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Multi-Unit Operations Considerations

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Abstract

Several nuclear weapons programs have or are pursuing the implementation of multi-unit operations for tasks such as disassembly and inspection, and rebuild. A multi-unit operation is interpreted to mean the execution of nuclear explosive operating procedures in a single facility by two separate teams of technicians. The institution of a multi-unit operations program requires careful consideration of the tools, resources, and environment provided to the technicians carrying out the work. Therefore, a systematic approach is necessary to produce safe, secure, and reliable processes. In order to facilitate development of a more comprehensive multi-unit operations program, the current work details categorized issues that should be addressed prior to the implementation of multi-unit operations in a given weapons program. The issues have been organized into the following categories: local organizational conditions, work process flow/material handling/workplace configuration, ambient environmental conditions, documented safety analysis, and training.

Contents

1. Introduction

The purpose of this report is to delineate the human factors issues that should be considered in the implementation of multi-unit operations. The document represents a tri-lab (Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories) human factors effort. A summary of preceding efforts supporting the current report is provided. The implications of multi-unit operations are significant, but particularly with respect to nuclear explosive safety. It is desirable then for safety engineers and assessors to use these delineated factors as prompts for issues that may require design changes and hopefully foster safer, reliable, and effective nuclear explosive operations.

Multi-unit operations can take many specific forms including staged components, lockstep, and independent teams. A staged component context typically involves a single team with more than one energetic component within the facility. Lockstep operations include two teams performing separate, identical tasks simultaneously. Finally, independent multi-unit operations involve two teams performing the same or different tasks in whatever order necessary. The independent teams can be performing assembly operations adjacent to disassembly operations. The independent team approach is generally the context of most interest to programs considering implementing multiple operations per facility.

Given the nature of the multi-unit context of interest, the use of the term "multi-team operations" may be a helpful alternative. The implementation of multiple teams represents a significant element of distinction relative to single teams with co-located hazardous components. Furthermore, many of the considerations delineated in this report would not pertain to single team operations with multiple hazardous components.

An approach generally regarded as not feasible includes having different weapon systems in the same facility for maintenance. In addition, having more than two teams in a given facility has not been given serious consideration.

1.1. Background

Little documentation is available to describe the extent and nature of historical nuclear explosive operations that involved multiple teams working separately in a single facility on separate components or units. Nevertheless, anecdotal evidence indicates that multi-team operations were a common feature in assembly and maintenance processes and the need to perform more work per facility continued through history to current efforts.

One of the more recent efforts to consider multi-team operations, associated with the W76 program, documented some of the thinking surrounding proposals to implement multi-team operations (Pond, Gilmore, Houghton, 1998). Based on observations of W69 dismantlement multi-team operations, the authors identified numerous features of the context that increase the complexity of the work relative to single unit or single team operations. The findings from Pond, Gilmore, and Houghton served as a foundation for subsequent efforts including the current report.

In 2004, the opportunity arose for the authors to observe warhead operations involving multi-team activity at the Pantex Plant. Work was observed and interviews were conducted with technicians and supervisory staff with regards to the nature of multi-team operations. The input gained served to enhance and validate the Pond, Gilmore, and Houghton findings and contributed to the current document.

In the spring of 2005, Nathan Brannon and Walter Gilmore were provided tours of nuclear explosive maintenance facilities at the Atomic Weapons Establishment (AWE), Burghfield in the United Kingdom. AWE had periods of work that included multiple teams performing work in a single facility. As a result, experienced workers were interviewed to discuss some of the content described in the current document. The interviews served as a means of validation.

With respect to presentations and publications, the multi-unit/multi-team issue and related concepts have been presented at the 2004 and 2005 Nuclear Explosive Safety Workshops (Brannon et al., 2004; Brannon, Gilmore, & Bennett, 2005a). Complimentary to this report is the more abstract “Principles” memorandum (Brannon, Gilmore, and Bennett, 2005b) that summarizes the human factors elements that are generally agreed to be necessary to address when implementing multi-team operations. In addition, a conceptual job safety analysis (Gilmore, Brannon, & Bennett, 2005) was prepared to describe adverse safety conditions and recommended remedial measures associated with the considerations listed in this report. So if a consideration was reviewed that had not been addressed correctly, one could turn to the conceptual job safety analysis to determine why the issue is significant and find suggestions for how the adverse condition could be resolved.

2. Considerations

The following list of questions is intended as a tool to facilitate a more objective, consistent, and thorough review of human factors issues associated with multi-team operations. While this list represents a significant step forward in the resources available to support programmatic implementation, it is understood that improvements can and should continue.

2.1 Local Organizational Conditions (Within Team/Between Team Interactions)

- Have pre-operational responsibilities been explicitly and centrally delegated?
- Have protocols been established and standardized across facilities and programs for the transfer of facility ownership?
- Has facility oversight/ownership been communicated so that workers are aware of who is responsible for the facility and the means by which they can be contacted?
- Is the membership of each team designed so that right skills and number of team members precludes the need for assistance from an adjacent team?
- Does the team staffing ensure two-person control within each operating area to make sure program requirements are not violated?
- Are operations designed and coordinated to ensure safe and effective behavior within and among teams?
- Has cross team interaction been controlled to eliminate distraction while ensuring emergency communication (such as an evacuation notice) is effective?
- Has cross team interaction been controlled to eliminate the potential for confusion with reversible directions (e.g., raise or lower trunions?), reversible numbers (23 or 32 psi?), or numbers that sound similar (e.g., 17 or 70 inches?)
- Are immediate action procedures appropriate and understood in the context of multi-team operations?

2.2 Work Process Flow/Material Handling/Workplace Configuration

- Have mobile objects (such as tools, carts, and testers) been evaluated to make sure appropriate space is available for movement, entry, and/or exit without inhibiting adjacent team operations?

- Does the arrangement of the facility contents (e.g., work stands, tool carts, etc.) facilitate direct, smooth, unimpeded movement of objects (such as nuclear explosives, other energetic components) whether manually (e.g., using appropriate carts) or hoists?

- Have alternative means of moving objects been developed should a conflict for the use of limited equipment (such as testers and single facility resources) occur?

- Have arrangements been made for the staging of nuclear explosives or energetic components that will accommodate potential process flow bottlenecks such as limited satellite facilities?

- Have criteria been developed to prioritize the movement of materials in the event of cross team interference?

- Have testers with limited or fixed location constraints been evaluated to eliminate interference from moving hazardous objects or components into the area where the tester is located?

- Has a list of shared/common equipment been derived for each operation and if so, are protocols in place to manage simultaneous demand for this equipment?

- Will the potential increase in waste compromise combustible loading limits?

- Have all tasks requiring personal protective equipment (PPE) been evaluated to either prohibit operations by an adjacent team or determine if the adjacent team will be required to wear the same equipment, even if not needed for their task?

- Has the generation of excess materials including 35 account items been evaluated to make sure program requirements are not violated?

- Has restacking/rehandling necessary to access or move about in the facility been evaluated to make sure task performance is not compromised?

- Will the temporary placement of equipment inhibit access to tools, parts, and other facility equipment?

- Is appropriate workspace available (e.g., bench space) to allow technicians to perform all tasks, particularly closeout steps?

- Have hazards been separated to comply with requirements (such as distances between donor and receptor)?

- Given the potential for humans to extend donor and/or receptor hazard positions, are hazards (including, but not limited to, lightning and electrostatic discharge) still appropriately separated?

- Have transfer windows been evaluated to control the incentive to rush the movement of materials to meet a window or some competing activity?

- Is a plan in place to handle support personnel activities (e.g., photography, lights etc.) so as to control potential distractions with neighboring activities in the facility (e.g., needing to clear neighboring components from the viewing angle for photographs)?

- Is the number of RMMA squares appropriate for multiple teams, while still ALARA?

- Have the positions and range of movement of cables, cords, hoses, etc., been evaluated to eliminate interference with neighboring work?

- Have tools and parts been organized to eliminate the potential of inadvertently switching tools or parts between teams?

- Is the interlock area organized to ensure the correct receipt, organization, and distribution of parts and tools for the respective teams?

- Are components that are being removed for inspection organized to ensure the correct inspection is applied to the correct part and that parts are not overlooked?

- Are components that are being removed for inspection organized in such a way that the neighboring team is kept unaware of the results and unbiased in their own inspections?

- Have all tasks that must be completed before the process reaches a "STOP Permitted" point been evaluated and reconciled to handle conflicts between teams?

2.3 Ambient Environmental Conditions

- Are lighting levels adequate for each team considering the new layout and increased bay contents?

- Have sound pressure levels been measured for all noise producing equipment and compared to recommended levels for voice communication?

- Has excessive ambient and neighboring noise from talking, tools, and equipment been evaluated and controlled to eliminate between team interference for individual team communication such as reader-worker interaction?

- Has the use of multiple noise producing devices/equipment simultaneously been evaluated to control noise amplification due to resonance?

- Have noise abatement steps been taken as necessary?

- Have atmospheric conditions been re-measured in the full context of multi-team operations to ensure comfortable and appropriate working conditions?

- Have facility power demands been re-evaluated to ensure adequate power is available for the successful simultaneous use of equipment (such as the Phoenix cart?

2.4 Documented Safety Analysis

- Does the HAR and/or SAR module clearly explain how the multi-team operations will proceed and specifically identify which concurrent operations are allowed, restricted, or prohibited?

- Does the HAR identify specific hazards associated with multi-team operations (beyond that which are addressed in this programmatic document) and implement specific controls in the TSRs?

2.5 Training

- Does the training and certification program incorporate appropriate facets of the multi-team operations considerations discussed in the preceding material, emphasizing the need for stringent conduct of operations?

3. Conclusions

Among the alternative approaches under consideration to expedite the processing of the nuclear weapons stockpile, the use of multiple teams in a single facility is the primary option. The limited number of facilities is noted as a constraint driving the interest in multi-team operations.

Finally, human performance will continue to be relied upon in the day-to-day operations at facilities such as the Pantex Plant. Consequently, the nature of human error must be understood and controlled. The considerations listed represent a step forward in a more systematic analysis of the factors that can influence human error and the overall effectiveness of a multi-unit context.

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