

GUIDELINES

FOR RS SURVEYORS ON FMEA REVIEW AND CONDITION ASSESSMENT OF DYNAMIC POSITIONING SYSTEMS DURING TECHNICAL SUPERVISION OF DP VESSELS AFTER CONSTRUCTION, DURING ANNUAL AND FIVE-YEAR SURVEYS

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**GUIDELINES FOR RS SURVEYORS ON FMEA REVIEW AND CONDITION ASSESSMENT
OF DYNAMIC POSITIONING SYSTEMS DURING TECHNICAL SUPERVISION
OF DP VESSELS AFTER CONSTRUCTION, DURING ANNUAL AND FIVE-YEAR SURVEYS**

Guidelines for RS Surveyors on FMEA Review and Condition Assessment of Dynamic Positioning Systems during Technical Supervision of DP Vessels after Construction, during Annual and Five-year Surveys of the Russian Maritime Register of Shipping (RS, the Register) have been approved in accordance with the established procedure and come into force on 1 April, 2023.

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REVISION HISTORY¹

(purely editorial amendments are not included in the Revision History)

For this version there are no amendments to be included in the Revision History.

¹ Amendments and additions introduced at re-publication or by new versions based on circular letters or editorial amendments.

Guidelines for RS Surveyors on FMEA Review and Condition Assessment of Dynamic Positioning Systems during Technical Supervision of DP Vessels after Construction, during Annual and Five -year Surveys
(Section 1)

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1 GENERAL

1.1 APPLICATION

These Guidelines for RS Surveyors on FMEA Review and Condition Assessment of Dynamic Positioning Systems during Technical Supervision of DP Vessels after Construction, during Annual and Five- year Surveys are intended for supporting of the FMEA approval as well as the initial and periodical surveys to deliver an effective and resource efficient service.

Recommendations are given on the scope of verification and validation for the assignment of the **DYNPOS-1**, **DYNPOS-2** or **DYNPOS-3** distinguishing mark to the class notation.

1.2 DEFINITIONS AND EXPLANATIONS

Worst Case Failure Design Intent (WCFDI) means the specified minimum dynamic positioning 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.

Compensating provisions means of protection against the failure and of mitigation for the consequences of the failure.

Technical System Configuration (TSC) means a setup of ship's systems for Dynamic Positioning including all elements with an impact on the redundant separation, performance, protection and detection. The setup(s) can be provided in a tabulated format at system and subsystem levels with a specific operating mode and status identified.

FMEA developer means the organization appointed by the shipowner to develop DP FMEA. A developer shall be independent from the shipowner. It is recommended to nominate as FMEA developer the organizations having personnel with marine background and experience in operation and design of DP vessels.

Advanced generator protection (AGP) means a generator protection system with fault detection and isolation functions which is monitoring the operational state by comparing to either a model or to other running generators based on a voting principle.

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.

DP practitioner means the representative of the organization appointed by the shipowner to perform the DP proving trials. A DP practitioner shall be independent from the shipowner. It is recommended that the person is also involved in the development and updating of the FMEA which the DP proving trials are based on.

1.3 ABBREVIATIONS

AGP –	Advanced General Protection
DP –	Dynamic Positioning
TSC –	Technical System Configuration
IJS –	Independent Joystick System
DP vessel –	Dynamically positioned vessel
PMS –	Power Management System
STW –	Speed through the water
SOG –	Speed over the ground
FMEA –	Failure Mode and Effects Analysis
FMECA –	Failure Mode, Effects and Criticality Analysis
WC FDI –	Worst Case Failure Design Intent

1.4 GENERAL RECOMMENDATIONS

1.4.1 The items reviewed and surveyed can be prioritised as follows:

- .1** for DP Class 1, 2 and 3. It is the thruster fail safe condition by design and the performance of DP control, thruster and power systems;
- .2** for DP Class 2 and 3. It is also the fault tolerance against the single point failure.

2 APPROVAL OF DP FMEA

2.1 REVIEW RECOMMENDATIONS

2.1.1 The FMEA shall meet the requirements of the Register. The items in [Table 2.1.1](#) are provided as non-exhaustive recommendations for the document review.

Table 2.1.1

Review of FMEA documentation

DP class	To be confirmed	Reasons for FMEA rejection
1, 2 and 3	Thruster loop monitoring system meets RS requirements for a fail-safe condition, segregation of the control and monitoring loops in the drawings and the relevant FMEA sections is confirmed. The result obtained from the Proving Trials supports the conclusions.	No loop monitoring described or tested.
1, 2 and 3	The DP system can run at 100 % in post-WCF condition as confirmed by performance tests of generators and thrusters and by running thrusters at 100 % in DP joystick mode. Rated output at 100 % given in FMEA and in theoretical capability plots is confirmed by testing with a 10 % tolerance.	Performance tests not done as per minimum requirements specified in the Guidelines for DP Trials, ND No. 2- 030101- 056-E (15 min duration or until temperatures stabilise)
1	FMEA takes into account the lack of overall redundancy by including the criticality analysis into the FMEA tables with columns for the severity and probability of each failure allowing to identify all failures, which lead to a loss of the DP capability. DP 1 FMEA can also be referred to as FMECA (Failure Mode, Effects and Criticality Analysis).	Failures, which lead to a loss of DP capability, are not identified in the submitted FMEA or FMECA.

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(Section 2)*

DP class	To be confirmed	Reasons for FMEA rejection
2 and 3	<p>When the submitted FMEA is compared against own failure effect study conducted by the Register for a selection of critical equipment, the conclusions on redundancy and fault propagation are identical. No additional cross-connections are identified by the Register from the drawings and found missing in the submitted FMEA for the equipment selected by the Register.</p> <p>The following components of a DP system shall be studied:</p> <ol style="list-style-type: none"> 1. One power source (one generator). 2. One thruster. 3. One sensor or position reference system, e.g. gyro. <p>The Guidelines for FMEA development, ND No. 2-030101-055-E can be followed. Referenced drawings shall be collected for each of the above mentioned items.</p> <p>All links to other elements and in particular to other redundant groups shall be identified, to the traced DP station-capability and compared to the FMEA conclusions of the sections and to the list of cross connections.</p> <p>The links shall include the functional links, piping and cabling for DP2, as well as compartment segregation in addition for DP3.</p>	<p>Additional cross-connections between redundant groups are identified by the Register from the drawings and found missing in the submitted FMEA for the equipment selected by the Register. Discrepancies in the connections between any elements found by the Register.</p>
1, 2 and 3	<p>All systems (power, thruster, auxiliary, DP control, etc.) and sub-systems relevant for DP shall be described in the FMEA. The Guidelines for FMEA development, ND No. 2-030101-055-E, can be referred to.</p>	<p>Missing descriptions of systems installed onboard. Missing System Summary for each system separately.</p>
1, 2 and 3	<p>Proving trial document has a format in compliance with the Guidelines for DP Trials, ND No. 2-030101-056-E.</p>	<p>The references are missing to specific sections of FMEA which is being validated. Test sheets for tests in automatic DP mode do not provide conclusions on the global effect on the DP capability, i.e. it is not stated if the position or heading were lost or not following the failure.</p>

*Guidelines for RS Surveyors on FMEA Review and Condition Assessment of Dynamic Positioning Systems during Technical Supervision of DP Vessels after Construction, during Annual and Five- year Surveys
(Section 2)*

DP class	To be confirmed	Reasons for FMEA rejection
1, 2 and 3	TSCs defined in FMEA include the status of cross connections	TSCs are not defined in FMEA. The cross-connections or their status (open, closed, etc.) are missing in a definition of a TSC.
1, 2 and 3	Proving Trials validate specific TSCs described in FMEA. Unless FMEA or Proving Trials Report prove that certain test results can be applicable for multiple submitted TSCs, each TSC is tested separately with the name of the TSC marked in the trials test sheet.	Proving Trials test sheets do not include references to specific TSCs. FMEA describes TSCs which were not tested in the Proving Trials document.
1, 2 and 3	FMEA presents the features of the DP system in full compliance with the applicable RS Requirements	FMEA includes statements about the features which are non-compliant to the applicable RS Requirements
2 and 3	Each common element and cross connection is supported by a reference to the technical documentation on the protection e.g. discrimination studies and short circuit simulations. The technical documentation is to be produced by organisations independent from the Shipowner.	FMEA does not contain the cross connection worksheets or equivalent information as described in the Guidelines for FMEA development, ND No. 2- 030101-055-E. FMEA mentions cross connections which are not isolated in the system and which do not have any credible documented compensating provisions.

2.2 USE OF THE PROVING TRIALS DOCUMENT

2.2.1 FMEA shall be approved only when its statements are supported by a Proving Trial document. The DP performance trials allow checking the actual output of the critical systems and fail-safe conditions. The DP redundancy validation trials are conducted to confirm the redundant group attribution for ship's components and to validate the assumptions corresponding to the common elements and relevant protection.

2.3 CROSS CONNECTIONS

2.3.1 The verification and validation of fault tolerance can range in complexity depending on the onboard equipment and the corresponding TSCs.

As a general rule for an open bus configuration all the cross connections shall be identified and either removed, isolated or managed onboard with lock-out tag-out procedures.

Any common elements or cross-connections can only be used with reliable compensating provisions, i.e. with elements which offer protective functions to isolate failed DP system segments stopping failure propagation or which guarantee a fault ride through to reduce the impact of failures.

The compensating provisions can be deemed as acceptable on the basis of 3rd party assessments and reports mentioned below:

- short circuit calculation;
- protection selectivity study for power distribution system;
- vendor's FMEA for the common element, changeover system;
- AGP Factory Acceptance Tests;
- coordination study between the groups of the protective arrangements including the governors, AVR, Power Management System;
- live short circuit test protocols.

3 ONBOARD SURVEY RECOMMENDATIONS

3.1 GENERAL

3.1.1 In order to assign and maintain either **DYNPOS-1, DYNPOS-2 or DYNPOS-3** notations a ship's DP system shall undergo surveys for performance and redundancy. At least one TSC from DP FMEA shall be verified and validated to grant a class notation.

3.1.2 Surveys focus on the technical compliance to the Register rules, while the operational aspects are out of the scope. Although an applicant shall submit to the Register the DP operations manual which includes operational documentation including ASOG, the manual is submitted for information only.

3.1.3 The RS Guidelines for development of DP FMEA (refer to ND №2- 030101- 055- E and the Guidelines for DP Trials (refer to ND №2-030101-056-E) provide recommendations for the 3rd parties, referred to as DP FMEA Developers and Practitioners, on how to prepare the vessel for the documentation review and survey by RS. If the FMEA, including its provisional versions for a new-built vessel, and its Proving Trials have been reviewed before by RS, the verified test sheets can be used by a RS Surveyor.

It is recommended to conduct the Proving Trials with attending Surveyor to witness the entirety of the testing, so that the applicable technical scope can be fully credited towards the survey for **DYNPOS-1, DYNPOS-2 or DYNPOS-3** class notation.

3.1.4 The RS Guidelines for DP Trials, ND №2-030101-056-E, can be referred to by the RS Surveyors to support a captain in managing the risk to the ship, when the Survey is performed on a vessel that is not taken out of the offshore operations. Periods of standby can be used by the RS Surveyor to complete the checks and functional tests.

3.1.5 The DP station keeping capability shall be understood as the ability of a vessel to maintain both its heading within a 5 degree and its position within 5 m tolerance in the automatic DP mode without the need for an intervention of an operator on the Bridge or in the Engine room.

3.1.6 [Table 3.1.6](#) provides a scope for each survey. Where 100 % is given, a complete set of tests shall be performed as described in the Register's Guidelines for DP Trials applicable for a vessel's system being checked.

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Table 3.1.6

		Survey scope				
Test groups		Details	Initial	Annual	5 yearly	
Performance trials	Performance tests	Functional tests	100 % with additional scope: thorough visual examination of all components, cabling and piping for consistency check against drawings mentioned in FMEA,	100 %	100 % with additional scope: visual examination of electrical components not covered by the mandatory Class survey	
		Thruster loop monitoring tests - Controlled Pitch		Not required		
		Thruster loop monitoring tests - Fixed Pitch				
	Tests for protection at operational limits	Functional tests		100 %		Maintenance records
	Detection checks - alarms and indications related to the performance tests					
	Detection checks - alarms and indications related to the operational limits					
Redundancy validation trials	Redundancy validation tests	WCF partial blackout tests	test of all DP control and PMS operational modes intended for DP,	100 % with additional scope: visual examination of electrical components not covered by the mandatory Class survey		
		Closed bus configuration fault ride through	3 hour endurance in automatic DP mode			
		Units transferable between redundant groups	completion of a changeover matrix for all onboard stations provided with the thruster control capability			
		Units dual fed by redundant groups	capability plot validation in joystick, sideways thrust test, if there is any doubt about the validity of the plots			
		Units in a standby mode with an autostart mode enabled				
		Other redundancy validation tests	Not required			
	Tests for protection supporting the redundancy	Functional tests	Maintenance records			
	Detection checks - alarms and indications related to redundancy					
Detection checks - alarms and indications related to the protection						

3.2 INITIAL SURVEY

3.2.1 The applicable tests described in the RS Guidelines for DP Trials, ND №2- 030101-056-E, are supplemented by paras [3.2.2](#) and [3.2.3](#) in compliance with [Table 3.1.6](#).

3.2.2 Three hour endurance in the automatic DP mode.

3.2.2.1 The vessel shall demonstrate a DP station-keeping capability for 3 consecutive hours. For efficient use of the time of the seatrials, the redundancy validation tests can be selected such that the time is cumulated during their completion.

3.2.3 Control changeover matrix.

3.2.3.1 In order to validate the controls from DP, manual, IJS and emergency stations it is recommended to witness completion of a changeover matrix by the Bridge team for all onboard stations provided with the thruster control capability. Row names and header shall be equal and represent the control stations. The cells shall be used to record the actions required to transfer the control from one station to another. An extract from a changeover matrix is given in [Table 3.2.3.1](#) as an example. A completed Table can be posted on the Bridge in A3 format.

Table 3.2.3.1

Extract from a Changeover matrix

FROM	TO					
	DP OS1 Aft	DP OS2 Aft	DP cJoy Fwd	IJS Aft	Manual lever Aft	Manual lever Fwd
DP OS1 Aft	---	While both DP OS are online, press take control on DP OS2	Option 1: press "Take" twice on the Fwd K-Master's utility panel; Option 2: press "Take" twice on the cJoy panel	Option 1: press "Take" twice on the Aft K-Master's utility panel; Option 2: slide "Take" on the IJS Touch Screen Panel. Pass from Stby to Joystick mode; and Enable thrusters	On the Aft K-Master's utility panel press "Take" twice, then press "Lever" twice	On the Fwd K-Master's utility panel press "Take" twice, then press "Lever" twice
DP OS2 Aft	While both DP OS are online, press take control on DP OS!	---	Option 1: press "Take" twice on the Fwd K-Master's utility panel; Option 2: press "Take" twice on the cJoy panel	Option 1: press "Take" twice on the Aft K-Master's utility panel; Option 2: slide "Take" on the IJS Touch Screen Panel. Pass from Stby to Joystick mode and Enable thrusters	On the Aft K-Master's utility panel press "Take" twice, then press "Lever" twice	On the Fwd K-Master's utility panel press "Take" twice, then press "Lever" twice
Manual lever Fwd	Option 1: Press twice "Take" on Aft utility panel, and press "DP" twice. Option 2: press twice "DP" on Fwd utility panel and Press twice "Take" on Aft utility pane	Option 1: Press twice "Take" on Aft utility panel, and press DP twice. Option 2: press twice "DP" on Fwd utility panel and Press twice "Take" on Aft utility pane	press twice "DP" on Fwd utility panel	Press "Take" twice on the Aft K-Master's utility panel; and press twice on "IJS"	On the Aft K-Master's utility panel press "Take" twice	---

3.2.4 Capability plot validation in joystick sideway thrust test

3.2.4.1 The test is conducted when there are doubts about the correctness of the theoretical capability plots. The main goal is to measure the maximum speed through the water developed sideways at 100 % thrust output in intact and in WCF conditions. It will match the maximum current that the vessel can resist abeam.

Step 1: Ensure that wind is low, less than 5 kts and current below 1.0 kt

Step 2: Drift with wind compensated by the DP Joystick semi-automatic mode.

Step 3: Turn the ship abeam of the current (can be port or starboard side), activate an Automatic Heading function to hold the heading. Set propulsion to the Worst Case Failure or intact TSC.

Step 4: Set Auto Surge to compensate for any force from the stern

Step 5: With joystick in Manual Sway achieve 100 % on transverse thrust output with only sway to starboard side. Maintain it for 5 min or till the speed stabilizes, whatever occurs first, record the observed speed over the ground (SOG). Being at right angle to the current speed vector (if step 3 is complied with) this SOG is equal to the maximum speed through the water (STW) sideways plus the environmental effect.

Step 6: Start again from step 2 and repeat the same with motion to the port side. Record the speed and then calculate the average of the results on port and starboard motion to eliminate the environmental effect.

3.2.4.2 The goal is to find the maximum steady-state velocity, not the varying speed during the acceleration period. Consequently, a tolerance of 15 % can be applied when validating the corresponding point on a theoretical capability plot.

3.3 ANNUAL SURVEY

3.3.1 The applicable tests described in the RS Guidelines for DP Trials, ND №2- 030101-056-E, are supplemented by para [3.3.2](#) in compliance with [Table 3.1.6](#).

3.3.2 Visual examination of electrical components not covered by the mandatory Class annual survey shall be carried out.

3.4 SPECIAL SURVEY

3.4.1 The applicable tests described in the RS Guidelines for DP Trials, ND №2- 030101-056-E, are supplemented by para [3.4.2](#) in compliance with [Table 3.1.6](#).

3.4.2 Additional visual examination of electrical components not covered by the mandatory Class special survey shall be carried out.

Russian Maritime Register of Shipping

Guidelines for Surveyors on FMEA Review and Condition Assessment of Dynamic Positioning Systems during Technical Supervision of DP Vessels after Construction, during Annual and Five-year Surveys

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