Assessing and Managing Knowledge Loss Risk

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Ontario Power Generation

Interregional Knowledge Management Workshop on Life Cycle Management of Design Basis Information
28 October – 1 November, 2013
Presentation Overview

▪ Design Basis Management
  • COG Principles for DB Management
  • Safe Operating Envelope (SOE) Project

▪ Design Basis Knowledge Management
  • OPG Approach – Risk Informed Knowledge Management (KM) Toolkit
  • CEI Approach

▪ Recent Industry-Wide Initiatives to Strengthen Design Basis Knowledge
COG DB Management Principles

- COG initiative driven by lack of clarity, consistency and common processes to guide:
  - Definition of the Design Basis, its scope and relationship to the Licensing Basis
  - Conduct of periodic Design Basis reviews
  - Initiation of Design Basis reviews in response to emerging issues
  - Criteria for assigning the urgency to any review.
  - How and when the results of the review are to be integrated in the plant configuration.

- Team includes utilities, vendors, regulator

- Recommended set of 14 principles for managing Design Basis

- Recommendations for managing changes in response to:
  - New technical knowledge
  - Changes in Regulatory expectations
  - Other drivers.

- COG Report Issued in March 2013: COG 11-9024
COG DB Management Principles

1. The DB process and configuration must be well established and be part of the QA process of the station.

2. DB Documentation should be accessible for reference by Design Authorities.

3. DB Requirements should not be in conflict with License Basis (codes and standards).

4. The DB limits should be clearly defined.

5. The timeliness of updating the DB Requirements and DB Documentation should be consistent with the nature of the change in DB SSC.

6. A DB change should be consistently propagated to all relevant documentation.

7. Safety margins should be maintained.
8. New information (e.g. from Operating Experience, research or surveillance) or conditions (e.g. environmental or technological) should be assessed for potential impact on DB elements such as DB Requirements, and the Reference Safety Case.

9. The impact of new analysis techniques on the Reference Safety Case should be handled conservatively.

10. Modifications to SSCs should ensure that the DB Requirements are not compromised.

11. The impact of materials on the DB should be explicitly considered.

12. Conformance to proven operating and maintenance procedures is necessary for DB management.

13. A design extension condition (DEC) should be used to identify those BDBA (Beyond Design Basis Accidents) that are considered in the design.

14. The initial Design Basis as established in the initial Final Safety Report should be maintained as a separate core of the Design Basis.
Safe Operating Envelope (SOE) Project

- **Project Drivers**
  - Provide readily traceable line-of-sight between safety analysis requirements and Operating & Maintenance documents
  - Make essential Design Basis information more readily accessible to Engineers

- **History**
  - Safety Analysis report organized along the lines of accident analysis, not systems, structures and components
  - No readily available documentation that shows how requirements are captured in operations and maintenance documentation.

- **Project Deliverables**
  - Produced “Operational Safety Requirements” organized along the lines of systems important to safety
  - Produced table correlating key requirements to operational documents, including tests / surveillances to confirm functional requirements met

- **Impacts**
  - Configuration Management:
    - Some new testing requirements identified and completed or scheduled
  - Knowledge Management:
    - System engineers understand the safety basis for their systems
    - Much less reliance on Safety Analysts for interpreting requirements of SR
    - Improves scoping of modifications – reduces likelihood of error or omission
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KM Toolkit: History

- Outcome of 10-year workforce plan
  - Demographics
  - Impending Retirements
  - Lengthy Training and Development
- Endorsed by Executive Leadership Team
- KM Process
  - Built upon TVA process and initial OPG pilot 2007-2009
  - Incorporated lessons learned
  - 4 more pilots in 2011
  - Toolkit published on internal web
  - KM Process managed within existing processes

KM & Human Resource Processes Flow of Information
Knowledge Management (KM) Toolkit

- KM Toolkit based on a 3-step model
  - Knowledge Loss Risk Assessment
  - Knowledge Retention Plans
  - Monitor, Evaluate and Adjust

**STEP 1: Conduct Knowledge Loss Risk Assessment**
- Complete the Knowledge Loss Risk Assessment Form
- Identify the business critical roles
- Determine the availability of knowledge across organization
- Identify high priority roles - inventory knowledge and skills, assess impact of loss and prioritize needs

**STEP 2: Develop and Implement Knowledge Retention Plans**
- Complete the Knowledge Retention Plan Form
- Describe and evaluate the critical knowledge, skills and expertise required for each high priority role (identified in Step 1)
- Select KM mitigation tools that meet the department’s needs
- Finalize knowledge retention plans
- Assign accountability for the knowledge retention plans with key milestones and timelines

**STEP 3: Monitor and Evaluate Knowledge Retention Plans**
- Integrate KM objectives into performance reviews, development plans and department work programs
- Implement knowledge retention plans and monitor completion timelines
- Review and assess the effectiveness of the knowledge retention plans
- Identify ways to incorporate knowledge transfer into work activities going-forward
KM Toolkit: Step 1

STEP 1: Conduct Knowledge Loss Risk Assessment

- Complete the Knowledge Loss Risk Assessment Form
- Identify the business critical roles
- Determine the availability of knowledge across organization
- Identify high priority roles - inventory knowledge and skills, assess impact of loss and prioritize needs

Departure Factor × Position Risk Factor = Total Attrition Factor
<table>
<thead>
<tr>
<th>DEPARTURE RISK FACTOR</th>
<th>PROJECTED DEPARTURE DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>within current or next fiscal year</td>
</tr>
<tr>
<td>4</td>
<td>within 3rd fiscal year</td>
</tr>
<tr>
<td>3</td>
<td>within 4th fiscal year</td>
</tr>
<tr>
<td>2</td>
<td>within 5th fiscal year</td>
</tr>
<tr>
<td>1</td>
<td>within or greater than 6th fiscal year</td>
</tr>
<tr>
<td>POSITION RISK FACTOR</td>
<td>RISK</td>
</tr>
<tr>
<td>----------------------</td>
<td>------</td>
</tr>
</tbody>
</table>
| 5                    | • Mission-critical knowledge and skills with the potential for significant reliability or safety impacts.  
• OPG or site-specific knowledge. Knowledge undocumented.  
• Requires 3-5 years of training and experience.  
• No ready replacements available. |
| 4                    | • Critical and unique knowledge and skills.  
• Some limited duplication exists at other sites and some documentation exists.  
• Requires 2-4 years of focused training and experience. |
| 3                    | • Important, systematized knowledge and skills.  
• Documentation exists and/or other personnel on-site possess the knowledge/skills.  
• Recruits generally available and can be trained in 1 to 2 years. |
| 2                    | • Proceduralized or non-mission critical knowledge and skills.  
• Clear up-to-date procedures exist.  
• Training programs are current and effective and can be completed in less than one year. |
| 1                    | • Common knowledge and skills.  
• Internal/external hires possessing the knowledge/skill are readily available and require little training. |
<table>
<thead>
<tr>
<th>TOTAL ATTRITION FACTOR</th>
<th>RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 – 25</td>
<td>• High Priority - Action needed.</td>
</tr>
<tr>
<td></td>
<td>• Specific replacement or mitigation action plans with due dates need to be developed.</td>
</tr>
<tr>
<td>16 – 19</td>
<td>• Priority – Staffing plans should be established to address knowledge transfer.</td>
</tr>
<tr>
<td>10 – 15</td>
<td>• High Importance – Look ahead on how the position will be filled/ work will be accomplished.</td>
</tr>
<tr>
<td>1 – 9</td>
<td>• Important – Recognize the functions of the position and determine the replacement need.</td>
</tr>
</tbody>
</table>

**Knowledge Retention Plans are:**

- **REQUIRED** for every individual with a Total Attrition Factor of 20 – 25
- **RECOMMENDED** for every individual with a Total Attrition Factor of 16 – 20
STEP 2: Develop and Implement Knowledge Retention Plans

- Complete the Knowledge Retention Plan Form
- Describe and evaluate the critical knowledge, skills and expertise required for each high priority role (identified in Step 1)
- Select KM mitigation tools that meet the department’s needs
- Finalize knowledge retention plans
- Assign accountability for the knowledge retention plans with key milestones and timelines

Importance X Rarity of Knowledge X Recovery Difficulty = Criticality Score
## KM Toolkit: Step 2a

<table>
<thead>
<tr>
<th>Importance, Rarity and Recovery</th>
<th>Priority</th>
</tr>
</thead>
</table>
| 5                               | • High Priority- Action needed.  
• Mission-critical knowledge and skills with significant impact on the execution of department work activities.  
• OPG, site or department specific knowledge.  
• Knowledge undocumented and not transferred to other employees.  
• Requires 3-5 years of training and experience.  
• No ready replacements available. |
| 3-4                             | • Medium Priority  
• Important knowledge and skills.  
• Some limited duplication exists at other sites and some documentation exists.  
• Employees generally available and can be trained in 1 to 2 years. |
| 1-2                             | • Low Priority- No action required.  
• Proceduralized, systematic or common knowledge and skills.  
• Clear up-to-date procedures exist.  
• Training programs are current and effective and can be completed in less than one year.  
• Employees available with knowledge and skill set required to complete the work. |
<table>
<thead>
<tr>
<th>TOTAL CRITICALITY SCORE</th>
<th>RISK</th>
</tr>
</thead>
</table>
| 45 +                    | • High Priority – Action needed.  
                           • Specific knowledge transfers tools need to be identified with accountabilities and due dates.  
                           • Staffing plans should be established to address method and timing of replacement, recruitment efforts, training, shadowing with the current incumbent, etc. |
| 25 - 45                 | • Medium Priority – Consider action.  
                           • Knowledge transfer tools should be explored to determine what can be proactively completed to stop the item from moving to high-priority. |
| 1 – 25                  | • Low Priority – No action required.  
                           • Look ahead on how the work will be completed. |

**Knowledge Retention Solutions are:**

- **REQUIRED** for every item with a Total Criticality Score of 45 +
- **RECOMMENDED** for every individual with a Total Criticality Score of 25 +
**KM Toolkit: Step 2c**

- **Knowledge Retention Tool Selection**
  - 14 Tools
  - Customizable to Department / Individual
  - Accommodate other options

- **Knowledge Retention Plan**
  - Concrete, Actionable Responses
  - SMART: Specific, Measureable, Achievable, Resources (Money), Time

<table>
<thead>
<tr>
<th>TIME</th>
<th>HIGH</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONEY</td>
<td>Training Pre-Hiring</td>
<td>Peer Assists Job Rotation Video/Audio Recording</td>
</tr>
<tr>
<td>LOW</td>
<td>Knowledge Repositories Codification and Procedure Writing Mentoring</td>
<td>Case Studies, OPEX &amp; Lessons Learned Communities of Practice Industry Forums &amp; Networking Job Aids Job Shadowing</td>
</tr>
</tbody>
</table>
## KNOWLEDGE REPOSITORIES

<table>
<thead>
<tr>
<th>What</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>A knowledge repository is a way to capture, organize and store information. Repositories are web-based applications that provide access to data on a just-in-time basis.</td>
<td></td>
</tr>
<tr>
<td>When</td>
<td></td>
</tr>
<tr>
<td>Employees need to be able to find information quickly to complete and collaborate on their work.</td>
<td></td>
</tr>
<tr>
<td>New employees enter a group and accelerated learning is needed.</td>
<td></td>
</tr>
<tr>
<td>Work tasks are completed on an infrequent basis and issues are varied such that the information is likely to be forgotten.</td>
<td></td>
</tr>
<tr>
<td>Historical knowledge of the organization's practice is important and held by experienced individuals, information is not well-documented and central location is needed.</td>
<td></td>
</tr>
<tr>
<td>Central repository is required.</td>
<td></td>
</tr>
<tr>
<td>How</td>
<td>Benefits of Knowledge Repositories:</td>
</tr>
<tr>
<td>Determine which documents need to be categorized and stored. Develop a system to manage the entire life cycle of a document from creation through revisions and finally into storage and records management.</td>
<td>✓ Supports department and cross-functional project teams that need to access, share, and collaborate on work.</td>
</tr>
<tr>
<td>Users access a central portal and proceed to search or navigate to find of the specific information they require.</td>
<td>✓ Easily manage documents and help ensure integrity of content</td>
</tr>
</tbody>
</table>

### Examples of documents to include:

- Working files
- Planning documents
- Project proposals
- Presentations
- Lessons learned
- Timelines

### Tips

- Start with a high-level strategy to ensure that the volume of information gathered does not become unmanageable. Include a review cycle to keep information up-to-date.
- Knowledge portal can be department or project based.
- Focus on the employees that will be using the information and make sure it is categorized for easy retrieval.
- Examples of web-based tools available at OPG are SharePoint Team Sites, shared drives and uPerform.
STEP 3: Monitor and Evaluate Knowledge Retention Plans

- Integrate KM objectives into performance reviews, development plans and department work programs
- Implement knowledge retention plans and monitor completion timelines
- Review and assess the effectiveness of the knowledge retention plans
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KM Toolkit: Process Oversight

- Progress tracked by Engineering Leadership Team
  - Chief Nuclear Engineer and Direct Reports
  - Bi-annual review

- Quality of Knowledge Retention Plans (KRPs) graded
  - 0 = No KRP or vague plan outlined; knowledge transfer solutions are not sufficient; no timelines or accountability established; little indication of plan status or residual risk to the business
  - 1 = KRP completed; outlines critical knowledge risk areas and knowledge transfer solutions; timelines and accountabilities need to be re-assessed; solutions are potentially feasible; no clear implementation path-forward; status is up-to-date
  - 2 = KRP completed; addresses the critical knowledge risk areas and uses more than 1 mitigation tool; transfer solutions are high cost or implementation is not yet fully in place; status is up-to-date.
  - 3 = KRP completed; addresses the critical knowledge risk areas and uses multiple knowledge transfer tools that differentiates based on specific knowledge needs and clear timelines and accountabilities are indicated; the plan cost is small relative to the risk; infrastructure to implement the KRP is in place and sustainable; status is up-to-date.

- Corrective Actions assigned to improve KRPs
KM Toolkit: Lessons Learned

- About 10% of OPG Nuclear Engineering staff require Knowledge Retention Plans
- Process requires nurturing
  - Systematic approach to KM is fundamentally sound
  - Opportunities for improving effectiveness of application
  - May be challenging to implement in smaller organizations
- Essential to success:
  - Strong support from senior management
  - Easy-to-use web based tools to promote understanding and support the process
  - A consistent grading mechanism for KRP
  - Senior management oversight
    - Codification to ensure consistency of application and to capture lessons learned / continuous improvement
  - Integration of KM into key business processes
KM Toolkit: Lessons Learned

- Opportunities and challenges
  - Assess adequacy and consistency of risk assessments: apply lessons
    - Sufficiently conservative, and not unduly conservative
  - Assess effectiveness of KRPs taken to completion: apply lessons
    - Develop approaches for measuring effectiveness of knowledge transfer
  - Strategies for balancing knowledge loss due to succession planning with need for knowledge retention
  - Periodic re-assessment of core competencies, and balance between internal vs. external reliance
  - Encouraging vendors of engineering services to put into place programmes for sustaining essential knowledge
  - Identifying and adding new capability requirements (e.g., cyber-security) into KM process/toolkit from the outset
Candu Energy KM Approach for Knowledge Workers

- Assessment relative to all the skills required to design, maintain and refurbish the CANDU Reactor via:
  - Skills Matrix – a competency rated inventory of skills at the individual level.
  - Primary Skills Criticality Assessment - a grading of primary skills essential for the assurance of CANDU plant nuclear systems and structures design basis.
  - Succession Planning Assessment - a mapping of individuals within the organization against the primary knowledge areas (combination of primary skills) to define the health of each primary skill and the period required for staff to move from one knowledge level to another.

- Maintenance of design basis knowledge achieved (based on the assessment above) via a combination of:
  a - On the job experience or training.
  b - Classroom training courses on various CANDU areas of knowledge.
  c - Project and Site assignments.
  d - Mentoring programs - employing senior staff/retirees with specialised knowledge to work with junior and intermediate level employees to enhance capability in the design basis of various plant systems and structures.
  e - Development programs of new products and systems to address operational issues of existing plants and new licensing requirements.
  f - Involvement in standards organizations to revise and/or develop new standards to guide the nuclear industry.
As OEM (Original Equipment Manufacturer), Candu Energy’s New Build Projects use an integrated KM approach with tool advancements to manage plant Design Basis and optimise the work. This approach includes:

1. A Requirements Management System (REMS) to provide traceability from regulatory and standards requirements to the implementation of the design data (e.g., DR and DD).
2. Utilisation of a Data Centric Approach to add intelligence to the design object rather than the traditional coarser level of 2D drawings, for example:
   - Authoring applications generate information at a design object level;
   - Design data QA is performed within the authoring tool before being “published” into a centralized data “repository”;
   - The “published” data is revision-controlled and is available for use by downstream applications – e.g., P&ID data is used by 3D piping design; and
   - Document deliverables are extracted by the authoring application, a snapshot of QA’d design data - e.g., GA’s, ISO’s, extracted from 3D piping and layout models.
3. Integration of Work Processes between different applications to facilitate design data validation at the source.
4. Deployment of Knowledge-Based Engineering:
   - emphasis on workflow as opposed to point-wise automation of task specific manual methods; and
   - use technology to allow the production of detailed design from controlled database tools.
5. Enabling information to be shared between collaborating organizations while preserving Intellectual Property rights.
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- **Recent Industry-Wide Initiatives to Strengthen Design Basis Knowledge**
Recent Industry-Wide Developments

- Sustaining design basis knowledge recognized as a strategic industry-wide need in Canada
- Several initiatives have been developed over the past few years based on industry collaboration
  - University Network of Excellence in Nuclear Engineering (UNENE)
  - UOIT Graduate Diplomas in Nuclear Engineering
  - Advanced Operations Overview for Managers (AOOM)
Recent Industry-Wide Developments

- University Network of Excellence in Nuclear Engineering (UNENE)
  - Canadian based alliance of:
    - universities,
    - nuclear power utilities,
    - research organizations
    - regulatory agencies
  - Mandate: support and development of nuclear education, research and development capability in Canadian universities
  - Established as a not-for-profit corporation in 2002
  - Offers accredited M. Eng.
  - Courses include reactor physics, chemistry, thermodynamics, safety design, risk, radiation, waste and decommissioning, nuclear fuel management, risk and nuclear materials.
Recent Industry-Wide Developments

- Advanced Operations Overview for Managers
  - Originally administered through the Candu Owners’ Group (now OPG), delivered by UOIT
  - Approximately 4-5 months in duration, full-time
  - Approximately 20 students per class
  - Syllabus is comparable to technical portion of training given to authorized shift managers
  - Originally targeted at senior managers
  - OPG Nuclear Engineering has recently decided to cycle all Nuclear Engineering section (first line) managers stationed at its NPPs through this program, as a first priority.
Recent Industry-Wide Developments

- **UOIT Graduate Diploma in Nuclear Design Engineering**
  - Commissioned by OPG in 2012; pilot currently in progress
  - Envisioned as a 4-course, 20 month program
  - Includes
    - Nuclear Safety Design Concepts
    - Quality Management and application of Quality Codes
    - Regulations, Codes and Standards
    - Design Basis, System Classification and Establishment of Safety Requirements
    - Specifying Engineering Requirements, and Overseeing and Accepting Engineering Work
    - Interface of Design with Commissioning, Testing and Operation
  - Targeted at utility design engineers, vendors of engineering design services, regulators

- **UOIT Graduate Diplomas in Nuclear Technology**
  - Fuel, Materials and Chemistry;
  - Health Physics;
  - Operation and Maintenance;
  - Radiological Applications;
  - Reactor Systems; and
  - Safety, Licensing and Regulatory Affairs.
Industry-Wide KM Challenges

- New Build
- Government support
- Young generation
Summary

- Sustaining Design Basis Knowledge is a strategic need for long term safe and reliable operation
- Utilities need to manage knowledge in a systematic manner, based on identifying areas of risk, developing and implementing plans to mitigate the risk, and exercising oversight of those plans
  - Approaches will differ depending upon organizational functions and needs
- Individual utility efforts are not sufficient: they need to be complemented by a larger scale infrastructure in the academic and research communities
- The Canadian nuclear industry has been collaborating to actively support and expand the academic infrastructure to sustain design basis knowledge
- KM initiatives require constant nurturing for sustainability
  - Internationally recognized guidance on Characteristics, Attributes and Best Practices for governmental, industrial and academic contributions to KM is important to sustainability
Thoughts on Characteristics / Attributes of a KM Framework

- Shared responsibility between government, industry and academia – systematically and sustainably managed and maintained based on a shared vision and objectives
- Leadership support and commitment to knowledge management and maintenance
- Intrinsic to the fabric of the enterprise – culture and processes – not a standalone function
- Supported by a comprehensive and easily accessible data, information and configuration management framework
- Carry-around knowledge supports appropriate level of nuclear safety risk awareness amongst all decision makers, from shop-floor to board of directors: enables “questioning attitude”
- Founded on an understanding of “why”, not just “what” and “how”
- Commercial and security constraints are explicitly recognized and addressed to ensure the promulgation of knowledge essential to safety
- Performance metrics support periodic self-assessment and independent reviews of knowledge maintenance
Thank you!