RULES FOR CLASSIFICATION OF

Ships

PART 6 CHAPTER 26

NEWBUILDINGS
SPECIAL EQUIPMENT AND SYSTEMS – ADDITIONAL CLASS

Dynamic Positioning System - Enhanced Reliability **DYNPOS-ER**

JANUARY 2011

This chapter has been amended since the main revision (January 2011), most recently in July 2011.
See "Changes" on page 3.

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The Rules lay down technical and procedural requirements related to obtaining and retaining a Class Certificate. It is used as a contractual document and includes both requirements and acceptance criteria.

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CHANGES

General

The present edition of the rules includes amendments and additions approved by the Executive Committee as of November 2010 and supersedes the July 2010 edition of the same chapter.

The rule changes come into force as described below.

Text affected by the main rule changes is highlighted in red colour in the electronic pdf version. However, where the changes involve a whole chapter, section or sub-section, only the title may be in red colour.

This chapter is valid until superseded by a revised chapter.

Amendments July 2011

- **Sec.1 General Requirements**

— In Table D1 references to documentation type “Z030 – System arrangement plan” and “Z020 – Local arrangement plan” have been amended to read “Z030 – Arrangement plan”.

- **Sec.2 General Arrangement**

— In item B406 a reference has been corrected.

Main changes coming into force 1 January 2011

- **Sec.2 General Arrangement**

— D100 Reference to internal communication has been updated.

CONTENTS

SECTION 1
GENERAL REQUIREMENTS

A. Introduction

A 100 Background and objective

101 The traditional industry practice for redundant dynamic position systems is typically based on an approach where the redundancy is based on running machinery, not utilising stand-by units or change over mechanism. Typical examples of standards used are DNV **DYNPOS-AUTR** and **DYNPOS-AUTRO** notations, and IMO MSC/Circ. 645 "Guidelines for vessels with dynamic positioning systems" equipment class 2 and equipment class 3.

These rules are based on somewhat different principles and philosophies which are adapted to, and make it possible to better utilize the latest technology within power generation, power distribution, thruster technology and advanced integrated control systems in order to allow for flexible and efficient operation of the power and thruster plant.

The rules also allows for and sets specific requirements to, power plant that may be designed for running with connected power systems and on specific conditions standby start and change-over may be used as bases for redundancy, which allows for more flexible, economic and environmental friendly operation.

In addition a new approach is taken towards separation of components and systems providing redundancy.

Hence, these rules are not directly comparable with the traditional standards for dynamic positioning system. By applying these rules the intention is to achieve integrity towards loss of position and heading keeping ability which meets intentions comparable to or exceeding IMO MSC/Circ. 645 equipment class 2 and equipment class 3 (depending on which failure mode being evaluated). The standard which will be the most suitable for a given vessel and/or operation must therefore be evaluated in each case.

102 The main objectives for the **DYNPOS-ER** notation are to provide a Dynamic Positioning System with the following properties:

— Redundancy in technical design
— A60 separation between redundancy groups in high fire risk area
— A0 separation between redundancy groups in other areas
— Watertight separation between redundancy groups below damage waterline
— Redundant main DP-control system
— Independent single alternative DP-control system
— Operator stations for main and alternative DP-control systems placed in the same space (e.g. the bridge)
— Flexibility and increased availability of power and thrust by use of connected power systems, standby start and change-over.

103 Dynamic positioning systems characterised and structured in line with the IMO MSC/Circ.645 "Guidelines for vessels with dynamic positioning systems" are described in Pt.6 Ch.7.

A 200 Scope and application

201 The rules in this chapter apply to systems for dynamic positioning of ships and mobile offshore units, termed hereafter as, vessels. These rules do not include requirements or recommendations in regard to the vessels operation or other characteristics.

Guidance note:
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.

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202 The requirements in these rules are additional to the rules for main class.

Guidance note:
In particular see the relevant sections of:
Pt.4 Ch.1 Machinery Systems, General
Pt.4 Ch.2 Rotating Machinery, General
Pt.4 Ch.3 Rotating Machinery, Drivers
Pt.4 Ch.4 Rotating Machinery, Power Transmissions
Pt.4 Ch.5 Rotating Machinery, Driven Units
Pt.4 Ch.8 Electrical Installations
Pt.4 Ch.9 Instrumentation and Automation.

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A 300 Class notation

301 Vessels built and tested in compliance with the requirements in this chapter and the requirements of the rules for main class may be assigned the class notation **DYNPOS-ER**.

302 A qualifier **(A)** can when requested by the vessel owner be assigned to vessels with notation **DYNPOS-ER** which then shall undergo annual survey according to the applicable 5 yearly complete survey scope.

Guidance note:
Example of notation: **DYNPOS-ER(A)**

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A 400 Capability plots and environmental regularity numbers (ern)

401 Capability plots and environmental regularity numbers **(ern)** shall be made for the vessel in accordance with the requirements in Sec.7.

B. Definitions

B 100 General

101 *Capability plot:* Graphic illustration of vessel's position and heading keeping capacity in a specified vessel condition and specified environmental condition. See Sec.7.

102 *Consequence analysis:* A monitoring function in the DP control system that issue an alarm if the vessel (in its current operating mode) in the current weather conditions would not be able to keep the heading and position in the case that any of the predefined worst case failures should occur.

Guidance note:
For detailed information and requirements to the consequence analysis function see Sec.3 G200.

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103 *DP-control system:* All control systems and components, hardware and software necessary to dynamically position the vessel. The DP-control system consists of the following:

— dynamic positioning control system (computer system)
— sensor system
— display system
— operator panels
— positioning reference system
— associated cabling and cable routing.

Guidance note:
The DP-control system is often referred to as the DP-system, but is only a part of the DP-system by rule terminology.

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104 *Dynamic positioning system (DP-system):* The complete installation necessary for dynamically positioning a vessel comprises of the following systems:

— power system
— thruster system
— DP-control system
— independent joystick system (if installed).

105 *Dynamically positioned vessel (DP-vessel):* A vessel which automatically maintains its position and heading (fixed location or predetermined track) exclusively by means of thruster force.

Guidance note:
In this context transverse force may be generated by the combined use of propellers and rudders, see Sec. 4.

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106 *Failure:* An occurrence in a component or system causing one or both of the following effects:

— loss of component or system function
— deterioration of functional capability to such an extent that the safety of the vessel, personnel, or environment is significantly reduced.

Guidance note:
Single failure will include flooding below damage waterline and fire in high fire risk areas. Certain exceptions will

be allowed in the definition of single failure in other areas. See Sec.2. Loss of stability (e.g. as a result of flooding) is not a relevant failure mode.

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107 *Joystick:* A device for readily setting of vectorial thrust output including turning moment.

Operational mode: The manner of control under which the DP-system may be operated, e. g.:

— automatic mode (automatic position and heading control)
— joystick mode (manual position control with selectable automatic or manual heading control)
— manual mode (individual control of thrust, azimuth, start/stop of each thruster)
— auto track mode (considered as a variant of automatic position control, with programmed movement of reference point).

108 *Position/heading keeping:* Maintaining a desired position/heading within the normal excursions of the control system and the environmental conditions.

109 *Positioning/heading reference system:* All hardware, software and sensors that supply information and or corrections necessary to give position/heading reference, including power supply.

110 *Power system:* All components and systems necessary to supply the DP-system with power. The power system includes:

— prime movers with necessary auxiliary systems including piping
— generators
— switchboards
— uninterruptible power supplies (UPS) and batteries
— distribution system including cabling and cable routing
— power management system (PMS) including power plant protection systems.

111 *Redundancy:* The ability of a component or system to maintain its function when one failure has occurred. Redundancy can be achieved, for instance, by installation of multiple components, systems or alternative means of performing a function.

112 *Redundancy group:* All components and systems that are subject to a relevant single failure as specified in Sec.2 B.

Guidance note:

The redundancy groups will emerge as a consequence of the worst case single failure within each group. The Rules does not give requirements to the number of (beyond 2) or ratio between the defined groups. The groups shall be identified in the FMEA, verified by testing and incorporated in the consequence analysis.

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113 *Reliability:* The ability of a component or system to perform its required function without failure during a specified time interval.

114 *Thruster system:* All components and systems necessary to supply the DP-system with thrust force and direction. The thruster system includes:

— thruster with drive units and necessary auxiliary systems including piping
— thruster control
— associated cabling and cable routing
— main propellers and rudders if these are under the control of the DP-system.

115 *Worst case failure:* Failure modes which, after a failure, results in the largest reduction of the position and/or heading keeping capacity. This means loss of the most significant redundancy group, given the prevailing operation.

Guidance note:

This will typically be loss of the most significant thruster group(s) and/or generator group(s) subject to common mode failure(s). Relevant failure modes are specified in Sec.2.

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C. Certification

C 100 General

101 The dynamic positioning control systems shall be certified.

102 In case an independent joystick system is installed this shall be certified.

103 If specifically required as part of the approval process thruster control mode selection system shall be certified.

Guidance note:
Additionally, components and systems should be certified according to main class requirements.

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D. Documentation

D 100 General

101 The documentation submitted, shall include descriptions and particulars of the vessel and cover the requirements given in Table D1 and 200 to 400, as appropriate. These documentation requirements are in addition to the requirements for main class.

Table D1 Documentation requirements

Object	*Documentation type*	*Additional description*	*Info*
Dynamic positioning system	I260 – Cable routing layout drawing	Note 1	AP
	Z030 – Arrangement plan	Fire and flooding separation.	AP
	Z071 – Failure mode and effect analysis (FMEA)	See D300.	AP
	Z140 – Test procedure for quay or sea trial	Redundancy and failure modes based on FMEA. See also E. Survey and Test upon Completion.	AP
	Z200 – Environmental regularity number **(ern)** calculation	See D200.	FI
	Z201 – Position keeping capability plot	See D200.	FI
Position keeping control centres	Z030 – Arrangement plan	Showing the physical arrangement and location of all key components in the DP-control centre, ref. Sec.2 C200 for definition of key components.	AP
Thrusters	Z110 – Data sheet	— thrust output and power input curves — response time for thrust changes — response time for direction changes — anticipated thrust reductions due to interaction effects.	FI, R
	Z060 – Functional description	Systems for re-start and change-over. Time for re-start. Auxiliary systems required for re-start and operation.	AP
Main and alternative automatic dynamic positioning control systems	I010 – Control system philosophy		AP
	I020 – Control system functional description		AP
	I030 – Block diagram		AP
	I040 – User interface documentation		AP
	I050 – Power supply arrangement		AP
	I070 – Instrument and equipment list		FI
	I080 – Data sheet with environmental specifications		AP
	I140 – Software quality plan	Note 2	FI, L
	I150 – Circuit diagram	Note 3	AP
	Z071 – Failure mode and effect analysis		AP
	Z120 – Test procedure at manufacturer		AP
	Z140 – Test procedure for quay and sea trial	See also E. Survey and Test upon Completion.	AP
	Z160 – Operation manual	Notes 2 and 4	FI, L
	Z170 – Installation manual	Note 2	FI, L
	Z180 – Maintenance manual	Note 2	FI, L

Table D1 Documentation requirements (Continued)			
Object	*Documentation type*	*Additional description*	*Info*
Independent joystick control system (If installed.)	I020 – Control system functional description		AP
	I030 – Block diagram		AP
	I040 – User interface documentation		AP
	I050 – Power supply arrangement		AP
	I070 – Instrument and equipment list		FI
	I080 – Data sheet with environmental specifications		AP
	I140 – Software quality plan	Note 2	FI, L
	Z120 – Test procedure at manufacturer		AP
	Z140 – Test procedure for quay and sea trial	See also E. Survey and Test upon Completion.	AP
	Z160 – Operation manual	Notes 2 and 4	FI, L
Thruster control mode selection system	I020 – Control system functional description		AP
	I030 – Block diagram		AP
	I040 – User interface documentation		AP
	I050 – Power supply arrangement		AP
	I070 – Instrument and equipment list		FI
	I080 – Data sheet with environmental specifications		AP
	I140 – Software quality plan	Note 2	FI, L
	I150 – Circuit diagram	Note 3	AP
	Z120 – Test procedure at manufacturer		AP
	Z140 – Test procedure for quay and sea trial	See also E. Survey and Test upon Completion.	AP
	Z160 – Operation manual	Notes 2 and 4	FI, L
Position reference systems	I040 – User interface documentation		AP
	I050 – Power supply arrangement		AP
	I070 – Instrument and equipment list		FI
	I080 – Data sheet with environmental specifications		AP
	Z140 – Test procedure for quay and sea trial	See also E. Survey and Test upon Completion.	AP
	Z160 – Operation manual	Notes 2 and 4	FI, L
Vertical reference, heading reference, wind and other sensor systems	I040 – User interface documentation		AP
	I050 – Power supply arrangement		AP
	I070 – Instrument and equipment list		FI
	I080 – Data sheet with environmental specifications		AP
	Z140 – Test procedure for quay and sea trial	See also E. Survey and Test upon Completion.	AP

Table D1 Documentation requirements (Continued)			
Object	*Documentation type*	*Additional description*	*Info*
Main electric power system	E040 – Alternating current (AC) power consumption balance	Note 5	AP
	Z060 – Functional description	Description of protection, discrimination, interlocks, starting arrangements, magnetising arrangements, operation modes, under voltage ride through capability, change-over arrangements etc. as applicable.	AP
Power management system	Z071 – Failure mode and effect analysis		AP
Info: AP – For approval, FI: For information, L: Local handling, R: On request			
Note 1: The documentation shall also include a list of relevant cables crossing fire zones. For the cable routing layout drawing it is recommended that colours are used to indicate the cable routes that are designed and physically arranged to provide redundancy. The cable routing layout drawing shall indicate all cables relevant to the DP system, e.g. power cables, control cables, cables used for indication etc. Note 2: Shall be available during certification and trials. See also D400 and Pt.4 Ch.9. Note 3: For essential hardwired circuits (for emergency stop, shutdown, interlocking, mode selection, back-up selection etc.). Details of input and output devices and power sources for each circuit. Note 4: One copy shall be submitted to the approval centre. Note 5: For dynamic positioning operation. The load calculations shall also reflect the situation after the maximum single failures. May be a part of the power consumption balance as required in Pt.4 Ch.8 Electrical Installations.			

102 For general requirements to documentation, see Pt.0 Ch.3 Sec.1.

103 For a full definition of the documentation types, see Pt.0 Ch.3 Sec.2.

D 200 Capability plots and environmental regularity numbers (ern)

201 Capability plots shall be submitted for information in accordance with the requirements in Sec.7 A. The capability plots shall be presented in form of a report, which in addition to the required plots, shall include the following information as a minimum:

— Thruster data: Maximum thrust, location, power
— Vessel data used in the calculations to be presented as numerical values together with (simplified) layout drawings showing both projected frontal and lateral areas affected by wind and current. Information about length (overall and Lpp), breath, draught shall also be given.
— Calculation: Description of mathematical method used in the calculations. Tables giving information for each calculated point: Environmental forces for wind, wave and current. Thrust output for each thruster, total thruster force and total turning moment
— Environmental regularity number, ern, shall be extracted from the capability plots as specified in Sec.7 B.

D 300 Failure mode and effect analysis (FMEA)

301 Documentation of consequences of single failures in accordance with rule requirements is required in the form of a failure mode and effect analysis (FMEA).

302 The purpose of the FMEA is to give a description of the different failure modes of the equipment when referred to its functional task. Special attention shall be paid to the analysis of systems that may enter a number of failure modes and thus induce a number of different effects on the dynamic positioning system performance. The FMEA shall include at least the information specified in 303 to 306.

303 The FMEA shall clearly describe the design intent and the intended overall redundancy. The system operational mode(s) for DP operation(s) shall be described and prerequisites for achieving the required failure tolerance and redundancy shall be included.

304 A breakdown of the dynamic positioning system, into functional blocks shall be made. The functions of each block shall be described. The breakdown shall be performed to such a level of detail that the functional interfaces between the functional blocks are shown.

305 A description of each physically and functionally independent item and the associated failure modes with their failure causes related to normal operational modes of the item shall be furnished.

306 A description of the effects of each failure mode alone on other items within the system and on the overall dynamic positioning system shall be made.

Guidance note:
Description of FMEA systematic may be found in IEC Publication 60812 and IMO HSC Code, Annex 4.

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307 FMEA(s) and redundancy test program(s) shall be kept on board. The FMEA(s) and redundancy test program(s) shall at all times be updated to cover alterations to the DP-system hardware or software.

Guidance note:

This is not to be understood as a requirement for an FMEA for the software. However the FMEA (or other relevant documentation) should include identification of the software version(s) installed, and documentation giving this information should be updated when new versions are installed.

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D 400 Operation manuals

401 Operation manuals according to Table D1 shall be kept on board. The manuals shall include information on the DP-system, its installation and structure as well as operation and maintenance.

Guidance note:

These manuals cover the technical systems. Manuals for DP operations are not normally included and may be produced separately, according to operational requirements.

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402 They shall at least cover the following:

— definitions of symbols and nomenclature
— functional description
— operating instructions, normal conditions
— operating instructions, failure conditions
— man and machine communication systems
— back-up systems
— monitoring
— maintenance and periodical performance test
— fault-finding procedures.

Functional description

— different functions including back-up, change-over and stand-by start functions shall be explained in detail.

Operating instructions

— description of the normal operation of the equipment, including adjustments and change of limit values, possible modes of presentation, starting and stopping systems
— description of operation of the DP-system in different operational modes
— description of transition from one operational mode to another.

Fault-finding procedures

— description of fault symptoms with explanation and recommended corrective actions
— instructions for tracing faults back to functional blocks or systems.

E. Survey and Test upon Completion

E 100 General

101 Upon completion, the dynamic positioning system shall be subjected to final tests. The program shall contain test procedures and acceptance criteria.

Guidance note:

It is assumed that prior to the DP-control system test, all systems and equipment included in the dynamic positioning system have been tested according to main class. This should at least include:

- load test according to main class
- communication systems
- main alarm system as for main class and E0 (if applicable).
- Switchboard protection and functionality
- Power management system
- Safety, control and automation system for power generation, thrusters, steering and propulsion, including their auxiliaries.

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102 When deemed necessary by the attending surveyor, tests additional to those specified by the test program may be required.

E 200 Measuring system

201 All sensors, peripheral equipment, and reference systems shall be tested as part of the complete DP-system. Failures of sensors shall be simulated to check the alarm system and the switching logic.

E 300 Thrusters

301 The following shall be tested:

— functional tests of control and alarm systems of each thruster
— check all signals exchanged between each thruster and the DP-control system, including thruster "ready" signals
— manual override of thruster control
— transfer of thruster control (mode selection)
— function test and loop monitoring alarms for emergency stop
— failure in thruster command/feedback signals
— check different control modes
— any possible change-over arrangements.

E 400 Thruster mode selection

401 The following shall be tested:

— Functional tests
— Alarms (if applicable)
— Failure simulation.

E 500 UPS power supply

501 The following shall be tested:

— capacity of the UPS batteries
— Alarms.

E 600 Complete DP-system test

601 The complete DP-system shall be tested in all operational modes, with simulation of different failure conditions to try out switching modes, back-up systems and alarm systems.

Guidance note:
Different operational modes apply to the DP-control system, the power system, thruster systems etc.

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602 Change of command between the automatic DP control systems, independent joystick system (if installed) and the individual thruster lever systems shall be demonstrated.

603 Position and heading keeping function shall be demonstrated on all possible combinations of position reference systems (PRS), and on each PRS as a single system. Position change function shall be demonstrated on each PRS as a single system. Selecting and de-selecting of PRS shall also be tested.

604 During sea trials the offset inputs for each position reference system and relevant sensors in the dynamic position control system should be verified and demonstrated to the attending surveyor by setting out the offsets on drawings. It should be verified that these fit with the actual placing of the equipment.

605 Manual override, as required by Sec.3 C and Sec.4 A303 shall be demonstrated during normal operation and failure conditions.

606 A duration test shall be carried out for at least 8 hours with the complete automatic system in operation. All failures shall be recorded and analysed.

Guidance note:
The time spent on DP operational tests may normally be deducted from the time required for the duration test.

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607 A high seas trial shall be required with full system operation for at least 2 hours. The weather conditions must be such that an average load level on the thrusters of 50% or more is achieved.

Guidance note:
The test described in 607 is dependent on weather conditions and may be omitted if satisfactory results were obtained from the test described in 606. Typically this will be required for DP-control systems of novel design.

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608 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.

Guidance note:

The test should be carried out with the propeller(s) running with an average propulsion thrust of not less than 50%, unless the control system ensures that rudder operation is performed at zero propulsion thrust only, upon which the test may be carried out without the propeller(s) running. Number of steering gear pumps connected and rotation speed are to be the maximum allowed during DP operation.

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E 700 Redundancy tests

701 A selection of tests within each system analysed in the FMEA shall be carried out. Specific conclusions of the FMEA for the different systems shall be verified by tests when redundancy or independence is required.

Guidance note:

This implies that loss of all systems in relevant fire zones or within watertight compartments should be tested.

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702 The test procedure for redundancy shall be based on the simulation of failures and shall be performed under as realistic conditions as practicable.

703 When redundancy is based upon change-over and/or stand-by start, then the functionality and availability of these mechanisms after failure shall be demonstrated at sea-trials.

SECTION 2
GENERAL ARRANGEMENT

A. General

A 100 General

101 The general requirements for DP-system design are presented in Table C1.

102 The design and level of redundancy employed in system arrangements shall be to the extent that the vessel maintains the ability to keep position after worst case failure(s).

Guidance note:

Table C1 gives general requirements only, detailed requirements are given in Sec.3, 4 and 5.

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B. Redundancy and Failure Modes

B 100 Redundancy

101 The DP-system shall be designed with redundancy. A position keeping ability shall be maintained without disruption upon any single failure.

102 Automatic start of equipment may be accepted as contributing to redundancy if their reliability and simplicity of operation is satisfactory so that they can be brought automatically into operation before position and heading keeping performance is degraded. Monitoring of availability of standby start functions shall be implemented for the most probable failures for the relevant system, e.g. power failure, wrong mode, loop failures, etc. Software based systems shall have self diagnostics.

103 Full stop of thrusters and subsequent start-up of available thrusters will not be accepted as contributing to the redundancy. Change over of thruster main power supply can be accepted as long as all the following conditions are met:

- The thruster is fully ready with maximum power available for DP control within 30 seconds without manual intervention. Available thrust output may be reduced to zero during change-over but ready signal to DP-control systems shall be maintained.
- "Ready for change-over" signal is communicated to the DP-control systems
- Change over is automatic
- Any situation when available thrust is reduced due to any control system action, e.g. change-over of main supply, is communicated to the DP-control systems.
- Start and any necessary reset after full stop of thruster is available in DP control centre
- No failure mode should result in change over of main power to all thrusters, after a failure maximum 50% of the remaining thruster power shall be based on change-over arrangement. Power supply shall be distributed evenly between the power systems
- Auxiliary systems is autonomous for each thruster according to Sec.6 A106 and A300
- Supply to auxiliary and control systems is continuously available
- Thruster failure or trip shall prevent automatic re-start.

104 Stand-by start or change over of generators can be accepted to contribute to the redundancy as long as all the following conditions are met:

- Start and connection is automatic
- "Ready for stand-by start" and/or "ready for change-over" signal is communicated to the DP-control systems
- Single failure does not cause total black-out, full black-out and subsequent standby start is not accepted as bases for redundancy.
- Generator is connected fast enough in order to be able to maintain position and heading keeping ability as required by the operation. If no specific time can be documented the maximum allowed is 45 seconds after the need for more power appeared.
- Auxiliary systems is autonomous for each set according to Sec.6 A106
- In case of any failure it is assumed that any one of the available stand-by generators may not start. This means that the power contribution from stand-by generators shall be based on the total number of available stand-by generators after failure minus one. This includes also the stand-by generator giving the largest contribution to the position keeping ability. However, failure of standby-generators to start upon request does not have to be considered consecutive to:

— an engine room fire (in another redundancy group).
— busbar-failures (in another redundancy group) in switch-boards with high integrity towards short-circuit.

Guidance note 1:

Component and system redundancy, in technical design and physical arrangement, should be available with the capacity required for the DP-system to safely terminate the work in progress. The consequence analysis required in Sec.3 G200 will give an indication whether the position and heading can be maintained after a single failure.

The transfer to components or systems designed and arranged to provide redundancy, should be automatic and operator intervention should be avoided.

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Guidance note 2:

Switch-boards with high integrity towards short-circuits may be achieved by use of e.g. insulated bus-bars or SF_6 insulated systems.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

105 In case change over is arranged the arrangement must be so that neither:

— a single failure in one redundancy group, nor
— a single failure in the change over arrangement it selves, nor
— a single failure in a common power or control system connection, nor
— a single failure in the system or component being changed over.

can cause failure of more than one redundancy group.

106 Stand-by start must also be arranged so that it will not cause failure of the redundancy group it is being connected to.

B 200 Failure modes

201 Loss of position shall not be allowed to occur in the event of a single failure. Single failure criteria include:

— any active component or system
— all static components
— a single inadvertent act of operation. If such an act is reasonably probable
— systematic failures or faults that can be hidden until a new fault appears
— automatic interventions caused by external events, when found relevant
— all components within any fire zone and/or watertight compartment as given in B400, (not on the bridge).

Guidance note 1:

In order to reduce the probability of inadvertent acts, the following may be used:

— double action
— operation of two separate devices
— using screen based question pop-ups.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

In these rules the following are also considered active:

— coolers
— filters
— motorised valves
— fuel oil, fuel oil service tanks and appurtenant piping supplying the engine(s)
— electrical and electronic equipment (this includes all onboard equipment and systems, e.g. any safety shut-down systems and vessel control systems).
— When considering single failures of switchboards, the possibility of short-circuit of the bus-bars has to be considered.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 3:

The **DYNPOS-ER** notation aims for a very high reliability and integrity between redundant groups. In the FMEA special attention should be given to verification of integrity where common mode failures between redundant groups may exist. Examples of such systems may be, but are not limited to:

— Operation with closed bus-tie breakers
— Redundancy is based on change-over and/or stand-by start of thrusters and/or generators
— Redundancy and/or separation is based on discrimination

— Power management systems.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

202 Based on the single failure definition, worst case failures shall be determined in the FMEA. The consequence of the identified worst case failure(s) in terms of reduction in position and heading keeping ability shall be used as the criterion for the consequence analysis described in Sec.3 G200.

Guidance note:
For detailed information and requirements to the consequence analysis function, see Sec.3 G200.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

203 In order to meet the single failure criteria, redundancy of components will be necessary for all components affecting station keeping and physical separation of these components as required in B400.

B 300 Independence

301 Independence shall take into account all technical functions. Use of shared components can be accepted only if specifically mentioned.

B 400 General separation requirements

401 Systems that form the designed redundancy requirement shall be separated by bulkheads and decks fire insulated by at least A-0 class division. In high fire risk areas A-60 class division is required between the redundancy groups.

Guidance note 1:
Definition of high fire risk areas: Reference to be made to SOLAS Chapter II-2 Reg. 3.31 Machinery spaces of category A, and MODU Code Chapter1.3.34.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:
The term “systems” shall be understood to also include components, cabling, and piping.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 3:
Cables should be routed and equipment installed such that the risk of failure due to heat exposure of cables and equipment belonging to different redundancy groups is reduced in case of fire in one space.

Equipment and cables should generally not be mounted directly on bulkheads separating redundant groups nor should equipment or cables belonging to more than one group be mounted directly on bulkheads to a common adjacent space.

On open deck, cables in separate pipes that are separately routed may be accepted.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

402 It will be accepted that cables from separated power systems supplying the same component may enter a common space as long as discrimination is in place for both feeders.

403 Systems that forms the designed redundancy requirement shall be separated by watertight bulkheads if located below the damage water line. Watertight separation shall also be provided in other areas where large quantity of liquids may occur as a consequence of leakage.

Guidance note:
Special attention should be paid to areas where leakage of flammable liquids is possible.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

404 Watertight doors in A60 insulated bulkheads need not to be insulated. Reference is made to SOLAS Chapter. II-2 Reg. 9.4.2.4. In such cases the materials of the doors shall have melting points of not less than 950 °C and combustible materials shall be installed with a minimum distance of 450 mm from the door.

405 In the DP control centre separation with bulkheads is not required. Physical separation between main and alternative DP-control systems shall be provided by installation in separate cabinets and cables installed on separate cable trays.

406 The main controllers for the main DP control system shall neither be located in the DP control centre nor in the same space as the main controller for the alternative DP control system. The separation shall be bulkheads and decks of at least A-0 class. (Location of DP operator stations, see 407 and C200.)

Guidance note:
Cabinets installed on raised floor with openings down to a common cable space will be accepted in line with main class requirements.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

407 Levers, operator stations, HMI and other such equipment necessary for the operator shall be installed in the DP-control centre. Other parts of the DP system shall be installed in accordance with the requirement in 401.

Guidance note:
As an example this means that the thruster controllers and appurtenant cabling must be distributed and separated in accordance with the redundancy groups as required in 401.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

B 500 Gas in non hazardous areas

501 On vessels where gas release is a possible scenario, air intakes for combustion air shall be separate from other ventilation systems. The air intakes for separate engine rooms shall be separated as far as practicable. It shall be possible to operate machinery long enough to safely terminate the operation after shut down of machinery room ventilation.

Guidance note:
This requirement will typically apply to drilling and production units.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C. System Arrangement

C 100 General

101 The requirements for system arrangement is summarised in Table C1. Specific requirements for each subsystem are presented under the respective section headings.

Table C1 System arrangement

Subsystem or component		*Fundamentals for class notation*	
Power system	Generators and prime movers	Redundant in technical design and physical separation. A-60 between machinery spaces of category A. Watertight below damage waterline.	
	Auxiliaries	Autonomous systems within each redundancy group	
	Main switchboard	Minimum 2 switchboards in separate compartments. A-0 between redundant switchboards. Watertight below damage waterline.	
	Bus-tie breaker	2, 1 in each switchboard.	
	Distribution system and thruster groups	Redundant in technical design and physically separated with A-0 division. Watertight below damage waterline.	
	Power management	Yes	
Thrusters	Arrangement	Redundant. A-0 and water tight separation.	
	Auxiliaries	Autonomous systems within each thruster groups	
Manual thruster control	Individual Control Levers for each Thruster	Yes	
DP Control		Main DP Control system	Alternative DP Control system
Controllers and operator stations	Automatic Control - Number of Computers (See also B406)	2	1
	Automatic Control - Number of operator stations (See also C202)	2	1
Position reference systems & sensors	Position reference system	3	1*)
	External Wind Sensors	3	1*)
	Vertical Reference Sensor (VRS)	3	1*)
	Gyro compass	3	1*)
	Electronic Data logger	1	**)
Power Supply	Uninterruptible power supply (UPS) for DP control systems	2	1

*) The main DP control system shall be able to read all sensors.

**) The data logger for the main DP-control system shall also log the alternative DP control system, alternatively two logger systems will be accepted.

C 200 DP-control centre

201 The DP-vessel shall have its DP-control centre designated for DP operations, where at least the required indicators, displays, alarm panels, control panels and internal communication systems are installed. This equipment shall be arranged with easy access to the operator so that he does not need to change position when operating the control systems at the DP-control centre.

202 The operator stations for the main DP control system shall be located in the DP control centre. The operator station for the alternative DP control system shall be in the same space.

Guidance note 1:

Changing orientation can be accepted provided that the operator's view of the operating area will not change significantly. This implies that the operator should not be forced to turn his back to the operating area when changing between main DP control system and manual thrusters' levers. The operator station for the alternative DP-control system and any possible independent joystick system may be installed with different orientation.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

This may be a dedicated part of the navigation bridge. System components that do not require frequent or immediate operator attention may be installed in alternate locations.

Systems that are normally required to be located at the DP control centre includes: Main DP control operator stations, required position reference systems HMI, manual thruster levers, mode change systems, thruster emergency stops, internal communications.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

203 The location of the DP-control centre shall be chosen to suit the main activity of the vessel.

204 The DP-control centre shall be arranged such that the DP operator has a good view of the vessel's exterior limits and the surrounding area.

Guidance note:

If physical arrangements make it difficult to get direct view to all required areas from one location, camera systems may be used to compensate for lack of direct view to some areas. At least one monitor shall be located at and controlled from the DP control centre.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C 300 Arrangement and layout of control panels

301 The information sources like displays, indicators, etc. shall provide information in a readily usable form.

302 The operator shall be provided with immediate information of the effect of any actions, preferably with graphics.

303 Where applicable, feedback signals shall be displayed, not only the initial command.

304 Easy switch-over between operational modes shall be provided. Active mode shall be positively indicated.

305 Positive indications of the operational status of the different systems shall be given.

306 Indicators and controls shall be arranged in logical groups, and shall be co-ordinated with the geometry of the vessel, when this is relevant.

307 If control of a sub-system can be carried out from alternate control stations, positive indication of the station in charge shall be provided. When responsibility is transferred from one station to another, this shall be indicated.

Guidance note:

For control transfer arrangements, see Pt.4 Ch.9 Sec.3.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

308 Precautions shall be taken to avoid inadvertent operation of controls if this may result in a critical situation. Such precautions may be proper location of handles etc, recessed or covered switches, or logical requirements for operations.

309 Interlocks shall be arranged, if erroneous sequence of operation may lead to a critical situation or damage of equipment.

310 Controls and indicators placed on the navigation bridge shall be sufficiently illuminated to permit use at night without difficulty. Lights for such purposes shall be provided with dimming facilities.

C 400 Arrangement and layout of data communication links

401 When the main DP-control system uses a data communication link, this link shall neither be common with the communication link(s) for manual control nor the communication link(s) for alternative DP control system.

402 The communication link for the main DP-control system shall be arranged with redundancy in technical design and physical separation as specified in B400.

403 When two or more thrusters and their manual controls are using the same data communication link, this link shall be arranged with redundancy in technical design and physical separation as required for the communication link for the main DP control system.

404 The alternative DP control system may share a redundant communication link with the manual thruster control and/or indication, but not with the main DP-control system.

D. Internal Communication

D 100 General

101 For internal communication requirements see Pt.6 Ch.7 Sec.2 D100.

SECTION 3
CONTROL SYSTEM

A. General Requirements

A 100 General

101 Thrusters and sensors used in DP-operations shall have indications for:

— "running"
— "available for DP"
— "in DP operation".

B. Automatic control systems

B 100 General

101 Unless otherwise specified, all requirements in this section apply both to the main and to the alternative DP control system.

102 The positioning control systems shall perform self-check routines. An alarm shall be initiated in case of failure.

103 Automatic control mode shall include control of position and heading. Set points for control of position and heading shall be independently selectable. It shall be possible to individually enter new position and heading set points in automatic control mode.

Guidance note:

The Rules does not give any specific acceptance criteria for positioning performance. However, in moderate weather conditions and with a fully operational DP-system the vessel should generally be able to demonstrate position keeping accuracy with a 3 meter radius and ± 1° of heading.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

104 It shall be possible to control the thrusters manually by a common joystick at all DP operator stations. The joystick mode shall include selectable automatic and manual heading control.

105 It shall be possible to select any combination of manual (joystick and/or heading wheel) and automatic control of surge, sway and yaw.

106 When stopped, either by automatic or manual means the positioning control system shall set the thrust commands to zero.

107 Loss of one or multiple position reference system input and/or one or multiple sensor inputs shall not lead to significant change in thrust output.

Guidance note:

This includes the situation when DP control system loses the last available position reference system input or sensor input. Position or heading drive off is not accepted after such failures.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

108 Upon recovery of position and heading reference input the DP control system shall not automatically apply the last position or heading set point (set points before loss of input) when this is significantly different from the actual vessel position and/or heading. If any other set point than the actual vessel position and/or heading is applied then it is to be operator chosen.

109 When combining position reference systems and/or sensors in one unit were more than one function or system can be lost upon one common failure, the consequence to the total system upon such a failure shall not exceed loss of any one non-combined unit in a minimum configuration as specified in Sec.2 Table C1.

Guidance note:

Unit is to be understood as one piece of equipment (or one system) for each sensor and position reference system as required in Sec.2 Table C1. The rule is applicable when equipment/systems serving more than one such function are part of the DP system.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

110 When more than two position reference systems and/or sensors are inputs are used by the DP control system then voting mechanisms shall be utilised in order to: identify incorrect input, take correct action upon the failure in order to minimize the consequence of failure and alarm the operator.

B 200 Main DP-control system

201 The main DP control system shall be arranged with redundancy such that, after the occurrence of any single failure within the DP-control system, command output to a defined group of thrusters able to control position and heading of the vessel, can still be produced without disruption. Changeover between redundant controllers shall be automatic and bump less.

202 One of the controllers in the main system shall be selected as the online controller. This selection shall be possible by manual means and by automatic action upon failure of the online system. The other controller(s) shall be in standby mode for auto or manual change over. It shall not be possible to automatically or manually select a controller which is not ready to assume command as the active controller.

203 Self monitoring and comparison between controllers shall be arranged so that alarm is released upon detection of an unexpected difference in thrust command or position or heading. This shall not jeopardise the independence of each system or risk common mode failures.

204 The automatic transfer of online responsibility shall not cause thrust changes of such magnitude that it will be detrimental to the positioning of the vessel.

205 All required positioning reference system and sensors connected to the alternative DP control system shall also be available to the main DP control system.

B 300 Alternative DP control system

301 The alternative DP control system shall be able to operate independently of the main system

302 There shall be at least one positioning reference system and one set of sensors connected to the alternative DP control system.

Guidance note:

This system should have high availability and be easily available, typically DGPS.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

303 The alternative DP control system shall at all times be ready to assume command, and maintain the position from the moment of assuming command.

304 The alternative DP control system shall perform self check routines and communicate its status to the main DP control system. An alarm shall be initiated in the main DP control system if the alternative DP control system fails or is not ready to take control.

C. Thruster control mode selection

C 100 General

101 The thruster control mode, i.e. manual, main DP and alternative DP, shall be selectable at the DP control centre. The control mode selector system shall be intuitive and simple to operate. It shall only be possible to select one automatic system at a time. Combined automatic and manual control of individual thrusters is acceptable.

102 The control mode selector shall be arranged so that it is always possible to select manual controls after any single failure in the automatic DP-control mode or in the independent joystick control mode (if installed).

103 The mode selector shall not violate redundancy or independency requirements.

Guidance note:

A common switch will be accepted, but each system should be electrically independent.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

104 The main and alternative DP control systems shall be capable of being activated by the operator. The nature of the switching shall be such that no single failure will render the alternative DP control system inoperable together with the main system.

D. Positioning Reference System

D 100 General

101 At least four position reference systems are required. These shall be based on at least two different principles and maximum two of the required systems shall be based on the same principle.

Guidance note:

This is to be understood so that four separate systems based on two different principles will be accepted.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 In order for two satellite based systems to be considered as separate units it must be possible to set them up with different differential correction signals.

103 When more than one satellite based system is installed, at least one system shall be able to utilise a different satellite system than the others, e.g. one DGPS system is also able to utilise GLONASS, and in addition at least one shall be a dual frequency receiver.

104 Position reference systems can be utilised by both the main and alternative DP control system provided that the independence requirements between the main and alternative DP control systems is not compromised.

105 Position reference systems shall be independent with respect to signal transmission, and shall be interfaced to the DP-control systems in accordance with the overall redundancy requirement. Systems shall be distributed between the redundant groups, and so arranged that systems based on the same principle are distributed between the redundant groups.

106 Power supply to the position reference systems shall be from UPS. Arrangement of power supply shall be in accordance with the overall redundancy requirement.

Guidance note 1:

Power supplies should be equally distributed between the UPSs, and so arranged that power supply to systems based on the same principle are equally distributed between the UPSs.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

Power supply to units providing correction signal to DGPSs must follow the same redundant distribution principle.

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Guidance note 3:

The requirement for UPS supply for position reference systems is not applicable for parts of the systems which are not actively in use during positioning. E.g. Hydro acoustic positioning reference system transducer hoist system or taut wire derrick control systems.

For taut wire systems, the heave compensation system need not be powered by UPS.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

107 Positioning reference systems shall comply with the relevant main class rules for electrical, mechanical, and hydraulic components and subsystems.

108 Monitoring of positioning reference systems shall include alarms for electrical and mechanical functions, i.e. power, pressure, temperature as relevant.

109 Positioning reference systems shall provide new position data with a refresh rate and accuracy suitable for the intended DP-operations.

Guidance note 1:

Systems that only produce new position data with long intervals relative to the response time of DP-vessels, will not be considered as positioning reference systems, as required in Sec.2 Table C1 and D101, unless it can be demonstrated that the performance is adequate in all operational modes and operational weather conditions.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

The accuracy of the position reference data is generally to be within:

- a radius of 2% of water depth for bottom-based systems,
- a radius of 3 m for surface-based systems.

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Guidance note 3:

For satellite based systems, interface and necessary equipment for receiving differential correction signals is required installed.

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110 It shall be simple for the operator to establish the operational status of all position reference systems at any time. Which systems that is in operation, with data accepted or discarded, shall be clearly identified.

111 When data from several position references are combined into a mean positioning, by filtering techniques, the reference position of each shall, at least, be available at the operator's request.

112 When several systems are combined to provide a mean reference, the mean value used shall not change abruptly by one system being selected or deselected.

113 Failures in a positioning reference system that might give degraded quality, loss of position signal or loss of redundancy shall initiate an alarm.

114 Limit alarms shall be provided for systems, which have defined range limits.

115 If a positioning reference system can freeze or otherwise produce corrupt data output, a method shall be provided to enable rejection of the data.

116 The DP-control centre is the main control station for position reference systems. All position reference systems connected to the main DP control system shall have HMI independent of the DP-control systems.

Guidance note:

Exemption may be given to systems in excess of the minimum requirements if no separate HMI is available in the market.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

117 At least one position reference system connected to alternative DP controller shall have HMI independent of the DP control systems.

E. Sensors

E 100 General

101 Sensors for the same service shall be independent with respect to power, signal transmission, and interfaces.

102 Power supply to the sensors shall be from UPS. Arrangement of power supply shall be in accordance with the overall redundancy requirement, i.e. sensors for the same service shall be from three different UPSs.

103 Sensors can be utilised by both the main and alternative DP control system provided that the independence requirements between the main and alternative DP control systems is not compromised.

104 For redundant sensors the possibility for common mode failures shall be minimised.

Guidance note:

Use of all of the same principle should as far as practical be avoided. Examples of sensors that should not all be based on the same principle is wind sensors and gyros.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

105 Monitoring of sensors shall include alarms for electrical and mechanical functions, i.e. power, pressure, temperature as relevant.

106 When failure of a sensor is detected during a DP operation, an alarm shall be released even if the sensor is in standby at the time of failure.

Guidance note:

During DP-operations, it is important that permanent failures of any sensor, whether it is being used or not at the time, is brought to the attention of the operator. Temporary trouble of an operational nature, e.g. disturbance of acoustic systems, out of range warnings, in standby sensors do not need to initiate an alarm.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

107 Sensors and/or reference systems may be shared with other systems provided failure in any of the other systems cannot spread to the DP-system.

Guidance note:

Sensors and reference systems that are separated electrically are regarded as fulfilling the requirement in 104.

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108 The DP-control centre is the main control station for sensors in the DP-control system which requires manual operation.

Guidance note:

Equipment and cables located outdoor should be installed with suitable physical distance in order to reduce the risk of common failure.

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F. Display and indication

F 100 General

101 The display unit shall present a position plot including the location of the vessel relative to the reference sources. The plot may be vessel relative, or a true motion presentation.

102 For positioning control systems, designed with redundancy, there shall be at least two DP-control system operator stations.

103 If the display is used for presentation of warnings or alarms, these shall have priority over other information and not be inhibited by other data currently being displayed.

104 As a minimum the following information shall be available to the operator on the main and alternative DP control systems operator station(s):

Continuously available:

— Actual or wanted position and heading
— Deviation from set points as applicable; e.g. position and heading deviation from position and heading set point
— Operator station in command
— Latest unacknowledged alarm
— The presence of any active alarm shall be continuously indicated
— Active mode
— Thrusters and position reference systems in use
— Running status of consequence analysis *).

On request (may be in separate or combined display views):

— Vessel mimic with selected positioning reference point for the vessel
— Vessel mimic showing thruster location and actual forces and direction for each thruster
— Resultant thruster force, direction and turning moment
— Thruster allocation mode
— Thruster set point and feedback
— Position plot including the location of the vessel relative to the reference sources. The plot may be vessel relative, or a true motion presentation.
— Power generation mimic including: Generators, main bus-bars, thrusters, breakers status, consumed and available power. For split-bus power arrangements, indications shall be provided for individual bus sections.
— Selectable trace line of position movement, minimum 30 minutes storage
— Online capability plots; shall be able to indicate the online capability as well as drift off simulation and simulation of the most relevant failure modes, i.e. loss of redundancy groups*)
— Alarm list
— Possibility to trend the most important parameters*)
— Status and value of all position reference systems and sensors, including weighting if implemented
— Supporting mimics and indication required for safe operation in all functional modes implemented in the system
— System status, e.g. controller in command, network status
— System information; e.g. SW version.

*) Needs not to be available in the alternative DP control system.

Guidance note:
Requirements for indication of thrusters are given in Sec.4

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

G. Monitoring

G 100 Alarm system

101 The DP-control centre shall receive alarms and warnings reflecting the status of the DP-system.

Guidance note:
The alarms from power and thruster systems may be group alarms for each prime mover, generator, or thruster, as generated by the general alarm system of the vessel.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 If the alarms in the DP-control centre are slave signals of other alarm systems, there shall be a local

acknowledgement and silencing device.

103 The alarms to be presented in the DP-centre shall normally be limited to functions relevant to DP-operation.

104 An alarm shall be initiated when the vessel exceeds pre-set position and heading limits.

105 Any failure of an online or standby positioning control system, sensor or positioning reference system selected, shall initiate an alarm.

106 The following data shall be continuously recorded by a separate data logger:

— Operational status of the main and alternative DP control system
— All manual input to main and alternative DP control system
— All automatic input and output to/from main and alternative DP control system

107 The data logger shall have capacity for storage of data for minimum 7 days of operation. The data shall be accessible for the operator. It shall be possible to upload to offline storage media, for data storage longer than the logger capacity.

Guidance note:

The data logger should preferably be time synchronised with other alarm and logging systems to support performance and incident analysis.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

G 200 Consequence analysis

201 The dynamic positioning control systems shall perform an analysis of the ability to maintain position after worst case failures. An alarm shall be initiated, with a maximum delay of 5 minutes, when a failure will cause loss of position in the prevailing weather conditions.

Guidance note:

This analysis should verify that the thrusters and generators remaining in operation after the worst case failure can generate the same resultant thruster force and moment as required before the failure.

The analysis should consider the average power and thrust consumption. Brief, dynamic effects should be removed by filtering techniques.

Systems for load shedding or tripping may be accepted as contributing to the available power after failure if verified to be reliable and fast enough.

For operations which will take a long time to safely terminate, the consequence analysis should include a function which simulates the thrust and power remaining after the worse case failure, based on manual input of weather trend.

Typically, the worst case failure will be loss of one complete switchboard, one engine room, or a group of thrusters that are subject to a common failure mode.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

202 The consequence analysis shall be repeated automatically at pre-set intervals. The operator shall be able to monitor that the analysis is in progress.

203 The analysis shall have a lower priority than the control and alarm tasks. If the analysis is not completed within 2 minutes then an alarm shall be initiated.

204 If stand-by start is accepted as contributing to redundancy according to Sec.2 B104 this must be included in the consequence analysis. This means that the consequence analysis can consider the contribution from stand-by generators available after failure as long as the conditions outlined in Sec.2 B104 are taken in to consideration.

205 The consequence analysis can consider the contribution from change over of thrusters after a failure as long as the conditions outlined in Sec.2 B103 are taken in to consideration.

SECTION 4
THRUSTER SYSTEMS

A. General

A 100 General

101 Thrusters shall comply with main class requirements.

102 The thrusters shall be designed as "dynamic positioning thrusters" or "propulsion thrusters" according to Pt.4 Ch.5. The thruster systems shall be designed for continuous operation.

Guidance note:

Generally no restrictions should be put on the starting intervals of electrical machines. If required, the arrangement is subject to approval in each case.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

103 When the main propulsion propellers are included under DP-control, they shall be considered as thrusters and all relevant functional requirements of these rules will apply.

104 When the main steering system is included under DP-control, the steering gear shall be designed for continuous operation.

Guidance note:

For requirements for steering gear under DP control, see Pt.4 Ch.14.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 200 Thruster configuration

201 The thruster configuration shall include thrust units where after any single failure the remaining thrusters together will simultaneously produce transverse and longitudinal thrust, and a yawing moment.

Guidance note 1:

Reference is made to the definition in Sec.1 B105 with corresponding guidance note.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

The rules do not specify the number or size of thrusters to make up the configuration. The position holding capability resulting from a chosen configuration will be indicated by capability plots and "environmental regularity numbers" (ern) as required in Sec.7.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 300 Thruster control

301 In the DP-control centre, it shall be possible to manually control the thrusters individually by use of a separate lever for each thruster. This manual mode shall be a closed loop (follow up) control system.

302 This manual control shall be independent of the main DP-control system and shall include the ability to start/stop the prime mover, azimuth and pitch or rpm. control.

Guidance note:

It may be accepted for two or more thrusters to use the same mechanical lever provided that after failure of any one lever, as a minimum, manual thruster control is available in accordance with the designed redundancy intent for the vessel.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

303 Manual thruster control shall be available at all times, also during all failure conditions in the main DP-control system.

Guidance note:

Manual thruster control shall be understood as manual control of main propulsion, auxiliary thrusters and rudders.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

304 A single failure in the thruster control system shall neither cause significant increase in thrust output nor make the thruster rotate. The intention is that the thruster shall fail to safe so that the vessel does not lose heading or position.

Guidance note 1:
This also applies to rudders when the rudders are under DP-control. See Pt.3 Ch.3 Sec.2.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:
It may be accepted that a thruster rotates, if at the same time the thrust output is set to zero.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

305 It shall be possible to stop the thrusters individually from the main DP-control centre by means independent of the positioning and thruster control systems. This emergency stop shall be arranged with separate cables for each thruster.

306 An alarm shall be initiated upon loop failure, i.e. broken connections or short-circuit, in the emergency stop system.

307 The emergency stop activation buttons shall be placed in a dedicated mimic representing the thruster location and which is consistent with the vessel axis and layout, or they may be arranged together with the corresponding thruster levers if these are arranged in accordance with the physical thruster layout.

A 400 Indication

401 Running and stop, pitch and rpm and azimuth for each thruster shall be displayed at the DP-control centre. This indication shall be independent of the main DP-control system and shall be continuously available by indicators/screens independent of the main and alternative DP-control systems operator stations.

402 At least pitch and rpm and azimuth displays shall be readable from the normal position of the DP-operator. Slave panel meters shall be installed if the displays are not readable from the normal position of DP-operator.

403 The indication shall not be common with the feedback used by the closed-loop control system.

404 Azimuth thruster used for steering, additional monitoring shall be arranged as required in Pt.4 Ch.14 Sec.1 Table E1.

405 Feedback to main and *alternative* DP-control systems shall not be common with the feedback used by the closed-loop thruster control system, unless voting is arranged in the closed-loop thruster control system.

SECTION 5
POWER SYSTEMS

A. General

A 100 General

101 The power systems shall comply with the relevant rules for main class. Additional requirements will apply in regard to redundancy and with respect to maximum single failure. See Sec.2 for the definition of a single failure.

102 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. In this case, it shall be arranged with bus-tie breakers to separate automatically upon failures which could be transferred from one system to another.

Guidance note:

In this context, failures are not limited to only overloading and short circuit, but should include all possible system and component failures. This means that for any system, all identified possible system and component failure should be analysed in the FMEA, and all failures should be concluded with an acceptable integrity level.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

103 In case redundancy and/or separation are depending on discrimination (e.g. when a component or system has two or more power supplies originating from redundant systems) special attention shall be paid to the design in order to ensure that the discrimination is in place upon any relevant failure mode.

Guidance note:

Discrimination is important to maintain integrity between redundant groups when power supplies are entering the same fire zone. The physical installation should as far as possible limit the possibility for a failure to affect both systems.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 200 Number and capacity of generators

201 The number of generators shall comply with the redundancy requirements as defined in the single failure criteria in Sec.2.

Guidance note:

These rules give no specific requirements with respect to the capacity.

Particular attention should be paid to starting conditions of thruster motors, especially with one generator out of service. Thrusters should have arrangements to prevent large start currents and voltage drop during the start sequence. The effect of voltage drop during starting periods may cause under-voltage trips of control circuits, and main class requirements must be observed. When starting thrusters on dedicated generators with no other loads connected which would be affected by voltage deviations, voltage drop in excess of rules' limits may be accepted.

The high reactive load demands, which may occur in DP thruster operation should be considered when selecting number and type of generators, further, the dynamic load variations for diesel engines should be taken into consideration.

Attention should also be paid to connection of large transformers where the inrush currents may make it difficult to maintain discrimination in the power distribution system. Large transformers should have pre-magnetising system or other equivalent arrangements to prevent large inrush currents.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 300 Power management

301 An automatic power management system shall be arranged, operating with both open and closed bus-tie breakers. This system shall be redundant so that the functionality is maintained after a failure or, alternatively, one failure will only affect one section of the power system in accordance with the redundancy design intent.

302 This system shall be capable of performing the following automatic functions:

— load dependent starting of additional generators
— block starting of large consumers when there is not adequate running generator capacity, and to start up generators as required, and hence to permit requested consumer start to proceed
— if load dependent stop of running generators is provided, facilities for disconnection of this function shall be arranged
— black-out recovery on individual switch-board sections by starting of generators and recovery of full automatic thruster control from DP within 45 seconds after black-out. This means that the DP control systems shall receive ready signal within 45 seconds.

303 A failure in the power management system shall not cause alteration to the power generation, and shall initiate an alarm in the DP-control centre.

Guidance note:

Special attention should be paid to ensure redundant distribution of I/O signals so that effects of single failures in the PMS system will be in accordance with the overall redundancy requirements.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

304 It shall be possible to operate the switchboards in manual as required for the main class, with the power management system disconnected.

305 Means shall be implemented in order to prevent overloading of the power plant, e.g. by use of interlocks, thrust limitations or other means. Means shall also be implemented to prevent reactive overload. In case trust is reduced by any other system than the DP-control system this shall be communicated to the DP-control system.

306 Overload, caused by the stopping of one or more generators subject to common mode failure, shall not create a black-out. Reduction in load, e.g. thruster pitch or speed reduction shall be introduced to prevent blackout and enable standby generators to come online.

Guidance note:

Load reductions should preferably be achieved through the tripping of unimportant consumers, and the requirement does not exempt such means. But, it is common that the relative load proportions will require thruster load reduction, in order to effectively reduce overload situations.

The functions for tripping and load reduction in various control systems must be co-ordinated, e.g. between power management system, DP-control system, thruster control system, drilling control system etc.

During load recovery the voltage and frequency variations should be kept within acceptable limits. Maximum allowed variations is specified in Pt.4 Ch.8.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

307 When generators are running in parallel there shall be protection systems able to detect failures that may result in a full or partial black-out situation and effectuate actions to prevent such incidents. The effectuated actions shall be so that the consequence of the failure is minimized. This means that for failures where the system has sufficient time the faulty component shall be tripped before a full or partial black-out situation occurs.

Guidance note:

These requirements will be in addition to main class requirements. Typically, but not limited to, this means that the protection system should have the following functionality:

- trip generators upon governor failure
- trip generators upon AVR failure.

Other examples of failure modes that need to be considered are:

- under voltage e.g. as a consequence of short circuit (, and system “ride through” capability)
- overvoltage, including transients
- short circuits and over-current
- earth failures
- negative sequence-high harmonic distortion (THD)
- failures related to load sharing (active and reactive load, reverse power, communication, I/O…)
- failures in the power management system.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

308 When the system is designed to operate with closed bus-tie breakers between separated switchboards and the failure mode can not be isolated by tripping a component as required in 307, the protection system shall be able to open bus-tie breakers to separate the redundant switchboard sections before the failure effect could propagate from one system to another.

Guidance note:

Separation of redundant switchboard sections should be performed by opening of both bus-tie breakers in series.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

309 If the first action performed by the protection system does not remove the failure or is not performed due to e.g. hidden failure, then the protection system shall execute alternative actions to isolate the faulty component or system.

Guidance note:

A typical example is to open bus-tie breakers if the faulty generator does not trip or if the failure is still present after tripping one generator.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 400 Main and distribution switchboards arrangement

401 The switchboard arrangement shall be such that no single failure will give a total black-out.

402 When considering single failures of switchboards, the possibility of short-circuit of the bus-bars has to be considered.

403 The main switchboard system shall consist of at least two sections located in separate spaces. It shall be possible to connect the switchboards with bus-tie breakers or inter-connector breakers.

404 When the system is designed to operate with closed bus-tie breakers in DP mode, these breakers shall be circuit breakers which:

— are capable of breaking the maximum short circuit current in the system, and
— provides discrimination towards the generator breakers in case of short circuit, and
— shall be arranged to open automatically upon failures which could be transferred from one system to another.

405 It is required that each bus-bar section is isolated from the other(s) by A-0 partitions and in addition watertight if below the damage waterline. There shall be a bus-tie breaker on each side of this partition.

Guidance note:
As part of the separation requirement the possibility of leakage of other liquids such as fuel, cooling medium, fire water etc. has to be considered.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

406 Bus-bar control and protection systems shall be designed to work with both open and closed bus-tie breakers.

407 The online power reserve, i.e. the difference between online generator capacity and generated power at any time, shall be displayed in the DP-control centre. The indication shall be continuously available. For split-bus power arrangements, indications shall be provided for individual bus sections.

B. Control System Power Supply

B 100 General

101 The DP control systems shall be powered from uninterruptible power supplies, (UPS). The arrangement and number of UPS shall be in accordance with Table C1 in Sec.2.

102 The UPSs for the main DP control system shall not be located in the same space as the UPS for the alternative DP control system, nor shall the cables supplying the main and alternative systems be routed through the same spaces.

103 The alternative DP control system and its sensors and reference systems shall be fed from the dedicated UPS only. Dual feeding from a main system UPS is not allowed.

104 The battery installed for each UPS shall be able to provide output power at maximum load for 30 minutes after loss of charger input power. Loss of charger input power and UPS on bypass power shall initiate an alarm in the DP-control system.

105 The input power supply to the redundant UPSs for the main DP-control system shall be derived from different sides of the main switchboard.

Guidance note:
The intention with the battery backup in UPS and battery distributions is to provide continued supply during voltage drop and black-outs.

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106 UPS and battery supplies to other systems relevant for DP shall be derived from the same redundancy group as the system(s) being served.

SECTION 6
AUXILIARY SYSTEMS

A. General

A 100 General

101 All auxiliary systems that are part of the DP system (Machinery, thrusters, electrical components and all other systems and components necessary for supplying the DP system with power and/or thrust.) shall be arranged in accordance with the redundancy requirements, and failures shall be considered as given in Sec.2 B.

102 Piping shall not be shared between the redundancy groups. Cross-over pipes are acceptable, except in ventilation ducts, provided these can be closed at both sides of separating bulkheads. Separating valves may be manual or remote controlled as long as these fail to safe position.

Guidance note:

These includes at least, but not limited to, the following systems: Sea and fresh water cooling, other cooling systems, ventilation and HVAC, compressed air, combustion air, exhaust systems, crank case ventilation, pneumatic and hydraulic systems, fuel systems, lubrication, etc…

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

103 In addition to the requirement in 101, pumps within each redundancy group shall be arranged with redundancy such that a failure of one pump will not result in stop of more than one:

— prime mover, or
— generator set, or
— transformer, or
— power converter, or
— thruster,

when these components are parts of the DP system.

104 When dual pumps are required they shall be arranged with automatic duty-standby functionality. The duty pump must be fed from within the same redundancy group as the component or system it serves.

105 In any space where more than one of the components listed above (in 103) are located, ventilation fans and/or air temperature control systems shall be arranged with redundancy so that acceptable temperature can be maintained after any single failure in active components. This requirement also applies for switchboard rooms and instrument rooms containing components that are parts of the DP system.

106 When redundancy is to be based upon stand-by start or change-over of generator sets and/or thrusters, auxiliary systems that are connected directly on/to the engine, generator or thruster shall be autonomous for each generator set and for each thruster. See Sec.2 B103 and Sec.2 B104.

Guidance note:

These includes typically, but not limited to, the following systems: Fresh water cooling, compressed air, exhaust systems, crank case ventilation, fuel systems, lubrication, etc.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 200 Additional requirements for fuel oil systems

201 There shall be at least one service tank serving each dedicated system. Each service tank shall be in separate compartments. Cross-over facilities may be arranged, but must, if arranged, be kept closed in normal operation.

202 If the fuel system requires heating, then the heating system shall be designed with the appropriate level of redundancy unless diesel oil tanks, which do not require heating, are arranged as required in 101.

A 300 Power supply to auxiliary systems

301 Power shall be taken from within the redundancy group.

302 When redundancy is to be based upon stand-by start or change-over of generator sets and/or thrusters power to auxiliary function required to be autonomous by A106 shall be taken directly from the main switchboard level or from a dedicated switchboard supplied directly from it. This dedicated switchboard shall have an additional alternative supply. Alternatively these functions can be engine driven.

SECTION 7
CAPABILITY PLOTS AND ENVIRONMENTAL REGULARITY NUMBERS

A. Capability plots

A 100 Capability plots

101 The position keeping ability of the vessel shall be calculated and presented in form of capability plots as outlined in these rules. The capability plots shall be kept onboard.

Guidance note:

The International Marine Contractors Association (IMCA) document M 140 “Specification for DP Capability Plots” may be used as a guideline for making capability plots.

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102 The capability plots shall be produced in polar form, as a static analysis with coincident forces of wind, waves, and current. In the analysis the vessel shall maintain fixed position and heading, and shall be exposed to forces from a fixed current speed of 0.75 m/s and correlated wind and waves.

103 Thus there shall at the same time be a balance of forces and a balance of moments, i.e. including all moments generated by the thrusters, and those caused by environmental forces.

104 The limiting wind speed where the current, wind and wave forces equals the maximum available thruster forces shall be plotted at least every 15° around the vessel. Linear interpolation between points is acceptable.

105 The environmental forces caused by wind, waves, and current shall be calculated by recognised methods. Alternatively, environmental forces established by model testing can be used. The correlation between wind and waves used for ern is given in Table B1.

106 The capability plots shall be based upon available power and the thrust output that is under control, in the most efficient control mode.

107 A minimum of four plots is required:

— Case 1 shall represent optimal use of all thrusters
— Case 2 shall represent minimum effect of single-thruster failure
— Case 3 shall represent the maximum effect single-thruster failure
— Case 4 shall represent the worst case failure modes. There shall be one plot for failure of each redundancy group.

All plots shall be produced on the same scale.

Guidance note:

It is recommended that the wind speed scale is 15 mm = 10 m/s and with range 0 to 50 m/s.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

B. Environmental Regularity Numbers (ern)

B 100 Environmental Regularity Numbers (ern)

101 Based on the capability plots described in A the position keeping ability of the vessel shall be established according to the concept of the environmental regularity numbers, hereafter called **ern**.

Guidance note:

Vessels that are not encumbered by their operation to maintain a specific heading may be exempted.

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Guidance note:

The ern represents the static balance of environmental forces and thruster output. ern is quantified with its basis in the weather statistics of a chosen location in the North Sea, the location of the weather ship “M”.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Amended July 2011, see page 3

Table B1 (ern) wind and wave statistics		
P (H_s)	*H_s(m)*	*V_1 (m/s)*
2.5	0.66	1.40
5.0	0.79	2.19
10.0	1.0	3.30
20.0	1.35	4.95
30.0	1.7	6.21
40.0	1.9	7.48
50.0	2.3	8.74
60.0	2.6	10.01
70.0	3.0	11.39
80.0	3.5	13.11
90.0	4.2	15.53
95.0	4.9	17.60
97.5	5.3	19.32
98.0	5.6	19.90
98.5	5.8	20.59
99.0	6.1	21.51
The relationship between significant wave height H_s and 1 minute average wind speed V_1 shall be used for computation of the **ern**. $P(H_s)$ is based on data from the reference ocean area.		

102 The format of the **ern** shall be a series of 4 numbers, ranging from 0 to 99. The **ern** will be given in the register as information: **ern (a, b, c, d)**.

103 The **ern** shall be extracted from the capability plots required in A at the incidence angle of forces which causes the maximum load on the vessel. The four numbers shall represent:

— a) represent optimal use of all thrusters and shall be extracted from case 1
— b) represent minimum effect of single-thruster failure and shall be extracted from case 2
— c) represent the maximum effect single-thruster failure and shall be extracted from case 3
— d) represent the worst case failure mode(s) and shall be extracted from case 4.

Guidance note:
The **ern** is intended to reflect a "worst case situation", which for mono-hull vessels normally will be the situation with the weather on the beam. The ern will be based on this situation regardless of the vessel's ability to select other headings in operation.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---