 Examination of the technical documentation

Technical documentation of machines rated at 100kW and over is to be available for examination by the Surveyor.

4.1.2 Visual inspection

A visual examination is to be made of the machine to ensure, as far as is practicable, that it complies with technical documentation.

4.2 Insulation resistance measurement

Immediately after the high voltage tests the insulation resistances are to be measured using a direct current insulation tester between:

a) all current carrying parts connected together and earth,
b) all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltages and corresponding insulation resistances are given in Table 2. The insulation resistance is to be measured close to the operating temperature, or an appropriate method of calculation is to be used.

Table 2

Related Voltage Un (V)	Minimum Test Voltage (V)	Minimum Insulation Resistance (MΩ)
$Un \leq 250$	2 x Un	1
$250 < Un \leq 1000$	500	1
$1000 < Un \leq 7200$	1000	(Un / 1000) + 1
$7200 < Un \leq 15000$	5000	(Un / 1000) + 1

4.3 Winding resistance measurement

The resistances of the machine windings are to be measured and recorded using an appropriate bridge method or voltage and current method.

E13

cont d

4.4 Verification of the voltage regulation system

The alternating current generator, together with its voltage regulation system, is to be verified that, at all loads from no-load running to full load, the rated voltage at the rated power factor is maintained under steady conditions within ± 2.5%. These limits may be increased to ± 3.5% for emergency sets.

When the generator is driven at rated speed, giving its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage is not to fall below 85% nor exceed 120% of the rated voltage.

The voltage of the generator is then to be restored to within plus or minus 3% of the rated voltage for the main generator sets in not more than 1.5 s. For emergency sets, these values may be increased to plus or minus 4% in not more than 5 s, respectively.

In the absence of precise information concerning the maximum values of the sudden loads, the following conditions may be assumed: 60% of the rated current with a power factor of between 0.4 lagging and zero to be suddenly switched on with the generator running at no load, and then switched off after steady - state conditions have been reached.

4.5 Rated load test and temperature rise measurements

The temperature rises are to be measured at the rated output, voltage, frequency and the duty for which the machine is rated and marked in accordance with the testing methods specified in IEC Publication 60034-1, or by means of a combination of other tests.
The limits of temperature rise are those specified in Table 1 of IEC Publication 60034-1 adjusted as necessary for the ambient reference temperatures specified in UR M40.

4.6 Overload/overcurrent tests

Overload test is to be carried out as a type test for generators as a proof of overload capability of generators and excitation system, for motors as a proof of momentary excess torque as required in IEC Publication 60034-1. The overload test can be replaced at routine test by the overcurrent test. The over current test shall be the proof of current capability of windings, wires, connections etc.of each machine. The overcurrent test can be done at reduced speed (motors) or at short circuit (generators).

4.7 Verification of steady short-circuit conditions

It is to be verified that under steady-state short-circuit conditions, the generator with its voltage regulating system is capable of maintaining, without sustaining any damage, a current of at least three times the rated current for a duration of at least 2 s or, where precise data is available, for a duration of any time delay which may be fitted in a tripping device for discrimination purposes.

4.8 Overspeed test

Machines are to withstand the overspeed test as specified in to IEC Publication 60034-1. This test is not applicable for squirrel cage motors.

4.9 Dielectric strength test

Machines are to withstand a dielectric test as specified in IEC Publication 60034-1.

For high voltage machine an impulse test is to be carried out on the coils according to UR E11.

▶

E13
cont d

4.10 No load test

Machines are to be operated at no load and rated speed whilst being supplied at rated voltage and frequency as a motor or if a generator it is to be driven by a suitable means and excited to give rated terminal voltage.

During the running test, the vibration of the machine and operation of the bearing lubrication system, if appropriate, are to be checked.

4.11 Verification of degree of protection

As specified in IEC Publication 60034-5.

4.12 Verification of bearings

Upon completion of the above tests, machines which have sleeve bearings are to be opened upon request for examination by the Classification Society Surveyor, to establish that the shaft is correctly seated in the bearing shells.

E15 Electrical Services Required to be Operable Under Fire Conditions and Fire Resistant Cables

(Nov. 1999) (Rev.1 May 2004) (Rev.2 Feb 2006)

1. Electrical services required to be operable under fire conditions are as follows:
   - Control and power systems to power-operated fire doors and status indication for all fire doors
   - Control and power systems to power-operated watertight doors and their status indication
   - Emergency fire pump
   - Emergency lighting
   - Fire and general alarms
   - Fire detection systems
   - Fire-extinguishing systems and fire-extinguishing media release alarms
   - Low location lighting
   - Public address systems
   - Remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion

2. Where cables for services specified in 1. including their power supplies pass through high fire risk areas, and in addition for passenger ships, main vertical fire zones, other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be achieved by either of the following measures:

a) Cables being of a fire resistant type complying with IEC 60331-31 for cables of greater than 20 mm overall diameter, otherwise 60331-21, are installed and run continuous to keep the fire integrity within the high fire risk area, see Figure 1.

b) At least two-loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.

Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted.

E15
(cont'd)

Notes:

a) For the purpose of E15 application, the definition for "high fire risk areas" is the following:

(i) Machinery spaces as defined by Chap. II-2 / Reg. 3.30 of SOLAS.

(ii) Spaces containing fuel treatment equipment and other highly flammable substances

(iii) Galley and Pantries containing cooking appliances

(iv) Laundry containing drying equipment

(v) Spaces as defined by paragraphs (8), (12), and (14) of Chap. II-2 / Reg. 9.2.2.3.2.2 of SOLAS for ships carrying more than 36 passengers

b) Fire resistant type cables should be easily distinguishable.

c) For special cables, requirements in the following standards may be used:

IEC60331-23: Procedures and requirements – Electric data cables
IEC60331-25: Procedures and requirements – Optical fibre cables

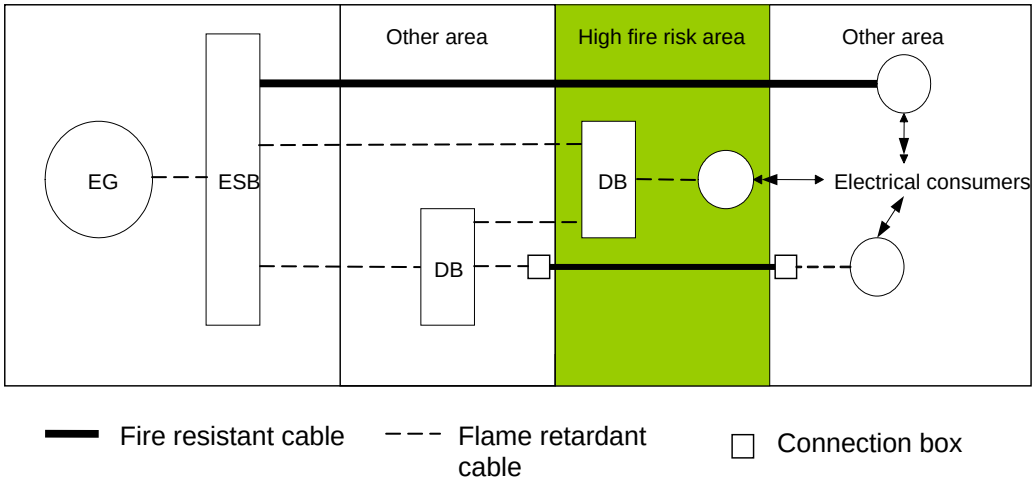

Figure 1

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E16 Cable trays/protective casings made of plastics materials

(June 2002)

1. General requirement

Cable trays/protective casings made of plastics materials are to be type tested [1].

Note: "Plastics" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and fibre reinforced plastics - FRP. "Protective casing" means a closed cover in the form of a pipe or other closed ducts of non-circular shape.

2. Installation Requirements

2.1. Cable trays/protective casings made of plastics materials are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

Note: When plastics cable trays/protective casings are used on open deck, they are additionally to be protected against UV light.

2.2. The load on the cable trays/protective casings is to be within the Safe Working Load (SWL). The support spacing is not to be greater than the Manufacturer's recommendation nor in excess of spacing at the SWL test. In general the spacing is not to exceed 2 meters.

Note: The selection and spacing of cable tray/protective casing supports are to take into account:
- cable trays/protective casings' dimensions;
- mechanical and physical properties of their material;
- mass of cable trays/protective casings;
- loads due weight of cables, external forces, thrust forces and vibrations;
- maximum accelerations to which the system may be subjected;
- combination of loads .

2.3. The sum of the cables' total cross-sectional area, based on the cables' external diameter, is not to exceed 40% of the protective casing's internal cross-sectional area. This does not apply to a single cable in a protective casing.

Note:

1) Cable trays/protective casings made of plastic materials are to be type tested in accordance with the Type Approval Procedure applied by the Society. For guidance on testing, refer to REC 73.

E17 Generators and generator systems, having the ship's propulsion machinery as their prime mover, not forming part of the ship's main source of electrical power.

(June 2002)

Generators and generator systems, having the ship's propulsion machinery as their prime mover but not forming part of the ship's main source of electrical power [1] may be used whilst the ship is at sea to supply electrical services required for normal operational and habitable conditions provided that:

1. there are sufficient and adequately rated additional generators fitted, which constitute the main source of electrical power required by SOLAS, meeting the requirements of IEC 60092-201[2] paragraph 6.2.3.

2. arrangements are fitted to automatically start one or more of the generators, constituting the main source of electrical power required by SOLAS, in compliance with paragraph 2.2 of SC 157 and also upon the frequency variations exceeding ± 10% of the limits specified below.

3. within the declared operating range of the generators and/or generator systems the specified limits for the voltage variations in IEC 60092—301[3] and the frequency variations in UR E5 can be met.

4. the short circuit current of the generator and/or generator system is sufficient to trip the generator/generator system circuit-breaker taking into account the selectivity of the protective devices for the distribution system.

5. where considered appropriate, load shedding arrangements are fitted to meet the requirements of paragraph 2.3 of SC 157.

6. on ships having remote control of the ship's propulsion machinery from the navigating bridge means are provided, or procedures be in place, so as to ensure that supplies to essential services are maintained during manoeuvring conditions in order to avoid a blackout situation [4].

Notes:

1. Such generator systems are those whose operation does not meet the requirements of IEC 60092-201, paragraph 6.2.3.
2. IEC 60092-201 Electrical installations in ships - part 201: System design - General
3. IEC 60092-301 Electrical installations in ships - part 301: Equipment — Generators and motors.
4. A 'blackout situation' means that the main and auxiliary machinery installations, including the main power supply, are out of operation but the services for bringing them into operation (e.g. compressed air, starting current from batteries etc.) are available.

E18 Recording of the Type, Location and Maintenance Cycle of Batteries

(July 2003)

1. Where batteries are fitted for use for essential (UI SC134) and emergency services a schedule of such batteries is to be compiled and maintained. The schedule, which is to be reviewed by the Society, is to include at least the following information regarding the battery(ies):

- Type and manufacturer's type designation.
- Voltage and ampere-hour rating.
- Location.
- Equipment and/or system(s) served.
- Maintenance/replacement cycle dates.
- Date(s) of last maintenance and/or replacement.
- For replacement batteries in storage, the date of manufacture and shelf life.[1]

2. Procedures are to be put in place to ensure that where batteries are replaced that they are of an equivalent performance type.

3. Where vented[2] type batteries replace valve-regulated sealed[3] types, it is to be ensured that there is adequate ventilation[4] and that the Society's requirements relevant to the location and installation of vented types batteries are complied with.

4. Details of the schedule and of the procedures are to be included in the ship's safety management system and be integrated into the ship's operational maintenance routine as appropriate[5] to be verified by the Society's surveyor.

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[1] Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specified performance.

[2] A vented battery is one in which the cells have a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.

[3] A valve-regulated battery is one in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value.

[4] The ventilation arrangements for installation of vented type batteries which have charging power higher than 2kW are to be such that the quantity of air expelled is at least equal to:

Q	=	$110I/n$	where
n	=	number of cells in series	
I	=	maximum current delivered by the charging equipment during gas formation, but not less than 25 per cent of the maximum obtainable charging current in amperes	
Q	=	quantity of air expelled in litres/hr.	

The ventilation rate for compartments containing valve-regulated batteries may be reduced to 25 per cent of that given above.

[5] See section 10 of the IMO ISM Code.

E19 Ambient Temperatures for Electrical Equipment installed in environmentally controlled spaces

(July 2003) (Rev.1 Sept. 2005)

1. Where electrical equipment is installed within environmentally controlled spaces the ambient temperature for which the equipment is to be suitable may be reduced from 45°C and maintained at a value not less than 35°C provided:

- the equipment is not for use for emergency services.
- temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature.
- the equipment is able to be initially set to work safety within a 45°C ambient temperature until such a time that the lesser ambient temperature may be achieved; the cooling equipment is to be rated for a 45°C ambient temperature.
- audible and visual alarms are provided, at a continually manned control station, to indicate any malfunction of the cooling units.

2. In accepting a lesser ambient temperature than 45°C, it is to be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

3. The equipment used for cooling and maintaining the lesser ambient temperature is to be classified as a secondary essential service, in accordance with UI SC 134 and to be subject to survey in accordance with the requirements of the relevant Society.

END

E20 Installation of electrical and electronic equipment in engine rooms protected by fixed water-based local application fire-fighting systems (FWBLAFFS)

(May 2004) (Rev.1 June 2009)

Definitions:

Protected space:

- Is a machinery space where a FWBLAFFS is installed.

Protected areas:

- Areas within a protected space which is required to be protected by FWBLAFFS.

Adjacent areas:

- Areas, other than protected areas, exposed to direct spray.
- Areas, other than those defined above, where water may extend.

See also Fig. 1

Electrical and electronic equipment enclosures located within areas protected by FWBLAFFS and those within adjacent areas exposed to direct spray are to have a degree of protection not less than IP44, except where evidence of suitability is submitted to and approved by the Society.

The electrical and electronic equipment within adjacent areas not exposed to direct spray may have a lower degree of protection provided evidence of suitability for use in these areas is submitted taking into account the design and equipment layout, e.g. position of inlet ventilation openings, cooling airflow for the equipment is to be assured.

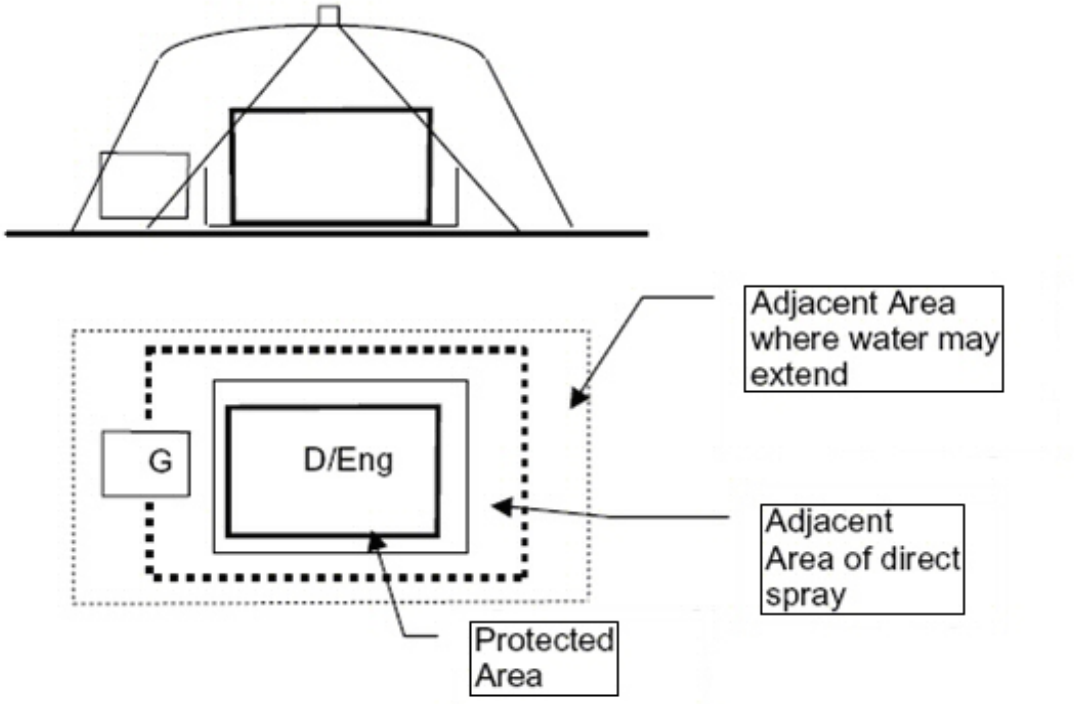
Note

1. Additional precautions may be required to be taken in respect of:

    a. tracking as the result of water entering the equipment
    b. potential damage as the result of residual salts from sea water systems
    c. high voltage installations
    d. personnel protection against electric shock

E20
(cont)

Fig. 1



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E21 Requirements for uninterruptible power system (UPS) units as alternative and/or transitional power

(Sept. 2005)

Scope:

These requirements to UPS units, as defined in IEC 62040, apply when providing an alternative power supply or transitional power supply to services as defined in SOLAS Chapter II-1, Regulations 42 and 43.

A UPS unit complying with these requirements may provide an alternative power supply as an accumulator battery in terms of being an independent power supply for services defined in SOLAS Chapter II-1, Regulation 42, 2.3 or 43, 2.4.

Definitions:

Uninterruptible Power System (UPS) - combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure *[IEC 62040:1999]*

Off-line UPS unit - a UPS unit where under normal operation the output load is powered from the bypass line (raw mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 ms) break in the load supply.

Line interactive UPS unit - an off-line UPS unit where the bypass line switch to stored energy power when the input power goes outside the preset voltage and frequency limits.

On-line UPS unit - a UPS unit where under normal operation the output load is powered from the inverter, and will therefore continue to operate without break in the event of the supply input failing or going outside preset limits.

1. Design and construction

1.1 UPS units are to be constructed in accordance with IEC 62040, or an acceptable and relevant national or international standard.

1.2 The operation of the UPS is not to depend upon external services.

1.3 The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

1.4 An external bypass is to be provided.

1.5 The UPS unit is to be monitored and audible and visual alarm is to be given in a normally attended location for

- power supply failure (voltage and frequency) to the connected load,
- earth fault,
- operation of battery protective device,
- when the battery is being discharged, and
- when the bypass is in operation for on-line UPS units.

E21 cont

2. Location

2.1 The UPS unit is to be suitably located for use in an emergency.

2.2 UPS units utilising valve regulated sealed batteries may be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements of IEC 62040 or an acceptable and relevant national or international standard.

3. Performance

3.1 The output power is to be maintained for the duration required for the connected equipment as stated in SOLAS Chapter II-1, Regulation 42 or 43.

3.2 No additional circuits are to be connected to the UPS unit without verification that the UPS unit has adequate capacity. The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in the regulations.

3.3 On restoration of the input power, the rating of the charge unit shall be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

4. Testing and survey

4.1 UPS units of 50 kVA and over are to be surveyed by the Society during manufacturing and testing.

4.2 Appropriate testing is to be carried out to demonstrate that the UPS unit is suitable for its intended environment. This is expected to include as a minimum the following tests:

- Functionality, including operation of alarms;
- Temperature rise;
- Ventilation rate;
- Battery capacity.

4.3 Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.

END

E22 On Board Use and Application of Programmable Electronic Systems

(Dec 2006) (Corr.1 Oct 2007) (Rev.1 Sept 2010)

1. Scope

These Requirements apply to the use of programmable electronic systems which provide control, alarm, monitoring or safety functions which are subject to classification requirements.

Aids to Navigation and loading instruments are excluded.

Note: For loading instrument / stability computer, REC No. 48 may be considered.

2. Requirements applicable to programmable electronic systems

2.1 General

2.1.1 Programmable electronic systems are to fulfil the requirements of the system under control for all normally anticipated operating conditions, taking into account danger to persons, environmental impact, damage to vessel as well as equipment, usability of programmable electronic systems and operability of non computer devices and systems, etc.

2.1.2 When an alternative design or arrangements deviating from these requirements are proposed, an engineering analysis is required to be carried out in accordance with a relevant International or National Standard acceptable to the Society, see also SOLAS Ch II-1/F, Reg. 55.

Note: As a failure of a category III system may lead to an accident with catastrophic severity, the use of unconventional technology for such applications will only be permitted exceptionally in cases where evidence is presented that demonstrates acceptable and reliable system performance to the satisfaction of the Society.

Note:

1. This UR is to be applied only to such systems on new ships contracted for construction on and after 1 January 2008 by IACS Societies.

2. Rev.1 of this UR is to be applied only to such systems on new ships contracted for construction on and after 1 January 2012 by IACS Societies.

3. The “contracted for construction” date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of “contract for construction”, refer to IACS Procedural Requirement (PR) No. 29.

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2.2 System categories

2.2.1 Programmable electronic systems are to be assigned into three system categories as shown in Table I according to the possible extent of the damage caused by a single failure within the programmable electronic systems.

Consideration is to be given to the extent of the damage directly caused by a failure, but not to any consequential damage.

Identical redundancy will not be taken into account for the assignment of a system category.

Table I System categories

Category	Effects	System functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and / or threat to the environment.	- Monitoring function for informational / administrative tasks
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the vessel and / or threat to the environment.	- Alarm and monitoring functions - Control functions which are necessary to maintain the ship in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and / or threat to the environment.	- Control functions for maintaining the vessel's propulsion and steering - Safety functions

2.2.2 The assignment of a programmable electronic system to the appropriate system category is to be made according to the greatest likely extent of direct damage. For examples see Table II.

Note: Where independent effective backup or other means of averting danger is provided the system category III may be decreased by one category.

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Table II Examples of assignment to system categories

System category	Examples
I	Maintenance support systems Information and diagnostic systems
II	Alarm and monitoring equipment Tank capacity measuring equipment Control systems for auxiliary machinery Main propulsion remote control systems Fire detection systems Fire extinguishing systems Bilge systems Governors
III	Machinery protection systems / equipment Burner control systems Electronic fuel injection for diesel engines Control systems for propulsion and steering Synchronising units for switchboards

The examples listed are not exhaustive.

2.3 Data Communication links

2.3.1 These requirements apply to system categories II and III using shared data communication links to transfer data between distributed programmable electronic equipment or systems.

2.3.2 Where a single component failure results in loss of data communication means are to be provided to automatically restore data communication.

2.3.3 Loss of a data communication link is not to affect the ability to operate essential services by alternative means.

2.3.4 Means are to be provided to protect the integrity of data and provide timely recovery of corrupted or invalid data.

2.3.5 The data communication link shall be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link. Detected failures shall initiate an alarm.

2.3.6 System self-checking capabilities shall be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

2.3.7 The characteristics of the data communication link shall be such as to transmit that all necessary information in adequate time and overloading is prevented.

2.4 Additional requirements for wireless data links

2.4.1 These requirements are in addition to the requirements of 2.3.1 to 2.3.7 and apply to system category II using wireless data communication links to transfer data between distributed programmable electronic equipment or systems. For system category III, the use of wireless data communication links is to be in accordance with 2.1.2.

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2.4.2 Functions that are required to operate continuously to provide essential services dependant on wireless data communication links shall have an alternative means of control that can be brought in action within an acceptable period of time.

2.4.3 Wireless data communication shall employ recognised international wireless communication system protocols that incorporate the following:

(a) Message integrity. Fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;

(b) Configuration and device authentication. Shall only permit connection of devices that are included in the system design;

(c) Message encryption. Protection of the confidentiality and or criticality the data content;

(d) Security management. Protection of network assets, prevention of unauthorised access to network assets.

2.4.4 The wireless system shall comply with the radio frequency and power level requirements of International Telecommunications Union and flag state requirements.

Note: Consideration should be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

2.5 Protection against modification

2.5.1 Programmable electronic systems of category II and III are to be protected against program modification by the user.

2.5.2 For systems of category III modifications of parameters by the manufacturer are to be approved by the Society.

2.5.3 Any modifications made after performance of the tests witnessed by the Society as per item 6 in Table III are to be documented and traceable.

3. Documents to be submitted

3.1 For the evaluation of programmable electronic systems of category II and III, documents according to IEC 60092-504 paragraph 10.11 are to be submitted.

3.2 When alternative design or arrangement is intended to be used, an engineering analysis is to be submitted in addition.

3.3 For all tests required in accordance to the system category a test plan shall be submitted and the tests shall be documented.

3.4 Additional documentation may be required for systems of category III. The documentation is to include a description of the methods of test and required test results.

3.5 For wireless data communication equipment, the following additional information shall be submitted:

(a) Details of manufacturers recommended installation and maintenance practices;

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(b) Network plan with arrangement and type of antennas and identification of location;

(c) Specification of wireless communication system protocols and management functions; see 2.4.3

(d) Details of radio frequency and power levels;

(e) Evidence of type testing in accordance with UR E10;

(f) On-board test schedule, see 7.3.

3.6 Documents for the evaluation of programmable electronic systems of category I are to be submitted if requested.

3.7 Modifications shall be documented by the manufacturer. Subsequent significant modifications to the software and hardware for system categories II and III are to be submitted for approval.

Note: A significant modification is a modification which influences the functionality and / or safety of the system.

4. Tests and Evidence

4.1 Tests and evidence are to be in accordance with Table III. Definitions and notes relating to Table III are given in Appendix 1.

Table III Tests and evidence according to the system category

M = Evidence kept by manufacturer and submitted on request
S = Evidence checked by the Society
W = To be witnessed by the Society
* = The level of witnessing will be determined during the assessment required by 2.1.2

No.	Tests and evidence	System Category		
		I	II	III
1.	**Evidence of quality system**			
	Quality plan for software		**M**	**M**
	Inspection of components (only Hardware) from sub-suppliers		**M**	**M**
	Quality control in production		**M**	**M**
	Final test reports	**M**	**M**	**S**
	Traceability of software	**M**	**M**	**S**
2.	**Hardware and software description**			
	Software description		**M**	**S**
	Hardware description		**M**	**S**
	Failure analysis for safety related functions only			**S**
3.	**Evidence of software testing**			
	Evidence of software testing according to quality plan		**M**	**S**
	Analysis regarding existence and fulfilment of programming procedures for safety related functions			**S**

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4.	**Hardware tests**			
	Tests according to Unified Requirement E 10		**W**	**W**
5.	**Software tests**			
	Module tests		**M**	**S**
	Subsystem tests		**M**	**S**
	System test		**M**	**S**
6.	**Performance tests**			
	Integration test		**M**	**W**
	Fault simulation		**W**	**W**
	Factory Acceptance Test (FAT)	**M**	**W**	**W**
7.	**On-board test**			
	Complete system test	**M**	**W**	**W**
	Integration test		**W**	**W**
	Operation of wireless equipment to demonstrate electromagnetic compatibility		**W**	**W***
8.	**Modifications**			
	Tests after modifications	**M**	**S/W**	**S/W**

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Appendix 1

Definitions and notes relating to Table III, Tests and Evidence

1. Evidence of quality system

1.1 Quality plan for software

A plan for software lifecycle activities is to be produced which defines relevant procedures, responsibilities and system documentation, including configuration management.

1.2 Inspection of components (only Hardware) from sub-suppliers

Proof that components and / or sub-assemblies conform to specification.

1.3 Quality control in production

Evidence of quality assurance measures on production.

1.4 Final test reports

Reports from testing of the finished product and documentation of the test results.

1.5 Traceability of software

Modification of program contents and data, as well as change of version has to be carried out in accordance with a procedure and is to be documented.

2. Hardware and software description

2.1 Software description

Software is to be described, e.g.

- Description of the basic and communication software installed in each hardware unit
- Description of application software (not program listings)
- Description of functions, performance, constraints and dependencies between modules or other components.

2.2 Hardware description

Hardware is to be described, e.g.

- System block diagram, showing the arrangement, input and output devices and interconnections
- Connection diagrams
- Details of input and output devices
- Details of power supplies

2.3 Failure analysis for safety related functions only (e.g. FMEA)

The analysis is to be carried out using appropriate means, e.g.

- Fault tree analysis

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- Risk analysis
- FMEA or FMECA

The purpose is to demonstrate that for single failures, systems will fail to safety and that systems in operation will not be lost or degraded beyond acceptable performance criteria when specified by the Society.

3. Evidence of software testing

3.1 Evidence of software testing according to quality plan

Procedures for verification and validation activities are to be established, e.g.

- Methods of testing
- Test programs producing
- Simulation

3.2 Analysis regarding existence and fulfilment of programming procedures for safety related functions

Specific assurance methods are to be planned for verification and validation of satisfaction of requirements, e.g.

- Diverse programs
- Program analysis and testing to detect formal errors and discrepancies to the description
- Simple structure

4. Hardware tests

Tests according Unified Requirement E 10 “Test Specification for Type Approval” will normally be a type approval test.
Special consideration may be given to tests witnessed and approved by another IACS member society.

5. Software tests

5.1 Module tests

Software module tests are to provide evidence that each module performs its intended function and does not perform unintended functions.

5.2 Subsystem tests

Subsystem testing is to verify that modules interact correctly to perform the intended functions and do not perform unintended functions.

5.3 System test

System testing is to verify that subsystems interact correctly to perform the functions in accordance with specified requirements and do not perform unintended functions.

6. Performance tests

6.1 Integration tests

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Programmable electronic system integration testing is to be carried out using satisfactorily tested system software, and as far as practicable intended system components.

6.2 Fault simulation

Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response. The results of any required failure analysis are to be observed.

6.3 Factory Acceptance Test (FAT)

Factory acceptance testing is be carried out in accordance with a test program accepted by the Society. Testing is to be based on demonstrating that the system fulfils the requirements specified by the Society.

7. On-board tests

7.1 Complete system test

Testing is to be performed on the completed system comprising actual hardware components with the final application software, in accordance with an approved test program.

7.2 Integration tests

On board testing is to verify that correct functionality has been achieved with all systems integrated.

7.3 For wireless data communication equipment, tests during harbour and sea trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not its self fail as a result of electromagnetic interference during expected operating conditions.

Note: Where electromagnetic interference caused by wireless data communication equipment is found to be causing failure of equipment required for Category II or III systems, the layout and / or equipment shall be changed to prevent further failures occurring.

8. Modifications

8.1 Tests after modifications

Modifications to approved systems are to be notified in advance and carried out to the Society's satisfaction, see paragraph 3.7 of this UR.

End of Document

E23 (Feb 2007) Selection of low voltage circuit breakers on the basis of their short circuit capacity and co-ordination in service

Withdrawn April 2008, pending further review by the Machinery Panel.

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