LEARNINGS FROM INSIGHTS MTS DP SUBCOMMITTEE FOR LFIS LFI(n) 004/26

PROTECTION AND CONTROL-POWER RIDE-THROUGH MUST BE COORDINATED ACROSS SYSTEM BOUNDARIES

This LFI(n) highlights that selective fault clearance does not by itself ensure an acceptable DP outcome. Control-power supplies, UPS transfer behaviour and the control-power undervoltage protection of connected equipment must be coordinated so that essential equipment rides through the credible disturbances created while faults are detected, isolated and supplies transfer.

Why this Learning Is Being Issued

A DP vessel with a high-voltage power plant experienced a significant position excursion after several thrusters shut down following a single-phase fault associated with a large pump supplied from a three-phase 690 V switchboard.

Investigation of the event identified that the pump had a history of tripping. Its overcurrent protection had previously been adjusted upwards in an attempt to avoid repeated or apparently spurious trips. This intervention reduced the feeder protection margin and should have triggered investigation of the underlying cause, together with review of protection selectivity and the consequences of any setting change. Raising a protection setting to suppress repeated trips can conceal a developing equipment problem and transfer fault-clearing duty to upstream protection, increasing the extent of the resulting power-system disturbance.

The faulty motor was not isolated by its feeder protection. Instead, protection at the 690 V switchboard incomers operated. The wider loss of the 690 V switchboard also interrupted the normal supply to an emergency switchboard that supplied the control-power UPSs for the thrusters.

The UPSs were of the line-interactive type. Under normal conditions, the connected loads were supplied from the incoming source, with transfer to stored-energy operation when the source failed. The transfer produced a short interruption. The original design relied on ride-through within the thruster-drive control-power supplies to bridge this interruption.

Unknown to the vessel owner, the thruster OEM had changed the drive control-power undervoltage trip timing so that the drives would shut down more quickly following loss of control power. This was protection responding to undervoltage of the drive control-power supply, not the drive main-power undervoltage protection associated with the propulsion power input. The change removed the previous margin between the UPS transfer interruption and the drive control-power undervoltage protection. When the emergency-switchboard supply was lost, the brief UPS transfer disturbance caused multiple thrusters to shut down.

The immediate initiating fault, the incomer protection response, the emergency-switchboard dependency, UPS transfer performance and thruster-drive control-power undervoltage protection were each associated with different equipment packages and technical disciplines. The unacceptable consequence arose from their interaction.

Central learning: Ride-through is a system property. It must be demonstrated from the credible initiating disturbance, through protection operation and control-power transfer, to the final response

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of every essential connected load. An OEM change to one protection setting can invalidate the coordination margin of the complete DP system.

Target Audience for this Learning

- Charterers and their Project Teams.
- DP Vessel Owners & Operators / Management Teams.
- Vessel crew including Industrial Mission personnel.
- Verification and assurance providers.
- Industry bodies / regulators.

What was learned?

Selective protection and control-power continuity cannot be assessed independently. A fault may be cleared without causing a blackout, yet still remove multiple thrusters if the associated voltage disturbance or UPS transfer exceeds the ride-through capability of connected control equipment.

The UPS did not necessarily fail. The transfer interruption was an expected characteristic of the installed arrangement. The vulnerability arose because the transfer characteristic and the revised drive control-power undervoltage timing were no longer compatible.

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The Failure Sequence

A single-phase fault occurred on or in association with a large 690 V pump motor.

- The pump had a history of tripping, and its overcurrent protection had been adjusted upwards in an attempt to avoid further trips. The investigation therefore considered the effect of this setting change on feeder sensitivity and selectivity.
- The pump feeder did not isolate the fault selectively. Protection at the 690 V switchboard incomers operated.
- Loss of the 690 V switchboard interrupted the normal supply to the emergency switchboard.
- The line-interactive UPSs supplying thruster control power transferred to stored-energy operation and produced a brief interruption.
- The revised thruster-drive control-power undervoltage protection operated before control power recovered. The main propulsion-power undervoltage protection was not the function responsible for the shutdown.
- Several thrusters shut down, producing a loss of thrust disproportionate to the initiating pump fault.

Ride-Through Is an End-to-End Requirement

A statement that equipment is supplied from a UPS is not sufficient evidence of continuity. The complete ride-through chain includes the source disturbance, upstream and downstream protection, switchboard voltage decay, UPS input limits, transfer detection, transfer interruption, output recovery and the response of each connected load.

The control-power response may be influenced by control-power undervoltage threshold, delay, dropout and restart logic, internal DC-link or control-power storage, contactor hold-in characteristics, phase-loss detection, waveform quality, frequency limits and the equipment state at the time of the disturbance.

The required ride-through time should include the worst credible disturbance and protection operating sequence, together with appropriate engineering margin. The available equipment ride-through should be demonstrated to exceed that requirement.

UPS Topology and Transfer Behaviour

UPS arrangements should be assessed according to their measured or substantiated behaviour, not solely by the generic description “UPS supplied”. Line-interactive and standby arrangements can introduce a transfer interruption. Double-conversion arrangements may avoid a transfer interruption in normal operation but can still contain bypass, overload, battery, inverter and common-control failure modes that require assessment.

Testing by opening an ideal upstream supply may not reproduce the voltage collapse, phase discontinuity, waveform distortion, frequency excursion, recovery or repeated transfer behaviour associated with a real switchboard fault. The verification method should represent the credible

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disturbance as closely as practicable.

Supplying all thruster-control UPSs from one emergency switchboard creates a significant common dependency with the potential to interrupt control power to multiple thrusters and defeat the intended DP redundancy concept. This arrangement is generally not recommended unless the common-point risk is demonstrably prevented or reduced to an acceptable level by segregation, independent alternative supplies, adequate ride-through capability or equivalent measures. Connection to the emergency distribution system may provide some secondary benefit for blackout recovery and black-start activities by making thruster control power available from the emergency source, but that benefit does not normally outweigh an inadequately mitigated common-mode vulnerability. The assessment should include credible failures of the emergency switchboard and both its normal and emergency sources.

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Management of Change Across OEM Boundaries

Control-power undervoltage thresholds and delays, UPS transfer characteristics, control-power storage and restart logic are part of the approved DP system design basis. Changes to these parameters can alter the consequence of a failure even where the affected equipment continues to meet its standalone product requirements.

Management of change should therefore identify all interfaces affected by a modification. A drive OEM, UPS supplier, switchboard protection provider, PMS provider and vessel integrator may each control only part of the response, but the vessel owner requires assurance of the combined behaviour.

Changes to firmware, parameter files, replacement hardware, protection settings or internal power-supply design should trigger review of the affected coordination cases, DP FMEA assumptions and verification programme.

FMEA, Coordination Study and Testing Implications

The DP FMEA should trace the initiating fault through all dependent power and control supplies to the final effect on thrusters and DP capability. Common distribution dependencies, including emergency switchboards and UPS input supplies, should be explicit.

The comprehensive coordination study should include feeder and incomer protection, emergency-switchboard supply continuity, UPS transfer time, connected-load ride-through, drive control-power undervoltage protection and the eventual restart or recovery sequence.

Proving trials and appropriate analytical or model-based methods should confirm the end-to-end response for representative disturbances. Where a live fault test is not reasonably practicable, the evidence should combine validated models, recorded waveforms, equipment test results and controlled functional testing. Limitations should be documented.

Computer-based simulation can include protective and limiting functions implemented within the power-management system and thruster drives, provided that the relevant logic, settings, timing and equipment response are represented in the model. Current model-based testing (MBT) practice in the DP community is not yet generally capable of integrating and validating this type of detailed package-level protection interaction across the complete power and control system. MBT should therefore not presently be treated as a substitute for suitable computer simulation, equipment evidence and targeted functional testing for this coordination case. It is expected that MBT capability will develop over time and may increasingly support integrated verification of these functions as suitable interfaces, models and methods become available.

Suggested Action

Vessel owners, operators and DP assurance stakeholders should review control-power ride-through for essential DP equipment. Actions may include:

- Confirming selective isolation of faults on switchboards that supply common control-power or emergency-switchboard dependencies.
- Identifying UPS topology, transfer criteria, maximum transfer interruption and output recovery for

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credible input disturbances.

- Establishing the control-power undervoltage thresholds, delays, dropout behaviour and restart logic of every essential connected load, while distinguishing these from main-power undervoltage protection.
- Comparing the required disturbance ride-through time with the demonstrated capability of the complete connected system, including engineering margin.
- Reviewing OEM firmware, hardware and setting changes through a cross-system management-of-change process.
- Updating the DP FMEA, coordination study, planned maintenance and verification programme when ride-through assumptions change.
- Testing the complete chain from the credible initiating disturbance to the final equipment response, rather than proving only that the UPS transfers.
- Applying operational restrictions or design changes where coordinated ride-through cannot be demonstrated.
- Selecting verification methods according to demonstrated capability, using computer simulation where detailed PMS and drive protection functions must be represented, and documenting any present limitations of MBT.
- Avoiding supply of all thruster-control UPSs from one emergency switchboard unless the resulting common dependency is demonstrably mitigated, while treating any black-start benefit as secondary to preservation of the DP redundancy concept.
- Treating repeated equipment trips as a condition requiring investigation, and subjecting any increase in protection pickup or delay to formal review of equipment protection, selectivity, coordination and DP consequences.

Conclusions

The initiating pump fault did not directly require the loss of multiple thrusters. The wider consequence resulted from failed feeder selectivity, interruption of a common emergency-switchboard supply, the transfer characteristic of line-interactive UPSs and revised thruster-drive control-power undervoltage timing.

The event demonstrates that a locally acceptable equipment change can invalidate a system-level ride-through assumption. Protection settings, UPS performance and connected-equipment immunity must be treated as one coordinated response.

Double-conversion UPS arrangements generally present fewer ride-through difficulties than line-interactive or standby types because the connected load is normally supplied continuously from the inverter and does not depend on a transfer to stored-energy operation when the input supply is disturbed. This can remove or reduce the transfer interruption that contributed to this event. However, double-conversion topology should not be treated as proof of continuity: bypass operation, inverter overload, battery condition, internal protection, common controls and downstream equipment

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immunity still require assessment and verification for the credible disturbance.

Assurance should establish that each essential connected load remains available throughout the credible voltage disturbance and control-power transfer, or that any loss remains within the accepted DP worst-case failure design intent.

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