PART II RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF VESSELS IDENTIFIED BY THEIR MISSIONS

TITLE 103 DYNAMIC POSITIONING SYSTEMS

SECTION 8 NAUTICS AND ELECTRONICS

CHAPTERS

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CHAPTER F
DYNAMIC POSITIONING SYSTEM

CHAPTER CONTENTS

F1. PURPOSE AND APPLICATION

100. Purpose and responsibility

101. The purpose of these Rules is to recommend design criteria, necessary equipment, operating requirements, and a test and documentation system for dynamic positioning systems to reduce the risk to personnel, the vessel, other vessels or structures, sub-sea installations and the environment while performing operations under dynamic positioning control.

102. The responsibility for ensuring that the provisions of the Rules are complied with rests with the owner of the DP-vessel.

103. Unless otherwise stated the equipment class of the vessel required for a particular operation shall be agreed between the owner of the vessel and the customer based on a risk analysis of the consequence of a loss of position. Else, the RBNA may decide the equipment class for the particular operation.

200. Application

201. The Rules apply to dynamically positioned units or vessels, the keel of which is laid or which is at a similar stage of construction on or after 1 July 1994.

F2. RULES AND STANDARDS

100. Rules and standards

101. These Rules are in conformity with the following regulations and standards:

a. NORMAM 06 – Annex 4 – Form 15 - FSVAD

b. NORMAM 15 – Annex 13-A - FSVAD

c. NORMAM 15 – Chapter 13 – Dynamic positioning for vessels destined for diving

d. IMO MSC/Circular 645 (1994) as amended, “Guidelines for Vessels with Dynamic Positioning Systems”.

e. IMCA (International Marine Contractors Association) M 103 – “Guidelines for the Design and Operation of Dynamically Positioned Vessels”, revision 1.

102. For machinery components such as Thrusters, the relevant requirements of Part II, Title 11, Section 5 of the RBNA Rules for the Construction and Classification of Sea Going Vessels are applicable.

103. For electrical installations the relevant RBNA Rules for the Construction and Classification of Sea Going Vessels are applicable.

104. For electronic components, the RBNA Rules for the Construction and Classification of Sea Going Vessels, Part III, Title 63, Section 8, Chapter A are applicable

105. Requirements, additional to these Rules may be imposed by the national authority with whom the vessel is registered and/or by the administration within whose territorial jurisdiction it is intended to operate. Where national legislative requirements exist, compliance with such regulations shall also be necessary.

F3. DEFINITIONS

100. Definitions applicable to this Rules

101. "*Dynamically positioned vessel (DP-vessel)*" means a unit or a vessel which automatically maintains its position (fixed location or predetermined track) exclusively by means of thruster force.

102. "*Dynamic positioning system (DP-system)*" means the complete installation necessary for dynamically positioning a vessel comprising the following sub-systems:

a. power system,

b. thruster system, and

c. DP-control system.

103. "*Position keeping*" means maintaining a desired position within the normal excursions of the control system and the environmental conditions.

104. "*Power system*" means all components and systems necessary to supply the DP-system with power. The power system includes:

a. prime movers with necessary auxiliary systems including piping,

b. generators,

c. switchboards, and

d. distributing system (cabling and cable routeing).

105. "*Thruster system*" means all components and systems necessary to supply the DP-system with thrust force and direction. The thruster system includes:

a. thrusters with drive units and necessary auxiliary systems including piping,

b. main propellers and rudders if these are under the control of the DP-system,

c. thruster control electronics,

d. manual thruster controls, and

e. associated cabling and cable routeing.

106. "*DP-control system*" means all control components and systems, hardware and software necessary to dynamically position the vessel. The DP-control system consists of the following:

a. computer system/joystick system,

b. sensor system,

c. display system (operator panels),

d. position reference system, and

e. associated cabling and cable routeing.

107. "*Computer system*" means a system consisting of one or several computers including software and their interfaces.

108. "*Redundancy*" means ability of a component or system to maintain or restore its function, when a single failure has occurred, i.e., redundancy is the ability to cope with a single failure without loss of position. A single failure can be, amongst others:

a. Thruster failure

b. Generator failure

c. Powerbus failure (when generators are combined on one powerbus)

d. Control computer failure

e. Position reference system failure

f. Reference system failure

109. "*Flag State Verification and Acceptance Document (FSVAD)*" means the document issued by the Administration to a DP-vessel complying with these Rules. See Circular IMO MSC 645, also NORMAM 15 – Annex 13-A and NORMAM 06, Annex 4-A-15 for model form.

110. *Active failure* concerns all failures which have an immediate effect either on the operation of the installations or on the monitoring circuits.

111. *Passive failure* has no immediate effect on the operating conditions of the installations and is not detected by the monitoring circuits but could lead, in certain conditions, to a failure of the system.

112. *Safe situation'* means one where the work has or could immediately cease with no serious consequences from position loss and the vessel is left in a state where operations can readily resume once the disturbance is corrected.

113. *"FMEA – Failure Modes and Effects Analysis*, is a procedure in product development and operations management for analysis of potential failure modes within a system for classification by the severity and likelihood of the failures. A successful FMEA activity helps a team to identify potential failure modes based on past experience with similar products or processes, enabling the team to design those failures out of the system with the minimum of effort and resource expenditure, thereby reducing development time and costs.

a. *"Failure modes"* are any errors or defects in a process, design, or item, especially those that affect the customer, and can be potential or actual.

b. *"Effects analysis"* refers to studying the consequences of those failures.

114. *"HPR"* means any hydro-acoustic position reference system.

115. *"UPS"* – means Uninterruptible power supply.

116. *"MTBF – Mean Time Between Failures"* or average period between failures is a value attributed to a device or equipment to describe its reliability. This value indicates when a failure may occur on the equipment. The larger this index, the higher the degree of reliability. This value is presented by the manufacturer in the technical specifications. The time is indicated in hours.

200. Dynamic positioning (DP)

Guidance

A ship can be considered to have six degrees of freedom in its motion, i.e., it can move in any of six axes.

1) Three of these involve translation:

a. surge (forward/astern)

b. sway (starboard/port)

c. heave (up/down)

2) and the other three rotation:

a. roll (rotation about surge axis)

b. pitch (rotation about sway axis)

c. yaw (rotation about heave axis)

Dynamic Positioning System: for the purposes of these Rules a fully operational DP system is defined as one that is able to reliably keep a vessel in position when working up to the rated environment, such that the maximum excursion from vessel motions (surge, sway and yaw) and position control system accuracy (DP footprint) is equal to, or less than, half the critical excursion for the work being carried out.

End of guidance

201. The DP control system should provide adequate information to operators such that any change of status of the DP system due to weather, equipment malfunction or operator action should be clearly indicated at the permanently manned position where corrective action is possible and where the limitation, if any, can be understood by operators. The indication should be such that the operator is unlikely to make a mistake in assessing the severity and effect of the status change.

202. Safe working limits should be determined for each geographical location, expected environmental condition/force and type of task to be performed. These limits need to consider every failure mode defined by the FMEA and the likely time to restore position control, recover the divers, disconnect a gangway or riser or otherwise move clear of an area to return to a safe situation. In the case of simultaneous or close operations, failures on the other vessels also need to be considered.

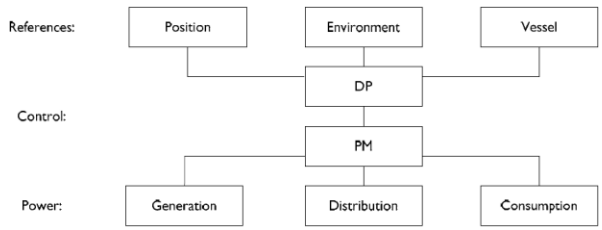
203. The DP system comprises three areas: power, control and references:

a. Power can be sub-divided into power generation, distribution and consumption (by propulsion systems).

b. Control refers to a power management system (automatic or manual) and the position control system.

c. References are essentially sensors giving position, environmental and vessel attitude information.

FIGURE F3.203.1 – DYNAMIC POSITIONING SYSTEM (IMCA)



204. Position reference sensors, combined with wind sensors, motion sensors and gyro compasses, provide information to the computer pertaining to the vessel's position and the magnitude and direction of environmental forces affecting its position.

205. Equipment malfunction or operator action shall be clearly indicated at the permanently manned position where corrective action is possible and where the limitation, if any, can be understood by operators. The indication shall be such that the operator is unlikely to make a mistake in assessing the severity and effect of the status change.

Guidance

The computer program contains a mathematical model of the vessel that includes information pertaining to the wind and current drag of the vessel and the location of the thrusters. This knowledge, combined with the sensor information, allows the computer to calculate the required steering angle and thruster output for each thruster. This allows operations at sea where mooring or anchoring is not feasible due to deep water, congestion on the sea bottom (pipelines, templates) or other problems.

Dynamic positioning may either be absolute in that the position is locked to a fixed point over the bottom, or relative to a moving object like another ship or an underwater vehicle. One may also position the ship at a favourable angle towards wind, waves and current, called weathervaning.

End of guidance

F4. CLASS NOTATIONS AND DEGREE OF REDUNDANCY

100. General

101. A DP-system consists of components and systems acting together to achieve sufficiently reliable position keeping capability. The necessary reliability is determined by the consequence of a loss of position keeping capability. The larger the consequence, the more reliable the DP-system shall be.

102. To achieve this philosophy the requirements have been grouped into three equipment classes. For each equipment class the associated worst case failure shall be defined as in F4.201 below.

103. The equipment class of the vessel required for a particular operation shall be agreed between the owner of the vessel and the customer based on a risk analysis of the consequence of a loss of position. Else, the Administration may decide the equipment class for the particular operation.

200. Equipment classes

201. IMO Resolution MSC/645 as amended establishes the equipment classes defined by their worst case failure modes as follows:

202. **For equipment class 1**, loss of position may occur in the event of a single fault.

203. **For equipment class 2**, a loss of position is not to occur in the event of a single fault in any active component or system. Normally static components will not be considered to fail where adequate protection from damage is demonstrated, and reliability is to the satisfaction of the Administration. Single failure criteria include:

a. Any active component or system (generators, thrusters, switchboards, remote controlled valves, etc.).

b. Any normally static component (cables, pipes, manual valves, etc.) which is not properly documented with respect to protection and reliability.

204. **For equipment class 3**, a single failure includes the items listed above for class 2, and any normally static component is assumed to fail.

a. All components in any one watertight compartment, from fire or flooding.

b. All components in any one fire sub-division, from fire or flooding.

205. **For equipment classes 2 and 3**, a single inadvertent act shall be considered as a single fault if such an act is reasonably probable.

206. Based on the single failure definitions in F4.200 the worst case failure shall be determined and used as the criterion for the consequence analysis (see F6.504).

207. The RBNA shall assign the relevant equipment class to a DP-vessel based on the criteria in F4.200 and state it in the Flag State Verification and Acceptance Document (FSVAD).

208. When a DP-vessel is assigned an equipment class this means that the DP-vessel is suitable for all types of DP-operations within the assigned and lower equipment classes.

209. It is a provision of the rules that the DP-vessel is operated in such a way that the worst case failure, as determined in F4.200, can occur at any time without causing a significant loss of position

300. RBNA additional class notations for dynamically positioned vessels

301. See Table T.F4.301.1 below, where the RBNA additional class notations are defined and compared with IMO MSC/645 equipment classes.

TABLE T.F4.301.1– EQUIPMENT CLASS AND RBNA ADDITIONAL CLASS NOTATION FOR DP VESSELS

DESCRIPTION	IMO EQUIPMENT CLASS	RBNA ADDITIONAL CLASS NOTATION FOR DP
Manual position control and automatic heading control under specified maximum environmental conditions	NA	SPD0
Automatic and manual position and heading control under specified maximum environmental conditions	CLASS 1	SPD1
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault excluding loss of a compartment. (Two independent computer systems).	CLASS 2	SPD2
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault including loss of a compartment due to fire or flood. At least two independent computer systems with a separate backup system separated by A.60 class division.	CLASS 3	SPD3

302. The DP additional class notation is comprised of two parts:

a. Letters SPD – indicative of Dynamic Postioning System (Sistema de Posicionamento Dinâmico in Portuguese)

b. A number from 0 to 3 indicating the IMO Class as well as the redundancy level.

400. Redundancy

401. In so far as is practicable all components in a DP-system shall be designed, constructed and tested in accordance with international standards recognized by the. RBNA.

402. In order to meet the single failure criteria given in sub-chapter F4.200 of these Rules, redundancy of components will normally be necessary as follows:

a. for equipment class 2, redundancy of all active components;

b. for equipment class 3, redundancy of all components and physical separation of the components.

403. For equipment class 3, full redundancy may not always be possible (e.g., there may be a need for a single change-over system from the main computer system to the back-up computer system). Non-redundant connections between otherwise redundant and separated systems may be accepted provided that it is documented to give clear safety advantages, and that their reliability can be demonstrated and documented to the satisfaction of the RBNA. Such connections shall be kept to the absolute minimum and made to fail to the safest condition. Failure in one system shall in no case be transferred to the other redundant system.

404. Redundant components and systems shall be immediately available and with such capacity that the DP-operation can be continued for such a period that the work in progress can be terminated safely. The transfer to redundant component or system shall be automatic as far as possible, and operator intervention shall be kept to a minimum. The transfer shall be smooth and within acceptable limitations of the operation.

F5. PLANS AND DOCUMENTS

100. Documents to be submitted for approval

101. Vessel Data:

a. Location of thrusters

b. Locations of propellers and rudders

c. Location of moon pools

d. Location of taught wires

e. Location of position referencing systems, aerials, etc

f. Location of ROV station

g. Location of all relevant equipment (service apparatus, cranes, pipe lay stingers, carousels, sub-sea equipment)

102. DP system philosophy: the company’s philosophy in regards DP operations

103. DP system description:

a. Control and display information

b. Available position reference systems

c. Diagram of the DP system specific to the vessel

d. Diagram of power distribution systems and UPS

e. Description of propulsion system, power production and distribution, thrusters, thrust affected zones, diver umbilical lengths

f. Description of monitoring and alarms

g. Communication system matrix

h. DP system operation

104. Capability plots for intact operation and with various combinations of thrusters down including worst case failure (at least with all thrusters alive and the most critical failure)

105. DP trials procedure:

a. Test program at the manufacturer

b. Test program for quay / sea trials

106. Documentation on the environment conditions long term distribution

107. Diagram of the environmental limit conditions (also called foot prints, or environmental envelopes, or capability plots) for the conditions defined in the specification (wind speed, current and waves)

108. Functional block diagram of the sensor and reference systems (position/environmental conditions)

109. Functional block diagram of the control unit

110. One line diagram and specification of the cables between the different equipment units (power, control, display)

111. Balance of power

112. List of the equipment units with, for each one, Manufacturer's identification, type and model

113. Type test reports of the sensors of the measurement systems, or equivalent

114. Test report of the computer units; check of the behaviour of the installation when submitted to radiated and conducted electromagnetic interference

115. Estimation of reliability figures when required for symbols **SPD2** and **SPD3**. The document to be submitted is to demonstrate the reliability of the system. This is to be achieved with appropriate analysis such as:

a. A Failure Mode and Effect Analysis (FMEA) using, as far as possible, the fault tree method describing the effects due to failures leading to the destruction of the automation system. In addition, this document is to show the consequences on other systems, if any. It is to be detailed up to a level which allows the RBNA to evaluate the necessity of redundancy. This analysis is to be presented in accordance with IEC Standard 60812, IMCA M 166 (Guide on Failure Modes and Effects Analysis) or any other recognised standard

b. test report/life test

c. MTBF calculation

Or any other document which proves to the RBNA the reliability of the system

116. For approval of propulsion, based on rotary azimuth thrusters:

a. layout drawings of thrust units, thrust shafts and blocks

b. arrangement of hull passages

c. thrust curves of each propulsion unit

117. Electrical power management layout drawings and specification if provided on board

118. Internal communication system description

119. Description of the control stations (layout on board, descriptive diagrams of the display consoles)

120. Alarm list and parameter values displayed on the consoles

121. Study of possible interaction between thrusters

200. Documents to be submitted for information

201. Technical specification of the positioning system

202. Operator's manual of the positioning system including:

a. description of the equipment

b. maintenance guide

c. emergency procedures

F6. DESIGN PRINCIPLES

100. System Capability Definition

101. The maximum continuous operational station keeping capability for the DP system shall be calculated for the following cases:

a. All thrusters operational with maximum effective thrust;

b. All thrusters, except the most effective thruster, operational with maximum effective thrust;

c. The maximum number of thrusters and/or power units that could be operational after the worst single failure depending upon the class modes;

d. The equivalent loading on all thrusters in the failed mode shall not exceed the available power in c) above.

102. The above shall be presented in polar plot form for various current speeds, for example 1.0, 1.5 and 2.0 knots, co-incident with wind and associated wave loads from a fully developed sea. A realistic allowance shall be made for losses from, for example, interaction, thruster tunnel length, high current, control system response, non-steady conditions and normal deck wind loading conditions when working. Other external forces shall also be considered if appropriate.

103. The purpose of 101.a) is to be able to calculate predicted capability, and assess the practical working limits.

.104. The purpose of 101.b) as a single composite plot is to provide operators with a limit that cannot be exceeded if position is to be kept when the most effective thruster suddenly stops.

105. The purpose of 101.c) is to provide operators with guidance on working limits which shall be imposed for the most difficult or sensitive tasks where the consequences of a loss of position are particularly severe, for example, loss of life or injury to many people. Using this limit shall mean that there will be a 'safe situation' (see Chapter F, sub-chapter F.3, items 112 and 202 of the present Rules) after the worst single failure.

106. The purpose of 101.d) is to give operators information so that they can assess from available power and thrust usage whether safe working limits have been exceeded. This is generally known as consequence analysis because the consequence of a failure, when this warning is active, is a loss of position.

107. This theoretical procedure is to provide plots that are easily verified during proving trials and in the first year of DP operation. It is essential for the wave conditions used in the calculations be stated on all capability plots.

Guidance

Capability plots do not show the excursions of a DP vessel. They show the likely environmental limits within which a DP vessel will effectively return to the wanted position when an excursion takes place from normal external disturbing forces. The excursions of a vessel depend on the environmental conditions, the control system tuning and the accuracy of the position references. In marginal conditions working within the defined safe working limits DP vessels shall record the vessel's excursions and so develop a 'footprint' for the vessel in these conditions.

End of guidance

108. Online capability plots provided as an additional facility with a DP control system shall be verified by full scale testing and are a useful tool in reassessing safe working limits but shall not be used in isolation.

200. Failure Modes and Effect Analysis

201. A failure modes and effect analysis (FMEA) is to be carried out and is to be sufficiently detailed to cover all the systems associated with the dynamic positioning of the vessel and is to include but not be limited to the following information:

a. A description of all the systems associated with the dynamic positioning of the vessel and a functional block diagram showing their interaction with each other. Such systems would include the DP electrical or computer control systems, electrical power distribution system, power generation, fuel systems, lubricating oil systems, cooling systems, backup control systems, etc.

b. All significant failure modes

c. The most predictable cause associated with each failure mode

d. The transient effect of each failure on the vessels position

e. The method of detecting that the failure has occurred

f. The effect of the failure upon the rest of the system's ability to maintain station

g. An analysis of possible common failure mode

202. Where parts of the system are identified as non-redundant and where redundancy is not possible, these parts are to be further studied with consideration given to their reliability and mechanical protection. The results of this further study are to be submitted for review.

Guidance

FMEA procedures and systematic may be found in IEC 60812 standard and in IMO HSC Code Appendix 4 2.

End of guidance

300. Operation, Training and Documentation

301. Every DP vessel shall have an operations manual that is particular to that DP system and the operating practice of

the owners or operators of the vessel. It shall cover all the work for which the vessel is designed or likely to be used. It shall include but not be limited to the following:

a. Capability plots;

b. Trials data;

c. Working profiles and capabilities of equipment;

d. DP status, alerts, emergency responses and procedures;

e. Responsibilities and communications;

f. Approach, setting up, checking and testing of the DP system;

g. Reporting and recording;

h. DP footprints;

i. Manning.

302. All documents shall be controlled and updated in accordance with the vessel's ISM code procedure.

Guidance

In addition to the above general document, each work location, task or operation of the DP vessel may require a site- or well-specific document that further specifies additional constraints or procedures for a particular project if the general document will not suffice for example project safety plan, HAZID (hazard identification) / HAZOP (hazardous operation) drills, SIMOPS (simultaneous operations) and close out documentation. This site- or well-specific document shall include:

a. plans for positioning and handling equipment, operating with other vessels or near platforms, or changing some of the operations manual normal procedures because of special circumstances.

b. findings of any risk analysis carried out for that project or similar projects. The principle here is that each task is given individual consideration prior to its being performed and, unless it is a standard operation that is covered by the general manual, a suitable project specific procedure shall be produced.

End of guidance

400. Design of Position Reference Systems

401. The number and types of position references installed will be determined by the class notation sought or assigned, as well as the environment in which they are required to operate.

402. Due attention is to be paid to determine whether redundancy is completely provided by duplication of similar sensors which may have common failure modes.

403. All position references shall be designed so that they cannot give an unchanging position when data is lost and the vessel is moving. For example taut wires, whether horizontal or vertical, shall be designed so that they cannot fail in a way which will provide a constant position signal to the DP control systems, because of a fouled wire, inadequate bottom weight or a faulty head sensor. To meet the requirements of F3.201 such faults shall be brought to the notice of the operator in the form of alarms and the sensor data rejected by the DP control system. Position references shall be deselected, if they have not already been rejected, once they no longer reasonably contribute to the estimated position.

404. A DP vessel's HPR shall be designed so that it cannot accept any signal that is not intended (by design or procedure) to be used for position information. The limits of performance of an acoustic position reference shall be determined prior to work commencing so that the limits of movement of the vessel using the HPR, as deployed, are known. Seabed sensors that are tethered, or attached to vessel equipment, so that they could give a false steady position reference with the vessel moving, shall be avoided whenever practicable, and this limitation considered when determining redundancy and safe working limits. The positioning of acoustic units in the hull shall take into account the likely sources of noise that could interfere with the acoustic signals and result in the loss of position reference data. If two acoustic systems are installed their independence or dependence shall be clearly established and this reflected in how they are treated by the DP control software.

500. Computers

501. For equipment class 1, the DP-control system need not be redundant.

502. For equipment class 2, the DP-control system shall consist of at least two independent computer systems. Common facilities such as self-checking routines, data transfer arrangements, and plant interfaces shall not be capable of causing the failure of both/all systems.

503. For equipment class 3, the DP-control system shall consist of at least two independent computer systems with self-checking and alignment facilities. Common facilities such as self-checking routines, data transfer arrangements and plant interfaces shall not be capable of causing failure at both/all systems. In addition, one back-up DP-control system shall be arranged. An alarm shall be initiated if any computer fails or is not ready to take control.

504. For equipment classes 2 and 3, the DP-control system shall include a software function, normally known as '

consequence analysis', which continuously verifies that the vessel will remain in position even if the worst case failure occurs. This analysis shall verify that the thrusters remaining in operation after the worst case failure can generate the same resultant thruster force and moment as required before the failure.

505. The consequence analysis shall provide an alarm if the occurrence of a worst case failure would lead to a loss of position due to insufficient thrust for the prevailing environmental conditions. For operations which will take a long time to safely terminate, the consequence analysis shall include a function which simulates the thrust and power remaining after the worst case failure, based on manual input of weather trend.

506. Redundant computer systems shall be arranged with automatic transfer of control after a detected failure in one of the computer systems. The automatic transfer of control from one computer system to another shall be smooth, and within the acceptable limitations of the operation.

507. For equipment class 3, the back-up DP-control system shall be in a room separated by A.60 class division from the main DP-control station. During DP-operation this back-up control system shall be continuously updated by input from the sensors, position reference system, thruster feedback, etc., and be ready to take over control. The switch-over of control to the back-up system shall be manual, situated on the back-up computer and shall not be affected by failure of the main DP-control system.

508. An uninterruptible power supply (UPS) shall be provided for each DP-computer system to ensure that any power failure will not affect more than one computer.

509. UPS battery capacity shall provide a minimum of 30 minutes operation following a mains supply failure.

F7. POSITION REFERENCES

100. General

101. Position reference systems shall be selected with due consideration to operational requirements, both with regard to restrictions caused by the manner of deployment and expected performance in working situation.

102. For equipment classes 2 and 3, at least three position reference systems shall be installed and simultaneously available to the DP-control system during operation.

103. When two or more position reference systems are required, they shall not all be of the same type, but based on different principles and suitable for the operating conditions.

104. The position reference systems shall produce data with adequate accuracy for the intended DP-operation.

105. The performance of position reference systems shall be monitored and warnings provided when the signals from the position reference systems are either incorrect or substantially degraded.

106. For equipment class 3, at least one of the position reference systems shall be connected directly to the back-up control system and separated by A.60 class division from the other position reference systems.

107. Short range radio position reference systems shall be designed so that they cannot accept any signal that is not unique by design or procedure to the DP vessel on which they are being used because they can suffer sudden failure from loss of line of sight or a fault at a remote station.

108. Precautions shall be taken to avoid all failures or faults that cause the position data to ‘freeze’ irrespective of whether the vessel is stationary or not.

Guidance

Deploying more than one transponder does not make the acoustic position reference redundant if it is still subject to a common failure mode, for example thruster noise.

The use of DGPS as more than one position reference depends on the level of independence achieved with respect to hardware and software, the number of satellites available, the antennae locations, the quality and number of differential corrections available and their effects if giving the same incorrect data.

However when two separate DGPS inputs of position are used by the DP control system, their contribution to the estimated position together with other position references needs to be properly balanced. Here balanced means that two DGPSs (or GPS or GPS Relative) shall never out-vote one or more other position references and operate the system such that a loss of position could result.

The DGPS input shall also provide information on fix quality for use by the DP control systems.

The use of pseudo signals to simulate a different position reference so that the DP control system can accept it, for example accepting the DGPS signal as an Artemis signal on the DP control where there is no available input for DGPS itself, shall be avoided whenever possible. If such use is unavoidable all failure modes shall be thoroughly tested.

End of guidance

200. Environmental Sensors

201. The position keeping performance and speed of response of the DP system can be improved by the incorporation of environmental sensors to provide feed forward to the DP control system. DP control systems shall use wind sensors as a minimum.

202. To provide an overall position keeping improvement the wind sensor(s) shall be positioned such that they are not subject to vessel turbulence or interference for example from cranes, helicopters and platforms.

203. Irrespective of the suitability of the location of the sensor, the wind feed forward input to position control shall be so arranged that it will not cause a critical excursion when suddenly shielded or unshielded from the wind.

204. It shall also be noted that wind sensors may be subject to icing up in certain conditions.

205. Where the vessel has more than one wind sensor every consideration shall be made so that all wind sensors are available for use by the DP control system.

300. Vessel Sensors

301. Vessel sensors shall at least measure vessel leading, vessel motions, and wind speed and direction.

302. When an equipment class 2 or 3 DP-control system is fully dependent on correct signals from vessel sensors, then these signals shall be based on three systems serving the same purpose (i.e. this will result in at least three gyro compasses being installed).

303. Sensors for the same purpose, connected to redundant systems shall be arranged independently so that failure of one will not affect the others.

304. For equipment class 3, one of each type of sensors shall be connected directly to the back-up control system and separated by A.60 class division from the other sensors.

Guidance

Position keeping includes the control of the vessel's heading; gyro compasses are normally used for this purpose.

Provision of gyro compass redundancy and the ability of the DP system to detect failure, including a slow drift of the on-line unit, shall be taken into account when determining safe limits, particularly on mono-hulled vessels because failure of heading input has a dramatic effect on position keeping and excursion, particularly if the heading data is lost to all position references or if the DP rotation centre is remote from the geometrical centre of the vessel.

Other sensors that are required for accurate position keeping are the vertical or motion reference sensors. These devices, that measure roll and pitch and sometimes heave, shall be, whenever possible, in separate spaces and located near the rotation centre of the vessel. If they are located some distance from the rotation centre then this shall be corrected for in the DP software whenever this cannot be done on the sensor itself. The DP system requires this information to correct position reference sensors for X and Y offsets caused by vessel inclination and motion. Loss of these inputs degrades DP system performance particularly with some HPR systems in deep water

It is recommended that current control is used for sensors rather than voltage.

End of guidance

305. For vessels with a SPD 0 or SPD 1 notation, a two position reference systems, a wind sensor and a gyro compass are to be fitted.

306. For vessels with a SPD 2 notation in addition to the requirements for SPD 1 notation, a third independent position reference system, two additional wind sensors and two additional gyro-compasses are required. Two of the position reference systems may operate on the same principle. A single failure is not to affect simultaneously more than one position reference system.

307. For vessels with a SPD 3 notation, the third wind sensor, third gyro-compass and the third independent position reference system are to be directly connected to the back-up control station with their signals repeated to the main control station.

308. Where three position reference systems are required, the control computers are to use signal processing techniques to validate the data received. When out of range data occurs, an alarm is to be given.

309. For diving support vessels, equipped with a dynamic positioning system, the class notation **SPD-2** or higher is mandatory.

F8. CONTROL SYSTEMS

100. General

101. In general the DP-control system shall be arranged in a DP-control station where the operator has a good view of the vessel' s exterior limits and the surrounding area.

102. The DP-control station shall display information from the power system, thruster system, and DP-control system to ensure that these systems are functioning correctly. Information necessary to operate the DP-system safely shall be visible at all times. Other information shall be available upon operator request.

103. Display systems and the DP-control station in particular, shall be based on sound ergonometric principles. The DP-control system shall provide for easy selection of control mode, i.e. manual, joystick, or computer control of thrusters, and the active mode shall be clearly displayed.

104. For equipment classes 2 and 3, operator controls shall be designed so that no single inadvertent act on the operators' panel can lead to a critical condition.

105. Alarms and warnings for failures in systems interfaced to and/or controlled by the DP-control system are to be audible and visual. The DP-control system shall receive alarms and warnings reflecting the status of the DP system. The alarms to be presented in the DP-centre shall be limited to functions relevant to DP operation. A permanent record of their occurrence and of status changes shall be provided together with any necessary explanations.

106. The DP-control system shall prevent failures being transferred from one system to another. The redundant components shall be so arranged that a failure of one component shall be isolated, and the other component activated.

107. It shall be possible to control the thrusters manually, by individual joysticks and by a common joystick, in the event of failure of the DP-control system.

108. The software shall be produced in accordance with an appropriate international quality standard recognized by the Administration.

200. Control system design principles

Guidance

Automatic DP control systems are generally supplied in single, dual or triple configurations with a back-up DP control system for DP equipment class 3 vessels.

Manual systems are a combined lever or joystick, with or without automatic heading control. Joysticks can be completely independent of the computer(s) used for automatic position control, or an integral part of the automatic system in that they use the same I/O, network or cables to the thrusters.

End of guidance

201. The minimum DP control facility is a single automatic control system with an integral joystick, which is adequate for some tasks.

202. Irrespective of the number of control systems and types of joystick certain essential features are required to ensure adequate reliability of each. These include the following:

a. Secure power supplies with backup (usually batteries) provided in case of a mains failure;

b. Independent emergency stop for each thruster, adequately protected against inadvertent operation and for DP equipment class 3, arranged so thrusters do not trip from fire or flood damage to the stop circuits;

c. Separate output command signals for each thruster or sets of thrusters;

d. Secure location with negligible risk of fire, flood or overheating;

e. Comprehensive data display and alarms;

f. Internal self checking;

g. Independent I/Os for sensors.

203. DPO inputs to the system shall require a confirming action before being accepted by the computer to prevent accidental changes being made by a single inadvertent act.

204. Power supplies for position control shall be redundant, secure and so arranged that no short circuit, cable damage, earth fault, or automatic changeover could result in the loss of position control.

205. The location of the secure power supplies shall be chosen such that:

a. they can be easily checked;

b. they are unlikely to be misused or to fail from mechanical damage, fire, inadequate ventilation etc.

206. Where position references, environmental sensors and vessel sensors are powered by the position control system's secure supply, care shall be taken to ensure adequate sensors remain after the worst power failure, for example failure of the UPS's inverter.

207. Control information shall be displayed or be easily available to meet the principles outlined in F3.201.

208. For all DP vessels this shall include the following:

a. Thrust units status and power ordered and used;

b. Power generation and distribution arrangement in use;

c. Reference sensor status and performance;

d. Position performance present and past;

e. Alarm status and sensor trends.

209. The DP control shall enable automatic position and heading changes to be made in any preselected direction at rates within the vessel's capability so that the new heading and/or position is quickly established without instability, or a position excursion, or overshoot above acceptable limits for the work.

300. Control and Monitoring System Components:

301. In general, control and monitoring (alarms and instrumentation) system components for dynamic positioning systems of vessels intended to be assigned with

DPS notations are to comply with the provisions of Part II, Title 11, Section 5, Chapter E, subchapter E6.

400. Control Stations

401. The DP control console shall be located so that the operator can see the controls, the external environment and the working operations of the vessel. Every reasonable effort shall be made to compensate in the event that this is not fully achievable for example by CCTV.

402. Control station arrangement. The main dynamic positioning control station is to be so arranged that the operator is aware of the external environmental conditions and any activities relevant to the DP operation.

403. Emergency shutdown. An emergency shutdown facility for each thruster is to be provided at the main dynamic positioning control station. The emergency shutdown facility is to be independent of the automatic control systems, manual position control system and manual thruster control system. The emergency shutdown facility is to be arranged to shut down each thruster individually.

404. *Vessels with* **SPD-3** *notation*. For **SPD-3** notation, an emergency back-up control station is to be provided in a separate compartment located and arranged such that no single fault, including a fire or flood in one compartment, will render both the main and back-up control system inoperable.

500. Position Keeping Control System Redundancy

501. *Vessels with* **SPD-1** *notation*. An automatic control system and a manual position control system with automatic heading control are to be fitted. Transfer of control between the two systems is to be initiated manually.

502. *Vessels with* **SPD-2** *notation*. Two automatic control systems and a manual position control system with automatic heading control are to be fitted as follows:

a. The two automatic control systems located at the dynamic positioning control station are to be independent, self-monitoring and arranged such that, shall one fail, control is automatically transferred to the other.

b. The cabling for the control systems and the thrusters is to be arranged such that under single fault conditions, including loss of a compartment due to fire or flood, it will remain possible to control sufficient thrusters to stay within the specified operating envelope. Control system with automatic heading control are to be fitted.

503. *Vessels with* **SPD-3** *notation.* Three automatic control systems and a manual position control system with automatic heading control are to be fitted. The two automatic control systems located at the dynamic positioning control station are to be independent, self-monitoring and arranged such that, shall one fail, control is automatically transferred to the other. The third automatic control system is to be located in the emergency back-up control station and transfer of control to it is to be initiated manually. The cabling for the control systems and the thrusters is to be arranged such that under single fault conditions, including loss of a compartment due to fire or flood, it will remain possible to control sufficient thrusters to stay within the specified operating envelope.

600. Manual Position Control System

601. The manual position control system is to be independent of the automatic control systems so that it will be operational if the automatic control systems fail. The system is to provide one joystick for manual control of the vessel position and is to be provided with the arrangements for automatic heading control.

602. Manual Thruster Control System: In addition, a manual thruster control system is required. The manual thruster control system is to be independent of the automatic control systems so that it will be operational if the automatic control systems fail. The system is to provide an effective means of individually controlling each thruster from the navigation bridge. The system is to provide an individual joystick for each thruster.

603. Any failure in the manual position control system is not to affect the capabilities of the manual thruster control system to individually control each thruster.

700. Consequence Analysis and DP Alert System

701. Only for vessels with **SPD-2** or **SPD-3** notation, the DP control system is to incorporate a consequence analyser that monitors the vector thrust necessary to maintain position under the prevailing environmental conditions and perform calculations to verify that in the event of a single failure there will be sufficient thrust available to maintain position in steady state and during transients.

F9. POWER SYSTEMS

100. Power systems

101. The power system shall have an adequate response time to power demand changes.

102. For equipment class 1, the power system need not be redundant.

103. For equipment class 2, the power system shall be divisible into two or more systems such that in the event of failure of one system at least one other system will remain in operation. The power system may be run as one system during operation, but shall be arranged by bus-tie breakers to separate automatically upon failures which could be transferred from one system to another, including overloading and short-circuits.

104. For equipment class 3, the power system shall be divisible into two or more systems such that in the event of failure of one system, at least one other system will remain in operation. The divided power system shall be located in different spaces separated by A.60 class division. Where the power systems are located below the operational waterline, the separation shall also be watertight. Bus-tie breakers shall be open during equipment class 3 operations unless equivalent integrity of power operation can be accepted according to F4.403.

105. For equipment classes 2 and 3, the power available for position keeping shall be sufficient to maintain the vessel in position after worst case failure according to F4.200.

106. If a power management system is installed, adequate redundancy or reliability to the satisfaction of the Administration shall be demonstrated.

107. The type, number and arrangement of power generation units, will have a direct bearing on the safe working limits of the DP system, because the effect of the failure of any one unit, or common sub-system, will be considered in the determination of safe working limits (see F3.202).

108. This includes the number and type of engine shutdowns. The number of engine rooms and engines shall be determined by the safety, reliability and availability required for the work as well as the time to completely shut down.

109. Utilities supporting power generation systems, e.g. cooling water, ventilation, fuel oil, lubricating oil shall be arranged so that their total failure is not more critical than failure of the equipment they support.

110. Safety systems that enable shut down of power generation automatically or manually shall be designed to fail safe so that unwanted shut down does not take place from single faults.

111. If the design philosophy is that a single fault also includes a fire in any one compartment (IMO DP equipment class 3) then the shut down control system shall withstand fire damage or be separated so that in the worst case adequate power remains to meet the safe working limits.

200. Power management

201. A system to prevent overload and blackout is essential on all DP vessels. A system for the prudent starting and stopping of diesel generators is also desirable, although on some vessels this management can be manual if there is ample time for operators to react and manage the power on line. On DP vessels that rely on automatic power management the system will need to be fast and reliable for the vessel to work efficiently and give the required priority to maintaining position.

202. Power management and position control are inseparable in that they both affect thrust for position keeping. It is essential to clearly define the interfaces and responsibilities for all operational modes of every vessel. DP vessels which use substantial amounts of power for equipment other than thrusters, for example, for cranes, fire pumps, drilling and hotel facilities, need to be able to shed or reduce load (phase back) to maintain power to thrusters.

203. The speed, effectiveness and reliability of load shedding by a power management system are factors to take into account when determining safe working limits.

300. Power distribution

Guidance

A basic requirement for a DP vessel is to maintain power to thrusters for as long as possible, even in some alarm conditions, so that a safe situation with respect to position can be maintained until the work is terminated.
This very often conflicts with the shut downs and protection systems normally installed on ships and rigs.

End of guidance

301. Where emergency switchboards are provided as a classification society requirement, careful consideration shall be given when using this switchboard for critical DP equipment: loss of the emergency switchboard shall not prevent starting of main generators after a blackout.

302. The electrical power distribution to thrusters is usually the aspect of the DP system design which determines the worst case failure mode. For DP equipment class 3 vessels fire and flood subdivision shall not make the design failure case worse.

Guidance

Examples of single failures in power distribution include the following:

a. undervoltage;

b. underfrequency i.e. governor failure;

c. earth faults;

d. phase-phase short circuits;

e. faults on a bus tie breaker;

f. over/under excitation.

End of guidance

303. For DP equipment class 3 vessels the following additionally apply:

a. fire or flood at the DP control station;

b. fire or flood in a switchboard room;

c. fire or flood along a common cable route;

d. fire or flood in the emergency switchboard room;

e. fire or flood in a main or auxiliary machinery space;

f. fire or flood in the engine control room.

304. Note: Flood in the above context can be taken as water spray throughout the space if flooding is unrealistic.

305. The highest priority shall always be given to clearing faults that risk the overall power and control networks, and maintaining enough power to give time to cease any operation and reach a safe situation.

400. Thruster systems

401. The thruster system shall provide adequate thrust in longitudinal and lateral directions, and provide yawing moment for heading control.

402. For equipment classes 2 and 3, the thruster system shall be connected to the power system in such a way that F9.401 can be complied with even after failure of one of the constituent power systems and the thrusters connected to that system.

403. The values of thruster force used in the consequence analysis (see F10.204) shall be corrected for interference between thrusters and other effects which would reduce the effective force.

404. Failure of thruster system including pitch, azimuth or speed control, shall not make the thruster rotate or go to uncontrolled full pitch and speed.

405. Speed of response, efficiency and interference shall be considered for all thrust units and the arrangement shall be made to give, as far as is possible, a balanced configuration even after the worst failure.

406. Means shall be provided to avoid a thruster control fault that results in full power or power in an unwanted direction which can destabilise the whole DP control system. Such problems are overcome by a fail safe design; that is, the thruster:

a. fails as set;

b. fails to zero thrust;

c. trips the drive motor or engine.

407. While these safety features shall be automatic means shall be provided for an independent emergency stop for each thrust unit, suitably protected against inadvertent operation and operated from the DP control console or nearby.

408. Thrust units shall be as independent as possible in terms of location, cable runs, electrical and control power and cooling, to maximise the safe working limits. Each thrust unit shall be independently monitored and alarmed.

409. Sensors causing a thrust unit to trip shall be the minimum in number, i.e. tripping shall only take place in situations where continued running will cause the unit to be damaged within a short space of time, e.g. 30 seconds.

410. Sensors that initiate warning alarms shall themselves be designed to cause an alarm on failure; sensors that trip important equipment, e.g. generators, pumps, motors and engines shall not themselves fail such that an unwanted loss of important equipment is caused, i.e. they shall fail safe.

F10. COMPUTER SYSTEMS

100. Computers

101. For equipment class 1, the DP-control system need not be redundant.

102. For equipment class 2, the DP-control system shall consist of at least two independent computer systems. Common facilities such as self-checking routines, data transfer arrangements, and plant interfaces shall not be capable of causing the failure of both/all systems.

103. For equipment class 3, the DP-control system shall consist of at least two independent computer systems with self-checking and alignment facilities. Common facilities such as self-checking routines, data transfer arrangements and plant interfaces shall not be capable of causing failure at both/all systems. In addition, one back-up DP-control system shall be arranged. An alarm shall be initiated if any computer fails or is not ready to take control.

104. For equipment classes 2 and 3, the DP-control system shall include a software function, normally known as 'consequence analysis', which continuously verifies that the vessel will remain in position even if the worst case failure occurs. This analysis shall verify that the thrusters remaining in operation after the worst case failure can generate the same resultant thruster force and moment as required before the failure.

105. The consequence analysis shall provide an alarm if the occurrence of a worst case failure would lead to a loss of position due to insufficient thrust for the prevailing environmental conditions. For operations which will take a long time to safely terminate, the consequence analysis shall include a function which simulates the thrust and power remaining after the worse case failure, based on manual input of weather trend.

106. Redundant computer systems shall be arranged with automatic transfer of control after a detected

failure in one of the computer systems. The automatic transfer of control from one computer system to another shall be smooth, and within the acceptable limitations of the operation.

107. For equipment class 3, the back-up DP-control system shall be in a room separated by A.60 class division from the main DP-control station. During DP-operation this back-up control system shall be continuously updated by input from the sensors, position reference system, thruster feedback, etc., and be ready to take over control. The switch-over of control to the back-up system shall be manual, situated on the back-up computer and shall not be affected by failure of the main DP-control system.

108. An uninterruptible power supply (UPS) shall be provided for each DP-computer system to ensure that any power failure will not affect more than one computer.

109. UPS battery capacity shall provide a minimum of 30 minutes operation following a mains supply failure.

F11. CABLES AND PIPING SYSTEMS

100. Cables

101. For equipment class 2, cables shall be located with due regard to fire hazards and mechanical damage.

102. For equipment class 3, cables for redundant equipment or systems shall not be routed together through the same compartments. Where this is unavoidable such cables could run together in cable ducts of A.60 class, the termination of the ducts included, which are effectively protected from all fire hazards, except that represented by the cables themselves. Cable connection boxes are not allowed in such ducts.

200. Piping systems

201. For equipment class 2, piping systems for fuel, lubrication, hydraulic oil, cooling water shall be located with due regard to fire hazards and mechanical damage.

202. For equipment class 3, redundant piping system (i.e. piping for fuel, cooling water, lubrication oil, hydraulic oil, etc.) shall not be routed together through the same compartments. Where this in unavoidable, such pipes could run together in ducts of A.60 class, the termination of the ducts included, which are effectively protected from all fire hazards, except that represented by the pipes themselves.

Guidance

Quick Reference Guide	*DP-0 (Class 0)*	***DP-1 (Class 1)***	***DP-2 (Class 2)***	***DP-3 (Class 3)***
Independent, Manual Thruster Controls and by a common joystick	*1*	*1*	*1*	*1*
Automatic System (DP)	***NA***	*1*	*2*	*2+1*
Gyrocompasses	*1*	*1*	*3*	*3*
Wind Sensors	*1*	*1*	*3*	*3*
Motion Reference Sensors	*1*	*1*	*3*	*3*
Position Reference Systems	*1*	*2*	*3*	*3*
UPS w/ 30 min. battery	*1*	*1*	*2*	*3*
Consequence Analyzer	*0*	*0*	*1*	*1*
Printer	*NA*	*NA*	*NA*	*NA*
Power Management System	*0*	*0*	*1*	*1*

End of guidance

F12. REQUIREMENTS FOR ESSENTIAL NON-DP SYSTEMS

100. Requirements for essential non-DP systems

101. For equipment classes 2 and 3, systems not directly part of the DP-system but which in the event of failure could cause failure of the DP-system, (e.g., common fire suppression systems, engine ventilation systems, shut-down systems, etc.), shall also comply with relevant requirements of these Rules.

CHAPTER G
DP SYSTEMS FOR DIVING SUPPORT VESSELS

G1. ALARM AND ALERT LEVELS

100. Alarm and Alert Levels

101. ***Normal status - Green*** Normal operational status (green light). The vessel can be defined as in normal operational status when all the following conditions apply:

a. Vessel under DP control and DP system operating normally with appropriate backup systems available;

b. Thruster power and total power consumption is equal to or less than 80% of the maximum thrust and power that would be available after the worst single failure;

c. Vessel's indicated position and heading are within predetermined limits and the worst single failure would not result in safe working limits being exceeded;

d. Negligible risk of collision exists from other vessels.

102. ***Level 1 - Yellow*** - Degraded status (yellow alert). The vessel can be defined as being in a degraded status when any of the following conditions applies:

a. A failure in a sub-system has occurred leaving the DP system in an operational state (possibly after reconfiguration) but with no suitable backup available, such that an additional fault would cause a loss of position;

b. In case any of the thrusters employed to maintain the vessel's position exceeds 80% of the total capacity or if the total power consumed by the thrusters exceeds 80% of the total power for a period of time over 30 minutes maximum;

c. Vessel's position keeping performance is deteriorating and/or unstable;

d. Vessel's indicated position deviates beyond limits determined by risk analysis or HAZOP without simple explanation;

e. Risk of collision exists from another vessel;

f. Weather conditions are judged to be becoming unsuitable for DP diving;

g. Any other condition or circumstance affecting the operation of the vessel which could reduce the status from normal.

103. ***Level 2 Red*** - Emergency status (red alert). A vessel can be defined as in emergency status if either of the following conditions applies:

a. System failure results in an inability to maintain position or heading control;

b. Any external condition exists, including imminent collision, preventing the vessel maintaining position.

c. Onboard this alert is often referred to as 'abandon dive'.

Guidance

The following diving operational responses would be expected to the change of alert status initiated by the DP operator:

Green Normal Operational Status
Full DP diving operations can be undertaken.
Yellow Degraded Status

The diving supervisor shall instruct the divers to suspend operations and move to a safe location. The DPO, after consultation with the diving supervisor, shall decide if any further action is necessary. If the diving supervisor is unable to get clear advice from the DPO he will instruct divers to return to the bell and obtain a seal or to return to the surface as appropriate.

Note: Flexibility has been provided in this alert response (1994 revision) so that (a) this alert is sounded early rather than late, (b) discussion can take place between senior personnel and (c) the safety of diving operations is improved.

Red Emergency status

The diving supervisor shall instruct the divers to return immediately to the bell (or deployment device as appropriate) and obtain a seal. The bell shall be recovered as soon as possible after due consideration of hazards involved in the recovery (for example fouling of mooring lines or jacket members).

Key DP personnel shall use all reasonable means available to limit the loss of position while the divers are being recovered.

End of Guidance

200. DP Alert Status System: Visual and Audible Characteristics

201. A system of lights and audible alarms shall be provided in dive control, saturation control, air diving control area, working area, ECR and, where applicable, the ROV or submersible control position, manually activated from, and repeated in, the DP control room. The lights shall be:

a. Steady green light to indicate vessel under automatic DP control, normal operational status and confirming the alert status system functional;

b. Flashing yellow light to indicate degraded DP control;

c. Flashing red light to indicate DP emergency.

d. In addition the distinctive alarm for the red alert shall sound in the master/OIM's cabin, operations superintendent's cabin (if applicable) and the senior diving supervisor's cabin in conjunction with the flashing red light.

202. Provision of a means of acknowledging and silencing the audio and flashing functions of the signals from the receiving positions shall be made.

203. When supporting divers on DP a clear procedure indicating the recommended responses to yellow and red alerts is required. The events that shall trigger these alerts shall be based upon a minimal number of standard operating status levels reflecting the capability of the DP system to maintain the vessel on station within safe working limits.

G2. DESIGN

100. Design Philosophy

101. In addition to the basic principles outlined in Chapter F of the present Rules, a DSV shall meet the following:

a. No known single failure mode shall prevent the safe recovery of divers or cause a red alert.

b. The determination of safe working limits shall consider the time necessary for divers to return to the bell on initiation of a yellow or red alert, the likely rate of loss of position and the increased position excursion after the worst case failure mode.

c. Safe working limits can vary depending on location and water depth; lower limits shall apply when divers are working inside a steel jacket structure or habitat than when divers are working in open water over a pipeline.

200. Redundancy

201. Redundancy to reduce the effect of failure modes and improve safe working limits is expected on all DP DSVs.

202. The minimum level of redundancy for DP-DSV vessels is IMO Class 2 (RBNA SPD 2) defined in Chapter F4.300 of the present Rules, according to NORMAM 15, Chapter 13, item 1302.

300. Thruster Units

301. The arrangement of thrust units shall be such as to provide, as far as practicable, a good all around DP capability for intact and worst case failure situations, so the vessel is not unduly heading limited. In addition, consideration shall be given to providing a balanced athwartships capability in the intact and worst case failure conditions. Crossover power facilities for thrusters shall meet class requirements.

302. The thrusters shall, as far as is practicable, be independent in location, cable routes and control power so that a power fault, fire or flood would not result in the loss of more than one thruster. If separation for fire and flood is not reasonably achievable the risk of fire and flood shall be considered in high risk areas. The cabling for redundant equipment shall avoid engine rooms, boiler rooms, machinery spaces and similar spaces. It is important that cables are not routed such that the designed worst case failure mode, for example a switchboard fault, is compromised, resulting in a more significant failure than the designed worst case failure mode.

400. Power Generation

401. The DP system design and operation shall take into consideration a sudden unexpected failure of one diesel engine.

402. The design and operation shall take into consideration a fire in one engine room. An adequate fire detection system is to be installed to grant for a period of time during which divers could be recovered, i.e., to avoid an instant loss of power through a fire.

403. Vessels with independent engine rooms, capable of supplying enough thrust units to keep position with one shut down, have a lower risk of position loss and shall have higher allowable safe working limits.

404. Provisions shall be taken so that smoke from a fire in one engine room cannot be drawn into the another engine room and impede operators or activate additional smoke alarms so as to make the fire appear worse than it is.

500. Power Management and distribution

501. For vessels with complex and redundant power generation and thruster systems with load shedding systems the power management has to be automatic, comprehensive and operate for all switchboard combinations.

502. It has also to be redundant itself or fail safe so that no loss of power or thrust takes place on failure of the power management system.

503. Designers shall ensure that there is a clear interface between the blackout prevention control by the DP control system and that exercised by the power management or the individual thruster protection.

504. Communication between the two is not essential for control, but if this communication is to improve the speed of response to a power demand, failures of this communication

shall also be considered when determining safe working limits.

505. The power management system shall be redundant as far as its failure directly affects position keeping. If its failure modes do not result in loss of power to thrust units until a change of status takes place, redundancy is not essential.

506. The power management need only operate for the normal DP mode of operation, i.e. with a common switchboard (bus tie closed) provided this meets the requirements of F3.202, G2.507 and G2.508. If the vessel is designed to operate with the bus ties open while diving and closed for other work, then a power management system will be needed that can operate for each side, or section, of the switchboard independently.

507. For diving support work using DP the power distribution arrangement shall be set up so that a fault on any switchboard section separated by bus ties shall not cause the loss of the whole switchboard. This shall be the case for every working combination of generators and thrusters.

508. To achieve this requirement the bus ties shall be set and tested at regular intervals so that they split the bus before any tripping of generators has taken place on the healthy sections of the switchboard. If there is a realistic chance of the bus ties not opening or not opening fast enough then the switchboard shall be split for the work.

600. Position Control

601. For dive support work using DP, the minimum control requirement is for two automatic and fully redundant control systems providing, on the loss of one, a smooth transfer to the other which would be unnoticed by divers working near the diving bell. In addition there shall be a joystick facility for manoeuvring which can either be separate from or an integral part of the DP control system.

602. If fire or flood is assessed as a realistic failure mode within the DP control location then consideration shall be given to separate DP control system equipment in a location independent of the main system (DP equipment class 3).

603. When locating equipment within the DP control area and its cabling, designers shall consider both the risk of fire and its subsequent detection.

604. DP control computers, sensors and UPS units located remotely from the DP control console shall be separated so that maximum protection is given to the redundant DP control system. If located together, the space requires a fire and temperature detection system. In tropical climates where the temperature is expected to rise significantly above ambient when ventilation alone is used, air conditioning may also be required.

605. At least one computer shall be uninterrupted by the worst power loss fault possible and be able to continue operating with associated equipment for at least 30 minutes. It is prudent to provide an independent UPS for each DP control system, with independent battery back up for each and no cross connection.

700. Position References

701. For diving work at least three references shall be on line and at least two shall be of a different type. Two DGPSs using different correction stations may be usable but could still be subject to common failure in the satellite section of the system.

702. Re-plumbing a taut wire, when it is one of the three position references, does not constitute a violation of the above requirements, if such action is completed as quickly as is safe and practicable and the station keeping was stable when the taut wire was deselected prior to re-plumbing. Power supplies to position references shall not be common and cable routes shall be separated. Furthermore no single factor shall affect more than one reference so as to cause a common failure.

703. The three position references selected for use shall reflect the circumstances such as deep water, shallow water, open water, close proximity to a fixed or moored platform or simultaneous DP operations

704. The DP control system shall be able to identify a fault in a position reference, alert operators, and reject the suspect sensor.

800. Environmental Sensors

801. At least two wind sensors in different locations, with separate supplies and cable routes, shall be provided. If a third unit is installed it shall be in a different location or in the better of the two locations for the other wind sensors. If the wind sensors are at significantly different heights they shall be corrected so that operators can compare them easily.

802. Whenever possible all wind sensors shall be selected. If the wind sensors can be shielded by the platform to the detriment of DP control system performance, repositioning of the wind sensors shall be considered.

803. The DP control shall be able to identify a faulty unit and alert operators before a position change takes place.

900. Vessel Sensors

901. At least two vertical reference sensors shall be provided. If a third unit is installed it shall be in a separate location with a separate power supply.

902. Three gyro compasses shall be provided particularly for mono-hulled vessels, because of the critical nature of heading control. The DP control system shall be able to identify a faulty unit and alert operators before a heading and/or position degradation takes place. Vessel sensors shall be physically separated so that the redundant units are unlikely to suffer from the same fire, flood or mechanical damage event.

903. The design and arrangement of these sensors shall ensure that the independence of the position references is not compromised if one of them fails because all position references are using the same vertical reference sensor and/or gyro compass.

G.3. COMMUNICATIONS

100. Voice Communications

101. Voice communication by a priority system or dedicated channel shall be available between dive control and the DP control location.

102. In addition there shall be a dedicated system between the control centres of the vessel for its various working scenarios. This system shall include DP control, ECR, dive control, ROV control, crane control and other control stations as applicable.

103. There shall be a back up to this system which in most cases would be a common internal telephone network. These communications shall be checked as part of the location checks made during the initial DP stabilisation period.

CHAPTER T
TESTS AND INSPECTIONS

CHAPTER CONTENTS

T1. SURVEYS AND TESTING

100. Surveys and Testing: general requirements

101. Each DP-vessel which is required to comply with the Rules is subject to the surveys and testing specified in the present Chapter.

102. Initial survey which shall include a complete survey of the DP-system to ensure full compliance with the applicable parts of the rules. Further it includes a complete test of all systems and components and the ability to keep position after single failures associated with the assigned equipment class. The type of test carried out and results shall be documented in the Flag State Verification and Acceptance Document (FSVAD).

103. Periodical survey at intervals not exceeding five years to ensure full compliance with the applicable parts of the rules. A complete test shall be carried out as required in T1.102. The type of test carried out and results shall be documented in the FSVAD.

104. Annual survey shall be carried out within three months before or after each anniversary date of the initial survey. The annual survey shall ensure that the DP-system has been maintained in accordance with applicable parts of the rules and is in good working order. Further an annual test of all important systems and components shall be carried out to document the ability of the DP-vessel to keep position after single failures associated with the assigned equipment class. The type of test carried out and results shall be documented in the FSVAD.

105. A survey either general or partial according to circumstances shall be made every time a defect is discovered and corrected or an accident occurs which affects the safety of the DP-vessel, or whenever any significant repairs or alterations are made. After such a survey, necessary tests shall be carried out to demonstrate full compliance with the applicable provisions of the Rules. The type of tests carried out and results shall be recorded and kept on board.

106. These surveys and tests shall be witnessed by a RBNA surveyor.

107. The Administration may entrust the owner of the vessel to carry out annual and minor repair surveys according to a test programme accepted by the Administration.

108. After any survey and testing has been completed, no significant change shall be made to the DP-system without the sanction of the Administration, except the direct replacement of equipment and fittings for the purpose of repair or maintenance.

200. Initial Survey: quay trials

201. The preset item T1.200 is comprised of additional surveys and trials referent to the DP System. The testing of equipment and installation in general must follow the contents of the RBNA Rules for the Construction and Classification of Sea Going Vessels, Part 2 II, Chapter T of the several Titles.

202. After completion the DP system is to be subjected to the following tests:

a. Sensors: all sensors are to be tested as part of the complete DP system

b. The Position Reference Systems are to be tested as part of the complete DP system

c. Thrusters: Functional tests of control and alarm systems for each of the thrusters

d. Interaction of the thrusters and the DP system computers

e. Control: different modes of thrusters

f. Power systems:

f.1. mode selection

f.2. electric power supply

f.3. capacity of UPS batteries

g. Independent joystick systems

300. Sea Trials

301. A duration test is to be carried out with a duration of at least 8 hours.

302. A high sea trial of 2 hours is to be performed if the weather conditions are such that an average level on the thrusts above 50% is required, but may be dispensed in case the duration test described in T1.301 above is satisfactory.

303. The following is to be verified during the sea trials:

a. Position reference systems: all possible combinations of Position Reference Systems and each Position Reference System individually

b. Manual override where applicable

c. In case steering gear systems are included under DP control the maximum design temperature of the steering gear is to be tested by continuously moving the rudder from SB to PS and back until the temperature is stabilized.

d. For steering gears included under DP-control a test shall be carried out verifying that maximum design temperature of actuator and all other steering gear components is not exceeded when the rudder is continuously put over from border to border within the limits set by the DP-control system, until temperature is stabilized. In case the rudder operation is performed at zero propulsion thrust only, the test may be carried out during the quay trials.

400. Extent of Dynamic Positioning FMEA Proving Trials

401. DP vessels have to undergo FMEA proving trials, in addition to and after, dockside testing, commissioning and owner (customer) acceptance trials.

402. The DP system shall be proven as far as is reasonably practicable in all the normal modes of operation expected during the life of the vessel.

403. When all normal modes of operation appear to be functioning correctly, failure modes shall be simulated and the results of such tests documented, by a third party.

404. Finally, performances shall be demonstrated in both the intact and various failed conditions. (Moderate or rough weather is ideally required for these tests, but is not essential for acceptance of the DP capability and system stability.)

405. Such proving trials shall be properly documented and the results made available to operators, owners, charterers, surveyors and responsible authorities, to obviate the necessity of repetition of some of the design related trials during the vessel's working life and as input into operational manuals and vessel familiarisation procedures.

500. Capabiltity Plots

101. All vessels fitted with Dynamic Positioning Systems shall carry out a Capability Plot procedure, in accordance with IMCA M140 "Specifications for DP Capability Plots".

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