Polski Rejestr Statków

RULES

PUBLICATION NO. 120/P

REQUIREMENTS FOR VESSELS AND UNITS WITH DYNAMIC POSITIONING (DP) SYSTEMS

2018

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

GDAŃSK

Publication No. 120/P – Requirements for Vessels and Units with Dynamic Positioning (DP) Systems – 2018, is an extension of the requirements contained in the following PRS *Rules*, in which reference to the *Publication* has been made:

Part I – *Classification Regulations* of *the Rules for the Classification and Construction of Sea-Going Ships*
Part II – *Hull,*
Part III – *Hull Equipment*
Part V – *Fire Protection*
Part VI – *Machinery Installations and Refrigerating Plants*
Part VII – *Machinery, Boilers and Pressure Vessels*
Part VIII – *Electrical Installations and Control Systems*

The *Publication* was approved by the PRS Board on 29 January 2018 and enters into force on 1 February 2018.

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1 GENERAL

1.1 Purpose

The purpose of this *Publication* is to address the design criteria, equipment, operation, testing and documentation requirements for dynamic positioning systems in order to assure that the safety standard of the dynamic positioning system is not less than recommended by the IMO Circular MSC.1/Circ.1580.

Compliance with the requirements of this *Publication* shall be documented by means of a Dynamic Positioning Verification Acceptance Document (DPVAD) for the dynamic positioning system.

If PRS exempts any vessel or unit, which embodies features of a novel kind from any of the requirements of this *Publication*, the relevant exemptions shall be listed in the DPVAD.

If alternative design or arrangements have been applied for compliance with any particular provision of this Publication, pertinent technical information about the approval should be summarized and annexed to the DPVAD.

1.2 Application

1.2.1 The present requirements are applicable to vessels and units constructed on or after 9 June 2017.

1.2.2 For vessels and units constructed on or after 1 July 1994 but before 9 June 2017, the dynamic positioning systems shall fulfill the recommendations specified in IMO MSC./Circ.645 – Guidelines for Vessels with Dynamic Positioning Systems, however it is recommended that section 3 *Operational Requirements* of the present *Publication* be applied to all new and existing vessels and units, as appropriate.

1.2.3 The requirements contained in this *Publication* are additional to those listed in the PRS Rules for the Classification and Construction of Seagoing Ships and should be read in conjunction with the relevant *Parts* of the a/m *Rules*.

1.2.4 The sea-going ships and mobile offshore units classed with PRS upon compliance with the requirements set forth in this *Publication*, may be assigned the additional class notation (DP1, DP2 or DP3), affixed to the symbol of class.

1.3 Definitions

For the purpose of this *Publication*, unless expressly provided otherwise, the terms used herein are defined hereunder:

1.3.1 Activity-Specific Operating Guidelines (ASOG) means guidelines on the operational, environmental and equipment performance limits for the location and specific activity. (For drilling operations, the ASOG may be known as the Well-Specific Operating Guidelines (WSOG)).

1.3.2 Bus-tie breaker means a device connecting/disconnecting switchboard sections ("closed bus-tie(s)" means connected).

1.3.3 Company means the owner of the ship or any other organization or person such as the manager, or the bareboat charterer, who has assumed the responsibility for operation of the ship from the owner of the ship and who on assuming such responsibility has agreed to take over all duties and responsibilities imposed by the International Safety Management Code.

1.3.4 Computer system means a system consisting of one or more computers and associated hardware, software and their interfaces.

1.3.5 Consequence analysis means a software function continuously verifying that the vessel will remain in position even if the worst-case failure occurs.

1.3.6 Dynamic Positioning control station (DP control station) means a workstation designated for DP operations, where necessary information sources, such as indicators, displays, alarm panels, control panels and internal communication systems are installed (this includes: DP control and independent joystick control operator stations, required position reference systems' Human Machine Interface (HMI), manual thruster levers, mode change systems, thruster emergency stops, internal communications).

1.3.7 Dynamic Positioning operation (DP operation) means using the DP system to control at least two degrees of freedom in the horizontal plane automatically.

1.3.8 Dynamic Positioning Verification Acceptance Document (DPVAD) means the document issued by PRS to a DP vessel complying with these requirements.

1.3.9 Dynamically positioned vessel (DP vessel) means a unit or a vessel which automatically maintains its position and/or heading (fixed location, relative location or predetermined track) by means of thruster force.

1.3.10 Dynamic Positioning control system (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:

- **.1** computer system/joystick system;
- **.2** sensor system(s);
- **.3** control stations and display system (operator panels);
- **.4** position reference system(s);
- **.5** associated cabling and cable routing;
- **.6** networks.

1.3.11 Dynamic Positioning system (DP system) means the complete installation necessary for dynamically positioning a vessel comprising, but not limited to, the following sub-systems:

- **.1** power system;
- **.2** thruster system; and
- **.3** DP control system.

1.3.12 Failure means an occurrence in a component or system that causes one or both of the following effects:

- **.1** loss of component or system function; and/or
- **.2** deterioration of functional capability to such an extent that the safety of the vessel, personnel or environment protection is significantly reduced.

1.3.13 Failure Modes and Effects Analysis (FMEA) means a systematic analysis of systems and sub-systems to a level of detail that identifies all potential failure modes down to the appropriate sub-system level and their consequences.

1.3.14 FMEA proving trials means the test program for verifying the FMEA.

1.3.15 Hidden failure means a failure that is not immediately evident to operations or maintenance personnel and has the potential for failure of equipment to perform an on-demand function, such as protective functions in power plants and switchboards, standby equipment, backup power supplies or lack of capacity or performance.

1.3.16 Joystick system means a system with centralized manual position control and manual or automatic heading control.

1.3.17 Loss of position and/or heading means that the vessel's position and/or heading is outside the limits set for carrying out the DP activity in progress.

1.3.18 Position keeping means maintaining a desired position and/or heading or track within the normal excursions of the control system and the defined environmental conditions (e.g. wind, waves, current, etc.).

1.3.19 Power management system means a system that ensures continuity of electrical supply under all operating conditions.

1.3.20 Power system means all components and systems necessary to supply the DP system with power. The power system includes but is not limited to:

- **.1** prime movers with necessary auxiliary systems including piping, fuel, cooling, pre-lubrication and lubrication, hydraulic, pre-heating, and pneumatic systems;
- **.2** generators;
- **.3** switchboards;
- **.4** distribution systems (cabling and cable routing);
- **.5** power supplies, including uninterruptible power supplies (UPS); and
- **.6** power management system(s) (as appropriate).

1.3.21 Redundancy means the ability of a component or system to maintain or restore its function when a single failure has occurred. Redundancy can be achieved, for instance, by the installation of multiple components, systems or alternative means of performing a function.

1.3.22 Time to safely terminate (operations) means the amount of time required in an emergency to safely cease operations of the DP vessel.

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

- **.1** thrusters with drive units and necessary auxiliary systems including piping, cooling, hydraulic, and lubrication systems, etc.;
- **.2** main propellers and rudders if these are under the control of the DP system;
- **.3** thruster control system(s);
- **.4** manual thruster controls; and
- **.5** associated cabling and cable routeing.

1.3.24 Worst-Case Failure Design Intent (WCFDI) means the specified minimum DP system capabilities to be maintained following the worst-case failure. The worst-case failure design intent is used as the basis of the design. This usually relates to the number of thrusters and generators that can simultaneously fail.

1.3.25 Worst-Case Failure (WCF) means the identified single fault in the DP system resulting in maximum detrimental effect on DP capability as determined through the FMEA.

1.4 Class notations

1.4.1 The ship or unit depending on the degree of the redundancy of the system may be assigned one of the following additional class notations affixed to the symbol of class:

DP1

The dynamic positioning system is capable of automatically keeping position and heading, the loss of ship's position or heading may occur in the event of a single fault:

– redundancy of any active or static component is not needed.

This notation meets recommendations of IMO class 1.

DP2

The dynamic positioning system is capable of automatically keeping position and heading, the loss of ship's position or heading is not to occur in the event of a single fault:

– in any active component or system,
– redundancy of all active components is required (generating sets, distribution system in main switchboards, thrusters, remote controlled valves, etc.),
– in any normally static component which is not properly documented with respect to protection and reliability.

This notation meets recommendations of IMO class 2.

DP3

The dynamic positioning system is capable of automatically keeping position and heading, the loss of position is not to occur in the event of single fault:

– in any active components (as listed for DP2) or systems and any static component of propulsion system,
– in all components of propulsion system in any one watertight compartment (from fire or flooding),
– all components in any one fire sub-division, from fire or flooding (for cables, see also paragraph 2.5.1).

Redundancy of all components of propulsion systems and its physical separation by location in separate rooms is required.

This notation meets recommendations of IMO class 3.

1.4.2 When a vessel is assigned DP class notation this means that the DP vessel is suitable for DP operations within the assigned and lower class notations.

1.5 Worst case failure analysis

1.5.1 For class notations DP2 and DP3, a single inadvertent act should be considered as a single fault if such an act is reasonably probable.

1.5.2 Based on the single failure criteria in paragraph 1.4 the worst-case failure should be determined and used as the criterion for the consequence analysis (see paragraph 2.4.2.4 - Computers).

1.5.3 It is a provision of this *Publication* that the DP vessel is operated in such a way that the worst-case failure, as determined in accordance with paragraph 1.4, can occur at any time without causing a breach of acceptable excursion criteria set for loss of position and/or heading for class notations 2 and 3.

1.6 Documentation

The documentation listed below should be submitted as a complementary to those required for the vessel's mandatory class notation.

Table 1.6

System	Document	For Info	Reviewed / approved	To be kept onboard
Dynamic Positioning System	**Documents listed in this section are mainly related to the global functionality, performance and characteristics of an integrated DP system.**			
	DP Operations Manual		x	x
	System description including a functional diagram		x	
	Details of the DP alarm system and its relations with the main alarm system		x	
	General Arrangement drawing for DP Control Station including control console, control panel, layout of Navigation bridge deck, list of equipment, etc.		x	
	Layout diagram of fire and watertight subdivisions for DP3 requirement of resistance to worst case failure from fire and/or flooding		x	x
	Failure modes and effects analysis (FMEA) for DP2 and DP3		x	x

	DP station keeping capability analysis including environmental force calculation, thruster force calculation and capability polar plots for normal operational case and for post Worst Case Failure operational case		x	
	DP system testing plan (quay side and sea trials)		x	x
	For **DP3** the cableways for the different systems have to be identified in different colours.		x	
	Specification of environmental conditions (wind and sea) for DP operation with respective DP capability analysis	x		
	Basic design of DP system redundancy (**DP2**, **DP3**)		x	
	Description of vessel emergency shutdown (ESD) system if applicable	x		
	Description of emergency disconnecting system (EDS) if applicable	x		
	Planned inspection and maintenance	x		x
	Documentation of users interfaces (panel views)	x		
Power System	**Documents listed in this section are mainly related to the power system including all components and subsystems necessary to supply the DP system with power.**			
	Electrical power generation and distribution system		x	
	Electrical power balance		x	
	Auxiliary systems distribution (piping, fuel, cooling, pre-lubrication and lubrication, hydraulic, pre-heating, and pneumatic systems)		x	
	Uninterruptable power, battery and 24V DC supply systems		x	
	Bus-tie breaker protective functions (where applicable)		x	
	For **DP2** and **DP3** a power balance with power demand of the DP system under the specified environmental conditions (wind, wave, current) and after the worst case failure and power demand for the supply of the vessel (basic load)		x	
Thruster System	Thruster system arrangement		x	
	Thruster control system		x	
	Thrust output and power input curves		x	
	Thruster auxiliary system		x	
	Thruster monitoring system		x	
	Description of emergency stop system for thrusters		x	
	Thrust response time for thrust and direction changes	x		
	Thrust reductions due to interaction effects	x		

	Manufacturer test procedure		x	
	DP trial test procedure (quay side and sea trials)		x	x
	Manual for operation and maintenance	x		x
DP Control System	DP Control system, scope and arrangement		x	
	Details of the position reference system and environmental monitoring systems		x	
	Details of the consequence analysis (**DP2**, **DP3**)		x	
	Certification of suitability of control equipment for the marine atmosphere	x		x
	Control system functional description	x		
	Manufacturer's equipment operation documents		x	
	Software quality plan	x		
	FMEA of DP control system (**DP2**, **DP3**)		x	x
	Manufacturer test procedure		x	x
	DP trial test procedure (quay side and sea trials)		x	x
	Manual for operation and maintenance	x		x

1.6.1 Redundancy concept

With the classification contract for **DP 2** and **DP3** the following DP operation related information has to be provided:

Redundancy concept document (FMEA of basic design) with worst case failure design intent including the following information:

– General arrangement (for information)
– Power plant configuration for DP operation (DP2 or DP3-Mode)
– Permissible number of failed thrusters
– Required power sources for DP operation and permissible loss of power sources after one failure.
– Percentage of remaining main power after worst case failure
– Definition of time period for safely terminating a DP operation.

1.6.2 Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) concerning availability of the DP system after a single failure shall be provided for the class notations **DP2** and **DP3,** for the desired DP2 or DP3 power plant configuration.

DP FMEA shall be performed, based on IEC 60812 or equivalent e.g. (IMCAM166, IMCA M178), according to common DP FMEA industrial requirements.

The results of DP FMEA shall be verified during DP FMEA proving trials.

The relevant test program for DP FMEA proving trial has to be provided for approval.

1.6.2.1 DP FMEA and DP FMEA test programs are to be kept onboard and they are to be updated to cover subsequent alterations to the DP system hardware or software.

1.6.2.2 Failure Mode Analysis

Single failure includes, but is not limited to following:

– All redundant components, systems or subsystems
– A single inadvertent act of operation (ventilation, fire suppression, ESD) where applicable and if such an act is reasonably probable
– Hidden failures (such as protective functions on which redundancy depends) where applicable

– Common failure modes
– Governor and AVR failure modes where applicable
– Main switchboard control power failure modes
– Bus-tie protection where applicable
– Power management system
– DP control system input and output arrangement
– Position reference processing
– Networks
– Communication failure
– Automatic interventions caused by external events, when found relevant (e.g., automatic action upon detection of gas)

The Failure Mode Analysis is also to include:
– The most predictable cause associated with each failure mode
– The method of detecting that the failure has occurred
– The effect of the failure upon the rest of the system's ability to maintain position
– An analysis of possible common failure modes

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.

When there are more configurations for the diesel electric plant design to cope with equipment unavailability (e.g., failures or equipment taken down for maintenance), it is important that all configurations that are possible to be included in DP operations are to be analyzed in the vessel's DP system FMEA to prove that the DP system remains redundant. Fault tolerance of the configurations is to be made visible and understood by the crew.

An FMEA worksheet is to be prepared for each equipment failure assessment. Some pertinent aspects to be included in the worksheets are:
– System name (including main system, system, and subsystem)
– Reference drawings
– Equipment name or number
– Function description
– Operational mode
– Failure modes
– Failure causes
– Failure effects (including local effect and end effect)
– Failure detection
– Corrective action
– Severity of failure effect (providing definitions of categories of severity)
– Remarks

1.6.2.3 FMEA Report

1.6.2.3.1 FMEA Analysis Report

DP FMEA analysis report is to be sufficiently detailed to cover all the systems associated with the dynamic positioning of the vessel.

DP FMEA analysis report is to be a self-contained document including, but not limited to the following:
– A brief description of the vessel, vessel's worst-case failure design intent and whether the analysis has confirmed or disproved it
– Definitions of the terms, symbols and abbreviations
– Analysis method and assumptions
– 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.

- System block diagrams are to be included where appropriate
- A description of each physically and functionally independent item and the associated failure modes
- A description of the effects of each failure mode alone on other items within the system and on the overall dynamic positioning system
- Analysis findings and recommendations
- Conclusions including worst case failure and recommended changes
- Recommended FMEA tests

FMEA analysis report is to be updated after major modifications and is to be kept onboard the vessel.

1.6.2.4 FMEA Proving Trial Report

FMEA proving trial procedure is to be developed as part of FMEA study. The objective of FMEA proving trial is to confirm FMEA analysis findings and also to confirm that essential functions and features upon which the fault tolerance of the DP system depends are functional in so far as it is practical to do so (protections, power management, etc.). The proving trial report is to establish FMEA test list and the corresponding test procedures including but not limited to the following:

- Purpose of test or failure mode
- Vessel and equipment setup
- Test method
- Expected results
- Observed results
- Failure detection
- Failure effects
- Outstanding or resolved action items
- Comments
- Witness name, signature and date for each test

After completion of DP proving trials, the final version of DP FMEA analysis and DP proving trial report, including final analysis/conclusions based on actual results from DP testing, are to be submitted.

1.6.3 Documents to be kept on board in case of ship's modifiactions

1.6.3.1 When a vessel is commissioned or following major modifications and additions to the electrical and machinery installations, the documents listed in Table 1.6 which show the final arrangement of the system are to be supplied on board.

2 FUNCTIONAL REQUIREMENTS

2.1 General

2.1.1 Insofar as is practicable, all components in a DP system should be designed, constructed and tested in accordance with international standards recognized by PRS.

2.1.2 If external forces from mission-related systems (cable lay, pipe lay, mooring, etc.) have a direct impact on DP performance, the influence of these systems should be considered and factored into the DP system design. Where available from the DP system or equipment manufacturer, such data inputs should be provided automatically to the DP control system.

Additionally, provisions should be made to provide such data inputs into the DP control system manually. These systems and the associated automatic inputs should be subject to surveys, testing and analysis specified in paragraph 4.1.

2.1.3 In order to meet the single failure criteria given in paragraph 1.4, redundancy of components will normally be necessary as follows:

.1 for class notation DP2, redundancy of all active components; and

.2 for class notation DP3, redundancy of all components and A-60 physical separation of the components.

2.1.4 For class notation DP3, full redundancy of the control systems may not be possible. (i.e. there may be a need for a single changeover system from the main computer system to the backup computer system). Such connections between otherwise redundant and separated systems may be accepted when these are operated so that they do not represent a possible failure propagation path during DP operations. Failure in one system should in no case be transferred to the other redundant system.

2.1.5 For class notations DP2 and DP3, connections between otherwise redundant and separated systems should be kept to a minimum and made to fail to the safest condition. Failure in one system should in no case be transferred to the other redundant system.

2.1.6 Redundant components and systems should be immediately available without needing manual intervention from the operators 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 of control should be smooth and within acceptable limitations of the DP operation(s) for which the vessel is designed.

2.1.7 For class notations DP2 and DP3, hidden failure monitoring should be provided on all devices where the FMEA shows that a hidden failure will result in a loss of redundancy.

2.1.8 The DP control station should be arranged where the operator has a good view of the vessel's exterior limits and the surrounding area. Equipment that should be located at the DP control station includes, but is not limited to:

- **.1** DP control and independent joystick control operator stations;
- **.2** manual thruster levers;
- **.3** mode change systems;
- **.4** thruster emergency stops;
- **.5** internal communications; and
- **.6** position reference systems' HMI, when considered necessary.

2.2 Power system

2.2.1 The electrical installations are to be designed, constructed and tested according to the relevant applicable requirements, in particular for:

- **.1** . rotating machines;
- **.2** transformers;
- **.3** switchboards;
- **.4** electrical cables;
- **.5** batteries and/or UPS;
- **.6** convertors;
- **.7** electronic equipment;

All above equipment is to include its associated auxiliaries and control system and relevant power supply, i.e. electric (24V DC, UPS and batteries), pneumatic, hydraulic, electronic, as applicable

2.2.2 The power system should have an adequate response time to changes in power demand.

2.2.3 For class notation DP1, the power system need not be redundant.

2.2.4 For class notation DP2, the power system should be divisible into two or more systems so that, in the event of failure of one sub-system, at least one other system will remain in operation and provide sufficient power for station keeping. The power system(s) may be run as one system during operation, but should be arranged by bus-tie breaker(s) to separate the systems automatically upon failures which could be transferred from one system to another, including, but not limited to, overloading and short circuits.

2.2.5 For class notation DP3, the power system should be divisible into two or more systems so that, in the event of failure of one system, at least one other system will remain in operation and provide sufficient power for station keeping. The divided power system should be located in different spaces separated by A-60 class divisions. Where the power systems are located below the operational waterline, the separation should also be watertight. Bus-tie breakers should be open during class notation DP3 operations unless equivalent integrity of power operation can be accepted according to paragraph 2.1.4.

2.2.6 For class notations DP2 and DP3, the power available for position keeping should be sufficient to maintain the vessel in position after worst-case failure according to paragraph 1.5.

2.2.7 For class notations DP2 and DP3, at least one automatic power management system (PMS) should be provided and should have redundancy according to the class notation and a blackout prevention function.

2.2.8 Alternative energy storage (e.g. batteries and fly-wheels) may be used as sources of power to thrusters as long as all relevant redundancy, independency and separation requirements for the relevant notation are complied with. For class notations DP2 and DP3, the available energy from such sources may be included in the consequence analysis function required in paragraph 2.4.2.4 when reliable energy measurements can be provided for the calculations.

2.2.9 Sudden load changes resulting from single faults or equipment failures should not create a blackout.

2.2.10 For DP2 and DP3, the following applies:

- **.1** the power available for position keeping is to be sufficient to maintain the ship in position after the worst case failure occurring, as specified in 1.3.25;
- **.2** a power management system (PMS) is to be provided and is to be redundant in such a way the failure of the power management system is not to produce a failure exceeding the worst case failure of 1.3.25, to be demonstrated through FMEA. A failure in the power management system is to initiate an alarm in the DP control station.

For **DP3**, the requirements as per .1 and .2 above are to be complied with also in case of fire or flooding in one compartment.

2.2.11 The power management system is to be continuously supplied by means of an uninterruptible power supply system (UPS). Where power management system is required to be redundant, the redundancy is to be achieved also by the relevant power supply.

2.2.12 The power management system is to be capable of:
.1 enabling quick supply of active power to consumers in all operating conditions, including generator failure or change of thruster configuration;
.2 maintaining a proper balance between power demand and power generating configuration, in order to avoid a black-out, following sudden load changes resulting from single failures or equipment failures;
.3 disconnecting or reducing automatically the excess load in case of inadequate available power in order to maintain power to thrusters.

2.3 Thruster system

2.3.1 Each thruster on a DP system should be capable of being remote-controlled individually, independently of the DP control system.

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

2.3.3 For class notations DP2 and DP3, the thruster system should be connected to the power system in such a way that paragraph 2.3.2 can be complied with even after failure of one of the constituent power systems and the thrusters connected to that system.

2.3.4 The values of thruster force used in the consequence analysis (see paragraph 2.4.2.4) should be corrected for interference between thrusters and other effects which would reduce the effective force.

2.3.5 Failure of a thruster system including pitch, azimuth and/or speed control, should not cause an increase in thrust magnitude or change in thrust direction.

2.3.6 Individual thruster emergency stop systems should be arranged in the DP control station. For class notations DP2 and DP3, the thruster emergency stop system should have loop monitoring. For class notation DP3, the effects of fire and flooding should be considered.

2.4 DP control system

2.4.1 General

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

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

.3 Display systems and the DP control station in particular should be based on sound ergonomic principles which promote proper operation of the system. The DP control system should provide for easy accessibility of the control mode, i.e. manual joystick, or automatic DP control of thrusters, propellers and rudders, if part of the thruster system. The active control mode should be clearly displayed.

.4 For class notations DP2 and DP3, operator controls should be designed so that no single inadvertent act on the operator's panel can lead to a loss of position and/or heading.

.5 Alarms and warnings for failures in all systems interfaced to and/or controlled by the DP control system should be audible and visual. A record of their occurrence and of status changes should be provided together with any necessary explanations.

.6 The DP control system should prevent failures being transferred from one system to another. The redundant components should be so arranged that any failed component or components may be easily isolated so that the other component(s) can take over smoothly with no loss of position and/or heading.

.7 It should be possible to control the thrusters manually, by individual levers and by an independent joystick, in the event of failure of the DP control system. If an independent joystick is provided with sensor inputs, failure of the main DP control system should not affect the integrity of the inputs to the independent joystick.

.8 A dedicated UPS should be provided for each DP control system (i.e. minimum one UPS for class notation DP1, two UPSs for class notation DP2 and three UPSs for class notation DP3) to ensure that any power failure will not affect more than one computer system and its associated components. The reference systems and sensors should be distributed on the UPSs in the same manner as the control systems they serve, so that any power failure will not cause loss of position keeping ability. An alarm should be initiated in case of loss of charge power. UPS battery capacity should provide a minimum of 30 minutes operation following a main supply failure.

For class notations DP2 and DP3, the charge power for the UPSs supplying the main control system should originate from different power systems.

.9 The software should be produced in accordance with an appropriate international quality standard recognized by PRS.

2.4.2 Computers

.1 For class notation DP1, the DP control system need not be redundant.

.2 For class notation DP2, the DP control system should consist of at least two computer systems so that, in case of any single failure, automatic position keeping ability will be maintained. Common facilities such as self-checking routines, alignment facilities, data transfer arrangements and plant interfaces should not be capable of causing failure of more than one computer system. An alarm should be initiated if any computer fails or is not ready to take control.

.3 For class notation DP3, the main DP control system should consist of at least two computer systems arranged so that, in case of any single failure, automatic position keeping ability will be maintained. Common facilities such as self-checking routines, alignment facilities, data transfer arrangements and plant interfaces should not be capable of causing failure of more than one computer system. The two or more computer systems mentioned above do not include the backup computer system; thus, in addition, one separate backup DP control system should be arranged, see paragraph 2.4.2.6. An alarm should be initiated if any computer fails or is not ready to take control.

.4 For class notations DP2 and DP3, the DP control system should 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 should verify that the thrusters, propellers and rudders (if included under DP control) that remain in operation after the worst-case failure can generate the same resultant thruster force and moment as required before the failure. The consequence analysis should provide an alarm if the occurrence of a worst-case failure were to lead to a loss of position and/or heading due to insufficient thrust for the prevailing environmental conditions (e.g. wind, waves, current, etc.). For operations which will take a long time to safely terminate, the consequence analysis should include a function which simulates the remaining thrust and power after the worst-case failure, based on input of the environmental conditions.

.5 Redundant computer systems should 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 should be smooth with no loss of position and/or heading.

.6 For class notation DP3, the backup DP control system should be in a room separated by an A-60 class division from the main DP control station. During DP operation, this backup control system should be continuously updated by input from at least one of the required sets of sensors, position reference system, thruster feedback, etc. and be ready to take over control. The switchover of control to the backup system should be manual, situated on the backup computer, and should not be affected by a failure of the main DP control system. Main and backup DP control systems should be so arranged that at least one system will be able to perform automatic position keeping after any single failure.

.7 Each DP computer system should be isolated from other on-board computer systems and communications systems to ensure the integrity of the DP system and command interfaces. This isolation may be effected via hardware and/or software systems and physical separation of cabling and communication lines. Robustness of the isolation should be verified by analysis and proven by testing. Specific safeguards should be implemented to ensure the integrity of the DP computer system and prevent the connection of unauthorized or unapproved devices or systems.

2.4.3 Position reference systems

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

.2 For class notation DP1, at least two independent position reference systems should be installed and simultaneously available to the DP control system during operation.

.3 For class notations DP2 and DP3, at least three independent position reference systems should be installed and simultaneously available to the DP control system during operation.

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

.5 The position reference systems should produce data with adequate accuracy and repeatability for the intended DP operation.

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

.7 For class notation DP3, at least one of the position reference systems should be connected directly to the backup control system and separated by an A-60 class division from the other position reference systems.

.8 When acoustic position references are used, hydrophone is to be chosen for minimising influence of mechanical and acoustical disturbance on the transmission channels, such as propeller noise, spurious reflection on the hull, interference of riser, bubble or mud cluster on the acoustic path. The directivity of transponders and hydrophones is to be compatible with the availability of the transmission channels in all foreseeable operational conditions. It is to be possible to select the frequency range and the rate of interrogation according to prevailing acoustical conditions, including other acoustical system possibly in service in the area.

.9 When taut wires system is used, materials used for wire rope, tensioning and auxiliary equipment are to be appropriate for marine service. The anchor weight is to be designed to avoid dragging on the sea floor and is not to induce, on recovery, a wire tension exceeding 60% of its breaking strength, and the capacity of the tensioner is to be adapted to the expected movement amplitude of the unit.

.10 When a GPS or DGPS is used, it is to be designed according to IMO resolutions A.525(13), A.694(17), A.813(19) for communication and performance standards. The equipment is to be either type approved or MED, or accepted by the Flag Administration, as applicable,. The relevant certificates are to be ready available and in course of validity. For other reference systems the principle of equivalency is applied.

2.4.4 Vessel sensors

.1 Vessel sensors should at least measure vessel heading, vessel motions and wind speed and direction.

.2 When a class notation DP2 or DP3 DP control system is fully dependent on correct signals from vessel sensors, these signals should be based on three systems serving the same purpose (i.e. this will result in at least three heading reference sensors being installed).

.3 Sensors for the same purpose which are connected to redundant systems should be arranged independently so that failure of one will not affect the others.

.4 For class notation DP3, one of each type of sensor should be connected directly to the backup DP control system, and should be separated by an A-60 class division from the other sensors. If the data from these sensors is passed to the main DP control system for their use, this system should be arranged so that a failure in the main DP control system cannot affect the integrity of the signals to the backup DP control system.

Table 2.4

Summary of DP System requirements for PRS DP Notations

Subsystems or components	Equipment	Minimum Requirements for each Class Notation		
		DP1	**DP2**	**DP3**
POWER SYSTEM	Generators and Prime Movers	Non-redundant	Redundant	Redundant, in separate compartments.
	Main switchboard	1 *See note (*)*	1 with 2 busbars connected by normally closed 1 bus-tie	At least 2 with bus-ties arranged in separate compartments
	Bus-tie breaker	0 *See note (*)*	1	2 kept open, one in each main switchboard
	Distribution system	Non-redundant. *See note (*)*	Redundant arrangement	Redundant arrangement in separate compartments
	Power management system (PMS)	Not required	Redundant	Redundant, in separate compartments
THRUSTER SYSTEM	Thrusters	Non-redundant	Redundant arrangement	Redundant arrangement in separate compartments
DP-CONTROL SYSTEM	Number of Control Computers	1	2	2 + 1 in backup control station
	Joystick with automatic heading	Required *See note (**)*	Required	Required
	Manual Thruster Control	Yes	Yes	Yes
REFERENCE SYSTEM	Position Reference system	2	3	2 + 1 in backup control station
	VRS / MRU	1	3	2 + 1 in backup control station
	Wind sensor	2	3	2 + 1 in backup control station
	Ship heading sensor	2	3	2 + 1 in backup control station
	Gyro	2	3	2 + 1 in backup control station
UPS UNIT		1	2	2 + 1 in separate compartment
Backup Control Station for Backup Unit		N/A	N/A	Yes
Consequence Analyzer		No	Yes	Yes
FMEA		No	Yes	Yes

(*) According to Rules for Classification and Construction of the Sea-Going Ships, Part VIII.
(**) Where provided failure of the joystick is to bring the system in a safe situation.

2.5 Cables and piping systems

2.5.1 For class notation DP3, cables for redundant equipment or systems should not be routed together through the same compartments. Where this is unavoidable, such cables may 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 may not be provided within such ducts.

2.5.2 For class notation DP2, piping systems for fuel, lubrication, hydraulic oil, cooling water and cables should be located with due regard to fire hazards and mechanical damage. Flooding and fire shall not be considered beyond main class requirements.

2.5.3 For class notation DP3, redundant piping systems (e.g. piping for fuel, cooling water, lubrication oil, hydraulic oil, etc.) should not be routed together through the same compartments. The systems that form the designed redundancy requirement shall be separated by a A-60 class division fire -insulated in a proper way, and moreover watertight if placed below the damage water line. Watertight division shall be considered also above the damage water line where large quantity of liquids may occur as a consequence of a leakage, especially in case of flammable liquid leakage possibility.

Where this is unavoidable, such pipes may 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. Cables in separate pipes that are separately routed are acceptable on open-deck.

2.5.4 For **DP3**, cables for redundant equipment or systems are not to be routed through the same compartments. However, electrical cables of one system may be considered to remain operational if routed through the compartment of the other redundant system, provided that:

- **.1** the cables of redundant systems are not routed together;
- **.2** the cables comply with standard IEC 60092-359, in order to be considered operational during a flooding scenario, and they have no connections, no joints, no equipment connected to them within the space; if connections, joints and devices are fitted, they are to have a degree of protection IPX8 in accordance with standard IEC 60529, and
- **.3** the cables are fire-resistant type complying with standards IEC 60331-1 and IEC 60331-2 and they have no connections, joints and equipment connected to them within the space or, alternatively, they are contained in a trunk closed at all boundaries constructed to "A-60" standard.

2.6 Alarm and Monitoring System

2.6.1 An alarm and monitoring system is to be provided in accordance with the applicable requirements of Rules for the Classification and Construction of the Sea-Going Ships, Part VIII.

Table 2.6
Summary of minimum instrumentation at DP Control Station

System	Monitored Parameters	Indicator	Alarm
Power Distribution System	Status of automatically controlled circuit breakers	x	
	Bus bar current and power levels	x	
	High power consumers – current levels	x	
	Status of power management system	x	x
	Spinning reserve	x	
Thruster Power System	Engine lubricating oil pressure – low		x
	Engine coolant temperature – high		x
	CPP hydraulic oil pressure – low and high		x
	CPP hydraulic oil temperature – high		x
	CPP pitch	x	
	Thruster RPM	x	
	Thrust direction	x	
	Thruster motor/semiconductor converter coolant leakage		x
	Thruster motor semiconductor converter temperature	x	
	Thruster motor short circuit		x
	Thruster motor exciter power available	x	
	Thruster motor supply power available	x	
	Thruster motor overload		x
	Thruster motor high temperature		x
	Thruster operation (on-line/off-line)	x	
System Performance	Excursion outside operating envelope		x
	Control system fault		x
	Position sensor fault		x
	Vessels target and present position and heading	x	
	Wind speed and direction	x	
	Selected reference system	x	
Specific Requirements for DP2 & DP3	Thruster location (pictorial)	x	
	Available thrust used and thrust vector	x	
	Available thrusters on stand-by	x	
	Consequence analyzer alert		x
	Position information of individual position reference systems connected	x	

2.7 Software

2.7.1 The software is to comply with requirements of *PRS Publication 9/P*, p.3.1, 3.3 and 3.4.

2.8 Requirements for essential non-DP systems

For class notations DP2 and DP3, 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, heating, ventilation and air conditioning (HVAC) systems, shutdown systems, etc.), should also comply with relevant requirements of these requirements.

2.9 Independent joystick system

2.9.1 A joystick system independent of the automatic DP control system should be arranged. The power supply for the independent joystick system (IJS) is to be independent of the DP control system UPSs. An alarm should be initiated upon failure of the IJS.

2.9.2 The IJS should have automatic heading control.

3 OPERATIONAL REQUIREMENTS

3.1 Before every DP operation, the DP system should be checked according to applicable vessel specific location checklist(s) and other decision support tools such as ASOG in order to make sure that the DP system is functioning correctly and that the system has been set up for the appropriate mode of operation.

3.2 During DP operations, the system should be checked at regular intervals according to the applicable vessel-specific watchkeeping checklist.

3.3 DP operations necessitating class notation DP2 or DP3 should be terminated when the environmental conditions (e.g. wind, waves, current, etc.) are such that the DP vessel will no longer be able to keep position if the single failure criterion applicable to the class notation should occur. In this context, deterioration of environmental conditions and the necessary time to safely terminate the operation should also be taken into consideration. This should be checked by way of environmental envelopes if operating in class notation DP1 and by way of an automatic means (e.g. consequence analysis) if operating in class notation DP2 or DP3.

3.4 The necessary operating instructions should be kept on board.

3.5 DP capability polar plots should be produced to demonstrate position keeping capacity for fully operational and post worst-case single failure conditions. The capability plots should represent the environmental conditions in the area of operation and the mission-specific operational condition of the vessel.

3.6 The following checklists, test procedures, trials and instructions should be incorporated into the vessel-specific DP operations manuals:

- **.1** location checklist (see paragraph 3.1);
- **.2** watchkeeping checklist (see paragraph 3.2);
- **.3** DP operating instructions (see paragraph 3.4);
- **.4** annual tests and procedures (see paragraph 4.1.1.3);
- **.5** initial and periodical (5-year) tests and procedures (see paragraphs 4.1.1.1 and 4.1.1.2);
- **.6** examples of tests and procedures after modifications and non-conformities (see paragraph 4.1.1.4);
- **.7** blackout recovery procedure;
- **.8** list of critical components;
- **.9** examples of operating modes;
- **.10** decision support tools such as ASOG; and
- **.11** capability plots (see paragraph 3.5).

4 SURVEYS, TESTING AND DYNAMIC POSITIONING VERIFICATION ACCEPTANCE DOCUMENT (DPVAD)

4.1 Surveys and testing

4.1.1 Each DP vessel to which the requirements apply should be subject to the surveys and testing specified below:

- **.1** an initial survey which should include a complete survey of the DP system and FMEA proving trials for class notations DP2 and DP3 to ensure full compliance with the applicable parts of the requirements. Furthermore it should include a complete test of all systems and components and the ability to keep position after single failures associated with the assigned class notation. The type of tests carried out and results should be recorded and kept on board;
- **.2** a periodical testing at intervals not exceeding five (5) years to ensure full compliance with the applicable parts of the requirements. A complete test should be carried out as required in paragraph 4.1.1.1. The type of tests carried out and results should be recorded and kept on board;
- **.3** an annual survey should be carried out within three (3) months before or after each anniversary date of the Dynamic Positioning Verification Acceptance Document[1]. The annual survey should ensure that the DP system has been maintained in accordance with applicable parts of the requirements and is in good working order. The annual test of all important systems and components should be carried out to document the ability of the DP vessel to keep position after single failures associated with the assigned class notation and validate the FMEA and operations manual. The type of tests carried out and results should be recorded and kept on board; and
- **.4** a survey, either general or partial according to circumstances, should be carried out 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 should be carried out to demonstrate full compliance with the applicable provisions of the requirements. The type of tests carried out and results should be recorded and kept on board.

4.1.2 For class notations DP2 and DP3, an FMEA should be carried out. This is a systematic analysis of the systems to the level of detail required to demonstrate that no single failure will cause a loss of position or heading and should verify worst-case failure design intent. This analysis should then be confirmed by FMEA proving trials. The FMEA and FMEA proving trials result should be kept on board and the FMEA should be kept updated so that it remains current.

4.1.3 These surveys and tests should be witnessed by PRS surveyors.

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

4.2 Dynamic Positioning Verification Acceptance Document (DPVAD)

4.2.1 Compliance with these requirements should be verified by a DPVAD issued by PRS.

4.2.2 A DPVAD should be issued, after survey and testing in accordance with these requirements, by the PRS.

4.2.3 The DPVAD should be drawn up in the official language of the issuing country. If the language used is neither English nor French, the text should include a translation into one of these languages.

4.2.4 The DPVAD is issued for a period not exceeding five years, or for a period specified by the PRS.

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[1] If a Dynamic Positioning Verification Acceptance Document is not available, the anniversary date of the initial survey should be used to determine the date of the annual survey.

4.2.5 The DPVAD should cease to be valid if significant alterations have been made in the DP system equipment, fittings, arrangements, etc. specified in the requirements without the sanction of PRS, except the direct replacement of such equipment or fittings for the purpose of repair or maintenance.

4.2.6 The DPVAD issued to a DP vessel should cease to be valid upon transfer of such a vessel to the flag of another country.

4.2.7 The privileges of the DPVAD may not be claimed in favour of any DP vessel unless the DPVAD is valid.

4.2.8 Results of the DPVAD tests should be readily available on board for reference.