



TECHNICAL AND OPERATIONAL GUIDANCE (TECHOP)

TECHOP_ODP_04_(D)_(FMEA GAP ANALYSIS)

DECEMBER 2013

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1 INTRODUCTION - TECHOP (TECHNICAL AND OPERATIONAL GUIDANCE)

1.1 PREAMBLE

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

- Classification Societies (DNV, 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 Web Site.

1.1.3 It became apparent that a mechanism is 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)).

- EG 1 TECHOP_ODP_01_(O)_(HIGH LEVEL PHILOSOPHY).
- EG 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.

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

1.4 MTS DP GUIDANCE REVISION METHODOLOGY

1.4.1 TECHOP 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 TECHOP_ODP_04_(D)_(FMEA GAP ANALYSIS). This TECHOP addresses the wide variation in the scope and quality of DP FMEAs for DP vessels of all types entering service or following conversion for dynamic positioning.

2.2 IMPACT ON PUBLISHED GUIDANCE

2.2.1 This TECHOP impacts MTS DP Vessel Design Philosophy Guidelines Part II, Section 22.

3 CASE FOR ACTION

3.1 WIDE VARIATION IN QUALITY AND SCOPE OF DP FMEAS

- 3.1.1 All dynamically positioned vessels of DP Equipment Classes 2 & 3 are required to be single fault tolerant in respect of defined failure criteria appropriate to the equipment Class. Fault tolerance should be demonstrated to the satisfaction of the Classification society. These requirements are traditionally satisfied by carrying out a Failure Modes and Effects Analysis (FMEA) which is validated by DP FMEA proving trials.
- 3.1.2 There is wide variation in the quality and scope of FMEAs being approved as demonstrating such fault tolerance. Failure to detect single point failures and vulnerability to common cause failures in the design of DP systems leaves the vessel vulnerable to loss of position and heading when the undetected failure mode occurs while carrying out DP operations.
- 3.1.3 The potential consequences of such failures depend on the nature of the work but typically include:
- Damage to the DP vessel and/or vessels operating in the vicinity.
 - Damage to infrastructure and subsea installations.
 - Damage to the environment.
 - Financial losses.
 - Risk to life.
 - Loss of reputation.
- 3.1.4 Even when a poor quality FMEA is not approved and is rejected by Class the fact that a significant amount of design and construction work has often been completed by the time the FMEA is rejected means that there may be a need for significant and costly rework to correct issues not identified by the FMEA. This can delay vessel delivery and threaten contracts if the vessel is not available to perform the work on time.
- 3.1.5 Classification societies recognise the importance of a good quality FMEA and the significant risks associated with an incompetent analysis and trials program. Guidance is now available in the form of a recommended practice for 'FMEA of Redundant Systems'. Such guidance goes a long way to addressing the shortfalls but is not yet universally applied.
- 3.1.6 Note: In this context the term 'DP system' implies all equipment involved in maintaining position and heading including power generation propulsion and control systems. This is the official definition from IMO MSC 645 although the term 'DP system' is sometimes used informally to refer to the DP control system.

3.2 RECOMMENDED ACTION

- 3.2.1 FMEA stakeholders should review and comment upon FMEAs submitted as part of the approval process. The most effective and objective way to confirm whether a DP FMEA is competent is to carry out a formal gap analysis between the document submitted and the industry guidance on FMEAs referenced in this TECHOP.
- 3.2.2 A significant deviation from the scope and methodology recommended in the referenced guidance indicates that the FMEA may not have been executed in a competent manner and the DP vessel may not have the required level of fault tolerance.
- 3.2.3 FMEA stakeholders should then ensure the identified deficiencies are addressed which may require comprehensive rework of the FMEA and proving trials.

4 SUGGESTED IMPLEMENTATION METHODOLOGY

4.1 INTRODUCTION

4.1.1 The purpose of this TECHOP is to help ensure FMEAs for DP Vessels:

- Are competently executed.
- Analyse all DP related systems.
- Consider the influence of the industrial mission on the DP redundancy concept.
- Are effectively validated by the DP FMEA proving trials.

4.2 GUIDANCE FOR USE IN THE PREPARATION OF A GAP ANALYSIS

4.2.1 There are several sources of information on the scope and details of failure modes and effects analysis:

- MTS DP Vessel Design Philosophy Guidelines Part II.
- DNV Recommended Practice for FMEA of Redundant Systems, RP-D102.
- IMCA Guidance M166 – ‘Guidance on Failure Modes and Effects Analysis’, April 2002.
- IMCA M206 A Guide to DP Electrical Power and Control Systems.
- IMCA Information Note M04/04 - IMCA Study – ‘Methods of Establishing the Safety and Reliability of DP Systems’ – 2004, Appendices D & E in particular.

4.2.2 New sources of guidance are published periodically and further revision of the MTS DP Vessel Design Philosophy Guidelines will reference these sources as they become available. The sources of guidance listed above have been used to prepare the gap analysis table in Appendix A.

4.3 CARRYING OUT A GAP ANALYSIS

4.3.1 The purpose of the gap analysis is to check the scope and methodology used in the DP FMEA against published industry guidance and not to repeat or correct the analysis. The gap analysis is typically carried out using only the FMEA report itself as source material.

4.3.2 A FMEA gap analysis can be performed using the table in Appendix A. The large number of issues to be checked is indicative of the complexity of modern DP vessels and the number of systems, subsystems and equipment items that influence the redundancy concept. Checklist items related to the correct application of FMEA methodology are repeated in each subsystem which creates repetition but to restrict these issues to a single table entry is to risk overlooking essential elements of the analysis.

4.3.3 A simple colour coding scheme can be used to identify whether the FMEA issue in the table have been satisfactorily addressed, partially addressed, omitted completely or contains significant errors. Grey can be used to indicate issues that do not apply to the design of the subject DP vessel.

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

- 4.3.4 An example of a significant error would be presenting incorrect failure effects or omitting to analyse a failure mode with effects exceeding the worst case failure design intent. This is not intended to imply a re-analysis of the original design only that there are demonstrable errors in the FMEA.
- 4.3.5 The gap analysis table includes two types of issues to be checked:
1. Issues associated with application of DP FMEA methodology.
 2. Lists of equipment and systems which would typically be discussed in a DP FMEA.
- 4.3.6 A DP FMEA should have sufficient information to allow a complete understanding of the redundancy concept. However, in some cases, when considering items that should be discussed in a DP FMEA it may not be obvious from the FMEA report whether the equipment is not fitted to this particular vessel or it is fitted but the analysis has been omitted. The following rules may be applied to determine the category to assign in the gap analysis table:
- If the omission could conceal failure effects of severity greater than the worst case failure design intent it would be categorised as RED.
 - If the omission would have no significant impact on the severity of failure effects then the issue may be categorised as GREY.
- 4.3.7 For example, the absence of discussion of a remote valve control systems may mean that a single point failure associated with all cooling valves failing to the closed position has been overlooked particularly if there is no explicit statement indicating that all valves are manually controlled. However, the absence of the discussion of fuel oil coolers in a system with independent fuel and cooling water systems for each redundant machinery group is unlikely to be significant.
- 4.3.8 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.
- 4.3.9 A summary report discussing the problems and major deficiencies can also be provided along with suggestions on how to remedy the analysis and complete it to the required level.
- 4.3.10 Four columns in the table indicate the DP system arrangements to which each issue applies: There are typically entries in several columns for each issue.
1. **Closed busties:** A tick in this column indicates that issues should be discussed in FMEAs for all Classes of vessel (2 & 3) that operate their power plant as a single common power system.
 2. **Open busties:** A tick in this column Indicates that the issue should be considered for all Classes of vessels that operate their power plant as two or more isolated systems.
 3. **DP Class 3** An entry in this column indicates the issue should be considered for DP Class 3 designs. If this is the only entry against a particular issue then it is typically an issue associated with the effects of fire and flooding.
 4. **Fail Safe:** An entry in this column indicates the issue is related to systems which can fail in such a way as cause a drive off, typically thruster controls systems or DP control system, references and sensors.

Note: The most useful time to carry out a FMEA gap analysis is on the draft revision of the FMEA when it is submitted to the vessel owner for review prior to submission to Class for approval. It may be difficult to influence further development after Class has approved it with comments. A similar process can be applied to the DP FMEA proving trials and annual DP trials programs.

4.4 PROCESS FOR MITIGATING OUTPUT OF DP SYSTEM FMEA GAP ANALYSIS

4.4.1 Figure 4-1 provides a flowchart which describes the process for mitigating the output of the DP system FMEA gap analysis. There are essentially six steps to be completed if the gap analysis indicates that action is required:

1. Carry out the gap analysis.
2. Confirm any yellow and red findings by reference to the original vessel design documentation.
3. Perform additional Failure Modes and Effects Analysis to address the gaps.
4. If unacceptable failure effects are identified then there are two courses of action depending on whether the vessel is a newbuild or already in service.
5. If the vessel is already in service at the time of the gap analysis:
 - i. Develop effective means to mitigate the risks based on the key elements of Design, Operations and People (or combinations of these)
 - ii. Document the mitigations and evaluate the potential for updating the vessels DP system FMEA as part of the FMEA management process.
 - iii. Manage the mitigating measures.
6. If the vessel is a new-build awaiting proving trials then the DP FMEA and proving trials program should be updated to remedy the deficiencies before the vessel enters service. This process may identify the need for system modifications.

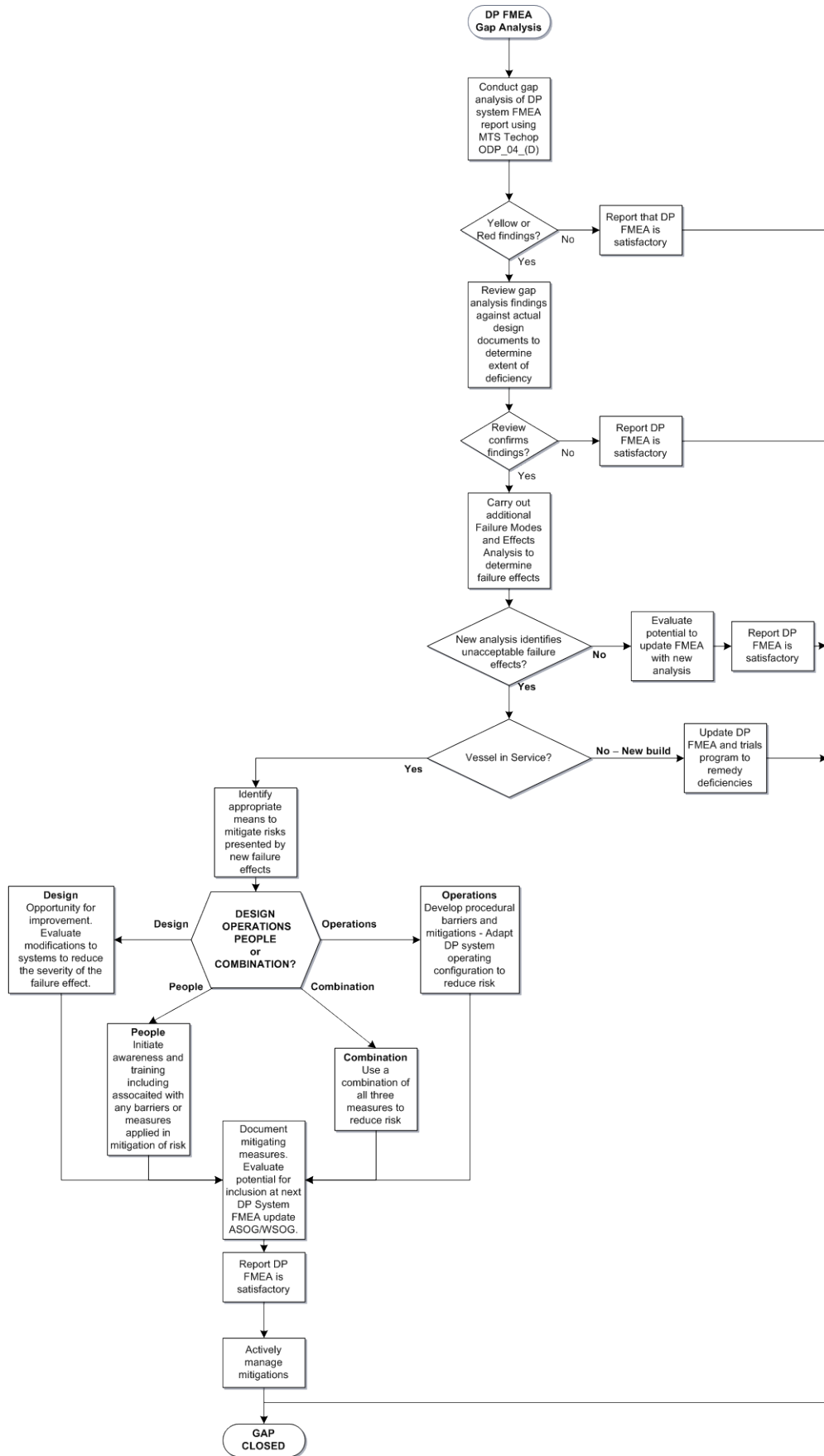


Figure 4-1 Process for Mitigating Output of Gap Analysis

4.5 CONCLUSION

- 4.5.1 There is very significant variation in the quality and scope of DP vessel FMEAs currently being approved. The FMEA gap analysis is a useful quality indicator and should be carried out whenever there is concern regarding the scope, competence and veracity of a FMEA. There is a significant amount of useful guidance on FMEAs and DP system design against which any analysis can be judged.

5 MISCELLANEOUS

Stakeholders	Impacted	Remarks
MTS DP Committee	✓	To track and incorporate in next rev of MTS DP Operations Guidance Document Part 2 Appendix 1. Communicate to DNV, USCG, Upload in MTS website.
USCG	✓	MTS to communicate- FR notice impacted when Rev is available.
DNV	X	MTS to Communicate- DNV RP E 307 impacted.
Equipment vendor community	✓	MTS to engage with protection suppliers
Consultant community	✓	MTS members to cascade/ promulgate.
Training institutions	X	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.

APPENDIX A FMEA GAP ANALYSIS TABLE

A.1 REVIEW OF PREAMBLE

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X				
SYSTEM	ID NO.	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERNS
Applicable rules	1			
Vessel class notation	2			
FMEA standards	3			
Main machinery outline	4			
Critical activity mode identified	5			
Redundancy concept overview	6			
Redundant levels of power	7			
Previous FMEA analysis	8			
Vessel modifications	9			
Worst case failure design intent	10			
Summary/conclusion	11			
Action items	12			
Reference to all software revisions in use at time of proving trials	13			
Reference to DP FMEA proving trials document	14			
System drawings	15			

A.2 REVIEW OF CONTENT

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary Systems	Fuel	Document reference with revision numbers.	1	✓	✓	✓				
		Location for DP Class 3.	2			✓				
		Description of fuel system and redundancy concept.	3	✓	✓	✓				
		System configuration for DP.	4	✓	✓	✓				
		Analysis identifies redundant groups in fuel system.	5	✓	✓	✓				
		Analysis identifies common points between redundant groups.	6	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	7	✓	✓	✓				
		Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	8	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary Systems	Fuel	Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	9	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	10	✓	✓	✓				
		Analysis identifies any external common cause failure and the barriers used to mitigate them.	11	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	12	✓	✓	✓				
		There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, their interfaces to other systems.	13	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary Systems	Fuel	The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	14	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	15	✓	✓	✓				
		Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	16	✓	✓					
		A60 separation of redundant groups.	17			✓				
		Watertight separation of redundant groups.	18			✓				
		A60 separation of pipework for redundant groups for DP Class 3.	19			✓				
		Watertight separation of pipework.	20			✓				
		Storage tanks free of ballast lines etc.	21	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary Systems	Fuel	Storage and transfer facilities allow fuel to be quarantined.	22	✓	✓	✓				
		Water detection.	23	✓	✓	✓				
		Day/service/settling tanks.	24	✓	✓	✓				
		Tank level indications.	25	✓	✓	✓				
		Quick closing valves and their panels/levers.	26	✓	✓	✓				
		Fuel modules including DO to HO changeover.	27	✓	✓	✓				
		HFO fuel heating – Steam / technical oil.	28	✓	✓	✓				
		Automated valves.	29	✓	✓	✓				
		Pumps, mechanical and electrical.	30	✓	✓	✓				
		Purifiers.	31	✓	✓	✓				
		Flow meters, supply and return.	32	✓	✓	✓				
Filters, suction and discharge	33	✓	✓	✓						

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary Systems	Fuel	Low level alarms.	34	✓	✓	✓				
		Pressure alarms.	35	✓	✓	✓				
		Supply lines.	36	✓	✓	✓				
		Return lines with valves.	37	✓	✓	✓				
		Fuel coolers – leaks from cooling water to fuel.	38	✓	✓	✓				
		Electrical supplies to pumps and automation.	39	✓	✓	✓				
		Valve actuation.	40	✓	✓	✓				
		Effects of most common leaks.	41	✓	✓	✓				
		Leak protection.	42	✓	✓	✓				
		Leak alarms.	43	✓	✓	✓				
		Flexible lines.	44	✓	✓	✓				
Hot surface protection.	45	✓	✓	✓						

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary Systems	Remote Valve Control	Document reference with revision numbers.	46	✓	✓	✓				
		Location for DP Class 3.	47			✓				
		Description of RCV system and redundancy concept.	48	✓	✓	✓				
		Analysis identifies redundant groups in RCV system.	49	✓	✓	✓				
		Analysis identifies common points between redundant groups.	50	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	51	✓	✓	✓				
		Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	52	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Remote Valve Control	Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	53	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	54	✓	✓	✓				
		Analysis identifies any external common cause failure and the barriers used to mitigate them.	55	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	56	✓	✓	✓				
		There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, their interfaces to other systems.	57	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Remote Valve Control	The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	58	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	59	✓	✓	✓				
		Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	60	✓	✓					
		A60 separation of redundant groups	61			✓				
		Watertight separation of redundant groups	62			✓				
		A60 separation of pipework for redundant groups for DP Class 3.	63				✓			
		Generator CW valves 'fail as set'.	64	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Remote Valve Control	Valves for DP essential services fail safe.	65	✓	✓	✓				
	Engine & Generator Lubricating Oil (see also Thrusters)	Document reference with revision numbers.	66	✓	✓	✓				
		Location for DP Class 3.	67			✓				
		Description of lubricating system and redundancy concept.	68	✓	✓	✓				
		System configuration for DP.	69	✓	✓	✓				
		Analysis identifies redundant groups in lubrication system.	70	✓	✓	✓				
		Analysis identifies common points between redundant groups.	71	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	72	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Engine & Generator Lubricating Oil (see also Thrusters)	Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	73	✓	✓	✓				
		Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy	74	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	75	✓	✓	✓				
		Analysis identifies any external common cause failure and the barriers used to mitigate them.	76	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	77	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Engine & Generator Lubricating Oil (see also Thrusters)	There is a system drawings that identifies all DP related components, the redundant groups to which they belong and their interfaces to other systems.	78	✓	✓	✓				
		The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	79	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	80	✓	✓	✓				
		Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	81	✓	✓					
		A60 separation of redundant groups.	82			✓				
		Watertight separation of redundant groups.	83			✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Engine & Generator Lubricating Oil (see also Thrusters)	A60 separation of pipework for redundant groups for DP Class 3.	84			✓				
		Storage.	85	✓	✓	✓				
		Transfer.	86	✓	✓	✓				
		Filling.	87	✓	✓	✓				
		Sump arrangement.	88	✓	✓	✓				
		Pumps, mechanical and electrical.	89	✓	✓	✓				
		Level alarms and watch-keeping procedures.	90	✓	✓	✓				
		Low pressure alarms.	91	✓	✓	✓				
		Alarm and shutdown modes.	92	✓	✓	✓				
		Alternator bearings.	93	✓	✓	✓				
		Filters.	94	✓	✓	✓				
Coolers.	95	✓	✓	✓						

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Engine & Generator Lubricating Oil (see also Thrusters)	Automated valves.	96	✓	✓	✓				
		Purification and cross connection of generators.	97	✓	✓	✓				
		Crank case ventilation – commonality in pipework & spark arresters.	98	✓	✓	✓				
		Oil mist detectors active shutdown and common air supply.	99	✓	✓	✓				
		Priming pumps and readiness for standby starts.	100	✓	✓	✓				
		Electrical supplies to pumps and automation.	101	✓	✓	✓				
		Pre-lubrication for BOR – independence of emergency generator. Override for pre-lubrication.	102	✓	✓	✓				
	Seawater Cooling	Document reference with revision numbers.	103	✓	✓	✓				
		Location for DP Class 3.	104			✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Seawater Cooling	Description of seawater cooling systems and redundancy concept.	105	✓	✓	✓				
		System configuration for DP.	106	✓	✓	✓				
		Analysis identifies redundant groups in seawater system.	107	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	108	✓	✓	✓				
		Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	109	✓	✓	✓				
		Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	110	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Seawater Cooling	Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	111	✓	✓	✓				
		Analysis identifies any external common cause failure and the barriers used to mitigate them.	112	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	113	✓	✓	✓				
		There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, and their interfaces to other systems.	114	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Seawater Cooling	The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	115	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	116	✓	✓	✓				
		Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	117	✓	✓					
		A60 separation of redundant groups.	118			✓				
		Watertight separation of redundant groups.	119			✓				
		A60 separation of pipework for redundant groups for DP Class 3.	120				✓			
		Bulkhead valves either side for DP Class 3.	121				✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Seawater Cooling	Sea chests.	122	✓	✓	✓				
		Seawater pressure alarm.	123	✓	✓	✓				
		Strainer differential pressure alarm.	124	✓	✓	✓				
		Seawater flow alarm.	125	✓	✓	✓				
		Sea strainers.	126	✓	✓	✓				
		Anti-fouling - biocide treatment.	127	✓	✓	✓				
		Remote/Automatic valves, actuation and control.	128	✓	✓	✓				
		Emergency shell isolation, actuation and control.	129	✓	✓	✓				
		Overboard and valves (common?)	130	✓	✓	✓				
		Pumps, mechanical and electrical.	131	✓	✓	✓				
		Electrical supplies to pumps and automation.	132	✓	✓	✓				
		Recirculation to sea chests.	133	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Seawater Cooling	Winterisation.	134	✓	✓	✓				
		Blow downs.	135	✓	✓	✓				
		Coolers.	136	✓	✓	✓				
		Emergency cross-connection from fire main etc.	137	✓	✓	✓				
		Leaks – bilge alarms etc.	138	✓	✓	✓				
	Freshwater Cooling	Document reference with revision numbers.	139	✓	✓	✓				
		Location for DP Class 3.	140			✓				
		Description of fresh water cooling systems and redundancy concept.	141	✓	✓	✓				
		System configuration for DP.	142	✓	✓	✓				
		Analysis identifies redundant groups in freshwater system.	143	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Freshwater Cooling	Analysis identifies common points between redundant groups.	144	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	145	✓	✓	✓				
		Analysis identified any protective functions upon which redundancy depends to prevent failure effects propagating.	146	✓	✓	✓				
		Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	147	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	148	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Freshwater Cooling	Analysis identifies any external common cause failure and the barriers used to mitigate them.	149	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	150	✓	✓	✓				
		There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, and their interfaces to other systems.	151	✓	✓	✓				
		The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	152	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	153	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Freshwater Cooling	Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	154	✓	✓					
		A60 separation of redundant groups.	155			✓				
		Watertight separation of redundant groups	156			✓				
		A60 separation of pipework for redundant groups for DP Class 3.	157			✓				
		Bulkhead valves either side for DP Class 3.	158			✓				
		Fuel valve cooling.	159	✓	✓	✓				
		LTFW – TLVs power and signal source.	160	✓	✓	✓				
		HTFW – TLVs power and signal source.	161	✓	✓	✓				
		Pumps, mechanical and electrical duty and standby.	162	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Freshwater Cooling	Header tanks (commonality for Class 3).	163	✓	✓	✓				
		Electrical supplies for pumps.	164	✓	✓	✓				
		Thermostatic valves.	165	✓	✓	✓				
		Coolers – burst, blocked, cross leak.	166	✓	✓	✓				
		Water makers – Vacuum, heaters, CW supply.	167	✓	✓	✓				
		Remote/Automatic valves.	168	✓	✓	✓				
		System cross-connection.	169	✓	✓	✓				
		Tank level alarms.	170	✓	✓	✓				
		High temperature alarms and shutdowns.	171	✓	✓	✓				
		Leaks.	172	✓	✓	✓				
		Flexible pipes.	173	✓	✓	✓				
Marine Auxiliary System	Charge Air	Document reference with revision numbers.	174	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Location for DP Class 3.	175			✓				
		Description of charge air systems and redundancy concept.	176	✓	✓	✓				
		System configuration for DP.	177	✓	✓	✓				
		Analysis identifies redundant groups in charge-air system.	178	✓	✓	✓				
		Analysis identifies common points between redundant groups.	179	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	180	✓	✓	✓				
		Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	181	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Charge Air	Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	182	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	183	✓	✓	✓				
		Analysis identifies any external common cause failure and the barriers used to mitigate them.	184	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	185	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Charge Air	There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, and their interfaces to other systems.	186	✓	✓	✓				
		The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	187	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	188	✓	✓	✓				
		Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	189	✓	✓					
		A60 separation of redundant groups.	190			✓				
		Watertight separation of redundant groups.	191			✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Charge Air	A60 separation of pipework for redundant groups for DP Class 3.	192			✓				
		Bulkhead valves either side for DP Class 3.	193			✓				
		Turbochargers.	194	✓	✓	✓				
		Rig savers – failure modes source of power and control.	195	✓	✓	✓				
		Dump valves.	196	✓	✓	✓				
		Jet assist – failure effects, air supply.	197	✓	✓	✓				
		Coolers, burst blocked, cross leak.	198	✓	✓	✓				
		Air temperature control.	199	✓	✓	✓				
		Control valves, including actuation and control.	200	✓	✓	✓				
	Compressed Air	Document reference with revision numbers.	201	✓	✓	✓				
	Location for DP Class 3.	202			✓					

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Compressed Air	Description of compressed air systems and redundancy concept.	203	✓	✓	✓				
		Configuration for DP.	204	✓	✓	✓				
		Analysis identifies redundant groups in compressed air system.	205	✓	✓	✓				
		Analysis identifies common points between redundant groups.	206	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	207	✓	✓	✓				
		Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	208	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Compressed Air	Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	209	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	210	✓	✓	✓				
		Analysis identifies any external common cause failure and the barriers used to mitigate them	211	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this	212	✓	✓	✓				
		There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, and their interfaces to other systems.	213	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Compressed Air	The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	214	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	215	✓	✓	✓				
		Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	216	✓	✓					
		A60 separation of redundant groups.	217			✓				
		Watertight separation of redundant groups.	218			✓				
		A60 separation of pipework for redundant groups for DP Class 3.	219			✓				
		Bulkhead valves either side for DP Class 3.	220			✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Compressed Air	Start air.	221	✓	✓	✓				
		Compressors.	222	✓	✓	✓				
		Receivers.	223	✓	✓	✓				
		Operating modes.	224	✓	✓	✓				
		Cross-connections.	225	✓	✓	✓				
		Reducing valves failure to zero / overpressure.	226	✓	✓	✓				
		Electrical supplies.	227	✓	✓	✓				
		Compressor automation – lead, lag.	228	✓	✓	✓				
		Pressure alarms.	229	✓	✓	✓				
		Emergency start air connection.	230	✓	✓	✓				
Leaks.	231	✓	✓	✓						

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Emergency Generator	Document reference.	232	✓	✓	✓				
		Analysis confirms no E-gen involvement in DP redundancy concept.	233	✓	✓	✓				
		Interface with DP related equipment.	234	✓	✓	✓				
		Mode indication - emergency/harbour.	235	✓	✓	✓				
		Role in BOR.	236	✓	✓	✓				
	Engine Management and Safety System	Document reference.	237	✓	✓	✓				
		Description of engine control and safety systems.	238	✓	✓	✓				
		Analysis confirms independence of control and safety functions.	239	✓	✓	✓				
		Cross connections between safety systems.	240	✓	✓	✓				
		Power supply segregation.	241	✓	✓	✓				
		VMS interface.	242	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Marine Auxiliary System	Engine Management and Safety System	Shutdowns – susceptible to common mode failures? (Oil mist, crankcase pressure).	243	✓	✓	✓				
		Switchboard interface- MODBUS etc.	244	✓	✓	✓				
		Emergency load up ramps.	245	✓	✓	✓				
		Emergency shutdown – commonality.	246	✓	✓	✓				
		Slow turning – effect on standby start times.	247	✓	✓	✓				
		Start interlocks.	248	✓	✓	✓				
		Starting and connection time – PMS supervision of 'Hot Standby / Cold Standby)	249	✓	✓	✓				
		Engine failure modes e.g. trip on RP, Slow down and stop, over power/ speed, hunting, catastrophic mechanical failure.	250	✓		✓				
Power	Generators	Document reference.	251	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Generation		Location for DP 3.	252			✓				
		Description of generator, type, speed, Hz, current, pf, voltage, kW, kVA. Excitation system, PMGs, auxiliary winding etc.	253	✓	✓	✓				
		Severe line and/or phase voltage imbalance.	254	✓		✓				
		Severe line current imbalance.	255	✓		✓				
		Under voltage.	256	✓		✓				
		Over voltage.	257	✓		✓				
		Under frequency.	258	✓		✓				
		Over frequency.	259	✓		✓				
Power Generation	Generators	Earth fault.	260	✓		✓				
		Insufficient active power.	261	✓		✓				
		Excess active power.	262	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Unstable active power.	263	✓		✓				
		Insufficient reactive power.	264	✓		✓				
		Excess reactive power.	265	✓		✓				
		Unstable reactive power.	266	✓		✓				
		Loss of synchronisation – pole slipping.	267	✓		✓				
		Harmonics to be maintained within defined limits.	268	✓		✓				
		Power factor.	269	✓		✓				
		Earthing system, NETs, NERs etc.	270	✓		✓				
		Hidden failure to start / connect.	271	✓		✓				
Power Generation	Generators	Hidden failure insufficient capacity kW & kVAr.	272	✓		✓				
		Hidden failure poor load acceptance & rejection.	273	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Generation	Generator Switchgear	Description of switch. gear HV / LV arc proof, bus bar insulation type, gas insulated etc.	274	✓	✓	✓				
		Arc detection – optical, pressure – potential vulnerability to common mode failures.	275	✓	✓	✓				
		Power management interface.	276	✓	✓	✓				
		Temperature control and HVAC.	277	✓	✓	✓				
		Synchronisation and crash sync.	278	✓		✓				
		Dead bus connection.	279	✓		✓				
		Interlocks – electrical and mechanical.	280	✓	✓	✓				
		Manual controls & synchronising.	281	✓	✓	✓				
Power Generation	Generator Switchgear	Connection of stopped generator.	282	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Connections crossing boundaries between switchboards for status, power, sync VT signals etc. A60 & WT for DP class 3	283	✓	✓	✓				
		Hidden failure to close / connect (one or more poles).	284	✓		✓				
		Hidden failure to trip on fault.	285	✓		✓				
		Hidden failure to open on PMS order.	286	✓		✓				
	HVAC and Chilled Water Systems	Document reference with revision numbers	287	✓	✓	✓				
		Location for DP Class 3.	288			✓				
		Description of HVAC / Chilled water systems and redundancy concept.	289	✓	✓	✓				
		Configuration for DP.	290	✓	✓	✓				
		Analysis identifies redundant groups in HVAC / chilled water system.	291	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Generation	HVAC and Chilled Water Systems	Analysis identifies common points between redundant groups.	292	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	293	✓	✓	✓				
		Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	294	✓	✓	✓				
		Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	295	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	296	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Generation	HVAC and Chilled Water Systems	Analysis identifies any external common cause failure and the barriers used to mitigate them. e.g. cement dust in all air intakes causing F&G to detect smoke and initiate ESD, Gas ingestion etc.	297	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	298	✓	✓	✓				
		There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, and their interfaces to other systems.	299	✓	✓	✓				
		The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	300	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Generation	HVAC and Chilled Water Systems	There is a link to the proving trials program that confirms the findings of the FMEA.	301	✓	✓	✓				
		Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	302	✓	✓					
		A60 separation of redundant groups.	303			✓				
		Watertight separation of redundant groups.	304			✓				
		A60 separation of pipework for redundant groups for DP Class 3.	305			✓				
		Bulkhead valves either side for DP Class 3.	306			✓				
		Fan Coil Units.	307	✓	✓	✓				
		Backup package air conditioners and supplies.	308	✓	✓	✓				
Power Generation	HVAC and Chilled Water Systems	Supports time to terminate if non-redundant.	309	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Condensation – failure effects.	310	✓	✓	✓				
	Generator Protection	Document reference.	311	✓	✓	✓				
		Discussion of how protection scheme philosophy supports redundancy concept.	312	✓	✓	✓				
		Switchgear - circuit breakers and contactors.	313	✓	✓	✓				
		Differential protection.	314	✓		✓				
		Over current protection.	315	✓		✓				
		Over/under excitation.	316	✓		✓				
		Over/under voltage protection.	317	✓		✓				
Power Generation	Generator Protection	Over/under frequency.	318	✓		✓				
		Reverse power protection.	319	✓		✓				
		Negative sequence protection.	320	✓		✓				
		Temperature alarms – shutdowns.	321	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Lube oil pressure alarms – shutdowns.	322	✓		✓				
		Earth fault protection - zero sequence protection.	323	✓	✓	✓				
		UPSs 110Vdc & 24Vdc - rating, type, split diode cross connections.	324	✓	✓	✓				
		kW imbalance protection & alarm.	325	✓		✓				
		kVAr imbalance protection & alarm.	326	✓		✓				
		Arc detection.	327	✓		✓				
		Directional earth fault protection.	328	✓		✓				
		Advanced protection for generators.	329	✓		✓				
Power Generation	Generator Protection	Busties pre-tripped by generator faults.	330	✓		✓				
		Connections between generator protection such as VT and broken delta signals – effect of failure.	331	✓	✓	✓				
		Failure to excess or full fuel considered.	332	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Failure to zero or insufficient fuel.	333	✓		✓				
		Asymmetric load sharing and failure modes.	334	✓		✓				
	Governors	Document reference.	335	✓	✓	✓				
		Isochronous/droop.	336	✓		✓				
		Speed/load control.	337	✓		✓				
		PMS connections raise/lower sticking etc.	338	✓		✓				
		Overload protection - load reduction function.	339	✓		✓				
Mechanical backup governor.	340	✓		✓						
Power Generation	Governors	Rack position indication.	341	✓		✓				
		Sharing lines.	342	✓	✓	✓				
		Default to droop on sharing line failure.	343	✓		✓				
	Voltage Dip	Ride through capability at all levels.	344	✓	✓*	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Effect on system voltage, clearing SC faults.	345	✓	✓*	✓				
		Effect of starting heavy consumers.	346	✓		✓				
		Effect on contactors for pumps etc.	347	✓		✓				
		Effect on power electronic drives – settings.	348	✓		✓				
		Effect on instrumentation and control systems.	349	✓		✓				
	AVR	Document reference.	350	✓	✓	✓				
		Type of regulator and exciter.	351	✓		✓				
		Droop characteristics.	352	✓		✓				
	Power Generation	AVR	Failure mode - to over / under excitation.	353	✓		✓			
Reactive power sharing.			354	✓		✓				
Control by power management raise / lower.			355	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Excitation limiters – effect on selectivity.	356	✓		✓				
		Field failure protection.	357	✓		✓				
		Interaction with thrust limitation.	358	✓		✓				
		Hidden failure - Current boost systems.	359	✓		✓				
		Hidden failure - Excitation support.	360	✓		✓				
		Hidden failure – fault or not specified PMG.	361	✓		✓				
		Cross current compensation.	362	✓	✓	✓				
		Interface with protection for alternator – differential protection.	363	✓		✓				
Power Generation	AVR	Interface with HV switchgear – earth switch.	364	✓		✓				
Power	Power Management	Document reference.	365	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Management	Scope	Philosophy - Continuity of electrical power, Ability to restore propulsion capability Ability to restore propulsion capability.	366	✓	✓	✓				
		Security and failure modes of 'Power Available' calculator.	367	✓	✓	✓				
		Topology of PMS hardware – distributed system or centralised.	368	✓	✓	✓				
		PMS functions considered as potential hidden failures.	369	✓	✓	✓				
		Diesel automation.	370	✓	✓	✓				
		Control of engine starting requirements.	371	✓	✓	✓				
Power Management	Power Management Scope	Control of engine specific requirements.	372	✓	✓	✓				
		Selection of generator running order.	373	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Load dependent starting of generators on kW, kVAr, Amps? – Appropriate.	374	✓	✓	✓				
		Load dependent stop – inhibited on DP.	375	✓	✓	✓				
		Alarm start – but no shutdown.	376	✓	✓	✓				
		Blackout prevention system – Philosophy integrated with drives, industrial consumers, DP control systems.	377	✓	✓	✓				
		Auto reconfiguration of circuit breakers.	378	✓	✓	✓				
		Advanced power reservation – start blocking.	379	✓	✓	✓				
		Interface with electronic governor.	380	✓	✓	✓				
		Interface with AVR.	381	✓	✓	✓				
Power Management	Power Management Scope	Interface with engine management system.	382	✓	✓	✓				
		Active power sharing.	383	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Reactive power sharing.	384	✓		✓				
		Net frequency control.	385	✓		✓				
		Asymmetric load sharing.	386	✓		✓				
		Protective functions in PMS – Bespoke.	387	✓	✓	✓				
		Maintain harmonics within limits.	388	✓	✓	✓				
		Control of switchboard fault levels –e.g. open busties on connection of last generator.	389	✓	✓	✓				
		Control of regenerated power from draw works etc. prevent generators tripping on reverse power.	390	✓	✓	✓				
		Reference to Vendor FMEA.	391	✓	✓	✓				
Power Management	Transducers & Status	Bus tie status.	392	✓	✓	✓				
		Generator circuit breaker status.	393	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X											
DESCRIPTION				APPLICATION				GAP ANALYSIS			
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN	
		Transducer's power supplies and failure modes.	394	✓	✓	✓					
		Dead bus and blackout detection – security of blackout protection effect of spurious detection may create real blackout.	395	✓	✓	✓					
	Architecture	Hierarchy of control systems – local, PMS, DP control.	396	✓	✓	✓					
		Redundancy concept centralised or distributed.	397	✓	✓	✓					
		System independence and segregation.	398	✓	✓	✓					
		Autonomy of main machinery.	399	✓	✓	✓					
		Common points between redundant systems.	400	✓	✓	✓					
	Power Management	Architecture	Common mode failures.	401	✓	✓	✓				
			Hidden failures.	402	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X											
DESCRIPTION				APPLICATION				GAP ANALYSIS			
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN	
		Barriers to operator error – maloperation.	403	✓	✓	✓					
		Data communications networks.	404	✓	✓	✓					
		Analogue I/O distribution across redundant groups – particular for DP Class 3, effects of fire and flooding on same.	405	✓	✓	✓					
	Synchronising	Control of dedicated synchronisers.	406	✓		✓					
		Voltage control.	407	✓		✓					
		Frequency control.	408	✓		✓					
		Reduce power transfer across bus tie.	409	✓		✓					
		Crash sync of generators and switchboards.	410	✓	✓	✓					
	Power Management	Synchronising	Connection of a stopped generator.	411	✓		✓				
			Loss of sync due to mechanical failure.	412	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
	Load Sharing	Speed droop.	413	✓		✓				
		Compensated droop.	414	✓		✓				
	Blackout Prevention	Load dependent start.	415	✓		✓				
		Start blocking.	416	✓		✓				
		Heavy consumer protection.	417	✓		✓				
		Load limitation/shedding.	418	✓	✓	✓				
		Thrust limitation/reduction.	419	✓	✓	✓				
		Thruster tripping.	420	✓	✓	✓				
		Preferential tripping.	421	✓	✓	✓				
		Interfaces with other blackout protection.	422	✓	✓	✓				
		Other systems interaction.	423	✓	✓	✓				
		Power Management	Blackout Prevention	Thruster priority.	424	✓	✓	✓		
Heading priority.	425			✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Process/drilling priority.	426	✓	✓	✓				
		Process phase back.	427	✓	✓	✓				
		Analysis considers - Effect of large thruster driving off initiating phase back on other thrusters.	428	✓	✓	✓				
		Effect of governor failure to full fuel initiating phase back leading to loss of position and/or blackout.	429	✓		✓				
	Blackout Restart	Generator starting sequence or start all simultaneously.	430	✓		✓				
		Dead bus connection.	431	✓		✓				
		Protection against faulty generator connection.	432	✓		✓				
Power Management	Blackout Restart	Protection against simultaneous connection of generators.	433	✓	✓	✓				
		Staged reconnection of loads.	434	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		Lock outs of healthy generators – unnecessary – prevents reconnection of healthy generators.	435	✓	✓	✓				
	Static Power Estimate	Configurations for DP CAM & TAM – Note CAM previously referred to as SMO – Safest Mode of Operation, in previous revisions.	436	✓	✓	✓				
		Load and thrust levels that provide fault tolerance.	437	✓	✓	✓				
		Calculations consider active power, reactive power, current and power factor, load acceptance and rejection.	438	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Management	Interfaces	Drilling PMS - Interfaces – failure modes – hidden failures – means to reveal loss of data link analogue connections etc. Modes for 'locked to bottom', Drilling priority and means to dump it, staged phase back of mud pumps etc., reserved power margin for active heave compensation. – landing BOP etc.	439	✓	✓	✓				
		Crane – Phased back before thrusters.	440	✓	✓	✓				
		Pipe lay systems – Phased back before thrusters – reserved power margin.	441	✓	✓	✓				
		Other industrial mission equipment.	442	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Distribution	Concept and Philosophy	Document reference with revision numbers.	443	✓	✓	✓				
		Description of power distribution systems and redundancy concept.	444	✓	✓	✓				
		Type and location of all switchboards DBs etc. for DP Class 3.	445			✓				
		Type and location of all service and industrial mission transformers – cooling etc.	446	✓	✓	✓				
		Configuration for DP CAM & TAM etc.	447	✓	✓	✓				
		Analysis identifies redundant power systems and confirms they support surge sway and yaw in intact and post WCF.	448	✓	✓	✓				
		Analysis identifies common points between redundant power systems.	449	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Distribution	Concept and Philosophy	Analysis identifies all failure effects that can propagate from one redundant group to the other.	450	✓	✓	✓				
		Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	451	✓	✓	✓				
		Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	452	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	453	✓	✓	✓				
		Analysis identifies any external common cause failure and the barriers used to mitigate them.	454	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Distribution	Concept and Philosophy	The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	455	✓	✓	✓				
		There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, and their interfaces to other systems.	456	✓	✓	✓				
		The worst case failure for those systems is clearly stated in relation to its effects on generators, thrusters, position and heading.	457	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	458	✓	✓	✓				
		Type of power system – three wire, three phase for example.	459	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Distribution	Concept and Philosophy	Single bustie switchboards – analysis of potential for unscheduled closing.	460		✓	✓				
		Master slave busties – potential for both to close together – leading to crash sync	461		✓	✓				
		Protection against damage for passive components where exempt from failure analysis as part of redundancy concept for DP Class 2.	462	✓	✓					
		A60 separation of redundant groups.	463			✓				
		Watertight separation of redundant groups.	464			✓				
		Protection philosophy.	465	✓		✓				
	Studies	Reference to load balance.	466	✓	✓	✓				
		Reference to selectivity / coordination study	467	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Distribution	Studies	Reference to harmonics study in intact and post WCF of harmonic control features	468	✓		✓				
		Reference to transient stability study showing effects of WC short circuit, effects of crash sync of generators and switchboard, connection of a stopped generator	469	✓		✓				
		Reference to short circuit and earth fault test of main switchboards on DP.	470	✓		✓				
	Interlocks and Protection	Interlocks and intertrips – crossing redundant groups	471	✓	✓	✓				
		Short circuit protection	472	✓		✓				
		Earth fault protection	473	✓		✓				
		Motor starting and protection	474	✓		✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Distribution	Concept and Philosophy	List MCCs and distribution boards & tables of DP related consumers.	475	✓	✓	✓				
		Power for switchboard controls.	476	✓	✓	✓				
		Power for spring winders from where?	477	✓	✓	✓				
		UPSs for VMS and DP control systems-analysis confirm the type of UPS e.g. double conversion or line interactive type. If line interactive the analysis investigates the potential for switching transients to pass through this type of UPS. Bypass arrangements reviewed and alarms for 'bypass selected' – normal and alternative supplies. Means to prevent transfer of faults. Alarms for on-batteries and battery disconnected confirmed.	478	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Distribution	Concept and Philosophy	Maintaining DP ready signal during switching of transferable thrusters.	479	✓	✓	✓				
		Transformer cooling fan supplies.	480	✓	✓	✓				
		Emergency generator starting.	481	✓	✓	✓				
		Shore power interlocks and inter trips.	482	✓	✓	✓				
		Back feeding from emergency generator.	483	✓	✓	✓				
		Protection against primary to secondary faults in service transformers.	484	✓		✓				
		Pre-magnetising systems – effects of failure to operate, effects of spurious operation.	485	✓		✓				
		Consumers on deck fed from DP switchboards.	486	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Power Distribution	Safety Systems	Interface to ESD.	487	✓	✓	✓				
		Interface to group emergency stops.	488	✓	✓	✓				
		Interface to F&G, Water mist etc.	489	✓	✓	✓				
	Concept and Philosophy	Commonality created by colocation of industrial consumers for DP Class 3 – effects of fire and flooding – voltage dips on all redundant power systems for > WCFDI.	490			✓				
		Effects of fire and flooding on protection coordination – multiple fault paths – sequential voltage dips.	491			✓				
		Cable routes for DP Class 3 and high risk areas for DP Class 2.	492	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Propellers and Steering Gear	Main Propellers	Role of main propellers in redundancy concept – system drawings showing all interfaces and services upon which the propulsion train depends.	493	✓	✓	✓				
		Drawing reference.	494	✓	✓	✓				
		Gearbox – common to more than one redundant group – shaft generators on PTO etc.	495	✓	✓	✓	✓			
		Clutch – Failure modes on loss of power and signal.	496	✓	✓	✓	✓			
		CPP – Failure modes on loss of power and signal command / feedback.	497	✓	✓	✓	✓			
		Speed control – failure modes on loss of command / feedback – signal and ground – earth fault / short circuit / open circuit.	498	✓	✓	✓	✓			
		Interaction of variable speed control.	499	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Propellers and Steering Gear	Main Propellers	Power supplies, main, auxiliary and backup.	500	✓	✓	✓	✓			
		Pumps from main supply, from emergency supplies.	501	✓	✓	✓	✓			
		Hydraulics – Effect of loss of pressure (loss of ready?)	502	✓	✓	✓	✓			
		Lube oil – Can prop run without forced circulation.	503	✓	✓	✓	✓			
		Cooling as part of marine auxiliary systems for other thrusters? Or shared with service transformers in some cases – Failure effects.	504	✓	✓	✓				
		Operating modes.	505	✓	✓	✓				
		Failure to ahead condition for main Class.	506	✓	✓	✓				
		Control stations, alternative controls.	507	✓	✓	✓				
Propellers and Steering Gear	Steering Gear	Control power supplies main/alternative.	508	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
		DP ready signal requirements.	509	✓	✓	✓				
		Alarms.	510	✓	✓	✓				
		Control loop protection.	511	✓	✓	✓				
		Interface with rudder.	512	✓	✓	✓				
		Drawing reference.	513	✓	✓	✓				
		Power supplies, main, auxiliary and backup – commonality introduced by using emergency switchboard.	514	✓	✓	✓				
		Pumps.	515	✓	✓	✓	✓			
		Hydraulics.	516	✓	✓	✓	✓			
		Cooling.	517	✓	✓	✓	✓			
		Operating modes.	518	✓	✓	✓	✓			
Propellers and Steering	Steering Gear	Defaults, especially on loss of propulsion.	519	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Gear		Control stations, alternative controls.	520	✓	✓	✓	✓			
		Alternative controls.	521	✓	✓	✓	✓			
		Emergency controls.	522	✓	✓	✓	✓			
		Control power supplies.	523	✓	✓	✓	✓			
		Ready signal requirements.	524	✓	✓	✓	✓			
		Control loop protection.	525	✓	✓	✓	✓			
		Angle indication.	526	✓	✓	✓	✓			
		Mechanically linked rudders on twin screw vessels.	527	✓	✓	✓	✓			
		Failure modes including to 'hard over'.	528	✓	✓	✓	✓			
		High lift rudders for DP.	529	✓	✓	✓	✓			
		Alarms.	530	✓	✓	✓	✓			
Propellers and Steering	Tunnel and Azimuth	Drawing reference.	531	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Gear	Thrusters	Location – drawing? – Plan view showing thruster locations and association with each redundant machinery group.	532	✓	✓	✓	✓			
		Type FPP, CPP, Tunnel, Azimuth, Combinator, Voith Schneider, etc.	533	✓	✓	✓	✓			
		Specification – Thrust / Power curve presented.	534	✓	✓	✓	✓			
		Prime movers – Motors, diesel engines? Interlocks and start / run permissive – any commonality introduced by this discussed?	535	✓	✓	✓	✓			
		Main power – Interlocks – drive controls CB? Estop independent of thruster control system?	536	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Propellers and Steering Gear	Tunnel and Azimuth Thrusters	System drawings showing all thruster auxiliary services and their interfaces to other systems.	537	✓	✓	✓	✓			
		Gearbox- services, lubrication, sealing air pressure	538	✓	✓	✓	✓			
		Clutch – Failure modes on loss of power and signal open? Slipping clutch for direct drive, pulsed clutch?	539	✓	✓	✓	✓			
		CPP- Failure mode to full pitch on loss of hydraulic pressure?	540	✓	✓	✓	✓			
		Speed/torque control – means of transferring between the two modes – Failure modes and effects of control loops.	541	✓	✓	✓	✓			
		Interaction of variable speed control – Does thrust drop while thruster is rotating in azimuth?	542	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Propellers and Steering Gear	Tunnel and Azimuth Thrusters	Power supplies, main, auxiliary and backup	543	✓	✓	✓	✓			
		Pumps – duty standby? – What triggers C/O?	544	✓	✓	✓	✓			
		Hydraulics – effect of loss of pressure?	545	✓	✓	✓	✓			
		Lube oil – Operation without forced lubrication?	546	✓	✓	✓				
		Cooling – commonality with other systems?	547	✓	✓	✓				
		Control stations, alternative controls on field stations etc.	548	✓	✓	✓				
		Control power supplies main/alternative	549	✓	✓	✓				
		DP ready signal requirements	550	✓	✓	✓				
		Barred zones – Does analysis confirm zones deactivate when thruster is deselected?	551	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Propellers and Steering Gear	Tunnel and Azimuth Thrusters	Mode selection switches – NFU controls – effects of fire and flooding on same for DP Class 3?	552	✓	✓	✓				
		Rate of turning – 2 RPM?	553	✓	✓	✓				
		Ramp rate 0 to 100% thrust < 30s.	554	✓	✓	✓				
		Thruster control modes.	555	✓	✓	✓				
	Azimuth Thrusters	Drawing reference.	556	✓	✓	✓				
		Power supplies, main, auxiliary and backup.	557	✓	✓	✓				
		Pumps.	558	✓	✓	✓				
		Hydraulics.	559	✓	✓	✓				
		Cooling.	560	✓	✓	✓				
		Control stations.	561	✓	✓	✓				
Alternative controls.	562	✓	✓	✓	✓					

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Propellers and Steering Gear	Azimuth Thrusters	Emergency controls.	563	✓	✓	✓	✓			
		Control power supplies.	564	✓	✓	✓	✓			
		DP ready signal requirements.	565	✓	✓	✓	✓			
		Control loop protection.	566	✓	✓	✓	✓			
		Angle indication.	567	✓	✓	✓	✓			
		Alarms.	568	✓	✓	✓	✓			
		Azimuth control loops – Failure modes.	569	✓	✓	✓	✓			
Vessel Management System	General	Drawing reference.	570	✓	✓	✓				
		General description.	571	✓	✓	✓				
		System architecture.	572	✓	✓	✓				
		Redundancy concept.	573	✓	✓	✓				
		System segregation.	574	✓	✓	✓				
		System independence and duplication.	575	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Vessel Management System	General	Switching and protective functions.	576	✓	✓	✓				
		Common mode failures.	577	✓	✓	✓				
		Hidden failures.	578	✓	✓	✓				
		Multiple independent failures.	579	✓	✓	✓				
		Operator error.	580	✓	✓	✓				
	Switchboard PLC Comms	Reaction of engines to PLC failures.	581	✓		✓				
	Air Conditioning	Component susceptibility to overheating.	582	✓	✓	✓				
		Provision of A/C redundancy.	583	✓	✓	✓				
		Alarms for temperature increase / A/C failure.	584	✓	✓	✓				
	Network Topology and Redundancy Concept	Document reference with revision numbers.	585	✓	✓	✓				
Description of vessel management system and redundancy concept.		586	✓	✓	✓					

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Vessel Management System	Network Topology and Redundancy Concept	Type and location of all switchboards DBs etc. for DP Class 3.	587			✓				
		Thruster control modes – bias, fixed, variable.	588	✓	✓	✓				
		Type and location of all hubs, switches, field stations, operator stations etc. for DP Class 3.	589	✓	✓	✓				
		Analysis identifies assignment of field stations and their UPS power supplies to thrusters and confirms they support surge sway and yaw in intact and post WCF.	590	✓	✓	✓				
		Analysis identifies assignment of field stations and their UPS power supplies generators and switchboards and confirms the arrangement support the WCFDI.	591	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Vessel Management System	Network Topology and Redundancy Concept	Analysis identifies assignment of field stations and their UPS power supplies to marine auxiliary systems and confirms it introduces no unacceptable commonality.	592	✓	✓	✓				
		Analysis identifies assignment of field stations and their UPS power supplies to ESD and F&G systems and confirms it introduces no unacceptable commonality.	593	✓	✓	✓				
		Analysis identifies common points between redundant power systems?	594	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	595	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Vessel Management System	Network Topology and Redundancy Concept	Analysis identifies any protective functions upon which redundancy depends to prevent failure effects propagating.	596	✓	✓	✓				
		Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	597	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	598	✓	✓	✓				
		Analysis identifies any external common cause failure and the barriers used to mitigate them.	599	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this.	600	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Vessel Management System	Network Topology and Redundancy Concept	There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, and their interfaces to other systems.	601	✓	✓	✓				
		The worst case failure for this system is clearly stated in relation to its effects on generators, thrusters, position and heading.	602	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	603	✓	✓	✓				
		Common mode failures – Network storms.	604	✓	✓	✓				
		Capacity sufficient for intact and post WCF.	605	✓	✓	✓				
		Alarm to indicate hidden failures – Field stations, Ethernet cables, hubs, failure of one dual power supply.	606	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Vessel Management System	Network Topology and Redundancy Concept	Virus protection.	607	✓	✓	✓				
		Scan rates.	608	✓	✓	✓				
		Remote access for diagnostics.	609	✓	✓	✓				
		Reference to VMS vendor FMEA.	610	✓	✓	✓				
DP Control Systems	Concept	Document reference with revision numbers.	611	✓	✓	✓				
		Reference to DP control system vendor FMEA.	612	✓	✓	✓				
		Location for DP Class 3.	613			✓				
		Manufacturer, type and model number of DP control system-duplex, triplex etc.	614	✓	✓	✓				
		Description of DP control systems and redundancy concept.	615	✓	✓	✓				
		Configuration for DP.	616	✓	✓	✓				
		Analysis identifies redundant groups in DP control system.	617	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	Concept	Analysis identifies common points between redundant groups.	618	✓	✓	✓				
		Analysis identifies all failure effects that can propagate from one redundant group to the other.	619	✓	✓	✓				
		Analysis identified any protective functions upon which redundancy depends to prevent failure effects propagating.	620	✓	✓	✓				
		Analysis identifies any potential hidden failure that could defeat redundancy, including any alarms or standby redundancy.	621	✓	✓	✓				
		Analysis identifies any internal common cause failures and the barriers employed to mitigate them.	622	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	Concept	Analysis identifies any external common cause failure and the barriers used to mitigate them.	623	✓	✓	✓				
		The analysis identifies any configuration errors that could defeat redundancy and any barrier to prevent this	624	✓	✓	✓				
		There is a system drawing that identifies all DP related components, the redundant groups to which they belong and, and their interfaces to other systems.	625	✓	✓	✓				
		The worst case failure for the DP control system is clearly stated in relation to its effects on generators, thrusters, position and heading.	626	✓	✓	✓				
		There is a link to the proving trials program that confirms the findings of the FMEA.	627	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	Concept	In DP control systems with an analogue interface to the thrusters the provision of interface modules / IO cards matches the overall split in the redundancy concept.	628	✓	✓	✓				
		Changeover switch between main and backup for DP Class 3 – all failure modes considered including effects of fire (and flooding if below damaged waterline).	629			✓				
		Changeover switch between DP and manual, IJS etc. – Failure modes.	630	✓	✓	✓				
		Analysis confirms no single failure of the mode selection switch prevents manual control.	631	✓	✓	✓				
		Analysis confirms no single failure of the mode selector switch exceeds WCFDI.	632	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	Concept	Analysis discusses means to prevent inadvertent operation – double push or its successor.	633	✓	✓	✓				
		Drawing reference.	634	✓	✓	✓				
		Analysis confirms at least three independent position reference systems based on two different principles.	635	✓	✓	✓				
		Analysis confirms the reference systems are suitable for the vessel's industrial mission	636	✓	✓	✓				
		Analysis confirms the worst case loss of reference systems leaves at least one operational (DNV), does not exceed one (ABS)	637	✓	✓	✓				
		Independent joystick (IJS) – Failure modes and effect on DP system while in auto DP.	638	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	IJS	IJS – Analysis confirms independence of main DP control system, independent of VMS network, independent of DP power supply.	639	✓	✓	✓				
	PMS	DP Thrust Limitation – discussed –failure modes effects of transducer and status contact failure – single bus philosophy for dual fed thrusters.	640	✓	✓	✓				
	Networks	Local Networks - Commonality in local networks from interface to I/O modules for gyro ready signal, thruster, thruster command and feedback ready signal etc. RS485 susceptible to jabber.	641	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	References and Sensors	Heading – Analysis confirms the provision of three gyros – common mode failures associated with common measurement principle addressed. Perhaps by spinning mass/ FOG combo.	642	✓	✓	✓	✓			
		Motion – Analysis confirms the provision of at least 3 MRUs – failure modes include inert state and false roll, pitch or heave? – Faulty telegram etc.	643	✓	✓	✓	✓			
		Wind sensors – Failure modes to high and low wind speed and erroneous direction. Common mode failures including icing, trace heating failure, common mode failure of ultrasonic wind sensors in rain.	644	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	References and Sensors	GNSS (Satnav) – Analysis confirms that DGNSS systems are well separated in terms of power supplies, receivers for GNSS and corrections. Protective functions designed to reject or reduce the risk faulty GNSS data are discussed – Elevation masks etc. common mode failures related to radio interference, poor antenna separation, tropical rain storms, constellation jumps, use of > 2 DGNSS in DP control systems.	645	✓	✓	✓	✓			
		Hydro acoustic – Analysis confirms the independence of dual HPRs and discusses the provision of power supplies, gyro, MRU and DGNSS inputs. Potential common mode failures in respect of thruster noise and sub sea activities etc.	646	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	References and Sensors	Taut wire – Alignment of supplies for various parts of TW, TW computer etc. Effect of losing hoist power, air supply. Discussion of alarms and protective functions to reduce the risk of faulty TW data – ships side box, effects of thruster wash on TW. Barred zones analysed.	647	✓	✓	✓	✓			
		Microwave – Artemis – Provision of power supplies, range restrictions interference of older sets from radar.	648	✓	✓	✓	✓			
		Laser – Fan beam – Provision of power supplies for scanning head, control box and monitor. Discussion of short comings of laser position references, range – reflector v prism in. Locking on to false targets. Saturation of receiver in direct sunlight.	649	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	References and Sensors	Seapath – Use as heading input discussed, interface to gyro, MRUs, power supply discussed in relation to overall redundancy concept for DP control system.	650	✓	✓	✓	✓			
		Radius – Power supplies reflect split in redundancy concept.	651	✓	✓	✓	✓			
		RadaScan as for Radius.	652	✓	✓	✓	✓			
		Draught sensor – nature of input / automatic V manual – Failure modes, commonality of sensor inputs (single field station for all). Appropriate bounds on draft data.	653	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	References and Sensors	Riser angle – unlikely to be used as position reference but available to DPO as confirmation of position excursion during position reference system problems.	654	✓	✓	✓	✓			
		Tensioner stroke - available to DPO as confirmation of position excursion during position reference system problems.	655	✓	✓	✓	✓			
		Pipe tension – Manual input versus automatic. Potential for erroneous input to affect mathematical model – systems engine room approach taken to design of input.	656	✓	✓	✓	✓			
		Crane angle – Effect of failures, range of failure modes considered including erroneous angle.	657	✓	✓	✓	✓			

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	References and Sensors	Survey package – Effects of failures, IMCA S009 considered	658	✓	✓	✓				
		Analysis considers 'jabber' on serial interface from reference systems etc. casing process overload and loss of position.	659	✓	✓	✓				
		Analysis discusses all protective functions associated with rejecting an erroneous reference signal.	660	✓	✓	✓				
		Analysis discusses all protective functions associated with rejecting an erroneous vessel sensor signal.	661	✓	✓	✓				
	DP Alert and Comms.	Provision of DP status lights – hard wired or over network (should operate during total systems failure).	662	✓	✓	✓				
		Location of alarms and indication.	663	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
DP Control Systems	DP Alert and Comms.	Automatic functions related to position failure.	664	✓	✓	✓				
	Cable Routes	Cable route for thruster control and feedback.	665			✓				
		Philosophy of cable routing in respect of fire.	666			✓				
		Cable routes to vessel sensors and reference.	667			✓				
	Backup DP System	Independent and isolated from main DP system except for network connections etc.	668			✓				
		Isolation box for shared reference systems.	669			✓				
		Backup updated from main DP system.	670			✓				
		Backup should have separate climate control.	671			✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
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SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Emergency Shut Downs	ESDs	Drawing reference.	672	✓	✓	✓				
		I/O and field stations Split along lines of redundancy concept.	673	✓	✓	✓				
		Lower level shutdowns (below total) match redundancy concept so that one redundant machinery group can be shutdown at a time without loss of position.	674	✓	✓	✓				
		Effect on DP.	675	✓	✓	✓				
		Line monitoring to prevent operation in fire or flood.	676			✓				
		Isolation of batteries.	677	✓	✓	✓				
		Stop of battery charging on loss of ventilation.	678	✓	✓	✓				
		Failure modes of control system.	679	✓	✓	✓				
Protection against inadvertent operation.	680	✓	✓	✓						

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
DESCRIPTION				APPLICATION				GAP ANALYSIS		
SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Emergency Shut Downs	ESDs	No single button for ESD (total shutdown).	681	✓	✓	✓				
		No direct acting ESD (total shutdown) at external locations.	682	✓	✓	✓				
	F & G	Takes executive action or alarm only.	683	✓	✓	✓				
		If takes action, are the means to confirm fire robust e.g. combination of different types of detectors.	684	✓	✓	✓				
		Does action match split in redundancy concept.	685	✓	✓	✓				
		Does ventilation system introduce a common point in terms of smoke or gas ingestion.	686	✓	✓	✓				
	Thruster Emergency Stops	Hardwired.	687	✓	✓	✓				
		Available within easy reach of DPO.	688	✓	✓	✓				
		Button layout representative of thruster locations.	689	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
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Emergency Shut Downs	Thruster Emergency Stops	Line monitored.	690	✓	✓	✓				
		Alarm on failure of E-Stop power.	691	✓		✓				
	Group Emergency Stops	Split along lines of redundancy concept.	692	✓	✓	✓				
		Failure modes of actuators and valves.	693	✓	✓	✓				
		Failure modes of control system.	694	✓	✓	✓				
		Cable route considerations.	695			✓				
		Protection against inadvertent operation.	696	✓	✓	✓				
		Cause and effects for fans and flaps.	697	✓	✓	✓				
	Fans	Effect on loss of ventilation.	698	✓	✓	✓				
		Ventilation provided following redundancy concept.	699	✓	✓	✓				
		Alarms for compartment temperature.	700	✓	✓	✓				
	Flaps	Failure effect on loss of actuation power and control power.	701	✓	✓	✓				

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Emergency Shut Downs	Flaps	Link to ESD and F&G.	702	✓	✓	✓				
		Remote indication.	703	✓	✓	✓				
		Protection against inadvertent operation.	704	✓	✓	✓				
		Effect of pressure drop on engine crankcase pressure detectors.	705	✓	✓	✓				
	Watertight Doors	Actuation power and control power.	706			✓				
		Remote indication.	707			✓				
	Fire Fighting Systems	Control system.	708	✓	✓	✓				
		Pipe work and valves.	709	✓	✓	✓				
		Division between compartments.	710	✓	✓	✓				
		Protection against inadvertent operation.	711	✓	✓	✓				
	Quick Closing Valves	Split along lines of redundancy concept.	712	✓	✓	✓				
		Commonality between engine rooms.	713	✓	✓	✓				

DP FMEA GAP ANALYSIS - FMEA DOCUMENT NUMBER AXXXXX-X										
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SYSTEM	SUB SYSTEM	ITEMS FOR ANALYSIS	ID NO.	CLOSED BUSTIE OPERATION	OPEN BUSTIE OPERATION	DP CLASS 3	FAIL SAFE	CROSS REFERENCE TO FMEA	YES / PARTIAL / NO / NOT APPLICABLE GREEN / YELLOW / RED / GREY	CONCERN
Emergency Shut Downs	Quick Closing Valves	Failure mode of valves.	714	✓	✓	✓				
		Protection of valves.	715	✓	✓	✓				
		Protection against inadvertent operation.	716	✓	✓	✓				
Effects of Fire and Flooding DP Class 3	Philosophy and Concept	List of compartments, cable trunks etc. associated with DP related equipment.	717			✓				
		Cable routes (power and control) – Analysis refers to dedicated cable route drawings provide from DP Class 3 and confirms correct separation to A60 and WT.	718			✓				
		Fire subdivisions between redundant equipment.	719			✓				
		WT segregation below damaged waterline.	720			✓				

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Effects of Fire and Flooding DP Class 3	Philosophy and Concept	Effects of flooding in any compartment or group of compartments associated with large bore pipework.	721			✓				
		Pipe routes.	722			✓				