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GUIDELINES ON **DYNAMIC POSITIONING SYSTEMS WITH CLOSED BUS-TIES**

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Guidelines

Dynamic Positioning Systems with Closed Bus-Ties

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Introduction

Dynamic Positioning (DP) systems that require redundancy are typically designed to operate with open bus-ties, allowing the power system to run as segregated units. This configuration enhances system integrity and ensures a safe mode of operation during faults by preventing fault propagation.

However, increasing emphasis on reducing emissions and improving fuel efficiency (through fewer running engines and optimized engine loading) is driving the adoption of DP configurations with closed bus-ties. These configurations aim to achieve comparable levels of integrity and safety while offering operational and environmental benefits.

This document provides guidance and clarifies the requirements for vessels with DP systems requiring redundancy, where the power system is intended to be operated with closed bus-ties. These Guidelines outline the necessary considerations for fault tolerance, fault resistance, and fault ride-through capability to ensure compliance with redundancy requirements under closed bus-tie operation.

Section 1

General

1.1 Scope and Applicability

1.1.1 These Guidelines are applicable to vessels that achieve the integrity level required for redundant DP systems (**DP(2)** and **DP(3)**) operating with closed bus-tie(s).

1.1.2 The requirements in these Guidelines are additional to those given in the various parts of the relevant IRS *Rules and Regulations for the Construction and Classification of Steel Ships*.

1.1.3 Vessels with DP notations that operate in closed bus-tie mode in compliance with these Guidelines may be assigned one of the following additional class notations:

a) **CLB** – This notation may be assigned to DP (2) and DP (3) vessels with closed bus-ties. (Refer Table 1)

b) **CLB-S** – This notation may be assigned to DP (2) and DP (3) vessels with closed bus-ties having provisions for simulation testing for verification of FRT (fault ride through) capability using built-in test system. (Refer Table 1)

c) **CLB-T** – This notation may be assigned to DP (2) and DP (3) vessels with closed bus-ties having the provisions for live short circuit and earth fault testing and simulation testing using built-in test system for verification of FRT (fault ride through) capability. (Refer Table 1)

1.2 Definitions

1.2.1 *Closed Bus-tie* refers to a configuration in which the power plant is operated as a common power system, where all redundancy zones of the power plant are electrically connected.

1.2.2 *Fault Ride Through* is the capability of the vessel's power system to remain connected and maintain operation during and after short-duration voltage or frequency disturbances, such as faults, without unintended disconnection of generators, thrusters, or other essential loads, thereby ensuring continuity of DP capability.

1.2.3 *Hidden Failures* means a failure that is not immediately evident to operations or maintenance personnel and has the potential for failure of equipment to perform an on-demand function, such as protective functions in power plants and switchboards, standby equipment, backup power supplies or lack of capacity or performance.

1.2.4 *Redundancy* means ability of a component or system to maintain or restore its function, when a single failure has occurred. Redundancy can be achieved, for instance by installation of multiple components, systems or alternative means of performing a function.

1.2.5 *Droop Mode* A generator control mode in which the generator's output frequency or voltage varies in proportion to changes in load. In closed bus-tie operation, droop mode enables active and reactive load sharing between generators without direct communication links.

1.2.6 *Isochronous Mode* A generator control mode in which the generator maintains a constant output frequency regardless of load changes. In closed bus-tie operation, typically only one generator operates in isochronous mode to control system frequency, while others operate in droop mode for load sharing.

1.3 Documentation

1.3.1 The following additional documents/details/drawings are required to be submitted to IRS:

a) for information:

i. Closed Bus Operation Philosophy

To support the application for CLB notation, a closed bus operation philosophy document is to be submitted. The document is to describe:

- how closed bus operation is implemented and managed on board
- operational modes, safety logic, automatic separation criteria, fallback procedures, and integration with DP FMEA and operational procedures.

The document is also to include:

- Power Management System configuration specific to closed bus architecture
- operational safeguards.

b) for approval:

i. Technical Analysis

Technical analysis refers to various engineering evaluations and studies that validate the behaviour of the vessel's electrical and control system under closed bus conditions. These include, but are not limited to:

- Short-circuit analysis and fault current calculations
- Power flow and power distribution analysis
- Dynamic stability studies including AVR and governor response
- Protection selectivity and coordination analysis
- Bus-tie fault analysis and automatic separation logic. The analysis is to specify the time limit considered for the bus-tie breaker to be open, to limit the propagation of fault from one bus section to another bus section.
- Fault ride through analysis

ii. Automatic Voltage Regulator (AVR)/Governor response studies

This is to provide dynamic response analysis of the AVR and governor systems. Demonstrate effective reactive power sharing through voltage droop, frequency stability during load variations, and excitation system behaviour under fault conditions. The document is to clearly describe how AVR and governor settings are coordinated to ensure stable parallel operation. AVR and governor are to be capable of operating in droop mode, isochronous mode, or a combination thereof, as appropriate for the system configuration.

iii. Enhanced Failure Modes and Effects Analysis (FMEA)

The document is to include fault scenarios specific to closed bus operation. The analysis is to demonstrate automatic quick bus separation upon fault detection. The response time is to be specified. (Refer 2.4)

iv. System Architecture Documentation

Electrical single-line diagrams showing redundancy groups and bus-tie arrangements. Control system logic for fault detection and isolation.

v. Computer Simulations

Duly reviewed Simulation studies are to be submitted for DP (3) vessels and DP (2) vessels with CLB, CLB-S and CLB-T notation in addition to technical documentation and analysis, Validated simulation tools are to be used to support these engineering studies.

vi. Test Protocol

In addition to tests required to be demonstrated for DP (2) and DP (3) vessels, additional tests to confirm the FMEA including FRT capability for the closed bus system are to be carried out during Factory Acceptance Tests, Harbour Acceptance Tests and Sea Trials as relevant and applicable. CLB notation will be assigned only upon satisfactory demonstration of compliance.

vii. Control and monitoring system documentation for Power management system, AVR and Governor

viii. Thruster control system

ix. Documentation supporting and demonstrating the physical live tests (e.g., test protocols, tests setups, methodologies, results, etc.)

x. Description of automatic blackout recovery procedure

xi. Cable routing plan

Table 1 : Comparison: DP (2) and DP (3) Vessels Without CLB Notations vs With CLB Notations

Requirement	**DP (2) and DP (3) Vessels Without CLB Notation**	**DP (2) and DP (3) Vessels**		
		with CLB Notation	**with CLB-S Notation**	**with CLB-T Notation**
FMEA	Basic FMEA	Enhanced FMEA		
Protection coordination study	Basic	Mandatory to consider fault in closed bus condition		
Bus-Tie Logic	Not required	Required		
Auto Separation	Not required	Required		
Computer simulations	Not required	Required		
Operational Safeguards	Basic	Detailed		
Short-circuit analysis	Optional	Required		
FRT capability verification by simulation test with a built-in test system.	Not required	Not required	Required	Required
FRT capability verification by live short circuit and earth fault testing	Not required	Not required	Not required	Required
AVR/Governor Studies	Not required	Required		
Power flow analysis	Basic	Detailed with closed bus impact		
Bus-tie fault impact	Not applicable	Required		

Section 2

System Design Requirements

2.1 General

2.1.1 A system designed for operation with closed bus-ties is to have minimum one mode based on open bus-tie(s) to avoid blackout, protect redundancy and prevent thrust loss.

2.1.2 All operation modes and their appurtenant worst case single failure conditions intended for DP are to be defined, considered in an FMEA, and verified by testing. This applies not only to the operation of generator and bus-tie breakers, but also to control system modes (PMS, governor, AVR, machinery auxiliaries) and other relevant systems.

2.1.3 Communication lines between redundant groups are to be segregated to prevent the spread of incorrect data. If segregation is not possible, measures to address the risk and relevant installation instructions thereto are to be provided by the OEM. The above aspect is to be considered during FMEA and verified during trials.

2.1.4 The key aspects which are to be considered in the design of closed bus tie operation are:

- Quick and reliable fault detection
- Fast and selective tripping of breakers as per discrimination analysis
- Fault ride-through capability
- Technical analysis of various fault scenarios, including hidden faults
- Detailed FMEA considering the above aspects and testing

2.2 Hidden Failures

2.2.1 Protection and safety systems are to have independent back up. If the first action performed by the protection system (Main /primary) does not address the failure or is not performed (due to hidden failure), the back-up system is to execute secondary (independent alternative) actions to isolate the faulty component or system. Subsequent to activation of the back-up system secondary action, the consequence of the failure is to remain in line with the overall intent of the redundancy design.

2.2.2 The number of possible hidden failures is to be kept as low as practicable. To achieve this, additional monitoring functions need to be arranged. Typically, these may consist of:

- self-monitoring
- consistency checks
- loop monitoring (command and feedback)
- watchdog signal
- monitoring of communication lines.

2.2.3 Hidden failures are to be considered for all components and systems. This applies both for hardware and software and will require extensive use of monitoring and self-diagnostics. Such functions will, however, not be considered to eliminate the possibility of hidden failures.

2.2.4 Where the design requires differential protection and directional protection, failures which can result in unintended operation are to be considered.

2.3 Fault Ride Through (FRT) Capability

2.3.1 General

2.3.1.1 Fault Ride Through (FRT) capability is to be demonstrated on vessels operating in closed bus configurations by testing. FRT testing is to include live short circuit testing, and other tests such as under and over fueling testing, excitation testing, overvoltage testing, earth fault testing for proving single fault tolerance.

2.3.1.2 Short circuit FRT capability should be verified initially through computer modeling and simulation, followed by live testing.

Note: Live short circuit testing and earth fault testing to prove FRT capability are only for DP (2) and DP (3) vessels with CLB-T notation.

2.3.1.3 The FMEA is to assess how transient voltage dips and surges can lead to unintended shutdowns or malfunctions of key components like frequency converters, thrusters, motors, and other power system equipment, and is to recommend preventive measures.

2.3.1.4 Power system attributes are to be proven by a combination of simulation and testing processes to demonstrate FRT capability. Depending on the system voltage level, the relevant test requirements are to be appropriately selected, and the test procedures are to be finalised in consultation with equipment manufacturers. The trial document is to be submitted to IRS.
(Refer to Section 5.2 of MTS TECHOP_D-07_Rev.1, Jan 2021 as applicable)

Note: MTS TECHOP_D-07_Rev.1, Jan 2021 outlines a method for proving fault ride-through capability in Dynamic Positioning (DP) vessels equipped with High Voltage (HV) power plants in ensuring DP system resilience during electrical faults. Requires mathematical modelling to predict system behaviour and validate test outcomes. The suggested procedure involves simulation-based testing, testing under a controlled environment and monitoring system response.

2.3.1.5 Alternative methods, tailored to the specific power system design, are to be developed to demonstrate the FRT capability of low voltage power systems, considering the high fault current levels (refer to Section 10 of MTS TECHOP_D-07_Rev.1, Jan 2021).

2.3.1.6 Risk assessments are to be carried out for all specified tests, addressing personnel safety, equipment protection, and possible unexpected results.

2.3.1.7 With closed bus-ties, the transient voltage dips and overshoots may affect the entire distribution system. The power system failures are to be analyzed (through FMEA) to prevent problems such as:

- tripping of frequency converters or generators
- loss of thrusters from DP control
- tripping of motors or essential auxiliaries
- unintended operation of voltage protection
- over-voltages during faults or fault clearance

Note: Equipment outside the affected redundancy group is to ride through the transient and remain available when voltage is restored. Equipment in operation before the fault is to continue operating after clearance without restart or operator action. For motor starters, main contactors are to remain closed during the transient.

2.4 Failure Mode and Effects Analysis

2.4.1 A failure mode analysis is to be carried out considering various modes, including hidden failures, as specified in this document. The analysis is to demonstrate system redundancy and identify any single point of failure. The analysis is to be verified through a detailed FMEA trials procedure. Document MTS TECHOP D-05, which provides guidance for detailed review of FMEA to identify and address gaps related to hidden and operational aspects in the initially developed FMEA, may be referred to in the preparation of the final FMEA for submission to IRS.

2.5 Additional requirements for DP (3) Vessels

2.5.1 In DP (3) vessels, open bus-tie systems are considered the default mode of operation. Closed bus-tie operation mode can be considered when analysis, simulation and testing verify that the system integrity under closed bus-tie mode is equivalent to that of open bus-tie configuration.

2.5.2 The failure modes and mitigation measures suggested in these Guidelines are indicative. A detailed analysis based on the specific concept is to be carried out and submitted to IRS. Additional failure modes and redundancy methods could be advised upon review of the submitted philosophy.

2.5.3 The enhanced power system control unit is to be designed with philosophy of secondary backup protection.

Section 3

Equipment Requirements

3.1 Requirements for DP (2) vessels with closed bus-ties

3.1.1 Switchboard

3.1.1.1 A minimum of two bus-tie breakers, one on each side, between buses, is to be provided, with breaker status monitoring and control.

3.1.1.2 Switchboards are to be protected against potential arc damage either by arc detection, by insulated bus bars, or by any other means.

3.1.1.3 Selectivity between generator breakers and bus-ties for earth fault and short circuit protection is to be provided.

3.1.1.4 For the required selectivity there is to be a margin between the protection settings (time/current) to account for inaccuracy in protection units, current transformers, decrement curves, and breaker tripping time.

3.1.1.5 Synchronization functions (generators and closing of bus-tie breakers) are to be designed with very high reliability. Typically, crash synchronization is prevented by arranging two independent sync check barriers in series.

3.1.1.6 Following functions are to be arranged to ensure switchboard protection and monitoring functions:

- arc protection (pressure monitoring or optical) and/or bus-bar differential protection
- directional earth-fault protection
- circuit breaker failure protection
- switch-on-to-fault (SOTF) protection
- trip circuit supervision
- monitoring of current, voltage, phase balance, broken wires, fuses.

3.1.1.7 For designs where the sequence of bus-tie(s) tripping is essential, e.g. bus sections without generators there is to be clear functional description of the philosophy and principles used, for the specific design.

3.1.1.8 For vessels with CLB-T notation, high voltage (HV) switchboards are to be of a type suitable for live short-circuit tests and earth-fault testing.

3.1.1.9 For DP vessels with CLB-T notation having low voltage power systems, alternative testing methods may be considered and as minimum, testing is to demonstrate fault current and voltage dip ride-through. Tests are to show the fault isolation time of protective functions and confirm Fault Ride Through as per the testing plan.

3.1.2 Power Management System (PMS)

3.1.2.1 It is to be ensured that the PMS design will not have any harmful effect on the chosen redundancy concept. This includes both normal operation and failure response, including hidden failures.

3.1.2.2 Overload is to be handled by the functionality in control systems. Correct functionality is to be documented by relevant control system documentation, FMEA and functional testing. The analysis and testing are also to be considered, if input or output communication failure between DP/PMS/Switchboard may cause an unacceptable single failure effect.

3.1.2.3 In closed bus-tie mode, two or more power sources are to be online, where:

.1 overload of a single power source (as the first failure) is not to cause load reduction of all thrusters (temporary reduction may be accepted)

.2 tripping of one or more power sources with common mode failures is not to cause the blackout of healthy sections. Worst-case scenario is to be verified.

.3 tripping of bus-tie breaker is not to cause the blackout of healthy sections.

3.1.2.4 An automatic blackout recovery function is to be arranged. This system is to perform blackout recovery on individual switchboard sections. The recovery time is to be such that the DP control systems receive thruster ready signals within 45 seconds. Enabling of thrusters in the DP control system can be done manually.

3.1.2.5 Typical features and failures in the PMS system that are to be considered are as follows:

- communication links failures
- sufficient barriers against unintended operations
- sufficient barriers against unintended automatic actions, e.g. unnecessary blackouts, partial blackouts, lack of power or unintentional load reduction
- signal validation, faulty signal, loss of signal.

3.1.2.6 The FMEA is to carefully consider failure modes related to voltage and frequency. This applies to both signal failures and situations where the actual voltage and/or frequency deviate from normal values.

3.1.2.7 Unintended load reduction is to be treated as a potential common-mode failure affecting thrusters across redundancy groups. Analyses and testing of PMS functions are to be carried out.

3.1.2.8 It is to be ensured that not all thrust is unintentionally lost or reduced at the same time by common mode failure. Both thrusters and generators including their auxiliaries are to be considered when evaluating the potential failure modes and possible load reductions. All systems that can trip or reduce thruster power are to be identified and evaluated.

3.1.2.9 Relevant failures are to be considered to occur in all operational modes.

3.1.2.10 Following functionalities are required to improve the robustness of the PMS:

- monitoring to prevent hidden failure in trip circuits for generator and bus-tie breaker(s)
- high integrity serial communication or direct hardware open command signals to each generator and tiebreaker(s)
- redundant open command signals to each generator and bus-tie breaker(s)
- clear indication of local/remote status of breakers
- autonomy and distribution of functionality
- dual action functionality to prevent unintended acts of operation
- mode monitoring in PMS/ alarm system: warning/alarm if power system setup conflicts with defined prerequisites for DP operation
- validation of feedback signals to PMS to prevent:
    - connection of generator (or bus-tie) without synchronization
    - unintended load reduction of thrusters

- generator frequencies decreasing to a level that causes a risk of automatic load reduction of drives/ tripping of drives
- frequency increasing to a level that causes systems to trip.

Note :For a specific design, additional functionalities as identified through philosophy document and FMEA could be required.

3.1.3 Automatic Voltage Regulator (AVR)

3.1.3.1 The automatic voltage regulator (AVR) controls the generator excitation and hence the voltage and reactive power output. The failure modes will typically be related to these parameters. Over excitation/ excitation break-down/ under excitation are to be analyzed in the FMEA. Typical failures that are to be considered are as follows:

- AVR power supply failure or loss of excitation
- loss of sense or over excitation (test by disconnecting the voltage transformer feedback or increasing excitation)
- over excitation
- under excitation

If communication between AVRs on different generators is arranged, this is to be carefully considered, analyzed and failure testing is to be performed.

3.1.3.2 In the case of reactive load sharing, the generators are to be able to operate in voltage droop mode, without the need for reactive load sharing communication between the AVRs. If reactive load sharing is implemented by means of reactive load sharing lines, the system is to automatically switch to voltage droop mode operation if a failure in the reactive load sharing lines occurs. Means to test the transfer to voltage droop mode conveniently are to be provided.

3.1.4 Governor Control

3.1.4.1 The governor controls the generator prime mover speed and hence the frequency and active power output.

3.1.4.2 Governors can typically operate in droop mode and isochronous mode.

3.1.4.3 In case of active load sharing, if a scheme for isochronous load sharing is implemented, the generator speed controllers are to automatically switch to load sharing in droop mode upon failure of isochronous load sharing. Means to test the transfer conveniently are to be provided.

3.1.5 Enhanced Power System Protection

3.1.5.1 Enhanced protection is required to detect and take action, on failures not addressed by traditional generator and switchboard protection systems, to prevent blackouts. This feature could be achieved by an additional control unit operating at system level.

3.1.5.2 The following functions, as a minimum, are to be provided for enhanced generator protection:

- Identification of fault based on continuous monitoring of generator voltage and speed.
- Identification of a faulty generator.
- Trigger alarms if anomalies have continued beyond the pre-set intervals set by failure analysis.
- Detect and trigger alarm at least the following anomalies included but not limited to:
  - Over/ under fuel
  - Over/ under excitation
  - Hunting
  - Active and reactive power sharing imbalances

- Following AVR features are to be monitored.
  - Excitation including its protection
  - Over/under voltage
  - Field current
  - hunting

3.1.5.3 Self-assessment of the enhanced protection system is to be provided, including monitoring of signals, detection of mismatches in redundant signals, frozen signals, transducer failures and communication faults.

3.1.5.4 The effects on the power system, including protection, due to transformer inrush currents are to be evaluated, and suitable arrangements are to be provided to limit such currents.

3.2 Requirements for DP (3) Vessels with closed bus-ties

3.2.1 Switchboard

3.2.1.1 In addition to the requirements for switchboards specified from 3.1.1.1 to 3.1.1.8, the following are to be complied with:

.1 High voltage switchboards are to be used, and they are to have high level of integrity for short circuits.

.2 For DP (3) vessels with closed bus-tie operation, all protective functions are to have dual, independent primary and secondary barrier functions (to mitigate the effect of hidden failure).

.3 Operational procedures are to include synchronization operations and are to consider the risks due to mechanical failures of breakers.

3.2.2 Power Management System (PMS)

3.2.2.1 PMS is to be in accordance with 3.1.2.

3.2.3 Automatic Voltage Regulator (AVR)

3.2.3.1 AVR is to be in accordance with 3.1.3.

3.2.4 Governor Control

3.2.4.1 Governor control is to be in accordance with 3.1.4.

3.2.5 Enhanced Power System Protection

3.2.5.1 Enhanced power system protection is to be in accordance with 3.1.5.

Section 4

Testing

4.1 General

4.1.1 Monitoring and logging of key parameters during testing are to be carried out to compare actual and expected results, validate simulation tools, and confirm generator decrement curves.

4.1.2 Live short-circuit and earth-fault tests are to be carried out with a planned approach for the vessel's operational life, covering the following aspects:

- Use built-in test functions and distribute testing across generators to avoid test strain on each unit.
- Test in different operational modes for wider verification.
- Log and report all test results.
- Evaluate results against acceptance criteria and previous data.

4.1.3 Recommendations in document MTS TECHOP D-07, Rev.1, Jan 2021 are to be referred to in developing and executing test procedures. The test procedures are to be submitted to IRS for review.

4.2 Tests to prove FRT capability

4.2.1 Requirements for verification of FRT capability by Computer modeling and simulations (Refer to Section 9 of MTS TECHOP D-07, Rev.1, Jan 2021)

4.2.1.1 The entire electrical network is to be modelled for a specific FRT capability analysis. All equipment being tested is to meet OEM specifications.

4.2.1.2 Computer aid tools appropriate for the analysis are to be used.

4.2.1.3 Several fault locations, system configurations, fault types, and operational modes are to be selected to identify the worst-case fault scenario(s).

4.2.1.4 Simulations are to demonstrate voltage dip ride-through following the worst case short circuit current fault for electrical equipment essential to DP.

4.2.1.5 The most practical and least risk fault condition may be selected from the simulation to conduct live test.

4.2.2 Requirements for verification of FRT capability by Live test (Refer to Section 8 of MTS TECHOP D-07, Rev.1, Jan 2021)

4.2.2.1 Live test is to be in accordance with a prescribed test protocol.

4.2.2.2 All equipment essential to the DP system is to be FRT capable, ensuring that short circuit conditions are cleared before undervoltage protection activates. Low voltage transients during the fault are not to cause motor starters to drop out or other drives to fail.

4.2.2.3 If major changes are made to the system that can affect the FRT capability of DP system then, the tests are to be repeated, and results are to be revalidated.

4.2.2.4 The live physical tests are to be performed under an Electrical Hazard Safety Program.

4.2.2.5 Where UPSs and DC power systems arrangements belonging to different redundancy groups are fed by a common power source through diodes or automatic changeover, such arrangements are to be tested to prove FRT capabilities.

4.3 Initial Testing

4.3.1 System approval of CLB, CLB-S and CLB-T is to be based on successful completion of all required tests based on approved test protocol, covering relevant failure modes in DP (2) and DP (3) configurations. All initial testing is to be witnessed by the Surveyor.

4.3.2 Examples of verification items are to include the following, but not be limited to:

- Generator excitation
- Generator speed control
- Under and over fuelling testing
- Overvoltage testing
- Blackout prevention/load reduction
- Backup/dual power
- FRT capability (Refer 4.3.3)
- Trip of generators with common mode failures

4.3.3 For DP vessels with CLB notation, systems are to be designed to carry out the tests specified in 4.3.2. In addition, CLB-T notation requires live short-circuit and earth fault tests and simulation testing using built-in test equipment, while CLB-S notation requires simulation testing using built-in test equipment. These are to be performed without significantly reducing equipment life.

4.4 Periodical Testing

4.4.1 A record of maintenance, repairs, equipment modifications (if any) and test results are to be available on-board for review by the Surveyor.

4.4.2 Following tests are to be conducted at intervals not exceeding 5 years and to be witnessed by the Surveyor:

4.4.2.1 Test based on the updated DP FMEA test program covering all required test activities to reveal possible hidden failures, and to ensure the intended FRT capabilities.

4.4.2.2 Live short circuit and earth-failure testing for DP (2) and DP (3) vessels with CLB-T notation.

Note: This testing can include a narrower scope than the tests conducted during initial DP FMEA trials, and DP FMEA trials after major modifications.

4.4.2.3 Simulation testing using built-in test equipment which enables verification of the power plant protective functions for DP (2) and DP (3) vessels with CLB-S and CLB-T notations. The simulation testing is to at least include verification of all protection functions as required for DP (2) and DP (3) class notations.

References

[1] MTS TECHOP D-07, Rev.1, Jan 2021: A method for proving the fault ride-through capability of DP vessels with HV power plant.

[2]. MTS TECHOP D-05, Rev.1, Jan 2021: FMEA Gap Analysis.

[3] IMO MSC.1/Circ.1580: Guidelines for vessels and units with Dynamic Positioning (DP) systems.

End of Guidelines