MTS DP COMMITTEE GAP ANALYSIS TOOLSET

DP FMEA Proving Trials Gap Analysis - Practitioner Manual

A manual-first, evidence-centred method for comprehensive and defensible DP assurance review

For competent DP FMEA practitioners, independent assurance providers and trial reviewers

Final revision - 9 October 2026

Purpose: This manual explains how to use the DP FMEA Proving Trials workbook to determine whether the programme, executed trials and retained evidence comprehensively demonstrate the current DP redundancy concept and WCFDI. The workbook is an assurance guide; it is not Class, Flag or client approval.

1. Objectives and assurance boundary

The assessment must answer a practical question: can another competent reviewer reconstruct the vessel configuration, the intended failure, the actual system response, the post-failure DP capability and the restoration sequence from controlled evidence? A narrative statement alone is not sufficient where an objective test record or native data should exist.

1. Establish the exact vessel, configuration, class notation, redundancy concept and WCFDI against which the trials are judged.
2. Check technical completeness without turning the review into an unbounded re-performance of the FMEA or the trials.
3. Link every conclusion to a test, page, drawing, data record or other controlled evidence locator.
4. Prioritise gaps using WCFDI, redundancy significance and the MTS weighting scheme.
5. Provide a clear, auditable pathway from gap identification to independently verified closure.
6. Retain stable Criterion IDs and structured evidence records so approved AI assistance is possible without making AI the decision-maker.

Non-approval statement: The practitioner records an independent assurance opinion. Only the authorised Class society, Flag Administration, owner and client governance processes can provide their respective approvals or acceptances.

2. Tool architecture and technical coverage

Workstream	Criteria
Trial Basis, Governance & Scope	16
DP Control, Networks, PRS & Sensors	37
Power, Protection & Distribution	46
Thrusters, Propulsion & Auxiliaries	22

Workstream	Criteria
Safety Interfaces & DP3 Separation	9
Evidence & Data Centricity	10
ESS, DC Power & Future Fuels	26

Coverage statement: The workbook contains 166 stable criteria, grouped by workstream in dashboard order and then by Criterion ID, and the project-reference register. The design crosswalk maps all 116 rows from the applicable legacy MTS tool to at least one current Criterion ID. The specialist layers add DP3, closed/common-bus, DC, ESS/hybrid, fuel-cell, future-fuel and IACS UR E26/E27 checks.

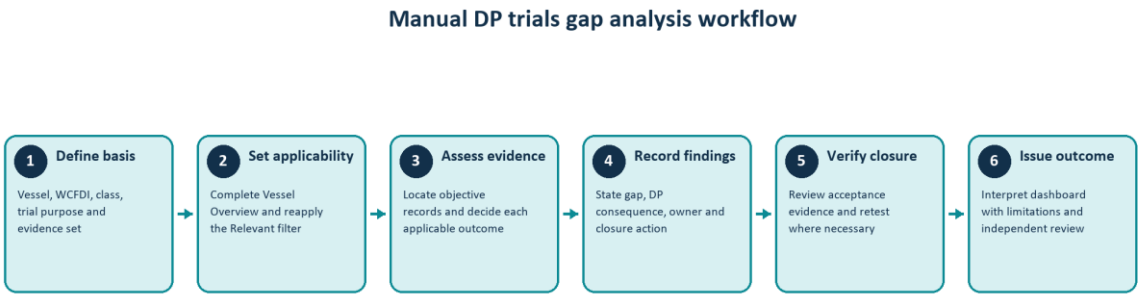

Figure 1 - End-to-end manual workflow

3. Before opening the checklist

3.1 Confirm the controlled basis

1. Vessel name, IMO number, build or major-conversion date, Flag, Class society, full class notation and DP equipment class.
2. Normal and approved alternative bus configurations; AC, DC or mixed distribution; redundant groups or zones; credited energy sources and thruster groups.
3. Redundancy concept, WCFDI, post-WCFDI capability, limiting conditions and CAM/TAM/ASOG relationships.

4. Current FMEA/revalidation, one-line and redundancy diagrams, Class approval records and the exact trials programme/report under review.
5. Configuration-sensitive systems: ESS/hybrid, fuel cell, low-flashpoint or alternative fuels, common bus, DC distribution, DP3 segregation and cyber applicability.

3.2 Establish document control and evidence authority

Record each source in DOCUMENT REGISTER before relying on it. A file is not evidence merely because it was provided. Confirm identity, revision, approval or witness status, location and how it was used. The REFERENCE REGISTER gives each document's issuer, edition, issue date and issuer link. Verify the vessel's governing edition and clause in the controlled document before issuing a conclusion; the criteria are guidance against those documents.

3.3 Plan the review

1. Create a working copy for the project and preserve a clean master.
2. Agree the review scope, deliverable audience, evidence cut-off and treatment of missing evidence.
3. Set an evidence naming convention that links documents, data records and test IDs to the workbook.
4. Do not start with the dashboard. Establish the basis first, then assess evidence criterion by criterion.

4. Worksheet-by-worksheet procedure

Worksheet	Purpose
GUIDE	Read outcome, weighting, finding, scoring and closure rules before assessment.
VESSEL OVERVIEW	Set applicability once and record the one-line, WCFDI and configuration basis.
DOCUMENT REGISTER	Record every controlled source and evidence package actually used.
GAP ANALYSIS	Assess only Relevant = Yes rows; enter objective evidence, exact locator and concise gap in the blue input columns (the sheet is protected).
FINDINGS REGISTER	Own consequences, corrective action, due date, status and independently reviewed closure.
DASHBOARD	Interpret progress, weighted coverage and finding counts; never treat it as automatic approval.

Worksheet	Purpose
REFERENCE REGISTER	Check applicable editions and follow the issuer links.

4.1 Vessel Overview

Complete every selector that is known. Blank, 'To confirm' or 'Other' values deliberately keep potentially relevant specialist checks visible; each selector accepts only the values in its list. Paste or insert a legible review schematic, but cite the controlled drawing in DOCUMENT REGISTER. Summarise the redundant groups, normal tie state, credited sources, DP-essential auxiliaries, fire/flood boundaries, WCFDI and approved operating configurations. Rows 1 to 18 are protected except the blue selector and particulars cells; the schematic area from row 19 down is editable and accepts pasted pictures. The note in A17 lists the selectors that are recorded for the report only and do not change which criteria are shown.

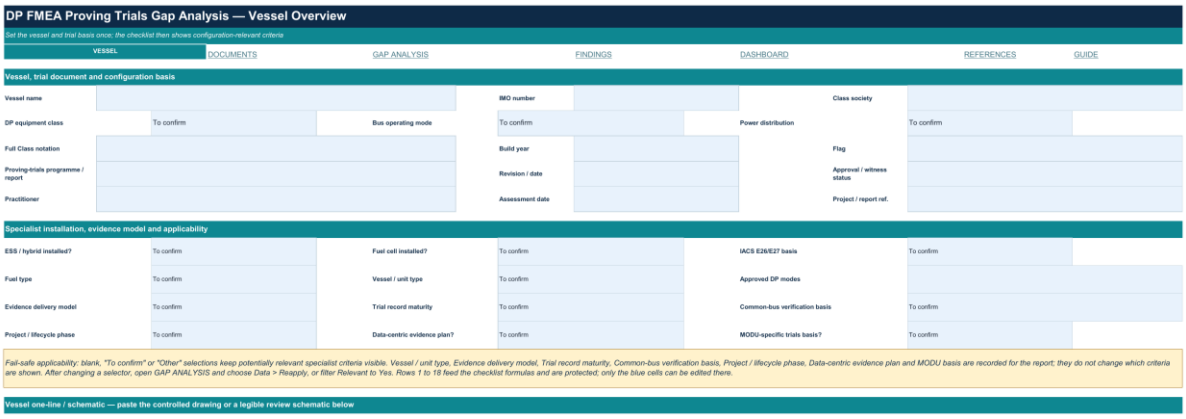

Figure 2 - Vessel and applicability basis

4.2 Document Register

Use unique Ref IDs. Record document number, revision, date, status, issuer, location and the reason for use. For data files, include the acquisition system, export date, native format, checksum or controlled archive path when available.

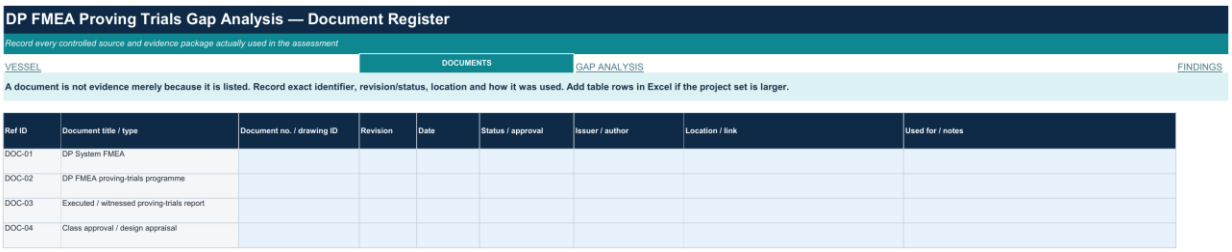

Figure 3 - Controlled evidence register

4.3 Applicability and filters

1. Change selectors only in VESSEL OVERVIEW.
2. Choose Data > Reapply after a selector change, or use the Relevant slicer and select Yes.
3. Use the Workstream, Weighting, Assessment result and Finding classification slicers only to change the working view. They do not change dashboard metrics. Sorting is disabled on the protected sheets; use the filters and slicers instead.
4. Do not classify a criterion Not applicable merely to reduce the workload. Record the vessel-specific basis in the evidence note.

4.4 Gap Analysis

Read the Review point and What good looks like columns together. Locate the exact test or evidence. Enter a precise reference, a factual reviewer note, and a concise gap only when something remains unresolved. Do not paste recommendations into the main checklist; the Findings Register owns closure work. Only the blue input columns accept entries; criterion text, weighting, relevance and classification are locked.

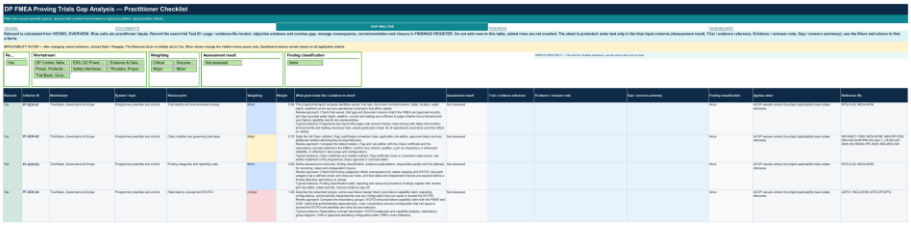

Figure 4 - Practitioner checklist and slicers

Illustrative worksheet views: These show the tool layout, not a completed assessment or a conclusion about any vessel.

4.5 Findings Register

The register opens on Track? = Yes and may initially show no rows. Cell A5 shows the live count of tracked findings; after assessment changes choose Data > Reapply to show them. Finding ID and Criterion ID are stored keys. Assessment fields are looked up by Criterion ID; action and closure fields stay with those keys. Only columns L to S accept entries. Status is one of Open, Action in progress, Pending verification, Closed, Accepted residual risk or Deferred. State the DP/WCFDI consequence, the corrective pathway, owner, target date, closure evidence and independent reviewer. Do not close by status alone.

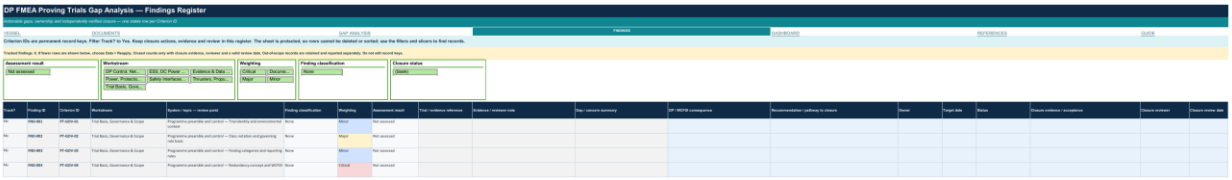

Figure 5 - Finding ownership and closure

4.6 Dashboard

Use the dashboard to prioritise work and communicate the state of the assessment. Relevant review points are configuration-dependent. Assessment completion counts defined reviewed outcomes, including justified Not applicable; blanks, invalid entries and Not assessed remain unassessed. Weighted coverage reflects evidence quality and criterion importance. Major Findings and open findings require disposition. Current-scope closure counts use relevant findings only. Closed requires closure evidence, an identified reviewer and a valid review date that is not in the future; incomplete closure is flagged and remains open. Out-of-scope retained findings are reported separately. These field checks do not establish engineering acceptance.

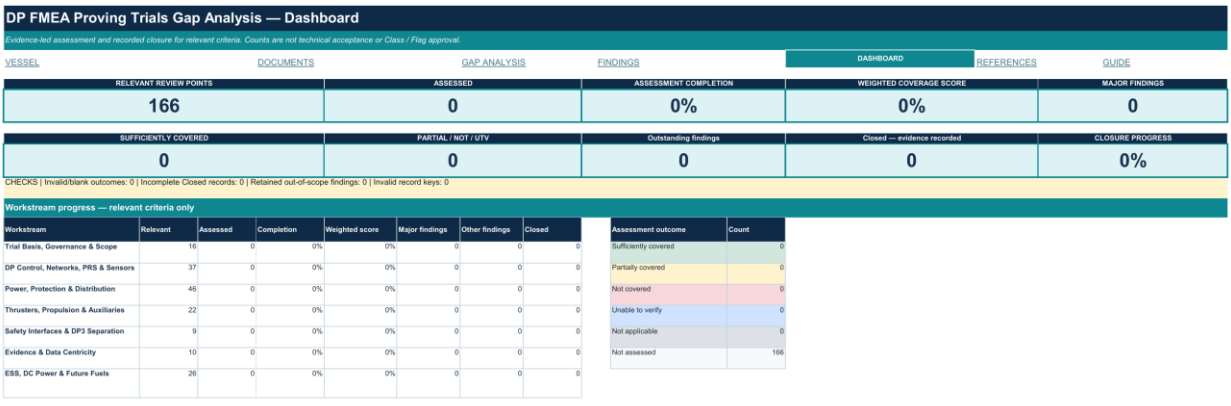

Figure 6 - Outcome dashboard

5. Evidence decision rules

5.1 Assessment outcomes

Outcome	Traffic light	Decision rule
Sufficiently covered	Green	Criterion is fully and objectively demonstrated for the stated configuration.
Partially covered	Amber	Material evidence exists, but one or more defined elements are incomplete or weak.

Outcome	Traffic light	Decision rule
Not covered	Red	The required analysis, test or evidence is absent or does not address the criterion.
Unable to verify	Blue	A conclusion cannot be reached from the evidence available. Treat as unresolved, not as a pass.
Not applicable	Grey	A documented vessel or project basis proves the criterion is not applicable.
Not assessed	White/light grey	No assessment has yet been completed.

5.2 Weighting and WCFDI significance

Weighting	Weight	Use
Critical	1.00	Potential to defeat the redundancy concept, exceed the WCFDI, or invalidate single-fault tolerance.
Major	0.75	Potential to equal the WCFDI or materially weaken a credited protective or recovery provision.
Minor	0.50	Limited technical weakness that should not by itself reach the WCFDI.
Documentation	0.10	Primarily a traceability, clarity or record-control requirement with no demonstrated technical loss.

5.3 Calculated finding classification

Assessment	Weighting	Calculated class
Not covered / Unable to verify	Critical or Major	Major Finding
Not covered / Unable to verify	Minor	Minor Finding
Not covered / Unable to verify	Documentation	Observation
Partially covered	Critical	Major Finding

Assessment	Weighting	Calculated class
Partially covered	Major	Minor Finding
Partially covered	Minor	Observation
Partially covered	Documentation	Opportunity
Sufficiently covered plus recorded concern	Critical / Major / other	Minor Finding / Observation / Opportunity, respectively

Preserve IDs and formulas: Do not change stored Finding IDs or Criterion IDs. Preserve calculated Weight, relevance, classification and dashboard fields. Use blue input cells and controlled vessel selectors. The sheets are protected without a password: rows and columns cannot be inserted or deleted and sorting is disabled; filters, Data > Reapply and slicers work.

5.4 Weighted score

For relevant assessed criteria, Sufficiently covered scores 1.0, Partially covered scores 0.5, and Not covered or Unable to verify scores 0. Not applicable and Not assessed are excluded from the denominator. The criterion weighting multiplies both numerator and denominator. A high score does not neutralise a single Major Finding or an unresolved WCFDI vulnerability.

6. Trial evidence standard

1. Unique test or evidence ID linked to the current FMEA failure mode and configuration.
2. Objective, initial conditions, method, injected or simulated failure, acceptance criterion and expected result.
3. Actual configuration: online generators or energy sources, bus ties, thrusters, auxiliaries, control modes, limitations and unavailable equipment.
4. Time-synchronised alarms, events and measurements sufficient to reconstruct propagation, detection, isolation, ride-through, DP consequence and restoration.
5. Instrument identity, calibration status, sampling rate, units, time base, channel dictionary and pre/post-event window.
6. Witness, deviations, aborted or substituted steps, anomalous results, concessions and controlled retest record.
7. Native data or lossless export with provenance and integrity controls where digital evidence should exist.

Data-centric principle: JDP 01 and the OCIMF DP FMEA Assurance Framework are used as assurance lenses: evidence must be traceable, configuration-aware and independently reproducible. Stable IDs, raw/native records, provenance and explicit uncertainty support the decision; they do not replace engineering judgement.

7. Specialist-system review prompts

Layer	Review focus
ESS / hybrid	Credited power and energy; SoC/SoH, reserve duration and time-to-terminate consequence; BMS/EMS/PMS; converter/contactor faults; isolation, thermal/ventilation safety; ride-through and degraded restart.
DC or mixed AC/DC	Topology and zones; fault current source and decay; protection/selectivity; earth and arc faults; converter blocking; bus capacitance and stored energy; isolation boundaries; voltage stability; instrumentation and restoration.
Parallel sources / bus ties	Parallel sources: excitation/governor, protection, synchronising and stable load sharing within each group with ties open. Closed/common bus additionally: cross-tie propagation, ride-through, inter-trips and enhanced V&V.
Future fuel / fuel cell	Fuel conditioning and availability; pumps, compressors, reformers and purge/inerting; ventilation; gas detection; ESD/F&G/QCV interfaces; transition and blackout response; control dependencies; hazardous release and safe shutdown.
IACS UR E26/E27	System inventory; network segmentation; access control; secure configuration; patch and vulnerability control; logging/time sync; backup/restore; change control; supplier evidence; cyber failure consequence on minimum-risk DP state.
DP3 segregation	Physical and functional independence; fire/flood boundaries; cable, pipe and ventilation routes; remote closing/opening; common services; hidden cross-connections; post-casualty control and communication.

8. Proving-trials-specific method

1. Confirm every FMEA failure mode that requires proving is represented by a unique trial or justified analysis/alternative verification.
2. Check prerequisites, safe test boundaries, authority, communications, data capture and stop-work rules before considering the programme witness-ready.

3. Validate acceptance criteria against the FMEA prediction, redundancy concept, WCFDI, alarm/detection timing and post-failure capability.
4. Check that fault insertion reaches the intended failure without substituting an easier or non-equivalent condition.
5. Confirm the result records actual response, not only a pass statement, and that deviations are controlled and retested.
6. Use closed/common-bus, ESS, DC and alternative-fuel criteria where applicable; these systems can change fault energy, propagation and recovery assumptions.

9. Finding pathway to closure

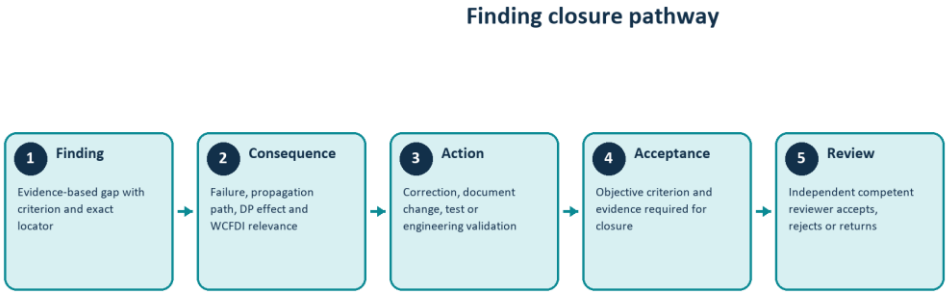

Figure 7 - Evidence-based closure pathway

1. Criterion and evidence: identify the exact requirement and objective evidence gap.
2. Technical consequence: state failure, propagation path, DP effect, WCFDI relationship and credited detection/mitigation.
3. Corrective action: specify whether closure requires analysis, document revision, design change, configuration control, test or retest.
4. Acceptance evidence: define what must be observed, measured or approved before work starts.
5. Independent review: a competent reviewer confirms the evidence meets the criterion and records the decision and date.
6. Residual limitation: record any remaining operating restriction, concession, CAM/TAM change or follow-on action.

10. Interpreting and issuing the outcome

1. State the vessel, configuration, evidence cut-off, standards/editions, limitations and excluded scope alongside every dashboard extract.

2. Require 100% assessment completion or explicitly qualify every omission before issue.
3. Disposition every Major Finding and every Unable to verify outcome; do not average them away through the weighted score.
4. Review workstream patterns. Repeated partial evidence in one domain can indicate a systematic assurance weakness even when individual findings are lower class.
5. Confirm closed findings have objective acceptance evidence and an independent reviewer; Status = Closed alone is not sufficient.
6. Retain the issued workbook, document register, evidence archive, reference edition record and any AI disclosure as a controlled assurance package.

11. Final practitioner QA checklist

1. Vessel and trial identity, class notation, redundancy concept and WCFDI are explicit.
2. Applicability selectors are complete and Relevant filter has been reapplied.
3. Every relied-upon document/data set is in DOCUMENT REGISTER with identity and revision.
4. Every relevant criterion has an evidence locator and defensible outcome.
5. Facts, inferences, assumptions and unavailable evidence are distinguishable.
6. All Major Findings and Unable to verify results have disposition and an owner.
7. Closure criteria were defined before acceptance evidence was reviewed.
8. Dashboard is consistent with the visible findings and is not presented as automatic approval.
9. Reference editions and project applicability have been confirmed.
10. Any AI assistance is disclosed and every AI-assisted entry has been reviewed by a competent DP consultant.

12. Principal source set

Source	Use in the assessment
IMO MSC.1/Circ.1580	DP system guidelines and equipment-class assurance basis.
IMCA M166 Rev 3 (May 2024)	FMEA development and proving-trial code of practice.
IMCA M190 Rev 3.2 (May 2024)	Annual-trials programme code of practice.
IMCA M250 Rev 0.2 (May 2024)	Instrumented data acquisition for DP trials; apply proportionately to the required evidence and event response.
IMCA M252 Rev 0.3 (April 2024)	Position reference systems and sensors for DP operations.

Source	Use in the assessment
MTS TECHOP D-02 / O-02	FMEA testing and annual DP trials/gap-analysis technical guidance.
JDP 01 Rev 1 (7 July 2025)	Unified verification, validation and assurance of DP single-fault tolerance.
OCIMF DP FMEA Assurance Framework (2020)	Risk-based, evidence-centred FMEA assurance framework.
ABS / DNV / Lloyd's Register / Bureau Veritas	Apply the vessel's governing DP, electrical, battery, DC, fuel-cell, alternative-fuel and cyber rules/notations.
IACS UR E26 Rev 1 / E27 Rev 1	Cyber resilience requirements, subject to contractual and build-date applicability.

Use the workbook REFERENCE REGISTER for complete source IDs. Verify governing editions and cited clauses against controlled originals before reliance.

13. Abbreviations

Abbreviations used in the workbook (criteria, guidance notes, selectors and Reference Register) and in this manual. Class notations, standards and rules are named as the issuer names them; confirm the governing edition in the REFERENCE REGISTER.

Abbreviation	Meaning
AC	Alternating current
ACU	Azimuth control unit
AI	Artificial intelligence
ASOG	Activity-specific operating guidelines
AVR	Automatic voltage regulator
BMS	Battery management system
BV	Bureau Veritas
CAM	Critical activity mode
CT / VT	Current transformer / voltage transformer
DC	Direct current
DGNSS / GNSS / GPS	Differential global navigation satellite system / global navigation satellite system / Global Positioning System
DP	Dynamic positioning

Abbreviation	Meaning
DP2 / DP3	DP equipment class 2 / 3
DPS / DYNPOS / DP(AA) / DYNAPOS	DP class notations of ABS, DNV, Lloyd's Register and Bureau Veritas; see the vessel's Class rules for each qualifier
EMS	Energy management system (ESS); engine management system (prime mover)
ESD	Emergency shutdown
ESS	Energy storage system
F&G	Fire and gas
FAT / SAT	Factory acceptance test / sea or site acceptance test
FMEA	Failure modes and effects analysis
HIL	Hardware-in-the-loop (testing)
HV / MV / LV	High / medium / low voltage
HVAC	Heating, ventilation and air conditioning
I/O	Input / output
IACS	International Association of Classification Societies
IAS	Integrated automation system
IGF Code	International Code of Safety for Ships using Gases or other Low-flashpoint Fuels
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
JDP 01	Joint DP guidance: unified approach to the verification, validation and assurance of DP systems
LFF	Low-flashpoint fuel
LNG / LPG	Liquefied natural gas / liquefied petroleum gas
LR	Lloyd's Register
MODU	Mobile offshore drilling unit
MSC	Maritime Safety Committee (IMO); MSC.1/Circ. denotes an MSC circular
MTS	Marine Technology Society (DP Committee)
NDU	Network distribution unit (DP network)
OCIMF	Oil Companies International Marine Forum
OEM	Original equipment manufacturer
OT	Operational technology

Abbreviation	Meaning
P&ID	Piping and instrumentation diagram
PMS	Power management system
PRS	Position reference system
QCV	Quick-closing valve
SOC / SOH	State of charge / state of health
SOLAS	International Convention for the Safety of Life at Sea
TAM	Task appropriate mode
TCU	Thruster control unit
TECHOP	MTS technical and operational guidance document
UHF	Ultra-high frequency
UPS	Uninterruptible power supply
UR	Unified Requirement (IACS), for example UR E26 and E27
UTV	Unable to verify (assessment result)
V&V	Verification and validation
VMS	Vessel management system
WCFDI	Worst case failure design intent

Criterion ID, Finding ID and Reference ID codes

Code	Meaning
PT-GOV	Trial basis, governance and scope
PT-DPC / PT-DPS / PT-POS	DP control system / DP sensors / position references
PT-DPN / PT-DPA / PT-IND / PT-AUT	DP network / DP alert / independent joystick / automation system
PT-POW / PT-ENG / PT-CLB	Power management and distribution / engine control and cooling / closed or common bus
PT-THR / PT-EME / PT-AUX / PT-COM	Thrusters / emergency stops / auxiliary systems / compressed air and communications
PT-FUE / PT-VAL / PT-HVA	Fuel system / valve control / HVAC
PT-SAF / PT-DPR	Safety systems / DP3 requirements
PT-DAT	Evidence and data centricity
PT-ESS / PT-DC / PT-FUF / PT-FCL / PT-CYB	ESS and hybrid / DC power / future fuels / fuel cells / cyber resilience

Code	Meaning
FND-nnn	Finding ID in the FINDINGS REGISTER (one per criterion, in table order)
RU / RP / ST / OS / CP	DNV rules / recommended practice / standard / offshore standard / class programme
GN	Lloyd's Register guidance notes
NR	Bureau Veritas rule note (for example NR467)
Pt / Ch / Sec	Part / chapter / section of a set of rules
M	IMCA marine division guidance document (for example IMCA M 166)