Appendix A

Power Management System Test Guidelines

The MTS DP Committee wants to thank Don Wilkes of Minden Engineering Company for his authorship of this appendix to the Test Guidelines

MARINE TECHNICAL SOCIETY
DP POWER MANAGEMENT SYSTEMS PERIODIC TEST GUIDELINES

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1 POWER MANAGEMENT SYSTEM

For the DP System to have the capability to accurately maintain position and permit DP and vessel operations to be carried out, power must be available to the thrusters when needed, and accurate information about the power system configuration and operation must be communicated to the DP system. The Power Management System (PMS) is used to provide the controls for the power generation and its distribution so that the vessel power system is reliable and dependable.

1.1 SCOPE

This test procedure is intended to serve as guidelines to be used in generating a Vessel Specific Test Procedure for all types of vessels that employ Power Management Systems, especially those with Dynamic Positioning (DP) Systems that must maintain specific positions or tracks for successful performance of their intended operation. Various Class Societies such as ABS or DNV may have specific tests that must be performed in addition to those defined in this Guidance Document. These should be incorporated in the Vessel Specific Test Procedures. This applies to Drilling Vessels (MODU's), Construction Vessels such as cranes, pipeline vessels, Service Vessels such as supply boats or anchor handlers, Production or Support Vessels such as FPSO's or tankers, etc. These guidelines may not apply to a vessel that does not have a Power Management System. The vessel Specific Test Procedure must consider the performance requirements and equipment design for that vessel, and develop a procedure that demonstrates all those performance requirements. The characteristic of most of these vessels is that they have large power system loads associated with equipment that is employed in performing their primary tasks, and the PMS system must allocate and control the system to provide the power as needed to all users, including the thrusters needed for position control and navigation. To facilitate the general application of this document this added specialized equipment will be referenced as the "Mission" equipment. Part of the function of the PMS is to allocate power to the various systems as their priority demands. Under most circumstances the DP system and thrusters will be a higher priority than the Mission equipment, but there are circumstances when the specific mode of operation will assign a higher priority to a part of the Mission equipment than is assigned to the thrusters. One example of such a circumstance is a drilling vessel with Active Heave Drawworks when it is performing critical operations, such as landing out a Blow-Out Preventer (BOP). The relative priority of the Mission equipment may change dependent on the operation and the PMS must account for this change in priority. The Test Procedures developed for such a vessel must include tests that confirm such changes in priority are properly handled by the PMS.

Within this document the vessel automation system remote control stations will be referenced as the IAS system.

1.2 PURPOSE

The purpose of these guidelines is to describe the types of tests needed and the content of the tests to be incorporated in the Vessel Specific Test Procedures. The tests in that procedure are to demonstrate the operation and effectiveness of the PMS system in providing reliable power distribution. The following System Test Objectives are intended to provide assurance of the quality of the PMS. Certain of the objectives, 1 and 2 will generally be covered in other class required periodic tests, so they are not fully defined in this document, but their function and accuracy are an integral part of the successful completion of the rest of the testing that relies upon these items. Other items such as 3, 5, 6, 7, 11, 12 and 14 do not have separate specific tests, but will be proven as part of the other test items detailed in this document.

1. Demonstrate the proper settings and operation of the generator protective relays.
2. Demonstrate the proper calibration of meters and transducers.
3. Demonstrate the proper operation of the engine generator sets to start, synchronize with the bus, close the circuit breaker and provide power when initiated under the control of the PMS or alternate generator management and protection system.
4. Demonstrate that both KW and KVAR are properly shared between on-line engines and generators for both static loads and dynamic load changes, for all bus configurations.
5. Demonstrate the proper synchronization and breaker operation for the Bus Tie Circuit Breakers.
6. Demonstrate the capability for each engine generator set to operate properly and free of faults, both independently and when parallel with other engine generator sets.
7. Demonstrate the proper communication of system configuration and operational parameters to the DP system and Mission equipment.

8. Demonstrate the proper reaction to engine shut down and/or the unexpected tripping of a generator off line. Response includes the immediate reduction of thruster and Mission equipment loads, with proper restoration of available loads on a time ramped basis along with starting an additional engine.
9. Demonstrate that, following a Worst Case Failure as defined by the Vessel Operational Guidelines or Constraints, the vessel can continue to deliver performance and provide safety of personnel in compliance with those Guidelines or the Philosophy for handling Worst Case Failures.
10. Demonstrate the PMS response to increasing loads by limiting the KW Available to the Mission equipment and the DP system and initiating the start of additional engines to alleviate the power limiting. In response to the reduced KW Available signals, the power demanded by the DP and/or Mission equipment systems will be limited by these systems to remain below the PMS supplied KW Available signal.
11. Demonstrate the capability to provide proper distribution of available power between ship's service, Mission equipment, and thrusters to permit concurrent operation of Mission equipment while maintaining position, and that relative priority supplies power to thrusters and then Mission equipment, subject to specific operations requiring a higher priority for some Mission equipment.
12. Demonstrate that normal changes in system configuration or number of on-line generators is accomplished without noticeable transient impact upon the power system and loads.
13. Demonstrate the capability to restore power rapidly in the event of a situation that results in a blackout of the vessel.
14. Demonstrate that the PMS system properly handles all possible combinations of power system configurations involving all possible combinations of Bus Tie connections.

Vessels have many different generation frequencies and voltage levels, based on the standards of the owner and the country of registration. For this Guidance Document, the specific voltage levels will not be used, but instead will reference the Main Generator Switchboard (for which 11 KV is a common voltage) and Vessel Distribution Switchboards (for which voltages of 480 VAC, 690 VAC, 440 VAC, 230 VAC, 220 VAC or 120 VAC are commonly implemented in these vessels). Use of Distribution SWitchborads at more than one voltage are common for all installations.

Major switchboards, as used in this document, are vessel distribution switchboards at any voltage that are rated to manage power levels rated 500 KVA or larger.

Special features that may not be considered as a typical feature of the PMS system must be considered as part of the developed test procedures to ensure the operation performs as anticipated. One example of such a feature is a parameter to allow the operating engineer to be able to adjust the rated capacity of engines to allow for age degradation or other problems that might limit the capability of the engine to deliver its rated power. Other features to be tested for special requirements include Base Loading on engines or provisions to ensure adequate rotating reserves that may be required for certain operating modes.

Engine-generator set control, monitoring and protection may be performed by sensors and logic that is totally within the PMS in the vessel IAS, or many portions of these functions may be performed by equipment or devices that that are not a part of the vessel IAS system. Examples of such separate systems (some of which terms or systems may be copyrighted, trademarked or patented) include Diesel Generator Monitoring System (DGMS), Advanced Generator Supervisor (AGS) or Advanced Generator Protection (AGP). In general terms all this equipment is a part of the total PMS system, but this guidance document assumes that the majority of the control and monitoring functions are performed with the IAS equipment, and protection is provided by equipment separate from the IAS equipment. The Vessel Specific Test Procedure should account for the specific arrangement in the vessel to which the procedure applies, and provide procedures and instructions associated with operation of that equipment.

1.3 ABBREVIATIONS

ABS	American Bureau of Shipping
AGP	Advanced Generator Protection
AGS	Advanced Generator Supervisor
AHC	Active Heave Compensation
AHD	Active Heave Drawworks
BOP	Blow Out Preventer
CB	Circuit Breaker

DGMS	Diesel Generator Management System
DNV	Det Norske Veritas
DP	Dynamic Positioning
FDS	Functional Design Specifications
FPSO	Floating Production Storage and Offloading vessel
HPU	Hydraulic Power Unit
IAS	Integrated Automation System
KVA	Kilo Volt-Amperes
KVAR	Reactive Kilo Volt-Amperes
KW	Kilowatts
MODU	Mobile Offshore Drilling Unit
PMS	Power Management System
VAC	Volts – Alternating Current
VFD	Variable Frequency Drive
VMS	Vessel Management System

1.4 GLOSSARY

The following terms are used in this document, based upon the following description of the term.

Base Loading
The capability to apply a fixed load to one engine while allowing the other on line engines to share the remaining system loads while controlling the bus voltage and frequency. This feature is generally used to operate the engine at a sufficiently high load to burn off any carbon that has built up in the exhaust system during operation at lighter operating loads.

Coordination Study
The Class approved engineering study that defines the relative protection level and time settings for Circuit Breakers that can disconnect certain loads within the distribution system.

Frequency Based Cutback
This feature is present in some utilization equipment to prevent overloading of engines to the extent that they would trip off line. The utilization equipment measure the system frequency, and based on that frequency reduces the power demanded by that equipment to reduce the loads on the engine that caused the drop in frequency.

Main Generator Switchboard
The vessel switchboard or switchboards to which the engine generator sets are connected, and through which their power is made available to the various loads on the vessel.

Mission Equipment
The specific equipment on the vessel that permits it to perform the work for which it is used. Examples are the Drilling Systems, Pipe Laying equipment, Cranes, Processing Equipment or other equipment not related the vessel itself or its maneuvering, transit or dynamic positioning equipment.

Rotating Reserves
The unused power that is connected to the bus – based upon the rated power for all the *connected* engine generator sets less the amount of power that is actually being used by all the operating loads.

2 Instrumentation

2.1 Protective Relays (Objective No. 1)

The protection relays for circuit breakers in the main generator switchboard and for circuit breakers in the downstream switchboards (at least the major circuits) should be tested periodically to maintain class approval. Even if not required by class these tests should be performed at intervals not exceeding five years to ensure the system protection will function as expected and defined in the Class Approved Coordination study.

The settings of all relays and circuit breakers in all Main Generator Switchboards and in all vessel distribution switchboards should be confirmed to match the settings defined in the Class Approved Vessel Coordination study and settings tables. Record the actual settings of all relays and protective devices.

2.2 Meters and Transducers (Objective No.2)

During Periodic Device testing the transducers should be retested and confirmed to perform according to the manufacturer's ratings. Even if not required by class these tests should be performed at intervals not exceeding five years for transducers used by PMS to ensure the system PMS will receive accurate information to enable it to function as expected and defined in PMS specifications

Meters are generally provided for local monitoring and their functionality should be monitored during normal operation, but no specific recertification is suggested.

3 Engine Control System (Objective No. 3)

During normal and routine operations, the following operational capabilities should be proved for each engine, so that complete testing of every engine is not generally needed. Select random engines to confirm each of the tests:

Test	Remarks	OK
Demonstrate that each engine can be started and stopped from each control location when activated, and that those positions not activated do not have control.	Verify that E-Stops function and that Local control can be activated when engine has been started remotely.	
Demonstrate that each engine can be synchronized and circuit breaker closed both manually and automatically with control at the main switchboard.	Observe the power sharing as the circuit breaker is closed and that it ramps up to a level equal with others already on line.	
Demonstrate that each engine can be manually tripped from supplying load.	Observe the power sharing after operation of CB Open switch, that power ramps down to a low value and CB opens.	
With the engine in a "Standby" mode cause the PMS system to initiate a START cycle and place the engine on line.	Record the time from the PMS initiation of the Start cycle until the Circuit Breaker closes for each engine.	
With the engine in "Not Standby" mode manually initiate a START cycle and place the engine on line.	Record the time from the initiation of the Start cycle until the Circuit Breaker closes for each engine.	
Demonstrate that the engine can be removed from the bus under control of the operator using commands via the IAS.	Observe the power sharing after operator command, that power ramps down to a low value and CB opens.	
Demonstrate that the IAS system will remove an engine from the bus when the engine load is lower than Auto Stop set point, and will automatically initiate the removal cycle.	Operational Mode must be set for automatic stopping of engines	

4 Static Load Sharing (Objective No. 4)

Define the parameters to facilitate efficient testing and verify that the various parameters are set according to the PMS specifications. For example start and stop times can be reduced to allow faster automated starts.

To demonstrate the load sharing at each engine loading configuration, set auto start mode off to prevent their being automatically started, or take engines out of auto mode until time for it to be added to the parallel sets. Set Load Share mode to Symmetric or equal sharing between all engines. At the step to add an engine one of the engines should be manually started and connected to the bus.

For these tests any unbalance that exceeds the class requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm (if equipped) will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger if it supplies sufficient details. It is suggested that the readings for KW, KVAR, Amps and Volts for each on-line generator be recorded for each test.

4.1 Single Bus Configuration

Configure the system into a single bus, and perform the tests as described below:

Begin testing with two engines on line and use thrusters and Mission equipment to produce loads as needed to approach full load on the operating engines.

After observation of load sharing with two engines, progressively add the rest of the engines one at a time. After each engine has stabilized at the previous load level, increase the load on the system to approach full load on all the operating engines.

With the system operating with most engines on line perform tests that prove that the PMS will properly account for engines that are on line, but not assigned to automatic load sharing. Generally this mode can be controlled at the IAS control station and at the Main Switchboard as well as possibly at the engine. All possibilities must be tested.

The method for proving the PMS operation for the above test is to place sufficient load on the system so that the engines are operating at near full load, and switch an engine out of auto mode and confirm that the PMS operates as expected. Available power should be decreased because of the change in mode, and it is anticipated that the engine will continue to operate at the power level prior to the mode switch. Then force the engine in manual mode to reduce its power until the other engines reach rated power, and confirm that the PMS reduces the thruster and Mission equipment power level as necessary to keep the remaining engines from being overloaded. If this setting does not cause phase back of the loads for limiting, increase the loads requested by the thrusters until such phase back is confirmed.

4.2 Other Bus Configurations

Configure the system with various combinations permitted by the system design, and repeat the above tests, adding generators alternately on each bus.

5 Dynamic Power Sharing (Objective No. 4)

This test is applicable for vessels with Mission equipment that can create large dynamic load variations that must be handled by the load sharing system. Drilling vessels are good examples with the loads created by drawworks during normal tripping operations, or by an active heave drawworks (AHD) in typical operations. Simulation of heave into the AHD can be used to force loads that will demonstrate the load sharing performance. Both aperiodic loads, such as the tripping exercise, and periodic loads, such as the AHD simulation, should be used when available.

Define the parameters to facilitate efficient testing and verify that the various parameters are set according to the PMS specifications. For example start and stop times can be reduced to allow faster automated starts.

To demonstrate the load sharing at each engine loading configuration, set auto start mode off to prevent their being automatically started, or take engines out of auto mode until time for it to be added to the parallel sets. Set Load Share mode to Symmetric or equal sharing between all engines. At the step to add an engine one of the engines should be manually started and connected to the bus. After the engine is connected, its load should ramp to the power level commensurate with sharing the system load with the existing on line engines.

For these tests any unbalance that exceeds the class requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm (if equipped) will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger if it supplies sufficient details. It is suggested that the readings for KW, KVAR, Amps and Volts for each on-line generator be recorded for each test.

5.1 Single Bus Configuration

Configure the system into a single bus, and perform the tests as described below:

Begin testing with two engines on line and use thrusters and Mission equipment to produce loads as needed to provide a normal load on the operating engines. Activate the dynamic load and observe load sharing performance.

After observation of load sharing with two engines, progressively add the rest of the engines one at a time. After each engine has stabilized at the previous load level, increase the static load on the system to a normal load level on all the operating engines, and then activate the dynamic load.

5.2 Other Bus Configurations

Configure the system with various combinations permitted by the system design, and repeat the above tests, adding generators alternately on each bus.

6 Frequency Based Load Reduction (Objective No. 9)

The purpose of this test is to prove that utilization equipment that incorporated frequency based load reduction performs as expected. All equipment that incorporates this feature must be included in this test, likely one or two units at a time. The engines manual control panel at the switchboard or engine should be used for this test to produce a manually control bus frequency on a portion of the main power system.

This section is applicable only to those vessels that incorporate frequency based cutback. If the vessel is not equipped with this facility, this section is to be omitted.

To facilitate the testing on specific units, the section of the bus from which the units are connected should be separated from the rest of the vessel power system. Reconfigure any vessel distribution systems that do not incorporate frequency supplied cutback to be supplied from the bus not being tested, if possible, to reduce the impact on equipment not being tested.

The function of the IAS based PMS must be evaluated and some signals may need to be manually forced to ensure that the tests are proving the functionality of the utilization equipment.

The data that is requested to be recorded may be derived from records from the Data Logger if it supplies sufficient details. It is suggested that the readings for KW, KVAR, Amps and Volts for each on-line generator be recorded for each test.

6.1 Test Procedure

Configure the system into a single bus, and perform the tests as described below:

Begin testing with two engines on line on the section of bus not being tested and one engine on the bus section to be tested. Use thrusters and Mission equipment connected to the bus section not being tested to maintain position and operate the Mission equipment required for operational functionality.

Reconfigure the vessel distribution where possible so that only the equipment being tested is supplied from the section of the bus that is under test.

Separate the bus into the two sections – one under test and one not being tested.

Manually apply or control the equipment being tested (e'g', thrusters and mud pumps) so that they are consuming sufficient power (10% to 20% of rated) to permit observation of the reduction when the frequency is reduced. Manually set any power limiting parameters being supplied to the equipment under test to a value that is above the power being consumed by the equipment.

Manually switch the engine that is supplying the bus being tested into manual control mode, likely at the Main Switchboard or possibly at the engine. In some cases this may be possible at the IAS console but the local manual panel generally provides smoother control.

Manually reduce the frequency of the engine in manual control to prove that the loads reduce in power as a result of the low frequency. Reduce the frequency to a value representative of the minimum frequency being handled by the design parameters. Following confirmation that the power reduction complies with the design specifications, raise the frequency slowly to nominal values and confirm that the equipment power is allowed to return to the level at which it was set prior to the test.

Reclose the bus into a single bus system. Return the engine under test to normal operating mode under control of the IAS and PMS system.

Return the equipment being tested to normal operating modes. Remove the manual setting for the parameters being sent from PMS to the equipment being tested.

Repeat the above tests for other sections of the bus to complete the test on all equipment that incorporates this feature.

7 Dynamic Propulsion Loads (Objective No. 4)

The purpose of this test is to use the propulsion system loads to create a dynamic load on the system and observe the performance of the load sharing system and the PMS as it handles the rapid changes in thruster demand. All thrusters that can be used for forward motion should be used for this test, when all engines are on line. The manual control panel used for vessel transit should be used for this test.

This test shall be performed at transit draft.

This test creates a large dynamic load by having the vessel travel through the water at full thruster load, then quickly bringing the forward command to zero, waiting 10 seconds and returning the command quickly to full. Movement of the throttle command should be as quick as possible, preferably within a half second. This fast reduction of load will reduce plant load to vessel services with no thruster loads, allowing the engine turbochargers to spool down reducing charge pressure. Returning the throttle to full will create rapid thruster power demand and invoke the ramping limits within the PMS system and any other functions that are implemented to protect the system from being overloaded. This test is different from a crash stop test by having the pause at low power creating much faster power transients.

Define the parameters to facilitate efficient testing and verify that the various parameters are set according to the PMS specifications. For example start and stop times can be reduced to allow faster automated starts.

To demonstrate the load sharing at each engine loading configuration, set auto start mode off to prevent their being automatically started, or take engines out of auto mode until time for it to be added to the parallel sets. Set Load Share mode to Symmetric or equal sharing between all engines. At the step to add an engine one of the engines should be manually started and connected to the bus.

For these tests any unbalance that exceeds the class requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm (if equipped) will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger if it supplies sufficient details. It is suggested that the readings for KW, KVAR, Amps and Volts for each on-line generator be recorded for each test.

7.1 Single Bus Configuration

Configure the system into a single bus, and perform the tests as described below:

Begin testing with about half the engines on line and half the thrusters. No Mission equipment is used for this test. Use the Joystick throttle on the Manual Thruster Control Panel to command full speed to reach full load on the operating engines, and allow the vessel to reach steady speed.

After the vessel has full way on the hull, bring the joystick control to zero rapidly. After the joystick control has been at zero for 10 seconds, bring the thruster controls to full ahead.

Place all engines on line, with no Mission loads and all thrusters in Transit Control mode. Using the joystick control at full ahead speed, apply max power to all the thrusters. After the vessel has full way on the hull, bring the joystick control to zero rapidly. After the joystick control has been at zero for 10 seconds, bring the thruster controls to full ahead.

7.2 Other Bus Configurations

Configure the system with one other bus combination as permitted by the system design, and perform the full power test.

Place all engines on line, with no Mission loads and all thrusters in Transit Control mode. Using the joystick control at full ahead speed, apply max power to all the thrusters. After the vessel has full way on the hull, bring the joystick control to zero rapidly. After the joystick control has been at zero for 10 seconds, bring the thruster controls to full ahead.

8 Engine Shutdown & Gen Tripping (Objective No. 8)

The purpose of this test is to demonstrate the reaction of the PMS and other system protection logic to a random generator trip, to immediately cut back the loads from the thrusters and drilling system to prevent a cascading loss of additional engines due to overload. As those loads will be allowed to ramp back up to a level commensurate with the new engine configuration, another engine should be started. After the new engine has been placed on line the load should be permitted to return to the previous level.

Depending on the system design, the overloads resulting from tripping of a generator when at heavy loads will result in actions being taken by the PMS system that is a part of the IAS system and/or utilization equipment based load reduction triggered by the drop in bus frequency. The test method is not dependent upon the system design for reduction of loads, but the measurements being recorded should be specific to the design to prove that the load reduction logic is functioning properly.

The engine that has been selected to be tripped must be E-Stopped to cause the circuit breaker to be manually tripped. The action of the PMS will then cause elimination or reduction of the thruster and Mission loads for a short period during stabilization of the system.

Do not use Heave Compensation modes for Drawworks, if such is fitted for the vessel.

Do NOT operate cranes during this test, but crane HPU's may be energized to create system vessel loads.

Define the parameters to facilitate efficient testing and verify that the various parameters are set according to the PMS specifications.

To demonstrate the load sharing at each engine configuration, set auto start mode due to load levels off to prevent their being automatically started, or set the start level to a high level to prevent auto starting due to load levels. Set Load Share mode to Symmetric or equal sharing between all engines. The system must be configured to automatically start one of the engines when the engine is tripped so that it will be started and connected to the bus.

For these tests any unbalance that exceeds the class requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm (if equipped) will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger if it supplies sufficient details. It is suggested that the readings for KW, KVAR, Amps and Volts for each on-line generator be recorded for each test.

8.1 Single Bus Configuration

Configure the system into a single bus, and perform the tests as described below:

Begin testing with three engines on line and use thrusters and Mission equipment to produce loads as needed to reach a load over 90% on the operating engines.

E-Stop one engine, and confirm that the PMS supplies proper signals to all thrusters to reduce thruster load and the Mission equipment load is also reduced. Confirm signals are supplied to Mission equipment and each thruster that is cut back. Confirm that the Load Shedding logic will trip loads as prescribed in the PMS specifications.

For systems with frequency based load reduction in the thrusters or Mission equipment, confirm that the amount of load reduction at each load is commensurate with the frequency to which the power system drops, and that its recovery to operating levels follows the design specifications for each load.

While another engine is starting and after the thrusters and Mission equipment power return to “normal” with the remaining two engines, observe the system performance with limited power available and that the system is sufficiently stable.

After the engine has been connected on line and power returns to normal, observe that the thrusters and Mission equipment power returns to the level at which it was operating with the original three engines.

Remove one engine and continue testing with two engines on line and use thrusters and Mission equipment to produce loads as needed to reach a load over 90% on the operating engines.

E-Stop one engine, and confirm that the PMS supplies proper signals to all thrusters to reduce thruster load and the Mission equipment load is also reduced. Confirm signals are supplied to Mission equipment and each thruster that is cut back. Confirm that the Load Shedding logic will trip loads as prescribed in the PMS specifications.

The method used to trip the breaker must be selected with knowledge of the PMS and IAS systems so that the condition is recognized as a breaker trip, and the tripped breaker is not reclosed by the IAS. An E-Stop generally accomplishes this, but there are other methods on most systems that may be more convenient relative to the test.

While another engine is starting and after the thrusters and Mission equipment power return to “normal” with the remaining engine, observe the system performance with limited power available and that the system is sufficiently stable.

After the engine has been connected on line and power returns to normal, observe that the thrusters and Mission equipment power returns to the level at which it was operating with the original two engines.

8.2 Dual Bus Configuration

Configure the system into a dual bus, splitting the bus into approximately equal sections, and perform the tests as described below:

Begin testing with two engines on line on each bus and use thrusters and Mission equipment to produce loads as needed to reach a load over 90% on the operating engines on the bus to be tested.

E-Stop one engine, and confirm that the PMS supplies proper signals on the bus being tested to all thrusters to reduce thruster load and the Mission equipment load is also reduced. Confirm signals are supplied to Mission equipment and each thruster that is cut back. Confirm that the Load Shedding logic will trip loads as prescribed in the PMS specifications. Loads on the bus section not being tested should not be affected as a result of the test, but there may be other relational controls that result in changes to the load level on that bus.

For systems with frequency based load reduction in the thrusters or Mission equipment, confirm that the amount of load reduction at each load is commensurate with the frequency to which the power system drops, and that its recovery to operating levels follows the design specifications for each load.

While another engine is starting and after the thrusters and Mission equipment power return to "normal" with the remaining engine, observe the system performance with limited power available and that the system is sufficiently stable.

After the engine has been connected on line and power returns to normal, observe that the thrusters and Mission equipment power returns to the level at which it was operating with the original two engines.

9 Engine Start with Increasing Loads (Objective No . 10)

Define the parameters to facilitate efficient testing and verify that the various parameters are set according to the PMS specifications. For example start and stop times can be reduced to allow faster automated starts.

To demonstrate that the PMS system automatically starts engines as the load levels reach the setpoints defined in the PMS specifications. Set auto start mode on to permit their being automatically started due to operating load. Set Load Share mode to Symmetric or equal sharing between all engines.

For these tests, the engine that is in Standby must come on line within the allowed time after the start cycle is initiated, or the test fails.

For these tests any unbalance that exceeds the class requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm (if equipped) will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger if it supplies sufficient details. It is suggested that the readings for KW, KVAR, Amps and Volts for each on-line generator be recorded for each test.

9.1 Single Bus Configuration

Configure the system into a single bus, and perform the tests as described below:

Begin testing with two engines on line and use thrusters and Mission equipment to produce loads as needed to approach produce a load on the operating engines below the start levels.

After observation of load sharing with two engines, progressively increase the load on the system to reach a load level on all the operating engines just above the start level being tested. Confirm the next engine in line automatically starts according to the starting sequence.

After the engines stabilize in the new configuration, progressively increase the load on the system to reach a load level on all the operating engines just above the start level being tested. Confirm the next engine in line automatically starts according to the starting sequence.

After all but one engine is on line, configure the system for special load sharing modes, such as asymmetric load that will shift the load to one engine at a heavy load level, such as is used to burn carbon off during normal operations.

After completion of the special mode testing, progressively increase the load on the system to reach a load level on all the operating engines just above the start level being tested. Confirm the last engine in line automatically starts according to the starting sequence.

After the engines stabilize in the new configuration, progressively decrease the load on the system to reach a load level on all the operating engines just below the stop level being tested. Confirm the next engine in line automatically stops according to the inverse of the starting sequence, or according to a stopping sequence if a separate sequence is provided.

Repeat decreasing the load until only two engines are left on line.

9.2 Other Bus Configurations

Configure the system with various combinations permitted by the system design, and repeat the above tests, increasing the load to add generators alternately on each bus.

Special mode operation and automatic stopping tests do not need to be performed for the other bus configurations.

10 Power Allocation and Load Dependent Engine Starting to provide Rotating Reserve (Objective No. 11)

This section is applicable only to those vessels that require additional rotating reserves for certain phases of its operation. The additional reserves are intended to make the vessel more tolerant of an unexpected failure that might otherwise limit operation of equipment needed for the specific operation. One example of such a requirement is the operation of a Heave Compensated Drawworks or Winch during critical operations of equipment or personnel. If the vessel is not equipped with this facility, this section is to be omitted.

Define the parameters to facilitate efficient testing and verify that the various parameters are set according to the PMS specifications. For example start and stop times can be reduced to allow faster automated starts.

This test is very similar to section 8.0, but adds special features such as the requirement to provide additional rotating reserves for special operating scenarios. This is written using the requirement for additional rotating reserves as an example for content of this section. Demonstrate that the PMS system automatically starts engines as the load levels reach the setpoints defined in the PMS specifications, accounting for the additional required rotating reserves. Set auto start mode on to permit their being automatically started due to operating load. Set Load Share mode to Symmetric or equal sharing between all engines.

For these tests, the engine that is in Standby must come on line within the allowed time after the start cycle is initiated, or the test fails.

For these tests any unbalance that exceeds the class requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm (if equipped) will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger if it supplies sufficient details. It is suggested that the readings for KW, KVAR, Amps and Volts for each on-line generator be recorded for each test.

10.1 Single Bus Configuration

Configure the system into a single bus under normal operating configuration, and perform the tests as described below:

Begin testing with two engines on line and use thrusters and Mission equipment to produce loads as needed to approach produce a load on the operating engines below the start levels.

Initiate a mode that requires additional rotating reserves, and calculate the load level change that the additional reserves represent.

After observation of load sharing with two engines, progressively increase the load on the system to reach a load level on all the operating engines just below the start level being tested, but that with the allowance for the additional reserves the load level will exceed the setpoint. Confirm the next engine in line automatically starts according to the starting sequence.

After the engines stabilize in the new configuration, change the operating mode to reflect a different reserve requirement, and progressively increase the load on the system to reach a load level on all the operating engines just below the start level being tested, but that with the allowance for the additional reserves the load level will exceed the setpoint. Confirm the next engine in line automatically starts according to the starting sequence.

Repeat the test for each operating mode that has associated rotating reserves.

10.2 Other Bus Configurations

Configure the system with various combinations permitted by the system design, and repeat the above tests, confirming the rotating reserve requirement is properly handled on each bus section, and that generators are added properly on each bus.

11 Blackout Recovery (Objective No. 13)

Specific time targets should be defined in the procedures and measured during the tests. The time measured is to begin at the inception of the blackout. Various target times may be defined to provide a measurement of the restoration of specific performance capabilities. Three target times are suggested:

1. The time will recorded when vessel control capability has been restored – a minimum of two engines and a minimum of two thrusters returned to DP operation to be used by the DP system to provide a degree of position control of the vessel.
2. The time will recorded when all available engines are back on line and all available thrusters have been returned to DP operation to be used by the DP system to regain or maintain position
3. A separate time target target may be defined and recorded for the restoration of Mission equipment to a specific operational state.

The time target for completing the restoration of equipment to meet the first time target should not exceed two minutes, and for many vessels this time target will be less than 60 seconds.

During this test some equipment, such as the engine tripped to create the blackout, will not be available. Other equipment may be under maintenance at the time of the test, or may develop a severe fault during the test. Such equipment will be excluded when determining the completion of the second time target. Efforts must always focus on minimizing the equipment that falls into this category.

Define the parameters to facilitate efficient testing and verify that the various parameters are set according to the PMS specifications. For example start and stop times can be reduced to allow faster automated starts.

Demonstrate that the PMS system automatically starts engines in reaction to a system blackout. Set auto start mode on to prevent their being automatically started due to operating load, or adjust the start level to a high level. The configuration must permit automatic starts as a result of system faults. Set Load Share mode to Symmetric or equal sharing between all engines.

For these tests, the time required for engines to start and come on line, and the time for thrusters to be available for DP will be measured. Time required for restoration of Mission equipment will also be monitored. The PMS specifications should include details of the performance expected. In some vessels the Emergency Generator is required to start and supply power to essential services prior to starting main engines. If such is a requirement, the timing of the starting of the Emergency Generator is to be measured, and becomes a part of successful test completion. If it is not required to start the main engines, it should not be considered as necessary to pass the test.

The data that is requested to be recorded may be derived from records from the Data Logger if it supplies sufficient details. It is suggested that the readings for KW, KVAR, Amps and Volts for each on-line generator be recorded for each test.

The method used to trip the breaker must be selected with knowledge of the PMS and IAS systems so that the condition is recognized as a blackout, and the tripped breaker is not reclosed by the IAS. An E-Stop generally accomplishes this, but there are other methods on most systems that may be more convenient relative to the test.

11.1 Single Bus Configuration

Configure the system into a single bus, and perform the tests as described below:

Begin testing with two engines on line and use thrusters and Mission equipment to produce loads as needed to have the equipment defined as active within the control system, so that it will be restarted automatically by the IAS recovery system.

Reduce loads as necessary to permit removing one engine from the bus if possible. Thruster load should be near zero to minimize potential for damage to the drive system. Stop one engine and allow it to return to the status to allow it to be started as part of the blackout recovery. If the loads will not permit operation on a single engine, the test must be performed by simultaneously e-stopping both engines.

Simultaneously E-Stop remaining generators. (These engines will be placed in NOT STANDBY mode by the PMS with SHUTDOWN status. Confirm proper disconnect of tie breakers according to the PMS specifications. Confirm all other feeder downstream breakers are opened as defined by the PMS specifications. The Emergency Generator must start and come on line – record the time for this action.

Observe the actions of the PMS in initiating start sequences in all available engines that were in Standby, and that only one engine on each bus is supplied a SYNC command concurrently. Observe that transformers are reconnected per the timed restart sequence in the PMS specifications.

Observe that motors are reconnected per the timed restart sequence in the PMS specifications or data table, provided they were running at the time of the blackout.

Observe that thrusters are enabled and reconnected according to the PMS specifications, and as DPO assigns each thruster as it becomes READY if that is a manual activation.

11.2 11.2 Dual Bus Configuration

Configure the system into a dual bus, splitting the bus into approximately equal sections, and perform the tests as described below:

Begin testing with two engines on line on each bus and use thrusters and Mission equipment to produce loads as needed to have the equipment defined as active within the control system, so that it will be restarted automatically by the IAS recovery system. If possible configure the system so the Emergency Generator is being supplied by the bus not being tested.

Reduce loads as necessary to permit removing one engine from the bus being tested. Thruster load should be near zero to minimize potential for damage to the drive system. Stop one engine and allow it to return to the status to allow it to be started as part of the blackout recovery.

E-Stop the remaining generator. (This engine will be placed in NOT STANDBY mode by the PMS with SHUTDOWN status. Confirm proper disconnect of tie breakers according to the PMS specifications. Confirm all other feeder downstream breakers are opened as defined by the PMS specifications. If it is involved, the Emergency Generator must start and come on line – record the time for this action.

Observe the actions of the PMS in initiating start sequences in all available engines that were in Standby, and that only one engine on each bus is supplied a SYNC command concurrently. Observe that transformers are reconnected per the timed restart sequence in the PMS specifications.

Observe that motors are reconnected per the timed restart sequence in the PMS specifications or data table, provided they were running at the time of the blackout.

Observe that thrusters are enabled and reconnected according to the PMS specifications, and as DPO assigns each thruster as it becomes READY if that is a manual activation.

APPENDIX A

Example of Vessel Specific Test Procedure

1 Example

This appendix provides an example of a test procedure based on these guidelines as they apply to a specific vessel. It is supplied to aid in interpreting the instructions in the guidelines, as relates to the vessel and its equipment that is being tested. It is not to be construed to be applicable to any other vessel or similar configuration, without adjusting the procedures and steps to reflect the configuration of the vessel.

The test numbers in this example are the same as the numbers in the guidelines, relative to each test.

2 Vessel Description

The vessel being tested is a drilling vessel that is equipped with eight main engines and eight thrusters, arranged on four buses, with two engines and two thrusters on each bus section. In addition there are four distribution transformers, one per bus, and two transformers to supply the drilling system.

The drilling system includes two drawworks, each with active heave compensation and a priority mode for the Drawworks system so that it has a higher priority than thrusters when in a mode called Locked to Bottom. There are also requirements for additional power reserves when either drawworks has Active Heave Compensation activated or when a Heavy Weight handling mode is activated.

The automation system is supplied By Kongsberg with their typical configuration for control and PMS, but with some special functions added, including a specific calculation for drilling power available, and the operator can select a derating parameter for the engines to allow to be calculated as having a capacity between 90% and 100% of the engine's rated power.

3 Engine Control System (Objective No. 3)

Set System DP Setpoint for Engine Capacity to 95%.

Set Start and Stop Percentages per table in FDS. Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

To demonstrate the load sharing at each engine loading configuration, set LDSTART off to prevent their being automatically started. Set Load Share mode to Symmetric. At the step to add an engine one of the engines should be manually started and connected to the bus.

For these tests any unbalance that exceeds the ABS requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger.

3.1 Single Bus Configuration

Configure the system into a single bus, and perform the tests as described below:

During Dockside testing the following operational capabilities should have been proven for each engine, so that complete testing of every engine will not be performed. Select random engines to confirm each of the tests:

No.	Test	Remarks	Results
3.1.1.	Demonstrate that each engine can be started and stopped from each control location when activated, and that those positions not activated do not have control.	Verify that E-Stops function and that Local control can be activated when engine has been started remotely.	
3.1.2.	Demonstrate that each engine can be synchronized and circuit breaker closed both manually and automatically with control at the main switchboard.	Observe the power sharing as the circuit breaker is closed and that it ramps up to a level equal with others already on line.	
3.1.3.	Demonstrate that each engine can be manually tripped from supplying power.	Observe the power sharing after operation of CB Open switch, that power ramps down to a low value and CB opens.	
3.1.4.	With the engine in a “Standby” mode cause the PMS system to initiate a START cycle and place the engine on line.	Record the time from the PMS initiation of the Start cycle until the Circuit Breaker closes for each engine.	
3.1.5.	With the engine in “Not Standby” mode manually initiate a START cycle and place the engine on line.	Record the time from the initiation of the Start cycle until the Circuit Breaker closes for each engine.	
3.1.6.	Demonstrate that the engine can be removed from the bus under control of the SVC by command from operator.	Observe the power sharing after operator command, that power ramps down to a low value and CB opens.	
3.1.7.	Demonstrate that the SVC system will remove an engine from bus when the engine load is lower than Auto Stop set point, and will automatically initiate the removal cycle.	Operational Mode must be set for automatic stopping of engines	

4 Static Load Sharing (Objective No. 4)

Set System DP Setpoint for Engine Capacity to 95%.

Set Start and Stop Percentages per table in FDS. Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

To demonstrate the load sharing at each engine loading configuration, set LDSTART off to prevent their being automatically started. Set Load Share mode to Symmetric. At the step to add an engine one of the engines should be manually started and connected to the bus.

For these tests any unbalance that exceeds the ABS requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger.

4.1 Single Bus Configuration

Configure the system into a single bus, and perform the tests as described below:

No.	Test	Remarks	Results
4.1.1.	Begin testing with two engines on line, no drilling load and low thruster power; add loads using DP mode.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.2.	Add enough thruster load to approach engine load rating.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.3.	Add another engine at the same thruster load.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.4.	Add enough thruster load to approach engine load rating.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.5.	Add another engine at the same thruster load.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.6.	Add enough mud pump load to approach engine load rating.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.7.	Add another engine at the same thruster and drilling load.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.8.	Add enough thruster load to approach engine load rating.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.9.	Add another engine at the same thruster and drilling load.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.10.	Add enough thruster load to approach engine load rating.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.11.	Add another engine at the same thruster and drilling load.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.12.	Add enough thruster and mud pump load to approach engine load rating.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.1.13.	Add another engine at the same thruster and drilling load.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	

No.	Test	Remarks	Results
4.1.14.	With the loads remaining the same, at the switchboard remove one of the engines from SVC control. Reduce load on engine to 100 KW.	Confirm that the PMS reduces the kW Available signals to all the thrusters and Aux Drilling as a result of not having the control of the engine, and have not yet been limited. Load sharing must be manually adjusted for engine in Local.	
4.1.15	With the loads remaining the same observe the KW Available signals distributed to the thrusters.	Confirm that the KW Available signal for each thruster is calculated to apportion the available KW to each thruster as a percentage above its actual usage. For example if two thrusters are using 2000 KW and 2500 KW each, with 10% power available (over total thruster usage) the Power Limit signals should be 2200 KW and 2750 KW.	
4.1.16.	With the loads remaining the same, for the engine not in SVC, at the switchboard initiate a disconnect, which will disconnect the gen from the switchboard.	Confirm that the PMS maintains the same kW available signals to all the thrusters and Aux Drilling, and that the loads are still shared by all engines, and have not yet been limited.	
4.1.17.	With the loads remaining the same, **and operating in DP mode**, at the SVC Console, place one of the engines into Manual Load Share mode. Reduce load on engine to 100 KW.	Confirm that the PMS reduces the KW Available signals to all thrusters and Aux Drilling as a result of not having the control of the engine, but at a reduced level, DP having priority, since the KW Available for Aux Drilling is now reduced. Load sharing must be manually adjusted for engine in Local.	
4.1.18.	Continue to request additional power from thrusters until thruster load is limited by Thruster KW Available signal.	Confirm that the Aux Drilling KW Power Available reduces to zero to make power available to DP. Record readings for KW, KVAR, Amps and Volts for each generator, and KW for each thruster and Drilling switchboard.	

4.2 Two Bus Configuration (DPS-3)

Configure the system as Port and Stbd power systems Buses 1A - 1B and 2A - 2B. Perform the testing on each bus section as follows for this bus arrangement.

No.	Test	Remarks	Results
4.2.1.	Begin test with two engines on each Swbd group, no drilling load and low thruster power.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.2.2.	Add enough thruster load to approach engine load rating on each bus, loading one bus first.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.2.3.	Add another engine at the same thruster load, first to one bus then the other.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.2.4.	Add enough thruster load to approach engine load rating on each bus, loading one bus first.	Record readings for KW, KVAR, Amps and Volts for each on-line generator	

No.	Test	Remarks	Results
4.2.5.	Add another engine at the same thruster load, first to one bus then the other.	Record readings for KW, KVAR, Amps and Volts for each on-line generator	
4.2.6.	With the loads remaining the same, **and operating in DP mode**, at the SVC Console, place one of the engines into Manual Load Share mode. Reduce load on engine to 100 KW.	Confirm that the PMS reduces the KW Available signals to all thrusters and Aux Drilling on the switchboard affected, from not having the control of the engine, at a reduced level, DP having priority, since the KW Available is now reduced. Load sharing must be manually adjusted for engine in Local.	
4.2.7.	With the loads remaining the same, for the engine in Manual, at the SVC Console initiate a disconnect, which will disconnect the gen from the switchboard.	Confirm that the PMS maintains the same KW Available signals to all thrusters and Drilling, and that the loads are still shared by all engines on the affected switchboard, and having already been limited.	
4.2.8.	Continue to request additional power from thrusters until thruster load is limited by thruster KW Available signal, **and operating in DP mode**.	Confirm that the Aux Drilling KW Power Available reduces to zero to make power available to DP. Record readings for KW, KVAR, Amps and Volts for each generator, KW for each thruster and Drilling switchboard.	

4.3 Four Bus Configuration

Configure the system split into four separate power systems Buses. Perform the testing on each bus section as follows for this bus arrangement.

No.	Test	Remarks	Results
4.3.1.	Begin testing with two engines on each bus, no drilling load and low thruster power.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.3.2.	Add enough thruster load to approach approximately 50% engine load rating for each bus.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.3.3.	Add enough thruster load and mud pump load to approach 100% engine load rating for each bus.	Record readings for KW, KVAR, Amps and Volts for each on-line generator.	
4.3.4.	With the loads remaining the same, **and operating in DP mode**, at the switchboard remove one of the engines on Swbd 2 from SVC control. Reduce load on engine to 100 KW.	Confirm that the PMS reduces the KW Available signal to thrusters for the affected switchboard, as a result of not having the control of the engine, but at a reduced level, since the KW Available is now reduced. Load sharing must be manually adjusted for engine in Local.	
4.3.5.	With the loads remaining the same, for the engine not in SVC, at the switchboard initiate a disconnect, which will disconnect the gen from the switchboard.	Confirm that the PMS maintains the same KW Available signals to all thrusters and Drilling, and that the loads are still supplied by the remaining engine on the affected switchboard, and having already been limited.	

No.	Test	Remarks	Results
4.3.6.	Continue to request additional power from thrusters, **operating in DP mode,** until thruster load is limited by DP KW Available signal on at least one switchboard with two engines.	Confirm that the Aux Drilling KW Power Available reduces to zero to make power available to DP. Record readings for KW, KVAR, Amps and Volts for each generator, and KW for each thruster and Drilling switchboard.	
4.3.7.	With the loads remaining the same, **and operating in DP mode**, at the SVC Console, place one of the engines on Swbd 1 into Manual Load Share mode. Reduce load on engine to 100 KW.	Confirm that the PMS reduces the KW Available signal to thrusters and the drilling system for the affected switchboard, as a result of not having the control of the engine, but at a reduced level, since the KW Available is now reduced. Load sharing must be manually adjusted for engine in Local.	
4.3.8.	With the loads remaining the same, for the engine in Manual, at the SVC Console initiate a disconnect, which will disconnect the gen from the switchboard.	Confirm that the PMS maintains the same KW Available signals to all thrusters and Drilling, and that the loads are still supplied by the remaining engine on the affected switchboard, and having already been limited.	
4.3.9.	Continue to request additional power from thrusters, **operating in DP mode,** until thruster load is limited by DP KW Available signal on at least one switchboard with two engines.	Confirm that the Aux Drilling KW Power Available reduces to zero to make power available to DP. Record readings for KW, KVAR, Amps and Volts for each generator, and KW for each thruster and Drilling switchboard.	

5.0 Dynamic Power Sharing (Objective No. 4)

Set System DP Setpoint for Engine Capacity to 95%.

Set Start and Stop Percentages per table in FDS. Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

To demonstrate the load sharing at each engine loading configuration, set LDSTART OFF to prevent their being automatically started. Set Load Share mode to Symmetric. At the step to add an engine one of the engines should be manually started and connected to the bus.

For these tests any unbalance that exceeds the ABS requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger.

5.1 Single Bus Configuration

Configure the system as a single bus. Set up all Mud Pumps to provide Aux Drilling Loads as needed. Configure the Main Drawworks to use all six motors. Activate all six VFD Drives. Do not configure for Heave Compensation, until the steps for that operation. Some tests use Aux DW with all four motors.

Have driller turn on drawworks, and prepare to move the empty block as the load.

For dynamic or transient load evaluations, chart recorders or the SVC data logger may be utilized to compare operations of parallel engines.

No.	Test	Remarks	Results
5.1.1.	With two engines on line, no drilling load and low thruster power begin the testing to apply dynamic loads. Use DP mode to set thruster power.	Record the maximum deviation (Static unbalance) from equal load (KW & KVAR) sharing.	
5.1.2.	Have driller use the foot throttle to raise the Main block at full speed simulating a tripping operation, holding the speed for 15 seconds.	Observe the load sharing for both KW and KVAR and record the maximum unbalance for each with the time duration for the unbalance.	
5.1.3.	Have the driller release the foot throttle (causing regenerative braking) and allow the block to stop.	Observe the load sharing for both KW and KVAR and record the maximum unbalance for each with the time duration for the unbalance.	
5.1.4.	Repeat the above two steps three times. (DW block motion test)	Record the maximum deviations (maximum unbalance) with the time duration for the unbalance.	
5.1.5.	Add two engines to the bus, add 2000 KW load from Mud Pumps and use thrusters to achieve a 10 MW total load.		
5.1.6.	Repeat the Main DW block motion test four times.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.1.7.	With the loads remaining the same, **and operating in DP mode**, at the SVC Console, place one of the engines into Manual Load Share mode. Engine should remain about 2500 KW.	Confirm that the PMS reduces the KW Available signals to Aux Drilling, from not having the control of the engine, at a reduced level, DP having priority, since the KW Available is now reduced. MP Loads continue at same power level. Load sharing must be manually adjusted for engine in Local.	
5.1.8.	With the loads remaining the same, initiate Heave Compensation mode on Aux DW, but not Locked To Bottom or Heavy Weight mode.		
5.1.9.	Initiate the Heave Compensation Simulation on Aux DW with peak power demand of about 1000 KW and a 12 second period. Operate for ten minutes.	Engine in Manual mode remains at 2500 KW. MP Loads are reduced to provide power to thrusters and DW. MP will begin to power up during DW regen and shut back down during power modes. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	

No.	Test	Remarks	Results
5.1.10.	Initiate Locked to Bottom Mode. Reduce load on engine in Manual mode to 100 KW. Continue simulation for 10 minutes. Increase period of simulation by 1 second every two minutes.	Engine in Manual mode remains at 100 KW during test. Confirm that the PMS reduces the KW Available signals to all thrusters and Aux Drilling, so that MP continues to turn on and off, and thrusters are phased back proportionally to allow DW simulation to run at same power levels as previous step. Because SDP does not limit power at same level as PMS, thruster limitation creates feedback errors or DP cutback in SDP system. Record trends and confirm rates at which thruster KW Available signals decrease and increase. Decrease should be rapid, but Increase should be approx. 160 KW per second for each thruster. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	
5.1.11.	Turn off Heave Compensation Simulation. Turn off (de-assign) four thrusters and raise power on remaining thrusters to reach 10 MW total system load.	MP Loads return and are steady, but may be reduced as thruster loads are returned to achieve system loads. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	
5.1.12.	Initiate the Heave Compensation Simulation on Aux DW with peak power demand of about 1000 KW and a 12 second period. Operate for ten minutes. Beginning at 13 seconds, decrease period of simulation by 1 second every two minutes.	Engine in Manual mode remains at 100 KW during test. Confirm that the PMS reduces the KW Available signals to all thrusters and Aux Drilling, so that MP continues to turn on and off, and thrusters are phased back proportionally to allow DW simulation to run at same power levels as previous step. Because SDP does not limit power at same level as PMS, thruster limitation creates feedback errors or DP cutback in SDP system. Record trends and confirm rates at which thruster KW Available signals decrease and increase. Decrease should be rapid, but Increase should be approx. 320 KW per second for each thruster. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	

No.	Test	Remarks	Results
5.1.13.	Turn off Heave Compensation Simulation and Locked to Bottom Mode. Switch engine from Manual mode to Symmetric Load Sharing mode. Return all thrusters to service and adjust power on thrusters to reach 10 MW total system load.	MP Loads return and are steady, but may be reduced as thruster loads are returned to achieve system loads. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	
5.1.14.	Add two engines to the bus, increase Mud Pump load to 4000 KW, and use thrusters to achieve a 16 MW total load.		
5.1.15.	Repeat the DW block motion test four times.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.1.16.	Initiate Heave Compensation mode on Main DW, but not Locked To Bottom mode. Increase Mud Pumps and thruster loads to achieve 19 MW total load		
5.1.17.	Initiate the Main DW Heave Compensation Simulation with peak power demand of about 2000 KW and a 12 second period. Operate for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.1.18.	Initiate Locked to Bottom mode on Main DW and continue simulation for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.1.19.	Deactivate Heave Simulation and Locked to Bottom Mode. Decrease MP load to 3000 KW and adjust thrusters to achieve 18 MW total system load, **and operating in DP mode**, at the SVC Console, place one of the engines into Manual Load Share mode. Engine should remain about 3000 KW.	Confirm that the PMS reduces the KW Available signals to Aux Drilling, from not having the control of the engine, at a reduced level, DP having priority, since the KW Available is now reduced. MP Loads continue at same power level. Load sharing must be manually adjusted for engine in Local.	
5.1.20.	With the loads remaining the same, initiate Heave Compensation mode on Main DW, with Locked To Bottom mode.		
5.1.21.	Initiate the Heave Compensation Simulation on Main DW with peak power demand of about 2000 KW and a 12 second period. Operate for ten minutes. Increase period of simulation by 1 second every two minutes.	Engine in Manual mode remains at 3000 KW. MP Loads are reduced to provide power to thrusters and DW. MP will begin to power up during DW regen and shut back down during power modes. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	

No.	Test	Remarks	Results
5.1.22.	Reduce load on engine in Manual mode to 100 KW. Continue simulation for 10 minutes. Beginning at 13 seconds, decrease period of simulation by 1 second every two minutes.	Engine in Manual mode remains at 100 KW during test. Confirm that the PMS reduces the KW Available signals to all thrusters and Aux Drilling, so that MP continues to turn on and off, and thrusters are phased back proportionally to allow DW simulation to run at same power levels as previous step. Because SDP does not limit power at same level as PMS, thruster limitation creates feedback errors or DP cutback in SDP system. Record trends and confirm rates at which thruster KW Available signals decrease and increase. Decrease should be rapid, but Increase should be approx. 240 KW per second for each thruster. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	
5.1.23.	Turn off Heave Compensation Simulation. Turn off (de-assign) four thrusters and raise power on remaining thrusters to reach 18 MW total system load.	MP Loads return and are steady, but may be reduced as thruster loads are returned to achieve system loads. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	
5.1.24.	With Locked to Bottom activated, initiate the Heave Compensation Simulation on Main DW with peak power demand of about 2000 KW and a 12 second period. Operate for ten minutes. Increase period of simulation by 1 second every two minutes.	Engine in Manual mode remains at 100 KW during test. Confirm that the PMS reduces the KW Available signals to all thrusters and Aux Drilling, so that MP continues to turn on and off, and thrusters are phased back proportionally to allow DW simulation to run at same power levels as previous step. Because SDP does not limit power at same level as PMS, thruster limitation creates feedback errors or DP cutback in SDP system. Record trends and confirm rates at which thruster KW Available signals decrease and increase. Decrease should be rapid, but Increase should be approx. 480 KW per second for each thruster. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	

No.	Test	Remarks	Results
5.1.25.	Turn off Heave Compensation Simulation and Locked to Bottom Mode. Switch engine from Manual mode to Symmetric Load Sharing mode. Return all thrusters to service and adjust power on thrusters to reach 19 MW total system load.	MP Loads return and are steady, but may be reduced as thruster loads are returned to achieve system loads. Record readings for KW, KVAR, Amps, Frequency and Volts for each generator, KW for each thruster and Drilling switchboard for DW and Aux Loads.	
5.1.26.	Shut off Main DW and Repeat the DW block motion test four times using Aux DW.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.1.27.	Initiate the Heave Compensation Simulation for Aux DW with peak power demand of about 1000 KW and a 12 second period. Operate for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.1.28.	Initiate Locked to Bottom mode on Aux DW and continue simulation for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.1.29.	Add two engines to the bus and use thrusters to achieve a 20 MW total load. Disengage the Aux DW Locked to Bottom and the Heave Compensation mode and simulation, and shut it down.		
5.1.30.	Repeat the DW block motion test four times using the Main DW.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.1.31.	Initiate Heave Compensation mode on Main DW, but not Locked To Bottom mode. Increase Mud Pumps and thruster loads to achieve 25 MW total load		
5.1.32.	Initiate the Heave Compensation Simulation on Main DW with peak power demand of about 2000 KW and a 12 second period. Operate for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.1.33.	Initiate Locked to Bottom mode on Main DW and continue simulation for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	

5.2 5.2. Two Bus Configuration (DPS-3)

Configure the system as Port and Stbd power systems Buses 1A – 1B and 2A – 2B. With two engines on each Swbd group, 2000 KW Mud Pump load, use thrusters to achieve 5 MW total load on each Swbd group begin the dynamic testing, using DP mode for thruster power.

Set up all Mud Pumps to provide Aux Drilling Loads as needed. Configure the Main Drawworks to use all six motors. Activate all six VFD Drives. Do not configure for Heave Compensation, until the steps for that operation. (All these tests will employ only the Main DW.)

Have driller turn on drawworks, and prepare to move the empty block as the load.

For dynamic or transient load evaluations, chart recorders or the SVC data logger may be utilized to compare operations of parallel engines.

No.	Test	Remarks	Results
5.2.1.	Repeat the Main DW block motion test four times.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.2.2.	Add two engines to the Stbd 1A- 1B bus and use thrusters to achieve a 12 MW total load on that bus, 5 MW total on Port 2A – 2B bus.		
5.2.3.	Repeat the Main DW block motion test four times.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.2.4.	Add two engines to the Port 2A – 2B bus and leave mud pump and thrusters at above 12 MW Stbd & 5 Mw Port total loads.		
5.2.5.	Repeat the Main DW block motion test four times.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.2.6.	Initiate Heave Compensation mode on Main DW, but not Locked To Bottom mode. Increase Mud Pumps and thruster loads to achieve 25 MW total load, balanced on the two switchboards		
5.2.7.	Initiate the Heave Compensation Simulation on Main DW with peak power demand of about 2000 KW and a 12 second period. Operate for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.2.8.	Initiate Locked to Bottom mode on Main DW and continue simulation for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.2.9.	Disengage Heave Compensation and Simulation. Reduce thrusters to about 12 MW Stbd & 5 Mw Port total load settings and disconnect Drilling transformer from Port Drilling switchboard. Close internal Bus Tie in Drilling Switchborad to supply entire switchboard from Stbd transformer.		

No.	Test	Remarks	Results
5.2.10.	Repeat the Main DW block motion test four times.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.2.11.	Initiate Heave Compensation mode on Main DW, but not Locked To Bottom mode. Increase Mud Pumps and thruster loads to achieve 19 MW total load, balanced on the two switchboards		
5.2.12.	Initiate the Heave Compensation Simulation on Main DW with peak power demand of about 2000 KW and a 12 second period. Operate for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.2.13.	Initiate Locked to Bottom mode and continue simulation for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	

Return Drilling transformer feeders to normal configuration.

5.3. Four Bus Configuration

Configure the system as four separate power systems. With two engines on each bus, no drilling load use thrusters to achieve 5 MW total load on each bus, begin the dynamic testing using DP mode for thruster power.

No.	Test	Remarks	Results
5.3.1.	Repeat the Main DW block motion test four times.	Record the maximum KW and KVAR deviations (maximum unbalance) for each test with the time duration for the unbalance.	
5.3.2.	Initiate Heave Compensation mode on Main DW, but not Locked To Bottom mode. Increase Mud Pumps and thruster loads to achieve 22 MW total load, relatively balanced on the four switchboards		
5.3.3.	Initiate the Heave Compensation Simulation on Main DW with peak power demand of about 2000 KW and a 12 second period. Operate for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	
5.3.4.	Initiate Locked to Bottom mode on Main DW and continue simulation for ten minutes.	Record the maximum KW and KVAR deviations (maximum unbalance) during test with the time duration for the unbalance.	

6 Frequency Based Load Reduction (Objective No. 9)

Set System DP Setpoint for Engine Capacity to 95%.

Set Start and Stop Percentages per table in FDS. Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

The data that is requested to be recorded may be derived from records from the Data Logger.

6.1 Bus 1A Test Procedure

Configure the system as a single bus. Set up all Mud Pumps to provide about 800 KW Aux Drilling Loads as needed. The Drawworks will not be used in this test.

Operate either DG1 or DG2. Place the other engine is Manual at the PMS console. Place at least two engines on line for the other three bus sections.

Open the feeder to the Drilling transformer from the Port side Bus 2B. Configure the 480 Distribution to be supplied from other switchboard sections.

Set T2 and T6 to Manual control at the MTC and set each thruster to operate at about half speed (approximately 15% power).

Set the KW Available signals for T2 and T6 to 750 KW. Set KW Available to the Stbd Drilling Transformer to 1500 KW.

Open the tie breaker between Swbd 1A and 1B so that Swbd 1A is isolated, and perform the following tests.

No.	Test	Remarks	Results
6.1.1	At the Main Swbd, set the engine that is on line to Manual mode.	Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.1.2	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 57 Hz.	Observe that the load begins to decrease. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.1.3	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 55 Hz.	Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.1.4	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 54 Hz.	Observe that the load is shut off. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	

No.	Test	Remarks	Results
6.1.5	At the Main Swbd, activate the Speed Raise Lower switch into the Raise position. Increase the frequency to about 57 Hz.	Observe that the load begins to increase, based on the setpoint in the equipment that allows loads to be restored. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.1.6	At the Main Swbd, activate the Speed Raise Lower switch into the Raise position. Increase the frequency to about 60 Hz.	Observe that the load returns to the levels prior to the test. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.1.7	At the Main Swbd return the engine to Remote Auto mode. At the PMS console restore the engine into Symmetric load sharing mode		
6.1.8	Remove Manual values being sent to loads and return thrusters into the DP system controls	System is back to normal mode of operation	

6.2 Bus 1B Test Procedure

Configure the system as a single bus. The Mud Pumps or Drawworks will not be used in this test.

Operate either DG3 or DG4. Place the other engine is Manual at the PMS console. Place at least two engines on line for the other three bus sections.

Set T3 and T7 to Manual control at the MTC and set each thruster to operate at about half speed (approximately 15% power).

Set the KW Available signals for T3 and T7 to 750 KW.

Open the tie breaker between Swbd 1A and 1B and the Interconnectors so that Swbd 1B is isolated, and perform the following tests.

No.	Test	Remarks	Results
6.2.1	At the Main Swbd, set the engine that is on line to Manual mode.	Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.2.2	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 57 Hz.	Observe that the load begins to decrease. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.2.3	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 55 Hz.	Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	

No.	Test	Remarks	Results
6.2.4	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 54 Hz.	Observe that the load is shut off. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.2.5	At the Main Swbd, activate the Speed Raise Lower switch into the Raise position. Increase the frequency to about 57 Hz.	Observe that the load begins to increase, based on the setpoint in the equipment that allows loads to be restored. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.2.6	At the Main Swbd, activate the Speed Raise Lower switch into the Raise position. Increase the frequency to about 60 Hz.	Observe that the load returns to the levels prior to the test. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.2.7	At the Main Swbd return the engine to Remote Auto mode. At the PMS console restore the engine into Symmetric load sharing mode		
6.2.8	Remove Manual values being sent to loads and return thrusters into the DP system controls	System is back to normal mode of operation	

6.3 Bus 2A Test Procedure

Configure the system as a single bus. The Mud Pumps or Drawworks will not be used in this test.

Operate either DG5 or DG6. Place the other engine is Manual at the PMS console. Place at least two engines on line for the other three bus sections.

Set T1 and T5 to Manual control at the MTC and set each thruster to operate at about half speed (approximately 15% power).

Set the KW Available signals for T1 and T5 to 750 KW

Open the tie breaker between Swbd 2A and 2B and the Interconnectors so that Swbd 2A is isolated, and perform the following tests.

No.	Test	Remarks	Results
6.3.1	At the Main Swbd, set the engine that is on line to Manual mode.	Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.3.2	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 57 Hz.	Observe that the load begins to decrease. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	

No.	Test	Remarks	Results
6.3.3	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 55 Hz.	Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.3.4	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 54 Hz.	Observe that the load is shut off. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.3.5	At the Main Swbd, activate the Speed Raise Lower switch into the Raise position. Increase the frequency to about 57 Hz.	Observe that the load begins to increase, based on the setpoint in the equipment that allows loads to be restored. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.3.6	At the Main Swbd, activate the Speed Raise Lower switch into the Raise position. Increase the frequency to about 60 Hz.	Observe that the load returns to the levels prior to the test. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test.	
6.3.7	At the Main Swbd return the engine to Remote Auto mode. At the PMS console restore the engine into Symmetric load sharing mode		
6.3.8	Remove Manual values being sent to loads and return thrusters into the DP system controls	System is back to normal mode of operation	

6.4 Bus 2B Test Procedure

Configure the system as a single bus. Set up all Mud Pumps to provide about 800 KW Aux Drilling Loads as needed. The Drawworks will not be used in this test.

Operate either DG7 or DG8. Place the other engine is Manual at the PMS console. Place at least two engines on line for the other three bus sections.

Open the feeder to the Drilling transformer from the Stbd side Bus 1A. Configure the 480 Distribution to be supplied from other switchboard sections.

Set T4 and T8 to Manual control at the MTC and set each thruster to operate at about half speed (approximately 15% power).

Set the KW Available signals for T4 and T8 to 750 KW. Set KW Available to the Port Drilling Transformer to 1500 KW.

Open the tie breaker between Swbd 2A and 2B so that Swbd 2B is isolated, and perform the following tests.

No.	Test	Remarks	Results
6.4.1	At the Main Swbd, set the engine that is on line to Manual mode.	Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.4.2	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 57 Hz.	Observe that the load begins to decrease. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.4.3	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 55 Hz.	Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.4.4	At the Main Swbd, activate the Speed Raise Lower switch into the Lower position. Reduce the frequency to about 54 Hz.	Observe that the load is shut off. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.4.5	At the Main Swbd, activate the Speed Raise Lower switch into the Raise position. Increase the frequency to about 57 Hz.	Observe that the load begins to increase, based on the setpoint in the equipment that allows loads to be restored. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.4.6	At the Main Swbd, activate the Speed Raise Lower switch into the Raise position. Increase the frequency to about 60 Hz.	Observe that the load returns to the levels prior to the test. Record the frequency, KW and KVAR for all engines. Record the KW and RPM for the thrusters under test. Record the KW being used by the Mud Pumps.	
6.4.7	At the Main Swbd return the engine to Remote Auto mode. At the PMS console restore the engine into Symmetric load sharing mode		
6.4.8	Remove Manual values being sent to loads and return thrusters into the DP system controls	System is back to normal mode of operation	

Return System to normal Single Bus operating configuration.

7 Dynamic Propulsion Loads (Objective No. 4)

Set System DP Setpoint for Engine Capacity to 95%.

Set Start and Stop Percentages per table in FDS. Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

To demonstrate the load sharing at each engine loading configuration, set LDSTART OFF to prevent their being automatically started. Set Load Share mode to Symmetric. At the step to add an engine one of the engines should be manually started and connected to the bus.

For these tests any unbalance that exceeds the ABS requirements for load sharing (+/- 15% for KW or +/- 10% for KVAR) or causes activation of the PMS KW or KVAR sharing alarm will constitute a failure of the test.

The data that is requested to be recorded may be derived from records from the Data Logger.

This test shall be performed at transit draft.

7.1 Single Bus Configuration

During the Vessel Performance tests a complete Crash Stop maneuver will be performed. During this test data will be collected from the power system relative to the operation of the load sharing system and will be evaluated to ensure that the load is properly shared between the engines that are on line. The criteria for acceptable operation are the same as for those tests performed specifically under this section.

Configure the system as a single bus. Place three engines on line, with no drilling loads. Set the four forward thrusters to manual mode at no speed. Azimuth of these thrusters should be set to 90 or 270 degrees. Using Joystick Control in the MTC Panel apply full power to the four stern thrusters, at full ahead speed.

No.	Test	Remarks	Results
7.1.1	After the vessel has full way on the hull, bring the joystick control to zero rapidly.	Record the maximum KW and KVAR deviations (KW and KVAR unbalance) during the maneuver with the time duration for the unbalance	
7.1.2	After the joystick control has been at zero for 10 seconds, bring the thruster controls to full ahead.	Record the maximum KW and KVAR deviations (KW and KVAR unbalance) during the maneuver with the time duration for the unbalance	
7.1.3	Place all eight engines on line, with no drilling loads and all thrusters in MTC mode. Using the joystick control at full ahead speed, apply max power to all the thrusters.		
7.1.4	After the vessel has full way on the hull, bring the joystick control to zero rapidly.	Record the maximum KW and KVAR deviations (KW and KVAR unbalance) with the time duration for the unbalance	

No.	Test	Remarks	Results
7.1.5	After the joystick control has been at zero for 10 seconds, bring the thruster controls to full ahead.	Record the maximum KW and KVAR deviations (KW and KVAR unbalance) with the time duration for the unbalance.	

7.2 Alternate Bus Configurations

Configure the system split into separate power systems – Buses 1B – 2A, and Bus 1A and Bus 2B each separate. Place all engines on line, with no drilling loads. Using Joystick in the MTC Panel apply maximum available power to all thrusters, at full ahead speed. Record the data from each bus section as follows for this bus arrangement.

No.	Test	Remarks	Results
7.2.1	After the vessel has full way on the hull, bring the joystick control to zero rapidly.	Record the maximum KW and KVAR deviations (KW and KVAR unbalance) with the time duration for the unbalance	
7.2.2	After the joystick control has been at zero for 10 seconds, bring the thruster controls to full ahead.	Record the maximum KW and KVAR deviations (KW and KVAR unbalance) with the time duration for the unbalance.	

8 Engine Shutdown & Gen Tripping (Objective No. 8)

The purpose of test is to demonstrate the reaction of the PMS to a generator trip, to immediately cut back the loads from the thrusters and drilling system to prevent a cascading loss of additional engines due to overload. After five seconds those loads will be allowed to ramp back up to a level commensurate with the new engine configuration, while another engine is started. After the new engine has been placed on line the load will be permitted to return to the previous level.

The engine must be E-Stopped to cause the circuit breaker to be manually tripped. The action of the PMS will then cause elimination of the thruster and drilling loads for a two second period.

Do not use Heave Compensation modes for Drawworks.

Do NOT operate cranes during this test, but the HPU's may be energized to create 480 VAC system loads.

Set System DP Setpoint for Engine Capacity to 95%.

Set Start and Stop Percentages per table in FDS, except for 3 engines, Set LDSTART OFF; Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

The data that is requested to be recorded may be derived from records from the Data Logger.

8.1 Single Bus Configuration

Configure the system as one bus, all engines in STANDBY, Load Share mode set to Symmetric, with three engines on line.

Use Mud Pumps to achieve 2000 KW drilling Load and thrusters 3000 KW load, or to reach a loading of 90% without exceeding the start level % load for 3 engines. Use Drawworks to simulate tripping.

No.	Test	Remarks	Results
8.1.1.	E-Stop one engine, timed to shut down just as the blocks are starting to be raised during the tripping simulation.	Confirm that the PMS supplies proper signals to all thrusters to reduce thruster load and the drilling system load is also reduced. Confirm signals are supplied to drilling and each thruster that is cut back. Since only two engines remain on line, the Load Shedding logic will trip loads in the Mud Processing and Drilling Equipment (Criticality II).	
8.1.2.	While another engine is starting and after the thrusters and drilling power returns to "normal" with the remaining two engines, observe…	Record the KW being used by the drilling systems, each thruster, and each engine KW and Amps. Because 480V Aux loads were shed, the mud pumps will not restart.	
8.1.3.	After the engine has been connected on line and power returns to normal, observe…	Record the time period required to obtain CB closure and the final values for Drilling KW, DP KW, and each engine KW and Amps. Restore the loads that were tripped.	

No.	Test	Remarks	Results
8.1.4.	Connect 480 VAC loads, including drilling auxiliaries and Hydralift HPU's to achieve a load of 6000 KW for 480 VAC distribution.	Reduce loading on thrusters and drilling to allow one engine to be removed from service. Do not use DW for this test. Add loads to reach ~90% on two engines	
8.1.5.	E-Stop one engine.	Confirm that the PMS supplies proper signals to all thrusters to eliminate thruster load and the drilling system load is also eliminated. Confirm signals are supplied to drilling and each thruster that is cut back. Since only one engine remains on line supplying both Ship Service Transformers, the Load Shedding logic will trip loads in the Essential Consumers (Criticality II), Non-Essential Consumers, Mud Processing and Drilling Equipment (Criticality I and II).	
8.1.6.	While another engine is starting and after the thrusters and drilling power returns to "normal" with the remaining two engines, observe…	Record the KW being used by the drilling systems, each thruster, and each engine KW and Amps. Because 480V Aux loads were shed, the mud pumps will not restart.	
8.1.7.	After the engine has been connected on line and power returns to normal, observe…	Record the time period required to obtain CB closure and the final values for Drilling KW, DP KW, and each engine KW and Amps. Restore the loads that were tripped.	

8.2 Two Bus Configuration (DPS-3)

Configure the system as split bus, all engines in STANDBY, Load Share mode set to Symmetric, with two engines on line on each bus.

Use Mud Pumps to achieve 2000 KW drilling Load and thrusters 3500 KW load, evenly split, or to a 90% load without exceeding the start level % load for 2 engines on each bus. Use Drawworks to simulate tripping.

No.	Test	Remarks	Results
8.2.1.	E-Stop one engine, timed to shut down just as the blocks are starting to be raised during the tripping simulation.	Confirm that the PMS supplies proper signals to the thrusters on the affected side to eliminate thruster load and half the drilling system also shuts off completely. Loads on the other side should not be immediately affected. Confirm signals are supplied to each thruster that is cut back. Since only one engine remains on line supplying one Ship Service Transformer, the Load Shedding logic will trip loads in the Mud Processing and Drilling Equipment (Criticality II).	
8.2.2.	While another engine is starting and after the thrusters and drilling power returns to “normal” with the remaining engine, observe...	Record the KW being used by the drilling systems, each thruster, and each engine KW and Amps.	
8.2.3.	After the engine has been connected on line and power returns to normal, observe…	Record the time period required to obtain CB closure and the final values for Drilling KW, DP KW, and each engine KW and Amps. Restore the loads that were tripped.	

9 Engine Start with Increasing Loads (Objective No . 10)

For these tests, the engine that is in Standby must come on line within 25 seconds after the start cycle is initiated, or the test fails.

Set System DP Setpoint for Engine Capacity to 100%.

Set Start and Stop Percentages per table in FDS. Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

Configure the system with all engines in STANDBY, LDSTART on and Load Share mode set to Symmetric.

Set changeover period for Asymmetric Load cycle to 5 minutes.

The data that is requested to be recorded may be derived from records from the Data Logger.

9.1 Single Bus Configuration

Configure the system as one bus, all engines in STANDBY, Load Share mode set to Symmetric, with three engines on line.

Use Mud Pumps to achieve 1500 KW drilling Load and thrusters 1000 KW load, or as much as can be supplied to create a 60% load for 3 engines.

No.	Test	Remarks	Results
9.1.1.	Increase thruster load to create a load of 79% on each engine, and hold for 15 seconds.	Confirm that the PMS system automatically starts the next engine in line in Standby after 15 seconds. Record time for CB to close after load increase.	
9.1.2.	With the fourth engine on line, increase thruster load to create a load of 89% on each engine.	Confirm that, after 5 seconds the PMS system automatically starts the next engine in line in Standby. Record time for CB to close after load increase.	
9.1.3.	With five engines on line, increase mud pump and thruster load to create a load of 84% on each engine, and hold for 15 seconds.	Confirm that the PMS system automatically starts the next engine in line in Standby after 15 seconds. Record time for CB to close after load increase.	
9.1.4.	With six engines on line, manually initiate a start of another engine.	Confirm that without further delay, the PMS system initiates a start of the next engine in line in Standby. Record time for CB to close after start command.	
9.1.5.	With seven engines on line place five engines in Asymmetric Load Share mode, with G1 (or G2) being the heavily loaded engine.	Confirm that the PMS system increases the load on G1 to 75% and load on other engines decreases and is shared equally. Confirm power factor of all engines is equal, regardless of load. Record KW and pf of all engines.	
9.1.6.	Wait at least ten minutes to allow the system to cycle through the next two engines in sequence.	Confirm load is shifted to the next engine and that the KW of remaining engines is shared equally, but all engines operate at same power factor. Record KW and pf of all engines.	

No.	Test	Remarks	Results
9.1.7.	With thrusters add enough load to achieve a total system load of 21 MW.	Confirm that the PMS raises the load on the Asymmetric engine and all engines share equally. Record KW and pf of all engines. Confirm Asymmetric load share mode is cancelled.	
9.1.8.	Reduce thruster loads to achieve a total system load of 13 MW. Re-activate Asymmetric load sharing mode for five engines.	Confirm that the PMS system increases the load on an engine to 75% and load on other engines decreases and is shared equally. Confirm power factor of all engines is equal, regardless of load. Record KW and pf of all engines, and which engine becomes Asymmetric.	
9.1.9.	Shut off mud pumps and reduce thruster load to create a load of 8 MW on the system.	Confirm PMS continues to operate engines in Asymmetric mode. Record KW and pf of all engines.	
9.1.10.	Remove thruster load completely. (Load should be below 6900 KW, or remove some 480 VAC loads.)	Confirm that the PMS system cancels Asymmetric mode and all engines share loads equally. Record KW and pf of all engines.	
9.1.11.	Place an engine in Fixed load mode.	Confirm that the PMS system places that engine in Fixed Load mode at the power level it was operating prior to the mode change. Record KW and pf of all engines, and which engine is in Fixed mode	
9.1.12.	Increase power on engine in fixed mode to 2000 KW.	Confirm that the PMS system increases the load on that engine to 2000 KW and load on other engines decreases and is shared equally. Confirm power factor of all engines is equal, regardless of load. Record KW and pf of all engines.	
9.1.13.	Continue to increase power level on engine that is in Fixed Mode.	Confirm that the PMS system increases the load on that engine until load on other engines decreases to 10%, still shared equally. Confirm the load increase on the Fixed mode engine stops at that point. Confirm power factor of all engines is equal, regardless of load. Record KW and pf of all engines, %load on engine in Fixed mode.	
9.1.14.	Decrease load on Fixed mode engine to 500 KW. Increase thruster load to achieve a total system load of 13 MW.	Confirm that the PMS system maintains the load on that engine at 500 KW and load on other engines is shared equally. Confirm power factor of all engines is equal, regardless of load. Record KW and pf of all engines.	
9.1.15.	Add mud pump and thruster loads to achieve a total system load of 22.5 MW.	Confirm that the PMS system increases the load on the engine in Fixed mode , switches it to Symmetric Load Share mode, and automatically starts the eighth engine after 15 seconds. Record time for CB to close after load increase. Record KW and pf of all engines.	

No.	Test	Remarks	Results
9.1.16.	Reduce total system load to 13 MW and reduce to five engines on line, one of which is an engine in Fixed Mode with load set to 2500 KW. Engines that are stopped should be returned to Standby.	Confirm that the PMS system maintains the load on that engine at 2500 KW and load on other engines is shared equally. Confirm power factor of all engines is equal, regardless of load. Record KW and pf of all engines.	
9.1.17.	Change engine from Fixed Mode to Manual load share mode, still at 2500 KW.	There should be no change in configuration at this time. Record KW and pf of all engines.	
9.1.18.	Reduce load on engine in Manual load share mode to 1000 KW, and hold for 15 seconds.	Confirm that, after 15 seconds the PMS system automatically starts another engine.	
9.1.19.	Return engine to Symmetric load sharing Mode.	Confirm that the PMS system resumes load sharing for all engines. Record KW and pf of all engines.	

Reset Changeover Period for Asymmetric load cycle to normal value, typically 4 hours.

9.2 Two Bus Configuration (DPS-3)

Configure the system as split bus, all engines in STANDBY, LDSTART on, Load Share mode set to Symmetric, with two engines on line on each bus.

Use Mud Pumps to achieve 2000 KW drilling Load and thrusters 1500 KW load, evenly split, or as much as can be supplied to create a 50% load for 2 engines on each bus.

No.	Test	Remarks	Results
9.2.1.	Increase thruster load to create a load of 75% on each engine on Stbd bus, and hold for 15 seconds.	Confirm that the PMS system automatically starts the next engine in line in Standby on the Stbd side after 15 seconds. Record time for CB to close after load increase. Port bus should remain unchanged as long as load remains below 70% on the two port engines.	
9.2.2.	Increase thruster load to create a load of 90% on each engine on Port bus.	Confirm that the PMS system automatically starts the next engine in line in Standby after 5 seconds. Record time for CB to close after load increase. Stbd bus should remain unchanged.	
9.2.3.	With three engines on line, increase thruster load to create a load of 90% on each engine on Stbd bus.	Confirm that the PMS system automatically starts the next engine in line in Standby after 5 seconds. Record time for CB to close after load increase. Port bus should remain unchanged.	
9.2.4.	With three engines on line, increase thruster load to create a load of 80% on each engine on Port bus, and hold for 15 seconds.	Confirm that the PMS system automatically starts the next engine in line in Standby after 15 seconds. Record time for CB to close after load increase.	

9.3 Alternate Bus Configurations

Configure the system as Bus 1B – 2A – 2B and Bus 1A separate, all engines in STANDBY, Load Share mode set to Symmetric, with two engines on line on Bus 1 and four on the combined bus.

Use Mud Pumps to achieve 3000 KW drilling Load and thrusters 7000 KW load, or as much as can be supplied to create a 75% load for 4 engines on combined bus.

No.	Test	Remarks	Results
9.3.1.	Increase thruster load to create a load of 83% on each engine on combined bus, and hold for 15 seconds.	Confirm that the PMS system automatically starts the next engine in line in Standby after 15 seconds. Record time for CB to close after load increase.	
9.3.2.	Increase thruster load to create a load of 90% on each engine on combined bus.	Confirm that the PMS system automatically starts the next engine in line in Standby after 5 seconds. Record time for CB to close after load increase.	

10 Power Allocation and Load Dependent Engine Starting to provide Rotating Reserve (Objective No. 11)

For these tests, the engine that is in Standby must come on line within 25 seconds after the start cycle is initiated, or the test fails.

Set System DP Setpoint for Engine Capacity to 95%.

Set Start and Stop Percentages per table in FDS. Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

The data that is requested to be recorded may be derived from records from the Data Logger.

10.1 Single Bus Configuration

Configure the system as one bus, all engines in STANDBY, LDSTART on, Load Share mode set to Symmetric, with three engines on line.

Use Mud Pumps to achieve 1500 KW drilling Load and thrusters 1000 KW load, or as much as can be supplied to create a 60% load for 3 engines.

No.	Test	Remarks	Results
10.1.1.	Increase thruster load to create a load of 8000 KW on the system.	No action should be taken at this point.	
10.1.2.	Place Aux DW in Heave Compensation mode, but not in Heavy Weight mode.	Confirm that, after 15 seconds the PMS system automatically starts the next engine in line in Standby. Record time for CB to close after mode switch.	
10.1.3.	Increase thruster load to create a load of 11,400 KW on the system. Place Main DW in Heave Compensation mode, but not in Heavy Weight mode.	Confirm that the PMS system automatically starts the next engine in line in Standby after 15 seconds. Record time for CB to close after mode switch.	
10.1.4.	With five engines on line, increase thruster load to achieve a total system load of 13,500 KW. Place Aux DW in Heavy Weight Mode.	Confirm that after 15 seconds, the PMS system initiates a start of the next engine in line in Standby. Record time for CB to close after mode switch.	
10.1.5.	Increase thruster load to create a load of 16,300 KW on the system. Place Main DW in Heavy Weight Mode.	Confirm that, after 5 seconds the PMS system automatically starts the next engine in line in Standby. Record time for CB to close after mode switch.	
10.1.6.	Activate Heave Compensation Simulation on Main DW, and operate for five minutes.	Confirm that PMS does not start any additional engines because of the actual DW power usage.	

Deactivate Heave Compensation Simulation.

Return Heave Compensation mode control to Off for both Main and Aux DW.

10.2 Two Bus Configuration (DPS-3)

Configure the system as split bus, all engines in STANDBY, LDSTART on, Load Share mode set to Symmetric, with two engines on line on each bus.

Use Mud Pumps to achieve 2000 KW drilling Load and thrusters 1500 KW load, evenly split, or as much as can be supplied to create a 50% load for 2 engines on each bus.

No.	Test	Remarks	Results
10.2.1.	Increase thruster load to create a load of 9000 KW on the system, but split about 4000/5000 KW on each side.	No action should be taken at this point.	
10.2.2.	Place Aux DW in Heave Compensation mode, but not in Heavy Weight mode.	Confirm that, after no more than 15 seconds the PMS system automatically starts the next engine in line in Standby on the side that is more heavily loaded. Record time for CB to close after mode switch. No action should be taken on the other side.	
10.2.3.	Place Main DW in Heave Compensation mode, but not in Heavy Weight mode.	Confirm that the PMS system automatically starts the next engine in line in Standby after 5 seconds, on the side with only two engines. Record time for CB to close after mode switch.	
10.2.4.	Activate Heave Compensation Simulation on Aux DW at 1000 KW max load and 12 second period, and operate for five minutes, then turn off simulation.	Confirm that PMS does not start any additional engines because of the actual DW power usage.	
10.2.5.	Increase thruster load to create a load of 15,000 KW on the system, balanced. With three engines on line on each side, place Main DW in Heavy Weight Mode.	Confirm that, the PMS system initiates a start of the next engine in line in Standby on each side – after 15 seconds on each side. Record time for CB to close after mode switch.	
10.2.6.	Return system loads to 9000 KW split 5000/4000. Activate Auto Stop mode for Load Dependent Stop. Deactivate Heavy Weight and Heave compensation modes on both Main and Aux Drawworks.	Confirm that, after 15 seconds the PMS system automatically stops one of the operating engines on each side and it returns to Standby.	
10.2.7.	Leave system operation in same settings	Confirm that, after 15 more seconds the PMS system automatically stops one of the operating engines on the side with lowest load and all are returned to Standby. (The other side should be just above setpoint for stop **-** ~ 4300 KW.)	
10.2.8.	Deactivate Auto Stop mode. Configure system with two engines on each bus.	No additional action should be taken by the PMS at this point.	
10.2.9.	Place Main DW in Heave Compensation mode, and in Heavy Weight mode.	Confirm that, after 5 seconds on one side and 15 seconds on the other side, the PMS system automatically starts the next engine in line in Standby on both sides. Record time for CB to close after mode switch.	

No.	Test	Remarks	Results
10.2.10.	Activate Heave Compensation Simulation on Aux DW at 1000 KW peak and a 12 second period, and operate for five minutes.	Confirm that PMS does not start any additional engines because of the actual DW power usage. (Depending on simulation characteristic, an engine may be started on the side more heavily loaded.)	

Deactivate Heave Compensation Simulation.

Return Heave Compensation mode control to Off for both Main and Aux DW.

11 Blackout Recovery (Objective No. 13)

Set System DP Setpoint for Engine Capacity to 95%.

Set Start and Stop Percentages per table in FDS. Set Start delay to 15 secs and 5 secs (for Start Limit 1 and Limit 2, respectively) and Stop delay to 15 secs for test (Normal settings about 60 seconds, 5 seconds and 30 minutes respectively).

The data that is requested to be recorded may be derived from records from the Data Logger.

11.1 Single Bus Configuration

Configure the system as one bus, all engines in STANDBY, LDSTART on, Load Share mode set to Symmetric, with three engines on line.

If possible by reducing 480 VAC loads and by adjusting start percentages for 1 and 2 engines on line, remove engines from service and shut down so that only one engine is being E-stopped to trigger the blackout.

No.	Test	Remarks	Results
11.1.1.	With no drilling load and thruster load set as low as possible, set start % for 1 and 2 engines to 100%. Reduce number of engines on line to 1 or 2.	It is anticipated that this measure with actual loads will allow reduction of number of engines to 2.	
11.1.2.	Place the engine(s) into Standby after it stops.	Confirm that all engines are now in standby.	
11.1.3.	Reduce thruster load to zero and simultaneously E-Stop remaining generators. (These engines will be placed in NOT STANDBY mode by the PMS with SHUTDOWN status.)	Confirm both transfer breakers are opened, the Emergency Generator starts and begins supplying load. Record time from blackout until Em Gen is on line (45 secs max). Confirm CB's supplying thruster drives and all other transformers are opened.	
11.1.4.	Observe the actions of the PMS in initiating start sequences in all six (or seven) of the engines that were in Standby, and that only one engine on each bus is supplied a SYNC command concurrently.	Record the time from the blackout until the connection of each engine to its respective bus.	
11.1.5.	Observe that transformers are reconnected per the timed restart sequence in the BOD	Record the time from the blackout until the connection of each transformer to its respective bus.	
11.1.6.	Observe that motors are reconnected per the timed restart sequence in the data table, provided they were running at the time of the blackout	Record the time from the blackout until the connection of each motor to its respective bus.	
11.1.7.	Observe that thrusters are enabled and reconnected as DPO assigns each thruster as it becomes READY.	Record the time from the blackout until the connection of each thruster to be available for service.	

Restore the feed for the Emergency Bus so that it is being supplied from the Stbd 480 VAC Ship Service distribution. Reset the two engines that were E-Stopped, and place them in Standby.

After power is restored reset Start % for 1 and 2 engines.

11.2 Two Bus Configuration (DPS-3)

Configure the system as split bus, all engines in STANDBY, Load Share mode set to Symmetric, with two engines on line on each bus, with Emergency Bus being supplied from the Stbd 480 VAC distribution system.

No.	Test	Remarks	Results
11.2.1.	With no drilling load and thruster load set as low as possible, set Start % for 1 engine to 100%. Stop one engine on Port side.	It is anticipated that this measure with actual loads will allow reduction of number of engines to 1.	
11.2.2.	Place it into Standby after it stops.		
11.2.3.	Reduce Port thruster load to zero and E-stop the remaining Port engine. (This engine will be placed in NOT STANDBY mode by the PMS with SHUTDOWN status.)	Confirm that the Stbd side and the Emergency Bus loads are not affected. Confirm CB's supplying Port thruster drives and distribution transformers are opened.	
11.2.4.	Observe the actions of the PMS in initiating start sequences in the other three Port Engines.	Record the time from the blackout until the connection of each engine to its respective bus.	
11.2.5.	Observe that transformers are reconnected per the timed restart sequence in the BOD	Record the time from the blackout until the connection of each transformer to its respective bus.	
11.2.6.	Observe that motors are reconnected per the timed restart sequence in the data table, provided they were running at the time of the blackout	Record the time from the blackout until the connection of each motor to its respective bus.	
11.2.7.	Observe that thrusters are enabled and reconnected as DPO assigns each thruster as it becomes READY.	Record the time from the blackout until the connection of each thruster to be available for service.	

Reset the engine that was E-Stopped, and place in Standby.

After power is restored reset Start % for 1 engine.