CONF-9210148--5

PNL-SA--20717

DE93 004403

ENVIRONMENTAL RISK ASSESSMENT FOR START-UP OF A NEW CONSOLIDATED MAINTENANCE FACILITY

J. G. Heubach
J. A. Wise

October 1992

Presented at the
Human Factors Society
1992 Annual Meeting
October 12-16, 1992
Atlanta, Georgia

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

ABSTRACT

This paper summarizes a case study of a risk assessment for a consolidated maintenance facility (CMF). An interdisciplinary team was formed to identify and evaluate "showstopper" risks which could delay or prevent on-time, safe, and economical operation of a CMF and to recommend ways to mitigate the risks. The risk assessment was constrained by time, information, incomplete plans and facilities, and a concomitant major transition in manufacturing process, organization, and technology.

Working within these constraints, the team integrated convergent findings into estimates of high, medium, and low risks based on the subjective likelihood of occurrence and predicted consequences of potential hazard events. The team also made risk-reduction recommendations for facility detail design and production start-up. The findings and recommendations reported in this study focus on risks related to environmental design and workstation ergonomics. Findings from the risk assessment effort should aid other constrained risk assessments and applied research on similar facilities.

ENVIRONMENTAL RISK ASSESSMENT FOR START-UP OF A NEW CONSOLIDATED MAINTENANCE FACILITY

J.G. Heubach and J.A. Wise
Pacific Northwest Laboratory [a]
P.O. Box 999
Richland, Washington 99352

Introduction

This paper reports the environmental components of a risk assessment that was performed as part of the planning process for a major move and reorganization of vehicle refurbishing and reassembly manufacturing lines to a new consolidated manufacturing facility.

In this project, the core of the manufacturing operations at an Army depot contained in eleven separate buildings will be consolidated into a new 378,000 square foot facility known as the Consolidated Maintenance Facility (CMF). Equal to nine football fields of area under one 36-foot-high roof, the CMF represents a $110 million investment. The structural system of the CMF is steel columns, open web girders and joists with a metal deck. The wall system is pre-cast concrete from footing to a typical height of eight feet above the floor, with insulated metal panels extending to the roof. The CMF design, construction, and equipment acquisition is being handled through three separate contracts for building, equipment, and information systems.

In the CMF, a total of approximately 1200 employees will overhaul (i.e., receive, pre-clean, disassemble, clean, reassemble, inspect, paint, and package) engines, generators, and drive train components for wheeled vehicles. The employees are also in the midst of a major transition from a traditional manufacturing line to a Just-In-Time program. The current workforce has a variety of concerns about the transition to the CMF, including job security, equipment congestion, restroom facilities, and workstation design.

The risk assessment uncovers what sorts of "show-stopper" risks can be anticipated in this massive undertaking and possible means to either avoid or mitigate such risks.

Method

A multi-disciplinary team was formed to assess risks of operations and safety in the CMF to start-up, operations, cost and safety. The team included human factors/ergonomics specialists, production system analysts, an environmental protection expert, an information systems expert, a safety

---

(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

engineer, and industrial/organizational psychologists. The team developed a risk assessment plan, visited the site, and integrated their findings using a seven-step approach.

1. Counterpart site transition team members were identified to serve as respective points of contact (POC). The POCs identified problems (e.g., incomplete production-line layout and ergonomic workstation design plans); obtained relevant documents (functional design specifications, fire protection plan); arranged onsite interviews with individuals and production line teams; and provided feedback on identified risks and recommendations.

2. The risk assessment team set initial criteria for "levels of risk". A 3x3 consequences by probability matrix guided the risk level assignments. Consequence categories included delay in meeting critical CMF start-up dates, increase in equipment and operating costs, and threats to safety. The projected consequences combined with subjective likelihoods of occurrence defined risk placement in the matrix; e.g., whether the risks required immediate action, active monitoring, or resources as permitted, etc.

3. The team reviewed documents that included the functional design program, facility plans (no elevation drawings were available), workstation layouts, safety and health documents, production item movement and scheduling plans, and prior organizational task reports.

4. The team visited the site for a full week of extensive interviews with numerous individuals, special interest groups (e.g., ergonomics/safety process action team), and production-line employees (e.g., transmission engine assembly) and participated in guided walk-throughs of existing and future facilities.

5. At the end of each of the four 10-hour days onsite, the research team and the site POCs reviewed the day's findings, answered questions, and planned any necessary adjustments of the following days' activities.

6. The preliminary risks identified by each disciplinary team were presented to the full research team for review, combined where appropriate to present a coordinated description of risk areas, and then compiled a report to the CMF director, Depot Management, and Site Transition Team (POCs).

7. The full team briefed the CMF director, the transition team leader, and one upper management director.

Results

The following section summarizes risks related to equipment and occupant movement, workstation ergonomics, morale, signals and signage, noise, and task lighting in the CMF. Each section also discusses some of the mitigation recommendations offered to the transition and management teams.

Traffic

Risks to occupants and vital equipment were likely to occur because of inadequate aisle width; extension into the aisles of switch boxes, breaker boxes, roof supports, and drinking fountains; high levels of forklift traffic; and shared use of facilities by 1200 workers. Critical safety issues also arose concerning the possible occurrence of accidents which would require emergency evacuation of victim(s) through narrow aisles in an huge building filled with production lines attended by forklifts. Accidents and traffic jams appeared likely to reduce production, lower morale, and increase operation costs.

This risk assessment made the following recommendations:

- Protect vital equipment from forklift damage by providing concrete curbing at a height sufficient to deflect worklift wheels.
- Provide a clear floor traffic pattern for workers and travel patterns for forklift operators.
- Install convex mirrors to increase visibility.
- Place clearly visible rotating amber lights on the forklifts.
- Paint all sensitive wall-mounted equipment in the facility to increase visibility.

Congestion from Placement and Number of CMF Amenities

Risks to production and morale are likely to arise from the congestion caused by the limited number of locker rooms (6 for men; 5 for women) and restrooms (6 for men; 5 for women) serving 920 men and 280 women on the shopfloor. The concentration of lockers, up to 856 in one lockerroom and limited number of sinks and toilet fixtures, combined with extremely short breaks, lunch time, and distance from workstations to these amenities ensured that excessive congestion is unavoidable.

Recommendations include staggering breaks, providing additional entry and exit points to the CMF, enlarging numbers and sizes of lockers, and replacing stand-alone sinks with circular, treadle-operated sinks.

Workstation Ergonomics

Observations of current operations revealed common workload stressors due to poor working postures, improper lifting, and repetitive work motions likely to cause cumulative traumas. Manipulators provided in the past to relieve excessive lifting went unused because they were too cumbersome for operators' use.

CMF workstation design assessment was made difficult by the lack of workstation elevation drawings and incomplete design revisions, and confusion because contractual responsibilities were not clearly defined. For example, it was erroneously assumed by management that new fatigue mats were part of the equipment or building contractor's responsibilities. However, these mats were not included in either contract. Consequently, no new mats for the cement floor on which workers stand 10 hours daily are provided.

In addition, employees seemed keenly aware that ergonomically inadequate workstations and job design can lead directly to occupational injuries (e.g., carpal tunnel and lower back injuries). Ergonomics and workstation safety awareness is reflected in the formation of employee volunteer work groups focused on studying carpal tunnel syndrome and ergonomics.

The existing workspace design concerns and ergonomic awareness suggested broadening the role of the ergonomics action team from a short-term risk assessment to include acting as a review panel and ergonomics advocacy group, an ergonomics training resource, and a workstation design advisory group.

Signals and Signage

At the time of the risk assessment, the safety, traffic, and production signal system remained undefined and responsibilities for different aspects of the signal and signage system were spread between the building contractor and the CMF transition team. Lack of signal system definition and identification of responsibilities is likely to result in the inconsistent use of color, visual, symbols, and sounds and a high level of confusion regarding their meaning. The problem is further compounded by the expected diversity of sounds and visual stimuli in the CMF.

To avoid confusion and ensuing threats to safety, production interruptions, and employee frustration, all signals and symbols throughout the CMF, e.g., flashing forklift poles, overall emergency exit alarms, eye wash location, background paint, Kanban inventory, were coordinated within a comprehensive visual and auditory system.

Employee Morale

Interviews with production line teams and action teams showed operators' high level of concern for the quality of work life in the CMF and their current work environments. Workers expressed anger over congested locker and restroom facilities, fear regarding job stability, and concern over the lack of ergonomically well-designed workstations and tasks. In order to improve morale, it was suggested that an operator work quality and workstation program be implemented to empower employees to use their expertise to develop programs and redesign tasks and the work environment. Further, highly visible workplace features ought to be incorporated into the CMF to fully demonstrate management's commitment to the workers.

Noise

Based on current noise levels (some areas exceed 105 dBA), movement of existing processes and technology to the CMF, and the limited acoustic baffles closely hung from the 36-foot ceiling, the background and workstation time-weighted average (TWA) noise levels are likely to exceed 85 dBA in places. The ceiling acoustic treatment of intermittent baffles hung 36 feet off the shop floor provides an incomplete absorption for the setting. The existing acoustic environment will most likely adversely affect worker morale, health, and the ability to communicate between work stations.

The open-space nature of this huge facility makes acoustic remediation difficult. Prior to CMF occupation, production processes should be examined

to determine how noise may be diminished through changes in equipment, processes, or handling procedures. In addition, the team recommended acoustic ray tracing analysis to identify best placement of additional treatments. Of equal importance is the development of a comprehensive and user-friendly hearing conservation program.

Task Lighting

A number of processes within the CMF require high levels of visual acuity for precision inspection tasks. The ambient lighting plan in the functional design program provided the only information relevant to task lighting, since the task lighting plan had been rejected and was not yet resubmitted. The facility program reported a target task illumination level of 100fc on the work surface for special needs and tasks, but the direct ambient HID lamps could provide only about half of this at locations needing the illuminations on the factory floor.

The assessment team recommended that the transition team identify specifically the tasks requiring high-visual inspection and review the forthcoming task lighting plan for light quantity, directionality, color rendering, flexibility for operator control, and inspection background characteristics prior to acceptance, and ensure the implementation of a lighting maintenance program.

Discussion

Consolidating a number of manufacturing facilities and processes into one giant facility poses significant challenges to management and facility designers. Here, a comprehensive risk assessment benefited from a coordinated, multi-disciplinary approach in which safety engineers, production systems analysts, and industrial/organizational psychologists worked together with ergonomists to define risks and suggest solutions.

Lessons learned were that in a facility such as this, multiple risks quickly radiated from single-point hazards. For example, absent forklift warning lights and movement lanes were not only liable to cause accidents, but delay production lines. Similarly, excessive operational noise cannot only veil emergency signals, but also produce unnecessary operator stress. The lessons learned show the need for interdisciplinary risk assessment and call for interdisciplinary mitigation plans.

END

DATE
FILMED
4 / 14 / 93