MTS DP Subcommittee for Learnings from Incidents and Insights

LEARNINGS FROM INCIDENTS MTS DP SUBCOMMITTEE FOR $LFI_{(n)}$ $LFI_{(n)}$ 001/26

Damage to Generator Engine During Testing

Why this Learning Is Being Issued

Testing of critical performance attributes and protective functions upon which the redundancy concept relies is not is without risk and should only be undertaken with a full knowledge of the consequence and the factors upon which an acceptable outcome depends. Awareness of the consequences of testing protective functions can assist in developing measures to ensure protective functions can be tested safely and with minimal risk of equipment damage.

DP systems must be built **(and maintained)** in manner that allows critical performance, protection and detection elements of the DP redundancy connect to be proven:

Test anxiety can be reduced by:

- Developing a proper engineering basis for tests
- Understanding their contribution to establishing single fault tolerance
- ensuring equipment and machinery is fully prepared to undergo testing

Target Audience for this Learning

- DP Vessel Owners and Management Teams
- DP Technical Support Function
- DP FMEA Practitioners
- Classification Societies
- Vessel Designers
- DP Assurance Teams and Charterers

What happened

A diesel electric DP Class 2 vessel was carrying out testing of its blackout prevention system in an open bus configuration when an engine over sped after its circuit breaker was tripped to create a load step. The engine overspeed trip did not operate, and the engine was severely damaged. Repair times are of the order of months due to parts availability and lead times.

Why it happened

The vessel was conducting routine blackout prevention tests as part of annual DP trials which involved connecting two generators in parallel and loading up the bus using thruster load to a

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level at which the surviving generator would be in overload after the other generator was tripped. This is intended to prove the blackout protection system will prevent the generator from tripping. During such tests the generator under test experiences a load acceptance step and the generator tripped to create the overload experiences a load rejection step. When the generator operating in parallel was tripped to create the defined load step it over sped damaging the crankshaft.

Such tests are routinely conducted as part of DP FMEA proving trials and annual DP trials with no unacceptable consequence. Unacceptable test results are typically limited to proving that:

- There is no alarm to indicate load reduction is in effect
- The blackout prevention systems (phaseback system) is not effective.

Notes: *Typically, there is a partial or full blackout*

Very very rarely is there any kind of equipment damge.

Engine damage occurred on the engine that was tripped offline to create the load step not on the engine that was forced to pick up the load. This happened because the engine governor failed to respond to the load rejection quickly enough to prevent the engine over speeding **and** the over speed trip failed to stop the engine when it over sped because of the sluggish governor response.

Note: *Critical levels of overspeed are not expected as consequence of a load rejection. A well-tuned, well maintained turbocharged marine medium-speed generator engines will typically exhibit and overspeed of **less than 10%** for a 100% load rejection. Testing at DP trials does not require generators to be tripped at 100% load but even if it did there should be no unacceptable consequences for a well-maintained engine. Overspeed alarm may be set at around 110% of nominal and the overspeed shutdown will operate at 115%.*

What investigation steps were carried out

As the engine was damaged beyond the point at which it could be returned to service without lengthy major mechanical repairs it was not possible to carry out operational testing, but the over speed trip was fault to be defective. It is postulated that the engine governor or its linkage was faulty causing poor response to the load rejection. This performance deficit combined with hidden failure of the overspeed led to catastrophic failure of the engines being used to create the test conditions - not the engine / blackout protection system under test.

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What was focused on: The conditions that let to the overspeed and how they could be prevented in future

Why was this focused on: Properly maintained well-tuned generator engines do not overspeed on load rejection and destroy themselves. There must be additional factors.

What was the outcome:

- Planned maintenance procedures for engines were reviewed and revised
- What pretest checks should be made before step load testing engines
- Testing procedures for engine performance and blackout prevention
    - Are the load acceptance and rejection levels being used appropriate / necessary
    - Are the test objectives well defined and understood
    - How should the test method be structured to account for bus configuration (open bus v closed bus)

      Note: *On loss of generating capacity, load is not instantly transferred to redundant DP equipment groups in open bus configurations. Although it's important that generator engines have a defined and proven static and dynamic performance regardless of configuration there may be opportunities to use different methods or combinations of tests to confirm performance meets expectations.*

Confidence level on outcomes: High

Basis of confidence: A faulty overspeed unit was confirmed in post event investigations

Lessons learned

- In blackout prevention testing there may be unwarranted focus on the evet of transient overload on the surviving generation to the exclusion of the effect of load rejection step on the genertos tripped to create the step load.
- Modern generator engines may be called upon to exceed their step load rating in a typical redundancy concept and therefore rely on assistance from:
    - jet assist to reduce turbo lag
    - blackout protection to reduce loads rapidly even within *their nominal rating*

Actions

Short-term remedial actions: The vessel owner operated the power plant in open busties configuration until a new testing regime for open and closed bus blackout prevent system

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testing could develop

Note: in open busties configuration *backout prevention testing can be done without tripping generators because the load transfer is determined by the rate of thruster transfer not by the instantaneous loss of generating capacity. Generator dynamic performance can be established by supplemental testing. A rapid load reduction system is not so essential in an open busties configuration.*

Medium-term remedial actions: Non-destructive methods for confirming governor response and overspeed trip testing were developed, implemented and checked prior to annual DP trials

Long-term remedial actions: Additional guidance on load step testing of generator engines to be developed and shared with industry through this LFI and guidance revisions.

Results breakdown from MTS LFI Tool

The chart below shows the breakdown of the causal and contributory factors as defined within the four criteria of Design, Operations, People and Process obtained using the MTS LFI (fishbone)

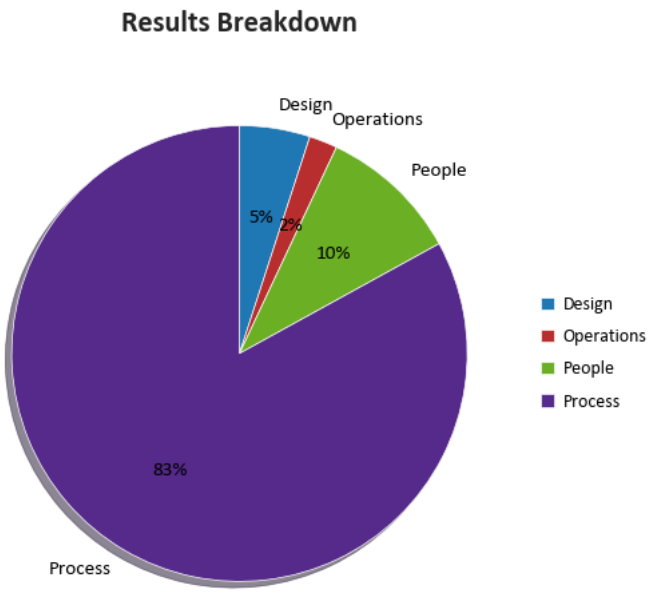

Figure 1 LFI Tool Results Breakdown

This insight has one strong causal and contributory element with a much smaller secondary

element related to :

- **Process** - The testing processes / methods in the Annual DP trials program for the blackout protection systems did not consider the barriers necessary to ensure a positive outcome from this type of testing - These barriers are effective speed control system tuning and overspeed protection. Planned maintenance would normally address these issues.
- **People and the processes they use -** The fact that the blackout protection system could be tested less aggressively in open bus configuration was not understood by those responsible for preparing the testing program. Sharing of knowledge information on this subject could be improved.

Design Sub-topics

• Ergonomics	• Was not a causal or contributory factor
• Commonality	• Was not a causal or contributory factor
• External Interfaces	• Were not a causal or contributory factor

Note: *The above Design Sub-topics have been found to be causal or contributory factors in many learning from incidents and are thus highlighted separately*

Suggested actions

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