Practical Examples of how Knowledge Management is Addressed in Point Lepreau Heat Transport Ageing Management Programs

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Abstract

In the mid-1990s, New Brunswick Power Nuclear implemented a Management System Process Model at the Point Lepreau Generating Station that provides the basic elements of a knowledge management program. As noted by the IAEA[1], the challenge facing the nuclear industry now is to make improvements in knowledge management in areas that are more difficult to implement. Two of these areas are:

- Increasing the value of existing knowledge, and
- Converting tacit knowledge to explicit knowledge (knowledge acquisition).

This paper describes some practical examples of knowledge management improvements in the Point Lepreau heat transport system ageing management program.

1. Introduction

For over a decade, the nuclear industry has been developing knowledge management approaches and strategies, primarily due to concerns about the loss of expertise with the age demographics of the experienced workforce. Nuclear power plants now use basic programs to capture, store, and retrieve information/knowledge, which are identified under the following knowledge management elements by the IAEA in Reference [1]:

- Plant policies and procedures
- Document control
- Configuration management
- Training and qualification
- Learning from Operating Experience
- Work control system
- Corrective action tracking
- Human resource management
- Communications
- Company intranet

The Point Lepreau Generating Station developed these basic program elements too, although not specifically for the purpose of knowledge management. After a period of poor performance in the mid-1990s, New Brunswick Power developed the current Management System Process Model to improve Point Lepreau station management and achieve station performance objectives [2]. This process model includes a tiered framework of interlinked Executive, Core and Support Processes, illustrated in Figure 1.

[1] IAEA – International Atomic Energy Agency

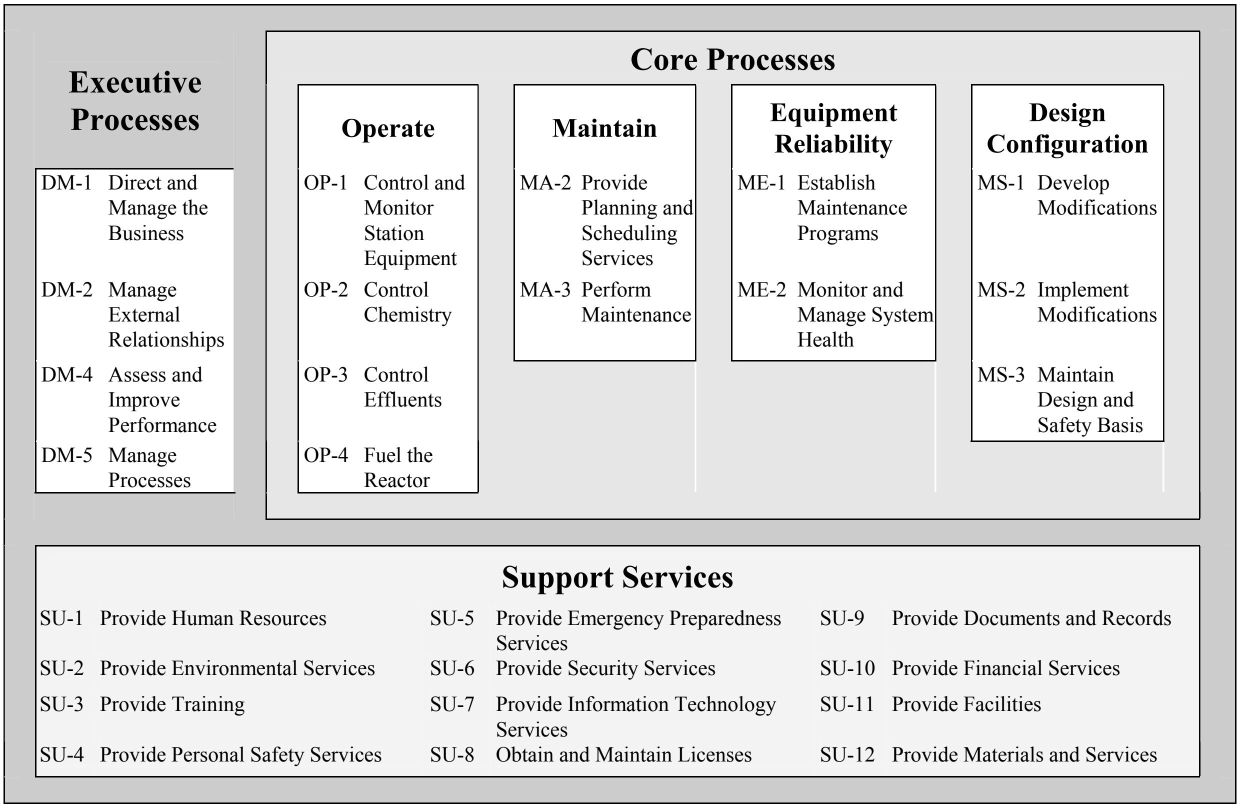

Figure 1 High-level map of the management processes at Point Lepreau.

The current focus of nuclear industry effort in knowledge management is to improve the value of these programs [1]. Many aspects of plant operation lend themselves to effective knowledge management because the activities can be codified using explicit knowledge. However, knowledge management in plant ageing management presents some unique challenges, not unlike those faced by the medical industry. For example, diagnoses and management of (human and structural components) ageing-related degradation often requires:

- Complex analyses using highly sophisticated instrumentation and technology
- Input from several technical disciplines
- Latest understanding of ageing phenomena and treatment technology from research and operating experience (case studies)
- Specialists that are not readily available when the degradation phenomenon is not common
- Experience-based judgement (tacit knowledge) by the specialist
- Working under time pressure to avoid continuing decline in condition, physical discomfort and ultimately death for human patients, and costs for utilities, particularly when diagnoses are on the critical path of an outage.

In addition, structural materials, like the human body, sometimes respond to environments and treatments in unanticipated ways.

In the past decade, serious degradation of key Point Lepreau heat transport system components [3] led New Brunswick Power to improve its ageing management practices in areas that have also been identified by INPO[2] [4] and the IAEA as areas for knowledge management improvement. In addition to the general shortage of technical resources in the nuclear industry, other specific drivers for NBPN to advance ageing management/ knowledge management practices are because Point Lepreau are:

- A single unit station with limited technical expertise in the area of materials degradation.
- Physically remote from most of the industry from which it draws technical support.
- A leading CANDU unit in terms of operating hours and has been the first to experience and manage some degradation mechanisms.

This paper provides practical examples of how New Brunswick Power improved its heat transport system ageing management practices by improvements in knowledge management. Specifically, means to increase the value of existing knowledge and to convert tacit knowledge to explicit knowledge are illustrated.

2. Increasing Value of Existing Knowledge

Nuclear power plantss have a large amount of data and explicit (documented) information available to them that can be useful for ageing management (operational data, safety report, procedures, design drawings, external operating experience, research results, etc.). Much of the original information was in hard copy documents, drawings, and microfiche. With the advancements in information technology in the past few decades, a lot of this information is now available via the Point Lepreau data historian, intranet browser, web-links to EPRI[3], COG[4], etc., and more recently, presented with some analysis within the SMART CANDU™ support applications [5]. Despite this wealth of information, a piece of useful knowledge has not been always easy to find nor available in a format that was easy to apply to ageing management.

For example, a few years ago, it was observed that responsible engineers were not using existing life management plan documents. The most common reasons cited were that plans were excessively lengthy and contained superfluous information, information was not presented in a format that was recognized as useful, and other important practical information was missing. As a result of these issues, critical technical information was not always considered in ageing management planning and sometimes, important planned activities were not being performed [3].

Based on feedback from utility staff, several improvements were made to more effectively implement technical information into ageing management activities. This section describes two examples where critical knowledge held by experts and stored within volumes of documented material was identified and presented in ageing management plans in a format that was easy for responsible engineers to use.

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[2] INPO - Institute of Nuclear Power Operations
[3] Electric Power Research Institute
[4] CANDU Owner's Group

2.1 Identification of Relevant Degradation

Point Lepreau ageing management plans now succinctly describe active and potential degradation mechanisms that, if not managed effectively, can result in an unacceptable level of risk to reactor safety and reliability. This knowledge is condensed from operating experience, plant process and chemistry monitoring data, design and materials information, and research results into the following value-added form [6]:

- *Key factors affecting degradation.* The key factors driving degradation can often be identified even if the fundamental details of a degradation mechanism are not known. An example is given for PLGS feeder pipe cracking in Table 1. The development of mitigation strategies is highly dependent on the potential to reduce or eliminate one or more key factors.
- *Identification of locations most susceptible to the degradation.* Knowledge of the presence of key factors in different system locations and during different operating conditions is required to establish the likelihood of degradation for these cases.
- *Evaluation of Operating experience.* Relevant internal and external operating experience is summarized briefly and illustrates possible current and future condition of components. Previous to this initiative, important positive operating experience, such as inspection results that did not detect feeder cracks or garter spring movement, was not always given adequate consideration in assessing the likelihood of degradation.
- *Statement of the management concern if the degradation is not adequately managed.* This section identifies qualitative consequences of degradation (e.g. perforation of the pressure boundary or unplanned shutdown for repair) but quantitative information could also be used. This section is important to establish the risk of degradation and the risk reduction of an activity employed to manage it.

Table 1 Factors Contributing to Point Lepreau Feeder Cracking

Primary Factors	Secondary Factors
Stress:	
Residual Stress: Based on physical evidence from spare bends and cracked feeders.	**Operating Stress**: Low amplitude cyclic stresses and other operational stresses postulated to increase susceptibility. No physical evidence.
Material:	
Cold Work/Hardness: Factors associated with observed cracks.	**Ovality and Impurities**: Postulated, based on operating experience and literature.
Environmental:	
Temperature: Cracks only in outlet feeders where temperature is 40°C higher than in inlets. Consistent for creep cracking which is highly dependent on time at temperature (usually >310°C).	**FAC-Generated Hydrogen**: Consistent with all crack locations; proposed to contribute to crack susceptibility. **Oxidizing Species and Impurities**: Based on literature and test results showing SCC in mildly oxidizing hot water (>100-150°C), exacerbated by anionic impurities.

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2.2 Simplification of Explicit Knowledge on Risk Reduction Strategies

Generally, the risk reduction strategies used at a plant to manage ageing are a combination of different activities that are multi-disciplinary and cross-functional. Very often these strategies benefit one component or system but might have an adverse affect on others; this is exacerbated when the affected systems are managed by different responsible engineers. One means to ensure the risk reduction strategies are understood within the organization is to raise awareness of their importance with the responsible engineers. This is done using easy reference tables in ageing management plans that link specific operations and maintenance activities to system-level and component materials degradation management strategies [6]. Examples are given for flow-accelerated corrosion in Table 2.

Table 2 Table Used to Show the Link Between the Degradation Mechanism, System-Level Issues, Management Options, and Risk-Reduction Activities.

(a) Example from the Heat Transport System Ageing Management Plan for Flow Accelerated Corrosion

Degradation Mechanism	Ageing Management Plan Strategy		
	Major Affected Components	**Relevant System-Level Issue**	**Management Options**
Flow Accelerated Corrosion	Outlet Feeders	Coolant temperature increase Decreased fuel cooling margins Increased radiation fields System chemistry limits	Inspection & Repair, Chemistry Control
	Large diameter outlet piping and headers	N/A	
	Steam generator internals	N/A	

(b) Example from the Feeder Piping Ageing Management Plan for Flow Accelerated Corrosion

Degradation Mechanism	Primary Strategy to Manage Degradation		
	Affected Components	**Management Option**	**Management Activities**
Flow Accelerated Corrosion	All outlet locations, especially tight radius bends & adjacent to Grayloc Hub	Inspection	Wall thickness measurements
		Repair	Replace components projected to thin below minimum acceptable thickness
		Chemistry Control	Control pHa to lower end of specification (10.2-10.4) to minimize FAC rate

3. Converting Tacit[5] Knowledge to Explicit Knowledge

Tacit knowledge is subconscious or instinctual knowledge based on experience, which has not been captured (explicitly) in written form. INPO [4] describes tacit knowledge as involving:

- Effective thought processes and know-why of the reasons for completing tasks
- Organizational understanding of how work is accomplished and the interactions and relationships necessary for effective navigation within the organization
- Historical knowledge regarding important events and the bases for decisions made in the past

INPO defines the capture and documentation of important tacit knowledge (to explicit knowledge) as knowledge acquisition. At Point Lepreau, pre-determined response plans (described in Section 3.1) have been so effective for ageing management knowledge acquisition that Point Lepreau would like to use this approach more widely. However, knowledge acquisition typically is very difficult [1, 4]. One reason it is difficult in ageing management is that much of the underlying scientific and technical information currently does not lend itself to this purpose. This is discussed in Section 4.

3.1 Pre-Determined Response Plans to Findings

Pre-determined response plans for possible findings from planned inspection and maintenance activities have been a very effective feature of the ageing management program. They capture on paper the analysis and judgment by experts of results that have not yet been obtained and provide them to responsible engineers that may not have the expertise or knowledge to perform this function. Knowledge of potential results that may challenge the current basis for safe operation early in an outage allows for prompt initiation of activities (e.g., inspection scope expansion) that will decrease the likelihood of an outage extension. Following pre-determined response plans also increases credibility with Management and Regulators and reduces the risk of errors in judgement during time-challenged, critical-path activities.

Response plans are developed using the results of operational assessments from the previous inspection. Probabilistic assessments are particularly useful for developing response plans [7] because they allow sensitivity analysis of several parameters using best estimates. Table 3 shows an example from the 2007 feeder ageing management plan [6]. The information that is obtained during feeder crack inspection is: approximate crack length, crack location, and the number of cracked feeders. The table lists potential inspection findings for these crack characteristics that would challenge the basis for inputs (initiation frequency, crack growth rate, key factors initiating cracks) used in the previous operational assessment. This information was used to identify actions required during and immediately following the outage.

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[5] In this paper, the term tacit knowledge also includes the concept of ‘implicit’ knowledge described in IAEA documents.

Table 3 2007 Outage Response Plan for Feeder Piping Crack Inspection.

Cracked Feeders in 2007	Max. Crack Length	Condition Assessment Valid	Impact on Inspection and Maintenance Strategy
Reportable Inside or Outside Surface cracks in Outlet Tight Radius Bends:			
0-6	~25mm	Yes	No supplementary activities or changes to the plan required. Remove requirement for crack inspection during an unplanned shutdown.
>6	~25mm	Review required	No inspection scope expansion. Prior to reactor restart, assess the validity of the condition assessment.
>0	>30mm	Review required	No inspection scope expansion. Perform NDE to characterize indications after feeders are removed. Depending on the severity of the cracks, destructive examinations to assess the validity of the condition assessment may be required prior to reactor restart.
Reportable Cracks in Other Locations:			
0	N/A	Yes	No supplementary activities or changes to the plan required.
>0	N/A	No	If cracks are found on an inlet bend, expand scope to all inlet first and second bends; operational assessment required prior to reactor restart.
>0	N/A	Review required	If circumferential cracks are found in a thinned region adjacent to the Grayloc hub, expand scope to other at-risk locations.

4. Concluding Remarks

New Brunswick Power has made improvements to the Point Lepreau ageing management program out of necessity to deal with serious component degradation and a lack of readily available expert technical resources. The improved processes have many elements of a successful knowledge management program. Examples of knowledge acquisition (converting tacit to explicit knowledge) and increasing the value of existing knowledge by making it easily available in a practical and useful format were described. The improvements to ageing management have led to measurable reductions in plant incapability, unplanned maintenance, and rework.

New Brunswick Power would like to apply these improvements more broadly to the ageing management program to assist staff in decision-making and planning without heavy reliance on external experts. However, the nature of the available information limits, to some degree, the feasibility to convert tacit to explicit knowledge. Research and engineering studies often focus on defining conservative acceptable operating conditions to minimize ageing rather than demonstrating available margins. If defined acceptable conditions are breached, guidelines (explicit knowledge) are often unavailable and expert judgments (tacit knowledge) are often required to determine appropriate actions.

A few areas that may warrant the research investment to convert tacit knowledge to explicit knowledge are:

- Fatigue usage for life extension,
- Response plans for:
    - Heat transport system operating chemistry transients,
    - Steam generator tube deposit analysis results, and
    - Selected system lay-up chemistry transients.

5. References

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