



TECHNICAL AND OPERATIONAL GUIDANCE (TECHOP)

TECHOP_ODP_15_(D) (RP D102 FMEA GAP ANALYSIS)

NOVEMBER 2017

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SUMMARY

The MTS DP committee is dedicated to providing the DP community with the means to assess documentation which references a particular standard so that stakeholders can determine the extent to which the standard is being applied. There are a number of FMEA methodologies and standards currently in use and nothing in this TECHOP is intended to imply that RP D102 should be used in preference to any other FMEA standard.

This document, TECHOP_ODP_15_(D)_(RP D102 FMEA GAP ANALYSIS) provides a tool and process to objectively assess an FMEA's compliance with the standard RP D102. The purpose of the tool is to assess the methodology used to create the FMEA document and not to assess the scope, accuracy or completeness of the content. (TECHOP_ODP_04_(D)_(FMEA GAP ANALYSIS) can be used in conjunction with this document to objectively assess both the methodology and the content of an RP D102 FMEA.

This gap analysis tool is not suitable for application to FMEAs that do not claim to follow the methodology described in RP D102.

CONTENTS

SECTION		PAGE
1	INTRODUCTION - TECHOP (TECHNICAL AND OPERATIONAL GUIDANCE)	5
1.1	PREAMBLE	5
1.2	TECHOP_ODP	5
1.3	TECHOP_GEN	5
1.4	MTS DP GUIDANCE REVISION METHODOLOGY	6
2	SCOPE AND IMPACT OF THIS TECHOP	7
2.1	SCOPE	7
2.2	IMPACT ON PUBLISHED GUIDANCE	7
2.3	ACKNOWLEDGEMENTS	7
3	CASE FOR ACTION	8
3.1	WIDE VARIATION IN UNDERSTANDING AND APPLICATION OF RP D102 FMEA METHODOLOGY	8
3.2	RECOMMENDED ACTION	8
4	SUGGESTED IMPLEMENTATION STRATEGY	9
4.1	INTRODUCTION	9
4.2	CARRYING OUT AN RP D102 GAP ANALYSIS	9
4.3	PROCESS FOR MITIGATING FINDINGS OF AN RP D102 GAP ANALYSIS	10
4.4	WHAT IS THE DELIVERABLE?	10
4.5	NOTES	10
5	MISCELLANEOUS	12
APPENDICES		13
APPENDIX A	RP D102 FMEA GAP ANALYSIS CHECKLIST	14

1 INTRODUCTION - TECHOP (TECHNICAL AND OPERATIONAL GUIDANCE)

1.1 PREAMBLE

1.1.1 Guidance documents on DP, Design and Operations, were published by the MTS DP Technical Committee in 2010 and 2011, subsequent engagement has occurred with:

- Classification Societies (DNV GL, ABS).
- United States Coast Guard (USCG).
- Marine Safety Forum (MSF).

1.1.2 Feedback has also been received through the comments section provided in the MTS DP Technical Committee website.

1.1.3 It became apparent that a mechanism was needed to be developed and implemented to address the following in a pragmatic manner.

- Feedback provided by the various stakeholders.
- Additional information and guidance that the MTS DP Technical Committee wished to provide.
- Means to facilitate revisions to the documents and communication of the same to the various stakeholders.

1.1.4 The use of Technical and Operations Guidance Notes (TECHOP) was deemed to be a suitable vehicle to address the above. These TECHOP Notes will be in two categories.

- TECHOP_ODP.
- TECHOP_GEN.

1.2 TECHOP_ODP

1.2.1 Technical Guidance Notes provided to address guidance contained within the Operations, Design or People (Future development planned by the MTS DP Technical Committee) documents will be contained within this category.

1.2.2 The TECHOP will be identified by the following:

TECHOP_ODP_SNO_CATEGORY (DESIGN (D), OPERATIONS (O), PEOPLE (P))

- EXAMPLE 1 TECHOP_ODP_01_(O)_(HIGH LEVEL PHILOSOPHY).
- EXAMPLE 2 TECHOP_ODP_02_(D)_(BLACKOUT RECOVERY).

1.3 TECHOP_GEN

1.3.1 MTS DP TECHNICAL COMMITTEE intends to publish topical white papers. These topical white papers will be identified by the following:

TECHOP_GEN_SNO_DESCRIPTION

- EXAMPLE 1 TECHOP_GEN_01 - WHITE PAPER ON DP INCIDENTS.
- EXAMPLE 2 TECHOP_GEN_02 - WHITE PAPER ON SHORT CIRCUIT TESTING

1.4 MTS DP GUIDANCE REVISION METHODOLOGY

- 1.4.1 TECHOPs as described above will be published as relevant and appropriate. These TECHOPs will be written in a manner that will facilitate them to be used as standalone documents.
- 1.4.2 Subsequent revisions of the MTS Guidance documents will review the published TECHOPs and incorporate as appropriate.
- 1.4.3 Communications with stakeholders will be established as appropriate to ensure that they are notified of intended revisions. Stakeholders will be provided with the opportunity to participate in the review process and invited to be part of the review team as appropriate.

2 SCOPE AND IMPACT OF THIS TECHOP

2.1 SCOPE

2.1.1 The Guidance and Standards committee develops 'Gap Analysis Tools' that allow stakeholders to assess the contents of key DP documentation against the industry standards they reference. Gap analysis tools have already been developed for:

- DP FMEA
- FMEA proving trials
- DP Ops manuals
- Annual DP trials

2.1.2 These have proved popular and are being used by various stakeholders. These gap analysis tools are based on guidance such as IMCA M190, M191, M04/04 (material now incorporated into M166) and guidance in MTS Techops. RP D102 'FMEA of Redundant Systems' is an open FMEA standard developed by DNVGL Maritime which is now being requested by DP vessel owners and referenced by DP FMEA practitioners. It is available for anyone to use. Because this standard uses a different methodology to that incorporated in existing gap analysis tools, the range of gap analysis Techops has been extended to include a short checklist on the methodology of RP D102.

2.1.3 There are a number of FMEA methodologies and standards currently in use. The MTS DP committee does not specifically recommend any particular standard but is dedicated to providing the DP community with the means to assess documentation which references a particular standard so that stakeholders can determine the extent to which the standard is being applied. Nothing in this Techop is intended to imply that RP D102 should be used in preference to any other FMEA standard.

2.1.4 This document, TECHOP_ODP_15_(D)_(RP D102 FMEA GAP ANALYSIS) provides a tool and process to objectively assess an FMEA's compliance with RP D102. The scope of the tool is to assess the methodology used to create the FMEA document and not to assess the scope, accuracy or completeness of the content. (TECHOP_ODP_04_(D)_(FMEA GAP ANALYSIS)) can be used in conjunction with this document to objectively assess both the methodology and the content of an FMEA document.

2.1.5 It is not intended that this gap analysis tool is applied to FMEAs that do not claim to follow the methodology described in RP D102.

2.2 IMPACT ON PUBLISHED GUIDANCE

2.2.1 None

2.3 ACKNOWLEDGEMENTS

2.3.1 The DP Committee of the Marine Technology Society greatly appreciates the contribution of the following individuals to the preparation of this TECHOP.

Participant	Company Affiliation
Kevin Comeau	Lloyd's Register
Guillaume Vileyn	Bureau Veritas
Joey Fisher	M3 Marine Expertise
Aleks Karlsen	DNVGL Maritime
Bolshoy Bhattacharya	Noble Denton marine services
Steven Cargill	Noble Denton marine services

3 CASE FOR ACTION

3.1 WIDE VARIATION IN UNDERSTANDING AND APPLICATION OF RP D102 FMEA METHODOLOGY

3.1.1 RP D102 methodology is intended to assist FMEA practitioners to identify the existence of common points between systems intended to provide redundancy and to assess the risks those common points represent for station keeping integrity.

3.1.2 The methodology was developed for applications such as DP systems and redundant propulsion where fault tolerance depends on redundancy. The identification and analysis of fault propagation paths through common points and external interfaces is central to this methodology.

3.1.3 Failures effects which propagate by way of common points may cause adverse effects in more than one redundant group leading to loss of position. Other components which do not span redundancy groups can be assessed as having failure effects restricted to a single redundant group. Typical common points or cross connections include:

- Control power supplies
- Data communication networks
- Closed bus-ties
- Open cross over valves
- Power management and DP control systems

3.1.4 The methodology focuses on identifying redundant equipment groups using graphical representations such as colour coded simplified drawings and redundancy verification tables. These features help to illustrate the boundaries of each redundant group and components which are common between them.

3.1.5 RP D102 was written as an extension to traditional FMEA methodologies used in standards such as MIL-STD-1629A, IEC 61802. RP-D102 is referenced from IMCA M166.

3.1.6 It has come to the attention of the MTS DP committee that reference to a particular standard within a report is not always a reliable indicator that the referenced methodology has been followed. Because RP D102 applies a specific analysis process, there is a need to objectively assess whether an FMEA written with reference to the RP D102 implements the methodology as described. The gap analysis tool in this Techop provides a structured means to assess the application of the methodology. The RP D102 gap analysis tool does not assess the scope or accuracy of the analysis.

3.2 RECOMMENDED ACTION

3.2.1 A two-stage process is recommended:

1. **Stage 1:** Stakeholders may use this gap analyse tool in paper or Excel™ spreadsheet form (both are provided) to assess a subject FMEA. Mitigating measures can then be taken to close the identified gaps and achieve the objective of the DP FMEA as required.

A significant deviation from the methodology recommended in RP D102 may indicate that the FMEA has been executed in a way that does not identify all the fault propagation paths.

2. **Stage 2:** Where significant deviations from RP D102 methodology are identified, stakeholders may consider it prudent to carry out a more detailed review of the vessel's design documentation to determine to what extent essential analysis has been affected by failure to apply the methodology.

4 SUGGESTED IMPLEMENTATION STRATEGY

4.1 INTRODUCTION

4.1.1 The purpose of this TECHOP is to help ensure the DP FMEA:

- Clearly identifies different redundant groups at a system and sub system level.
- Clearly identify cross connections between redundant groups across the various systems like mechanical, electrical and control.
- Uses graphical tools to enhance the FMEA process.

4.1.2 Note: It does not follow that a significant deviation from RP D102 means there are omissions or errors in the analysis; only that they have not been identified by the methods provided within RP D102. However, the fact that a FMEA does not follow a referenced standard may cause stakeholders to question the veracity of the analysis and seek reassurance by other means.

4.2 CARRYING OUT AN RP D102 GAP ANALYSIS

4.2.1 **Stage 1** - Only the FMEA document itself is required as the source material at Stage 1.

4.2.2 It is anticipated that most users will want to use the Excel™ spreadsheet version and take advantages of the macros that allow filtering and tabulation of results. The gap analysis can also be performed using the table in Appendix A. Anyone can use the tool but knowledge of the practice of DP FMEAs may be useful and may lead to a less pessimistic result in some cases.

4.2.3 The tool takes the form of a series of questions. Even though the tool is in the form of a checklist, each point may be relevant for more than one sub-section of the FMEA and it is up to the reviewer to confirm compliance at each instance.

4.2.4 A three-colour coding scheme using green, yellow and red has been used to identify whether a particular aspect of FMEA methodology has been satisfactorily addressed, partially addressed, omitted completely (or contains significant errors). Grey is used to indicate issues that do not apply for any reason.

- Green – Analysis satisfactory.
- Yellow – Analysis incomplete.
- Red - Analysis unsatisfactory (analysis omitted or contains significant errors).
- Grey – Not applicable.

4.2.5 An example of a significant omission in the FMEA is failing to define a redundancy design intent and identify the constituent redundant groups. This would disqualify the subject FMEA from being assessed as compliant with RP D102 philosophy as all further steps in the analysis process stem from the identification of redundancy groups.

4.2.6 The gap analysis highlights the different items for analysis as part of four themes:

- Operations
- Design
- People
- Combination of the above.

4.2.7 Once the grey entries have been discounted, the ratio of yellows and reds to the overall number of issues can be used to provide an indication of the level of deficiency in percentage terms.

4.2.8 A summary report discussing the problems and major deficiencies can also be provided along with suggestions on how to remedy the analysis deficiencies and complete the analysis to the required level. This concludes Stage 1.

4.3 PROCESS FOR MITIGATING FINDINGS OF AN RP D102 GAP ANALYSIS

4.3.1 Figure 1 provides a flowchart which suggests a process for mitigating the output of the DP system FMEA gap analysis. Although the tool is intended to identify issue of methodology it is possible the process will also identify issues of scope or unacceptable failure effects that have been overlooked.

4.3.2 There are essentially five steps to be completed if the gap analysis indicates that action is required:

1. Confirm any yellow and red findings by reference the vessel's detailed design documentation – This is stage 2.
2. Carry out sufficient analysis to understand the risks.
3. Two different courses of action are advised depending on whether the vessel is a newbuild or already in service.
4. **In Service** - If the vessel is already in service:
 - Develop effective means to mitigate the risks based on the key elements of Design, Operations, Process and People (or combinations of these).
 - Document the mitigations and evaluate the potential for updating the vessel DP System FMEA as part of the FMEA management process.
 - Manage the mitigating measures.
5. **New-build** - If the vessel is a new-build awaiting proving trials, then the DP FMEA and proving trials program should be revised to remedy the deficiencies before the vessel enters service. This process may identify the need for system modifications.

4.4 WHAT IS THE DELIVERABLE?

4.4.1 The deliverable from Stage 1 will be a report which clearly identifies the deficiencies of the DP FMEA under review, and the methodologies used therein, when compared to the RP D102 methodology. A table showing a percentage of greens, reds, yellows and greys is useful.

4.4.2 The deficiencies highlighted may be fundamental (global) or focused on a system or sub system. Where this is the case the mitigating measures to address the deficiencies should also be identified.

4.4.3 Stage 2 may only be required if the gap analysis shows a significant deficiency. In this case a review of the design documentation should confirm whether there are issues that have been over looked in the analysis. The deliverable from this stage would be a 'Gap Closure Path', means / barriers to manage the identified risks for a vessel in service and ultimately a revised DP system FMEA and proving trials.

4.5 NOTES

- **Failure criteria** – The gap analysis checklist refers to the term 'failure criteria' in relation to 'active' and 'passive' components. The failure criteria used in the FMEA being analysed should be those specified in rules and acceptance criteria referenced in the FMEA being analysed.
- **Configuration error** – A configuration error can be considered as hidden act of maloperation. That is to say, the DP system has been inadvertently set-up or configured in a manner that defeats the DP redundancy concept.

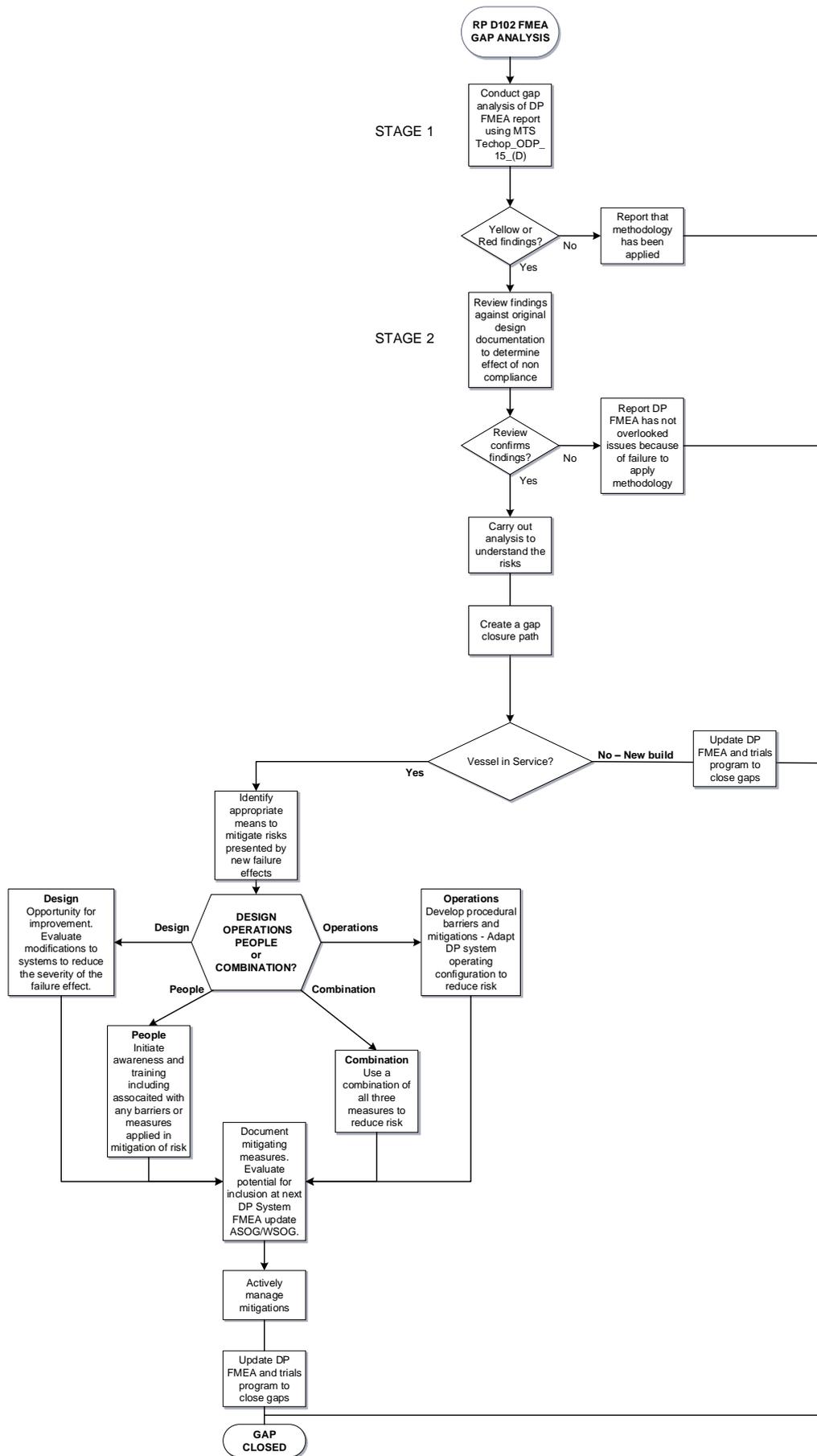


Figure 1 RP D102 Gap Analysis Process for Mitigating Output

5 MISCELLANEOUS

Stakeholders	Impacted	Remarks
MTS DP Committee	✓	To track and incorporate in next rev of MTS DP Guidance Documents
USCG	✓	MTS to communicate
ABS	✓	MTS to communicate
DNV GL	✓	MTS to communicate
Equipment vendor community	X	MTS to engage with suppliers.
Consultant community	✓	MTS members to cascade/ promulgate.
Training institutions	✓	MTS members to cascade/ promulgate.
Vessel Owners/Operators	✓	Establish effective means to disseminate information to Vessel Management and Vessel Operational Teams.
Vessel Management/Operational teams	✓	Establish effective means to disseminate information to Vessel Operational Teams.

APPENDICES

APPENDIX A RP D102 FMEA GAP ANALYSIS CHECKLIST

DP SYSTEM FMEA - DOCUMENT NUMBER XXXXX REV. Y DATED XXXXX					
APPLICATION OF RP D102 METHODOLOGIES GAP ANALYSIS					
SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CROSS REFERENCE TO FMEA	YES / GREEN PARTIAL / YELLOW NO / RED NOT APPLICABLE / GREY	CONCERN
General	Vessel Information Clearly defined	1.			
General	Revisions FMEA kept up to date	2.			
Design	Redundancy design intent , are the redundancy groups clearly defined	3.			
Design	Are the types of redundancy clearly identified e.g. active standby etc?	4.			
Design	Separation design intent is identified	5.			
Process	The limitations and assumptions of the FMEA are clearly defined	6.			
Design	Acceptance criteria is defined in relation to rule requirements and relevant guidance	7.			
Operation	System configuration for DP for all subsystems. All DP modes clearly defined and assessed	8.			
Process	FMEA work process takes redundancy and system commonality as primary driver	9.			
Design	System boundaries are clearly defined	10.			
Process	Fail safe conditions are assessed. Drive off proven not to occur following single failure.. Definition of 'fail-safe' provided relates to station keeping integrity	11.			
Design	Worst case failure design intent is clearly defined	12.			
Design	Failure criteria defined - Active, passive, fire and flood etc?	13.			
Process	Time requirement relevant to acceptance criteria taken into consideration - For fault propagation	14.			

DP SYSTEM FMEA - DOCUMENT NUMBER XXXXX REV. Y DATED XXXXX					
APPLICATION OF RP D102 METHODOLOGIES GAP ANALYSIS					
SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CROSS REFERENCE TO FMEA	YES / GREEN PARTIAL / YELLOW NO / RED NOT APPLICABLE / GREY	CONCERN
Process	Links between the FMEA analysis and the FMEA proving trials are provided which prove the conclusions of independence and fail safe	15.			
Process	Common points between redundant systems identified graphically	16.			
Design / Operations / Process	Sub System FMEAs with redundancy verification tables, specifications and analysis of dependencies	17.			
Design / Operations / Process	Is there a section on Marine Auxiliary Systems?	18.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	19.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	20.			
Design / Operations / Process	Is there a section on Ventilation Systems?	21.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	22.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	23.			
Design / Operations / Process	Is there a section on Power Generation?	24.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	25.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	26.			

DP SYSTEM FMEA - DOCUMENT NUMBER XXXXX REV. Y DATED XXXXX					
APPLICATION OF RP D102 METHODOLOGIES GAP ANALYSIS					
SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CROSS REFERENCE TO FMEA	YES / GREEN PARTIAL / YELLOW NO / RED NOT APPLICABLE / GREY	CONCERN
Design / Operations / Process	Is there a section on Power Distribution?	27.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	28.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	29.			
Design / Operations / Process	Is there a section on Power Management?	30.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	31.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	32.			
Design / Operations / Process	Is there a section on Thrusters, Propellers and steering gear?	33.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	34.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	35.			
Design / Operations / Process	Is there a section on Vessel Management Systems?	36.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	37.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	38.			

DP SYSTEM FMEA - DOCUMENT NUMBER XXXXX REV. Y DATED XXXXX					
APPLICATION OF RP D102 METHODOLOGIES GAP ANALYSIS					
SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CROSS REFERENCE TO FMEA	YES / GREEN PARTIAL / YELLOW NO / RED NOT APPLICABLE / GREY	CONCERN
Design / Operations / Process	Is there a section on DP Control Systems	39.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	40.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	41.			
Design / Operations / Process	Is there a section on Fire and Gas / Emergency Shutdown System?	42.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been followed?	43.			
Design / Operations / Process	Does the narrative show that RP D102 methodologies have been executed correctly?	44.			
Process	Does the FMEA report provide appropriate definitions for terms used in the analysis such as independence, fail-safe, drift off and drive off.	45.			
Process	Each subsection identifies hidden failures and analyses the effect of hidden failures in combination with a single point failure and mitigation of these effects	46.			
Process	Each subsection identifies configuration errors and analyses the effect of configuration errors and mitigation of these effects	47.			
Process	Each subsection identifies tentative acts of maloperation and analyses the effect of acts of maloperation and mitigation of these effects	48.			

DP SYSTEM FMEA - DOCUMENT NUMBER XXXXX REV. Y DATED XXXXX					
APPLICATION OF RP D102 METHODOLOGIES GAP ANALYSIS					
SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CROSS REFERENCE TO FMEA	YES / GREEN PARTIAL / YELLOW NO / RED NOT APPLICABLE / GREY	CONCERN
Process	Each subsystem identifies the protective functions upon which redundancy depends	49.			
Process	Each subsystem identifies the performance attributes upon which redundancy depends	50.			
Process	Each subsystem identifies alarms and operator intervention upon which redundancy depends	51.			
Design	Redundant groups are analysed to be capable of developing surge, sway and yaw thrust either together or in valid combinations	52.			
Design	The analysis of each subsystem identifies internal and external common cause failures (ICCs and ECCs)	53.			
Design	Analysis clearly links cross-connections with potential fault propagation paths	54.			
Design	If applicable, separation design intent and installation of redundant systems in fire and flooding protected compartments - physical (fire and flood) separation	55.			
Process	Each subsection is defined using a simplified sketch or drawing to assist the analysis	56.			
Process	Each subsystem section has conclusions or a statement of independence and fail safe	57.			
Design	There is a statement of compliance with acceptance criteria summarising the overall results of the analysis	58.			
Design	The report contains an analysis and tests to verify the analysis	59.			

DP SYSTEM FMEA - DOCUMENT NUMBER XXXXX REV. Y DATED XXXXX					
APPLICATION OF RP D102 METHODOLOGIES GAP ANALYSIS					
SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CROSS REFERENCE TO FMEA	YES / GREEN PARTIAL / YELLOW NO / RED NOT APPLICABLE / GREY	CONCERN
Process	Reference to equipment vendor FMEA is provided. It is noted where compliance is solely based on vendor FMEA	60.			
Process	Reference to supporting studies like short circuit analysis, voltage dip ride through, breaker coordination etc. should be provided and relevant information should be included in the FMEA.	61.			
Design	Each subsection has single fault propagation analysis leading to a drift off analysis .	62.			
Design	There is a link between redundancy design intent and post worst case failure capability	63.			
Design	There is a section to report the conclusions of the FMEA and compliance with / non-compliance with the worst-case failure design intent	64.			
Process	Categories for concerns / findings are defined and adhered to	65.			
Process	Concerns / Findings register records contain original entry and action taken to resolve. Closed concerns are not deleted and can be referred to	66.			
Design	Description of references are provided - including RP-D102	67.			