PLANS TO ADAPT POINT LEPREAU AGEING MANAGEMENT TO NEW INDUSTRY GUIDELINES

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Abstract

In preparation for PLGS life extension, NBPN spent considerable effort to evaluate the impact of ageing and to develop ageing management processes to maintain the required safety functions for extended operation. These were based on INPO AP-913.

Recently, the CNSC has been developing Canadian ageing management guidelines in line with the IAEA approach. In response, NBPN plans to document how current PLGS processes meet the new CNSC guidelines and to identify any areas for improvement. Best practices from utilities that have retrofitted IAEA guidelines and PLGS experience in applying risk-based methods for ageing management will be used to implement improvements.

1. Introduction

CNSC[1] staff have recently presented their approach to ensure that Canadian nuclear power plants (NPPs) have effective ageing management programs (AMPs) and their intention to publish a new regulatory document, RD-334 [1, 2]. The proposed regulatory document will represent the CNSC's adoption and where applicable, adaptation of guidance established by the IAEA[2] in draft safety guide DS382 [3].

Although regulatory guidelines for ageing management will be new to Canada, ageing management is not new to CANDU®[3] utilities. NBPN[4] has a relatively comprehensive and mature program at the Point Lepreau Generating Station (PLGS). Attention to ageing management increased significantly in the mid 1990s following a period of poor performance. At this time, NBPN undertook a major improvement initiative and began developing the current Management System Process Model. Ageing management activities expanded again in the late 1990s when NBPN began planning for PLGS life extension. Prior to IAEA/CNSC guidance becoming available, utilities have based their ageing management programs primarily on INPO[5] AP-913 [4] and according to best practices borrowed from EPRI[6] and other utilities. Regular WANO[7] and INPO audits are a means of continuous improvement of

[1] Canadian Nuclear Safety Commission
[2] International Atomic Energy Agency
[3] CANDU (CANada Deuterium Uranium) is a registered trademark of Atomic Energy of Canada Ltd.
[4] New Brunswick Power Nuclear
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[6] Electric Power Research Institute
[7] World Association of Nuclear Operators

these programs. Reduced plant incapability, unplanned maintenance, and rework are examples of tangible benefits from the improvements to ageing management at PLGS.

This paper briefly describes NBPN's initial review of PLGS processes in anticipation of the CNSC Regulatory Document on ageing management and plans to address the implications. Since the PLGS AMP is well established, NBPN does not believe that a major restructuring of station organization and processes is warranted at this time. It is considered important to adopt improvements from the Regulatory Document without major impact to the current PLGS management processes and while retaining other industry good practices.

2. Evaluation of new CNSC guidance

Our understanding from CNSC staff presentations, conference papers [1, 2] and informal communications is that a main driver for developing the new Regulatory Document is to establish a common set of benchmarks against which utility AMPs can be evaluated. Two main priorities for improvement are the adoption of a life cycle approach to ageing management and implementation of systematic and integrated AMPs. A related CNSC Regulatory Document RD-360 [5], which outlines guidelines for NPP life extension, describes a third ageing management priority, the Integrated Safety Review (ISR). These three priorities are discussed below.

2.1 Life-cycle approach

The CNSC has emphasised the need for early and proactive consideration of ageing management for all stages of a plant's life cycle: design, fabrication, construction, and commissioning, operation, and decommissioning. During the design stage for example, the CNSC recommends features to be incorporated into the design that will facilitate ageing management throughout the entire plant life.

Ageing was considered in the original PLGS design with knowledge of materials degradation from R&D and industry operating experience (OPEX), particularly from the early CANDU designs (NPD[8], Douglas Point, Gentilly-1, Pickering A, Bruce A). For example, problems with Cr-Mo steel weld cracking at Gentilly-1 led to a last-minute design change at Gentilly-2 and PLGS. Feeder piping was replaced at these stations prior to final construction, with SA 106 Grade B carbon steel to prevent this type of cracking. Materials, design allowances, and operating margins were selected for thirty-year service using the best knowledge at that time. Other features were specifically included in the design to facilitate ageing management. Although these examples are now out-dated, the heat transport system (HTS) autoclave system for corrosion coupon testing and the feeder freeze jackets were included in the original design to allow monitoring and maintenance of ageing materials, respectively.

Other design features have been incorporated after plant commissioning, in response to industry OPEX or improved technology. A good example at PLGS is the change from

[8] Nuclear Power Demonstration, a prototype CANDU reactor located in Rolphton, ON.

phosphate chemistry for the secondary system to “all-volatile-treatment”. A number of other design modifications have been made over the years because the importance of features to facilitate inspection and maintenance is much better recognized now than it was when PLGS was originally designed. Examples are the installation of inspection ports on Boiler 3, water lancing ports on all four boilers, and access platforms around the primary heads of all four boilers. PLGS has also been proactive to implement instrumentation for on-line monitoring of chemistry and corrosion. Examples in the HTS are monitors for coolant oxygen content, Feeder On-Line Thickness, and Hydrogen Effusion (measures flow accelerated corrosion rate).

During design planning for refurbishment, many other improvements have been made based on the most recent information from OPEX and R&D. For example, improvements to feeder steel material specifications, fabrication procedures (welding and heat treatment), installation procedures, and design dimensions (wall thickness) are expected to eliminate life-limiting thinning and cracking. The technical bases for these improvements are included in the project design and design review documents. However, documentation with a greater ageing management focus might be recommended in future. For example, the CNSC is considering guidance about addressing ageing management and its influence on operational limits and conditions in a separate section of the Safety Analysis Report [2].

PLGS is presently in an 18-month refurbishment outage for extended operation. In view of this stage in plant life, current ageing management effort is focussed on:

- Ensuring fabrication, installation, and commissioning is compliant with procedures
- Protecting systems, structures, and components (SSCs) from degradation during lay-up
- Collecting baseline condition information for new components (feeders) and original components that are normally impractical to inspect (calandria vessel internals), and
- Updating AMPs for post-refurbishment operation.

2.2 Integrated safety review

The ISR described in the CNSC Regulatory Document RD-360 [5] is a comprehensive assessment of plant safety and meets the requirements of a Periodic Safety Review (PSR) outlined in an IAEA Safety Standard [6]. Elements of the ISR evaluate the effects of ageing on NPP safety, the effectiveness of ageing management programs for future operation, and the need for improvements.

In 2000, NPBN requested CNSC review and concurrence with PLGS refurbishment plans, to reduce the regulatory risk in proceeding with the project. At that time, the CNSC had no specific regulatory requirements or policies in place covering refurbishment for plant life extension and suggested early completion of a safety review in accordance with the IAEA Safety Guide 50-SG-012 on PSR [7], a precursor to the current Safety Standard [6]. Since other Western nations had prepared PSRs, there were precedents for improved regulatory certainty by following this approach.

NPBN recognized that the IAEA PSR Guide [7], which is designed for stations licensed for their entire operating life (the international norm), contained many safety inputs that are assessed more regularly in Canada because of the shorter licensing period (generally < five years). Canadian utilities are obliged to keep the station safety analysis relatively current to support the licensing process. PLGS also undergoes periodic assessments by other outside agencies. WANO carries out comprehensive and formal assessment of station management, technical support, and operations and maintenance on a three-year cycle. PLGS undergoes an annual detailed assessment of risk by the station insurance agency. PLGS takes the results and recommendations from these distinctly focused but related assessments as vehicles for station improvement and safety risk reduction.

The IAEA PSR includes other review elements that were already being pursued by the PLGS refurbishment project assessment initiatives. PLGS had introduced an Environmental Qualification program to assure that safety related equipment would remain operational under accident conditions, a Quality Assurance program, and a comprehensive Condition Assessment Program (CAP), all required elements for assessment under a PSR. The CAP was a very comprehensive and detailed evaluation of the condition of PLGS SSCs, taking several years to complete and generating 162 reports. The CAP was an important one-time program that provides the underlying basis for an on-going AMP, as will be discussed in Section 3. Other reviews had direct application to the PSR. These included studies related to safety margin improvements, reviews of PLGS against safety-related design changes for newer reactors (Wolsong, Qinshan, enhanced CANDU 6 design) and against the generic CANDU 6 probabilistic safety assessment, and reviews of PLGS design against current codes and standards and the ability of PLGS systems important to safety to meet unavailability targets.

NBPN decided to integrate the review of the above efforts into the PSR process and called it an ISR. NBPN consulted with the IAEA on this modified approach and they concurred. In 2003, NBPN contracted an external service provider to perform an ISR of PLGS. NBPN believes that the completed ISR meets the intent of the recently issued CNSC Regulatory Document RD-360 [5] with respect to ageing management.

2.3 Systematic and integrated AMPs

A demonstrated systematic and integrated ageing program is a key element of the IAEA/CNSC guidance to ensure continued fitness for service of all plant SSCs important to safety. The IAEA/CNSC approaches use Deming's Plan-Do-Check-Act cycle as a model for guidance and to evaluate the extent by which an NPP has systematic processes in place to manage ageing.

The processes at PLGS were developed in the late 1990s using INPO AP-913 "Equipment Reliability Process Description" [4] that was prepared to assist member utilities to efficiently maintain safe and reliable plant operation. The INPO approach was selected at PLGS largely to meet the expectations of WANO reviews, which use performance objectives and criteria that are based primarily on best practices from the nuclear industry in the United States. Like the IAEA model, the INPO AP-913 model is also a Deming-type cycle to ensure continuous improvement. Both these models, if applied properly would result in effective systematic and integrated management processes. However, it would be difficult to assess management processes developed by one model using criteria from the other model because of some basic structural differences (e.g. terminology) between them. Demonstrating that the PLGS processes satisfy the intent of CNSC/IAEA model for ageing management is considered to be one of the primary risks associated with the new CNSC Regulatory Document. This issue is discussed in more detail later in this paper.

3. Status of PLGS AMP

Roughly simultaneous with the ISR to support development of a refurbishment project, PLGS continued to implement its Management System Process Model to improve station management and achieve station performance objectives. This process model included a tiered framework of Executive, Core and Support Processes, illustrated in Figure 1.

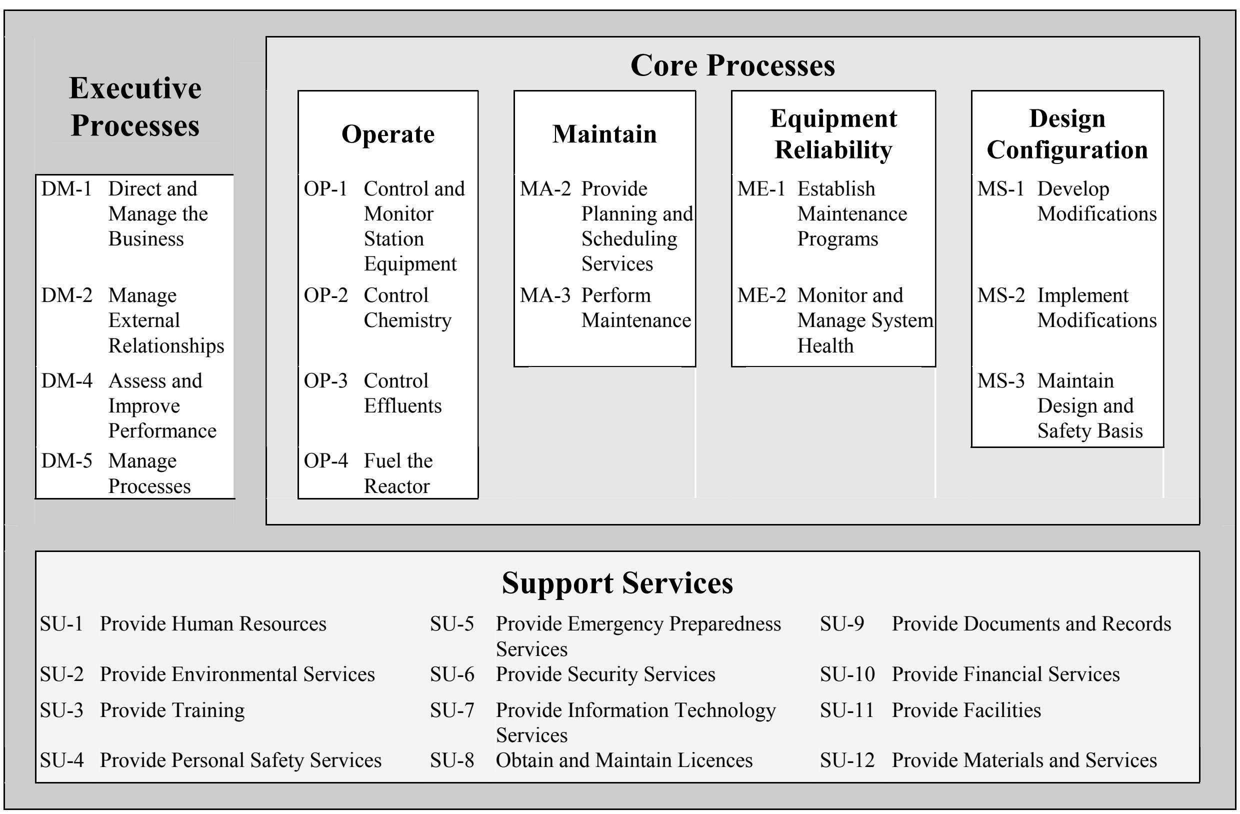

Figure 1 High level map of the management processes at PLGS.

Fundamentally, these processes represent interlinked activities that support and enable station staff to meet performance objectives. Several of the Core processes have direct application to ageing management. These processes are shown in Figure 2 as they would apply to the IAEA/CNSC Plan-Do-Check-Act model. The key ageing management processes of ME-1 "Establish Maintenance Programs" and ME-2 "Monitor and Manage System Health" are used to determine the overall scope of maintenance and capital projects at PLGS.

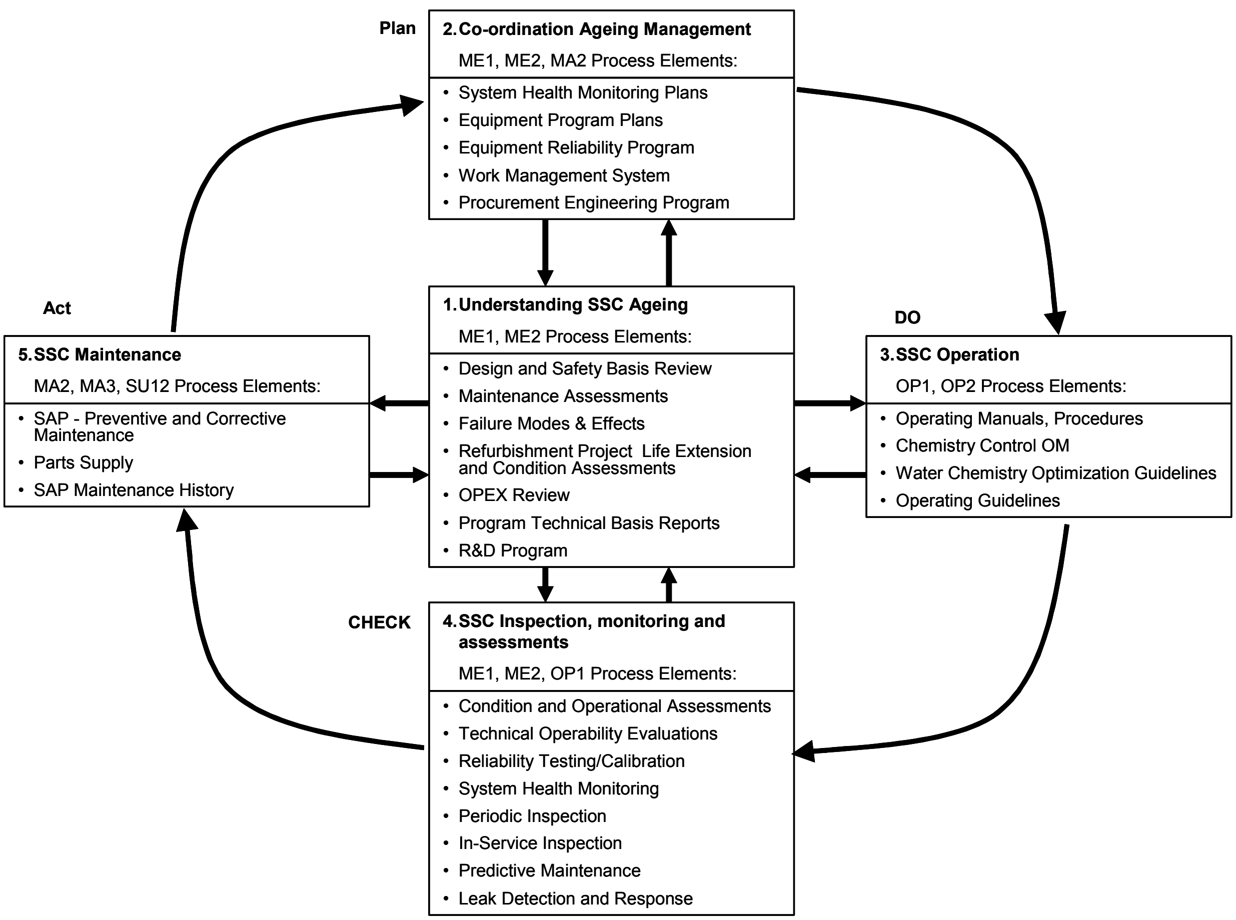

Figure 2 Mapping of ageing related management processes (see Figure 1 for process definitions) using the CNSC/IAEA model.

Implementation of these processes is supported by a tiered set of documents. The overarching document is the station's Nuclear Management Manual, which describes the Management System and sets out the policies, principles and processes through which the station meets its performance objectives. These processes are supported by a hierarchy of Process References, Process Instructions, and Working Level Documents. With respect to ageing management, the PLGS processes are focussed on meeting equipment reliability requirements, where SSC ageing is a key input. Sub-tier procedures for system health monitoring and equipment program plans require the evaluation of ageing and other degradation mechanisms to establish management options. These procedures also address degradation from out-of-specification operation unrelated to ageing (e.g. mechanical damage from debris ingress or corrosion from a chemical excursion). In addition, the system health monitoring (SHM) program utilizes a functional failure and criticality assessment to ensure the nuclear safety consequences are adequately considered.

When the ISR was being performed, the higher tier process documents (e.g. ME-1 Establish Maintenance Programs, ME-2 Monitor and Manage System Health) were already completed. Some of the sub-tier documents that provide the technical basis for ageing management were also issued (e.g. plant life assessments, condition assessments, SHM plans) but many of the key documents were not started (e.g. equipment program plans, SHM reports).

The Condition Assessment Program (CAP) that was performed to support the plant life extension assessment also formed the technical basis for the current PLGS SHM program. The CAP provided a one-time baseline plant condition assessment for the SHM program, which now updates SCC condition on an on-going basis. The interrelationships between programs carried out for the refurbishment project and the current PLGS ageing management processes are complex. Figure 3 shows a simplified flowchart of these relationships.

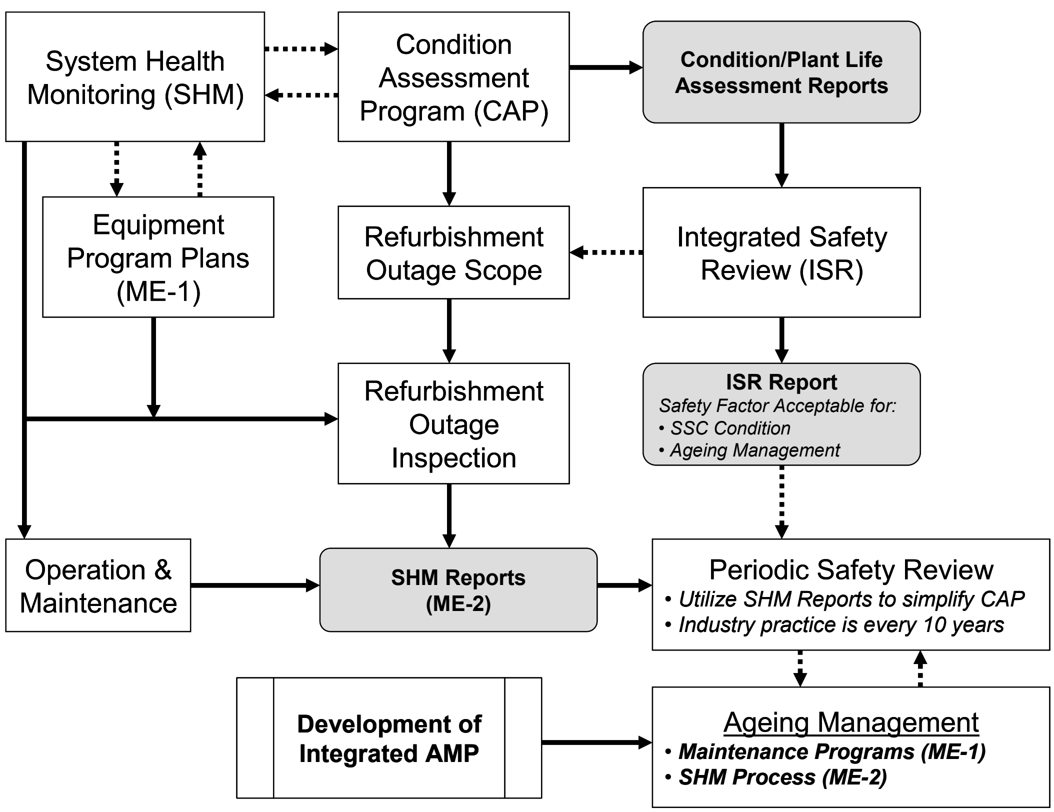

Figure 3 Simplified flowchart showing inputs to ageing management at PLGS.

Since the CAP, PLGS has expanded and fortified the SHM process to provide appropriate assurance that CAP condition assessments remain valid and that safety margins for the refurbished reactor will not be compromised. The objectives of SHM are essentially the same as the CAP:

- Ensure equipment condition, health, and performance is effectively assessed, and identified when maintenance is required;
- Minimize equipment failures by proactively assessing and addressing degradation;
- Develop and control the mandatory surveillance program to proactively determine failures of safety related SSCs.

To achieve these objectives, the SHM program includes the following fundamental elements:

- Staff responsibilities.
- Identification of applicable Systems based on defined criteria
- Development of a SHM Plan based on conducting Functional Failure and Criticality Analysis and assessment of degradation mechanisms.
- Development of a formal SHM Activity List, system walk-down requirements, performance indicators and targets, and record keeping and system logs to capture and trend pertinent data;
- Systematic review of OPEX, maintenance and operating history, design changes, and outstanding actions and recommendations;
- Preparation and issuance of formal periodic SHM Reports.

NBPN believes that the CAP and ongoing SHM program position PLGS to more effectively satisfy the requirements of future periodic reviews (PSR/ISR).

3.1 Results of the ISR

The PLGS ISR was performed following the approach developed to integrate on-going PLGS safety, reliability, and licensing assessments and other specific assessments for the PLGS refurbishment project with the requirements of a PSR (Section 2.2). This section summarizes the ISR results related to ageing management. The ISR concluded that PLGS programs and processes adequately address the issues of degradation of equipment performance and safety margins for extended life.

The review found that PLGS surveillance and maintenance programs were consistent with international practice. Degradation monitoring of critical equipment was effective; the fitness for service of pressure tubes and feeders were cited as good examples. The assessment of equipment condition did not identify any issues requiring immediate corrective action. Because the Canadian industry has adopted the INPO/WANO experience for improving station performance, PLGS programs and processes for managing work incorporate current safety standards and practices.

Two aspects of the PLGS AMP were judged reasonably important to safety and needed improvement:

1. PLGS does not appear to have a methodical and documented system for selecting the SSCs to include in the AMP. (This has since been addressed – see Section 3.2)

2. The programs that contribute to managing the aging aspects of critical SSCs are distributed among several station organizations (Operation, Maintenance, Technical Unit – System & Engineering). Evidence is required to show that health monitoring, inspection, testing, maintenance, and age management programs are covering all aspects necessary for an effective AMP.

There were three additional observations:

- A person or small group is needed to co-ordinate the AMP activities and to ensure that all areas are appropriately addressed.

- The maintenance program should address program implementation planning, calibration facilities, reduction of overdue preventative maintenance work orders, updating of the preventive maintenance documentation to reflect changes in managerial structure and procedural process.

- The process of introducing new changes/improvements to the technical surveillance program could be improved.

The ISR identified four strengths in the PLGS AMP:

1. All of the elements of an effective AMP are in place at PLGS.

2. The objectives and scope of the aging related programs are compliant with the IAEA Safety Report Series No. 15 [8] (a guide pre-dating reference 3).

3. The CAP provided a solid baseline on SSC condition and the SHM group monitors the ongoing condition of the SSCs.

4. The Station Business Plan recognizes the need for ageing management and provides adequate resources.

3.2 Improvements since 2003

In the period since 2003, there has been significant progress in the development of the lower tier documents that are used for ageing management. The most pertinent ageing related documents are:

- Basis for identification of the systems important to safety, which addresses the first item for improvement (Section 3.1).
- SHM plans and reports for safety significant SCCs.
- Equipment program plans to manage SSCs that require complex arrangements to manage ageing and degradation effectively.
- Chemistry optimization guidelines to ensure materials degradation is minimized.

In 2003, NBPN also initiated an improvement program to address serious degradation of the major components of the HTS [9]. To apply industry best practices to the program, international industry guidance documents and regulations for ageing and life cycle management were reviewed. It was found that many industry guidance documents have a generic and broad scope for addressing plant-wide issues. Guidance for developing specific O&M activities to implement guideline goals and objectives are not normally included. Most documents focus on common components and ageing and are not optimal for the most serious PLGS HTS degradation, which is random and isolated. On the other hand, regulations are often very specific and not applicable to PLGS issues. In cases where the Regulator is prescriptive and/or risk averse, station programs focus on demonstrating compliance with rules and regulations.

Overall, it was found that the Nuclear Energy Institute Guideline for the Management of Materials Issues, NEI 03-08 [10] prepared following the Davis-Besse vessel head corrosion experience, was most easily adaptable for managing PLGS HTS materials degradation. It provides the most specific materials degradation management guidance and also includes implementation aspects. The continuing improvement at PLGS has resulted in mature processes that provide a systematic and integrated program to manage SSC degradation and ageing. However, it is apparent that the PLGS governing documents do not adequately or clearly describe how ageing is managed when compared against the IAEA/CNSC model. This is the second item identified for improvement in Section 3.1. The mapping of the PLGS processes using the IAEA model shown in Figure 2 provides a cursory illustration of how the two methods compare.

4. Path Forward

Based on the available information [1,2] about the likely contents of RD-334, the PLGS aging management program likely meets the intent of most of the new CNSC guidance. One exception is that the PLGS governing documents may not adequately meet the intent to demonstrate that ageing is managed in a systematic and integrated manner. This shortcoming introduces regulatory risk to PLGS operation. To reduce this risk, NBPN plans to prepare a document illustrating how PLGS processes will meet the new CNSC Regulatory Document RD-334. It is expected that the document will include:

- Criteria to identify all SSCs important to safety
- A description of the systematic and integrated ageing management approach at PLGS for all plant SSCs important to safety. It will identify the relevant management processes, high-level program documents, and organizational responsibilities.
- Key interfaces to coordinate ageing management activities.
- High-level performance measures to evaluate the effectiveness of the AMP.
- Sub-tier processes for SSC Selection and Evaluation for the AMP
  - Systematic process to identify all SSCs important to safety that may be susceptible to ageing degradation.
  - Documented process, criteria, and information sources used to determine whether the selected SSCs are susceptible to ageing degradation.
  - Process for AMP Review and Continuous Improvement
  - Description of the Data Collection and Record Keeping System to support ageing management
- Specific programs that are required to manage ageing and materials degradation of SSCs that are important to the safe, reliable, and economic operation of PLGS.

NBPN expects that improvements to the PLGS AMP may also be required to meet the intent of RD-334. Areas for improvements will be identified by a detailed gap assessment. Second, NBPN plans to identify industry best practices for implementation by performing benchmarking evaluations of European Utilities that have already retrofitted IAEA ageing management guidelines into their processes for extended operation. The general focus for improvements in the near term is on:

- The operations phase of the life cycle; PLGS is entering the period of extended operation so design, manufacturing, construction, etc. activities are minimal.
- Using existing processes, procedures, organization and by revising lower tier management documents.
- Extending the risk-based methods that were developed for the management of ageing and degradation for the PLGS HTS to the remainder of the plant.

5. Conclusion

NBPN is confident that the existing PLGS processes will be effective to manage ageing and to maintain the required safety functions for extended operation. The next steps are to document how current PLGS processes meet new CNSC guidelines and to identify any areas for improvement. Best practices will be used to implement improvements using OPEX from European utilities that have retrofitted IAEA guidelines for extended operation and PLGS experience in applying risk-based methods for ageing management. The current focus is to ensure good ageing management practices during the refurbishment outage and to implement improvements for post-refurbishment operation.

6. References

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