Canadian Nuclear Society Conference
Waste Management, Decommissioning and Environmental Restoration
for Canada's Nuclear Activities: Current Practices and Future Needs
Ottawa, Ontario, Canada. May 8-11 2005

INCORPORATING HUMAN FACTORS IN DECOMMISSIONING PROJECTS - OPPORTUNITIES FOR ADAPTING APPLICATION

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ABSTRACT

The purpose of this paper is to promote discussion concerning the needs and opportunities for adapting the current nuclear industry model of human factors practice to better accommodate the characteristics and needs of decommissioning projects.

Over the past twenty years, the nuclear industry has progressively evolved and formalized the application of human factors methods to improve system and human performance in the operation of power plants and facilities. The standards, guidance and work practices established have evolved with respect to a 'design' and 'operation' application emphasis.

Decommissioning projects represent the final phase of a facility lifetime and exhibit some differences in characteristics from the 'design' or 'operation' project phases. Consequently, some adaptation of current human factors practices may be beneficial in applying human factors methods to the decommissioning phase for a facility.

This paper begins by discussing the human performance priorities and characteristics of decommissioning projects. Next the similarities and differences in characteristics of' design, operations, and decommissioning project phases are reviewed, and the suitability of the current human factors model elements in application to decommissioning projects are discussed. Lastly some suggestions on how the design-based human factors application model may be adapted to better meet decommissioning project needs are outlined.

BACKGROUND

The operations of all technical systems are dependent on the perception, decision-making and action effecting skills of human operators to achieve productive, error-free, and safe system performance. In spite of longstanding experience and efforts, difficulties in human-system interaction and problems with human performance remain major contributors to safety challenges and production ineffectiveness.

Within the Canadian nuclear industry, two initiatives are routinely applied to address these concerns.

- Application of Human Factors in Development - Application of human factors criteria and methods in facility and system design to ensure technical systems are developed to complement and support supervision and control responsibilities assigned to operators.

- Application of Event Free Tools to Operations - Adoption of formalized workplace behaviours and work practices to reduce the risk of negative impacts from human performance inefficiencies and errors.

The two initiatives are complementary, one having a development emphasis, the other an operations emphasis, and are focussed on achieving similar system goals.

For the balance of the paper, the equivalent application of human factors criteria and methods to decommissioning projects will be examined.

DECOMMISSIONING PROJECTS

Decommissioning is an end-of-life facility activity that is undertaken to eliminate hazards and prepare an operational site to a condition for next use. The process of decommissioning involves taking existing structures and processes apart, in contrast to the design phase where structures and facilities are assembled, and operations phases where structures and facilities are used and maintained in a state of operational readiness. In all three phases comprising a facility's lifetime, the role of humans in supervising and controlling the technical aspects of facility configuration and operations is a prime consideration.

The human performance priorities for decommissioning projects include:

- Safety Goals

    - Assurance of worker and public safety and environmental protection throughout decommissioning activities through containment, removal and elimination of site hazards accumulated from operations.

- Production Goals

    - Removal of operational structures and wastes, and return of the site to near original state that is suitable for next use within the project organizational, financial, and schedule constraints.

Examples of the unique characteristics of the decommissioning phase in comparison with design and operations phases include:

- Work Environment:

- Material Condition - At the end of operational life, a facility is usually in less than optimum material condition and there may be considerable variation in the material condition of identical components due to variations in use and operational lifetimes. In addition, the facility may have been left in state of dormancy and disrepair since operations were discontinued. This is in contrast to the design phase where material conditions of components are known with more certainty and are the same, and the operations phase where there is a strong incentive to maintain facility material condition to an established level.

- Hazards - Personnel and environmental hazards may be greater during decommissioning as the process of disassembly removes engineered barriers to contain hazards; and specific tasks to contain, collect, remove, and dispose of hazards must be undertaken which involve greater potential for human and environmental exposure. Often the full extent of all hazards is difficult to fully imagine, characterize, or predict prior to decommissioning activities being undertaken. In contrast, radiological hazards only begin to accumulate through facility operations, and are managed through a combination of engineered and operational defences.

- Configuration and Records - At the end of operational life, actual facility configuration may be less certain than in the design and operations phases due to declining attention to control and records upkeep. Records documentation is often dated, incomplete, and partially missing. Consequently, definition and planning of decommissioning activities must be undertaken in an environment of less certainty in comparison to the completeness of documentation available in other phases of a facility's lifetime.

- Work Planning:

  - Activity Uniqueness - Decommissioning projects often require a number of one-of-a-kind tasks due to site, facility, hazards and work constraint uniqueness. This can impose special project burdens on development and maintenance of staff skills and technical knowledge that is not found in other phases of a facility's lifetime. In some cases, the decommissioning experience of previous projects may not provide a sufficient relevant operational experience on which to base project practices.

  - Timeframe - Decommissioning projects may extend over long timeframes that challenge the preservation of organizational continuity and culture, staffing, and technical knowledge. In some cases, the timeframe for decommissioning may be longer than the combined timeframes for the design and operations phases. Projects with long timeframes may be at risk to disruption in organizational, teamwork, and technical understanding aspects as a result of such factors as planned organizational downsizing, breakdowns or obsolescence of record systems, transfers of project organizational authority, or unexpected departures of personnel with unique knowledge.

- Obsolescence - Limited usable life of equipment or work practices can offer a further complication to decommissioning project planning. Over the project timeframe, replacement of obsolescent systems and work practices may be required to meet mission requirements and evolving expectations for 'nuclear excellence' in how activities are performed. Similar uncertainties have been experienced in planning on reactor life extension initiatives.

- Human Performance Issues - One of the greatest challenges in work planning with decommissioning projects is having the imagination to identify the breadth and potential complexity of human performance issues to be encountered. Unique tasks often lead to unique or novel human performance issues. Tasks performed repetitively over long timeframes are at risk of informal operational modification through the introduction of formal or informal workarounds initiated in the workplace. Such task modifications may be locally expedient but may be counter to other broader project objectives.

- Work Execution

  - Adaptation - Due to the increased uncertainty and potential for 'discovery' work, the need for adaptation in decommissioning workplans and work practices can be expected as activities proceed. Execution of outage plans in current power station operations provides a work environment of appreciable discovery work and need for workplace adaptation. This is in contrast to the design and other operations phases where the facility environment is better characterized and work uncertainties are minimized.

  - Supervision and Control - The need for oversight of simultaneous activities requiring an understanding in multiple disciplines and use of equipment and work practices in ways different from the original intent are expected supervisory challenges. In addition, monitoring of remote and or automated operations and coordination and oversight of less knowledgeable contract staff are common supervisory complications with decommissioning projects. While such challenges may be faced in operations in non-standard conditions on a temporary basis, in decommissioning these challenges can complicate supervisory control on a more sustained basis.

  - Staffing Resources - A common concern with decommissioning projects is the management of the impacts of a declining staff resource as the project proceeds. Maintaining redundancy in core skills, technical knowledge, project understanding, documentation, and project momentum can be compromised in an environment where personnel resources are declining as the project proceeds. As staffing resources approach a critical number, remaining staff are required to takeover additional responsibilities for which additional technical understanding and training investment may be required. Such staffing challenges are less frequently encountered during design and operations phases.

These and other characteristics may warrant the need for changes in human factors application emphasis during the decommissioning phase in comparison to the design and operations phases for a facility.

HUMAN FACTORS APPLICATION MODEL

The nuclear industry has adopted a human factors application model in response to design and retrofit project needs. The model is based on application of specific analytical, design, assessment, and in-service tracking activities that incorporate human factors application emphasis. Use of the model has been formalized in regulatory expectations and industry engineering work processes [1,2].

Examples of the recommended human factors activities include:

- Analysis:
  - Review of operating experience
  - Specification of functional and performance requirements
  - Definition of the roles of staff and automation
  - Analysis of tasks and contexts of operation
  - Analysis of human error potential and effectiveness of defences
  - Identification of organizational, staffing and training needs
- Development:
  - Develop equipment interfaces
  - Procedure development
  - Organizational development
  - Training program development
- Assessment:
  - Design verification
  - Validation of system or facility operational effectiveness
- In-Service Tracking:
  - Control of implementation configuration
  - Performance monitoring and assessment

Three observations with respect to this application model and how it is applied are relevant to the discussion of the current model suitability for decommissioning projects.

First, the model is heavily weighted to front-end analytic activities, with the intent of focussing human factors influence on projects in specification of information that will influence facility requirements, and system or facility design. In contrast, the application emphasis of human factors in assessment is less extensive, and application to in-service tracking has only been a recent addition to the model. Such a requirements weighted model may be less effective for application areas like decommissioning where experience shows the full extent of project requirements are more difficult to full characterize exclusively during project planning.

Second, the current model is less accommodating and responsive to design and operating environment changes. For example, even with power reactor operations, operational environments change as a result of utility continuous improvement initiatives. Thus, some conditions under which a system or facility is required to operate may change substantially across the operational lifetime. This may be especially so for decommissioning projects which begin with less specification certainty and have the potential for extensive operational change via 'discovery' work.

Third, the model activity content has evolved with a safety related activities emphasis, driven by regulatory expectations. Application experience to date for decommissioning and other industry projects suggests that this may have contributed to an under emphasis of human factors application to the production or business performance aspects of project design and operation. To meet decommissioning project production objectives over long timeframes, the application of human factors criteria and design methods to project production activity optimization on an ongoing basis is likely of equal importance to the current safety related emphasis.

ADAPTATION OPPORTUNITIES

The current industry model for incorporating human factors in projects was formulated in response to design project needs and characteristics. Decommissioning projects exhibit somewhat different characteristics, and needs for human factors application emphasis. Project aspects where human factors application adaptation may be worth considering include:

- Design Principles versus Specifics - To better accommodate the need for workplan and practices adaptation as new project needs evolve, it may be better to place more emphasis on definition of guiding principles and reduce dependence on more rigid and less response to change design specifics. Guiding principles can be reapplied in the ongoing refinement of project solutions in response to changing needs.

- Adaptation versus Certainty in Analysis Emphasis - Project planning and analytic activities applied in project definition should be restructured to favour selection of solutions with adaptation flexibility, to better accommodate initial specification uncertainty and ongoing changes likely to be encountered over decommissioning project lifetimes.

- Performance Tracking versus Analysis and Assessment - Greater emphasis should be placed on performance tracking to confirm activities remain within the specified envelopes of acceptable operation to better balance human factors application emphasis between specification and project operations phases.

- Organizational versus System Design - Human factors application should be broadened beyond systems design scope to encompass organizational design. This will be especially important to give visibility to the potential impacts of changes in staffing resources and

organizational responsibilities typically encountered over the lifetime of decommissioning projects.

- Production Effectiveness and Safety Application Emphasis - Increased emphasis should be applied to applying human factors to the production or business performance aspects of project design and operation. This emphasis should be in addition to the current application effort on safety related aspects.

Specific suggestions for supplemental or modified human factors model activities emphasis include:

- Hazard Awareness - Increased emphasis applied to hazards definition, awareness and operating caution given the potential for missed aspects in characterization and greater project uncertainty. This should be especially so during ongoing facility operations.

- Characterization of Human Error Defenses - To assess the effectiveness of error prevention, detection and recovery features; specific tests of feature performance with representative tasks and error challenges should be conducted. Ideally, means should be sought to confirm the ongoing effectiveness of specific defences from collection of operational data.

- Operating Envelope - Greater emphasis should be given to characterizing the permissible envelopes of facility operation rather than specifying preferred operations conditions with reference to a narrow operating point.

- Work Control - With the propensity for ongoing changes, effective work control tools and data archives will be necessary to assist supervisory staff in tracking and controlling work. The best practices in this area from 'peer' organizations should be regularly reviewed and considered for adoption.

- Change Management - Given the likelihood of project changes, comprehensive, robust and effective change management practices should be adopted for the decommissioning project mission lifetime. The change management methods adopted should be capable of readily identifying departures in practice from the current plan, tracking both short and long term changes, and the recording the rationale for undertaking changes across the project lifetime.

- Organizational and Staff Planning - Increased definition should applied to organization design and evolution throughout the project lifetime. The organizational design and staff planning should identify how such items as core technical skills will be retained, how responsibilities will be consolidated in a reduced staff resource as the project progresses, and how staff skills and knowledge will remain current.

- Performance Tracking - Increased emphasis on actual project performance measurement to confirm project assumptions and performance standards are being met on an ongoing basis,

and less dependence on extrapolating from similar project experience via initial operating experience reviews.

- Periodic Reviews - With long operational timeframes it may be beneficial to establish periodic program reviews based on the nature of discovery work, duration since previous review, or pace of industry innovations that may lead to changes in project assumptions, goals, and practices.

- Records Management and Preservation - Preparation and retention of effective operational records will be important for characterizing and confirming facility performance and permitting analysts to track evolving trends.

CONCLUSION

The formal application of human factors methods to decommissioning projects is an acknowledgement of the importance of human-system interactions and human performance for such projects. Adaptation of the current industry human factors application model to address unique decommissioning project needs should result in more focussed and effective application benefit.

REFERENCES

1. Human Factors Engineering Program Review Model. United States Nuclear Regulatory Commission report NUREG-0711 Revision 2, 2004 January.

2. Human Factors Engineering Program Plans. Canadian Nuclear Safety Commission draft regulatory guide C-276, 2001 March.