Petrofac

# OFFSHORE PROJECTS and OPERATIONS

# OSV RELUME

# DP FMEA PROVING TRIALS

# Following K-POS and BOW TUNNEL THRUSTER UPGRADES

# Tuesday 5th - Friday 15th May 2015

# MMS-MAR-15-0029-RJY-R01 - Part 2

| | | |
|---|---|---|
| Approval | Name: Captain David Jones | Date: 01/06/2015 |
| Marine Manager | Signature: | |

| | | |
|---|---|---|
| Originator | Name: Richard J. Younger | Date: 01/06/2015 |
| Marine Technical Superintendent | Signature: | |

IMCA Member

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| 1 | Petrofac Marine Services | File | Electronic |
| 2 | Master - OSV Relume | | Electronic |
| 3 | Chief Engineer - OSV Relume | | Electronic |
| 4 | Paul Dunn - Vessel Superintendent, MMSL | | Electronic |
| 5 | | | |
| 6 | | | |

## REVISION CONTROL

| Rev. No. | Description of Change | Author | Q.A. | | Approved | Date |
|---|---|---|---|---|---|---|
| | | | Tech. | Admin. | | |
| 00 | Blank For Comment | RJY | AM | SC | | 27/01/2015 |
| 01 | Updated following Client Comments and with Kongsberg 'AS BUILT' Specification | RJY | AM | SC | | 20/02/2015 |
| 02 | First Draft of Final Proving Trials Document.<br>Not for Submission to Class | RJY | | | | 16/05/2015 |
| 03 | For Issue | RJY | AM | SC | DJ | 19/05/2015 |
| 04 | For Issue - Close Outs Added | RJY | AM | SC | DJ | 01/06/2015 |

## ASSOCIATED DOCUMENTS

| Document No. | Document Title |
|---|---|
| MMS-MAR-15-0029-RJY-R01 - Part 1 | FMEA Report |
| MMS-MAR-15-0029-RJY-R01 - Part 3 | Drawings |
| | |

# TABLE OF CONTENTS

# 1.0 INTRODUCTION

## 1.1 Instructions Received

Petrofac Marine Services were requested to witness and approve for and on behalf of MMSL the KPOS upgrade CAT, CJoy CAT, HiPAP 501 Calibration Tests, perform and witness the DP proving trials of the OSV RELUME off Rotterdam, Netherlands and Kristiansand, Norway from 5th May 2015 to 15th May 2015. Instructions for attendance were received from Mr. Paul Dunn - Vessel Superintendent, MMSL.

## 1.2 Scope of Work

Petrofac Marine Services attended the OSV RELUME off Rotterdam, Netherlands from 1st May 2015 to 15th May 2015.

- Witnessed and approve the KPOS upgrade CAT, CJoy CAT Trials and HiPAP 501 calibrations tests
- Perform and witnessed the DP FMEA proving trials

These proving trials were compiled from the vessel's Failure Mode and Effect Analysis and have been formatted in accordance with IMCA M190 Guidance for Developing and Conducting Annual DP Trials Programmes for DP Vessels to show that the vessel meets the requirements of IMCA M 103, "Guidelines for the Design and Operation of Dynamically Positioned Vessels, IMO - Guidelines for Vessels with DP Systems 1994 (MSC645)".

The DP proving trials were carried out off Rotterdam, Netherlands and Kristiansand, Norway between 1st May 2015 to 15th May 2015 in varying weather conditions and water depths of between 24m and 500m.

The completed trials test sheets, CAT procedure sheets and HiPAP 501 calibration sheets together with the status report of the DP related equipment is appended to this trials report.

## 1.3 Key Personnel in Attendance at the Trials

| Name | Rank | Company |
|---|---|---|
| N. Michael | Master | MMSL |
| J. Thomas | Chief Officer | MMSL |
| A. McDonald | 2nd Officer | MMSL |
| K. Johnson | 2nd Officer | MMSL |
| A. Dingwall | 2nd Officer | MMSL |
| P. Dixon | Chief Engineer | MMSL |
| G. Barton | 1st Engineer | MMSL |
| T. Mortimer | 3rd Engineer | MMSL |
| G. MacDonald | 3rd Engineer | MMSL |
| J. Newsom | ETO | MMSL |
| P. Dunn | Vessel Superintendent | MMSL |
| H. L. Reekers | Senior Electrical Engineer Surveyor | Lloyd's Register Maritime |
| J. Jedryk | Hardware Engineer | Kongsberg |
| L. E. Hals | Software Engineer | Kongsberg |
| K. Strandabo | Software Engineer | Kongsberg |
| R. Visser | Technician | Rolls Royce |
| R. J. Younger | Marine Technical Superintendent | Petrofac Marine Services |

## 1.4 Order of Trials

Mr. R. J. Younger - Marine Technical Superintendent, representing Petrofac Marine Services, witnessed the Kongsberg K-Pos DP System CAT, Kongsberg CJoy independent joystick CAT, HiPAP 501 calibration tests and DP FMEA proving trials, which are attached to this document and noted relevant results, alarms and printouts of various tests and disconnections as required.

The trials were conducted off Rotterdam, Netherlands and Kristiansand, Norway at the following Rotterdam, Netherlands:-

| | **RR Engine Trials PS/SB Aft Azimuth and 2 x Bow Tunnel Thrusters** | **Kongsberg/RR Scaling - Tuning** | **K-Pos CAT Trials** |
|---|---|---|---|
| Time / Date: | Start: 07:30 hours 01/05/2015<br>End: 12:00 hours 01/05/2015 | Start: 13:00 hours 01/05/2025<br>End: 22: 30 hours 04/04/2015 | Start:14:00 hours 05/05/2015<br>End: 19:45 hours 07/05/2015 |
| Start Latitude: | N: 52 14.4781 | N: 52 14.2163 | N: 52 10.2722 |
| Start Longitude: | E: 003 59.5481 | E: 003 59.3591 | E: 003 58.3171 |
| Water Depth: | 22 metres | 23.3 metres | 24.0 metres |
| Prevailing Wind: | 12 kts @ $360^0$ | 15 kts @ $270^0$ | 16.9 m/s @ $215.0^0$ |
| Residual DP Current: | N/A | N/A | 1.3 m/s @ $232.0^0$ |
| Heading: | $310^0$ | $101^0$ | $230.0^0$ |

| | **CJoy CAT Trials** | **HiPAP Test/Calibration** | **Proving Trials** |
|---|---|---|---|
| Time / Date: | Start: 09:00 hours 07/05/2015<br>End: 13:00 hours 07/05/2015 | Start: 09:30 hours 11/05/2015<br>End: 15:00 hours 11/05/2015 | Start: 13:00 hours 05/05/2025<br>End: 22:30 hours 15/05/2015 |
| Start Latitude: | N: 52 13.7725 | N: 58 06.8664 | N: 52 10.9066 |
| Start Longitude: | W: 003 59.4089 | W: 008 02.5812 | W: 004 00.1252 |
| Water Depth: | 24 metres | 200 metres | 21 metres |
| Prevailing Wind: | 10.2 m/s @ $260.0^0$ | 6.3 m/s @ $200^0$ | 15.1 kts @ $348^0$ |
| Residual DP Current: | 1.0 m/s @ $234.0^0$ | 0.3 m/s @ $310^0$ | 1.9 kts @ $042^0$ |
| Heading: | $242^0$ | $231.2^0$ | $026.8^0$ |

During the trial all important DP equipment was available.

## 1.5 Requirement During Testing

1.5.1 During the trials all relevant shipboard equipment is required to be fully operational. In particular, all propulsion units and their controls, both manual and automatic, all power generation equipment and all computer systems must be fully functional, including their alarms, standby units, battery backups, shutdowns, trips, etc.

1.5.2 All tests are to be co-ordinated by the independent auditor, with approval from the Master, and with full regard to the safety of navigation of the vessel.

1.5.3 All tests will be carried out in realistic environmental conditions or with some varying load on the system induced by movements of the vessel.

1.5.4 During the trials, the vessel staff will assist as required in recording alarms and failure locally (locally means not only at the DP console but also at the ECR, thruster room, etc.).

1.5.5 During failure tests, the system must not be reinstated until the operators, ECR staff and auditor are satisfied they understand the full effects of the failure and that all the information or indicators to show what has occurred have been noted.

1.5.6 When reinstating systems after failure simulations, two engineers will check that circuit breakers have been reinstated. Only when everyone is satisfied that the system has been reset and has stabilised, will the trials continue.

1.5.7 If there are any doubts about a test, it will be repeated. If test results are unexpected, then the test will also be repeated. It should be noted that seemingly small or spurious faults in control systems may be the first manifestations of a more serious problem.

1.5.8 Tests will continue only when all those involved have been informed and, where necessary, suitable communications have been set up, e.g. DP console to thruster room.

1.5.9 The tests will not only prove hardware redundancy and vessel capability after failures but also that the operators have the necessary training and experience to use the system and deal successfully with such failures.

## 1.6 IMO Definition of DP Class 2

Quote from IMO MSC/Circ. 645 for DP Classes

> ***2.2 The equipment classes are defined by their worst case failure modes as follows:***
>
> ***.2 For equipment class 2, a loss of position is not to occur in the event of a single fault in any active component or system. Normally static components will not be considered to fail where adequate protection from damage is demonstrated, and reliability is to the satisfaction of the Administration. Single failure criteria include:***
>
> ***.1 Any active component or system (generators, thrusters, switchboards, remote controlled valves. etc.).***
>
> ***.2 Any normally static component (cables, pipes, manual valves, etc.) which is not properly documented with respect to protection and reliability.***
>
> ***2.3 For equipment classes 2 and 3, a single inadvertent act should be considered as a single fault if such an act is reasonably probable.***

As per class notation (DPS (AA)) and IMO MSC/Circ. 645 DP Class 2 the vessel must be designed and commissioned to comply with the following basic rules:-

- automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault excluding loss of a compartment due to fire or flood
- two independent computer systems
- at least three different position references
- at least three sets of sensors

As a minimum the following must be provided:-

- 2 x VRS / MRU
- 2 x wind sensors
- 3 x gyro compass

## 1.7 Basic Requirements for LR Class Notation DP (AA)

- All systems necessary for the correct functioning of the DP system are to be configured such that a fault in any active component or system will not result in a loss of position.

- Passive components such as cables and pipes are to be located and protected such that the risk of fire or mechanical damage is minimised.

- No single fault in the generation and distribution systems is to result in the loss of more than 50 percent of the generating capacity.

- Two independent automatic control systems are to be provided and arranged such that no single fault will cause loss of both systems, a fault in one causing automatic bumpless transfer to the backup system.

- At least three position reference systems incorporating at least two different measurement techniques are to be provided and are to be arranged so that a failure in one system will not render the other systems inoperative.

- At least three gyrocompasses and two vertical reference units, if necessary, are to be provided.

## 2.0 VESSEL PARTICULARS

### 2.1 General

| | |
|---|---|
| Name: | OSV RELUME |
| Port of Registry: | Nassau |
| Flag: | Bahamas |
| Built: | 2004 |
| Classification Society: | Lloyd's Register of Shipping: 100A1 + LMC<br>UMS, DP(AA), NAV, IBS. SPS Code compliant |
| Length (LOA): | 82.6 m |
| Breadth: | 16.5 m |
| Design Draught: | 4.0 m |
| IMO Number: | 9280720 |
| Call Sign: | C6TR4 |
| GRT: | 3526 |

### 2.2 Power Generation and Propulsion

Main Engines: 2 x Diesel Engines of type: Wärtsilä 8L20/C2.1317kW, driving Alternators of type: ALCONZA - NIR 5670 A-8LW, 900rpm, 1300kW, 1625 kVA at 0.8 Pf, 3-phase, 690V, 60Hz

2 x Diesel Engines of type: Wärtsilä 6L20/C2. 988kW, driving Alternators of type: ALCONZA - NIR 5656 A-8LW, 900rpm, 1000kW, 1250kVA, 0.8 Pf, 3-phase, 690V, 60Hz

Main Switchboard: 2 x 690V, 2 x 440V and 2 x 230V

The thruster and propulsion system consists of:-

2 x aft azimuth propellers of type:-
- RR Marine Aquamaster US205 P20/3500 1500kW fixed pitch variable speed

2 x bow tunnel thrusters of type:-
- Rolls Royce TT1650 DPN CP tunnel thrusters (700kW each)

All thrusters are electrically driven and supplied from the 690V switchboard system.

## 2.3 Vessel Power Management System (PMS)

The vessel has an alarm, monitoring and power management system supplied by Imtech of type: RICOM 3500.

## 2.4 DP Control System

The vessel has a Kongsberg KPos DP system with three OS stations (one forward and one on each bridge wing aft).

## 2.5 Independent Joystick System

The vessel is equipped with a Kongsberg Marine C-Joy independent joystick system.

## 2.6 DP Sensors

- Gyro: 3 x Navigat X Mk1 Mod 10-4914
- VRS/MRU: 2 x Seatex, MRU 5 + MRU H
- Wind Sensors: 2 x RM Young

## 2.7 DP Reference Systems

- 1 x VERIPOS Ultra - DGPS1
- 1 x Simrad MX612 – DGPS2
- 1 x C-Nav - DGPS3
- 1 x Kongsberg HiPAP 501
- 1 x Kongsberg Radius 1000
- 1 x Fanbeam (unit hired for proving trials only, not normally fitted)
- 1 x Bandak 14B Light Weight Taut Wire

## 2.8 FME(C)A

MMS-MAR-14-0013-RJY-R01

## 2.9 Upgrades to Vessel since Previous Trials

A full Kongsberg upgrade from SDP to K-Pos

Both tunnel thrusters upgraded to RR - TT1650 DPN CP

DGPS 2 replaced with Simrad MXB612

Kongsberg Radius 1000 system added

HiPAP upgraded to Kongsberg 501 System

NAVIKNOT 600 SDT Speed Log added

## 2.10 Machinery Configuration for Trials

- In DP2 Mode (Consequence Analysis Active)
- All four DG engines running/available (Auto Standby Start as spinning reserve)
- DGs 1 and 3 connected to port 690V SWBD
- DGs 2 and 4 connected to stb'd 690V SWBD
- 690V SWBD bus tie OPEN
- 440V SWBD bus tie OPEN
- MSB 230V supplied via transformer from port 440V MSB
- NSB 230V supplied via transformer from stb'd 440V MSB
- ENSB PS and ENSB SB supplied from MSB 230V
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.

**Specific test configurations may vary in order to safely simulate failures.**

## 3.0 CONCLUSIONS

### 3.1 Trials Conclusions

Petrofac Marine Services witnessed the DP annual trials on the OSV RELUME and from the findings of the trials, subject to the correction of any unexpected results and major recommendations, the vessel are considered fit for purpose within its operational capability without exception.

### 3.2 Documentation

All DP documentation has been inspected and was found up to date.

### 3.3 Machinery Maintenance

All machinery maintenance records have been inspected and were found up to date.

### 3.4 DP System Maintenance

All DP maintenance records have been inspected and were found up to date.

### 3.5 Incidents

No DP incidents have been recorded within the last 12 months

### 3.6 Power Generation

The tests successfully demonstrated power generation, load sharing and shedding to be fully effective. Each generator was demonstrated as being able to deliver full power.

### 3.7 Power Distribution

The tests successfully demonstrated the power distribution system redundancy.

### 3.8 Power Management

The tests successfully demonstrated the power management system.

### 3.9 Control Loops

Control loops for the thruster (command and feedback) were successfully demonstrated, with the exception of the failure of the Kongsberg Command Signals to the Azimuth Steering of both Port & Starboard Aft Azimuth Thrusters.

See 'B' Recommendations 4.3.1 and 4.3.2

### 3.10 Environmental and Heading Sensors

All sensors were tested under normal and failed conditions and found to be satisfactory.

### 3.11 Position References

All available reference systems were tested under normal and failed conditions and found to be satisfactory.

### 3.12 DP Control

The tests successfully demonstrated the DP and independent joystick controls.

### 3.13 Personnel

Petrofac Marine Services would like to express their gratitude towards the Master and crew of the OSV RELUME for all their professionalism, help, hospitality and assistance received during the trials.

## 4.0 FINDINGS

### 4.1 Findings from Trials

Recommendations are made in three categories as follows:-

'A' For immediate attention and should be implemented to comply with DP Class 2

'B' Should be implemented as soon as practicable

'C' Are desirable or for enhancement of systems

During the trials on the OSV RELUME conducted off Rotterdam, Netherlands and Kristiansand, Norway between 5th May 2015 and 15th May 2015 the following recommendations were made:-

| | | |
|---|---|---|
| A | Nil | Recommendations were found and identified during the trials |
| B | 2 | Recommendations were found and identified during the trials |
| C | Nil | Recommendation was found and identified during the trials |
| Observations | | Nil |

### 4.2 'A' - Findings

No 'A' Recommendations were noted.

## 4.3 'B' - Findings

### 4.3.1 SUB SYSTEM 3 - THRUSTERS

| | |
|---|---|
| Test 34 | Azimuth Thrusters (PS) - Azimuth Signal Failures |
| Step 1 | Fail azimuth command signal from DP to ACU, restore. (WU4 U41 X4 4, 5) |
| Expected Results | Alarm, **'AZIMUTH AFT P NOT READY'**, drops out of DP, rotation freezes. RPM to Zero |

The failure of the Kongsberg Azimuth Command Signal (DP to ACU - Thruster Control Cabinet) resulted in an alarm in DP and **'AZIMUTH AFT P PREDICTION ERROR AZIMUTH'** , the azimuth rotated to the zero position (parking position) and the RPM went to the default value of 79 RPM (not zero).

Change in thrust vector produced an immediate **'Heading out of limits'** alarm.

Failure of the Rolls Royce Azimuth Command Signal (ACU-Thruster Control Cabinet to Thruster) produced the 'As expected' result: **'THRUSTER AFT P NOT READY'**, thruster dropped out of DP, azimuth freeze and RPM to zero.

This unexpected result was reported by the Kongsberg Hardware Engineer on board (Mr. J. Jedryk) and their Software Department are investigating the problem.

As a temporary measure until such time as a fix is fully implemented and tested a prominent sign should be displayed at all DP Operating Stations to the following effect:-

'IF AN **'AZIMUTH AFT P/S PREDICTION ERROR AZIMUTH'** OCCURS EITHER PORT OR STARBOARD AFT AZIMUTH THRUSTER, IMMEDIATELY DESELECT THAT THRUSTER FROM DP'

A blank trials sheet for Test 34 has been left with the Master.

Once a fix has been implemented the blank trials sheet Step 1 should be completed after suitable sea trials, all alarms and parameters noted, stamped, signed and returned to Petrofac Marine Services for close out.

**CLOSED** - PMS 29/05/2015.
See Appendix 2 Pages 89-93.

### 4.3.2 SUB SYSTEM 3 - THRUSTERS

| | |
|---|---|
| Test 36 | Azimuth Thrusters (SB) - Azimuth Signal Failures |
| Step 1 | Fail azimuth command signal from DP to ACU, restore. (WU7 U71 X4 4, 5) |
| Expected Results | Alarm, **'AZIMUTH AFT S NOT READY'**, drops out of DP, rotation freezes. RPM to zero. |

The failure of the Kongsberg Azimuth Command Signal (DP to ACU - Thruster Control Cabinet) resulted in an alarm in DP and **'AZIMUTH AFT S PREDICTION ERROR AZIMUTH'**, the azimuth rotated to the zero position (parking position) and the RPM went to the default value of 79 RPM (not zero).

Change in thrust vector produced an immediate **'Heading out of limits'** alarm.

Failure of the Rolls Royce Azimuth Command Signal (ACU-Thruster Control Cabinet to Thruster) produced the 'As expected' result: **'THRUSTER AFT S NOT READY'**, thruster dropped out of DP, azimuth freeze and RPM to zero.

This unexpected result was reported by the Kongsberg Hardware Engineer on board (Mr. J. Jedryk) and their Software Department are investigating the problem.

As a temporary measure until such time as a fix is fully implemented and tested a prominent sign should be displayed at all DP Operating Stations to the following effect:

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A blank trials sheet for Test 34 has been left with the Master.

Once a fix has been implemented the blank trials sheet Step 1 should be completed after suitable sea trials, all alarms and parameters noted, stamped, signed and returned to Petrofac Marine Services for close out.

**CLOSED** - PMS 29/05/2015.
See Appendix 2 Pages 94-98.

## 4.4 'C' - Findings

No 'C' Recommendations were noted.

Please Note:-

It is the owner's responsibility to process and close out any recommendations given, providing documentary evidence of such close outs necessary to update this document.

## 5.0 STATUS REPORT

### 5.1 Thrusters

| | BT(1) | BT(2) | AZ PS | AZ SB |
|---|---|---|---|---|
| Maintenance Records Checked | ✓ | ✓ | ✓ | ✓ |
| Outstanding Maintenance | Nil | Nil | Nil | Nil |
| Last Oil Analysis (Date) | Oil Renewed January 2015 | Oil Renewed January 2015 | Oil Renewed January 2015 | Oil Renewed January 2015 |
| Last Oil Analysis Condition | ✓ New | ✓ New | ✓ New | ✓ New |
| Running Hours | NA | NA | 64098 | 64338 |
| **Remarks:** | Azimuth P & S oil renewed following full overhaul January 2015.<br>Bow thrusters 1 and 2 oil renewed. New upgraded units fitted January 2015. | | | |

### 5.2 Generator Engines

| | GE1 | GE2 | GE3 | GE4 |
|---|---|---|---|---|
| Maintenance Records Checked | ✓ | ✓ | ✓ | ✓ |
| Outstanding Maintenance | Nil | Nil | Nil | Nil |
| Last Oil Analysis (Date) | 08/02/2015 | 08/02/2015 | 06/11/2014 | 06/11/2014 |
| Last Oil Analysis Condition | ✓ Normal | ✓ Normal | ✓ Normal | ✓ Normal |
| Running Hours | 51611 | 51660 | 42218 | 42129 |
| Last Generator Engine Governor Adjustment | January 2014 | January 2014 | May 2012 | May 2012 |
| **Remarks:** | DG 3 and 4: Serviced January 2014<br>DG 1 abd 2: Serviced May 2012 | | | |

## 5.3 Switchboard

| Circuit Breakers | Date | Company |
|---|---|---|
| Switchboard Ties | March 2015 | CROON/IMTECH, Netherland |
| Generator Breakers | March 2015 | CROON/IMTECH, Netherland |
| Thruster Breakers | March 2015 | CROON/IMTECH, Netherland |
| **Remarks:** | BT1: ACB Renewed - March 2015 | |

## 5.4 DP UPS

| Unit | Battery Check | Comments |
|---|---|---|
| **UPS 1** | ✓ | 30 min. duration test carried out during proving trials 15th May 2015. |
| **UPS 2** | ✓ | |
| **Remarks:** UPS 1 and 2 new at refit - 2014/2015 | | |

## 5.5 Sensors

| Sensor Records | Checked | Comments |
|---|---|---|
| MRU 1 - Seatex, MRU H | ✓ | Last Service: February 2014 |
| MRU 2 - Seatex, MRU 5 | ✓ | Last Service: December 2014 |
| Gyro 1 - Navigat X Mk1 | ✓ | Last Service: February 2015 |
| Gyro 2 - Navigat X Mk1 | ✓ | Last Service: February 2015 |
| Gyro 3 - Navigat X Mk1 | ✓ | Last Service: February 2015 |
| Wind Sensor 1 - RM Young | ✓ | |
| Wind Sensor 2 - RM Young | ✓ | |
| DGPS 1 - VERIPOS Ultra | ✓ | Upgraded to LD6-GG2. February 2015 |
| DGPS 2 - Simrad MX612 | ✓ | New 2015 |
| DGPS 3 - C-Nav | ✓ | Software upgrade February 2014 |
| Kongsberg HiPAP 501 | ✓ | New 2015 |
| LWTW - Bandak Mk 14B | ✓ | Last Service: |
| Radius 1000 | ✓ | New 2015 |
| Fanbeam - MDL 4.2 | ✓ | Unit hired for proving trials only, not normally fitted. |
| **Remarks:** | | |

## 5.6 DP Control Systems

| | |
|---|---|
| Type of system? | Kongsberg K-Pos |
| Has firmware upgrade been installed? *(Kongsberg K-Pos systems only)* | Date performed:- 24th September 2014 |
| Maintenance checked? | Full K-Pos Upgrade April 2015 |
| Last software revision? | 8.2.2 |

**Remarks:**

| | |
|---|---|
| **Delivery:** | MENAS RELUME |
| **Product:** | K-Pos |
| **SW Delivery:** | DP6732_CD_MIRROR_06-05-2015 |
| **SW Basis:** | 8.2.2 |
| **GMS:** | 61d_p1_LIF |
| **AK:** | 5.3.1.2 |
| **OSK:** | 2.10.2.44 |
| **PCK:** | 2.9.2.44 |
| **Windows:** | 6.1 Service Pack 1 (Build 7601) |
| **Panel:** | 03.00 |
| **DpOS.exe:** | Generated: 17:21:14 3 May 15 |

## 5.7 Hardware Modifications

| | |
|---|---|
| Have there been any modifications since last annual trials? | Full Kongsberg K-Pos upgrade |
| Have modifications been thoroughly tested? | Yes |
| Have trials procedures (Part 2) been updated? | Yes |

## 5.8 Capability and Footprint Plots

| | |
|---|---|
| Are the correct capability plots on board? Plots should include the intact state and post worst case failure state as a minimum. | Yes - new calculations performed by Kongsberg. Not yet received on board. |
| Are there verifying footprints on board? | Module for producing verifying footprints on screen from within the K-Pos System. |

## 5.9 Incidents

| | |
|---|---|
| Have any incidents been recorded? Incidents maybe recorded using the IMCA reporting format or the company's own reporting process. | No |
| If yes, number of incidents. | N/A |
| Is there a documented satisfactory explanation? Give brief details as appropriate. | N/A |

## 5.10 Key Vessel DP Personnel

| Name | Position | Training | Experience |
|---|---|---|---|
| N. Michael | Master | Certificate No: 383<br>Issued: 17/04/1991 | >10 years |
| J. Thomas | Chief Officer | Certificate No: 5021<br>Issued: 25/08/2005 | 9.5 years |
| A. McDonald | 2nd Officer | Certificate No: 14458<br>Issued: 05/05/2011 | 4 years |
| A. Dingwall | 2nd Mate | Certificate No: 9621<br>Issued: 12/06/2009 | 6 years |
| P. Dixon | Chief Engineer | N/A - SDP 21 Maintenance | 9 years |
| J. Newsom | ETO | K-Pos Maintenance<br>04/09/2014 | >10 years |
| Remarks | | | |

## 5.11 FMEA and Trials

| | Remarks |
|---|---|
| **FMEA - Last Revision and Date:** | 24025-0912-16117 \| Revision 9 - 30/05/2013<br>New FMEA in progress for K-Pos upgrade.<br>MMS-MAR-15-0029-R01 |
| Have all findings been closed out? | Yes |
| Any findings arising from the FMEA which are not documented as being closed out should be entered in the remarks column? | N/A |
| **Last Annual DP Trials - Date:** | These are the DP FMEA proving trials following a full K-Pos upgrade.<br>MMS-MAR-15-0029-RJY-R01 - Part 2 |
| Have all findings been closed out? | |
| Have any open findings been included in the relevant section of this report? | |

## 5.12 Other Documentation

| | Remarks |
|---|---|
| Is there a vessel specific DP Operations Manual as described in IMCA M103 Section 1.5?<br>Does the DP Operations Manual include an Operational Planning Section as described in IMCA M 220? | Yes - new section added to cover IMCA M220, Operational Planning. |
| Are there appropriate checklists covering field arrival trials, Rotterdam, Netherlands checklists, periodic checklists as appropriate for bridge and engine room? | Yes - tick box added to bridge six hourly check list to cover IMCA M220. |
| Is a DP logbook kept up to date? | Yes |
| Do the key DP personnel have access to appropriate IMCA guidance documents either via internet or hard copy? | Yes |
| Are records available for vendor visits for repair or service of DP system components? | Yes - Full K-Pos upgrade April/May 2015.<br>All documented. |

## 6.0 TEST RESULTS

### 6.1 Equipment Sub-System 1 - Electrical / Power Management

| 6.1.1 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL | | | |
|---|---|---|---|
| **Test: 1** | Simulate S/C on Port Main 690 Bus Bar (BB1 PS) | | |
| **Equipment Configuration:** | | | |
| • In DP2 mode (consequence analysis active).<br>• All four DG engines running/available.<br>• DGs 1 and 3 connected to port 690V SWBD.<br>• DGs 2 and 4 connected to stb'd 690V SWBD.<br>• 690V SWBD bus tie **OPEN.**<br>• 440V SWBD bus tie **OPEN.**<br>• MSB 230V supplied via transformer from port 440V MSB.<br>• NSB 230V supplied via transformer from stb'd 440V MSB.<br>• ENSB PS and ENSB SB supplied from MSB 230V.<br>• DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.<br>• Emergency generator in auto start mode. All available reference systems active. | | | |
| **Method:** | | | |
| **Reduce number of DG on line supplying BB1 to one**<br>1. Trip the breaker of the remaining online DG. | | | |
| **Results expected:** | | | |
| 1. Blackout of PS 690V switchboard. Loss of BT fwd (T1) and port azimuth (T3), loss of connected consumers. BT1 servo failure and loss of hydraulics.<br>• Connected pumps stop, alarm and auto changeover to power from starboard switchboard.<br><br>Vessel maintains position with remaining thrusters. | | | |
| **Results found:** | | | |
| 1. As expected. | | | |
| **Comments:** | | | |
| | | | |
| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |

## 6.1.2 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

| Test: 2 | Simulate S/C on Starboard Main 690 Bus Bar (BB2 SB) |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**Reduce number of DG on line supplying BB2 to one**

1. Trip the breaker of the remaining online DG.

**Results expected:**

1. Blackout of SB 690V switchboard. Emergency generator auto starts and connects. Loss of bow thruster 2 (T2) and stb'd azimuth (T4).
   - Connected pumps stop, alarm and auto changeover to power from port switchboard.

   Vessel maintains position with remaining thrusters.

**Results found:**

1. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

### 6.1.3 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

| Test: 3 | Simulate S/C on 440V Bus Bars Port and Starboard |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB
- NSB 230V supplied via transformer from stb'd 440V MSB
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each 440V bus bar section:**

1. Trip supply to port section, restore.
2. Trip supply to starboard section, restore.

**Results expected:**

1. Loss of port azimuth (T3), fwd BT (T1). Loss of consumers from port section, SW and FW pumps auto changeover to stand by pumps supplied from stb'd section. No loss of position.
2. Loss of stb'd azimuth (T4), aft BT (T2). Loss of consumers from starboard section, SW and FW pumps auto changeover to standby pumps supplied from port section. Emergency generator auto starts and connects.

   No loss of position.

**Results found:**

1. As expected.
2. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.4 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

| Test: 4 | Simulate Loss of 440V / 230V Transformers T1 and T2 |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.

All available reference systems active.

**Method:**

**Set up with transformer T1 online.**

1. Trip the breaker supplying T 1, restore. (PS Q10.10 440V MSB).

**Set up with transformer T2 online.**

2. Trip the breaker supplying T 2, restore. (SB Q1.10 440V MSB).

**Results expected:**

1. Loss of 230V port section consumers, no loss of DP functions.
2. Loss of 230V stb'd section consumers, no loss of DP functions.

**Results found:**

1. As expected.
2. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.5 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 5** Simulate Short Circuit of Individual Main 440V Distributions (PS)

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail each main 440V distribution (PS) in turn, restore.

| DB No. | Description |
|---|---|
| 1. | PDP 1 - (Q10.9) |
| 2. | PDP 2 - (Q10.8) |
| 3. | WS PDP 1 - (Q9.8) |
| 4. | Galley DP - (Q9.7) |
| 5. | HVAC Contr. Vent - (Q10.4) |
| 6. | HVAC Contr. AC3 - (Q9.9) |
| 7. | GSP 1 - (Q8.8 and ESB 10Q3) Dual Supply |
| 8. | Reefer PDP 2 - (Q10.6) |
| 9. | HVAC CP AC2 - (Q10.1 and ESB 8Q4) Dual Supply |

**Results expected:**

| PDP 1 | PDP 2 | WS PDP 1 | Galley DP | HVAC Contr. Vent |
|---|---|---|---|---|
| No loss of DP Function | Loss of PS Propulsion | No loss of DP Function | No loss of DP Function | No loss of DP Function |
| **HVAC Contr. AC3** | **GSP 1** | **Reefer PDP 2** | **HVAC CP AC2** | |
| No loss of DP Function | Loss of BT1 | No loss of DP Function | No loss of DP Function | |

**Results found:**

| PDP 1 | PDP 2 | WS PDP 1 | Galley DP | HVAC Contr. Vent |
|---|---|---|---|---|
| As expected | As expected | As expected | As expected | As expected |

| HVAC Contr. AC3 | GSP 1 | Reefer PDP 2 | HVAC CP AC2 |
|---|---|---|---|
| As expected | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.6 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 6** Simulate Short Circuit of Individual Main 440V Distributions (SB)

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Fail each main 440V distribution (SB) in turn, restore.

| DB No. | Description |
|---|---|
| 1. | HVAC Contr. AC2A Mech. Vent - (Q2.10 and ESB 11Q1) Dual Supply |
| 2. | HVAC Contr. AC1 - (Q10.2 and Q2.9) Dual Supply |
| 3. | Reefer PDP 1 - (Q10.6) |
| 4. | PDP 4 - (Q1.8) |
| 5. | WS PDP 2 - (Q2.8) |
| 6. | GSP 2 - (Q3.8 and ESB 10Q4) Dual Supply |

**Results expected:**

| | HVAC Contr. AC2A Mech. Vent | HVAC Contr. AC1 | Reefer PDP 1 |
|---|---|---|---|
| 1 | No loss of DP function | No loss of DP function | No loss of DP function |

| | PDP 4 | WS PDP 2 | GSP 2 |
|---|---|---|---|
| 1 | No loss of DP function | No loss of DP function | Loss of BT2 |

No loss of DP function.

**Results found:**

| | HVAC Contr. AC2A Mech. Vent | HVAC Contr. AC1 | Reefer PDP 1 |
|---|---|---|---|
| 1 | As expected | As expected | As expected |

| | PDP 4 | WS PDP 2 | GSP 2 |
|---|---|---|---|
| 1 | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.7 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 7** Simulate Short Circuit of Individual 230V Distributions (MSB 230)

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail each 230V distribution (supplied from **MSB 230**) in turn, restore.

| DB No. | Description |
|---|---|
| 1. | NLDP3 (12Q1) |
| 2. | NLDP4 (12Q3) |
| 3. | NLDP5 (12Q5) |
| 4. | Galley DP 230V (12Q7) |
| 5. | WS PDP2 (13Q1) |

**Results expected:**

1. No loss of DP function.

**Results found:**

| | NLDP3 | NLDP4 | NLDP5 | Galley DP 230V | WS PDP2 |
|---|---|---|---|---|---|
| 1 | As expected | As expected | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.8 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 8** Simulate Short Circuit of Individual 230V Distributions (NSB 230)

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail each 230V distribution (supplied from **NSB 230**) in turn, restore.

| DB No. | Description |
|---|---|
| 1. | NLDP1 (NSB - 12Q1) |
| 2. | NLDP2 (NSB - 12Q2) |
| 3. | WS PDP1 (NSB - 12Q5) |

**Results expected:**

1. No loss of DP function.

**Results found:**

| | NLDP1 | NLDP2 | WS PDP1 |
|---|---|---|---|
| 1 | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.9 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 9** Simulate Short Circuit of Individual 230V Distributions (ENSB PS 230)

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail each 230V distribution (supplied from **ENSB PS 230**) in turn, restore.

| DB No. | Description |
|---|---|
| 1. | NDP 1 (ENSB - 31Q1) |
| 2. | NDP 3 (ENSB - 31Q2) |
| 3. | DP UPS 1 (ENSB - 33Q1) |

**Results expected:**

1. No loss of DP function.

**Results found:**

| | NDP1 | NDP2 | DP UPS 1 |
|---|---|---|---|
| 1 | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R.J.Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.10 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 10** Simulate Short Circuit of Individual 230V Distributions (ENSB SB 230)

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail each 230V distribution (ENSB SB 230) in turn, restore.

| DB No. | Description |
|---|---|
| 1. | NDP2 (ENSB SB 41Q1) |
| 2. | NDP4 (ENSB SB 41Q2) |
| 3. | NDP6 (ENSB SB 41Q3) |
| 4. | DP UPS 2 (ENSB SB 43Q2) |

**Results expected:**

1. No loss of DP function.

**Results found:**

| | NDP2 | NDP4 | NDP6 | DP UPS 2 |
|---|---|---|---|---|
| 1 | As expected | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.11 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 11** Simulate Short Circuit of Individual Emergency 440V Distributions

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail each 440V distribution (ESB) in turn, restore.

| DB No. | Description |
|---|---|
| 1. | EPDP1 (ESB 440V - 10Q8) |

**Results expected:**

1. Loss of stb'd aft azimuth.

**Results found:**

| | EPDP1 |
|---|---|
| 1 | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.12 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 12** Simulate Short Circuit of Individual Emergency 230V Distributions

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail each 230V distribution (ENSB SB 230) in turn, restore.

| DB No. | Description |
|---|---|
| 1. | ELDP1 (ESB 230V - 11Q6) |
| 2. | ELDP2 (ESB 230V - 11Q8) |
| 3. | ELDP3 (ESB 230V - 12Q1) |
| 4. | ELDP4 (ESB 230V - 12Q3) |
| 5. | ELDP5 (ESB 230V - 12Q5) |

**Results expected:**

1. No loss of DP function.

**Results found:**

| | ELDP1 | ELDP2 | ELDP3 | ELDP4 | ELDP5 |
|---|---|---|---|---|---|
| 1 | As expected | As expected | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.13 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 13** Simulate Loss of Supply to Emergency Switchboard

**Equipment Configuration:**

- In DP2 Mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Fail 230V supply to emergency generator start battery charger, restore. (ESB 13Q3)
2. Trip the 230V supply breaker on the EM switchboard, restore. (10Q6)
3. Trip the 440V supply breaker on the main switchboard.

**Results expected:**

1. Alarm, **'CHARGER START BATTERY EM GEN FAIL'.**
2. Loss of ESB 230V consumers - no loss of DP functions.
3. Blackout of ESB. Emergency generator auto starts and connects (5 sec.), loss of stb'd azimuth (T4).

No loss of position.

**Results found:**

1. As expected.
2. As expected.
3. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.14 EQUIPMENT SUB-SYSTEM 1 - ELECTRICAL

**Test: 14** Simulate Failures of the 24VDC Systems

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.

**Method:**

**For each 24VDC distribution system in turn:**

1. Fail main switchboard supply to MSB1 24V, restore. (MSB 440V PS PDP1 Q1)
2. Fail emergency switchboard supply to MSB2 24V, restore. (ESB 440V 14Q4)

**For each battery bank in turn MSB1 24V and MSB2 24V.**

3. Fail main supply and test battery duration for 30 mins, restore
4. Simulate 24V S/C MSB 1 by tripping all breakers to consumers, restore.
5. Simulate 24V S/C MSB 2 by tripping all breakers to consumers, restore.

**Results expected:**

1. Alarm, '**BATTERY CHARGER 24V WHEELHOUSE FAIL**'.
2. Alarm, '**BATTERY CHARGER 24V ER FAIL**'.
   24VDC consumers auto changeover to battery backup.
3. Battery duration >30 mins.
4. **MSB1 S/C:** Loss of port azimuth ACU, loss all port azimuth indicators (ECR and bridge). Alarm, '**THRUSTER 3 NOT READY**', azimuth freezes, speed to zero, thruster rejected from DP. (Thruster failure condition confirmed by manual sighting at thruster local indicators.)
5. **MSB2 S/C:** Loss of stb'd azimuth ACU, loss all stb'd azimuth indicators (ECR and bridge). Alarm, '**THRUSTER 4 NOT READY**', azimuth freezes, speed to zero, thruster rejected from DP. (Thruster failure condition confirmed by manual sighting at thruster local indicators.)

**Results found:**

1. As expected.
2. As expected.
3. As expected.

| MSB1 24V | | | |
|---|---|---|---|
| **Start Time** | 13:45 hours | **Start Volts** | 25.5 V |
| **End Time** | 14:15 hours | **End Volts** | 24.69 V |
| **MSB2 24V** | | | |
| **Start Time** | 13:10 hours | **Start Volts** | 25.5 V |
| **End Time** | 13:40 hours | **End Volts** | 24.69 V |

4. As expected.
5. As expected.

**Comments:**

**Note:-** Manual changeover to 440V backup supply for battery chargers.
All batteries renewed March 2015.

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.15 EQUIPMENT SUB-SYSTEM 1 - POWER MANAGEMENT

**Test: 15** Simulate Loss of Power Supply to PMS and Alarm System

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each DG**

1. Fail 230V supply to Praxis AMCS UPS, restore. (ESB 230V - 13Q5)
2. Fail and restore the 24VDC supply to PMS, restore. (DG3-DP24V Q8, DG 1-Q9)( DG4-MSB2 24V Q8, DG 2-Q9)
3. Fail power supply to client computer from UPS, restore.
4. Fail power supply to server computer from UPS, restore.

**Results expected:**

1. Alarm. **'UPS AIM 230V FAIL'**. Supply to 24VDC UPS consumers from battery backup.
2. No immediate effects.
3. Loss of alarm and monitoring system. No effect
4. Loss of monitor. No effects.

**Results found:**

1. As expected.

| | DG1 | DG2 | DG3 | DG4 |
|---|---|---|---|---|
| 2. | As expected | As expected | As expected | As expected |

3. As expected.
4. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.16 EQUIPMENT SUB-SYSTEM 1 - POWER MANAGEMENT

**Test: 16** PMS Functions

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each 690V main bus bar (port and stb'd), set-up with one diesel generator running, the other in StBy start mode.**

1. Increase the load on bus bar, i.e. input move on DP, or operate in manual joystick.
2. Test heavy load consumers start inhibits (attempt to start a bow thruster).

**Results expected:**

1. Standby generator starts and connects. (Set at 50% load start for DP2 Operations)
2. Start blocked until 2nd generator starts and connects.

**Results found:**

| | BB1 (PS) | BB2 (SB) |
|---|---|---|
| 1. | As expected | As expected |
| 2. | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.17 EQUIPMENT SUB-SYSTEM 1 - POWER MANAGEMENT

**Test: 17** Failure of kW and Bus Tie Signals

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

**All DGs on line.**

1. For each DG: Disconnect kW signal cable from DP system
   (DG1 PS/Aft Load: WU4 U42 X1 2, 3) (DG2 PS/Fwd Load: WU4 U43 X1 2, 3)
   (DG3 SB/Fwd Load: WU7 U72 X1 2, 3) (DG4 SB/Aft Load: WU7 U73 X1 2, 3)
2. Disconnect bus tie status signal from DP system. (WU4 U43 X2 1, 3)

**Results expected:**

1. DP shows loss of generator on mimic, load still appears as calculated value, specific DG turns RED. Alarm, **'RIO OPEN LOOP CABLE BREAK'** and **'IO INPUT ERROR GENERATOR# POWER'**. No change in thruster or generator status.
2. No alarm given, mimic shows bus tie breaker remains open. PMS screen shows actual state of tie breaker.

**Results found:**

| | DG1 | DG2 | DG3 | DG4 |
|---|---|---|---|---|
| 1. | As expected | As expected | As expected | As expected |
| 2. | As expected | | | |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.18 EQUIPMENT SUB-SYSTEM 1 - POWER MANAGEMENT

**Test: 18** Failure of Field Bus Networks

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

**With all thrusters and generators on line, main server controlling PMS.**

1. Fail main field bus network FB3 at main I/O server, restore. (terminals 27 and 28)
2. Fail backup field bus network FB3 at backup I/O server, restore. (terminals 27 and 28)

**Results expected:**

1. Alarm for failure of field bus network, communications continue on backup network.
2. Alarm for failure of backup field bus network, communications continue on main network.

**Results found:**

1. As expected.
2. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.1.19 EQUIPMENT SUB-SYSTEM 1 - POWER MANAGEMENT

**Test: 19** Failure of DPU1 Through 5

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each DPU:**

1. Simulate failure of DPU1, restore. (F11)
2. Simulate failure of DPU2, restore. (F12)
3. Simulate failure of DPU3, restore. (F13)
4. Simulate failure of DPU4, restore. (F14)
5. Simulate failure of DPU5, restore. (F 23)

**Results expected:**

1. Alarm (Praxis), **'FIELD BUS 1 NOT PRESENT'** DPU 1 in alarm on system Diagnostics page.
2. Alarm (Praxis), **'FIELD BUS 2 NOT PRESENT'** DPU 2 in alarm on system Diagnostics page.
3. Alarm (Praxis), **'FIELD BUS 3 NOT PRESENT'** DPU 3 in alarm on system Diagnostics page.
4. Alarm (Praxis), **'FIELD BUS 4 NOT PRESENT'** DPU 4 in alarm on system Diagnostics page.
5. Alarm (Praxis), **'FIELD BUS 5 NOT PRESENT'** DPU 5 in alarm on system Diagnostics page. **'MAIN LINK NOT PRESENT'**

   No effect on DP.

**Results found:**

1. As expected.
2. As expected.
3. As expected.
4. As expected.
5. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.2 Equipment Sub-System 2 - Power Generation

### 6.2.1 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

**Test: 20** Fuel Oil System - Operation of Quick Closing Valves

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB
- NSB 230V supplied via transformer from stb'd 440V MSB
- ENSB PS and ENSB SB supplied from MSB 230V
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode
  All available reference systems active

**Method:**

1. Operate controls for quick closing valves located at the emergency headquarters, (representative sample from each zone)
2. Monitor the action of each valve and record result.

**Results expected:**

1. Valves closes and fuel supply shut off.
2. Quick closing valves close as per test schedule.

**Results found:**

1. As expected.
2. As expected.

**Comments:**

All tested 30/03/2015.

Rep. Sample: valves 29, 33, 3, 14, 7, 6, 37, 26, 39 and 2 tested 06/05/2015.

| Witnessed by: | R. J. Younger | Date: | 6th May 2015 |
|---|---|---|---|

## 6.2.2 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

**Test: 21** Fuel Oil System - Operation of ME FO Boost Pumps, Auto Standby Start

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB
- NSB 230V supplied via transformer from stb'd 440V MSB
- ENSB PS and ENSB SB supplied from MSB 230V
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode
  All available reference systems active

**Method:**

**For each ME:**

1. Bleed fuel oil pressure switch, reinstate (ME.1)
2. Bleed fuel oil pressure switch, reinstate (ME.2)
3. Bleed fuel oil pressure switch, reinstate (ME.3)
4. Bleed fuel oil pressure switch, reinstate (ME.4)

**Results expected:**

1. Alarm, low fuel supply pressure, standby pump starts.
2. Alarm, low fuel supply pressure, standby pump starts.
3. Alarm, low fuel supply pressure, standby pump starts.
4. Alarm, low fuel supply pressure, standby pump starts.

**Results found:**

1. As expected.
2. As expected.
3. As expected.
4. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.2.3 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

**Test: 22** Fuel Oil System - Operation of Service Tank Low Level and Fuel Filter Differential Pressure Alarms

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Simulate low level alarm sensor on port fuel oil service tank.
2. Simulate low level alarm sensor on starboard fuel oil service tank.
3. Simulate high differential pressure across filter DGs 1 and 2.
4. Simulate high differential pressure across filter DGs 3 and 4.

**Results expected:**

1. Alarm (Praxis): **'FO DAILY SERVICE TANK 01 PORT LEVEL 15%'.**
2. Alarm (Praxis): **'FO DAILY SERVICE TANK 02 STB'D LEVEL 15%'.**
3. Alarm (Praxis): **'ENG 1 PS FWD FO DIFF PRESS HIGH'.**
   **'ENG 2 SB FWD FO DIFF PRESS HIGH'.**
4. Alarm (Praxis): **'ENG 3 PS AFT FO DIFF PRESS HIGH'.**
   **'ENG 4 SB AFT FO DIFF PRESS HIGH'.**

**Results found:**

| | | | | |
|---|---|---|---|---|
| 1. | As expected | | | |
| 2. | As expected | | | |
| | **DG1** | **DG2** | **DG3** | **DG4** |
| 3. | As expected | As expected | NA | NA |
| 4. | N/A | N/A | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 6th May 2015 |
|---|---|---|---|

## 6.2.4 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

| Test: 23 | Lub Oil System - Test Operation of DG Low-Low Lub Oil Pressure Sensors and Operation of Pre-Lube Oil Pumps |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.

All available reference systems active.

**Method:**

1. Isolate low-low lube oil sensor and drain.
2. Isolate pre-lube pump and try to start generator engine.

**Results expected:**

1. Alarm (Praxis), **DG# EXTERNAL SHUT DOWN'**, generator trips and shuts down.
2. Generator will not start if pre-lub pump is not functional.

**Results found:**

| | DG1 | DG2 | DG3 | DG4 |
|---|---|---|---|---|
| 1. | As expected | As expected | As expected | As expected |
| 2. | As expected | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.2.5 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

**Test: 24** SW Cooling System

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each SW cooling pump in turn:**

1. Simulate low SW pressure, restore.
2. Confirm auto start of standby pump.

**Isolate standby pump**

3. Stop running pump, observe rise in temp.

**Results expected:**

1. Alarm (Praxis): **'SW LOW PRESSURE'**.
2. Alarm (Praxis): **'SW CIRC P/P# PRESS LOW'** and **'SW STBY P/P#ST BY START'.** Standby pump starts.
3. Alarm of high temperature, FW low temperature circuit, after five minutes.

**Results found:**

| | SW Pump 1 | SW Pump 2 |
|---|---|---|
| 1. | As expected | As expected |
| 2. | As expected | As expected |
| 3. | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.2.6 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

**Test: 25** FW Cooling System

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

**For each circulation pump in turn:**

1. Stop FW pump No. 1, restore.
2. Stop FW pump No. 2, restore.
3. Stop both FW pumps, observe temperature rise, restore.
4. Test FW expansion tank low level alarm.
5. Test FW expansion tank low low level alarm.

**Results expected:**

1. Alarm (Praxis): **'FW CIRC P/P# PRESS LOW'** and **'FW STBY P/P#ST BY START'.** Standby pump starts.
2. Alarm (Praxis): **'FW CIRC P/P# PRESS LOW'** and **'FW STBY P/P#ST BY START'.** Standby pump starts.
3. Alarm (Praxis): FW low pressure. Gradual increase in temperature on engines and thrusters.
4. Alarm (Praxis): **'LOW LEVEL FW EXPANSION TANK'.**
5. Alarm (Praxis): **'LOW LOW LEVEL FW EXPANSION TANK'.**

Shutdown of converter on high temp not initiated due to it being detrimental to the system.

**Results found:**

| | FW Pump 1 | FW Pump 2 |
|---|---|---|
| 1. | As expected | N/A |
| 2. | N/A | As expected |
| 3. | As expected | |
| 4. | As expected | |
| 5. | As expected | |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.2.7 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

**Test: 26** Simulate Loss of Service Air and Start Air

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Isolate service air, bleed pressure, restore.
2. Isolate Start air system PS, bleed pressure, restore.
3. Isolate Start air system SB, bleed pressure, restore.

**Results expected:**

1. Alarm (Praxis): **'SERVICE AIR VESSEL PRESSURE'**, no effect on system.
2. Alarm (Praxis): **'PT STARING AIR VESSEL PRESSURE A103'**, no effect on running engine.
3. Alarm (Praxis): **'ST STARING AIR VESSEL PRESSURE A104'**, no effect on running engine.

**Results found:**

1. As expected Alarm @ 5.0 bar.
2. As expected Alarm @ 18.0 bar.
3. As expected Alarm @ 18.0 bar.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 6th May 2015 |
|---|---|---|---|

## 6.2.8 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

**Test: 27** Diesel Engines, Speed Sensors

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each DG:**

1. Fail one speed sensor, restore and reset.

**Results expected:**

1. Alarm (Praxis), continues to run on remaining sensor.

**Results found:**

| DG1 | DG2 | DG3 | DG4 |
|---|---|---|---|
| Sensor 1<br>As expected | Sensor 2<br>As expected | Sensor 2<br>As expected | Sensor 1<br>As expected |

**Comments:**

Two speed sensors fitted - both connected to WECS (DCU1 and Relay Module).

During this test after failing the sensor the engine must be shut down to clear the alarm.

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.2.9 EQUIPMENT SUB-SYSTEM 2 - POWER GENERATION

**Test: 28** Diesel Engines, Emergency Stops

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each DG:**

1. Operate emergency stop, restore and reset.

**Results expected:**

1. Alarm, stop of generator engine.

**Results found:**

| DG1 | DG2 | DG3 | DG4 |
|---|---|---|---|
| As expected | As expected | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.3 Equipment Sub-System 3 - Thruster

### 6.3.1 EQUIPMENT SUB-SYSTEM 3 - THRUSTER

**Test: 29** Thruster - Hydraulic Systems

**Equipment Configuration:**

- In DP2 Mode (Consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
- All available reference systems active.

**Method:**

**For each tunnel thruster:**

1. Fail on line hydraulic pitch pump.
2. Fail standby pump.
3. Check start inhibits / restore hydraulics and start thruster, restore.
4. Check tunnel thruster header tank low level alarms.
5. Simulate cooling water leakage

**For each azimuth thruster**

6. Check azimuth thruster seal tank low level alarms.

**Results expected:**

1. Alarm, stop of on line pump, automatic start of standby pump.
2. Stop of thruster.
3. Thruster will not start.
4. Alarm (Praxis): **'BT FWD/AFT UNIT SEAL TANK LEVEL LOW'**
5. Alarm (Praxis): **'BT FWD/AFT CW LEAKAGE SENSOR'**
6. Alarm (Praxis): **'AZIMUTH PS/SB GT OIL TANK LEVEL LOW'**

**Results found:**

| | BT1 | BT2 |
|---|---|---|
| 1. | As expected | As expected |
| 2. | As expected | As expected |
| 3. | As expected | As expected |
| 4. | As expected | As expected |
| 5. | As expected | As expected |
| | **AZ P** | **AZ S** |
| 6. | As expected | As expected |

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 6.3.2 EQUIPMENT SUB-SYSTEM 3 - THRUSTER

**Test: 30** Thruster Emergency Stops

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each thruster:**

1. Activate emergency stop on bridge / restart.

**Results expected:**

1. Stop and start.

**Results found:**

| | | | | |
|---|---|---|---|---|
| | **BT1** | **BT2** | **Main Thr. PS** | **Main Thr. SB** |
| **1** | As expected | As expected | As expected | As expected |

**Comments:**

| | | | |
|---|---|---|---|
| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |

## 6.3.3 EQUIPMENT SUB-SYSTEM 3 - THRUSTER

**Test: 31** Bow Tunnel Thrusters (BT1) - Pitch Signal Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Fail pitch command signal from DP to TCC, restore. (WU3 U36 X3 4, 5)
2. Fail pitch feedback signal from TCC to DP computer, restore. (WU3 U36 X1 5, 6)
3. Fail pitch command signal from TCC to thruster and restore.
   (RR Elect Unit- Node 1. X1C-39, 40)
4. Fail pitch feedback signal from thruster to TCC and restore.
   (RR Elect Unit- Node 1. X1C-57, 58)

**Results expected:**

1. Alarm, '**TUNNEL BOW1 NOT READY**'. Thruster drops out of DP.
2. Alarm, '**TUNNEL BOW1 INPUT ERROR PITCH**', thruster follows command.
3. Alarm, '**TUNNEL BOW1 NOT READY**'. Thruster drops out of DP.
4. Alarm, '**TUNNEL BOW1 INPUT ERROR PITCH**', thruster follows command.

**Results found:**

1. As expected.
2. As expected.
3. As expected.
4. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.3.4 EQUIPMENT SUB-SYSTEM 3 - THRUSTER

| Test: 32 | Bow Tunnel Thrusters (BT2) - Pitch Signal Failures |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail pitch command signal from DP to TCC, restore. (WU6 U66 X3 4, 5)
2. Fail pitch feedback signal from TCC to DP computer, restore. (WU6 U66 X1 5, 6)
3. Fail pitch command signal from TCC to thruster and restore. (RR Elect Unit- Node 1. X1C-39, 40)
4. Fail pitch feedback signal from thruster to TCC and restore. (RR Elect Unit- Node 1. X1C-57, 58)

**Results expected:**

1. Alarm, '**TUNNEL BOW2 NOT READY**'. Thruster drops out of DP.
2. Alarm, '**TUNNEL BOW2 INPUT ERROR PITCH**' , thruster follows command.
3. Alarm, '**TUNNEL BOW2 NOT READY**'. Thruster drops out of DP.
4. Alarm, '**TUNNEL BOW2 INPUT ERROR PITCH**' , thruster follows command.

**Results found:**

1. As expected.
2. As expected.
3. As expected.
4. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.3.5 EQUIPMENT SUB-SYSTEM 3 - THRUSTER

**Test: 33** Azimuth Thrusters (PS) - Speed Signal Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Fail RPM command signal from DP to inverter drive, restore. (WU4 U41 X3 4, 5)
2. Fail RMP feedback signal from inverter drive to DP computer, restore.(WU4 U41 X2 5, 6)

**Results expected:**

1. Alarm, **'AZIMUTH AFT PORT PREDICTION ERROR RPM'** and **'RIO OPEN LOOP CABLE BREAK'**, RPM to zero.
2. Alarm, **'AZIMUTH AFT P INPUT ERROR RPM'** & **'RIO OPEN LOOP CABLE BREAK'.** thruster follows command.

**Results found:**

1. As expected.
2. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.3.6 EQUIPMENT SUB-SYSTEM 3 - THRUSTER

**Test: 34** Azimuth Thrusters (PS) - Azimuth Signal Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail azimuth command signal from DP to ACU, restore. (WU4 U41 X4 4, 5)
2. Fail azimuth feedback signal (Sin) from ACU to DP computer, restore. (WU4 U41 X2 2)
3. Fail azimuth feedback signal (Cos) from ACU to DP computer, restore. (WU4 U41 X2 3)
4. Fail azimuth command signal from ACU to Turning Motor and restore. (ACU-X1 E05 & E06)
5. Fail azimuth feedback signal from Turning Motor to ACU and restore. (X2 330, 331)

**Results expected:**

1. Alarm, '**AZIMUTH AFT P NOT READY**', drops out of DP, azimuth rotation to zero position, RPM to zero.
2. Alarm, '**AZIMUTH AFT P INPUT ERROR AZIMUTH**', thruster follows command.
3. Alarm, '**AZIMUTH AFT P INPUT ERROR AZIMUTH**', thruster follows command.
4. Alarm, '**AZIMUTH AFT P NOT READY**', drops out of DP, rotation freezes, RPM to zero.
5. Alarm, '**AZIMUTH AFT P INPUT ERROR AZIMUTH**', thruster follows command.

**Results found:**

1. Not as expected.
2. As expected.
3. As expected.
4. As expected.
5. As expected.

**Comments:**

**See 'B' Recommendation 4.3.1.**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.3.7 EQUIPMENT SUB-SYSTEM 3 - THRUSTER

| Test: 35 | Azimuth Thrusters (SB) - Speed Signal Failures |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail RPM command signal from DP to inverter drive, restore. (WU7 U71 X3 4, 5)
2. Fail RMP feedback signal from inverter drive to DP computer, restore.(WU7 U71 X2 5, 6)

**Results expected:**

1. Alarm, **'AZIMUTH AFT STARBOARD PREDICTION ERROR RPM'** and **'RIO OPEN LOOP CABLE BREAK'**, RPM to zero.
2. Alarm, **'AZIMUTH AFT S INPUT ERROR RPM'** & **'RIO OPEN LOOP CABLE BREAK'.** Thruster follows command.

**Results found:**

1. As expected.
2. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.3.8 EQUIPMENT SUB-SYSTEM 3 - THRUSTER

**Test: 36** Azimuth Thrusters (SB) - Azimuth Signal Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Fail azimuth command signal from DP to ACU, restore. (WU7 U71 X4 4, 5)
2. Fail azimuth feedback signal (Sin) from ACU to DP computer, restore. (WU7 U71 X2 2)
3. Fail azimuth feedback signal (Cos) from ACU to DP computer, restore. (WU7 U71 X2 3)
4. Fail azimuth command signal from turning motor to thruster, restore.(ACU-X1 E05 & E06)
5. Fail azimuth feedback signal from thruster to turning motor, restore. (X2 330, 331)

**Results expected:**

6. Alarm, '**AZIMUTH AFT S NOT READY**', drops out of DP, Azimuth rotation to zero position, RPM to zero.
7. Alarm, '**AZIMUTH AFT S INPUT ERROR AZIMUTH**', thruster follows command.
8. Alarm, '**AZIMUTH AFT S INPUT ERROR AZIMUTH**', thruster follows command.
9. Alarm, '**AZIMUTH AFT S NOT READY**', drops out of DP, rotation freezes, RPM to zero.
10. Alarm, '**AZIMUTH AFT S INPUT ERROR AZIMUTH**', thruster follows command.

**Results found:**

1. Not as expected.
2. As expected.
3. As expected.
4. As expected.
5. As expected.

**Comments:**

**See 'B' Recommendation 4.3.2.**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.4 Equipment Sub-System 4 - DP Control

| 6.4.1 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL | |
|---|---|
| **Test: 37** | Manoeuvring Changeover |

**Equipment Configuration:**

- **Vessel in manual manoeuvring Fw'd bridge console.**
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Take command aft bridge stations PS and SB, make moves and heading changes.
2. Take command on independent joystick (CJoy cC1) PS then SB make moves and heading changes at each station. (check correct heads up orientation)
3. Switch the selection switch to DP, take command in manual DP (OS1 Fwd).
4. Deselect DP by switching the selection switch to manual fwd bridge console.
5. Transfer command to manual aft bridge console then transfer to manual DP joystick.

**Results expected:**

1. Command transferred to aft bridge stations, operation satisfactory.
2. Command transferred to each joystick station in turn, operation satisfactory.
3. Command transferred to DP, operation satisfactory.
4. Command transferred to fwd bridge.
5. Command transferred to aft bridge then manual DP joystick.

**Results found:**

1. As expected - Performed and witnessed during CAT.
2. As expected - Performed and witnessed during CAT.
3. As expected - Performed and witnessed during CAT.
4. As expected - Performed and witnessed during CAT.
5. As expected - Performed and witnessed during CAT.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 6.4.2 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

**Test: 38** DP Joystick Function Test

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Move vessel by operating DP joystick, introducing auto sway, surge and yaw controls in turn.
2. Observe transfer of system to auto DP once third element is selected.

**Results expected:**

1. Vessel moves to commands.
2. Auto DP automatically selected.

**Results found:**

1. As expected - Performed and witnessed during CAT.
2. As expected - Performed and witnessed during CAT.

**Comments:**

Auto DP @ 06:30 hours.

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 6.4.3 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

| Test: 39 | DP Function Test |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Test present and marked position functions.
2. From present to marked, stop operation in middle.
3. Test low, medium and high gain setting functions.

**Results expected:**

1. Normal operation.
2. Vessel stops at present position, overshoot within system parameters.
3. Normal operation.

**Results found:**

1. As expected - Performed and witnessed during CAT.
2. As expected - Performed and witnessed during CAT.
3. As expected - Performed and witnessed during CAT.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 6.4.4 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

**Test: 40** DP Consoles OS1, OS2, OS3 and Network Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

**For each console:**

1. Check all pages on screen.
2. Change ranges and speed.
3. Lamp test.
4. Print page.
5. Switch off console power supply, restore (OS1:UPS1 F2), (OS2:UPS2 F2), (OS3: UPS2 F5)
6. Fail network hub A. Restore.
7. Fail network hub B. Restore.

**Results expected:**

1. Check all pages on screen.
2. Change ranges and speed.
3. Lamp test.
4. Print page.
5. Alarm, loss of console. DP maintained. **DPO to take manual control on second operating station.**
6. Alarm, '**ERROR NET A**' no affect on DP, continues on Net B.
7. Alarm, '**ERROR NET B**' no affect on DP, continues on Net A.

**Results found:**

| | OS1 | | OS2 | | OS3 |
|---|---|---|---|---|---|
| 1. | As expected | 1. | As expected | 1. | As expected |
| 2. | As expected | 2. | As expected | 2. | As expected |
| 3. | As expected | 3. | As expected | 3. | As expected |
| 4. | As expected | 4. | As expected | 4. | As expected |
| 5. | As expected | 5. | As expected | 5. | As expected |

6. As expected.
7. As expected.

**Comments:**

Performed and witnessed during CAT 05/05/2015.

| Witnessed by: | R. J. Younger | Date: | 5th May 2015 |
|---|---|---|---|

## 6.4.5 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

**Test: 41** Main Computer Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**Select DPC 21- A On line:**

1. Trip power supply to DPC 21 'A' (X11-F1, X81-F1) Dual supply.
2. Observe position accuracy, restore.

**Select DPC 21- B On line**

3. Trip power supply to DPC 21 'B' (X13-F1, X83-F1) Dual supply.
4. Observe position accuracy, restore.

5. Fail hub A and B one by one, restore.

**Results expected:**

1. Loss of DPC 21 'A', automatic changeover to DPC 21 'B'.
2. No change in position.
3. Loss of DPC 21 'B', automatic changeover to DPC 21 'A'.
4. No change in position.
5. Alarm, no affect on station keeping.

**Results found:**

1. As expected - Performed and witnessed during CAT 05/05/2015.
2. As expected - Performed and witnessed during CAT 05/05/2015.
3. As expected - Performed and witnessed during CAT 05/05/2015.
4. As expected - Performed and witnessed during CAT 05/05/2015.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 5th May 2015 |
|---|---|---|---|

## 6.4.6 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

| Test: 42 | Rotation Centre and Offset |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Rotate through 360° high gain, in 90° increments.
2. Observe difference in reference system positions and overshoot.

   **Move centre of rotation.**
3. Rotate through 90°, medium gain.

**Results expected:**

1. Vessel rotates smoothly.
2. Maximum overshoot within set parameters (3°).
3. Vessel rotates smoothly with no deviation from new CoR.

**Results found:**

1. As expected.
2. As expected. Start Hdg: **218.5°** - overshoot: **90°:** +2.9°, **180°:** +2.8°, **270°:** +0.7°, **360°:** +1.0°
3. As expected.

**Comments:**

Performed and witnessed during CAT 07/05/2015.

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 6.4.7 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

| Test: 43 | Box Manoeuvre |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Perform a 200M box manoeuvre.
2. Observe difference in reference system positions and overshoot at each cardinal point.

**Results expected:**

1. Vessel moves smoothly to commands.
2. Maximum overshoot within set parameters (3m).

**Results found:**

1. As expected - overshoot: Start Hdg: $231.4^0$
   1. 200M to Ahead and 200M to SB: -0.4m.
   2. 200M to SB and 200M Astern: -0.5m.
   3. 200M to Astern and 200M to PS: -0.3m.
   4. 200M Ahead: -0.4m.
2. As expected.

**Comments:**

Performed and witnessed during Kongsberg HiPAP Calibration Tests 11/05/2015.
See FMEA Part 1 - Appendix 3.

| Witnessed by: | R. J. Younger | Date: | 11th May 2015 |
|---|---|---|---|

## 6.4.8 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

**Test: 44** Mathematical Model

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.

**Method:**

1. Deselect all reference systems, allow vessel to drift for 5 minute period.
2. Observe vessel movements and measure drift.

**Results expected:**

1. Alarm, **'NO REFERENCE SYSTEM ACTIVE'**. After 30 seconds **'POSITION DROP OUT'** alarm on KPos OS, vessel in model control and station keeping degrades.
2. Vessel moved off position slowly.

**Results found:**

1. As expected - Performed and witnessed during CAT 05/05/2015.
2. As expected - Performed and witnessed during CAT 05/05/2015.

| | | |
|---|---|---|
| Start Time: 15:10 hours | End Time: 15:15 hours | |
| Start Position | N: 52 10.2644 | W: 003 58.2644 |
| End Position | N: 52 10.2704 | W: 003 58.303- |
| Wind | 17.1 m/s | $217^0$ |
| DP Residual Current | 1.4 m/s | $232^0$ |
| Heading | $224^0$ | |

**Comments:**

Drift of 35.19m @ $0.66^0$ measured on ECDIS.

| | | | |
|---|---|---|---|
| Witnessed by: | R. J. Younger | Date: | 5th May 2015 |

## 6.4.9 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

**Test: 45** UPS 1 Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail 230V main supply to UPS1. (ENSB PS 33Q1)
2. Test battery endurance for 30 minutes.
3. Trip UPS output supplies one by one and restore.

**Results expected:**

1. Alarms, **'UPS 1 FAILURE'**, local and on DP.
2. Batteries endurance > 30 minutes.
3. Systems fail as follows:-

| | | | | | |
|---|---|---|---|---|---|
| **F1** | DPC 21- A | **F2** | OS1 (Fwd Bridge) | **F3** | Fan Beam System |
| **F4** | DGPS 1-Veripos | **F5** | DP Alarm Printer | **F6** | Gyro 1 |
| **F7** | LTW MK14B El. Cab. 1 | **F8** | Radius (1) Outlet | **F9** | Wind 2 |
| **F10** | Spare | **F11** | Spare | **F12** | Spare |

**Results found:**

1. As expected - Performed and witnessed during CAT 05/05/2015.
2. As expected.

| | | | |
|---|---|---|---|
| Start Time | 08:10 hours | End Time | 08:40 hours |
| Start Volts | 110.4 V | End Volts | 98.3 V |

3. As expected - Performed and witnessed during CAT 05/05/2015.

**Comments:**

UPS output voltage at start: 230V 60Hz
Load current at start: 4.0A 0.76pf
Battery time remaining at end: Charge level 76%
Run time 94 mins.

| | | | |
|---|---|---|---|
| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |

## 6.4.10 EQUIPMENT SUB-SYSTEM 4 - DP CONTROL

**Test: 46** UPS 2 Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail 230V main supply to UPS2. (ENSB SB 43Q2)
2. Test battery endurance for 30 minutes.
3. Trip UPS output supplies one by one and restore.

**Results expected:**

1. Alarms, '**UPS 2 FAILURE**', local and on DP.
2. Batteries endurance > 30 minutes
3. Systems fail as follows:

| | | | | | |
|---|---|---|---|---|---|
| **F1** | DPC 21 - B | **F2** | OS2 | **F3** | Hard Copy Printer |
| **F4** | MP8200 and HiPAP OS | **F5** | OS 3 | **F6** | HiPAP Transceiver |
| **F7** | Gyro 2 (dual supply) | **F8** | Wind 1 | **F9** | MRU 5 No. 2/ VRS 2 |
| **F10** | Spare | **F11** | Spare | **F12** | Spare |

**Results found:**

1. As expected - Performed and witnessed during CAT 05/05/2015.
2. As expected.

| | | | |
|---|---|---|---|
| Start Time | 08:45 hours | End Time | 09:15 hours |
| Start Volts | 110.6 V | End Volts | 97.84 V |

3. As expected - Performed and witnessed during CAT 05/05/2015.

**Comments:**

UPS output voltage at start: 230V 60Hz
Load current at start: 3.6A 0.86pf
Battery time remaining at end: Charge level 77%
Run time 93 mins.

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.5 Equipment Sub-System 5 - Sensors

### 6.5.1 EQUIPMENT SUB-SYSTEM 5 - SENSORS

| Test: 47 | VRS/MRU Fault Simulation |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**Select VRS/MRU No. 1**

1. Fail **ready** signal to DP, restore (WU3 U34 X2 4, 6).

**Select VRS/MRU No. 2**

2. Fail **ready** signal to DP, restore (WU6 U64 X2 4, 6).

**Results expected:**

1. Alarm, **'VRS 1 NOT READY'**, automatic changeover to MRU 2.
2. Alarm, **'VRS 2 NOT READY'**, automatic changeover to MRU 1.

**Results found:**

1. As expected - Performed and witnessed during CAT 05/05/2015.
2. As expected - Performed and witnessed during CAT 05/05/2015.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 5th May 2015 |
|---|---|---|---|

## 6.5.2 EQUIPMENT SUB-SYSTEM 5 - SENSORS

**Test: 48** Gyro Signal Failure

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Check gyro headings.

**Select Gyro No. 1**

2. Disconnect serial line input to DP, restore. (WU3 U32 X2 1, 2)

**Select Gyro No. 2**

3. Disconnect serial line input to DP, restore. (WU6 U62 X2 1, 2)

**Select Gyro No. 3**

4. Disconnect serial line input to DP, restore. (WU3 U33 X1 1, 2)

5. Check gyro rejection by imputing difference.

**Results expected:**

1. Gyro headings agree.
2. Alarm **'GYRO 1 NOT READY'** and **'GYRO 1 COMMUNICATIONS ERROR'**, gyro rejected from DP system, auto selection of other gyro.
3. Alarm **'GYRO 2 NOT READY'** and **'GYRO 2 COMMUNICATIONS ERROR'**, gyro rejected from DP system, auto selection of other gyro.
4. Alarm **'GYRO 3 NOT READY'** and **'GYRO 3 COMMUNICATIONS ERROR'**, gyro rejected from DP system, auto selection of other gyro.
5. Gyro rejected on difference alarm.

**Results found:**

1. As expected - Performed and witnessed during CAT 05/05/2015.
2. As expected - Performed and witnessed during CAT 05/05/2015.
3. As expected - Performed and witnessed during CAT 05/05/2015.
4. As expected - Performed and witnessed during CAT 05/05/2015.
5. As expected - Performed and witnessed during CAT 06/05/2015.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 6th May 2015 |
|---|---|---|---|

## 6.5.3 EQUIPMENT SUB-SYSTEM 5 - SENSORS

**Test: 49** Gyro Power Supply Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS s ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**Select Gyro No. 1**

1. Fail main power supply, restore. (UPS1 F6)
2. Fail backup power supply, restore. (MSB1 24V Q6)

**Select Gyro No. 2**

3. Fail main power supply, restore. (UPS2 F7)
4. Fail backup power supply, restore. (MSB1 24V Q7)

**Select Gyro No. 3**

5. Fail main power supply, restore. (ENSB SB 43Q4)
6. Fail backup power supply, restore. (MSB1 24V Q24)

**Results expected:**

1. Alarm, local and fwd bridge console, auto changeover to backup supply.
2. Alarm, stays on main supply.
3. Alarm, local and fwd bridge console, auto changeover to backup supply.
4. Alarm, stays on main supply.
5. Alarm, local and fwd bridge console, auto changeover to backup supply.
6. Alarm, stays on main supply.

**Results found:**

1. As expected.
2. As expected.
3. As expected.
4. As expected.
5. As expected.
6. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.5.4 EQUIPMENT SUB-SYSTEM 5 - SENSORS

| Test: 50 | Wind Sensor Failures |
|---|---|

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

**For each wind sensor**

1. Fail serial line input from wind sensor, restore.
   (Wind 1: WU3 U32 X1 1,2) (Wind 2: WU6 U62 X1 1,2)
2. Fail power supply to wind sensor, restore. (Wind 1: UPS2 F8 - Wind 2: UPS1 F9)

**Results expected:**

1. Alarm '**WIND 1 NOT READY**' and '**WIND 1 COMMUNICATIONS ERROR**', wind sensor rejected from DP, other wind sensor selected.
2. Alarm '**WIND 2 NOT READY**' and '**WIND 2 COMMUNICATIONS ERROR**', wind sensor rejected from DP, other wind sensor selected.

**Results found:**

1. As expected - Performed and witnessed during CAT 05/05/2015.
2. As expected - Performed and witnessed during CAT 05/05/2015.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 5th May 2015 |
|---|---|---|---|

## 6.6 Equipment Sub-System 6 - Reference Systems

### 6.6.1 EQUIPMENT SUB-SYSTEM 6 - REFERENCE SYSTEMS

**Test: 51** DGPS1 (Veripos Ultra)

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Simulate communication failure by failing input telegram. (WU3 U32 X3 1,2)

**Select DGPS1 as only reference system**

2. Perform moves Ahd, Astern and Athwartships. 20m Astern, 40m Ahead, 20m Astern, 20m Port, 40m Stb'd and 20m Port.

**Re-select all available reference systems**

3. Simulate DGPS rejection by reducing the number of satellites from six downwards and wait to see when rejection takes place.
4. Fail Power supply to DGPS. (UPS1 F4)

**Results expected:**

1. Alarm, '**GPS1 IO ERROR**' and zero weight. DGPS rejected.
2. GPS is capable of maintaining position as standalone reference system.
3. Alarm, '**GPS1 IO ERROR**' & '**WARNING SPEED GPS1 NOT READY** and zero weight. DGPS rejected. Use of altitude aiding, rejection when four satellites, note number of satellites available when lost.
4. Alarm, '**GPS1 TELEGRAM TIMEOUT**' and zero weight. DGPS rejected.

**Results found:**

1. As expected.
2. As expected - Performed and witnessed during CAT 05/05/2015.
3. As expected - number of satellites when lost: **4.**
4. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.6.2 EQUIPMENT SUB-SYSTEM 6 - REFERENCE SYSTEMS

**Test: 52** DGPS2 (Simrad MX612)

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Simulate communication failure by failing input telegram. (WU6 U62 X3 1,2)

**Select DGPS2 as only reference system**

2. Perform moves Ahd, Astern and Athwartships.
   20m Astern, 40m Ahead, 20m Astern, 20m Port, 40m Stb'd and 20m Port.

**Re-select all available reference systems**

3. Simulate DGPS rejection by disconnecting RTCM Signal. (Port 4)
4. Fail power supply to DGPS. (TLDP1 Q22)

**Results expected:**

1. Alarm, '**GPS2 IO ERROR**' and zero weight. DGPS rejected.
2. GPS is capable of maintaining position as standalone reference system.
3. Alarm, '**GPS2 IO ERROR**' & '**WARNING SPEED GPS1 NOT READY** and zero weight. DGPS rejected. Use of altitude aiding, rejection when four satellites, note number of satellites available when lost.
4. Alarm, '**GPS2 TELEGRAM TIMEOUT**' and zero weight. DGPS rejected.

**Results found:**

1. As expected.
2. As expected - Performed and witnessed during CAT 05/05/2015.
3. As expected.
4. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.6.3 EQUIPMENT SUB-SYSTEM 6 - REFERENCE SYSTEMS

**Test: 53** DGPS3 (C-Nav)

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Simulate communication failure by failing input telegram. (WU3 U33 X3 1, 2)

**Select DGPS3 as only reference system**

2. Perform moves Ahd, Astern and Athwartships.
   20m Astern, 40m Ahead, 20m Astern, 20m Port, 40m Stb'd and 20m Port.

**Re-select all available reference systems**

3. Simulate DGPS rejection by reducing the number of satellites from 6 downwards and wait to see when rejection takes place.
4. Fail power supply to DGPS. (Display: MSB1 24V Q26, C-Nav: MSB1 24V Q27)

**Results expected:**

1. Alarm, '**GPS3 IO ERROR**' and zero weight. DGPS rejected.
2. GPS is capable of maintaining position as standalone reference system.
3. Alarm, '**GPS3 IO ERROR**' & '**WARNING HIGH VARIANCE**' and zero weight. DGPS rejected. Use of altitude aiding, rejection when four satellites, note number of satellites available when lost.
4. Alarm, '**GPS3 TELEGRAM TIMEOUT**' and zero weight. DGPS rejected.

**Results found:**

1. As expected.
2. As expected - Performed and witnessed during CAT 07/05/2015.
3. As expected - number of satellites when lost: **3.**
4. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 15th May 2015 |
|---|---|---|---|

## 6.6.4 EQUIPMENT SUB-SYSTEM 6 - REFERENCE SYSTEMS

**Test: 54** DGPS 1, 2 and 3 Performance

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Rotate vessel through 360° and check for blind sectors.
2. Carry out standard box manoeuvre. Record overshoot.
   20m Astern, 40m Ahead, 20m Astern, 20m Port, 40m Stb'd and 20m Port.

**Results expected:**

1. No sectors where position data is lost.
2. Good position keeping. Overshoot <2m.

**Results found:**

1. As expected - Performed and witnessed during CAT 07/05/2015 - No blind sectors. All reference systems remained within limits and agreed within 1m.
2. As expected - Performed and witnessed during CAT 07/05/2015 - max. at cardinal points -0.8 m.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 6.6.5 EQUIPMENT SUB-SYSTEM 6 - REFERENCE SYSTEMS

**Test: 55** HiPAP 501 Testing

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Test each transponder in turn.
2. Lift one transponder used for DP without deselecting.
3. Rotate vessel through 360° and check for blind sectors. Compare performance with other systems.
4. Carry out 200m box manoeuvre. Record overshoot.
5. Fail power to HIPAP 500 transceiver unit, restore. (UPS2 F6)

**Results expected:**

1. All transponders work.
2. Transponder rejected when moved.
3. Weighting equally divided with other reference systems.
4. Good correlation, within 3m.
5. HiPAP 501 rejected from DP.

**Results found:**

1. As expected.
2. As expected.
3. As expected.
4. As expected - overshoot: Start Hdg: $231.8^0$
   $90^0$: $1.1^0$, $180^0$: $0.8^0$, $270^0$: $1.0^0$, $360^0$: $0.9^0$
5. As expected - overshoot: Start Hdg: $231.4^0$
   5. 200M to Ahead and 200M to SB: -0.4m.
   6. 200M to SB and 200M Astern: -0.5m.
   7. 200M to Astern and 200M to PS: -0.3m.
   8. 200M Ahead: -0.4m.
6. As expected.

**Comments:**

Beacon M31 used.

| Witnessed by: | R. J. Younger | Date: | 11th May 2015 |
|---|---|---|---|

## 6.6.6 EQUIPMENT SUB-SYSTEM 6 - REFERENCE SYSTEMS

**Test: 56** LWTW

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Move to limits (in board and out board). Check distance agrees with other systems.
2. Disconnect taut wire input to DP, (voting check) or lift weight from seabed.
   (Beam: WU4 U44 X1 5, 6) (Alongship: WU4 U44 X1 2, 3)
3. Trip power supplies to the LWTW, restore. (UPS2 F7)

**Results expected:**

1. Correct scale of input, alarm '**LTW OUT OF LIMITS**' at first limit then '**LTW EXCEEDS FATAL LIMITS**' rejected from DP system
2. LWTW rejected by voting
3. Alarm at DP '**LTW MOORING NOT ON**', LWTW rejected.

**Results found:**

1. As expected.
2. As expected - weight lifted from sea bed.
3. As expected.

**Comments:**

| | | | |
|---|---|---|---|
| Water Depth: 522m | | Wind: | 18.1kts @ $256^0$ |
| N:57 54.8345 | | DP Current: | 0.3 kts @ $057^0$ |
| E: 007 58.3600 | | Hdg: | $270.0^0$ |
| LIMITS NOTED: | | | |
| Inboard: | Warning limit $7.7^0$ | | Fatal limit $8.1^0$ boom angle |
| Outboard: | Warning limit $11.2^0$ | | Fatal limit $16.3^0$ boom angle |
| Ahead: | Warning limit $11.49^0$ | | Fatal limit $16.1^0$ boom angle |
| Astern: | Warning limit $11.09^0$ | | Fatal limit $16.11^0$ boom angle |

| Witnessed by: | R. J. Younger | Date: | 10th May 2015 |
|---|---|---|---|

## 6.6.7 EQUIPMENT SUB-SYSTEM 6 - REFERENCE SYSTEMS

**Test: 57** Radius 1000

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode.
  All available reference systems active.

**Method:**

1. Verify correct function by locking onto a fixed reflector station.
2. Check distances against other references.

**Deselect all other reference systems**

3. Move vessel in a 40m box pattern with heading changes.
   20m Astern, 40m Ahead, 20m Astern, 20m Port, 40m Stb'd and 20m Port.

**Reselect all available reference systems**

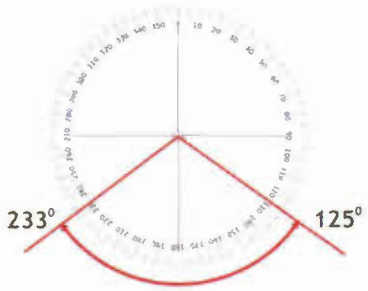
4. Rotate vessel through 360°, identifying blind spots.
5. Fail power supplies to PSU and monitor UPS1 F8.

**Results expected:**

1. Normal operation.
2. Normal operation.
3. Vessel moves and maintains position within 3m overshoot and heading within 2°. System can function as a standalone reference system.
4. Blind spots identified.
5. Alarm, rejected by DP.

**Results found:**

1. As expected.
2. As expected.
3. As expected.
4. As expected.
5. As expected.




**Target set up 180° astern.**
Moved In - Acquired Target: 233 m.
Rotate to Port - Target lost at: 233 °
Rotate to Stb'd - Target lost at: 125°

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 6.6.8 EQUIPMENT SUB-SYSTEM 6 - REFERENCE SYSTEMS

**Test: 58** Fanbeam

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Verify correct function by locking onto a fixed reflector station.
2. Check distances against other references.

**Deselect all other reference systems**

3. Move vessel in a 40m box pattern with heading changes.
   20m Astern, 40m Ahead, 20m Astern, 20m Port, 40m Stb'd and 20m Port.

**Reselect all available reference systems**

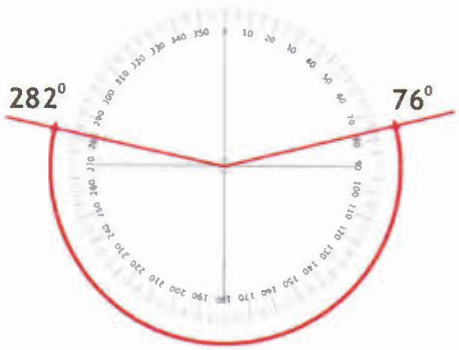
4. Rotate vessel through 360°, identifying blind spots.
5. Fail power supplies to PSU and monitor UPS1 F3.

**Results expected:**

1. Normal operation.
2. Normal operation.
3. Vessel moves and maintains position within 3m overshoot and heading within 2°. System can function as a standalone reference system.
4. Blind spots identified.
5. Alarm, rejected by DP.

**Results found:**

1. As expected.
2. As expected.
3. As expected.
4. As expected.
5. As expected.




**Target set up 180° astern.**
Moved In - Acquired Target: 233 m.
Rotate to Port - Target lost at: 282 °
Rotate to Stb'd - Target lost at: 76°

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 6.7 Equipment Sub-System 7 - Communication Devices

### 6.7.1 EQUIPMENT SUB-SYSTEM 7 - COMMUNICATION DEVICES

**Test: 59** Communication Devices

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Test all communications system (telephones, intercoms, etc.).
2. Check ergonomics DP consoles (blind spots, vision, Em-stop positions, etc.).
3. Test DP alerts.

**Results expected:**

1. All systems operational.
2. Acceptable ergonomics.
3. All systems operational.

**Results found:**

1. As expected.
2. As expected.
3. As expected.

**Comments:**

| Witnessed by: | R. J. Younger | Date: | 7th May 2015 |
|---|---|---|---|

## 7.0 APPENDIX 1

### 7.1 Temporary Measure for 'B' Recommendations 4.3.1 and 4.3.2

DP procedure in place as a temporary measure for 'B' Recommendations 4.3.1 and 4.3.2 - Azimuth Thrusters Aft PS and SB Command Signal Failure.

**MMSL**

**Procedure**

**"Thruster Prediction Error" warning alarms on DP**

Due to unexpected results obtained during the 2015 Annual FMEA Proving Trials – an undesired failure mode of the azimuth was experienced. An Azimuth direction wire break resulted in the Azimuth failing to "Park" position with a default RPM of 79.

Due to the above, DPO's need to pay particular attention to

"AZIMUTH AFT PORT/STBD PREDICTION ERROR AZIMUTH"

The cause of this alarm is when the Azimuth command signal is "interrupted". As such, the result of the above will lead to a potential induced "turning" moment caused by the 'healthy' thruster compensating.

In the event of any "Prediction Error Azimuth" the DPO is to immediately confirm de-selection of the indicated azimuth.

Where the above is observed the below should be followed :-

1) **When an alarm is given the DPO is to consult the 'Setpoint / feedback' mimic on DP and check both thruster status and setpoint / feedback**

2) **The Thruster in question should be 'deselected'; this should stop any speed command to thruster .**

**In the event the speed not reducing to zero.**
**EMERGENCY STOP the thruster – ENSURE THE CORRECT THRUSTER IS STOPPED.**

3) **The DPO shall initiate the recovery of any ROV's / crane loads / Divers in the water**

4) **Ensure that all alarms/events are printed and a 'Hardcopy' of necessary screens are printed**

5) **Commence a move out of the 500m Zone in a controlled manner**

6) **Notify the installation that the vessel is departing the 500m Zone due to a loss of Redundancy**

7) **DPO to investigate the root cause of the alarm when practicable**

MMSL

**Officers are to read and fully understand the aforementioned procedure with respect to the un-desired alarm and thruster movement.**

**MASTER**

..... .....

**C/O**

..... .....

**SDPO**

..... .....

**2/O – DPO**

..... .....

**2/O – DPO**

..... .....

# 8.0 APPENDIX 2 - Close Outs

## 8.1 Close Out Confirmation Mail

**From:** OSV Relume Master
**To:** Younger, Richard
**Cc:** "Paul Duner"
**Subject:** OSV Relume FMEA Close Out Actions
**Date:** 29 May 2015 13:50:33
**Attachments:** FMEA Test 34 280515.pdf
FMEA Test 36 280515.pdf

Good afternoon Richard,

Kongsberg and Rolls Royce completed there workscope to rectify the outstanding issues with regards to test 34 and 36 yesterday morning, the vessel then sailed for trials in the Europort area.

The following actions were taken for Test 34, Azimuth Thruster (PS) – Azimuth Signal Failures:

1. Vessel was set up as per Equipment Configuration detailed in MMS-MAR-14-0013-RJY-R01 Part 2
2. Azimuth thrusters were set to variable mode
3. Due to the slight weather conditions at the trials sight the load on the azimuths thruster was low, therefore a 10m bodily movement to port was instigated to increase the load on both azimuths.
4. The command signal to the between the DP and Port Azimuth ACU was failed as per the method dictated under the test protocol.
5. DP Alarm 'Azimuth aft PORT not ready' was received
6. The Port Azimuth thruster was dropped from the DP system
7. The Port Azimuth Thruster rotated to 0° and the RPM dropped to 0.
8. The following alarms were noted on the Praxis system
    a. Master / Slave Bridge warning
    b. Master / Slave Bridge failure
9. Hard copies of relevant DP screens were taken to support test results – *see attached; FMEA Test 34 280515*
10. The command signal was reinstated, after which the DPO took control of the Azimuth into the DP system and allowed the vessel to stabilise.
11. The DPO then selected Force Bias for Azimuth thruster 3 and 4 and allowed the vessel to stabilise.
12. Actions 3 and 4 were repeated and the results noted under Actions 5 – 8 (inclusive) were observed
13. Actions 9 and 10 were then repeated and the vessel was repositioned to continue with Test 36.

The following actions were taken for Test 36, Azimuth Thruster (SB) – Azimuth Signal Failures:

1. Vessel was set up as per Equipment Configuration detailed in MMS-MAR-14-0013-RJY-R01 Part 2
2. Azimuth thrusters were set to variable mode
3. Due to the slight weather conditions at the trials sight the load on the azimuths thruster was low, therefore a 10m bodily movement to port was instigated to increase the load on both azimuths.
4. The command signal to the between the DP and Starboard Azimuth ACU was failed as

per the method dictated under the test protocol.

5. DP Alarm 'Azimuth aft STBD not ready' was received
6. The STBD Azimuth thruster was dropped from the DP system
7. The STBD Azimuth Thruster rotated to 0° and the RPM dropped to 0.
8. The following alarms were noted on the Praxis system
   a. Master / Slave Bridge warning
   b. Master / Slave Bridge failure
9. Hard copies of relevant DP screens were taken to support test results - *see attached; FMEA Test 36 280515*
10. The command signal was reinstated, after which the DPO took control of the Azimuth into the DP system and allowed the vessel to stabilise.
11. The DPO then selected Force Bias for Azimuth thruster 3 and 4 and allowed the vessel to stabilise.
12. Actions 3 and 4 were repeated and the results noted under Actions 5 – 8 (inclusive) were observed
13. Actions 9 and 10 were then repeated.

Further to the above tests, the control signal failures were also simulated when the vessel was under control of the IJS, with the following results noted:

1. Control signal failed between IJS and Thruster ACU
2. IJS Alarm 'Azimuth Port/Stbd not ready' *Note: either Port or Stbd was displayed depending on which thruster control signal was failed*
3. The failed thruster was dropped from the IJS
4. The failed thruster rotated to 0° and the RPM dropped to 0
5. The Praxis alarms were noted to be as per those recorded under action 8 of test 34 and 36
6. Photos were taken of the IJS display to support test results – *can be emailed if required*
7. The command signal was then reinstated, allowing the operator to take control of the thruster and stabilise the vessel

All test were witnessed by Roll Royce as a 3rd party witness.

I believe that the results gained should satisfy all parties with the Azimuth thrusters both failing into the fail safe condition i.e. **Azimuth parked in the 0° position and RPM dropping to 0.** The only action remaining would be to edit the 'Results Expected' section of Test 34 and 36 of document MMS-MAR-14-0013-RJY-R01 – Part 2 to include that the azimuth thruster returns to the parked position (0°) and RPM drops to zero, as at present the expected result are for the azimuth rotation to freeze.

I await your further comments

Best regards

John Heale

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## 8.2 'B' Recommendation 4.3.1 - Test 34-Azimuth Thruster (PS) Azimuth Signal Failures

EQUIPMENT SUB-SYSTEM 3 - THRUSTER

**Test 34** Azimuth Thrusters (PS) - Azimuth Signal Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail azimuth command signal from DP to ACU, restore. (WU4 U41 X4 4, 5)
2. Fail azimuth feedback signal (Sin) from ACU to DP computer, restore. (WU4 U41 X2 2)
3. Fail azimuth feedback signal (Cos) from ACU to DP computer, restore. (WU4 U41 X2 3)
4. Fail azimuth command signal from ACU to Turning Motor and restore. (ACU-X1 E05 & E06)
5. Fail azimuth feedback signal from Turning Motor to ACU and restore. (X2 330, 331)

**Results expected:**

1. Alarm, '**AZIMUTH AFT P NOT READY**', drops out of DP, rotation freezes, RPM to zero.
2. Alarm, '**AZIMUTH AFT P INPUT ERROR AZIMUTH**', thruster follows command.
3. Alarm, '**AZIMUTH AFT P INPUT ERROR AZIMUTH**', thruster follows command.
4. Alarm, '**AZIMUTH AFT P NOT READY**', drops out of DP, rotation freezes, RPM to zero.
5. Alarm, '**AZIMUTH AFT P INPUT ERROR AZIMUTH**', thruster follows command.

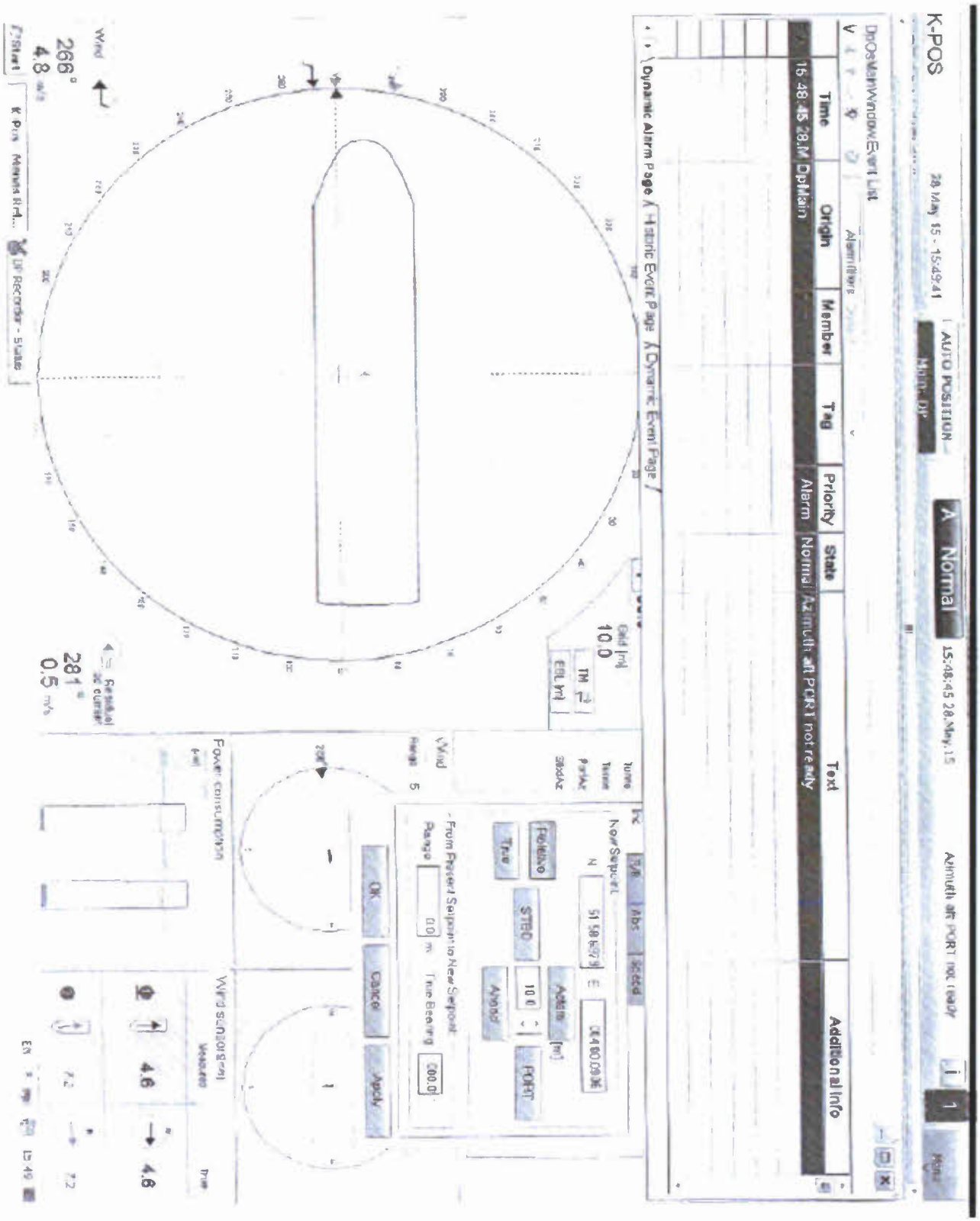
**Results found:**

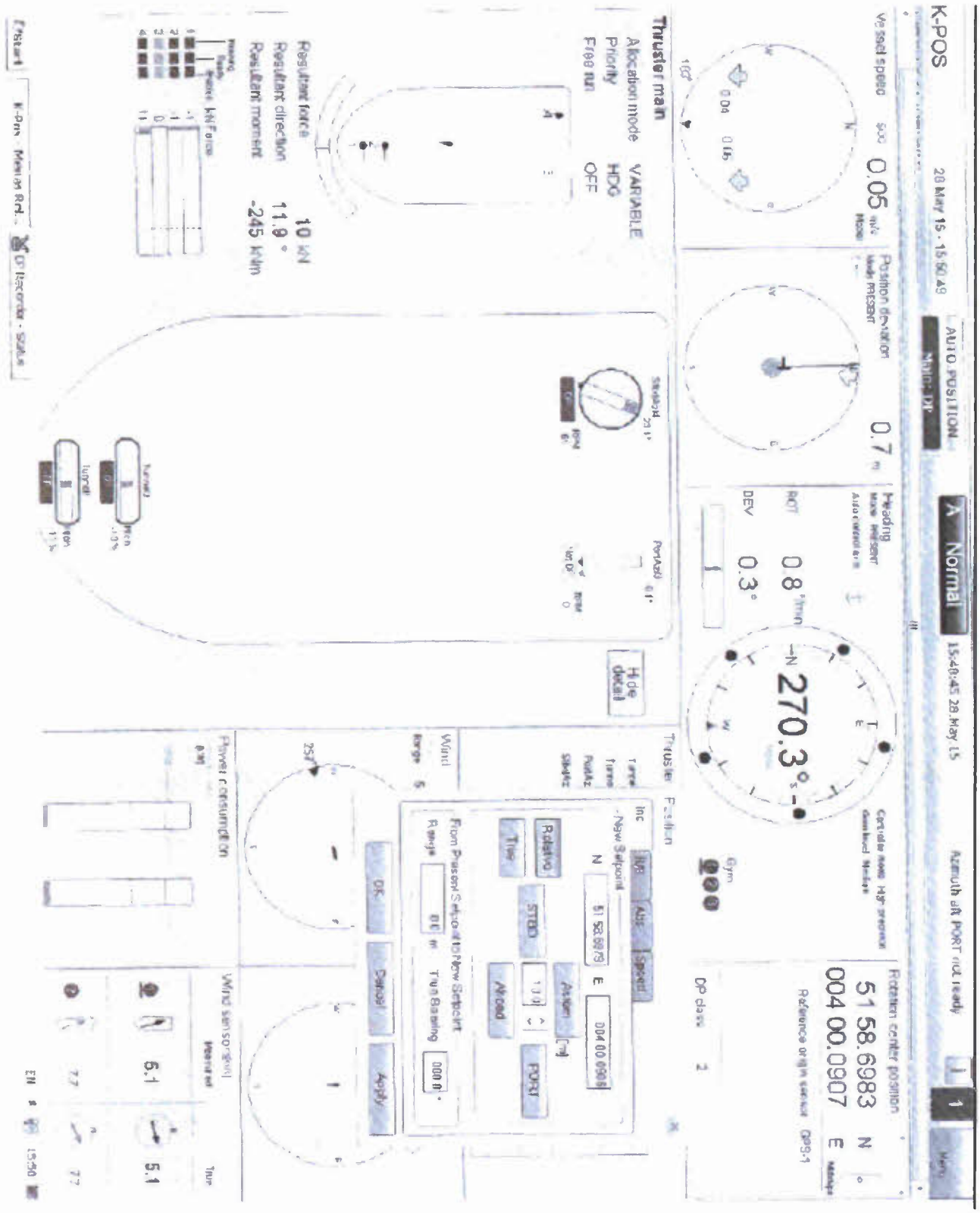
1. ALARM, 'AZIMUTH AFT P NOT READY', DROPS OUT OF DP, ROTATES TO 0°, RPM TO ZERO
2. As expected - tested 15/05/2015
3. As expected - tested 15/05/2015
4. As expected - tested 15/05/2015
5. As expected - tested 15/05/2015

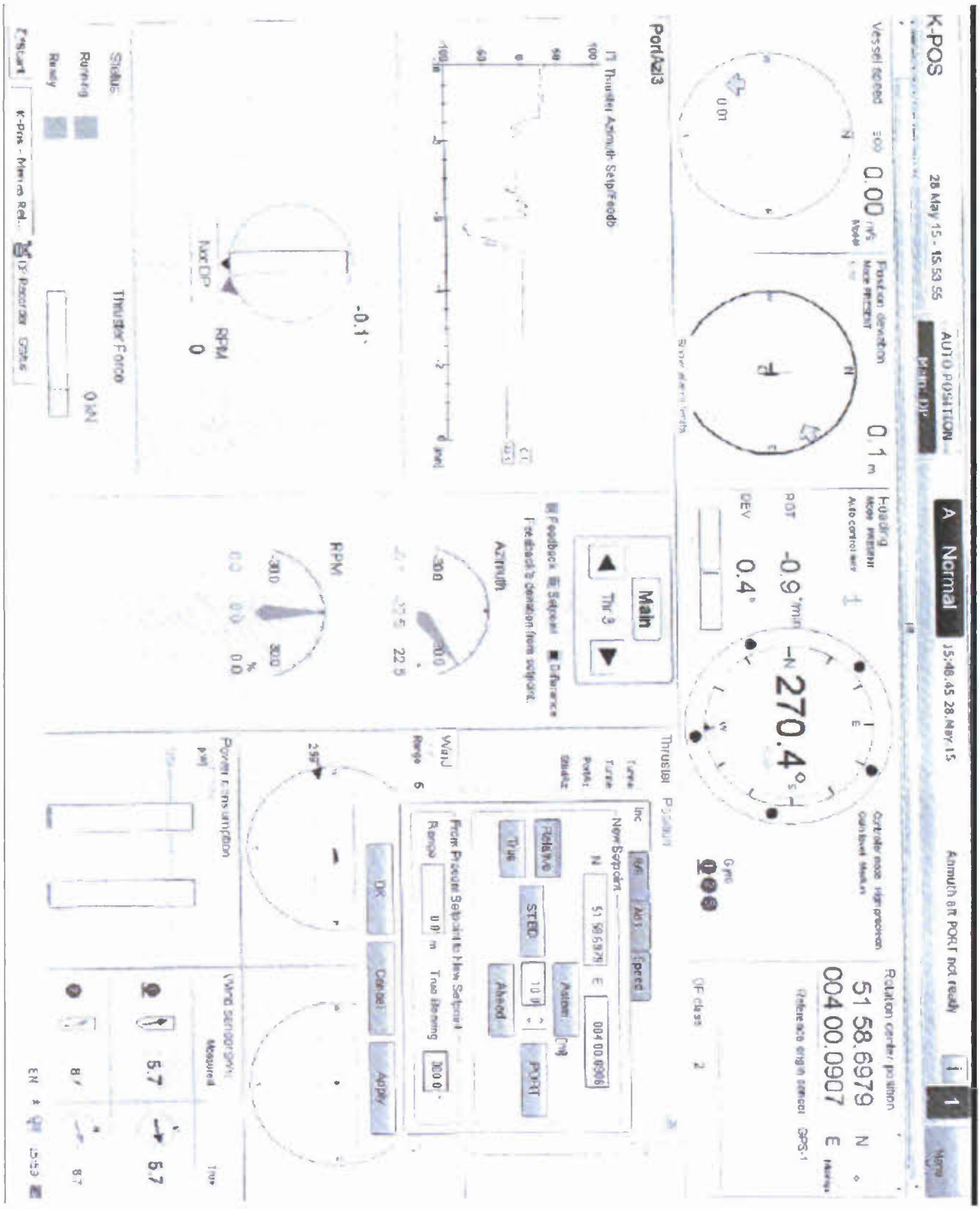
**Comments:**

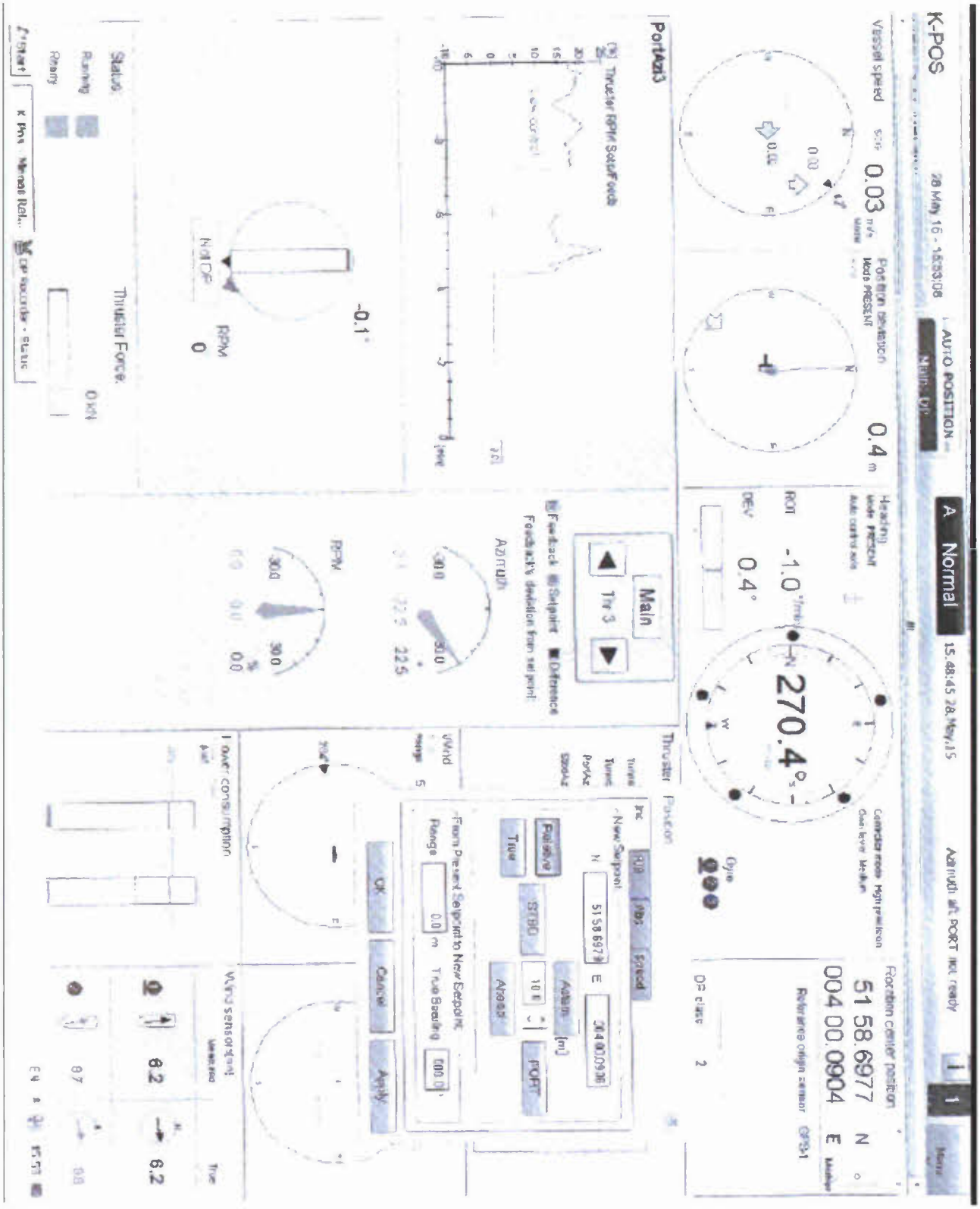
Witnessed by: J. Hoare Date: 28th May 2015

O.S.V. RELUME
NASSAU 9260720
GRT : 3626
NRT : 1057
KW : 4434









## 8.3 'B' Recommendation 4.3.2 - Test 36-Azimuth Thruster (SB) Azimuth Signal Failures

EQUIPMENT SUB-SYSTEM 3 - THRUSTER

**Test 36** Azimuth Thrusters (SB) - Azimuth Signal Failures

**Equipment Configuration:**

- In DP2 mode (consequence analysis active).
- All four DG engines running/available.
- DGs 1 and 3 connected to port 690V SWBD.
- DGs 2 and 4 connected to stb'd 690V SWBD.
- 690V SWBD bus tie **OPEN**.
- 440V SWBD bus tie **OPEN**.
- MSB 230V supplied via transformer from port 440V MSB.
- NSB 230V supplied via transformer from stb'd 440V MSB.
- ENSB PS and ENSB SB supplied from MSB 230V.
- DG1 and DG3 fuel from daily service tank 1, DG2 and DG4 from daily service tank 2. Fuel crossover valves (supply and return) closed.
- Emergency generator in auto start mode. All available reference systems active.

**Method:**

1. Fail azimuth command signal from DP to ACU, restore. (WU7 U71 X4 4, 5)
2. Fail azimuth feedback signal (Sin) from ACU to DP computer, restore. (WU7 U71 X2 2)
3. Fail azimuth feedback signal (Cos) from ACU to DP computer, restore. (WU7 U71 X2 3)
4. Fail azimuth command signal from Turning Motor to thruster, restore. (ACU X1 E05 & E06)
5. Fail azimuth feedback signal from thruster to Turning Motor, restore. (X2 330, 331)

**Results expected:**

1. Alarm, **'AZIMUTH AFT S NOT READY'**, drops out of DP, rotation freezes, RPM to zero.
2. Alarm, **'AZIMUTH AFT S INPUT ERROR AZIMUTH'**, thruster follows command.
3. Alarm, **'AZIMUTH AFT S INPUT ERROR AZIMUTH'**, thruster follows command.
4. Alarm, **'AZIMUTH AFT S NOT READY'**, drops out of DP, rotation freezes, RPM to zero.
5. Alarm, **'AZIMUTH AFT S INPUT ERROR AZIMUTH'**, thruster follows command.

**Results found:**

1. ALARM 'AZIMUTH AFT STBD NOT READY', DROP OUT OF DP, ROTATION TO 0°, RPM TO ZERO
2. As expected - tested 15/05/2015
3. As expected - tested 15/05/2015
4. As expected - tested 15/05/2015
5. As expected - tested 15/05/2015

**Comments:**

Witnessed by: J Hoare Date: 28th May 2015

O.S.V RELUME
NASSAU 9280720
GRT : 3628
NRT : 1057
KW : 4434