# IMPROVING REGULATORY OVERSIGHT OF MAINTENANCE PROGRAMS

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## ABSTRACT

Safe nuclear power plant operation requires that risks due to failure or unavailability of Structures, Systems and Components (SSCs) be minimized. Implementation of an effective maintenance program is a key means for achieving this goal. In its regulatory framework, the important relationship between maintenance and safety is acknowledged by the CNSC. A high level maintenance program requirement is included in the Class I Facilities Regulations. In addition, the operating licence contains a condition based on the principle that the design function and performance of SSCs needs to remain consistent with the plant's design and analysis documents.

Nuclear power plant licensees have the primary responsibility for safe operation of their facilities and consequently for implementation of a successful maintenance program. The oversight role of the Canadian Nuclear Safety Commission (CNSC) is to ensure that the licensee carries out that responsibility. The challenge for the CNSC is how to do this consistently and efficiently.

Three opportunities for improvement to regulatory maintenance oversight are being pursued. These are related to the regulatory framework, compliance verification inspection activities and monitoring of self-reporting. The regulatory framework has been improved by clarifying expectations through the issuance of S-210 "Maintenance Programs for Nuclear Power Plants". Inspection activities have been improved by introducing new maintenance inspections into the baseline program. Monitoring is being improved by making better use of self-reported and industry produced maintenance related performance indicators.

As with any type of program change, the challenge is to ensure the consistent and optimal application of regulatory activities and resources. This paper is a summary of the CNSC's approach to improving its maintenance oversight strategy.

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## 1. INTRODUCTION

It is well understood that safe nuclear power plant (NPP) operation requires that risks due to failure or unavailability of Structures, Systems and Components (SSCs) must be minimized. The implementation of an effective maintenance program is the key means for controlling such risks. In Canada, nuclear power plant licensees have the primary responsibility for safe operation of their facilities and consequently for implementation of a successful maintenance program. The oversight role of the Canadian Nuclear Safety Commission (CNSC) is to assure that the licensee's responsibilities are properly discharged.

Within the CNSC, managed processes are being developed to provide more structured direction to staff. One group of the core processes is titled "Assure Compliance". This group of processes is designed to provide assurance that the requirements of the *Nuclear Safety and Control Act* (NSCA), regulations and associated licences and certificates are met. One of the sub-tier processes in this group is titled "verify compliance". It covers the approach CNSC staff uses to verify compliance through inspection activities and review of licensee self reporting data. Analysis of the verification results allows an assessment of the various licensee programs and their performance for status reporting to the Commission.

The CNSC divides its regulatory assessment of licensee performance into nine safety areas. These are Operating Performance, Performance Assurance, Design and Analysis, Equipment Fitness for Service, Emergency Preparedness, Environmental Performance, Radiation Protection, Site Security and Safeguards. A chart displaying these areas is given in Figure 1. As shown in the figure, the safety area Equipment Fitness for Service includes those programs that impact the physical condition of the various SSCs and includes Maintenance.

The International Atomic Energy Agency (IAEA) defines maintenance as the organized activities, both administrative and technical, needed to keep structures, systems and components in good operating condition, and to ensure that they function as per design [1]. This definition results in a significantly broad scope of activities and when combined with the physical numbers of SSCs contained in a nuclear power plant it presents a significant oversight challenge for the CNSC. A detailed compliance verification approach to assess the program and confirm the condition of all SSCs would be unmanageable. Therefore a strategic approach to compliance verification is necessary.

As with any learning organization, the CNSC's approach to maintenance oversight is subject to continuous improvement based on feedback from stakeholders. The following paper discusses recent improvements to the CNSC's maintenance oversight strategy.

| SAFETY AREAS | PROGRAMS |
|---|---|
| 1. Operating Performance | 1.1 Organization and Plant Management |
| | 1.2 Operations |
| | 1.3 Occupational Health & Safety (Non-radiological) |
| 2. Performance Assurance | 2.1 Quality Management |
| | 2.2 Human Factors |
| | 2.3 Training, Examination, Certification |
| 3. Design and Analysis | 3.1 Safety Analysis |
| | 3.2 Safety Issues |
| | 3.3 Design |
| 4. Equipment Fitness for Service | 4.1 Maintenance |
| | 4.2 Structural Integrity |
| | 4.3 Reliability |
| | 4.4 Equipment Qualification |
| 5. Emergency Preparedness | 5.1 Emergency Preparedness |
| 6. Environmental Performance | 6.1 Environmental Management Systems |
| | 6.2 Effluent and Environmental Monitoring |
| 7. Radiation Protection | 7.1 Radiation Protection |
| | |
| 8. Site Security | 8.1 Site Security |
| 9. Safeguards | 9.1 Safeguards |
| ALL SAFETY AREAS | ALL PROGRAMS |

Figure 1: CNSC Safety Areas and Programs

## 2. MAINTENANCE OVERSIGHT CHALLENGES

On May 31, 2000, as the result of an act of Parliament, the Atomic Energy Control Board (AECB) was replaced by the Canadian Nuclear Safety Commission (CNSC). The Commission's creation followed the coming into force of the *Nuclear Safety and Control Act* [2] and its regulations [3]. This legislation introduced a new regime of legal requirements for licensees and gave responsibility for assuring that the requirements were met to the CNSC.

To meet the needs of the new regulatory regime the Commission staff was also reorganized and the Inspection Division was formed. Along with these changes came the recognition that more efficient managed processes were necessary to ensure a consistent and systematic approach to regulatory oversight.

In parallel to these regulatory changes the industry itself was changing. The classical role of maintenance had confined maintenance activities to those needed for reactive tasks such as repairs or replacements. More recently maintenance has been defined as “all activities aimed at keeping an item in, or restoring it to, the physical state considered necessary for fulfillment of its production function” [4]. Maintenance program review topics and performance measures were introduced within the CNSC in 1998 but these have not kept pace with new industry practices and performance measures.

The above changes have combined to challenge the way CNSC staff has assessed licensee maintenance programs. To meet this challenge, three opportunities for improvement have been identified. These are Regulatory Framework, Inspection Activities, and Monitoring and Self-Reporting. Each is discussed in further detail below.

## 2.1 Regulatory Framework

The *Atomic Energy Control Act* encompassed both the regulatory and developmental aspects of nuclear activities. The *Nuclear Safety and Control Act* (NSCA) separates these aspects and provides a distinct identity to the regulatory agency titled the Canadian Nuclear Safety Commission. The NSCA is a modern statute designed to provide more explicit and effective regulation of nuclear energy.

Section 44(1) of the NSCA states that *the Commission may, with the approval of the Governor in Council, make regulations:*

> *e) respecting the location, design, construction, installation, operation,* ***maintenance****, modification, decommissioning, abandonment and disposal of a nuclear facility or part of a facility;* [2]

Under the NSCA, the Commission has put in place regulations that are legally binding. These regulations attempt to cover the broad range of nuclear activities. A specific set of regulations was created for nuclear power plants. These are the Class I Facilities Regulations.

Section 6(d) of the Class I Nuclear Facilities Regulations states that '*An application for a licence to operate a Class I Nuclear Facility shall contain the following information in addition to the information required by section 3:*

> *(d) the proposed measures, policies, methods and procedures for operating and* ***maintaining*** *the nuclear facility;* [3]

The NSCA clause above indicates that the Commission may make regulations regarding maintenance. The Class I regulations clause states the specific regulation pertaining to operating reactors but it is at a very high level. Detailed requirements are not provided and this makes it difficult for licensees to know if they have met requirements and for CNSC staff to assess compliance with the requirements.

Section 26 of the NSCA requires that the operation of a nuclear facility be in accordance with a licence. Section 24(5) allows the Commission to establish licence conditions that are considered necessary for the purposes of the Act. To emphasize the need to maintain structures, systems and components (SSC), a licence condition was incorporated into all Nuclear Power Plant Operating Licences. This condition states the following:

> *For the purpose of limiting, during the lifetime of the nuclear facility, the risks related to the failure or unavailability of any structure, system or component whose performance may affect the safe operation or security of the nuclear facility, the licensee shall establish, document and implement a maintenance program.*
>
> *The maintenance program shall include testing and inspection and shall be of such quality and be performed in such a manner that the availability, reliability and effectiveness of structures, systems or components remain consistent with the design and analysis documents submitted in support of the licence."*

This licence condition sets up a basic philosophy concerning maintenance but the guidance provided for program content is limited. Both licensee and CNSC staff expectations can vary significantly.

In summary, the regulatory framework establishes high level legal requirements but does not provide sufficient detail for maintenance program expectations at a lower level. The lack of detailed requirements results in a challenge to program implementation from a licensee's perspective and to the CNSC staff from a compliance verification perspective.

### 2.2 Inspection Activities

The CNSC compliance process for power reactors includes baseline and focused inspection activities. The inspection activities are divided into two types. These are Program Inspections and Program Implementation Inspections.

Program inspections consist of detailed evaluations of the content and adequacy of a licensee's program or process. They are very time consuming and labour intensive for both CNSC staff and licensee staff.

Program Implementation inspections are evaluations of the outputs from implementation or performance of licensee programs or processes. They are less time consuming and labour intensive as compared to program inspections.

Traditionally CNSC staff has used Program inspections. However, the amount of time, effort, cost and human resources required to conduct them has limited the number of programs that can be assessed in any given year. There is good agreement among the Directors that more frequent program output inspections would allow broader coverage of licensee programs and processes.

Traditionally, there were no program implementation inspection guides that are focused specifically on maintenance programs. Assessment information is obtained through cross cutting other inspections. This is a second opportunity for improvement of CNSC maintenance oversight as uniformity and consistency of compliance determination is difficult in an environment where requirements are not completely prescriptive.

### 2.3 Monitoring and Self-Reporting

Regulatory compliance verification is supported by a framework of licensee self-reporting that is monitored by CNSC staff. The self-reporting requirements are described in the General Regulations as well as in regulatory documents S-99 [5], and S-98 [6] and through specific licence conditions. Data reported to the CNSC includes safety issues, unplanned events, non-compliances, safety performance statistics and regulatory performance indicators.

The regulatory performance indicators were developed with the licensees in an attempt to obtain performance data over a broad range of activities. They are submitted to the CNSC on a quarterly basis. Many of the indicators are cross cutting and do not focus on the maintenance program alone. In fact there is only one indicator directly related to maintenance. It is called the

Preventive Maintenance Completion Ratio (PMCR). It is an indication of the amount of preventive work being done in comparison to the total preventive and corrective work.

The benefit of one program indicator to help assess licensee performance is limited. In contrast the industry has been developing suites of performance indicators (measures) for their various programs and processes. Improving evaluation of performance indicator data is a third maintenance oversight opportunity for CNSC staff.

## 3. MAINTENANCE OVERSIGHT IMPROVEMENTS

Compliance verification is a continuous challenge for all regulators in all areas. The CNSC has been working to improve its regulatory tools and to clarify its expectations for licensees. This is evidenced by such things as the new NSCA and regulations, revision to S-99, the introduction of performance indicators and improvements to processes.

Initiatives to improve maintenance oversight have also been ongoing. In 2006 regulatory document S-210 titled "Maintenance Programs for Nuclear Power Plants" [7] was issued and CNSC power reactor regulatory management formed a maintenance oversight working group. The working group's purpose was to improve the CNSC's maintenance oversight strategy and to promote consistency with respect to maintenance expectations at the different power reactor sites.

The following is a discussion of improvements that have been made or are in progress to take advantage of the opportunities discussed above. The improvements are related to maintenance oversight, subject to continuous improvement and should not be considered to be all inclusive.

### 3.1 Regulatory Framework Improvements

The need for further regulatory guidance regarding maintenance programs was expressed by licensees and recognized by CNSC (AECB) staff prior to the enactment of the NSCA. As such, the development of a regulatory document S-210 titled 'Maintenance Programs for Nuclear Power Plants' was initiated. The stated purpose of the document was to set out the elements of an adequate maintenance program. The development followed a formal CNSC process that includes reviews by internal staff, the general public and stakeholders and legal services.

By expanding on requirements set out in the NSCA and associated regulations, regulatory documents provide a basis for regulatory expectations and decisions. S-210 was published in July 2007. Note that as of September 2007, all regulatory documents are categorized as "RD". This is due to additional improvement initiatives in the regulatory framework.

S-210 sets out the elements of an NPP maintenance program. Such a program consists of policies, processes and procedures that provide direction for maintaining structures, systems and components (SSCs) of the plant. The overall maintenance program was broken down into general elements with each element considered to have its own business processes. The elements identified by the CNSC in its maintenance program standard are:

- technical basis;
- maintenance organization;
- maintenance strategy;
- SSC monitoring;
- work execution;
- materials management;
- program assessment and review; and
- record keeping.

The addition of S-210 to the regulatory framework clarifies expectations for the licensee and allows CNSC staff to better link oversight activities to program elements. It is important to note that it is not the intent of S-210 to alter guidance provided by other codes and standards but rather to provide the framework within which codes and standards are applied to ensure that SSCs function as per design.

### 3.2 Compliance Inspection Improvements

The CNSC has been developing program implementation inspection guides to ensure there is a complete set of consistent inspections. The guides are being developed such that they are defensible, systematic and consistent in approach. With the issuance of S-210, better guidance was provided for maintenance program content and expectations.

In preparation for guide development, the maintenance working group divided the S-210 requirements into objectives. For each objective a set of criteria or low level expectations was compiled using regulatory and industry references. The criteria formed the basis for inspection guide activities to assess whether or not an objective was being met. Activities could include direct observation in the field, review of licensee produced records, interrogation of licensee databases and discussion with licensee personnel.

Once the criteria for maintenance were compiled it became readily apparent that a single inspection guide for maintenance would be too onerous. The scope must be reasonable from an implementation perspective. Too broad of a scope would not allow the inspection to be completed within a reasonable time frame. A structured sampling of program outputs could better be used to obtain a representative indication of licensee performance.

Consequently for maintenance it was decided to produce four inspection guides that touched on important aspects of the maintenance program. These would become baseline compliance inspections directly focused on the maintenance program elements and embedded in the CNSC's overall compliance verification plan.

The four key areas chosen were planning and scheduling, field work execution, system health monitoring and program performance measures. All inspections are scheduled to be completed on an annual basis with the exception of work execution which is performed each quarter. The major checks for the first three guides are discussed below. The fourth guide on performance

monitoring will be discussed in section 3.3.

The Work Planning and Scheduling guide is designed to cover expectations with respect to maintenance work planning and scheduling. Its major checks include work package assessment, job priority decisions, planning safety, work group coordination and schedule compliance.

The Maintenance Work Execution guide is designed to cover expectations with respect to the completion of work in the field. Its major checks include Pre-job Brief, work control and safety, field execution, post maintenance verification and work package closeout.

The system health monitoring guide is designed to cover expectations for the condition monitoring of structures, systems and components. It is equipment level focused with major checks that include failure mode assessment, monitoring activities and criteria, corrective actions and actual health of the system.

### 3.3 Monitoring of Self-Reporting Improvements

To monitor the complete maintenance program a full set of indicators would be required. Obtaining and analysing a full set of indicators for each plant would likely challenge CNSC resources. Consequently a subset using existing self-reporting data combined with a limited number of industry collected data is being considered. To limit the review scope, the focus will be put on indicators that can be closely related to the preventive maintenance program and work completion. The assumption being made is that industry understands the needs of its SSCs with respect to maintenance and only needs to implement them.

The preventive program (PM) is the cornerstone of the entire maintenance program and represents the majority of resource utilization [8]. Unless the PM program is effective, all subsequent maintenance activities will be sub-optimized [9]. The collection of monitoring data is proposed to be done in the form an annual inspection. The objective is to look for areas of declining performance and assess the need for enhanced regulatory oversight. Monitoring consists of collecting and reviewing performance indicator data. Ten indicators are proposed. Five could be specified by the CNSC as part of the S-99 self-reporting quarterly performance indicator program.

The sixth indicator is the number of maintenance related events that are reported under the unscheduled reporting requirements of S-99. These are managed using a CNSC event tracking system.

The remaining four indicators are related to preventive maintenance performance and work completion. They are indicators in general use throughout the industry and include corrective maintenance backlog, elective maintenance backlog, preventive maintenance deferrals and work schedule adherence.

If performance is determined to be declining then an assessment of the impact on safety is completed and additional regulatory oversight activities recommended.

## 4. SUMMARY AND CONCLUSIONS

Safe nuclear power plant operation requires that risks due to failure or unavailability of Structures, Systems and Components (SSCs) be minimized. This is done through implementation of an effective maintenance program and is the responsibility of the licensee. The oversight role of the Canadian Nuclear Safety Commission (CNSC) is to ensure that the licensee carries out that responsibility. The challenge for the CNSC is to design the method to do this consistently and efficiently within the framework of its own organization.

The main opportunities for improvement include Regulatory Framework, Inspection Activities, and Monitoring of Self-Reporting. The regulatory framework has been improved by clarifying expectations through the issuance of S-210 "Maintenance Programs for Nuclear Power Plants". Inspection activities have been improved by introducing new maintenance focused inspections. Monitoring is being improved by developing a set of ten maintenance related performance indicators.

As with any learning organization, the CNSC's approach to maintenance oversight is subject to continuous improvement based on feedback from stakeholders. The implementation of these improvements allows a more systematic and consistent approach to regulatory maintenance oversight. The overriding objective of this oversight role is to ensure that licensees are maintaining their structures, systems and components such that they will perform as designed.

## REFERENCES

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