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Large yachts — Quality assessment and acceptance criteria — Dynamic positioning on large yachts

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Foreword

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Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Dynamic positioning (DP) systems are common on ships and platforms in the offshore oil and gas industry. System reliability and positioning accuracy are of vital importance for ensuring safe operation at sea. These aspects are therefore an integral part of the vessel design, the operational procedures and the personnel requirements. The DP system reliability is expressed in the vessel class notation. The specific DP notations as defined by classification societies are usually derived from the IMO definitions for equipment Class 1, Class 2 and Class 3, indicating the level of redundancy in the DP system.

The application of DP systems on large motor yachts is a more recent trend. There is a need for a clear definition of the specific capabilities and the necessary equipment for large yachts with a DP system. The intended use of a DP system on board a large yacht is different from application in the offshore industry. The DP system on a yacht is intended for recreational use. The use of the DP system is considered recreational when the DP operation is not mission critical, its duration is relatively short (hours, rather than days) and the weather conditions are relatively mild.

Large yachts — Quality assessment and acceptance criteria — Dynamic positioning on large yachts

1 Scope

This document specifies the minimum requirements for dynamic positioning (DP) systems on large yachts intended for recreational use (i.e. not mission critical, short duration, mild weather). This document provides minimum requirements for equipment, as well as a calculation method to quantify the DP stationkeeping capability and guidance on testing and personnel requirements.

2 Normative References

There are no normative references in this document.

3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
dynamic positioning system
DP system
complete installation necessary for dynamically positioning a large yacht

Note 1 to entry: The dynamic positioning (DP) system includes a *power system* (3.2), *thrusters* (3.3) and a *DP control system* (3.4)

[SOURCE: MSC.1/Circ.1580: 2017, 1.2.11 — modified, “vessel” replaced by “large yacht”, and second sentence condensed into Note 1 to entry.]

3.2
power system
components and systems necessary to supply the *dynamic positioning system* (3.1) with power

Note 1 to entry: The power system includes prime movers and associated systems, generators, switchboards, cabling, UPS systems and power management systems.

[SOURCE: MSC.1/Circ.1580: 2017, 1.2.20 — modified, second sentence condensed into Note 1 to entry.]

3.3
thruster
devices providing thrust force to control the position of the large yacht

Note 1 to entry: Thrusters can include dedicated thrusters, such as transverse tunnel thrusters and auxiliary thrusters, as well as the main propulsion if controlled directly by the *dynamic positioning system* (3.1).

3.4
dynamic positioning control system
DP control system
control components and systems, hardware and software necessary to dynamically position the large yacht

Note 1 to entry: The DP control system includes a computer system, a control station, sensors and all necessary cabling and network connections.

[SOURCE: MSC.1/Circ.1580: 2017, 1.2.10 — modified, “vessel” replaced by “large yacht”, and second sentence condensed into Note 1 to entry.]

3.5
sensor
device including at least one position reference system, one heading sensor and one wind speed and direction sensor

Note 1 to entry: Optional sensors can include additional position reference systems, as well as additional types of sensors.

3.6
joystick control
system offering manual position and heading control of the vessel from the dynamic positioning control station

3.7
dynamic positioning operator
DP operator
DPO
crew member with the specific task to operate the *dynamic positioning (DP) system* (3.1) and monitor its correct operation from the DP control station

Note 1 to entry: DP operators have received an internationally standardized DPO training and certification.

3.8
dynamic positioning class notation
DP class notation
code to indicate the level of redundancy present in a *dynamic positioning system* (3.1)

Note 1 to entry: Class notations are generally derived from the IMO equipment class notations Class 1 (no redundancy), Class 2 (all components redundant) and Class 3 (all components redundant and physically separated). Examples of the classification society guidelines can be found in References [2] and [3].

3.9
dynamic positioning capability plot
DP capability plot
graphical representation of the results of a static dynamic positioning capability analysis

Note 1 to entry: For each wind direction the plot shows the maximum wind speed at which the vessel can maintain its position and heading, using the available thrusters to counteract the environmental loads. Examples of calculation methods to determine such plots can be found in References [4] and [5].

4 Application

This document provides a common frame of reference that can be used by yacht designers, equipment manufacturers, yacht builders and yacht owners. It is noted that this document is not intended as a replacement for specific dynamic positioning (DP) class notations, as provided for commercial ships by classification societies.

The DP system on board a large yacht may have the following modes of operation:

— Automatic position and heading control. This mode of operation may be used when staying at a stationary position in open water, without the use of an anchor.

— Manual joystick control. This mode of operation may be used for low speed manual manoeuvring of the ship, for example in a port.

— Automatic heading control at anchor. This mode of operation may be used to avoid oscillating motions of the ship (fish-tailing) when moored on a single anchor at the bow.

The recreational use of a DP system on a large yacht can be described as follows:

— for operation in mild weather conditions;

— for relatively short duration operations;

— when no other systems or operations rely on the functioning of the DP system;

— special attention should be paid to passenger safety.

Notable differences with DP systems on commercial vessels can be summarized as follows:

— Large yachts with a DP system do not have a specific DP class notation. The intention of this document is only to provide a uniform definition of the required equipment for large yachts with a DP system, as well as a calculation method to quantify the DP stationkeeping capability.

— DP systems on large yachts do not require redundancy of equipment. This means that a single failure in any of the components can result in a complete failure of the DP system. This level of redundancy is similar to DP-1 systems on commercial vessels.

— DP systems on large yachts do not require specialized personnel. Ships with a DP class notation have specific personnel requirements, such as the presence of a DP system operator (DPO).

The calculation method to analyse the DP capability of a large yacht consists of the following:

— Show that the thruster configuration has the capability to independently create longitudinal and transverse thrust forces, as well as yawing moments (F_X, F_Y, M_{XY}). These thrust forces can be generated in positive and negative directions. The specific thruster settings applied to achieve these loads should be indicated [propeller revolutions per minute (r/min), rudder angles, azimuth angles, …, etc.].

— Static calculations to determine equilibrium of mean environmental loads and mean thruster loads. Wind loads shall be considered, while current and wave loads may be ignored. Calculations are performed for all wind directions. The results are presented in the form of a polar plot, showing the maximum wind speed at which the vessel can maintain its position.

— Optional time-domain simulations may be performed to investigate aspects such as stationkeeping accuracy, DP control settings, fuel consumption, noise and vibrations.

5 Minimum equipment requirements

5.1 General

A large yacht with a DP system shall be equipped with the following systems and components:

— power system;

— thrusters;

— DP control system;

— position and heading sensors;

— wind speed and direction sensors.

This list corresponds with the minimum equipment requirements, as given in Reference [1].

5.2 Power system

The power system either directly drives the thrusters on board the vessel, or it generates the electrical power to drive thrusters. Furthermore, electrical power is generated for all other electrical systems on board the vessel. Diesel-electric configurations (system with generators, switch boards and electrical engines) offer the highest operational flexibility. Alternatively, generators connected to the main engine can be used.

5.3 Thrusters

The thrust force and direction required by the DP control system is generated by the thrusters. During DP operation, the thrusters are controlled directly by the DP control system.

The thruster configuration shall be designed such that thrust loads can be generated independently in the longitudinal and transverse directions, as well as a yawing moment. Azimuthing thrusters offer the most flexibility to generate the required forces, while vessel control may be more complicated using main propellers and rudders.

The response of the thrusters shall be sufficiently fast to accurately control the vessel position and heading. In general, electric thrusters are preferred for DP operation, due to their accurate thrust control and fast response. Thrusters that are driven directly by a diesel engine are usually of limited use for DP application, due to a slower response to a dynamically varying thrust demand.

5.4 DP control system

The DP control system typically includes a state estimator (e.g. a Kalman filter), a controller [e.g. a proportional-integral-derivative (PID) controller] and a thrust allocation algorithm. The DP control system determines the required action of the thrusters, based on the measured vessel position and heading.

The state-estimator determines the slowly varying motions of the vessel in the horizontal plane (surge, sway, yaw), ignoring wave frequency oscillating motions. The low frequency motions are input for the controller, which determines the total required forces (F_X, F_Y, M_{XY}) necessary to keep the vessel at its required position and heading. The allocation algorithm distributes the total required forces over the available thrusters, based on a power optimization.

5.5 Sensors

The large yacht shall be equipped with the following sensors:

— position measurement sensors, e.g. a GPS receiver;

— heading measurement sensors, e.g. a compass;

— wind sensor, measuring wind velocity and direction.

The sensor placement should be such to enable accurate measurement. For example, the wind sensor should be placed on a high position on the vessel, to enable undisturbed wind measurements.

The following sensors are optional:

— additional position measurement sensors, such as an alternative satellite navigation system, or an acoustic position reference system.

These optional sensors usually improve the performance of the DP system, for example with regard to accuracy of stationkeeping.

6 DP stationkeeping capability

6.1 General

The DP stationkeeping capability of a large yacht with a DP system can be assessed using static calculations. In these calculations, the mean thrust forces and the mean environmental forces acting on the vessel shall be evaluated. The calculation approach described in this chapter is intended for recreational use of DP systems on large yachts. The calculations are less extensive than the analysis typically performed for commercial vessels with a DP system. For example, only wind loads are considered, and no analysis of failure cases is required.

The DP stationkeeping capability of large yachts is assessed in three steps, as illustrated in 6.2 to 6.4. Vessels that meet the requirements in steps 1 and 2 can be identified by the notation "DP-R", indicating that they have a DP system for recreational use. Step 3 is optional, allowing for more detailed analysis of the vessel DP performance.

The notation "DP-R" indicates that a large yacht has a DP system for recreational use (i.e. not mission critical, short duration, mild weather). It means that the vessel has a suitable thruster configuration and all necessary equipment on board. The term "DP-R" is not intended as a replacement of specific class notations as used for commercial vessels with a DP system.

6.2 Step 1 - Thruster configuration analysis

During automatic stationkeeping, the DP system relies on the available thrusters to independently generate thrust forces in the longitudinal and transverse directions, as well as yawing moments. The first step in the DP capability analysis is to determine if the thruster configuration of the vessel is capable of generating sufficient thrust in all directions.

The results of the step 1 analysis shall include the following:

— Thruster settings (r/min, rudder angles, azimuth angles, …, etc.) to achieve a pure longitudinal thrust force F_X. Settings for positive (forward) and negative (aft) total forces shall be given.

— Thruster settings (r/min, rudder angles, azimuth angles, …, etc.) to achieve a pure transverse thrust force F_Y. Settings for positive (to port side) and negative (to starboard) total forces shall be given.

— Thruster settings (r/min, rudder angles, azimuth angles, …, etc.) to achieve a pure yawing moment M_{XY}. Settings for positive (bow to port side) and negative (bow to starboard) moments shall be given.

— The response times of all individual thrusters controlled by the DP system shall be listed. This includes response times of propeller revolutions per minute (zero to maximum), rudder angles (minimum to maximum) and thruster azimuth angles (0 degrees to 360 degrees). The response times shall be sufficiently short to respond to the dynamic forces and moments required by the DP system.

Annex A includes an overview of different thruster types that can be controlled by a DP system. It also includes some examples of thruster configurations.

6.3 Step 2 - DP capability plots

The DP stationkeeping capability of the vessel shall be quantified by determining for each wind direction the maximum conditions in which required position and heading can be maintained.