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Analysis of Advantages and Disadvantages of Closed and Open Bus-Tie on DP3 Class Vessel

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Abstract

Power management system (PMS) of DP3 semi-sub is designed to work in closed and open bus-tie configuration. Open bus-tie operation is required during DP3 (AUTRO) operation. In that mode, each power cell will be run independently from other sections. Closed bus-tie configuration could be used in other DP modes. Open bus-tie configuration is the most fault-tolerant option as it ensures that failure on one switchboard is not automatically transferred between the systems. However, open-bus tie results in more engines being online than may be required. This results in less efficiency of engines, more fuel consumption and carbon emissions. Therefore, semi-subs and rigs, operating in DP 3 mode are focusing on transitioning to closed bus-tie configuration. In this paper, we will analyze the advantages and disadvantages of open and closed bus-tie configuration on DP3 semi-sub and will conclude which one is the preferred configuration for safe execution of critical DP operations.

Keywords: Dynamic positioning; DP system; Open bus-tie; Closed bus-tie; Advantages; Disadvantages; DP3; Semi-sub

Introduction

Closed bus-tie configuration is not a new concept. Marine power systems are typically of the isolated type, with four to eight generators and the overall power system split into two, three or four sections. The power bus of each section is connected to the others by a bus tie, which utilizes a circuit breaker. As the IMO is implying more stringent rules for reducing carbon emissions, more rig owners are aiming at transitioning to this configuration. Operating in closed bus-tie will result in more efficient engine load and less emissions. However, in case of failure on one switchboard, it will be transferred to the entire system which could lead to blackout with all negative consequences for the DP operations. Therefore, before operating in closed bus-tie, a proper risk analysis should be carried out. Operating in closed bus-tie will require live short circuit testing or alternative ride through testing of the system, and demonstration that protective systems work with sufficient margins. Alternative ride-through testing methods are shown in [1].

Reliability Assessment of Closed Bus-Tie

Reliability expresses as the likelihood of surviving a certain time period under given operating conditions. Reliability is a probability distribution of the time to failure.

There are no class requirements for closed bus-tie configuration [2], states that bus-tie breakers should be open during equipment class 3 operations. Some classification societies require two circuit breakers between any two bus sections intended to provide redundancy when the vessel operates with closed bus-ties [3]. The reliability of closed bus-tie configuration could be assessed through live short circuit testing and live earth fault testing or other alternative methods of all protective systems. Protective systems for closed bus-tie operation on DP vessels are designed to ensure the highest reliability, flexibility, and fault tolerance. The protective systems for closed bus-tie operation on DP vessels include advanced fault detection, high-speed bus protection, and special protection schemes to ensure the reliability and fault tolerance of the power plant. These systems are designed to rapidly detect and isolate faults, island the faulty bus section, and maintain the operational integrity of the vessel, particularly in the event of a defective generator or other critical failures.

Additionally, the protective schemes incorporate advanced generator protection, motor protection, and common-mode generator protection to address the unique challenges associated with closed bus-tie operation on DP vessels. Furthermore, fault ride-through testing is conducted to demonstrate the safety and reliability of the protective devices for generators, thrusters, and essential loads necessary for station keeping in a closed bus configuration. These protective systems and testing procedures are essential for ensuring the safety, reliability, and operational integrity of DP vessels during closed bus-tie operation. Several critical protection areas and failure modes are addressed in the design of these systems, including:

i. Islanding of defective generators: Special protection schemes are required to island the faulty section or shed load in the event of a defective generator to maintain the vessel's operational integrity.

ii. Fast Fault Detection and Clearing: The protection systems are designed to rapidly detect and clear faults in electrical machinery to prevent widespread system failures and ensure continuous operation.

iii. Directional protection is useful in closed ring systems with several generators where it is essential to define the direction of the power flow that supplies the fault.

iv. Logic-Zone Discrimination: Modern protective systems are employed to ensure the highest reliability and flexibility in closed bus tie operations on DP vessels.

v. Fault Ride-Through Capability: To demonstrate the safety and reliability of closed bus tie configurations, fault ride-through testing is conducted to ensure that protective devices for generators, thrusters, and essential loads can withstand and "ride through" a fault without tripping before the bus-tie breaker opens.

These protective systems are essential for maintaining the safety, reliability, and operational integrity of DP vessels during closed bus tie operations. They are designed to address the unique challenges and requirements associated with closed bus tie configurations, ensuring that the vessel can continue to operate safely and effectively in these modes.

Statistics Related to Closed Bus-Tie

When assessing the reliability of closed bus-tie configuration, we will have to analyze the IMCA DP Incident reports. IMCA M181[4] looked at incident data from 1994-2003 and found that open bus-tie vessels were less likely to suffer full blackouts than closed bus-tie vessels but that open bus-tie vessels were more likely to suffer partial blackouts. IMCA guidance began to recommend open bus-ties. For example, IMCA Guidelines for the design and operation of dynamically positioned vessels noted the possibility of a realistic chance of the closed breaker not tripping and did not reference IMCA M126 (withdrawn). Later revisions (2016-) noted the advantages of closed bus operation but stressed the need for an advanced generator protection system to ensure redundancy of closed bus operation. Of the 333 DP incidents reported to IMCA between 2011 and 2015, 57 were impacted by their bus configurations [5]. In 23 cases bus configuration would not impact outcome of incident, in 24 cases closed bus configuration would have improved the outcome of the incident and in 3 cases open bus configuration would have improved the outcome of the incident.

Advantages of Closed Bus-Tie

Closed bus-tie systems on DP vessels have some advantages, including:

i. **Cost savings:** Operating a DP vessel in closed bus-tie configuration can provide cost savings in terms of reduced fuel and maintenance costs.

ii. **Reduced wear and tear:** Closed bus-tie systems can help reduce wear and tear on the vessel's equipment, leading to longer service intervals and lower overall operating costs.

iii. **Enhanced environmental performance:** Closed bus-tie systems can contribute to reduced emissions, which is particularly important in regions with stringent emission requirements, such as the Gulf of Mexico and the Arctic

iv. **Increased flexibility:** Closed bus-tie systems can provide more flexibility in terms of equipment operation and system configuration, allowing the vessel to adapt to different operational scenarios.

However, it is essential to note that these advantages must be weighed against the challenges and potential risks associated with closed bus-tie systems, such as decreased safety and reliability, challenges in control, protection, and management systems, and increased exposure to risk.

Disadvantages of Closed Bus-Tie

Closed bus-tie operation on DP vessels has several disadvantages, including:

i. **Decreased safety and reliability:** Closing the bus-tie can decrease safety and reliability, as it allows failures to affect multiple systems.

ii. **Challenges in control, protection, and management systems:** Operating a DP vessel in closed bus-tie configuration introduces challenges in designing and managing the control, protection, and management systems of the power plant, such as single point/common earth fault, AVR (advanced generator protection) overexcitation fault, and governor fault

iii. **Increased exposure to risk:** Closed bus-tie operation can increase the fault duty of switchgear, which increases exposure risk to technicians operating in the substation.

iv. **Restrictions on vessel operations:** Open bus-ties can impose other restrictions on a vessel's ability to carry out its industrial operations, often resulting in otherwise avoidable downtimes.

v. **Potential negative effects on emission budget:** In regions with stringent emission requirements, operating with

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bus-ties open in closed mode can help operators avoid exceeding their emission budget before the end of the operational phase.

In summary, closed bus-tie operation on DP vessels has several disadvantages, including decreased safety and reliability, challenges in control, protection, and management systems, increased exposure to risk, restrictions on vessel operations, potential negative effects on emission budget, and difficulty in demonstrating equivalent integrity.

Advantages of Open Bus-Tie

In terms of safety, open bus-tie systems are generally considered to be safer than closed bus-tie systems. This is because open bus-tie systems allow failures to affect only one system, while closed bus-tie systems allow failures to affect multiple systems. DP3 vessels usually operate in open bus-tie because separation is the default and definition of DP3. A closed bus-tie decreases safety, reduces reliability, and allows failure to affect multiple systems. Closed bus-tie operation can also increase the fault duty of switchgear, which increases exposure risk to technicians operating in the substation. Therefore, while closed bus-tie systems may offer some advantages in terms of cost savings and flexibility, they must be carefully evaluated against the potential risks and challenges associated with their operation. Open bus-tie systems mitigate safety risks by:

i. **Preventing cross-contamination:** Open bus-tie systems prevent electrical faults from spreading across the entire power system, reducing the likelihood of widespread system failure.

ii. **Maintaining system integrity:** By allowing failures to affect only one system, open bus-tie systems help maintain the integrity of the power system, making it easier to identify and isolate faults.

iii. **Reducing equipment stress:** Open bus-tie systems can help reduce equipment stress and the risk of cascading failures, as the power system is not reliant on a single path for power distribution.

iv. **Facilitating fault diagnosis:** Open bus-tie systems make it easier to identify and diagnose electrical faults, as the system can provide clear indicators of potential issues.

v. **Enhancing safety during maintenance:** Open bus-tie systems allow for safer maintenance and repair work, as technicians are not exposed to the risk of electrical faults when working on the system.

vi. **Compliance with industry guidelines:** Open bus -tie systems are often recommended by industry organizations, such as the International Marine Contractors Association (IMCA), due to their safety benefits and reliability.

In summary, open bus tie systems mitigate safety risks by preventing cross-contamination, maintaining system integrity, reducing equipment stress, facilitating fault diagnosis, enhancing safety during maintenance, and complying with industry guidelines.

Disadvantages of Open Bus-Tie

One disadvantage of open bus-tie systems on DP vessels is that they can impose restrictions on a vessel's ability to carry out its industrial operations, often resulting in otherwise avoidable downtimes. Additionally, open bus-tie systems can increase the risk of exceeding emission budgets in regions with stringent emission requirements. Open bus-tie configuration will result in less efficient engine load and higher fuel consumption. However, these disadvantages must be weighed against the safety benefits of open bus-tie systems, which are generally considered to be safer than closed bus tie systems.

Conclusion

In the above article we have analyzed the advantages and disadvantages of open and closed bus-ties for DP3 semi-sub vessel. Although the closed bus-tie configuration will result in more efficient engine load, less fuel consumption, and less carbon emissions, it is less reliable compared to open bus-tie configuration when it comes to critical DP operations. Therefore, during DP operations where electrical power is critical, the closed bus-tie should be avoided [2]. Recommends use of open bus-tie during critical activities. The IMO guidelines [6] require open bus-tie unless the bus-tie tripped to avoid failures blacking out both sides of the bus tie. The use of closed bus-tie is still possible if the bus tie breaker will be tripped before the power plants on both sides of the breaker are affected. If electric power is not critical then an open or closed bus-tie is unimportant. If electric power is critically important to safe DP operation, it requires the bus-tie to be open. The closed bus-tie configuration is justified on a thoroughly tested vessel with an intact protection system [7].

References

1. Roa Michael (2016) Alternative Approaches for Demonstration of Fault Ride through Capability on DP Vessels with Closed Bus Operation, American Bureau of Shipping.
2. USCG (2022) Safety Alert 11-22.
3. Marine Technology Society (2021) DP Vessel Design Philosophy Guidelines.
4. IMCA, M181 (2006) Analysis of station keeping incident data 1994-2003.
5. Craig M, Newton K, Whiteford S (2018) A Risk Based Case for Closed Bus High Voltage DP Operations .
6. IMO. MSC/Circ. 645 (2017) Guidelines for Vessels with Dynamic Positioning Systems.
7. Birolini A (2011) Reliability Engineering: Theory and Practice, (4th Edition), Springer.

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