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Guidelines for Shaft Generators

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CHAPTER 1 GENERAL

Section 1 General

101. Introduction

1. Shaft generators can enable vessels to operate efficiently and economically.
2. Even large ships with fixed-pitch propellers are increasingly being equipped with shaft generators to meet environmental regulations.
3. This guideline provides criteria and information for vessels considering the installation of shaft generators.

102. Purpose

1. The purpose of this guideline is to ensure the stability and reliability of the functioning of the shaft generators and their associated systems.

103. Application

1. It may be applied to relevant requirements to shaft generators used as PTO and/or PTI.
2. Items not specified in this Guideline are to be in accordance with each relevant requirement of the **Rules for the Classification of Steel Ships**.

104. Definitions

1. **Power Take-In (PTI) Mode:** The shaft generator functions as an auxiliary motor working concurrently with the main diesel engine or independently for electric propulsion in this mode. This mode provides propulsion power to the shaft which boosts the main engine with extra power or as an electric propulsion motor with the main engine clutched out or secured.
2. **Power Take-Off (PTO) Mode:** This operating mode takes the energy generated in the main engine as taken off by the shaft generator to produce electricity as an additional power source.
3. **Shaft generator:** The equipment is as generators using available power from the main engine and/or motors using onboard power for auxiliary propulsion.

105. Abbreviations

1. **PMS:** Power Management System.
2. **PTI:** Power Take-In
3. **PTO:** Power Take-Out
4. **SG:** Shaft Generator ↕

Section 2 Plans and Data to be Submitted

201. General

1. In general, for vessels using any combination of two or more power sources, documentation showing optimization calculations/ results is to be submitted to the Society for review. The combination can be acceptable with conventional generation and two or more new technologies.
 - (1) Internal combustion engine (Diesel/ dual fuel/gas) driven electric generators
 - (2) Power Take-Off (Shaft generators)
2. In addition to the plans, specifications, ship arrangements, test plans, and data required to be submitted to the Society for review and approval as per **Pt 6, Ch 1 of Rules for the Classification of Steel Ships**, drawings and data outlined in **202.** are to be submitted to the Society for review, as applicable.

202. Plans and Data to be Submitted

1. A description of the PMS, including location and arrangement plan.
2. Arrangements, details, and location of the propulsion control consoles and or panels including schematic diagrams of the system therein.
3. Arrangements, details, and location of the propulsion control consoles and or panels including schematic diagrams of the system therein.
4. Electric load analysis including shaft generator operation mode.
5. Wiring diagram of power systems with operation mode for shaft generator.
6. Wiring diagram of control systems with alarm, monitoring, safety and emergency shutdown system including a list of alarm and monitoring systems for shaft generators.
7. Operations and maintenance manual.
8. List of minimum alarms/displays and shutdowns as required in **Ch 2 105.**
9. Descriptions for
 - (1) Operation modes of the components, equipment and systems.
 - (2) Specific parameter values during each mode of operation during operation, transition from one mode to another and fault condition.
10. Details of piping system and components associated with shaft generators, where applicable.
11. Manufacturer's recommendation regarding shaft generators' service life and inspection cycles where applicable.
12. Arrangements and details of shaft generator electric coupling/clutch, where applicable.
13. Control strategy and detail arrangements for the interconnection of other power sources and conventional generators (including shaft generators) for the different operating modes.
14. Short circuit analysis. ⚡

CHAPTER 2 SYSTEM AND EQUIPMENT

Section 1 System Design

101. General

1. Shaft generator systems are usually a combination of the main engine (gas, diesel, and dual fuel internal combustion engine driven generators) and therefore the design, construction, installation testing and maintenance is to be in general in accordance with this Guideline and the Rules for Building and Classing
2. Where it is installed in mobile offshore units or combined with other power sources, refer to applicable rules and/or guidance.
3. Each shaft generator and converter should be capable of delivering/absorbing energy at the required rate to meet the power quality requirements (as specified for the project). For each operating mode, the following is to be specified:
 - (1) Permissible load based on submitted documents
 - (2) Programmed active/reactive power load sharing between Genset(s) and others as defined by the power management strategy.

102. Power Management System Functionality

1. In general, a PMS is to be provided in accordance with applicable **Pt 6 of Rules for the Classification of Steel Ships**.
2. **Function of PTI and/or PTO**
 - (1) Consideration is to be given to maximum values of sudden loads, e.g. during changes of operating modes, and it is to be based on starting conditions and the PMS arrangements.
 - (2) For vessels using combination with other power gensets, fuel consumption and emissions optimization and calculation processes are to be submitted to the Society for review.

103. Installation of Shaft Generators

1. Generators, motors and other rotating machines are to be installed preferably with their shafts in a fore-and-aft direction of the vessel and are to operate satisfactorily in accordance with the inclination requirements of **Pt 5, Ch 1, Table 5.1.2 of Rules for the Classification of Steel Ships**. Where it is not practicable to mount the generators with the armature shafts in the fore-and-aft direction, their lubrication will require special consideration. Arrangements are to be made to protect generators and motors from bilge water. Precautions are also to be taken to preclude any oil which may escape under pressure from entering machine windings.

104. Power Distribution System

1. In general, electrical power quality of shaft generators is to be maintained within the requirements of the applicable Rules and the standards to which the electrical power system, the components, and the equipment from which the electrical power system is constructed. In addition, it is to be complied with the specific requirements in the Rules as follows.
 - (1) Harmonic distortion: **Pt 6, Ch 1, 201. 8 of Rules for the Classification of Steel Ships**
 - (2) Voltage and frequency variations: **Pt 6, Ch 1, 201. 5. (3) of Rules for the Classification of Steel Ships**

105. Alarm for Control Systems

1. Upon failure of the power management system, the available electrical power is to remain unchanged and it is to be alarmed at a manned control station.
2. Failure of the SGs is to be alarmed at a manned control station.

106. Electrical Protection System

1. In general, the protection and control system is to be in accordance with the different requirements as specified in the **Pt 6 of Rules for the Classification of Steel Ships**.
2. Protection against fault conditions (e.g. short circuits) is also to take into account the following:
 - (1) Protection methods are acceptable provided coordination and selectivity is achieved.
 - (2) Due to different converter configurations used in the AC and DC distribution system, methods of calculations of fault currents and protection coordination methodologies are based on steady and transient states as needed. Application of standards and/or other modeling and simulation approaches are to be documented and submitted to the Society for review. Operational tests are to be carried out including but not limited to the testing of protective devices (over current, under-voltage, and preferential tripping, etc.), electrical interlocks, synchronization of generators and other alternative generating sources.

107. Equipment Earthing

1. Protection against electrical shock, exposed metal parts of electrical equipment earthing requirements are to be in accordance with **Pt 6, Ch 1, 201. 3. of Rules for the Classification of Steel Ships**.

Section 2 Equipment and Installation

201. General

1. In addition to the specific requirements in this Section of this Guideline, the following references may be also taken into account:
 - (1) In general, electrical equipment is to be designed, constructed and tested to a national, international or other recognized standard and in accordance with the applicable requirements of **Pt 6, Ch 1 of Rules for the Classification of Steel Ships.**
 - (2) Computer based systems where used for control, monitoring and safety systems are to comply with the applicable requirements of **Pt 6, Ch 2 of Rules for the Classification of Steel Ships.**
 - (3) The society may consider other industry standards and practices for electrical equipment, on a case-by-case basis, with justifications through novel features and/or comparative analyses to be provided to demonstrate equivalent level of safety to the recognized standards.

202. Transformers and Converters

1. Transformers and Converters as part of shaft generator systems are to be designed, constructed, and tested as follows:
 - (1) Transformers
 - (A) Transformers are to be designed, constructed, and tested in accordance with **Pt 6, Ch 1, 202. 2 and Sec 6 and 1502. 2. (3), 4. (3) and (6) and 1506. of Rules for the Classification of Steel Ships** as applicable.
 - (2) Electric power converters
 - (A) Power electronic converters are typically considered “two ports” devices capable of providing unidirectional or bidirectional conversions with independent control of the input/output frequency and input/output voltage ratio.
 - (B) Converters are to be designed, constructed, and tested in accordance with **Pt 6, Ch 1, 202. 2 and Sec 12 of Rules for the Classification of Steel Ships.**

203. Shaft Generators

1. General

- (1) SGs are used to generate electric power (in PTO mode) and support the ship's service loads if the prime mover has sufficient load margin. The SG is typically driven by slow or medium speed engines (ships' conventional propulsion power system). In some cases, the shaft generator may also be used to boost the propulsion system (used as a motor in PTI mode).
2. A generator driven by propulsion machinery capable of operating continuously at a constant speed, e.g., those fitted with controllable-pitch propellers, may be considered one of the generators required by **Pt 6, Ch 1, 202. 1. of Rules for the Classification of Steel Ships**, provided that the arrangements stated in follows:
 - (1) The generator and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in **Pt 6, Ch 1 201. 5., 305. and 306. of Rules for the Classification of Steel Ships** under all weather conditions during sailing or maneuvering and also while the vessel is stopped.
 - (2) The rated capacity of the generator and the generating systems is safeguarded during all operations given under **(1)** and is such that the services required by **Pt 6, Ch 1 202. 1. of Rules for the Classification of Steel Ships** can be maintained upon loss of any generator in service.
 - (3) An arrangement is made for starting a standby generator and connecting it to the switchboard, in accordance with **Pt 6, Ch 1 202. 1. (3) of Rules for the Classification of Steel Ships.**
3. A generator driven by propulsion machinery not capable of operating continuously at a constant speed may be used for normal operational and habitable conditions of the vessel, provided that the arrangements stated in i) to v) below are complied with. This type of generator will not be counted as one of the generators required by **Pt 6, Ch 1 202. 1. of Rules for the Classification of Steel Ships.**
 - (1) When the frequency variations at the main bus bar exceed the following limits due to the speed variation of the propulsion machinery which drives the generator, arrangements are made to

comply with **Pt 6, Ch 1 202. 1. (3) of Rules for the Classification of Steel Ships.**

(A) Permanent frequency variation: $\pm 5.5\%$

(B) Transient frequency variation: $\pm 11\%$ (5 sec)

- (2) The generators and the generating systems are capable of maintaining the voltage and frequency variation within the limits specified in **Pt 6, Ch 1 201. 5, 305. and 306. of Rules for the Classification of Steel Ships.**
- (3) Where load-shedding arrangements are provided, they are fitted in accordance with **Pt 6, Ch 1 202. 1. (3) of Rules for the Classification of Steel Ships.**
- (4) Where the propulsion machinery is capable of being operated from the navigation bridge, means are provided or procedures are in place to ensure that power supply to essential services is maintained during maneuvering conditions in order to avoid a blackout situation.

4. Gears

- (1) When the shaft generator is driven through a reduction gear, the gear box is to be designed, constructed and tested in accordance with **Pt 5, Ch 3 Sec 4 of Rules for the Classification of Steel Ships** as applicable.

5. Performance tests for shaft generators

- (1) Shaft generators are to be tested at the factory in accordance with **Pt 6, Ch 1, 309. of Rules for the Classification of Steel Ships.**
- (2) Systems related shaft generators are to be tested in accordance with **Pt 6, Ch 1, 103. of Rules for the Classification of Steel Ships.** ↕

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