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CONSIDERATIONS ABOUT SHIP CLASSIFICATION SOCIETIES RULES CONCERNING NAVAL PROPULSION SYSTEMS MONITORING GAS TURBINES FOR SAFE OPERATION CONDITIONS

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Abstract: *The work has been done on the study of bibliography and experience in the operation of the doctoral students in the field of gas turbine power plants. The paper highlighted that rules of ship classification societies concerning the main design and functional parameters of gas turbine integrated in naval propulsion systems, their design and construction, and a brief overview of the role of companies classification.*

INTRODUCTION

Naval propulsion plants with gas turbines (NPPGT) for a long time was used in navy , because of the advantages they present compared to other naval propulsion systems. Applied scientific research has highlighted the potential NPPTG in commercial marine transport.

In the field of commercial shipping, the naval propulsion plants with gas turbines are used on the following types of ships:

- *fast transient and cargo ships, where NPPTG reduced space bring more cargo space or places for accommodation*;
- *ships carrying liquefied natural gas (LNG),* where gas turbines can operate on diesel fuel or liquefied gas transported by burning what is lost by vaporization (boil-off gas) in good yield in propulsion systems combined cycle *COGAS type (**CO**mbined **G**as **A**nd **S**team turbine)*;

In addition to the above, other advantages of such propulsion systems are:

- short-term preparation for starting and possibility of introducing in short time in-service loads;
- safe operation and simplified service;
- gas turbines can be operated without water cooling or other liquid, cooling can be provided by airflow through protection block;
- maintenance of most cases is resumed to endoscopic inspection, following which can reprogram the maintenance and extension of gas turbine operating period;

AUTORITIES AND CLASSIFICATION SOCIETIES

Classification societies have emerged in the maritime industry as non-governmental organizations, which aim to establish and maintain technical standards for the design, construction and operation of ships and offshore.

The main role of these societies is ***to classify vessels and validate*** calculations and their design in accordance with applicable standards. Periodically these companies provide ship inspection to confirm compliance with the technical condition and functional parameters.

Personnel working in companies classification consists of specialized professionals as inspectors, mechanical engineers, engineers specialized in the materials study, equipment and piping engineers and electrical engineers. The classification society inspectors inspect all vessels and their construction and operation stages to ensure that the design, components and mechanical equipment, hydraulic and electrical are in accordance with the appropriate standard class they belong. The process it self consists in inspection of engines , pumps and other vital installations on board . Classification societies also inspects the instalations used on offshore drilling platforms, submersible and other marine structures. [3]

Currently there are over fifty vessels classification society, of which thirteen are members of ***IACS (International Association of Classification Societies)***.

In 1939 RINA organized a convention attended and ABS (American Bureau of Shipping), BV (Bureau Veritas), DNV (Det Norske Veritas), GL (Germanischer Lloyd), LR (Lloyd's Register) şi NK (Nippon Kaiji Kiokai). Second General Conference of ship classification societies held in 1955 and resulted in the creation of Working Party. In 1968 seven classification societies in IACS who ensured the periodic management association.

Applying the IACS Quality System Certification Scheme (QSCS) is required for any classification society member of IACS.

RULES OF NAVAL CLASSIFICATION SOCIETIES AND AUTHORITIES, TO BE TAKEN INTO ACCOUNT AT THE GAS TURBINES DESIGN [1,pag106]

At the gas turbines design which will equips the naval propulsion systems, the classification societies impose rules:

- at the design of rotors, bearings, discs and blades should take account of the mechanical and thermal stresses;.
- period of service is considered number of operating hours at rated speed and power; *number of operating hours between two repairs be at least 5000 hours, or the equivalent of at least one year of continuous service;*
- an important factor in the calculation of the compressors blades design is the intake air temperature value from the environment ($t_o \leq 15^oC$);
- checking, by calculation, from different types of vibrations (torsional, axial, lateral) and the effects of strenght composite;
- shall be taken into account when designing the turbine, it can be operated at maximum values 115% of the rated speed and power for short periods;
- the manufacturer of gas turbine recommended overhaul planning should be developed according to duration of service design. The maintenance planning, will coincide with cyclic or continuous examination of machinery plants.
- the manufacturer will present experimental data obtained at turbine testing, in the presence of authorized committees and accepted by the designer, builder, classification society and shipowner. The data will be transmitted by the shipowner as a planning document accompanying tests and data obtained relative to turbine design;
- *gas turbine housing* shall be designed so that at speeds exceeding 115% of rated speed, any elements there of blading or devices that will detached remain in housing.

INSPECTIONS DURING THE CONSTRUCTION OF POWER PLANTS GAS TURBINE IMPOSE FROM THE SHIP CLASSIFICATION SOCIETYS

A. Inspections during construction plant:

NPPGT will pass through several inspections by the classification society, but other authorized inspection companies in the construction of single or dual gas turbine fuel in LNG ships. Other societies specializing in the manufacture of gas turbines inspection will inspect the GT for:

- tehnology confirmation of the manufacturing and repair of gas turbine or gas turbine components. These technologies should correspond to the quality management
- system for design, procurement of spare parts, manufacturing and testing;
- verification of the professional skills of welders and specific procedures of welding;
- verification of documentation materials for piping, valves, threaded assemblage;
- assisteance at pressure testing and performance standards;
- assistance at nondestructive testings of welds check and review their results;
- participation in testing of subassemblies and assemblies as set out in the manufacturing procedure;
- check if gas installation complies with safety requirements, the turbine control system, consoles and tools are in accordance with the approved projects;
- participates in other inspections and final tests.

B. Inspections during installation which is running in accordance with the rules of classification societies**:**

- piping installations are visually inspected and pressure tested in accordance with the classification rules. Test results will be recorded as test charts throughout the test;
- electric cables and connectors must meet the requirements of their classification register and check their electrical continuity and compliance technology implementation;
- VD- *Vendor Documentation* – Vendor should supply documentation to guarantee that the material or the equipment complies with an acceptable standard (e.g., standard tests reports, ex certification, etc.);
- DR – *Design Review* – Design review required;
- MT – *Material Testing* – Material testing is to be witnessed by the Surveyor;
- MS – *Manufacture Survey* – Product is to be surveyed during fabrication stages by the Surveyor ;
- FS – *Final Survey* – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other required tests, and witnessed by the Surveyor at manufacturer's facility;
- measuring devices will be adjusted and tested to confirm their correct functioning;
- safety valves are tested before installation;
- control system and stop of the turbine will be tested for correct functioning;
- gas turbine should be tested if it works in accordance with the procedures of classification society;
- the inspections for quality certification of a dual-fuel type gas turbine are detailed in Table 1, according to ABS.[2.pgag.46]

Table1 – Certification of Dual Fuel Gas Turbines [2, pag.48]

Equipment	*VD*	*DR*	*MT*	*MS*	*FS*
BOG compressors		X			X
BOG heaters (1)		X			X
Master gas fuel valve and associated piping		X	X		X
Gas storage pressure vessels (1)					
Gas valve enclosure	X				
Fuel gas piping system in engine room incl. block and bleed valves		X	X		X
Fuel gas piping ventilation system		X			
Gas fuel manifold		X	X		X
Gas turbine enclosure ventilation system		X			
Gas turbine enclosure fire fighting system		X			
Dual fuel gas turbine		X		X	X
Gas turbine combustion air supply ducting		X			
Gas turbine exhaust system		X			
Gas detection system		X			X
Gas turbine combustion control system		X			X
Automatic shutdown and safety system		X			X

C. During operation for testing gas turbine must operate in accordance with the classification society rules for construction and classification of the ship, including related installations, system control and GT on / off . Turbine will be subject to all load regimes samples during sea trials.

SYSTEMS OF CONTROL , SURVEILLANCE, POWER SUPPLY AND PROTECTION

All gas turbines which are fitted on NPPGT, control and protection systems must meet the requirements of IACS by amendment M60 (Control and Safety of Gas Turbines for Marine Propulsion Use) 1970 [5 / pag.148-150] who subsequently assimilated and complemented by other authorities and ship classification societies:

- ***speed controller and overspeed protection device***:

- overspeed protection device must be set at 116% of the nominal speed for stop the gas turbine;
- for the gas turbines which drives a gear-box or gear-reversing-box, electric drive, controllable pitch propeller plant, will be install an independent speed governor for overspeed protection;

- ***various automatic protection devices***:

- all automatic protection devices proposed by manufacturers for gas turbine plant protection in the event of damage, are sent for analysis to the autorities and classification societies, along with documentation of technical research on failures and their effects;
- ***alarm systems*** that must, necessarily, mounted on GT, are detailed in Table 2, where marked with * react to critical operating conditions by triping the turbine.

Gas turbines which fit the NPPGT must be equipped with **automatic quick** stop interrupting the fuel supply in the following cases:

- overspeed;
- lubrication pressure below the minimum allowable;
- extinguishing the flame during operation;
- vibration operation over the maximum limits;
- excessive axial displacement for each rotor;
- excessive exhaust gas temperature;
- pressure lubrication of gear driven below the minimum allowable;
- excessive vacuum pressure at the compressor suction;

Table2. – List of alarm and shutdown *IACS/M60(1970)* [5, pag.M60-3] *;*

Parametrul monitorizat	***Alarmă***	***Oprire turbină***
Turbine speed	↑	◊
Lubricating oil pressure	↓*	◊
Lubricating oil pressure of reduction gear	↓*	◊
Differential pressure across lubricating oil filter	↓	
Lubricating oil temperture	↑	
Oil fuel supply pressure	↓	
Oil fuel temperature	↑	
Cooling medium temperature	↑	
Bearing temperature	↑	
Flame and ignition Failure	↔	◊
Automatic start Failure	↔	
Vibration	↑*	◊
Axial displacement of rotor	↑	◊
Exhaust gas temparature	↑*	◊
Vacuum pressure at the compressor inlet	↑*	◊

Loss of control system	↔	

↑ - *Alarm for maximum values;*
↓ - *Alarm for minimum values;*
↔ - *Alarm continues;*
◊ - *Stop the gas turbine.*

EQUIPMENTS FOR TEMPERATURE MONITORING AND FIRE DETECTION WHICH MAY OCCUR IN GAS TURBINES

NPPTG, under IACS, are fitted with individual detection systems for fire and explosive gas mixtures and fire protection and firefighting systems.

A. Rules imposed by ship classification societies for gas detection system

• For dual fuel gas turbines each acoustic enclosure and thermal insulation must be at least two independent continuous monitoring of gas leak;

• Each gas detection system must meet the following requirements:

- each monitoring system must be type "self-monitoring";
- where a detection system detects an error by its self-monitoring, the system will automatically self-disconnect for not generate a turbine emergency stop;
- each gas detection system shall be arranged so as to provide redundancy to the system where different detection system is broken;
- design and construct of gas detection system must allow easy testing;
- gas detection system will cover all machinery space where dangerous accumulation of gas or air circulation is reduced;
- failure of gas detection system shall automatically controlled turbine oil passage and close all sources of gas supply to the gas turbine;
- gas detection system will always be running when there is fuel gas piping during normal operation and during purging fuel system before maintenance operations;
- the gas detection system shall be interconnected with the gas turbine stop system.[1]

I. Adjusting the parameters of reference of gas detection system

• *gas detection system shall be set up to 5% LEL * (Figure 1), in the space inside the gas turbine working , gas supply it will be stopped automatically and automatically switches turbine oil. Acoustic and visual alarm shall indicate the defect.*

• *if the space inside the turbine working gas concentration increases up to 10% LEL, fueling shut, and the space will be electrically isolated;*

• *at a concentration greater than 10% is provided module gas discharge* [2, pag.42]

* *Lower Explosive Limit (LEL) - related to the gas concentration in air in percent.*

Fig.1. - Limits of the mixture of gas and oxygen [6]

I. Instalation

Location is key to the efficiency of the detectors. The exact location of gas detectors shall be determined taking into account their sensitivity to prevailing airflow.

Arrange detectors will be subject to an gas dispersion analysis on the base of the smoke test analysis, made for cooling and ventilation of enclosure thermal and acoustic insulated.[1]

II. Regular maintenance and testing facility

Installation of gas detection systems associated with the gas turbine "STOP", must be regularly tested and maintained to ensure reliability. Are periodically calibrated according to manufacturer's recommendations.

Explicit documentation of the test and maintenance must to be kept fully on board to be used by crew.[1]

B. A fire detection installations must meet the following requirements:

- Fire protection installations layouts for one or more gas turbine enclosures or machinery spaces should be integrated and capable of operating individually or simultaneously with those operating in machinery compartments;
- A fire detector inside thermal and acoustic insulation enclosure of the gas turbine is to close the supply of liquid or/and gaseous fuel (for dual-fuel gas turbines).

Conclusions

1. Ship classification societies registers are set rules for classification in the design and construction of gas turbines, their installation on board ships, their operation and maintenance safely.
2. In a growing number of vessels of different sizes and types are used gas turbine power plants, which most often have proved their superiority over other types of marine power plants and for which there special rules.
3. By maintaining main functional parameters within certain limits ensures turbine power plant operation gaze.în safely.
4.Correct positioning of the transducers fire in the gas turbine enclosure allows rapid detection and correct them.

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