DP Class 3 MODU exceeded WCF while operating with open busties during a heavy weather event

Target audience for this LFI

- Vessel Management and Operations Teams on DP Vessels
- DP Technical Support, Vessel Owners/Contractors
- Vessel Designers, Equipment Manufacturers
- FMEA providers
- Classification Societies / DP Approval Authorities

What happened

A DP Class 3 MODU carrying out drilling operations, and operating in a 3-split bus configuration, had a near simultaneous trip of 3 generators from two of the independent power systems during a heavy weather event.

Each of the vessels redundant power systems had the two generators and two thrusters connected and operating correctly. Due to the simultaneous trip of two generators from one of the redundant systems the vessel suffered blackout on one of the switchboards.

The vessel had been pushed off station by a large wave, but had remained within the yellow watch circle, and was recovering position when the blackout occurred and then continued to return to and maintain station while the technical team restored the power system.

The vessel at no time required to be disconnected from the wellhead and had been operating in accordance with the Class approved shipyard DP FMEA and within the requirements of the WSOG.

Why it happened

The initial investigation indicated that the three generators had been tripped, had not experienced a fuel or cooling system fault and had been tripped by the switchboard protection. The generators had continued to idle in a healthy condition disconnected from the switchboard.

It was observed that the generators had tripped from the switchboards during a period of significant load changes due to thruster operation during the position recovery and station keeping which suggested the that generator may have experienced fuel control or voltage control issues and that these may be causal or contributory factors.

Investigation was made difficult through the fact that, the two generators from the blacked out switchboard, the protection indications had been reset and cleared during the recovery process. However, the third generator was known to have tripped on reverse power as the indications had not yet been reset or cleared.

It was suspected that all three generators had therefore tripped on reverse power and the complexity of the control and protection system needed to be fully investigated and understood to determine how two generators on one switchboard could trip on reverse power simultaneously.

The mechanism by which this occurred was identified to be a function of the way the set, reset and activate intervals of the reverse power flag indication, within protection relay, operated and the interaction of this function with an oscillation which occurred within the power system which had developed between generators operating in parallel.

The reverse power function required a reverse power condition to occur for the flag to set and required the condition to be absent for 1 second for the flag to clear. If the flag was set for 5 seconds continuously then the reverse power function activates and disconnects the generator. The operation of this function was determined to be as per design and operated correctly and as intended.

The oscillation within the power system due to interference occurring between the parallel connected generators was determined to be a poorly configured and tuned electronic governor. A function of the governor allowed for an increase to the proportional gain, of the PID control loop, by a factor if the speed error exceeded a set value. The investigation determined that the primary cause of the oscillation was the allowable speed error set to low and the multiplying factor excessive. This resulted in the governor osculating alternatively into and out of reverse power every 1-second and the randomness of this process determined whether one or both generators for a switchboard would trip.

The incident investigation highlighted several factors in the People, Process, Operations and Design categories which either directly lead to the incident or extended the duration of the incident.

Poor tuning of all generator governor parameters introduced a vulnerability into an otherwise fault tolerant design by reducing the performance of redundant systems to the point where they responded incorrectly to a load transient which should have been within their capability.

The following points are considered to be casual factors which extended the duration of the incident and hampered the recovery. However, all points are considered to be as per normal design of the equipment and not requiring further action.

1. The automatic recovery function of the PMS for the blacked out switchboard did not occur due to both generators being tripped by the protection relay, but despite the generators remaining in operation.

2. The PMS automatic recovery system timeout occurs at 2 minutes and as the protection relays were not reset prior to this timeout occurring the system did not automatically recover.

3. The crew did not identify that the power system required manual recovery, instead relying on the automatic recovery system to operate after the protection relay reset; subsequently requiring the crew to shutdown the generators from the blacked out switchboard, to prevent overheating due to the loss of the cooling systems.

4. The design of the switchboard prevented remote closing of the circuit breakers due to the spring charge motors not operating as a result of the loss of auxiliary power. Manual charge facilities are

available and were considered to provide sufficient redundancy to the system. The use of the manual charge facility was not familiar to the crew.

The incident investigation determined that human factors were the contributory factor which extended the duration of the incident and hampered the recovery. This was primarily due to a lack of in depth technical and system knowledge of senior technical persons on shift during the incident with specific reference to the casual factors listed above and associated with insufficient training, drills and mentoring for the technical teams, which further impacted the crew's performance under abnormal conditions.

What investigation steps were carried out

Owner, client and third party technical support and including an independent assurance team, as requested by the Owner, was mobilised to the vessel along with manufacturer's support. The agenda was to find the root cause of the incident, resolve it and test the system to validate the remedial measures.

High speed digital recording equipment was used to monitor component parts of the power system and generator performance during the investigation and testing program.

All components of the DP System were investigated to identify all casual or contributory factors, systems included the DP control system, integrated vessel automation, switchboard protection, thruster drives, governors and AVRs.

The generator governors were the primary focus of the investigation as the incident data indicated that generator performance was a primary and contributing factor.

What was the outcome

The causal factor was considered that the generator governors were not properly tuned. The cause being a lack of robustness in the verification and validation processes which should have ensured the generator governors were properly tuned.

Contributory factors was considered to be there was no process for confirming the dynamic performance of the generators periodically. Additionally, the limited scope and methodology of the DP system FMEA and proving trials, which appear to have been done to a minimum standard, reduces the confidence these processes are intended to provide.

The confidence level on these outcomes is high as testing procedures were developed and testing performed to prove the robustness of the system and restore confidence and involved the collaborative input from Owner, client and 3rd party technical and assurance teams which included specialists from differing fields and backgrounds.

Lessons learned

1. Isolated power systems are vulnerable to common cause failures including total blackout if not correctly tuned with consideration for dynamic performance to cope with significant load transients associated with vessel motions and changing environmental conditions.

2. Governors and AVRs should be tuned to address the potential for oscillations developing for all operating conditions and including significant load transients. A means for confirming performance should be part of the vessel periodic testing.

3. Verification and validation processes need to be reviewed to ensure they confirm generator dynamic performance in a manner appropriate to DP systems.

4. Training drills should include failure scenarios to better equip crew with knowledge to improve their performance under abnormal conditions.

5. Overload of data during events should be avoided as processing relevant information from the data is a user process which cannot cope with large amounts of data created in a short time

6. Typical DP vessel power plant monitoring and trending functions have poor time resolution, are typically filtered and are considered to be insufficient for a generator's dynamic performance to be confirmed.

Recommendations

It is recommended that owners of DP vessels disseminate this LFI to Vessel Management Teams on all DP vessels and to their electrical contractors and vendors of DP FMEAs and to their DP Technical Support Function.

Remedial actions

Short Term: These actions were to find the root cause within the equipment and address it. This was achieved within two weeks of the initial incident and remedial work validated by testing.

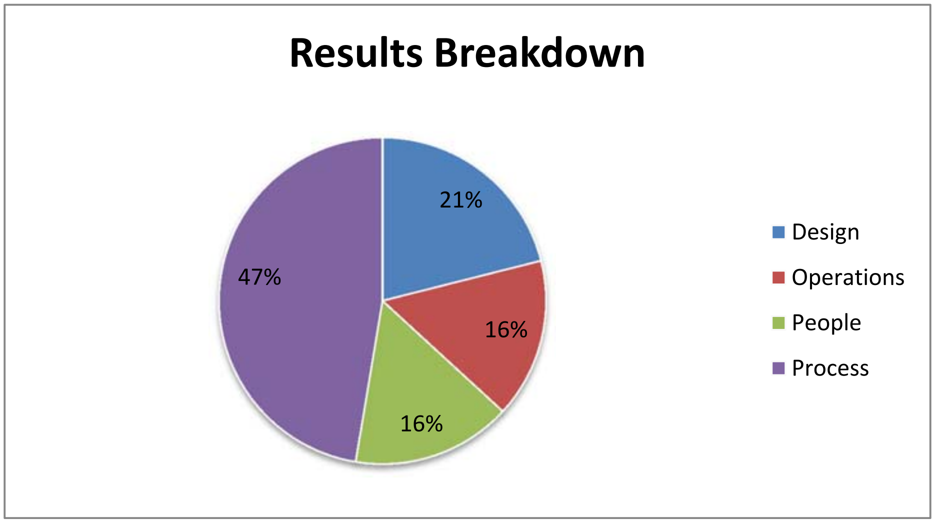
Medium Term: There were a variety of contributory factors identified within the LFI which relate to people and process. These include 'on-the-job' training, failure scenario drills, verification and validation processes etc. In the medium term these need to be reviewed to determine ways and means to improve response to failures and eliminate failure modes using available processes.

Long Term: Dissemination of all information and lessons learnt throughout the industry along with the various steps taken after the incident investigation to resolve the identified gaps. Commissioning processes, classification society approval processes for DP FMEAs. Minimum standards to include testing and validation to identify the gaps highlighted herein during the build phase.

Investigation breakdown

The chart below shows the breakdown of the identified causal and contributory factors as defined within the four criteria of Design, Operations, People and Process.

Design	4
Operations	3
People	3
Process	9



The results suggest the contributory factors were mostly related to process failures