

Polski Rejestr Statków

RULES

PUBLICATION NO. 25/P

TECHNICAL REQUIREMENTS FOR SHIPBOARD POWER ELECTRONIC SYSTEMS

2006

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków complete or extend the rules and are mandatory where applicable.



GDAŃSK

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**TECHNICAL REQUIREMENTS FOR SHIPBOARD
POWER ELECTRONIC SYSTEMS**

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1 GENERAL

1.1 Application

1.1.1 The present Rules apply, when:

- power electronic system is the main part of electrical equipment;
- power electronic systems are the main part of ship's power electric system.

1.1.2 The present Rules concern semiconductor devices subject to the PRS' survey and are the supplement for requirements contained in *Rules for the Classification and Construction of Sea-going Ships*, *Rules for the Classification of Naval Ships* and in the all other PRS' *Rules*, where the present Publication is called.

1.1.3 The present Rules do not apply to the power electronic elements used in power electronic systems with small power and measuring systems.

1.1.4 The present Rules apply to conducted audio frequency interference in the range from 50 Hz up to 10 kHz, besides the requirements specified in items 2.16, 2.18 and 2.19 of *Publication No. 11/P – Environmental Tests on Marine Equipment* or suitable requirements of *Publication No. 75/P – Environmental Tests on Naval Ships Equipment*. Requirements specified in items 2.17, 2.20 and 2.21 of *Publication No. 11/P – Environmental Tests on Marine Equipment* or suitable requirements of *Publication No. 75/P – Environmental Tests on Naval Ships Equipment* apply in the scope of radio frequency

1.2 Definitions

1.2.1 Power electronic element – power semiconductor elements (power diode, silicon controlled rectifier (SCR), bidirectional SCR, power transistor).

1.2.2 Power electronic system – electrical system used for electric power conversion utilising power semiconductor elements.

1.2.3 Control systems – electronic systems designed for conversion of control signal to pulses of gate current, controlling power electronic elements.

1.2.4 Distortion factor or Total Harmonic Distortion (THD) – ratio of harmonic voltages or currents referred to the fundamental component (measured in the frequency band up to 10 kHz) as a percentage

1.2.5 Factor of content of individual higher harmonics in voltage curve – ratio of RMS value of individual higher harmonics to RMS value of voltage fundamental component, in percents.

1.2.6 Voltage unbalance factor – ratio of highest deviation of phase to phase voltage (or phase voltage, in systems with earthed zero) from mean value of phase to phase voltage (or phase voltage, in systems with earthed zero) to its mean value of voltage, in percents.

2 RECOMMENDATIONS IN THE SCOPE OF ELECTRIC POWER PARAMETERS

2.1 Permissible deviation of voltage and frequency values from their rated values in shipboard electric power system

2.1.1 In any point of shipboard electric power system continuous and short-duration deviations of voltage and frequency must not exceed values specified in applicable Rules (e.g. in item 2.1.3 of *Part VIII Electrical Equipment and Automation*).

2.2 Harmonics and inter-harmonics in electric power systems of general purpose

2.2.1 In electric power systems of general purpose, voltage THD set for all harmonics and inter-harmonics in the frequency band up to 50-th harmonic with the resolution every 5 Hz should not exceed 5% during measurement in any point of bus-bars of main and emergency switchboard. Factor of content of individual higher harmonics in voltage curve and THD set together in the band from 50-th harmonic to 10 kHz should not exceed 3%. Above mentioned values of voltage THD (5%) and the factor of content of individual higher harmonics and THD set together (3%) apply to long-lasting aggregated values, for the aggregation time 10 minutes. For instantaneous value (measuring window 200 ms), mentioned factors may attain 150% above defined long-lasting value, that is 7.5% and 4.5% consequently.

2.3 Harmonics and inter-harmonics in electric power system designed to supply nonlinear consumers (i.e. dedicated systems)

2.3.1 In electric power systems designed to supply nonlinear consumers, such as e.g. electrical drives in which power electronic converters predominate, voltage THD set for all components in the frequency band up to 50-th harmonic with the resolution every 5 Hz should not exceed 10%, during measurement in any point of bus-bars of main and emergency switchboard. Factor of content of individual higher harmonics in voltage curve and THD set together in the band from 50-th harmonic to 10 kHz should not exceed 6%. Above mentioned values of voltage THD (10%) and the factor of content of individual higher harmonics and THD set together (6%) apply to long-lasting aggregated values, for the aggregation time 10 minutes. For instantaneous value (measuring window 200 ms), mentioned factors may attain 150% above defined long-lasting value, that is 15% and 9% consequently.

2.4 Voltage unbalance

2.4.1 In any electric power system the voltage unbalance factor should not be higher than 3%.

3 TECHNICAL DOCUMENTATION AND CALCULATIONS

3.1 Technical documentation

3.1.1 Prior to the commencement of survey on the manufacture of power electronic systems, technical documentation is to be submitted to the PRS for consideration, as follows:

- functional description and basic characteristic data, including equipment type and power, supply voltage, commutation method, etc.;
- material specification, in which elements used should be described and their technical characteristics should be given;
- assembly drawing with presumable cross-sections;
- schematic diagram;
- technical specifications and test programme;
- detailed information on proposed means of harmonics and inter-harmonics mitigation;

3.1.2 Prior to the commencement of construction, conversion or reconstruction of floating unit, technical documentation is to be submitted to the PRS for consideration, as follows:

- information on rated parameters of electric plant (power, voltages and currents of electric power sources and transformer impedances or sub-transient reactance of generating sets);
- specification of nonlinear consumers installed on floating unit, with their type, power, supply voltage, rated current and number of pulses;
- detailed information on proposed means of harmonics and inter-harmonics mitigation;
- calculation results of current in neutral conductor, for each switchboard in 4-wire electric power system (3-phase with neutral conductor).

4 ENVIRONMENTAL AND CONSTRUCTIONAL REQUIREMENTS

4.1 Environmental requirements

4.1.1 Power electronic system, with its individual elements, should be adapted to operate at exposure conditions existing on vessel. In particular the following exposures should be taken into consideration:

- power supply parameters variations;
- vibrations, mechanical surges;
- corrosion;
- high and low temperature;
- raised humidity;
- exposures in the scope of EMC.

4.1.2 Power electronic system should not affect the other consumers installed on the vessel, and additionally should be resistant against disturbances in the scope specified in relevant notes of *Publication No. 11/P* or *Publication No. 75/P*, respectively. To this end system should be subjected to full tests: emission and immunity against disturbances in the scope of EMC.

4.1.3 In the scope of immunity and emission environmental tests should be done according to 5.1.4.

4.1.4 Power electronic systems should be constructed to meet the following conditions:

- .1** temperature of any power electronic element should not exceed maximal working value determined by its producer and permissible at loading power electronic system with nominal current or with currents resulting of overload capacity in conditions of ambient temperature and cooling medium temperature;
- .2** for forced ventilation, failure of ventilating system alarm should be installed which should initiate system disconnection, with relevant delay when loss of cooling is detected;
- .3** power electronic elements should be fixed in the way that does not obstruct the cooling air circulation;
- .4** individual power electronic elements should be so selected, that their permissible work temperatures are not exceeded in the case of operation in the low temperatures.

4.2 Constructional requirements

4.2.1 Power electronic systems should meet the requirements of international standards suitable in that scope, and in particular PN-EN 60146 standard series: *Semiconductor Converters* and IEC 60092-304 Publication: *Electrical installations in ships Part 304: Semiconductor Converters*.

4.2.2 Electrical main propeller drive systems and their components should additionally meet requirements of IEC 60092-501 Publication *Electrical installations in ships Part 501: Special features – Electric main drive*.

4.2.3 Individual sub-assemblies, being separate parts of power electronic system, should have in visible place durable rating plate, containing following data:

- producer name,
- system name,
- factory number,
- type or model,
- year of production,
- number of standard or technical specification, basic technical data,
- technical check mark,
- place for classification institution mark.

4.2.4 Metal enclosure of power electronic system any part, being individual assembly, should have earth clamp protected against corrosion and durable marked by earth symbol.

4.2.5 Power electronic system should be mounted in the ship's place with possibly low mechanical vibration and should be protected against working loose electrical and structural joints.

4.2.6 In the place of installation, power electronic system should have provided protection against temperature rise above permissible value, caused by external warm sources.

4.2.7 Individual elements of power electronic system should be selected and installed, so that their exchange does not require system disassembly.

5 TESTS

5.1 Tests at the producer site

5.1.1 Tests at the power electronic system and their individual elements producer site should prove that all requirements regarding:

- .1** basic technical parameters,
- .2** functional features,
- .3** environmental immunity,

are complied.

5.1.2 Tests for the checking of basic technical parameters should include at least the following:

- .1** visual inspection and documents verification;
- .2** measurements of insulation resistance;
- .3** measurement of dielectric strength of insulation;
- .4** test at maximum and minimum supply voltage;
- .5** verification of current distribution between semiconductor elements, connected in parallel;
- .6** verification of voltage distribution on semiconductor elements, connected in series;
- .7** test with rated current;
- .8** test of system heating;
- .9** running test at no load;
- .10** test of auxiliary, signaling and protecting devices;
- .11** rated running test;
- .12** determination of the system load curve;
- .13** calculation of power losses;
- .14** calculation of efficiency;
- .15** determination of power factor;
- .16** over-current test;
- .17** short circuit and polarity alteration test;

5.1.3 Tests of functional features should include:

- .1 verification of power electronic system according to brief fore-design, for power electronic systems with forced ventilation;
- .2 verification of interlocking precluding system operation with ventilation switched off and test of ventilation system alarm;

5.1.4 Tests of power electronic system immunity and emission should be carried out according to requirements contained in:

- .1 *Publication No 11/P – Environmental tests on marine equipment*, for equipment installed in civil crafts;
- .2 *Publication No 75/P – Environmental test on naval ships equipment*, for equipment installed in naval crafts,
in the scope agreed with PRS in each case.

5.2 Tests onboard the ship

5.2.1 After installation on vessel, the power electronic system should be tested according to test programme agreed with PRS.

5.2.2 Besides the functional tests respective to the system purpose of electric power parameters should be carried out, including voltage curve distortion and voltage asymmetry on ship power system, caused by power electronic system operation at nominal operational load.

5.2.3 During ship's service, at least every 5 years, parameter measurements should be performed (including harmonic distortions) of electric power in ship's system containing power electronic systems. The parameter measurements should be carried out in the case when the rated power of biggest of power electronic systems exceeds 50% rated power of one of generating sets supplying it or when total power of all installed power electronic systems exceeds 30% rated power of ship's electric plant. Analogical measurements should be done when ship's electric system is power supplied across power electronic converter, irrespective of its power.
