DYNAMIC POSITIONING CONFERENCE
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VERIFICATION, TESTING AND TRIALS SESSION

FMEA Annual Trials and Experience of the *Ocean Intervention*

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FMEA Annual Trials – A tool for ensuring systems reliability and operator competency

Abstract: The FMEA proof, executed as part of an annuals trials program, is an effective tool to ensure continuing system reliability and crew proficiency. In the absence of frequent and continual testing, systematic failures in the lower sub-systems might occur which could expose the vessel operator to unwarranted high risk.

FMEA

FMEA (Failure Mode Effects and Analysis) is a disciplined systematic analysis of a system's design during the concept, design, commissioning, and operational life of a vessel. The intent is to identify and prevent potential design-based and operational procedural failure modes *prior to and during field deployments of systems (vessels) in the field.* This process is not new or unique to the DP industry.

The FMEA discipline was first established by the Department of Defense under Procedure MIL-P-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis, November 9, 1949. From work in 1988 by a Task Force from Chrysler, Ford and General Motors, the International Organization for Standardization (ISO) developed and issued QS9000 which calls for FMEA process as part of a Advanced Product Quality Planning system.

Det Noske Veritas (DNV) and the American Bureau of Shipping (ABS) adopted the requirement for FMEA in the mid 1970s and early 1980s.

The FMEA process should be undertaken early in the design process and continue to be reviewed and revised throughout the life of the vessel. As a living entity, there are many parallels to a FMEA and childhood trough adulthood development.

- Conception: The early vessel design takes shape and the FMEA process begins.
- Birth: The vessel is brought into service and the FMEA is proofed.
- Adolescence: The FMEA matures and its early life experiences are integrated to enhance systems reliability.
- Adulthood: A mature and reliable system steers a steady course, with a proud and nearly flawless service record achieved through do diligence of the FMEA process.

FMEA and Annual Audit

In the current upturned market the problem remains, scheduling time for those quarterly, semi-annual and annual Preventive Maintenance Schedule (PMS) items that are undesirable to attempt during live operations.

A request to perform one FMEA item could go like this: Master of the Vessel calls the Client Representative at 01:00. Master – "Sir, we are down-hole and there is a gale blowing outside. The Technical Manager has requested we turn the vessel to minimize the weathervane and trip #2 switchboard offline to perform FMEA proof #3". Client Rep – "Captain, how soon can you get that man on a chopper and off this vessel".

The vessel operator and their clients must be committed to a thorough PMS and Quality Assurance auditing program. This should include the FMEA proof, re-enacted completely at a minimum, during the annual audit. This is necessary to ensure systems continue to perform as designed. Particular attention should be directed towards the low-level subsystem where subtle faults tend to be masked.

A surveyor from the classification society and an independent auditor should attend the seatrial. Auditors are human and the evaluation systems they use are derived from criteria based on human understanding, initiatives and characteristics. Therefore, each auditing system is susceptible to bias, both intrinsically and during execution.

This need not be a negative issue, however. Changing auditors annually allows a broader spectrum of scrutiny over the years, giving the recipient the advantage of combined expertise and varied focus in the long run. This also increases the opportunity to eliminate 'holes' which may result from choosing a singular source or standardized audit process. What one might miss, the others may pick up, and where multiple auditors concentrate on the same issue as a priority, a reinforcement of the importance of that issue is gained. Of particular importance would be the year(s) immediately following the initial FMEA proof.

Utilizing FMEA as a Training and Evaluation Tool

The responsibility of the Master, DPOs, Engineers, DP Electronics Technicians, and Electricians is the 100% availability of systems and safe operation of the vessel to carry out specific missions as dictated by the vessel operator at the request of the charter. To execute these responsibilities those key personnel must have an intimate knowledge of the FMEA and the FMEA proof. There is no document or technical exercise, which can provide a greater source of systems overview than these.

As a means of assessing crew proficiency, the auditor should instruct the crew to perform certain FMEA proof items in a listed order of progression. Usually, these tests will start with the lower-level failures and work upwards towards the main power generation. The crew will then demonstrate the method of testing and be aware of the expected result prior to conducting the test. In this manner, the auditor will evaluate the crew's competency in their various areas of responsibilities as he/she observes them reacting to failure modes.

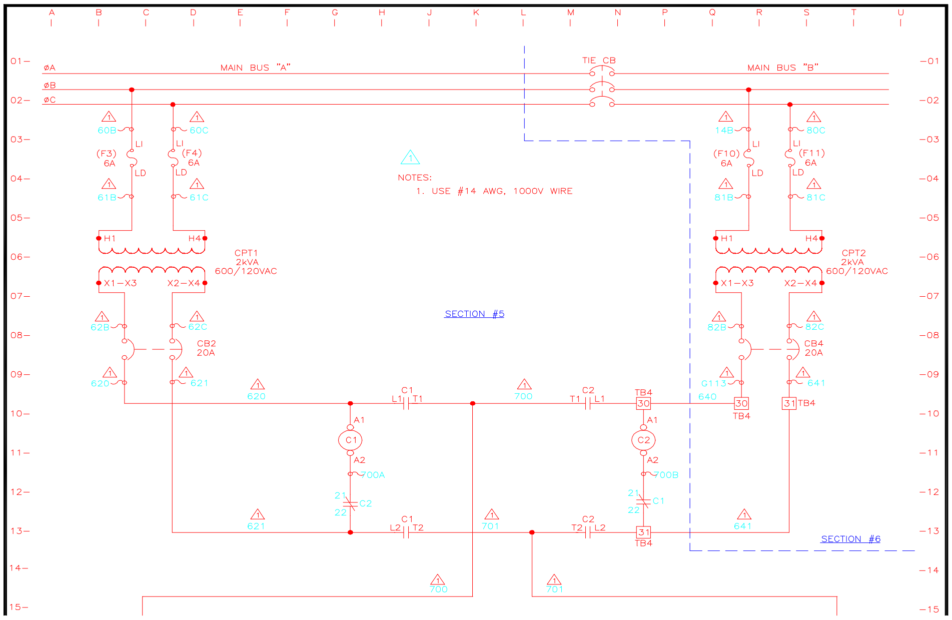
Over Reliance on the "Black

Of particular interest when examining MIL-P-1629, one finds that "failures are classified according to their impact on mission success and personnel/equipment safety". The trend in today's totally automated manufacturing processes is to eliminate the interchangeability of personnel/equipment in their impact on mission success/failure. In this context, since human factors have little or no presence in these manufacturing processes, this is a progression of natural selective extinction.

The reduction of weighting the importance of the operator to successful system performance is a trend seen in many DP and Vessel's FMEA. Modern day Integrated Systems are for the most part robust, reliable and fault tolerant. As the technology matured and greater Artificial Intelligence was built into the "black box", the FMEA's focus has been increasingly directed toward the equipment and the exclusion of human factors. In a DP and vessel operational scenario this assumption/omission could be viewed as an egregious action on the part of the FMEA author(s).

YR	Operator Error	Thruster/ Electrical	Reference Computer
Pre89	46%	21%	33%
1990	45%	26%	30%
1991	41%	27%	32%
1992	48%	25%	27%
1993	25%	25%	50%
1994	19%	14%	67%
1995	26%	39%	35%
1996	23%	37%	40%
1997	25%	32%	43%
1998	40%	20%	40%

A review of the DP incident Reports from 1989 through 1998 (published by DP Vessel Owners Association and The International Marine Contractors Association) clearly indicates, an



Schematic drawing showing power source for throttle control logic

equal weighting for human error as a cause of DP incidents. The chart, presented on the previous page, illustrates the cause distribution of these incidents by year:

Is the high rate of incidents attributed to reference system/computers really distributed to the proper category? It could be suggested, the root cause of these incidents is an over-reliance by the Operator on the "black box". The Operator is the best line of defense and the final QC over the machine. Do these operators possess the theoretical knowledge base and fundamental skill sets to make proper evaluation over the "black box"? Finally, is the FMEA testing these operators to expose this potential failure mode?

FMEA of Ocean Intervention II

Two significant events occurred during the initial FMEA proofing on the MSV Ocean Intervention II. 1) Control power was interrupted on simulated opening of the bus tie-breaker, and 2) the entire bus failed on unintended failure of one half of the bus.

In spite of the fact that Her sister ship the MSV Ocean Intervention had been commissioned and in service for 1 ½year, a subtle single point failure was found in the power source for the throttle control logic. A lower sub-system identical to that deployed on the Ocean Intervention, the 110Vac source voltage is derived off either A or B bus (depending on which one is energized first or which circuit breaker CB2 or CB4 is closed first). If that "first" bus fails then the contactors C1 & C2 allow for the alternate supply from the remaining bus. The inherent problem is the delay in the contactors is sufficient to cause the Allen Bradley Flex I/O modules (throttle control logic not depicted here) to reset to a zero state during the supply voltage transition. Steering motors, start/stop and SCR assignments controlled by these modules, all reset to a zero state during monetary power source switchover. The results were seen in manual and DP modes of operation.

To remedy the problem, the voltage source was migrated from the 600Vac/120Vac transformers and contactor network to the pilothouse and engine room 24Vdc battery backed-up supply system. This eliminated a potential failure point in the 120Vac/24Vdc Allen Bradley Power Supplies and ensured no single point failure.

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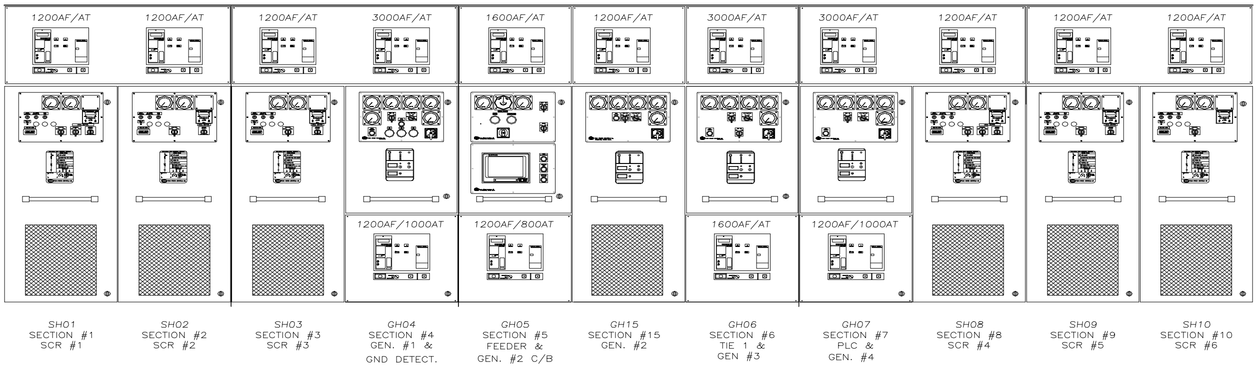
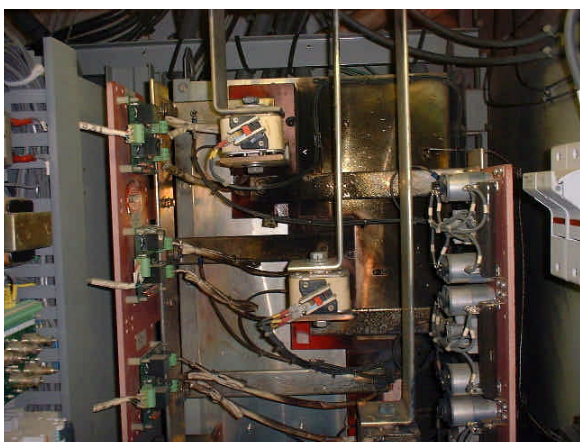


MSV Ocean Intervention 2 600Vac Main SwitchBoard

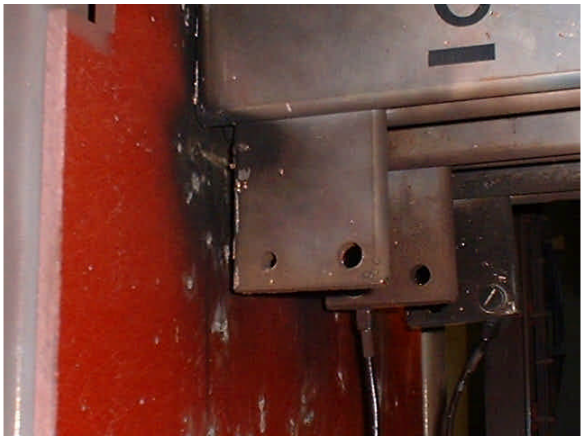
Arcin & Sparkin SeaTrials Picture #1

Picture #3



Picture #2

Picture #4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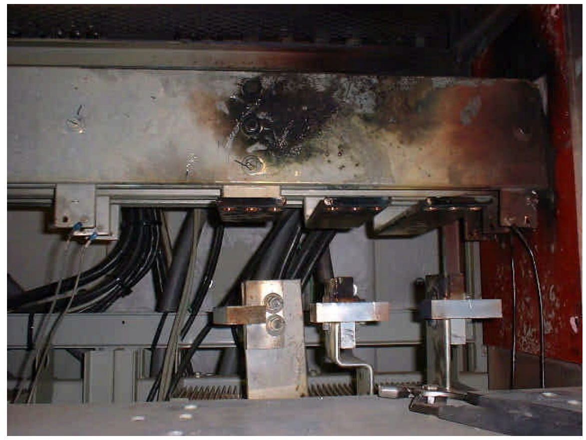
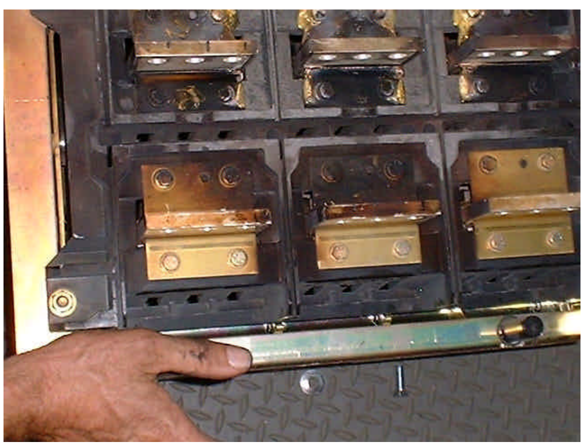
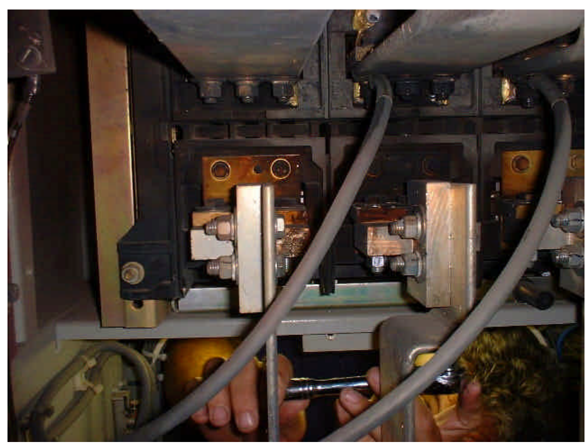

Picture #7


Picture #6


Picture #9


Picture #7


Picture #10

The second event occurred during full propulsion power test, with the Main B Bus suffering a catastrophic failure (section 10, SCR #6 aft Tunnel Thruster). Two phases arced over with spectacular results. Picture #1 depicts ½” to ¾” of “B” bus bar having been melted away. Picture #2 depicts the inside of Section #10 which may have been the initial source of the arc. Picture #3 is a close-up of picture #2. Picture #9 shows the considerable destruction to the bus bar.

However, the “A” bus was also lost as the tie-breaker failed to open. Additionally all of the SCR propulsion drives went off line on and under voltage trip when the short appeared on the “B” bus. In this case a single mode failure was identified by accident, which could not have been safely reproduced in a formal FMEA procedure as it was initiated by a genuine high current and very fast short on the bus.

The possible remedy in this case is to shorten the tie-breaker instantaneous trip time such that it might clear before the generator and SCR breakers on the opposite bus half (although this may not be guaranteed owing to the speed of the UV trips elsewhere).

The value of a FEMA study in this case is that it identifies a single mode failure of which the operators must be aware, even though there may be no way to remove the failure effect.

Conclusions:

The need for continued FMEA testing is ever present. The repeating of the FMEA proof serves as the single most effective training tool to prepare shipboard personnel to properly react to failure modes. Highlighted here is the importance that must be placed on evaluating crew knowledge, proficiency, and preparedness to react to these failure modes. The human factor is the best QC measure and the last line of defense.