NSNI/OSART/189/2016.
ORIGINAL: English

IAEA
International Atomic Energy Agency

REPORT

OF THE

OPERATIONAL SAFETY REVIEW TEAM
(OSART)
MISSION

TO THE

PICKERING
NUCLEAR POWER PLANT
CANADA

19 SEPTEMBER – 6 OCTOBER 2016.

DIVISION OF NUCLEAR INSTALLATION SAFETY
OPERATIONAL SAFETY REVIEW MISSION
IAEA-NSNI/OSART/189/2016

PREAMBLE

This report presents the results of the IAEA Operational Safety Review Team (OSART) review of Pickering Nuclear Power Plant, Canada. It includes recommendations for improvements affecting operational safety for consideration by the responsible Canadian authorities and identifies good practices for consideration by other nuclear power plants. Each recommendation, suggestion, and good practice is identified by a unique number to facilitate communication and tracking.

Any use of or reference to this report that may be made by the competent Canadian organizations is solely their responsibility.

FOREWORD
by the
Director General

The IAEA Operational Safety Review Team (OSART) programme assists Member States to enhance safe operation of nuclear power plants. Although good design, manufacture and construction are prerequisites, safety also depends on the ability of operating personnel and their conscientiousness in discharging their responsibilities. Through the OSART programme, the IAEA facilitates the exchange of knowledge and experience between team members who are drawn from different Member States, and plant personnel. It is intended that such advice and assistance should be used to enhance nuclear safety in all countries that operate nuclear power plants.

An OSART mission, carried out only at the request of the relevant Member State, is directed towards a review of items essential to operational safety. The mission can be tailored to the particular needs of a plant. A full scope review would cover thirteen operational areas: leadership and management for safety; training and qualification; operations; maintenance; technical support; operating experience feedback; radiation protection; chemistry; emergency preparedness and response, accident management, human, technology and organization interaction, long term operation, and transitional period from operation to decommissioning. Depending on individual needs, the OSART review can be directed to a few areas of special interest or cover the full range of review topics.

Essential features of the work of the OSART team members and their plant counterparts are the comparison of a plant's operational practices with best international practices and the joint search for ways in which operational safety can be enhanced. The IAEA Safety Series documents, including the Safety Standards and the Basic Safety Standards for Radiation Protection, and the expertise of the OSART team members form the bases for the evaluation. The OSART methods involve not only the examination of documents and the interviewing of staff but also reviewing the quality of performance. It is recognized that different approaches are available to an operating organization for achieving its safety objectives. Proposals for further enhancement of operational safety may reflect good practices observed at other nuclear power plants.

An important aspect of the OSART review is the identification of areas that should be improved and the formulation of corresponding proposals for improvement. In developing its view, the OSART team discusses its findings with the operating organization and considers additional comments made by plant counterparts. Implementation of any recommendations or suggestions, after consideration by the operating organization and adaptation to particular conditions, is entirely discretionary.

An OSART mission is not a regulatory inspection to determine compliance with national safety requirements nor is it a substitute for an exhaustive assessment of a plant's overall safety status, a requirement normally placed on the respective power plant or utility by the regulatory body. Each review starts with the expectation that the plant meets the safety requirements of the country concerned. An OSART mission attempts neither to evaluate the overall safety of the plant nor to rank its safety performance against that of other plants reviewed. The review represents a `snapshot in time'; at any time after the completion of the mission care must be exercised when considering the conclusions drawn since programmes at nuclear power plants are constantly evolving and being enhanced. To infer judgements that were not intended would be a misinterpretation of this report.

The report that follows presents the conclusions of the OSART review, including good practices and proposals for enhanced operational safety, for consideration by the Member State and its competent authorities.

CONTENT

EXECUTIVE SUMMARY

The purpose of an OSART mission is to review the operational safety performance of a nuclear power plant against the IAEA safety standards and make recommendations and suggestions for further improvement and identify good practices that can be shared among the NPPs around the world.

At the request of the government of Canada, an IAEA Operational Safety Review Team (OSART) of international experts visited Pickering Power Plant from 19 September to 6 October 2016. This report describes the results of this OSART mission.

This OSART mission reviewed thirteen areas: Leadership and Management for Safety; Training and Qualification; Operations; Maintenance; Technical Support; Operating Experience Feedback; Radiation Protection; Chemistry; Emergency Preparedness and Response; Accident Management; Interactions between Human Technology and Organization, Long Term Operations, and Transitional Period from Operation to Decommissioning.

The mission was coordinated by an IAEA Team Leader and Deputy Team Leader, the team was composed of experts from Belgium, Brazil, China, Czech Republic, France, Germany, Hungary, Romania, Slovak Republic, Sweden, United States of America and the IAEA staff members. The collective nuclear power experience of the team was approximately 396 years.

Throughout the review, the exchange of information between the OSART experts and plant personnel was very open, professional and productive.

The team identified 21 issues, 10 were recommendations, and 11 were suggestions. Eight good practices were also identified.

The most significant issues identified were:

- The plant should continue to aggressively pursue improvements in areas that directly impact plant operational safety.
- The plant should enhance its work control process to ensure that system, structures and components important to safety are repaired in a timely manner.
- The plant should enhance its practice for identification and reporting of deficiencies to ensure that deficiencies are identified and reported in a timely manner.

The most notable good practices were:

- The plant used Severe Accident Software Simulator application for supporting multi-unit severe accident management guideline development.
- The plant obsolescence management takes into consideration the long term aging management assessments and transition to decommissioning requirements.
- The plant has established longstanding positive relationships with community partners to develop young leaders and improve environmental stewardship and awareness.

Pickering NPP management expressed their commitment to address the issues identified and invited a follow up visit in about eighteen months to review the progress.

INTRODUCTION AND MAIN CONCLUSIONS

INTRODUCTION

At the request of the government of Canada, an IAEA Operational Safety Review Team (OSART) of international experts visited Pickering Nuclear Power Plant from 19 September to 6 October 2016. The purpose of the mission was to review operating practices in the areas of Leadership and Management for Safety; Training and Qualification; Operations; Maintenance; Technical Support; Operating Experience Feedback; Radiation Protection; Chemistry; Emergency Preparedness and Response; Accident Management; Interactions between Human Technology and Organization, Long Term Operations, and Transitional Period from Operation to Decommissioning. In addition, an exchange of technical experience and knowledge took place between the experts and their plant counterparts on how the common goal of excellence in operational safety could be further pursued.

Pickering Nuclear Power Plant has six reactors at the site, with an additional two reactors in safe shutdown state. Each operating reactor has a gross electrical output about 550 MWe (megawatts electrical). The reactors are CANDU pressurized heavy water reactors, which use natural uranium as fuel and heavy water as a coolant and moderator. Unit 1 came online in 1971, while unit 8 was connected to the grid in 1986.

The Pickering Nuclear Power Plant OSART mission was the 189th in the programme, which began in 1982.

Before visiting the plant, the team studied information provided by the IAEA and the Pickering Nuclear Power Plant to familiarize themselves with the plant's main features and operating performance, staff organization and responsibilities, and important programmes and procedures. During the mission, the team reviewed many of the plant's programmes and procedures in depth, examined indicators of the plant's performance, observed work in progress, and held in-depth discussions with plant personnel.

Throughout the review, the exchange of information between the OSART experts and plant personnel was very open, professional and productive. Emphasis was placed on assessing the effectiveness of operational safety rather than simply the content of programmes. The conclusions of the OSART team were based on the plant's performance compared with the IAEA Safety Standards.

The following report is produced to summarize the findings in the review scope, according to the OSART Guidelines document. The text reflects only those areas where the team considers that a Recommendation, a Suggestion, an Encouragement, a Good Practice or a Good Performance is appropriate. In all other areas of the review scope, where the review did not reveal further safety conclusions at the time of the review, no text is included. This is reflected in the report by the omission of some paragraph numbers where no text is required.

MAIN CONCLUSIONS

The OSART team concluded that the managers of Pickering NPP are committed to improving the operational safety and reliability of their plant. The team found some good practices, the most notable ones were:

- The plant used Severe Accident Software Simulator application for supporting multi-unit severe accident management guideline development.
- The plant obsolescence management takes into consideration the long term aging management assessments and transition to decommissioning requirements.
- The plant has established longstanding positive relationships with community partners to develop young leaders and improve environmental stewardship and awareness.

A number of proposals for improvements in operational safety were offered by the team. The most significant ones were:

- The plant should continue to aggressively pursue improvements in areas that directly impact plant operational safety.
- The plant should enhance its work control process to ensure that system, structures and components important to safety are repaired in a timely manner.
- The plant should enhance its practice for identification and reporting of deficiencies to ensure that deficiencies are identified and reported in a timely manner.

Pickering management expressed a determination to address the areas identified for improvement and indicated a willingness to accept a follow up visit in about eighteen months.

1. LEADERSHIP AND MANAGEMENT FOR SAFETY

1.1 LEADERSHIP FOR SAFETY

The plant developed a nuclear safety policy that is constantly reinforced as its core value. This policy is communicated to staff and interested parties through numerous different means (e.g.: station alignment meetings, plan of the next day meetings (POND), engineering alignment, pre- and post-job briefings, team excellence alignment meetings, significant issue resolution teams, bullhorn sessions, stand-up meetings) and multiple review committees (e.g.: corrective action review board, nuclear executive committee, nuclear safety culture monitoring panel, plant health committee, nuclear safety oversight committee and nuclear safety review board). This policy is a part of the plant vision of excellence and its strategy to achieve its passion for excellence program, “the roadmap to excellence”.

The leadership model of the plant behaviours establishes responsibilities of leadership at each level of the organization with human behaviours and performance as a fundamental contributor to the passion for excellence program. Many effective actions have been developed to foster the importance of human performance. Their implementation in the plant is monitored by the human performance steering committee.

The plant has developed an extensive leadership training program for the different staff levels of the organization (e.g.: initial leadership training, leadership continuous improvement training, leadership coaching, high potential development training called “Accelerate”, nuclear professional development seminar, international senior nuclear plant manager program).

The plant has comprehensive safety culture training and continuing training programs for first line managers and middle managers up to directors and high potential future leaders.

The plant has developed a “Values in Action” recognition program, and in 2014 implemented a personnel performance review process that includes a leadership plan with 6 aspects of leadership and 3 site objectives. This allows the monitoring and the evaluation of leadership traits demonstrated by managers and supervisors. The team identified this as a good performance.

1.2 INTEGRATED MANAGEMENT SYSTEM

The nuclear safety policy is embedded within the nuclear management system and all 42 subsidiary processes and their associated procedures. This integrated management system applies to the plant throughout all life-cycle phases, from conception to end of life and ensures safety is the overriding priority. It integrates requirements of all elements of the management of the facility including: safety, health, security, human and organizational factors, quality, societal and economic elements. Interfaces are defined in all process documents or programs. Roles and accountabilities are defined within each process and procedure.

The integrated management system is reviewed at least once a year and monitored by the fleet view program health and performance reporting process. The nuclear executive committee oversees this process.

The plant implements a fitness for duty program. However it does not use ‘without cause’ alcohol and drug tests. The team made a recommendation in this area.

1.3 NON-RADIATION RELATED SAFETY PROGRAM

The health and safety management system program is part of the plant integrated management system. This system includes:

- Occupational conditions and factors that could affect the health and safety of workers in all workplaces, or work-related activities under the plant's control;
- Non-occupational health conditions and factors that could affect the health of the company's workers, where they impact on the company's business objectives;
- Public safety, as it pertains to reporting requirements and operational risk management;
- Contractor safety.

Many tools like the pre-job and post-job briefings, the event-free tools for knowledge workers and safety analyses are regularly implemented. These safety analyses are mainly based on the risk assessment and challenge of the work situations. The Station Condition Record (SCR) is the starting point of many of the plant's initiatives to prevent and manage the risks of unexpected situations, including any gaps in industrial safety; however the team found some examples of industrial safety hazards that the plant has not adequately identified and addressed. The team made a suggestion in this area.

DETAILED LEADERSHIP AND MANAGEMENT FOR SAFETY FINDINGS

1.2 INTEGRATED MANAGEMENT SYSTEM

1.2(1) Issue: The plant does not use 'without cause' alcohol and/or drug tests in its existing fitness for duty program.

The team noted the following:

- The plant has not implemented 'without cause' illicit alcohol and drug tests in its fitness for duty program.

Without implementing 'without cause' alcohol and drug testing, plant staff who may be under the influence of alcohol and/or drugs could work on site without being detected.

Recommendation: The plant should include 'without cause' alcohol and drug tests as part of its existing fitness for duty program.

IAEA Bases:

SSR-2/2
3.13. A staff health policy shall be instituted and maintained by the operating organization to ensure the fitness for duty of personnel. Attention should be paid to minimizing conditions causing stress, and to setting restrictions on overtime and requirements for rest breaks. The health policy shall cover the prohibition of alcohol consumption and drug abuse.

NS-G-2.4
3.2. The operating organization management should have the following main responsibilities:
(3) Establishing and implementing an appropriate policy on an individual's suitability for duty, addressing adequate physical and mental fitness and aspects such as the illicit use of drugs or tobacco and alcohol abuse, in consonance with national regulations. This policy should be addressed to all employees, contractors and visitors, as applicable;

NS-G-2.14
4.5 Administrative controls should be established to allow the fitness for duty of shift personnel to be observed, verified and controlled. Elements of such administrative controls should include the identification of drug or alcohol abuse by personnel, monitoring of the psychological state of personnel, restrictions on excessive overtime and mandatory requirements for rests between shifts. Important elements of this programme are provisions to ensure active engagement and responsible attitudes on the part of the supervisors of the corresponding crews. Supervisors should routinely evaluate their crew members as early as possible at the beginning of each shift or period of work.

1.3 NON-RADIATION RELATED SAFETY PROGRAM

1.3(1) Issue: Industrial safety hazards are not always identified and addressed in a timely manner.

Some industrial safety hazards in the plant were observed:
- A maintenance worker was observed climbing up the ladder of scaffolding with tools in both hands. The scaffolding platform was about 3.5 meters high.
- The position of a lighting fixture was altered with a rope in order to make enough room to install scaffolding which was previously in the area. The scaffold was removed, but the position of the lighting fixture remains adjusted with the rope.
- Employee lockers are installed 1.2 metres away from a fan driven by an electrical motor.
- Scaffolding has been erected along the walkway to the Unit Emergency Control Centre. There are two unprotected scaffold pipes that protrude into the walkway which staff could potentially walk into.
- The electrical safety rescue hooks, which are available for use in the event of personnel electrical contact emergencies, do not specify a voltage range on them.
- One of the steel frames of the building structure in the turbine hall is not colour labelled to help personnel avoid walking into it.
- A scaffolding tube storage area has some unprotected tubes of scaffold protruding at eye level, with no warning signs. Personnel may walk into it.
- A set of revolving glass doors was observed to be lacking any warning signs at eye level to help prevent personnel from walking into the glass.
- Charging of cart batteries with their cover open was observed. No barriers were in place to prevent personnel from approaching uncovered batteries.

Without identifying and addressing industrial safety issues in a timely manner, worker health and safety may be at risk.

Suggestion: The plant should consider improving its industrial safety program to ensure that industrial safety risks are identified and addressed in a timely manner.

IAEA Bases:

GS-S-3.1
2.34. Senior management should have an understanding of the key characteristics and attributes that support a strong safety culture and should provide the means to ensure that this understanding is shared by all individuals. Senior management should provide guiding principles and should reinforce behavioural patterns that promote the continual development of a strong safety culture.
2.36. A strong safety culture has the following important attributes:
- ...
- Safety is integrated into all activities:
- Consideration of all types of safety, including industrial safety and environmental safety, and of security is evident.
- Housekeeping and material conditions reflect commitment to excellence.

GS-S-3.15
3.15. The processes for implementing each policy and the structure within which the policy is implemented should be clear. Individuals should know which parts of the processes are relevant to them, so as to understand the major risks in the activities at the installation and how they are controlled.

3.21. Since policies on safety, health and the environment are similar in content and nature, some organizations choose to combine them into one policy. The combined safety, health and environmental policy:

(d) Should state clear policy objectives and proposed means of:

- Eliminating injuries and health issues at work and minimizing radiation exposures;
- Ensuring that the activities and products of the organization are in compliance with applicable legislation and that its practices meet the relevant requirements and applicable standards of performance.

2. TRAINING AND QUALIFICATIONS

2.1. ORGANIZATION AND FUNCTIONS

The systematic approach to training is effectively applied at the plant. A nuclear training committee structure is established to implement nuclear training programs that enhance nuclear safety and performance.

There are four training committee levels. The highest level in the organization (Nuclear Training Oversight Committee) evaluates how well training addresses the organization's needs. Curriculum Review Committees enhance the training programs, taking into account Operating Experience, the need for just-in-time training, and feedback from line management and trainees.

The members of these committees are a mixture of people of the training organization and line organization. Line management is actively involved in the development, implementation and evaluation of the training policy. The team considers this a good performance.

2.2. QUALIFICATION AND TRAINING OF PERSONNEL

Candidates for the initial training program for Authorized Nuclear Operator (ANO) and Control Room Shift Supervisor (CRSS) go through a rigorous selection process to determine their potential for successful completion of the authorization training program and future certification as ANO and CRSS.

After the interview process, the candidate is scheduled for a five day selection course including classroom and simulator training, self-study and intensive examinations. The comprehensive candidate selection process increased overall throughput on the certification courses. The team considers this a good practice.

DETAILED TRAINING AND QUALIFICATION FINDINGS

2.2. QUALIFICATION AND TRAINING OF PERSONNEL

2.2 (a) Good practice: Comprehensive candidate selection process increases overall throughput on certification courses.

Candidates for the Initial Training Program for Authorized Nuclear Operator (ANO) and Control Room Shift Supervisor (CRSS) go through a rigorous selection process to determine their potential for successful completion of the Authorization Training Program and future certification as ANO and CRSS.

After the interview process, the candidate is scheduled for a five day selection course which is structured as follows:

– During the first two days the candidates are provided with classroom-based lectures on two station systems and course notes for two additional station systems to self-study. The purpose of the course is to determine if the candidate is able to study and retain the required knowledge from both the lecture course material and self study. The candidate then writes a rigorous, essay-style examination to confirm learning.
– During the third and fourth days the candidate is introduced to simulator-based training. A qualified instructor provides the candidate with instruction on how to use operating procedures in the simulator in response to alarms and other events associated with the systems studied in the classroom. The candidate is provided the opportunity to practice the skills. During this period, the qualified instructor will assess the candidate's ability to learn new skills and to apply the knowledge gained in the classroom.
– On the fifth day, the candidates complete a simulator-based performance examination based on the previous day's training. The Operations Manager or his/her delegate is in attendance to observe candidate's performance.

The Training Department compiles the results from both written knowledge and the simulator skills portions of the course. Candidates are ranked based on their ability to retain and assimilate the knowledge gained, their ability to read and execute procedures and their ability to maintain composure under highly stressful conditions. Only candidates who are able to meet required standards are considered to entry to the certified training programme.

The Operations Department reviews the rankings provided by the Training Department and, based in part on their own observations, selects the candidates most suitable to proceed to the initial training program.

Since implementing this process in 2012, the candidate throughput has increased from 42% to 83%.

3. OPERATIONS

3.1. ORGANIZATION AND FUNCTIONS

To ensure that operations staffing meets the needs of the plant, the resource planning and control team was established to critically examine, challenge and then endorse staffing plans. Current staffing level at the plant meets the needs of all units during normal and emergency conditions. The staffing levels including minimum complement are posted on the operations resources and schedules webpage. In order to ensure that minimum complement is maintained at all times, a live computer program, the Minimum Complement Co-ordination Program (MCCP) is used. The Minimum Complement Co-ordination Program records historical data, and as such the maintenance of minimum complement on site is readily auditable. In addition to looking back in time, The Minimum Complement Co-ordination Program can look forward to forecast which positions do not currently have coverage planned for future dates, if any. The Minimum Complement Co-ordination Program automatically interfaces with the employee timesheet software to show future dates on which minimum complement employees have requested vacation. Supervisors can then easily see which adjustments are required to be made to ensure minimum complement is met. The team found this a good practice.

3.4 CONDUCT OF OPERATION

Even though the plant has a housekeeping program, it is not always effective in supporting cleanliness and good housekeeping throughout the plant. For instance, housekeeping issues such as dust, dirt, debris on floors and pipes were found in the Reactor Building and other areas. The team made a recommendation in this area.

The team found that the plant has clearly written expectations on operator rounds and deficiency identification. However, the team noted that these expectations are not always met and identification and reporting of deficiencies are not always done in a timely manner. The team made a recommendation in this area.

Although the plant has an equipment labelling program, the plant expectation for maintenance of plant equipment labelling is not consistently maintained to provide clear identification of equipment. For instance, some identification tags and work request tags on system components were found missing and difficult to read. Without applying a consistent labelling practice, the risk of misidentification and inappropriate operation of equipment could increase and potentially lead to equipment damage, personnel injury and plant transient. The team made a suggestion in this area.

3.7 CONTROL OF PLANT CONFIGURATION

The team found a large number of status control tags hanging on plant equipment to identify temporary changes. The temporary changes are recorded in an electronic database called equipment status monitoring system and reviewed on a monthly basis by the plant status control functional group. However, there is no clear limit on the number of status control tags allowed and no time limit has been assigned to resolve these temporary changes. The team noted that the plant has been striving to reduce the number of temporary changes in effect and that operator challenges have been reduced significantly over the last year and a half. Nevertheless, the number of temporary changes is still very large at this time and this may challenge the operators during the day-to-day operation. The team encourages the plant to continue their effort to reduce the number of temporary changes.

DETAILED OPERATIONS FINDINGS

3.1 ORGANIZATION AND FUNCTIONS

3.1 (a) Good practice: Minimum Complement Co-ordination Program

The plant has a minimum complement of qualified staff which must be on site at all times to ensure the safe operation of the facility. Maintaining minimum complement is a license requirement. In order to ensure minimum complement is maintained at all times, a live computer program named Minimum Complement Co-ordination Program (MCCP) is used. The Minimum Complement Co-ordination Program is available on all employee computer terminals. There are also two separate kiosks located in the entrance areas of the plant. These kiosks contain computers which run the Minimum Complement Co-ordination Program badge scanners so employees can easily badge in and out, and large television screens which provide live updates of current staffing for minimum complement roles.

The Minimum Complement Co-ordination Program interfaces directly with training software to map employees only to the roles for which they meet all qualification criteria. These employees are then mapped to the minimum complement role for which they are qualified as they scan their badge at the Minimum Complement Co-ordination Program kiosk upon reporting to the plant. If an employee attempts to leave without the proper relief for their position, they will receive a warning from the Minimum Complement Co-ordination Program kiosk, and cannot leave until their replacement arrives. This ensures constant coverage of minimum complement positions.

The Minimum Complement Co-ordination Program records historical data, and as such the maintenance of minimum complement on site is readily auditable. In addition to looking back in time, the Minimum Complement Co-ordination Program can look forward to forecast which positions do not currently have coverage planned for future dates, if any. Minimum Complement Co-ordination Program automatically interfaces with the employee timesheet software to show future dates on which minimum complement employees have requested vacation. Supervisors can then easily see which adjustments are required to be made to ensure minimum complement is met.

3.4 CONDUCT OF OPERATION

3.4.(1) Issue: The plant expectation for equipment labelling is not consistently maintained to provide clear identification of equipment.

The team noted the following:

- Emergency coolant injection building – several labels on high pressure pumps were difficult to read because they were dirty or erased.
- Emergency coolant injection system –examples of informal information hand written on equipment.
- Emergency coolant injection system – an identification tag was found on the floor from equipment at a heater.
- Emergency coolant injection system – identification tag was found damaged and difficult to read on the valve.
- Auxiliary building – one valve from breathing air system (at the ceiling level) was tagged with metallic tag (aluminum) which was difficult to read.
- Auxiliary building – an electrical motor operating the fan of the containment ventilation system has neither identification label nor indication of the voltage on the connection box.
- Standby generator – a difficult to read label was found on a valve.
- Outside – missing labels on two electrical boxes outside the Unit 5 emergency control centre were found.

Without applying a consistent labelling practice, the risk of misidentification and inappropriate operation of equipment could increase and potentially lead to equipment damage, personnel injury and plant transient.

Suggestion: The plant should consider enhancing its practice for equipment labelling to consistently provide clear identification and status of equipment.

IAEA Bases:

SSR-2/2

7.12. The operating organization shall be responsible for ensuring that the identification and labelling of safety equipment and safety related equipment, rooms, piping and instruments are accurate, legible and well maintained, and that they do not introduce any degradation.

NS-G-2.14

5.1. A consistent labeling system for the plant should be established, implemented and continuously maintained throughout the lifetime of the plant. It should be ensured that the system is well known by the staff. The system should permit the unambiguous identification of every individual component in the plant. In addition to the labeling of plant components, labeling of the doors and compartments of the plant should be regarded as part of the same system.

5.2. The labeling standards used should be such as to ensure that the labels are suitable for the environmental conditions in the location in which they are to be mounted and that the equipment can be unambiguously identified. The format and placement of labels should allow the operators to identify the component quickly and easily and should prevent the easy or inadvertent removal or misplacement of labels.

5.3. The plant management should ensure that all valves, switches, breakers and components are labeled using the same labeling nomenclature as that prescribed in current design documents. Furthermore, operations procedures and documents should also reflect the same nomenclature. When discrepancies are found, they should be reported and corrected in accordance with the established procedure. To assist in the management of the labeling program, the number of discrepancies awaiting correction should be tracked and monitored.

5.4. Particular consideration should be given to the arrangement in the labeling system for the identification by operators of missing or necessary labeling and the process to ensure that the corresponding corrective action has been taken in a timely manner.

3.4(2) Issue: The plant housekeeping program is not always effective to support an appropriate working environment for the safety and reliability of the plant.

The team noted the following:

- On 254' elevation of Unit 8 reactor building, tools, gloves and plastic bags were found in the moderator collection pit.
- Inside Unit 8 reactor building, loose material and debris such as nuts, bolts and screws were found on the floor.
- On 289' elevation of Unit 8 reactor building, scaffolding pipe and attachment clamps were stored improperly on the floor.
- In both east and west purification room of Unit 8 reactor building, hoses, buckets and other materials were stored improperly on the floor.
- On 294' elevation of Unit 5 reactor auxiliary building, debris such as nuts and small thermal insulation material was found on the floor.
- Inside the screen house, debris was found under the conveyor.
- Inside the screen house a piece of pipe on its support was stored on the walkway between screens and the conveyor without temporary approval.
- On 254' elevation of Unit 4 turbine hall, some bags are improperly stored in the area of high pressure pumps.

Without an effective housekeeping program in the industrial zones and premises, the safety and reliability of the plant could be affected.

Recommendation: The plant should enhance its housekeeping program to support an appropriate working environment for safety and reliability of the plant.

IAEA Bases:

SSR-2/2
7.10. Administrative controls shall be established to ensure that operational premises and equipment are maintained, well lit and accessible, and that temporary storage is controlled and limited. Equipment that is degraded (owing to leaks, corrosion spots, loose parts or damaged thermal insulation, for example) shall be identified and reported and deficiencies shall be corrected in a timely manner.

NS-G-2.14
2.3. ...The following tasks, functions and responsibilities should be taken into consideration in determining the structure for the operations department:

- ...Verification of good housekeeping and material condition in the areas of the plant for which operations department is responsible.
-

3.1. The shift supervisor should manage plant operations on each shift and should be responsible for overall safety at the plant, protection and safety of personnel, coordination of plant activities and performance of the assigned shift. The responsibilities typically should include supervision of the shift personnel and direct control of plant operations in accordance with the operational limits and conditions and operating procedures. In addition, the responsibilities of the shift supervisor should normally be:

- ...To perform plant inspections to identify and correct problems involving the performance of personnel, policies and procedures, housekeeping, material conditions and hazards to personnel; to ensure that deficiencies are identified and corrective action is initiated.

4.36. Factors that should typically be noted by shift personnel include:

- …Indications of deviations from good housekeeping, for example the conditions of components, sumps, thermal insulation and painting, obstructions, posting of signs and directions in rooms, posting of routes and lighting, and posting and status of doors.

6.1 The equipment used by operation staff should be adequate to support the safe and reliable operation of the plant in all operating conditions and should be all maintained. Overall plant cleanliness, good lighting and good environmental conditions are important attributes of the operation of a plant and efforts should be made to maintain these.

6.20. Plant housekeeping should maintain good conditions for operation in all working areas. Working areas should be kept up to standard, well lit, clean of lubricants, chemicals or other leakage and free of debris; the intrusion of foreign objects should be prevented and an environment should be created in which all deviations from normal conditions are easily identifiable (such as small leaks, corrosion spots, loose parts, unauthorized temporary modifications and damaged insulation). The effects of foreign objects or the long term effects of environmental conditions (i.e. temperature effects or corrosion effects or other degradations in the plant that may affect the long term reliability of plant equipment or structures) should be evaluated as part the plant housekeeping program.

6.21. Administrative procedures should be put in place to establish and communicate clearly the roles and responsibilities for plant housekeeping in normal operating conditions, post-maintenance conditions and outage conditions. For all areas of the plant, it should be made clear who bears the responsibility for ensuring that an area is kept clean, tidy and secure. Operations personnel should periodically monitor housekeeping and material conditions in all areas of the plant and should initiate corrective action when problems are identified.

6.26. …When it is the practice at the plant to accept the retention of such equipment (i.e. disused) in work areas, the item of equipment should be clearly marked and should be covered by the housekeeping program…

3.4(3) Issue: The plant practice for identification and reporting of deficiencies does not consistently ensure that deficiencies are identified and reported in a timely manner.

The team noted the following:

- Leaks were observed at different locations in the plant listed below. About 25% of the leaks observed were not reported in the work request control system while the other leaks had work requests filed without a work request tag hung:
  - In Unit 8 reactor building, a large oil leak from the west fuel machine oil pack had created several litres in a pail and a puddle on the floor. The leak had not been reported.
  - In Unit 5, leaking steam was identified from the bolted joint of a boiler feed system motorized valve. This valve is included in the daily field operator rounds. There is evidence that the leak has existed for some time however no work request has been filed.
  - Inside the Unit 5 to 8 Screenhouse, water leaks from equipment were observed without work request tags hung and one leak was spraying on a junction box.
  - In the high pressure emergency coolant injection building, oil was found dripping from a few devices onto oil absorbing pads without a work request tag.
  - On Unit 4 boiler feed pump there was a leak from a flow gauge without a work request tag.
  - On Unit 8 auxiliary boiler feed water pump, there is an oil leak without a visible work request tag.
  - In the standby generator equipment room oil was found dripping from a few devices onto oil absorbing pads without a work request tag.
- Several instances of surface rust were observed on different components in the plant without a work request filed:
  - In the Unit 5 secondary control area there is a junction box that has surface rust on the top of it without a work request tag hung to show the deficiency has been identified.
  - In Unit 4, there are pipes for the generator hydrogen cooling service water supply that have obvious signs of surface rust.
  - In the Unit 4 reactor building on the high pressure service water system pipe, there are three elbows that have obvious signs of surface rust.
  - Traces of leaks and rust are evident on a building heating steam system valve.
- In the Unit 4 secondary control area there are overhead lights in poor condition. Half of the lights are absent or required to be changed out, but there is no work request filed.
- On Unit 6, a fire hose lying on the floor was observed to have several small cracks without a work request tag.

Without timely identification and reporting of deficiencies in the plant, the reliability of plant systems and equipment could be affected.

Recommendation: The plant should enhance its practice for identification and reporting of deficiencies to ensure that deficiencies are identified and reported in a timely manner.

IAEA Bases:

SSR-2/2

7.10. Administrative controls shall be established to ensure that operational premises and equipment are maintained, well lit and accessible, and that temporary storage is controlled and limited. Equipment that is degraded (owing to leaks, corrosion spots, loose parts or damaged thermal insulation, for example) shall be identified, reported and corrected in a timely manner.

NS-G-2.14
3.1. The shift supervisor should manage plant operations…In addition, the responsibilities of the shift supervisor should normally be: To perform plant inspections to identify and correct problems involving the performance of personnel, policies and procedures, housekeeping, material conditions and hazards to personnel; to ensure that deficiencies are identified and corrective action is initiated.

4.34. Rounds should be conducted regularly by the operators to identify actual and potential equipment problems and conditions that could affect the functioning of the equipment.
4.36. Factors that should typically be noted by shift personnel include:

- Deterioration in material conditions of any kind, corrosion, leakage from components, accumulation of boric acid, excessive vibration, unfamiliar noise, inadequate labelling, foreign bodies and deficiencies necessitating maintenance or other action;

6.1. …Overall plant cleanness, good lighting and good environmental conditions are important attributes of the operation of a plant and efforts should be made to maintain these.

6.20. Plant housekeeping should maintain good conditions for operation in all working areas. Working areas should be kept up to standard, well lit, clean of lubricants, chemicals or other leakage and free of debris; the intrusion of foreign objects should be prevented and an environment should be created in which all deviations from normal conditions are easily identifiable (such as small leaks, corrosion spots, loose parts, unauthorized temporary modifications and damaged insulation).

4. MAINTENANCE

4.4 PROCEDURES, RECORDS AND MAINTENANCE HISTORY

Since February 2016, a work report generator has been implemented to support maintenance work records in accordance with plant conduct of maintenance procedures. The program sets data input requirements based on the task attributes in the computerized maintenance management system. It also allows the user to select additional attributes, via check boxes, to identify the major aspects of the task such as pressure boundary, environmental qualification, and foreign material exclusion. This has increased the quality of maintenance records and reduced rework of reports. The team recognizes this as a good performance.

4.5 CONDUCT OF MAINTENANCE

The team identified that plant practices in maintaining workplace standards and local storage areas do not always provide appropriate conditions and therefore the safety of personnel and plant conditions could be put at risk. For example, during plant observations, spare parts and tooling were found in local storage areas with the risk of being damaged or damaging plant equipment. The team made a suggestion in this area.

4.6 MATERIAL CONDITION

The team noted that the plant has implemented a leak management program; however it is not fully implemented to support reliable and safe conditions for plant systems and components. Leak prevention strategies such as analyzing the root cause have not been implemented. The team made a recommendation in this area.

4.7 WORK CONTROL

The use of electronic flow sheets with a visual status of plant work control and equipment configuration was observed by the team. The interconnection of plant maintenance management system and the electronic flow sheets ensures that station staff has the most current information. Detailed notes can be retrieved, by clicking on the objects, to obtain a more detailed description of the mark-up. The team identified this as a good practice.

The team noted that the plant work control process is not always effective and efficient to ensure timely repair of system, structures and components. The backlog for both deficiencies and corrective maintenance is high and has not declined for several years. Several work orders were found exceeding their recommended time frame. The team made a recommendation in this area.

DETAILED MAINTENANCE FINDINGS

4.5. CONDUCT OF MAINTENANCE

4.5(1) Issue: The plant's practices in maintaining workplace standards and local storage areas do not always provide appropriate conditions for personnel and plant safety.

The team noted the following:

- In the valve and actuator workshop, new spare parts were stored together with previously used parts with the risk of being re-used. Further, O-rings for actuators were found stored in a manner that risks them being damaged and some were kept without proper packaging that would ensure their shelf life. Some had passed their expire date. Further, in the Fix-It-Now (FIN) team workshop and electrical breaker shop, spare parts, tools and other materials were stored unsorted.
- In the reactor building Unit 7, 254' elevation south accessible area, an air hose for breathing air was stored under scaffolding equipment with the risk of being damaged. In the same building near moderator heat exchangers 1 & 2, a scaffolding cart was stored blocking two fire extinguishers.
- In local storage areas it was identified that materials were stored on top of shelves without being properly fastened. Tooling was stored with the risk of being damaged, such as piping and generator stator cooling tooling. Personal protective equipment, chemicals, spare parts and tools were found stored together with inadequate housekeeping standards.
- Since 2014, several station condition reports had been raised due to improper equipment and materials storage.
- In the workplace for the main feed water pump, loose parts and materials were found on the floor. The workplace was classified as a Foreign Material Exclusion (FME) area 2, which is a standard FME risk area, with requirements for cleanliness. In reactor building 7, 254' and 274' elevations, small materials such as screws, nuts, and old gaskets were found under and near plant equipment. In the same building, beneath Unit 7 moderator system valve, a scaffolding pipe was left on the floor.
- Near the Unit 7 moderator heat exchangers an electric cable was found being used in a damaged socket. In one workplace near the condenser an adjustable wrench was left with the risk of falling. Poor lighting was noticed in some workplaces. In Unit 7, drain hoses that were routed on the floor sometimes posed a risk of tripping. On Unit 6, a drain hose was found in place blocking a fire extinguisher in two different locations.
- During insulation removal in Unit 7, two electric motors inside the workplace were not protected from insulation dust.
- In several workplaces, scaffolds were found with deficiencies such as touching piping and insulation e.g., on generator stator cooling system in Unit 7, in feed water chemical room 317 and Unit 7 reactor building 254' elevation.

Without maintaining maintenance workplace standards and local storage in appropriate condition the safety of personnel and plant equipment could be put at risk.

Suggestion: The plant should consider reinforcing its practices for maintaining workplaces and local storage areas to provide appropriate conditions for personnel and plant safety.

IAEA Bases:

SSR-2/2
Requirement 28:
The operating organization shall develop and implement programmes to maintain a high standard of material conditions, housekeeping and cleanliness in all working areas.

7.10. Administrative controls shall be established to ensure that operational premises and equipment are maintained, well-lit and accessible, and that temporary storage is controlled and limited. Equipment that is degraded (owing to leaks, corrosion spots, loose parts or damaged thermal insulation, for example) shall be identified, reported and corrected in a timely manner.

NS-G-2.6
8.32. The operating organization should ensure that storage facilities offer adequate space and provide for the secure retention of stocks in suitable environmental conditions, in order to prevent deterioration. Access and the installed handling equipment should be adequate for the types and sizes of items to be stored.

8.37. Items that have a limited shelf-life should, if not used, be replaced at the appropriate time in order to ensure suitability for the expected function when they are needed. Information on storage matters can be found in Safety Guide Q13 on Quality Assurance in Operation, in Ref. [2].

4.6 MATERIAL CONDITION

4.6(1) Issue: The plant leak management program is not fully implemented to support reliable and safe conditions for plant systems and components.

The plant has recently implemented a leak management program with clear expectations and categorizations of different leaks. The procedure has expectations when actions are needed and how different leaks should be reported and prioritized with respect to plant safety of system, structures and components.

However, the following facts were identified by the team:

- The plant has about 250 identified leaks per unit which have been classified by type of leak and the plant has focused on repairing the leaks. However, leak prevention strategies, such as analyzing the root cause, haven't been fully implemented. Moreover leaks are not consistently identified in the field and could therefore not be repaired and analyzed in a timely manner. For example:
  - In Unit 7, 254' elevation, an old oil leak was discovered from a moderator pump creating a puddle beneath it.
- Several old catch containers were noticed without any visible leaks. For example in Unit 7, 254' elevation near east fueling machine oil pack and behind primary heat collection system, old plastic catch containers were found.
- In other areas, catch containers were found without deficiencies being reported. For example, in Unit 8, at least 9 catch containment buckets with water were observed around the turbine generator.
- In Unit 6, an oil leak from the turbine lubrication oil system was drained to the floor without a catch containment.
- Numerous leaks in the plant have not been completed after several years and some have been completed but not closed out in the work management system, some of them are on critical components.

Without a fully implemented leak management program the safe conditions of the plant may not be supported.

Recommendation: The plant should enhance and fully implement its leak management program to support reliable and safe conditions for the plant systems and components.

IAEA Bases:

SSR-2/2
Requirement 28:
The operating organization shall develop and implement programmes to maintain a high standard of material conditions, housekeeping and cleanliness in all working areas.

7.10.Administrative controls shall be established to ensure that operational premises and equipment are maintained, well-lit and accessible, and that temporary storage is controlled and limited. Equipment that is degraded (owing to leaks, corrosion spots, loose parts or damaged thermal insulation, for example) shall be identified, reported and corrected in a timely manner.

4.35. Personnel assigned the task of carrying out rounds should be made responsible for verifying that operating equipment and standby equipment operate within normal parameters. They should take note of equipment that is deteriorating and of factors affecting environmental conditions, such as water and oil leaks, burned out light bulbs and changes in building temperature or the cleanness of the air. Any problems noted with equipment should be promptly communicated to the control room personnel and corrective action should be initiated.

4.36. Factors that should typically be noted by shift personnel include:
Deterioration in material conditions of any kind, corrosion, leakage from components, accumulation of boric acid, excessive vibration, unfamiliar noise, inadequate labelling, foreign bodies and deficiencies necessitating maintenance or other action;…

4.7 WORK CONTROL

4.7 (a) Good practice: Use of electronic flow sheets with a visual status of plant work control and equipment configuration.

Equipment Status Monitoring system is the officially approved information management system used for plant status control and work protection by maintenance and operations. It has many functions including the ability to electronically link work orders, deficiencies, different tags and others on the flow sheets.

Once the flow sheet has been retrieved and shown on the computer screen, information such as work orders, work requests and station control tags are documented in red on components in the flow sheet to stand-out.

The interconnection of plant maintenance management system and Equipment Status Monitoring system ensures station staff has the most information of what can be seen on the flow sheet. Detailed notes can be retrieved, by clicking on the objects, to obtain a more detailed description of the mark-up.

The main benefits of the program:

- Provides station staff a visual status of plant equipment and its equipment configuration electronically.
- Electronically link forms, tags and flow sheets for plant status control and work protection to get an overall picture.
- Interconnects with other programs to display work requests, work orders and master equipment list items associated with the flow sheet.

4.7.(1) Issue: The plant work control process is not always effective and efficient to ensure timely repair of system, structures and components.

The plant has several key performance indicators (KPI), for the work control process such as work schedule adherence, schedule completion and backlog for both corrective and deficient maintenance work orders. The work order backlogs are monitored daily by the plant, however the actual value is not meeting the KPI target and shortfalls exist regarding the control of work priorities. The following facts were identified by the team:

- The total backlog of deficiencies and corrective work orders for both online and outage work is 3287 and has not declined for several years
  - 61 work orders with priority 1 (highest priority) were not completed within the limit time frame. 21 of these were on critical 1 component.
  - 1142 work orders with priority 2 (schedule within 3 weeks) were not completed within the limit time frame. 307 of these were on critical 1 components.
- In the plant scorecard for work management, a KPI exists for corrective maintenance backlog. The quantity target is set to 55 online corrective work orders per unit; however no correlation is stated to work priority and its age. In relation to this, no KPI exists to ensure that work orders with high priority are done within their recommended time frame.
- Many work orders have not been completed for several years and can be found in the field, for example:
  - Boiler feed water pump 7 and 6, several old work orders exist due to leaks and one open temperature element connection.
  - Boiler auxiliary feed water pump 5 had an old work request from 2012, due to missing glass on temperature gauge.
  - Work order for the risk of a crane hoist hitting a pipe for breathing air in reactor building 8 has not been completed since 2011.
- Out of 15960 completed work orders, 57 % were prioritized as priority 1 (highest priority) and priority 2 (schedule within 3 weeks). Out of these, 40 % were not completed within the recommended time.
- The corrective maintenance for a heat transport pump gland filter replacement was set as priority 2, although this is critical to plant performance. The actual work was executed as a priority 1 with break plan (immediate action).

Without an effective and efficient work control process, the planning and prioritization can result in untimely repair of important systems, structures and components and have implications on plant safety.

Recommendation: The plant should enhance its work control process to ensure that system, structures and components important to safety are repaired in a timely manner.

IAEA Bases:

SSR-2/2
8.14. Corrective maintenance of structures, systems and components shall be performed as promptly as practicable and in compliance with operational limits and conditions. Priorities shall be established, with account taken first of the relative importance to safety of the defective structures, systems and components.

NS-G-2-6
5.14. A comprehensive work planning and control system applying the defence in depth principle should be implemented so that work activities can be properly authorized,

scheduled and carried out by either plant personnel or contractors, in accordance with appropriate procedures, and can be completed in a timely manner. The work planning system should maintain high availability and reliability of important plant SSCs.

5.18. Management of the work should be recognized as a cross-functional process, not exclusive to any one work group but integrating the important activities of all work groups. Consequently, for the work control process to be fully effective, all needs and concerns in relation to operations, maintenance, technical support, radiation protection, procurement and stores, contractors and other matters should be considered and should be accommodated wherever appropriate, consistent with the long term operating strategy for the plant.

5.19. The effectiveness of the work control process should be monitored by appropriate indicators (such as repeated work orders, individual and collective radiation doses, the backlog of pending work orders, interference with operations) and by assessing whether corrective action is taken whenever required.

5. TECHNICAL SUPPORT

5.1. ORGANIZATION AND FUNCTIONS

Engineering division has implemented an effective project controls system to manage the work of engineering staff and vendors. A strong resource management system has been established. This system ensures trained and capable engineering resources are available to the plant in a timely manner. The team recognized this as a good performance.

5.2. PERIODIC SAFETY REVIEW

The plant is performing a Periodic Safety Review (PSR) as a prerequisite for license renewal and in support of an evaluation of the potential to extend commercial operations of the plant beyond 2020. The scope of the plant PSR covers only aspects of plant operation regulated under the site power reactor operating licence. The Pickering Waste Management Facility and Western Waste Management Facilities are not included in the PSR as both operate under a separate licence. The plant should consider initiating performing PSR for Pickering Waste Management Facility and Western Waste Management Facilities. The team made a suggestion in this area.

5.5. USE OF PSA

The team recognized the extensive use of probabilistic safety assessment (PSA) applications at the plant for at power and shutdown conditions. PSA is used for risk-informed decision making in procedures, design changes and/or plant modifications to manage risk during planned or unplanned maintenance when the unit is online or in outage and for prioritization of maintenance. In addition to the use of PSA in everyday activities, the plant developed the methodologies for identifying and addressing potential seismically-induced internal fires and seismically-induced internal flooding. The team recognized this as a good performance.

5.6. SURVEILLANCE PROGRAMME

The plant surveillance programme is based on the industry standard process for equipment reliability. Surveillance test intervals and test strategies are derived through sensitivity assessment of the PSA. The performance engineering department trends the results of surveillance test data from operational testing and maintenance activities. Adverse trends are documented using the station condition record (SCR) process and unexpected test results are reviewed and analyzed by reactor safety and system engineering.

The plant should act more proactively in resolving problems related to the reliability of the fuel handling equipment. The team made a recommendation in the HTO area.

5.7. PLANT MODIFICATION SYSTEM

The plant has a robust engineering change control process that is well documented and used on a consistent basis to ensure that any design changes are not completed without ensuring that all operating documentation are updated. Design changes are uniquely tracked in a plant software program to provide traceability of the changes in the design documentation to work packages in the field and to procurement of materials. The team recognized this as good performance.

DETAILED TECHNICAL SUPPORT FINDINGS

5.2 PERIODIC SAFETY REVIEW

5.2(1) Issue: The scope of the current plant Periodic Safety Review (PSR) does not include Pickering Waste Management Facility and Western Waste Management Facilities to ensure a comprehensive review.

The team observed the following:

- The current plant PSR review does not include review of Pickering Waste Management Facility and Western Waste Management Facilities.
- The Pickering Waste Management Facility and Western Waste Management Facilities are not covered under the plant operating license. These facilities have separate operating licenses.
- The plant performed an Integrated Safety Review (ISR) in 2000 to support restart of Units 1 and 4. To support extended operation to 2025, an ISR for Unit 5-8 was performed in 2009. These two ISRs did not include Pickering Waste Management Facility and Western Waste Management Facilities.

Without performing PSR for Pickering Waste Management Facility and Western Waste Management Facilities the plant will miss the opportunity to continuously improve in this area.

Suggestion: The plant should consider initiating PSR for Pickering Waste Management Facility and Western Waste Management Facilities.

IAEA Bases:

SSR-2/2
4.44. Safety reviews, such as the periodic safety reviews or alternative arrangements shall be carried out throughout the lifetime of the plant, at regular intervals and as frequently as necessary, typically no less frequently than once in 10 years. Safety reviews shall address, in an appropriate manner, the consequences of the cumulative effects of plant aging and plant modification, equipment requalification, operating experience, including national and international operating experience, current national and international standards, technical developments, and organizational and management issues, as well as site related aspects. Safety reviews shall be aimed at ensuring a high level of safety throughout the operating lifetime of the plant.

4.46. The scope of the safety review shall include all safety related aspects of an operating plant…

SSG-25
2.7. The length of the review process will depend on the availability and retrievability of relevant information and the organizational structure of the operating organization. To provide a timely input, the PSR should be completed within three years, and normally less for the second or subsequent PSRs.

2.12. A PSR should provide a comprehensive assessment of the safety of the nuclear power plant. Since the complex process of conducting a PSR can be aided by appropriate subdivision of tasks, this Safety Guide sets out these tasks in accordance with 14 safety factors.... In cases where the number of safety factors used and/or their grouping is different (for example, to meet the specific needs of the operating organization or regulatory body or owing to particular aspects of the nuclear power plant under review), the comprehensiveness of the PSR should be ensured by other means....

2.17. In order to integrate the results of the reviews of individual safety factors, the operating organization should perform a global assessment of safety at the plant. The global assessment should consider all findings and proposed improvements from the safety factor reviews and interfaces between different safety factors.

4.1. The scope of the PSR should include all safety aspects of a nuclear power plant and should be agreed with the regulatory body. The review should cover all facilities and SSCs on the site covered by the operating licence (including, if applicable, waste management facilities, on-site simulators, etc.) and their operation, together with the operating organization and its staff.

4.7. The PSR should apply all relevant national safety regulations and standards. Other requirements such as international safety standards and operating practices, and national or international guides should be met to the fullest extent practicable…

6. OPERATING EXPERIENCE FEEDBACK

6.2. REPORTING OF OPERATING EXPERIENCE

The station condition record process is well established at the plant and identified by the staff and the contractors as the means to document an adverse condition. However, the station does not have a unified system for monitoring deficiencies. Not all deficiencies are reported in the Station Condition Report (SCR) database. In the SCR database, findings from field observations are not recorded. Some defects are fixed in the form of work orders. They are processed directly for corrections and are not considered for the plant summary trending of all deficiencies. Event and failures are not analyzed in their entirety and the precursors of significant events may not be identified on time. The number of identified near miss events is at a low level. The team encourages the plant to review and improve in this area.

6.3. SOURCES OF OPERATING EXPERIENCE

The plant is a member of the CANDU Owners Group (COG). COG collects events and lessons learned from its members, combines these with relevant operating experience (OPEX) drawn from different sources, and compiles the resulting events into a weekly OPEX agenda that is distributed to all COG members. The plant systematically reviews the weekly COG OPEX agenda for applicable and actionable items. The team recognizes this as a good performance.

6.5. INVESTIGATION AND ANALYSIS

The methodology used for evaluations varies based on the type of event and evaluation that is required and the preference of the evaluator carrying out the investigation is considered. For all root cause investigations, a recurrence control action is required. Apparent cause evaluations require an action that reasonably addresses the found apparent causes with the intent to prevent similar events in the future. Following investigations, all event resolution category A/B/C, significant level 1&2 are reviewed by the corrective action review board to ensure the correct root/apparent causes were found. The team found that some event analyses are not performed in a timely manner or with a sufficient level of detail. In some cases it was observed that not enough 'why's were asked before identifying the cause. Without an in-depth identification of the root causes of events, their recurrence cannot be prevented. The team made a suggestion in this area.

6.6. CORRECTIVE ACTIONS

The evaluating organization manager works with the evaluator to develop the corrective action plan. The corrective action plan is entered in the SCR database by the evaluator, and the actions migrate to a common database. The plant evaluates the effectiveness of corrective actions that have been implemented by performing an evaluating organization effectiveness review (EOER). This action is used to prompt a self assessment EOER 6 months after the last recurrence control (RC) action is complete. This is to verify that the actions were completed as written and intended, and that the effects of the actions were successful in correcting the underlying issue. The team observed that the corrective action program is not fully effective in ensuring development and implementation of corrective actions in timely manner. Without implementation of appropriate corrective actions in a timely manner the plant is missing opportunities to prevent recurrence of events. The team made a recommendation in this area.

6.8. TRENDING AND REVIEW OF OPERATING EXPERIENCE

Departments produce quarterly trend reports using inputs specific to their line of business (SCRs, other databases, industry information). These reports are used to provide input to the Nuclear Safety Culture Monitoring Panel. Ongoing trending is performed weekly by the Performance Improvement department using SCR data. Additionally, selected parameters are monitored through the cornerstone meetings with oversight for associated corrective actions. However, the thresholds for identification and evaluation of adverse trends are not clearly defined. The senior leadership team does not review the quarterly trend reports for awareness of identified low-level trends. The team encourages the plant to review and improve in this area.

DETAILED OPERATING EXPERIENCE FEEDBACK FINDINGS

6.5. INVESTIGATION AND ANALYSIS

6.5(1) Issue: The plant practice for investigation and analysis of events does not always ensure that causes of events are identified correctly in a timely manner.

During the review the team noted:
- In 2015 and 2016 a total of 15 Apparent Cause Evaluations (ACE) and Root Cause Analysis reports (RCA) were returned for revision by the Corrective Action Review Board (CARB). The following deficiencies were identified: not adequate analysis of organizational factors; not enough “WHYs” asked to get to the root cause; Recurrence Control (RC) action too narrow; analysis not sufficient; analysis not deep enough in change management; Operating Experience (OPEX) review incomplete and apparent cause weak.
- There are adverse trends of Corrective Action Program (CAP) Health Performance Indicators: Timely Completion of Category A, B Significance Level 1&2 Evaluations; Timely Completion of Category C Significance Level 1&2 Evaluations and Timely Completion of Category C Significance Level 3 Evaluations. Actual values exceed established annual targets.
- The timeline to complete the Correction Action Plan is the following: resolution for category A/B is 42 days and resolution for category C2 is 35 days. Currently there are 2 extended evaluations of category C2 events.
- The recent B2 evaluation for cable contact was not analysed on time.
- Apparent cause evaluations of significant level 3 event "Failed Turbine Test (unplanned outage)" was returned for revision by the CARB.
- The root cause for the Unit 4 boiler tube wall loss event wasn't identified.
- CAP health performance indicator "Effectiveness of Significance Level 1&2 Station Condition Report (SCR)" for August 2016 is 84%. This value is under the target value 88% for the year.
- Recurrence of events is assessed for events in category A and B, for which RCA is developed. It is not done for events in category C, for which ACE is developed.
- An analysis of external OPEX is required only for Significance Level 1&2 station condition reports. For significance level 3, only the Fleet wide OPEX searches are required.

Failure to identify the causes of events correctly and in a timely manner may lead to repeat events.

Suggestion: The plant should consider enhancing its practice for investigation and analysis of events to ensure that causes of events are identified correctly in a timely manner.

IAEA bases:

SSR-2/2
5.28. Events with safety implications shall be investigated in accordance with their actual or potential significance. Events with significant implications for safety shall be investigated to identify their direct and root causes, including causes relating to equipment design, operation and maintenance, or to human and organizational factors.

NS-G-2.11

4.1. The IAEA Safety Requirements publication on Safety of Nuclear Power Plants: Operation (2) states in para. 2.21 that "Operating experience at the plant shall be evaluated in a systematic way. Abnormal events with significant safety implications shall be investigated to establish their direct and root causes. The investigation shall, where appropriate, result in clear recommendations to the plant management, which shall take appropriate corrective action without undue delay. Information resulting from such evaluations and investigations shall be fed back to the plant personnel."

4.7. Event analysis should be conducted on a timescale consistent with the safety significance of the event.

5.2. The development of recommended corrective actions following an event investigation should be directed towards the root causes and the contributory causes, and should be aimed at strengthening the weakened or breached barriers that failed to prevent the event.

5.3. Recommendations on corrective actions should be proposed on the basis of the feedback of either internal or external information and should be identified prior to or as a result of a thorough analysis of an event.

6.6. CORRECTIVE ACTIONS

6.6(1) Issue: The plant's corrective action programme does not consistently ensure that effective corrective actions are developed and implemented promptly.

During the review the team noted:
- In August 2016, 17 out of 37 (45%) Significance Level 1&2 RC actions were extended or overdue. Average value for last 12 months is 30 %.
- In one case, during normal operation, digital control computer 1 (DCC1) stalled and a loss of both channel 1 and channel 2 command monitors took place. One of the contributing causes was not completing the recommended actions from previous assessments.
- In another case, during normal operation, a shutdown system channel tripped spuriously on heat transport high temperature while another shutdown system channel was in the opened state for planned maintenance, resulting in a partial liquid poison injection. The other shutdown system automatically tripped the reactor and resulted in a 9-day forced outage. The causes were similar to another event that happened 4 years before and not all actions were completed.
- During normal operation, several cases of unavailability of fuelling machine due to equipment issues and lack of fuel handling staff within a nine-day period resulted in unplanned power decrease to 85%. The apparent cause was ineffective preventive maintenance. Aging of a component was a contributor. Known problems with parts obsolescence were not corrected in a timely manner.
- Corrective action plan for event on heat transport system collection tanks across Units 5-8 was ineffective in preventing recurrence of the event. The same event occurred on Unit 8 in May 2014. Corrective action in 2011 was to replace a valve only on Unit 7. Evaluating Organization Effectiveness Review (EOER) was completed in 2016. Effectiveness review found actions not effective, requiring new actions to be generated.
- Root cause analysis of cable contact event was approved 2 months after the event. One month after approval it was reviewed by CARB and identified that the corrective action will not prevent similar events and new actions are required.
- When reviewing the SCR database, it was found that corrective measures are not always effective: EOERs concluded that CAPs of equipment availability events were ineffective.
- EOER for significance level 3 events is not required in plant procedure.
- No measures for similar events are in place to monitor the impacts of delayed implementation.

Without prompt and timely implementation of a corrective action and rigorous assessment of its effectiveness the plant is missing opportunities to prevent recurrence of events.

Recommendation: The plant should enhance timeliness and effectiveness of corrective actions.

IAEA bases:

SSR-2/2
4.37 The appropriate corrective actions shall be determined and implemented as a result of the monitoring and review of safety performance. Progress in taking the corrective actions shall be monitored to ensure that actions are completed within the appropriate timescales. The completed corrective actions shall be reviewed to assess whether they have adequately addressed the issues identified in audits and reviews.

5.30 As a result of the investigation of events, clear recommendations shall be developed for the responsible managers, who shall take appropriate corrective actions in due time to avoid any recurrence of the events. Corrective actions shall be prioritized, scheduled and effectively implemented and shall be reviewed for their effectiveness. Operating personnel shall be briefed on events of relevance and shall take the necessary corrective actions to make their recurrence less likely.

GS-G-3
6.71. Senior management should ensure that corrective actions are subject to approval, prioritized and completed in a timely manner, on the basis of their significance.

NS-G-2.11
5.7. A tracking process should be implemented to ensure that all approved corrective actions are completed in a timely manner…
1.8.(4) The relevant corrective actions are implemented promptly enough to prevent the recurrence of similar events that could be caused by underlying root causes of the same category;.

7. RADIATION PROTECTION

7.1 ORGANIZATION AND FUNCTIONS

The international standard dose limits for occupational workers are followed at the plant, except the limits for the lens of the eyes. Considering that there are studies to manage this question all over the world, the team encourages the plant to review and adopt the international standard limit of dose for the lens of the eyes in a timely manner.

7.2. RADIATION PROTECTION POLICY

Since early 2015, the plant has implemented use of remotely controlled radiofrequency technology to simulate radiation environments. The use of technology has been employed in Dynamic Learning Activities to simulate radiological conditions, including gamma and contamination hazards, and detector response without the need of radioactive sources.

The main benefits include a safe learning environment since no real radiation hazards exists at the scenario, allows workers to perform in a simulated radiation area with detailed preparation to improve the training objective and results, and permits the workers to clearly understand the radiation exposure and radiation of contaminated materials. The team recognizes this as a good practice.

7.3. RADIATION WORK CONTROL

Radiation work performed at the plant is controlled by a combination of engineered controls such as barriers and locked access, administrative controls such as procedures and instructions or postings, cultural controls related to the workers behaviours and supervision controls made by the radiation protection officers. However, there were observed instances when the layout of the working area did not provide effective barriers against the spread of contamination; postings and labels did not indicate the existing radiation and contamination levels; worker practices revealed knowledge gaps and inconsistent applications of standards when performing and measuring hazards in radiological contaminated areas. The team made a suggestion in this area.

7.4. CONTROL OF OCCUPATIONAL EXPOSURE

The ALARA plan and respective radiation exposure permits are created to allow qualified radiation workers to perform work safely in a radiological controlled area. However, the collective radiation exposure at the plant is on an increasing trend compared to the last three years and there are insufficient meaningful indicators to track and trend the plant's performance regarding radiological safety. Alarm set points are set much higher when compared to the actual levels at the working areas, which hinders prompt detection of radiation level changes to prevent unnecessary dose. In addition, the situational awareness of the workers is challenged by the absence, in some instances, of effective visible indication of radiation hazards and respective levels. The team made a recommendation in this area.

DETAILED RADIATION PROTECTION FINDINGS

7.2. RADIATION PROTECTION POLICY

7.2 (a) Good practice: Simulation of radiological conditions during learning activities system.

Since early 2015, the plant has implemented use of remotely controlled radiofrequency technology to simulate radiation environments. The use of technology has been employed in dynamic learning activities to simulate radiological conditions, including gamma and contamination hazards and detector response, without the need for radioactive sources.

Main benefits:

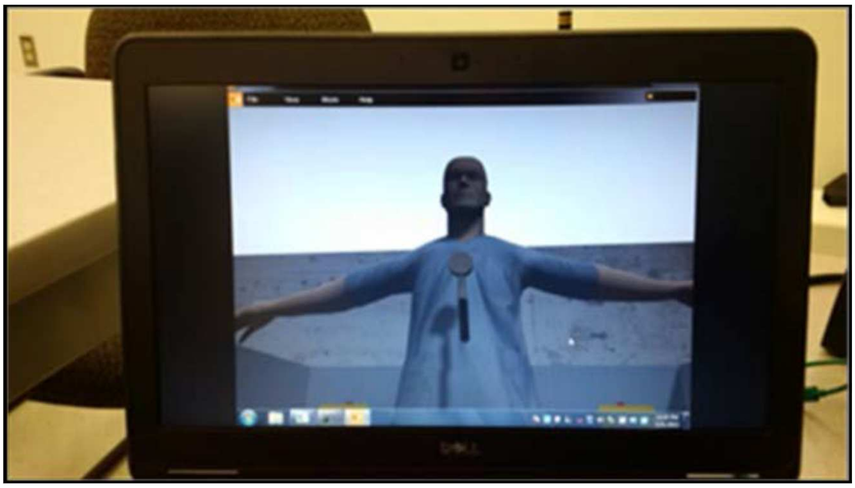
1. Provide a safe learning environment since no real radiation hazards exists at the scenario.
2. Allow workers to perform in a simulated radiation area with detailed preparation to improve the training objective and results.
3. Permit the workers to clearly understand the radiation exposure and radiation of contaminated materials.

Dynamic Learning Environment Room

Dosimeter operated by radiofrequency

Simulated gamma meter and radiofrequency remote control

Simulated pancake probe and radiofrequency remote control



Phantom simulating a worker to be monitored

7.3. RADIATION WORK CONTROL

7.3(1) Issue: The practices of some plant personnel are not always consistent to effectively control and fully understand the radiation hazards to plant personnel.

The team noted the following:

- During a decontamination task, several times a worker changed his top contaminated glove, without using the frisker or beta monitor to measure its contamination level. In another instance, the worker removed his contaminated gloves placing them over the desk, near the procedure datasheet. Only later were the gloves placed in a bin.
- A worker used the frisker incorrectly to assess the contamination, using the fast mode and wrong scale.
- A worker smeared the floor with a masslin tissue and when detecting a peak of counts in a point, simply threw the tissue in a bin without characterizing a possible discrete radioactive particle.
- A person in the rubber area of reactor building at Unit 7 touched his head with the rubber gloves when trying to adjust his mask.
- The removal of contaminated protective clothing bags is gamma monitored in contact with a point of the bag, and beta radiation is surveyed at the bottom of the bag. However, no radiation levels are indicated on the bags. In the same manner, the car-boxes transporting bags of used protective clothes are not posted with a radiation symbol and existing radiation levels.
- One worker was observed reaching his hand into Zone 3 to secure a trolley (about 20 cm into the Zone 3) while standing in Zone 2 area in Reactor Auxiliary Bay.
- A technician removed a plastic bag from inside the radioactive laboratory without passing it through small article monitor.
- A personal contamination event happened on 16 September 2016, when a worker carried a discrete radioactive particle internally to his lapel, in contact with the skin. The dose was assessed by the health physicist; however, the information is not complete in the plant's database, so it could not be used as operating experience to coach the workers about this possible event.
- The area layout for the primary sampling system at reactor building Unit 5 does not have a bin to collect contaminated gloves and used tissues, no table or hanger to mark up the procedure, and no physical barrier to avoid cross contamination.
- On 12 May 2016, according to a station condition report (SCR), two employees, while conducting a walk down on elevation 254', by mistake entered a radiation area without appropriate personal protective equipment and qualifications. There was a lack of physical barrier, lack of attention to details and lack of situational awareness in an error-likely situation.
- When sampling the primary system inside the Unit 5 - reactor building, the technician filled the procedure in his hand, in front of the panel, instead to retracting to a low dose area.
- A radiation posting fell to the floor and remained at the base of the shielding. Even after being asked to record the instance, RP personnel did not question that condition and left the posting as it was.

Without consistent radiation work control, integration of good working practices, correct use of monitoring instrumentation and detection techniques, radiation safety of the workers in the field may not be ensured.

Suggestion: The plant should consider enhancing its radiation protection practices consistently to fully understand and effectively control the radiation hazards at the plant.

IAEA Bases:

GSR Part 3
2.52. The … parties having specified responsibilities in relation to protection and safety… shall support good performance and good practices to prevent human and organizational failures, by ensuring among other things that:
(a) Sound ergonomic principles are followed in the design of equipment …, so as to facilitate the safe operation and use of equipment, to minimize the possibility that operator errors could lead to accidents, and to reduce the possibility that indications of normal conditions and abnormal conditions could be misinterpreted.
(i) …To reduce, as far as practicable, the possibility that human errors or inadvertent actions could give rise to accidents or to other incidents leading to the exposure of any person;…
3.94. Employers, registrants and licensees, in consultation with workers, or through their representatives where appropriate:
(d) …Shall ensure that any work in which workers are or could be subject to occupational exposure is adequately supervised and shall take all reasonable steps to ensure that the rules, procedures, and measures for protection and safety are observed;
(e) Shall designate, as appropriate, a radiation protection officer in accordance with criteria established by the regulatory body.
3.97. The type and frequency of workplace monitoring:
(b) …Shall be based on dose rate, activity concentration in air and surface contamination, ...

RS-G-1.1
4.22. Experience with a particular situation … This experience may be qualitative (e.g. the observation that the frequency of occurrence of minor contamination may have increased) or quantitative (e.g. a trend in the results of monitoring programmes)… This review should have the objectives of extracting appropriate lessons for any future operations and determining whether additional measures are needed to improve the current protection arrangements.

NS-G-2.7
3.13. Before items are removed from any contamination zone, and in any case before they are removed from controlled areas, they are required to be monitored as appropriate (Ref. [2], para. I.23) and suitable measures should be taken to avoid undue radiation hazards.
3.19. Three types of workplace monitoring and individual monitoring should be conducted for radiation protection purposes:
(b) …task related monitoring should generally be conducted to supply information about a particular task or operation and to provide, if necessary, a basis for immediate decisions on the execution of the task;
3.27. Special surveys may be undertaken to meet specific problems, for example, if high levels of airborne contamination or loose surface contamination are suspected, or when routine monitoring reveals unusual or abnormal conditions such as the occurrence of an area of elevated activity (also called a hot spot).

7.4. CONTROL OF OCCUPATIONAL EXPOSURE

7.4(1) Issue: The plant's radiation protection practices and ALARA controls are not effectively integrated to allow further reduction and to optimize the plant's personnel doses.

The team noted the following:
- Collective Radiation Exposure (CRE) – no visible reduction of CRE in online mode and the CRE for outage is presenting an adverse trend compared to the last three years.
- The ALARA control at the plant has no indicators regarding the trends of task's doses per person-hours, collective radiation exposure per person-hours (which could indicate the reduction of average dose rate or the need for corrective actions); trends for individual dose distribution over the years (which could indicate an effective dose reduction or the need for corrective actions).
- The plant has no clear written procedures to define how to set dose and dose rate alarms for radiological jobs.
- At the plant, the radiological exposure permit uses "Hazard Limits and Back Out Conditions", fixed limit for dose and dose rate for electronic personal dosimeters alarms, which does not reasonably reflect the actual dose and dose rates existing at the working areas for all the observed instances. Possible abnormal changes of radiation exposure at the working area could go unnoticed and prevent prompt corrective actions to avoid unnecessary dose.
- There are several hot spots (at least 3 in the first room of reactor building Unit 5) inside the zone 3 (equivalent to the controlled area), posted at the entry and at the hot spot point. However, there is no indication of the existing dose rate on the postings.
- Prior to being loaded (when at the waste facility), boxes containing low-level radioactive material do not clearly indicate the current dose rates and have no radiation symbols. The absence of radiation level information reduces the worker´s situational awareness.
- Beside the teledosimetry facility, there is a warehouse for storage of contaminated RP materials. There is a radiation symbol posted at the entry point. However, the entrance is not fenced to avoid unauthorized and or inadvertent access.

Limited meaningful indicators, no reasonable setpoint for alarms based on existing radiological conditions and cases of low standards of performance to identify and control radiation hazards in the field hampers the plant's efforts to minimize both collective and individual doses.

Recommendation: The plant should effectively integrate radiation protection practices and ALARA controls to proactively detect abnormalities, clearly identify and correct radiation risks, in order to minimize plant personnel doses.

IAEA Bases:

GSR Part 3
2.10. For all exposure situations, each party with responsibilities for protection and safety shall ensure, when relevant requirements apply to that party, that protection and safety is optimized.
3.77. Employers, registrants and licensees:
(b) Shall establish and use, as appropriate, constraints as part of optimization of protection and safety.
3.83. Workers:
(b) Shall use properly the monitoring equipment and personal protective equipment provided;

(e) Shall abstain from any wilful action that could put themselves or others in situations that would not be in accordance with the requirements of these Standards;

RS-G-1.1

4.13. As stated in the BSS (Ref. [2], para. 2.25):

"The process of optimization of protection and safety measures may range from intuitive qualitative analyses to quantitative analyses using decision aiding techniques, but shall be sufficient to take all relevant factors into account in a coherent way …"

4.17. The BSS definition [Ref. [2], Glossary] of 'dose constraint' states: "For occupational exposures, dose constraint is a source related value of individual dose used to limit the range of options considered in the process of optimization." …

4.18. The objective of a dose constraint is to place a ceiling on values of individual dose from a source, a set of sources in an installation, a practice, a task or a group of operations in a specific type of industry — that could be considered acceptable in the process of optimization of protection for those sources, practices or tasks.

4.19. To apply the optimization principle, individual doses should …with the appropriate dose constraint. Options … to give doses above the dose constraint would normally be rejected. Dose constraints should not be used retrospectively to check compliance with protection requirements.

4.20. Dose constraints should be used prospectively in optimizing radiation ... They should therefore be set on a case-by-case basis according … exposure situation. Since dose constraints are source related, the source to which they relate should be specified.

4.21. … For occupational exposure, the experience with well managed operations is of particular importance in setting constraints, as it should be for implementing the optimization principle in general. ...

RS-G-1.3

3.8. For supervised areas … In any case, individual monitoring for the purpose of dose records may be considered good practice for all workers in a supervised area.

NS-G-2.4

6.37. … Maintenance activities should be planned … while keeping the exposure of personnel ALARA.

NS-G-2.7

2.19. Operational considerations for a dose control programme include the actions … to optimize doses to workers involved in routine operation, maintenance, repairs, refueling, plant modifications, in-service inspection and waste management (the handling, transfer, storage and disposal of radioactive waste) ...

2.30. The requirements for optimization …. set targets such as a target for work to be performed with specified goals (in terms of doses, person hours, time) ...

2.31. … encourage site personnel to maintain a questioning and learning attitude to protection and safety, … discourage complacency by means of a safety policy implemented at the plant… encouraged by fostering a safety culture, enhances and supports the safety actions and interactions of managers, supervisors and personnel involved in … the safety of the plant.

Workers should also be committed and … motivated to adopt good practices in radiation protection and radioactive waste management. …

3.27. Special surveys may be undertaken to meet specific problems … such as the occurrence of an area of elevated activity (also called a hot spot).

3.43. Preparation of the work area may be necessary, for example by: cordoning it off and posting warning signs; …, additional radiation monitors, temporary radiation shielding ....
3.44. ... Information and instructions that may be given in the RWP in addition to a description of the work would include for instance:

(a) details of average dose rates and possible areas of elevated activity in the working area on the basis of a survey made prior to the work or otherwise estimated;

(b) estimates of contamination levels and how they might change in the course of the work;
(e) possible restrictions on working time and doses;

3.67. … consideration of the optimization of radiation protection is required … Methods of dose reduction that should be considered include:

(c) reducing working time in controlled areas;

8. CHEMISTRY

8.1. ORGANIZATION AND FUNCTIONS

Chemistry programme governance is provided by the corporate office. Corporate participates within relevant external nuclear organizations to assure the implementation of national and international industry operating experience in its activities. Corporate provides the chemistry programme and scientific and strategic support on-site and off-site. However, the interface between corporate chemistry and site chemistry with regard to competences and management responsibilities is not clearly established. The team encourages the plant to review and improve in this area.

8.2. CHEMISTRY PROGRAMME

The design of the heat transport system and the secondary side includes materials such as zirconium, carbon steel, stainless steel and nickel-copper alloys. The applied chemistry programme must respect the different chemical behaviour of these materials. The plant chemistry programme is not comprehensive enough to provide an effective evaluation of plant operational chemical conditions and assessment of chemical data. For example, the chemistry programme was slightly changed to reduce the deposition of magnetite on fuel bundles. However, the influence of the change on the integrity of the system is not comprehensively monitored as the transport of the single corrosion products (Fe, Ni, and Cu) is not measured. The team made a recommendation in this area.

The plant equipment conditions and plant processes to maintain chemistry parameters do not always support reliable and safe plant operation. For example, in two steam generators of Unit 4, outer diameter tube wall losses at several tubes were found during routine inspection by the plant. A detailed analysis performed by the plant and external expertise revealed denickelification due to acidic attack. The team made a recommendation in this area.

The chemistry quality control programme is implemented by adequate corporate and site procedures. A separate quality assurance group is assigned to its proper application. The group has its own manager. The team recognized this as a good performance.

Housekeeping in the reactor building service water sampling hut and some other sampling points do not meet the standards; the team encourages the plant to improve in this area.

The control of auxiliary chemicals and substances is not always effective to preserve the integrity and availability of the plant systems. For example, rolls with labels were observed not controlled in the chemical storage area of the turbine hall and in the air conditioning equipment room in the service wing. The team made a suggestion in this area.

8.2(1) Issue: The chemistry monitoring programme is not sufficiently comprehensive to provide an effective evaluation of plant operational chemical conditions and assessment of chemical data.

During the review the team noted:

- The pH in the Heat Transport System (HTS) was slightly increased to reduce the deposition of magnetite on fuel bundles. The influence on the integrity of the system is not comprehensively monitored as the release and transport of single corrosion products (Fe, Ni, and Cu) are not measured.
- Denickelification due to acidic attack contributed to the degradation of steam generators. However, the Hide Out Return (HOR) modelling did not include organic acids, which are decomposition products of morpholine.
- Responsibilities for assessment of long term and short term trend analysis are clearly assigned, however the frequency is not effective as evidenced by some heat transport system parameter trends and outliers.
- The plant measures airborne total carbon-14 and inorganic carbon-14 in the stacks. In some cases data for inorganic carbon-14 exceeded the value of total carbon-14, which is not possible. It was found that one time the two values were mixed, however for other data pairs there was no explanation.

Without an effective evaluation of plant operational chemical conditions and appropriate assessment of chemical data, adverse trends and errors may not be corrected in a timely manner.

Recommendation: The plant should improve its chemistry monitoring programme to provide an effective evaluation of plant operational chemical conditions and assessment of chemical data.

IAEA Bases:

SSR-2/2

7.13 The chemistry programme shall be developed prior to normal operation and shall be in place during the commissioning programme. The chemistry programme shall provide the necessary information and assistance for chemistry and radiochemistry for ensuring safe operation, long term integrity of structures, systems and components, and minimization of radiation levels.

7.14 Chemistry surveillance shall be conducted at the plant to verify the effectiveness of chemistry control in plant systems and to verify that structures, systems and components important to safety are operated within the specified chemical limit values.

SSG-13

3.4. In the chemistry programme, it should be ensured that: (a) A suitable chemistry regime exists and is in accordance with the original design and material intent, and account is taken of any structural modifications or operating experience at the plant or at other plants.

4.39. Impurity levels, in particular those of corrosion products, chloride ions and fluoride ions, should be kept within specified limits.

4.47. The influence of chemistry control on the integrity of the steam generator should be evaluated. The main tools for such an evaluation are: (b) The evaluation of 'hideout return' effects (the levelling of concentrations) during at least some of the shutdowns for refuelling;
5.13. Corrosion processes should be monitored, trended and controlled.

6.2. The objectives of a chemistry surveillance programme are: (b) To maintain the availability of structures, systems and components; (c) To detect and thus permit early corrective action for any abnormal chemistry condition before it becomes a consequence significant for safety;

6.5. Trending should be included in the surveillance programme in order to check if relevant control and diagnostic parameters are within the accepted limits.

6.19. In determining the analytical methods to be employed, expected concentration levels should be considered for the chemistry parameter of interest. The method chosen should provide sufficient sensitivity in the expected concentration range.

7.3. Analytical data should be reviewed to verify their completeness, accuracy and consistency. To identify actual and potential problems, assessment of chemistry data should commence promptly after the data have been recorded, depending on the importance and potential consequences of any deviation.

7.6. Data should be compared with operational limits and the evaluation and trending of data should be carried out to assess the efficiency of chemistry control, to identify inconsistencies in analytical data and adverse trends in chemistry conditions and to help in optimizing chemistry in the plant systems.

7.8. Trends should be reviewed soon after data have been recorded, in order to identify problems that may need corrective action before a parameter exceeds its specified limit.

8.2(2) Issue: The plant equipment conditions and plant processes to maintain chemistry parameters do not always support reliable and safe plant operation.

During the review the team noted:

- The indicator for chemistry hours out of specification is improving but still trending adversely over target, e.g. calandria vault dryer unavailability influences this indicator; the calandria vault humidity has a strong influence on corrosion processes in the vault.
- The quarterly calculated WANO CPI for all six units in operation is greater than the WANO target of 1.0 since at least 2014 (except unit 4 in Q2 2016).
- In two steam generators outer diameter tube wall losses at several tubes were found during routine inspection.
- The steam generators of unit 1 and units 5-8 were chemically cleaned in 1994/1995 and beginning 2000 respectively. Unit 1 was also waterlanced in 1994/95. However, chemical cleaning of the steam generators of unit 4 was deferred several times and then subsequently cancelled; the steam generators were waterlanced in 2000. During the chemical cleaning in unit 1 approximately 6700 kg of sludge were removed.
- Steam generator drain duration at the plant sometimes deviates from industry recommended standards. Steam generators have been drained longer than the 40 days as recommended by industry.
- A review of data showed that the concentration of corrosion inducing anions in the HTS is usually very low and far below limit values. However, single excursions of sulphate and fluoride have occurred.
- In unit 5 and Unit 7 reactor buildings, adhesive material and pen markings were found on liquid zone control system stainless steel piping.

Without maintaining optimal chemistry parameters, the long-term safe and reliable plant operation may be affected.

Recommendation: The plant should enhance its equipment conditions and plant processes to provide an optimal chemistry state for the continued safe and reliable plant operation.

IAEA Bases:

SSR-2/2

7.13 The chemistry programme shall be developed prior to normal operation and shall be in place during the commissioning programme. The chemistry programme shall provide the necessary information and assistance for chemistry and radiochemistry for ensuring safe operation, long term integrity of structures, systems and components, and minimization of radiation levels.

7.14 Chemistry surveillance shall be conducted at the plant to verify the effectiveness of chemistry control in plant systems and to verify that structures, systems and components important to safety are operated within the specified chemical limit values.

SSG-13

3.4. 4.12. During outages, equipment should be maintained under adequate lay-up conditions (e.g. dry lay-up, wet lay-up with a high pH, or normal operating water conditions) by means of chemicals or nitrogen, depending on the lay-up duration, and in accordance with safety requirements.

4.49. If necessary, an effective cleaning procedure should be applied to remove deposits that promote corrosion.

8.2(3) Issue: The control of auxiliary chemicals and substances is not always effective to preserve the integrity and availability of the plant systems.

During the review the team noted:

- Rolls with labels (red, yellow, green) were observed uncontrolled in the chemical storage area of the turbine hall and in the air conditioning equipment room in the service wing.
- Lubricant oil for safety related systems is delivered with a certificate of the supplier; however there is no independent identity check upon receipt implemented in plant procedures, although there is operating experience regarding incorrect receipt of lubricating oil for the plant's conventional systems.
- During a walk down some chemicals were found decanted without labels.
- In the chemical storage area of the turbine hall several instances of chemicals with no expiry date or already expired, were identified (e.g., Loctite, paint).
- In the control maintenance calibration shop at the service wing in a cabinet some 25 different auxiliary chemicals were identified either without an expiry date or already expired.

Without effective control of auxiliary chemicals and substances the integrity and availability of the plant systems cannot be assured.

Suggestion: The plant should consider enhancing the control of auxiliary chemicals and substances to preserve the integrity and availability of plant systems.

IAEA Bases:

SSR-2/2
7.17 The use of chemicals in the plant, including chemicals brought in by contractors, shall be kept under close control. The appropriate control measures shall be put in place to ensure that the use of chemical substances and reagents does not adversely affect equipment or lead to its degradation.

SSG-13
9.2. The operating organization should be responsible for the use of the proper chemicals and for their correct quality.
9.8. When receiving chemicals, the specified quality should be verified by chemical analysis and/or by a certificate and a chemical identification test.
9.9. Chemicals and substances should be labelled according to the area in which they are permitted to be used, so that they can be clearly identified. The label should indicate the shelf life of the material.
9.10. When a chemical is transferred from a stock container to a smaller container, the latter should be labelled with the name of the chemical, the date of transfer and pictograms to indicate the risk and application area.
9.12. Staff involved in receiving, storing, transporting and using chemical substances should be trained to understand storage compatibility, labelling requirements, handling, safety and impacts on structures, systems and components at the plant (see Section 8).

9. EMERGENCY PREPAREDNESS AND RESPONSE

9.2. EMERGENCY RESPONSE

The team found that the overall emergency response arrangements of the plant are robust. The plant has implemented an improvement program for about three years. Moreover, the relationship with off-site authorities is particularly healthy. In the Emergency Preparedness area, there are 7 memoranda of understanding and 2 response arrangements with off-site authorities. To reinforce this relationship, a dedicated member of the "Emergency Preparedness" department meets the Provincial point of contact every week in their office in Toronto. The plant also acts proactively with the Region of Durham to ensure a well-prepared and coordinated response in case of all kinds of emergencies; the team recognized this as a good performance.

In 2015, the plant, in a proactive partnership with off-site authorities, completed a potassium iodide (KI) pill distribution campaign with positive feedback from the public. This program also ensures that new residents who move into the primary zone are provided with the KI pills and information on a continuous basis. The team recognized this as a good practice.

The notification of an emergency situation to the Province is the responsibility of the Shift Manager. He/she is responsible to perform the notification within 15 minutes after the event is categorized. Prior to the categorization, he/she has to make the classification of the event; there are no specific time requirements for classification and categorization. The team encourages the plant to review these and make sure classification and categorization are made in a timely manner.

9.3. EMERGENCY PREPAREDNESS

The plant has implemented a list of performance criteria and requirements. The plant's schedule for exercises and drills do not ensure all objectives will be tested over time and the follow-up improvement actions to be taken are not systematic nor sufficiently comprehensive. The team made a suggestion in this area.

DETAILED EMERGENCY PREPAREDNESS AND RESPONSE FINDINGS

9.2. EMERGENCY RESPONSE

9.2(a) Good practice: The Potassium Iodide (KI) Pill Distribution Campaign was proactively organized and, will ensure new residents who move to the primary zone of the plant will continue to be included in the distribution.

In 2015, the plant, in a proactive partnership with off-site authorities completed, a KI distribution campaign which includes positive public awareness benefits and a sustaining program to ensure new residents who move into the zone are provided with the KI pills and information.

The plant campaign began in January 2015 with the first focus groups established in the primary zones. The intention was for focus groups to know about KI pills and emergency planning, but mainly about what they would think if a box of radiation-blocking pills suddenly landed on their doorsteps.

Results obtained from the focus groups helped to form the basis of a two-part communications strategy for pre-distribution and distribution campaigns. Pre-distribution was a focused and intensive education campaign that raised public awareness of KI distribution by explaining why it is taking place, and what it means. The distribution campaign utilized product packaging to improve the public’s understanding of when and how to use the KI pills.

The KI packages were sized to easily fit in medicine cabinets, with frequently asked questions and user instructions printed on the front. All of the information and the pills are in one easy-to-read package.

Pre-distribution took place from 4 September 2015 to 1 October 2015. It included a letter to all homes and businesses, newspaper and out-of-home advertising, a targeted Twitter campaign, a traditional media and social media outreach and an independent website (www.preparetobesafe.ca).

Then, the distribution of an over-packaging (uniquely coloured packaging) took place in October 2015. It was supported by ongoing advertising, an enhanced website, a social media campaign and community information sessions. The public information campaign also included ‘open house’ sessions for residents

A sustainability program was also set. Public access continues to be available through requests to a dedicated website and public information sessions continue. Moreover, the plant has set a specific agreement with Canada Post so that ‘New Neighbours’ are identified 3 times per years by the postal service and provided information packages including residential KI distribution.

9.3. EMERGENCY PREPAREDNESS

9.3(1) Issue: The plant's arrangements for exercises and drills do not ensure all objectives will be tested over time and the follow-up improvement actions to be taken are not systematic nor sufficiently comprehensive.

The team noted the following:

- According to the procedure about emergency preparedness drills and exercises all the major elements of the emergency plan should be tested every five years, with a full scale integrated exercise every three years. The list of these major elements was implemented in 2015 based on a 373 demonstration criteria list.
  There are also some requirements for having particular scenarios, such as Transportation Emergency Response Plan (TERP) drills and exercises, Radioactive Liquid Emergency Team (RLET) or notification drills and exercises.
  Nevertheless there is no 5-year established plan for drills and exercises at the moment to cover all these criteria and requirements.

- The multi-unit exercise conducted in November 2015, was suspended for lunch. The exercise was scheduled and began at 9:08 AM. This suspension doesn't allow the exercise to be performed in a realistic manner and to measure the completion of performance criteria such as the transfer of command and control from the Shift managers to the Site Management Center (SMC). The planning of exercises and drills has to respond to several constraints such as provincial labour regulation or turnover of the different crews, nevertheless some specific arrangements could be made in order to keep the scenario as realistic as possible.

- In the last performed Emergency Response Organization (ERO) availability test (9 May 2015), the Technical Support Manager (TSM) did not respond to the MIR3 (Activation System for Emergency Response Organization) notification within the required time. It was later determined that the on-duty TSM had been in the plant at the time of the drill, the gap was not counted because it is assumed, in a real event, that ERO staff would respond to their facility on the tones (as it is foreseen in the performance measure system). Nevertheless, it means that the drill doesn't test whether personnel respond to the tone.

- The feedback of drills is not systematic and sufficiently comprehensive:
  - Operations teams perform a Self-Assessed Crew Practice (SACP) twice a year. However the summary report is not mandatory and some are empty of any comment.
  - The report of the last performed drill for the response to the MIR3 notification, doesn't list the different time of arrival for each position. It doesn't allow trending of performance data.
  - The report of the full site assembly and accounting drill of April 2014 doesn't provide sufficient details about the number of people in each assembly area or the number of people present on site when the drill was launched. It does not describe in which conditions the drill was done and the organization was tested.
  - After each drill, exercise and event, a report is written which includes SCRs and opportunities for improvement. It also includes gaps that were coached on the spot. These last gaps are not registered in the SCR system. There is no general review to determine if, through individual issues, a wider issue should be raised.
    - During the event of 21 November 2014, an Emergency Shift Assistant (ESA) was coached on 2 tasks on MIR3. In the drill of 25 November 2015, an ESA

    had problems with the MIR3 software system. Despite these occurrences, only personal coaching actions were completed.
  - The last occurrence of a station emergency (in November 2014) lasted 24 hours. However, there is no mention about a turnover of the ERO shift in the report.
- The level of expectation for a regular participation to an exercise or drill can be improved:
  - The procedure for emergency preparedness drills and exercises, establishes that each crew has to perform an evaluated drill once a year. Crew B from Units 1 and 4, and crew D from Units 5 to 8 have not been scheduled to take part in a drill for at least 3 years.

Without appropriate arrangement for drills, exercises, and rigorous continuous improvement, the effectiveness of the plant response in emergency situations could be impacted.

Suggestion: Consideration should be given to improve arrangements for drills and exercises, and rigorously identify and implement improvement opportunities from all drills and exercises.

IAEA Bases:

SSR-2/2
4.34. Self-assessment by the operating organization shall be an integral part of the monitoring and review system. The operating organization shall perform systematic self-assessments to identify achievements and to address any degradation in safety performance. Where practicable, suitable objective performance indicators shall be developed and used to enable senior managers to detect and to react to shortcomings and deterioration in the management of safety.

4.35. Monitoring of safety performance shall include the monitoring of: personnel performance; attitudes to safety; response to infringements of safety; and violations of operational limits and conditions, operating procedures, regulations and licence conditions. The monitoring of plant conditions, activities and attitudes of personnel shall be supported by systematic walkdowns of the plant by the plant managers.

5.6. The emergency plan shall be tested and validated in exercises before the commencement of fuel loading. Emergency preparedness training, exercises and drills shall be planned and conducted at suitable intervals, to evaluate the preparedness of plant staff and staff from external response organizations to perform their tasks, and to evaluate their cooperation in coping with an emergency and in improving the efficiency of the response [1, 6].

GSR part 7
Requirement 19
6.18. The appropriate responsible authorities shall ensure that:
... *(d) Account is taken* in the content, features and extent of emergency plans of the results of any hazard assessment and any lessons from operating experience and from past emergencies, including conventional emergencies....
6.30. Exercise programmes shall be developed and implemented to ensure that all specified functions required to be performed for emergency response, all organizational interfaces for facilities in category I, II or III, and the national level programmes for category IV or V are tested at suitable intervals. These programmes shall include the participation in some exercises of, as appropriate.

6.36. Arrangements shall be made to maintain, review and update emergency plans, procedures and other arrangements and to incorporate lessons from research, operating experience (such as in the response to emergencies) and emergency exercises.

6.38. The operating organization and response organizations shall make arrangements to review and evaluate responses in actual events and in exercises, in order to record the areas in which improvements are necessary and to ensure that the necessary improvements are made.

NS-G-2.8.
4.32. A training programme for emergencies should be established to train and evaluate plant staff and staff from external emergency response organizations in confronting accident conditions, coping with them and maintaining and improving the effectiveness of the response. Emergency preparedness exercises should be designed to ensure that plant staff and staff from other participating organizations possess the essential knowledge, skills and attitudes required for the accomplishment of non-routine tasks under stressful emergency conditions [7].

4.33. While the emergency assignments of plant personnel are based on their routine job assignments for normal operation, they should also receive specialized training relevant to the duties they will have to perform in an emergency. The purpose of this training should be:
- to demonstrate how effectively an emergency plan, or part of it, can be implemented;
- to confirm the adequacy of the plan to deal with the emergency and to identify potential improvements;
- to verify that the appropriate lines of communication are established and maintained;
- to verify that all individuals participating in the exercise are familiar with, and capable of performing, the emergency duties assigned to them;
- to verify that emergency response and all related duties can be carried out in a timely manner according to the planned schedule and in stressful situations.

NS-G-2.14.
2.20. Periodic self-assessments should be carried out to reinforce high standards of performance and to identify areas for improvement. Corrective measures should be developed and implemented in a timely manner, on the basis of the results of the self-assessments and evaluations.

10. ACCIDENT MANAGEMENT

10.2. OVERVIEW OF THE SEVERE ACCIDENT MANAGEMENT PROGRAMME

The plant has a well-established severe accident management programme. This programme has been developed using insights from the full scope level 2 Probabilistic Safety Assessment (PSA) study that was done previously.

The severe accident domain was initially defined for accidents occurring at-power operating modes for a single unit. For other operating modes and for the irradiated fuel bay, severe accidents were assumed as being very unlikely. The accident progression starting from those states is likely to take considerably more time and as a result, more mitigating options and strategies may be available. Nevertheless, the related preventive actions were captured in the emergency operating procedures. A systematic review of operating experience was conducted and identified items applicable to updates of generic and plant-specific Severe Accident Management Guidelines (SAMG). As a result, the management of severe accidents originated from shutdown units, and at the irradiated fuel bay have recently been added to the SAMG as well.

The plant has six operating units. Events induced by beyond design basis external hazards such as large earthquakes could affect several units at the same time. Consequently, SAMGs must consider the possibility of accidents occurring concurrently in more than one unit. There are additional challenges that may impact the plant with multiple units connected to the same containment structure and using shared safety systems. In the event of a station blackout (SBO), enhancements and new portable emergency mitigating equipment (EME) with a set of fixed connections points were made available to allow removal of decay heat by prompt provision of emergency make-up water.

The plant has recently modified its SAM guidelines and background documents to enhance its capabilities to manage multi-unit accidents. Based on the revisions to the SAMG background documents supplementary guidance has also been created to assist the SAM Technical Support Group in determining the optimal overall recovery strategy and prioritization of response in the event of severe accidents on multiple units.

These recent enhancements are considered by the team as a good performance as they help to increase the scope of the managed severe accidents and to ensure the robustness of severe accident management.

10.3. ANALYTICAL SUPPORT FOR SEVERE ACCIDENT MANAGEMENT

For multi-unit plants, severe accident consequence analysis is not straightforward. The proper modelling of the concurrent transients, the connected containment systems, and the use of shared safety systems with explicit modelling of the interconnections between the different units is essential. A unique tool, a Severe Accident Software Simulator (SASS) has recently been developed for explicit modelling of multi-unit severe accidents. This simulator has enhanced the capabilities of the originally used software code to allow up to six parallel runs with different initiating events to model the concurrent but staggered accident development in the units. The team noted the application of this simulation tool as a good practice.

10.6. VERIFICATION AND VALIDATION OF PROCEDURES AND GUIDELINES

Validation of the different SAMG components is carried out during exercises and drills that are initiated in response to a major simulated radiological scenario that require invoking the SAMGs. Validation of recently introduced SAMG updates has not yet been completed.

A detailed habitability assessment has been performed for the plant locations from where the monitoring, control measures, valve operations and any other crucial accident management actions are carried out. To date, none of the validation exercises has taken into account the possible site habitability or environmental conditions that would be created by an extreme external event and by the eventual containment venting.

The team made a suggestion to update the validation of accident management procedures and guidelines to better reflect the complexity of the severe accidents.

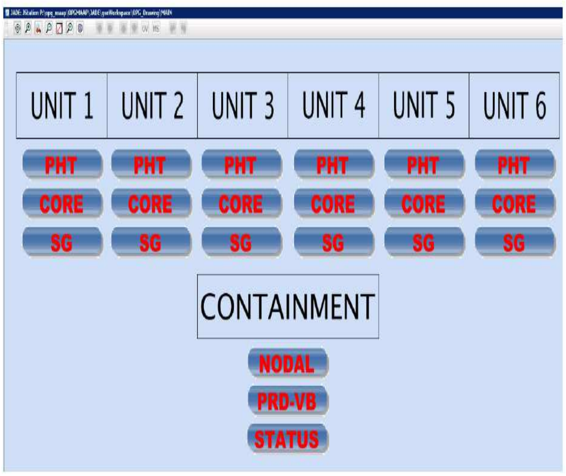
10.3. ANALYTICAL SUPPORT FOR SEVERE ACCIDENT MANAGEMENT

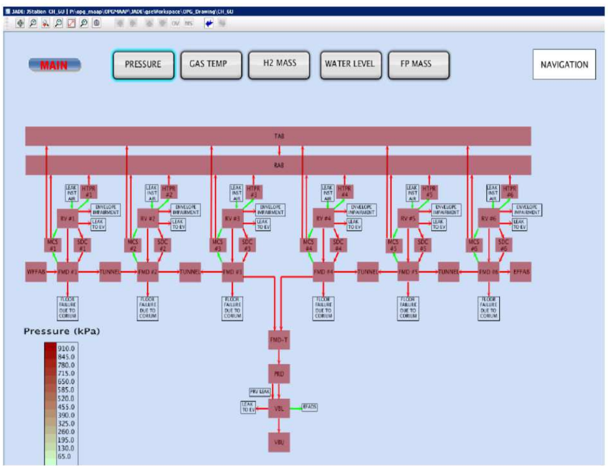
10.3(a) Good practice: Severe Accident Software Simulator application for supporting multi-unit severe accident management guideline development.

For multi-unit plants, severe accident consequence analysis is not straightforward. In accordance with recent practice, these types of analyses are usually carried out in a simplified manner by linear combination of the results of separate single-unit analyses with certain time shifts. Under these circumstances, the proper modelling of concurrent transients, connected containment systems, and the use of shared safety systems, etc., is not possible. For the purpose of the analytical support of severe accident management guideline, development of explicit modelling of the interconnections of the different units is essential.

A Severe Accident Software Simulator (SASS) has recently been developed, as a first-of-a-kind tool for explicit modelling of multi-unit severe accidents. This simulator has enhanced the capabilities of the originally used software code to allow up to six parallel runs with different initiating events to model the concurrent but staggered accident development in the units. The tool is able to properly synchronise the parallel runs and take into account any interconnections that are caused either by any common caused events, by shared safety systems or by the interconnected containment systems. In this way, the assessment of the accident progression timing, in-vessel retention, the containment behaviour, hydrogen generation, filtering and venting capabilities and instrument survivability is optimized and realistic.

The plant has recently modified its Severe Accident Management Guidelines (SAMG) to enhance its capabilities to manage multi-unit accidents. The development of this guidance was supported by a previous version of the multi-unit consequence analysis, which has now been confirmed by the results of SASS. Going forward, SASS will provide additional capabilities to assess more complex multi-unit scenarios, whose results will be used to further improve the SAMGs. This unique tool will also be applied for the whole-site level 2 probabilistic safety assessment, which is an ongoing activity at the plant.





10.6. VERIFICATION AND VALIDATION OF PROCEDURES AND GUIDELINES

10.6(1) Issue: The current state of the validation of the Accident Management (AM) procedures and guidelines does not address all parts of AM and does not take into account all the possible site habitability and environmental conditions.

Validation of the severe accident management guideline components is an ongoing activity at the plant and carried out during scheduled drills and exercises.

However, the team gathered the following observations:

- A detailed habitability assessment has been performed for the plant locations from where the monitoring, control measures, valve operations and any other crucial accident management actions are carried out. The assessment concluded that proper habitability of those places is ensured by the successful and timely termination of the severe accident in early stage before extensive core damage and the failure of the calandria vessel occur. If the severe accident were to develop any further, then the required control measures such as valve operations and monitoring could be performed during short temporary stays and may require application of additional actions to protect personnel.
- To date, none of the validation exercises have taken into account the possible site habitability or environmental conditions that would be created by extreme external events and by the eventual containment venting.
- The In-Vessel Retention (IVR) strategy is the cornerstone of the plants strategy in severe accidents. In all past drills, IVR was assumed to be successful. However, there is limited experimental validation of the effectiveness of the late phase In-Vessel Retention. As a result, some uncertainty may still exist regarding the IVR strategy, which is being addressed by on-going and future research and development projects.
- Validation of all the Severe Accident Management Guidelines (SAMG) components has not yet been completed. The shutdown operating events and accidents at the irradiated fuel bay were already captured in the emergency operating procedures but have just been recently added to the SAM guidelines. None of the drill scenarios to date for SAMG validation has used these guidelines**.**

Without further extension of the validation it is not possible to confirm that all the actions specified in the procedures and guidelines are effective.

Suggestion: The plant should consider updating the validation of its AM management procedures and guidelines and consider all the possible site habitability and environmental conditions.

IAEA Bases:

NS-G-2.15
2.29. The overall form of the guidance and the selected amount of detail should be tested in drills and exercises. Based on the outcome of such drills, it should be judged whether the form is appropriate and whether additional detail or less detail should be included in the guidance.

3.53. In the development of procedures and guidelines, account should be taken of the habitability of the control room and the accessibility of other relevant areas, such as the technical support centre or areas for local actions. It should be investigated whether expected dose rates and environmental conditions inside the control room and in other relevant areas may give rise to a need for restrictions for personnel. It should be determined what the impact of such situations will be on the execution of the accident management programme…

3.96. The accessibility and habitability of the physical locations of the teams of evaluators and implementers as well as of the emergency director under severe accident conditions should be checked and maintained.

3.100. All procedures and guidelines should be validated. Validation should be carried out to confirm that the actions specified in the procedures and guidelines can be followed by trained staff to manage emergency events.

3.101. …Scenarios should be developed that describe a number of fairly realistic (complex) situations that would require the application of major portions of the EOPs and the SAMGs. The scenarios encompass the uncertainties in the magnitude and timing of phenomena (both phenomena that result from the accident progression and phenomena that result from recovery actions).

3.109. Exercises and drills should be based on appropriate scenarios that will require the application of a substantial number of procedures and guidelines...

11. HUMAN, TECHNOLOGY AND ORGANIZATION INTERACTIONS

11.1 INTERFACES AND RELATIONSHIP

Senior executives and leaders provide clear expectations and direction that emphasize nuclear safety. Processes and procedures that govern day-to-day activities translate those expectations and direction into usable tools for employees. Programs implementing the integrated nuclear management system are frequently assessed for potential improvements and any needed changes are implemented accordingly.

The leadership team and employees are aligned around the plant vision and goals. Leaders effectively communicate the common vision of excellence to their respective teams. During the visit, cross-functional teamwork was frequently observed, contributing to improved performance in many areas.

The plant has fostered a strong relationship with stakeholders and interested public. A community advisory council, representing a cross-section of external stakeholders and plant personnel, meets frequently to collegially discuss matters of interest to the community and to promote plant and neighbourhood relations. A community-based program, promoting environmental stewardship, arts and culture, and Indigenous teachings, has provided over 16000 local youths with learning and leadership development opportunities. These initiatives also increased the public awareness of nuclear power. The team recognized this as a good practice.

11.3 CONTINUOUS IMPROVEMENT/LEARNING ORGANIZATION (MONITORING AND ASSESSMENT)

A Nuclear Safety Review Board (NSRB), comprised of senior, nuclear-experienced individuals, provides independent, critical assessments of safety performance at the plant. Meeting once per year, and with a mid-year follow-up, the NSRB reports their findings and recommendations to the Chief Nuclear Officer and the company board of directors. The team recognized this as a good performance.

The plant has strong self-assessment and benchmarking programs. Multidiscipline teams conduct in-depth reviews, and programmatic strengths and areas for improvement are identified. The team recognized this as a good performance.

The team identified several issues (e.g. general housekeeping and storage, leaks, and ALARA practices) that could be addressed, in part, with improved management observations. The plant is encouraged to review and improve their management observation program to ensure observers are appropriately critical during field observations.

In some cases, the plant's actions to drive continuous improvement were not effective in minimizing the challenges to operational safety. The team made a recommendation in this area.

11.4 SAFETY CULTURE

Leaders frequently communicate and reinforce safety as the highest priority. Discussion and use of nuclear safety culture traits is ingrained in the organization's day-to-day activities. Cross-functional teamwork is strong and embodies the safety traits. A Nuclear Safety Culture Monitoring Panel (NSCMP), consisting of plant managers and supervisors, assesses trends and potential issues related to the plant's nuclear safety culture. The NSCMP meets quarterly to review emerging issues that could impact nuclear safety culture and to ensure potential or actual issues are appropriately addressed. The NSCMP reports its findings to the plant leadership team.

During field observations, the team witnessed some positive safety culture attributes. Supervisors and workers were observed effectively using human performance error prevention tools to help ensure error-free performance of tasks. At the worksite, staff frequently demonstrated a good questioning attitude when unexpected conditions or circumstances arose, safely stopping to seek clarification. Supervisors were quick to reinforce good behaviours with positive feedback.

In contrast, the team observed a few behaviours that impact the overall positive safety culture. Challenges in addressing some longstanding issues such as maintenance backlogs, old temporary changes, and work protection events remain. In some cases, the plant may not have applied appropriate oversight and resources to effectively resolve those issues. Also, performance metrics sometimes portray an overly optimistic view of current or future performance and are not always rigorously challenged by the plant team.

DETAILED HUMAN, TECHNOLOGY AND ORGANIZATIION INTERACTION FINDINGS

11.1 INTERFACES AND RELATIONSHIPS

11.1 (a) Good practice: The plant has fostered a longstanding positive relationship with community partners to develop young leaders and improve environmental stewardship and awareness.

Since 2006, the plant has sponsored a community-based educational and leadership development program reaching over 16000 community members. Held at a local park adjacent to the plant site, "Tuesday's on the Trail" capitalizes on partnerships established between the plant and the local community to provide a unique opportunity for families to experience a fun, interactive and educational program focused on environmental stewardship, arts and culture, and Indigenous teachings. The program provides an additional forum for the plant to educate the public on their operations.

In addition, the program provides mentoring and leadership development opportunities for local high school students. These volunteers engage younger participants by assisting in delivery of the programs and serving as role models to participants. Many of the mentors are returning participants who went through the program themselves. This provides them with the opportunity to further grow as leaders and transfer knowledge and experience to subsequent participants. This will help develop community leaders and mentors for future generations.

Community partners participating in the program include a local university, a theatre group, an arts council, a museum, an Aboriginal group, and the national conservation foundation. These partners help to develop diverse educational and leadership development programs for families with school aged children.

Applicability to others: The identification of specific partnerships focused on education and leadership development opportunities for younger community members fosters foundational support by future generations. The program reinforces a plant's commitment to their host communities, demonstrates shared values, strengthens valuable relationships and partnerships, and increases the public awareness of nuclear power.

11.3 CONTINUOUS IMPROVEMENT/LEARNING ORGANIZATION (MONITORING AND ASSESSMENT)

11.3(1) Issue: Continuous improvements in some important areas are not effectively pursued to ensure challenges to operational safety are minimized.

Overall plant performance has improved in a number of areas in the past several years. Reductions in the number of plant trips and improved adherence to risk assessed schedules have decreased some challenges to operational safety.

However, the team noted improvement opportunities in some areas impacting operational safety:

- Fuel handling machine reliability:
  - The current fuel handling equipment reliability index is 60 versus a year-end projection of 75. The index has declined from a January 2016 value of 64 and has been in the upper 50's most of the year.
  - One of the main contributors to unplanned unit power derates is fuel handling machine reliability. These power derates have contributed to 74 percent of reactivity management index deductions from August 2015 to August 2016.
  - One of the main contributors to outage extension is fuel handling machine reliability. In the case of the most recent Unit 8 outage, fuel handing machine reliability contributed to approximately 21 days of outage extension.
  - During the team visit, Unit 1 experienced fuelling machine out of service time due to an elevator stall and Unit 4 was derated following a hydraulic leak from the fuelling machine "Y" drive main pump.
  - During the team's walkdown of the Unit 8 reactor building several oil leaks were identified in different parts of the fuel handing machine.
  - Fuel handling machine reliability related events:
    - In February 2016, the plant experienced two failures involving fuelling machine..
- Maintenance backlogs:
  - The on-line deficient critical and non-critical maintenance backlog is currently 295 items per unit. The year-end projected value is 196 items per unit. During the year, the backlog has gone up from 251 to 295 items per unit. It will be challenging to reach the goal of 196 items per unit by year-end with the current plans in place to reduce the existing backlog and additional incoming work.
  - The on-line corrective critical and non-critical maintenance backlog is currently 120 items per unit. The year-end projected value is 55 items per unit. During the year, the backlog has only been reduced by five items per unit. It will be challenging to reach the goal of 55 items per unit by year-end with the current plans in place to reduce the existing backlog and additional incoming work.
  - In 2016, 120 plant reliability list items have been completed through September. The year-end goal is 200 completions. Eighty items need to be completed in the last three months to meet the goal, twice the year to date completion rate.
- Outage planning and execution:
  - All planned outages since 2014 have been extended to various degrees. The most recent Unit 8 outage was extended for 90 days. Additionally, the extension of the Unit 4 outage resulted in 69 days of overlap between Unit 4 and Unit 8, causing resource challenges for outage execution in both units.

– In 2015, the plant accumulated over 12,000 hours of out-of-specification time for various chemistry parameters. The plant target for daily chemistry out-of-specification time is 20 hours per day. During the first two weeks of the team visit, the plant did not meet its daily chemistry out-of-specification goal on any day. The team made a recommendation in the chemistry area to enhance equipment conditions and plant processes to optimize chemistry states.

Without fully implementing effective improvement plans, challenges to plant operational safety may not be minimized in some important areas.

Recommendation: The plant should continue to aggressively pursue improvements in areas that directly impact plant operational safety.

IAEA Bases:

GSR Part 2
Requirement 2:
Managers at all levels in the organization, taking into account their duties, shall ensure that their leadership includes.
3.2 (a) Setting goals for safety that are consistent with the organization's policy for safety, actively seeking information on safety performance within their area of responsibility and demonstrating commitment to improving safety performance.
Requirement 4:
4.5 Senior management shall ensure that goals, strategies and plans are periodically reviewed against the safety objectives, and that actions are taken where necessary to address any deviations.

SSR-2/2
Requirement 9:
The operating organization shall establish a system for continuous monitoring and periodic review of the safety of the plant and of the performance of the operating organization.

GS-G-3.1
6.4 The management system should ensure that standards of performance are established. These standards should be directly related to the product provided by the organization and based on the objectives set by senior management. Once the standards have been established, performance should be measured against them. These measurements should be monitored at regular intervals to ascertain whether or not improvements in the quality of the product or processes are necessary.

NS-G-2.4
3.21 Where it is reasonable, the goals and objectives of all management levels should be measurable and stated in terms that allow measurement of progress and clear determination of achievement. They should be challenging, realistic and focused on specific improvements in performance, and should be limited in number to prevent dilution of efforts in key areas. They should be communicated, understood and supported within the organizational structure responsible for their accomplishment.

12. LONG TERM OPERATION

12.1. ORGANIZATION AND FUNCTIONS

A portion of the plant's Systems, Structures and Components (SSCs) will be required to perform their functions for several years after the shutdown date. To have an effective and optimised aging and obsolescence management for this time period, the plant has co-ordinated these programs with the transition to decommissioning program. This unique set up allows the team to look at a comprehensive strategy to select the most cost effective solution. The co-operation between these groups with different mandates enables the identification of all those necessary condition assessments that need to consider full component life span. All this contributes to safety when approaching the transition to final decommissioning. The team considered this as a good practice.

Due to the long term operation (LTO) project, the aging management related workload on the plants system and component engineers has increased significantly and this will continue into the future. Prior to the LTO project, there was a backlog in system and component engineering reviews of condition assessments for the current end of plant life. The team encourages the plant to maintain the enhanced oversight of the aging management evaluations.

12.3. REVIEW OF AGING MANAGEMENT AND AGING MANAGEMENT PROGRAMMES, AND REVALIDATION OF TIME LIMITED AGING ANALYSES

The plant's heat transport system aging management strategy proactively identifies necessary aging mitigation measures including analytical, operational and design changes. One of the major aging management challenges is related to the pressure tubes in each reactor core. The plant has developed a new fracture toughness model to account for material at end-of-life deuterium concentration. As a result, the plant's operating temperature and pressure ranges within which heat transport system warm-up and cool-down are executed were adjusted to ensure safe operation of pressure tubes to end-of-life. In addition, the plant has carried out enhanced fuel channel elongation measurements and has also performed probabilistic elongation assessments instead of deterministic ones to obtain more realistic treatment of tolerances used. These activities demonstrate a proactive approach to the mitigation of identified aging issues. The team recognised this as good performance.

The LTO work is currently in progress. Therefore all necessary condition assessments are not yet finalised to cover the whole Periodic Safety Review (PSR) period for safety related and non-safety related components. Also, some of the time limited aging assessments are not completed for this period. The team made a suggestion for the plant to consider expediting the progress of completing the required technical assessments that support the intended period of operation by the licence renewal application date as planned.

DETAILED LONG TERM OPERATION FINDINGS

12.1 ORGANIZATION AND FUNCTIONS

12.1(a) Good practice: Obsolescence management taking into consideration the long term aging management assessments and transition to decommissioning requirements.

The plant is simultaneously planning for both an extension of operation for a number of years and for the stabilization and safe storage project that will follow. To facilitate the extended operations, integrated aging management scoping and screening are being updated and revised Condition Assessments (CAs) are being completed to determine any actions required to enable the plant to safely operate until its new shutdown date. A portion of the plant's Systems, Structures and Components (SSCs) will also be required to perform for several years after the shutdown date. For example, items supporting the irradiated fuel bays will have to operate at least 10 years after shutdown, while some other SSCs may be needed even longer. As a result, the plant's long term operations team (LTO) has developed a system transition boundary report which documents the required lifespan of the various systems of the plant. It includes input from the decommissioning/safe storage team, to ensure it reflects the post-shutdown requirements, that are being documented in system end state determination reports.

The plant's obsolescence management program is supporting the long term operation plans and the transition to decommissioning. This obsolescence team consists of 9 individuals dedicated to identification and resolution of obsolescence issues. These individuals implement obsolescence solutions by providing both procurement and design engineering support. This arrangement allows the plant to have a more focused and consistent approach and reduce the number of hand offs between various engineering work groups. This arrangement allows the team to look at wider application strategically to select the most cost effective solution. The co-operation between these groups with different mandates enables the preparation of CAs which considers full component life span needs. All this leads to improved safety when approaching the transition to final decommissioning.

12.3. REVIEW OF AGING MANAGEMENT AND AGING MANAGEMENT PROGRAMS AND VALIDATION OF TIME LIMITED AGING ANALYSES

12.3(1) Issue: The plant is completing all the technical assessments in support of the intended period of operation but is challenged to have it all completed by the license renewal application as planned.

The plant will apply for an operating license renewal in August 2017.

The team noted the following:

- Since the Long Term Operation (LTO) work is in progress the plant has not yet identified all safety enhancements in accordance with the Periodic Safety Review (PSR). The plan is to have the results of the PSR available to support the license renewal application.
- The plant is in the process of updating the integrated aging management scoping and screening results. Some of these changes will result in new condition assessments, which are yet to be incorporated into the PSR (number estimated at roughly 500).
- The plant is behind the targets given in the project plan for reviewing and approving condition assessments of safety related components.
- Since scoping and screening work is still going on, new commodity groups may be needed or new screened-in components may have to be added into existing groups by December 2016.
- All condition assessments for Safe Operating Envelope systems and systems important to safety covering operation to 2024 are complete, but not all have been updated for the full period of PSR (24% complete).
- The major components life cycle management assessments up to 2024 are complete but are not currently documented in the life cycle management plans. The assessments to support the full PSR period have not started yet.
- The plants aging management program includes time limited aging assessments. Some of the assessments are complete to show fitness for service to 2024, but not all are complete to support the PSR period.
- Plant documentation describes the commodity grouping methodology at a high level. Explicit guidance (e.g. material, environment, temperature, pressure, etc.) is not provided. The plant relies on the use of experienced practitioners to determine appropriate groupings.
- The plant's first Component (Program) Health Report for non-qualified cables is in draft. Health of the cables is being taken into account in the system health reports of associated plant systems.
- Aging management critical components are tracked in a standalone Condition Assessment Database. Aging management critical components are not flagged in the plant's work management program. Plans are in place to better integrate the aging management database with the plant's work management program and the Equipment Reliability information management system.

Without progressing the technical assessments for the intended period of operation as planned, the license application process may be negatively impacted.

Suggestion: The plant should consider expediting the progress of completing the required technical assessments that support the intended period of operation as planned.

IAEA Bases:

SSR-2/2

4.53 The justification for long term operation shall be prepared on the basis of the results of a safety assessment, with due consideration of the aging of structures, systems and components. The justification for long term operation shall utilize the results of periodic safety review and shall be submitted to the regulatory body, as required, for approval on the basis of an analysis of the aging management programme, to ensure the safety of the plant throughout its extended operating lifetime.

Requirement 14: Aging management

The operating organization shall ensure that an effective aging management programme is implemented to ensure that required safety functions of systems, structures and components are fulfilled over the entire operating lifetime of the plant.

SSG-25

3.6. ...the scope of the safety factor relating to aging should be expanded to include an evaluation of the safety analyses with time limited assumptions and assessments of aging effects.....

3.7. If the PSR is to be used to justify long term operation or licence renewal,
the entire planned period of long term operation should be considered,....

5.28. .... to determine the actual condition of SSCs important to safety and so to consider whether they are capable and adequate to meet design requirements, at least until the next PSR.

5.51. The review should assess whether:

- The aging management programme will ensure continued safe operation
- for at least the period until the next PSR.

NS-G-2.12

2.17. …If an operating organization decides to pursue long term operation, justification is supported by the results of periodic safety reviews, including review of management of aging...

14. TRANSITIONAL PERIOD FROM OPERATION TO DECOMMISSIONING

14.1 ORGANIZATION AND FUNCTIONS

The plant comprises 8 reactor units of CANDU design 550 MWe, two of them in safe store (Units 2 and 3). Units 1 to 4 began commercial operation between 1971 and 1973. From 1982 to 1986, the plant was expanded to eight units with the addition of Units 5 to 8.

Preparation for decommissioning of the plant units started in the 1980s, and considered three basic strategies as suggested by the Canadian Nuclear Safety Commission (CNSC) guidelines:
- Prompt decommissioning
- Deferred decommissioning
- In-situ entombment

After evaluation of CNSC guidelines and the strategies used for decommissioning other nuclear generating stations worldwide, the plant chosen option was deferred decommissioning. This provides time for the transfer of used fuel into dry storage and for the reduction of radioactive dose for workers during dismantling.

The team observed an existing program between plant and Canadian universities which utilizes a fraction of the Decommissioning fund to focus on acceleration of Research and Development of key technical areas that would both advance and benefit decommissioning activities. The purpose is to utilize the potential for high payoff during decommissioning to reduce radiological hazards, and lower decommissioning costs. Funding for this is from the approved decommissioning fund.

The program leverages the resources of the University Network of Excellence in Nuclear Engineering (https://www.unene.ca/) which ties a number of Canadian Universities together and matches funding from the Federal Government. The program began in late 2015 and is expected to continue through 2047 with the existing funding that is in place.

As a result, Plant is now funding research in the following areas at five Canadian Universities:
- Waste Volume Reduction, Chemical Decontamination, Container integrity
- Heavy Water Strategies: Graphene for Tritium separation, C-14 Capture
- On-line Tritium monitoring, Waste capture and decontamination
- Aging management for concrete structures
- Drones for environmental and structural monitoring
- Robotics for dismantling , site imaging and modeling

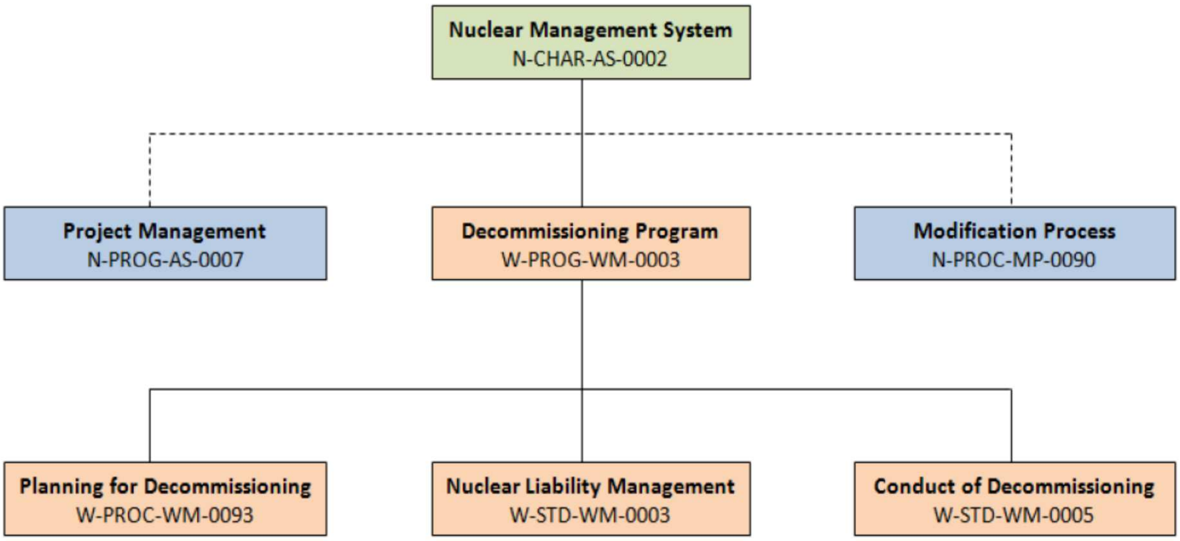
The cooperation with universities has potential for significant technical breakthroughs to reduce dose, radiological hazards, and worker dose. It also builds a network of experts and new talent to enhance the decommissioning industry in Canada. This is considered by the team as a good performance.

14.2 MANAGEMENT POLICIES AND ACTIVITIES

The transition to decommissioning of the plant will be conducted as a unit or multi-unit outage, and for this reason the Plant Integrated Management System will be fully applied. Part of the Plant Integrated Management System is the Decommissioning Program. It incorporates the following standards and processes:

– Planning for Decommissioning
– Nuclear Liability Management
– Conduct of Decommissioning

The following diagram indicates how the Decommissioning Program is included in the Plant Integrated Management system:



For planning purposes, the plant's intention is to shut down the reactor units in two steps: 2 units in 2022 and 4 units in 2024. After shut down, the reactors will be defuelled, dewatered and stabilized. The stabilization phase will last from 2023 until 2028 when the license for safe storage phase is expected. The plant may need to renew the license several times during the expected duration of the safe storage phase (30 years). The transition from operation to decommissioning includes both stabilization and Safe Storage phases.

Effective management of the plant transition to decommissioning will be regulated by following documents:
– Preliminary Decommissioning Plan (PDP)
– Stabilization Activity Plan (SAP)
– Storage with Surveillance Plan (SSP)
– Detailed Decommissioning Plan (DDP)

The purpose of above documents is to establish the planning of the arrangements and activities required to ensure a safe transition of the Plant from operation to decommissioning. The team observed that the documents are independent and not clearly linked to each other. The team made a suggestion in this area.

Currently the plant is developing documents that address the transition period in more detail. Among others, the plant is developing End State Determination Reports (ESDRs) that are based on analysis of interfaces or interconnections of all individual plant components. ESDRs are the basis for other documents such as schedule for plant isolation and drainage or water chemistry strategy. The project also has a number of engineering studies underway that will facilitate key technical decisions.

14.3 CONDUCT OF OPERATIONS

Units 1 and 4 were restarted after refurbishment in 2005. The current license for operation was issued by CNSC. In August 2013, the license determines operational status for reactor Units 1,4,5,6,7 and 8 and Safe Storage phase for reactor Units 2 and 3. The basis for issuance of the license included provisions ensuring the Units 2 and 3 are excluded from operation and stored in safe manner. While the majority of systems in those areas of the plant are removed from service, each of these units 2 and 3 has a few systems remaining in service to support their respective "twin" Unit 1 and 4, as well as other systems remaining operable to enable surveillance and radiological control. The inactive end stated components are marked via system labels, locks and painted signs. In addition, using dual-use locks for safe storage allows the application of work protection if needed.

Personnel working in an area where most components are de-energized or no longer in service may fail to recognize the remaining risks. Clear labeling (supported by a procedure that recognizes the meaning of these labels) allows for personnel to be wary of the special, permanently disabled status.

In addition, in some cases, there may be a need to perform work on a safe-stated component or system (for example, to inspect whether it is degrading or to harvest a component.). The Unit 2 and 3 labeling system allows for the plant's normal work protection tags and locks to be applied where needed, compliant with procedure. The consistent marking of inactive end stated systems clearly ensures configuration management to personnel working or observing in the plant. This demonstrates reduced risks to nuclear, conventional and radiological safety by clear and permanent avoidance of energization of items that are no longer maintained safe for energizing. The team recognized this as good performance.

DETAILED TRANSITIONAL PERIOD FROM OPERATION TO DECOMMISSIONING FINDINGS

14.2 MANAGEMENT POLICIES AND ACTIVITIES

14.2(1) Issue: The plant's Preliminary Decommissioning Plan does not conform to the structure of a standard decommissioning plan.

The team noted the following:

The Plant's documentation such as Project Management Plan, Stabilization Activity Plan, Safe Storage Fire Protection, and Storage with Surveillance Plan collectively cover areas of decommissioning as required by standards. However, the Preliminary Decommissioning Plan doesn't include or refer to these documents for specific areas such as:

- fire protection and suppression for entire plant
- periodical monitoring of all safety related components
- basic requirement for training program
- organizational structure
- requirements for on-site and off-site monitoring during decommissioning

Without including all the necessary items into the Preliminary Decommissioning Plan, the decommissioning document is not consistent and complete.

Suggestion: The plant should consider linking all necessary items already existing in other decommissioning documents in their Preliminary Decommissioning Plan.

IAEA Bases:

WS G 2.1
2.14. ...Fire protection and suppression for the complete site should be included in the decommissioning plan.
6.21. ... Periodical monitoring of all the safety related components of the installation should be incorporated into the decommissioning plan.
7.7. Basic requirements for a training programme and for refresher training for decommissioning activities should be described in the decommissioning plan
7.8. The organizational structure to be employed during decommissioning should be described in the decommissioning plan. In the description of the organizational structure, there should be a clear delineation of authorities and responsibilities amongst the various units.
7.16. The decommissioning plan should specify the requirement for on-site and off-site monitoring during decommissioning.

DEFINITIONS

DEFINITIONS – OSART MISSION

Recommendation

A recommendation is advice on what improvements in operational safety should be made in that activity or programme that has been evaluated. It is based on IAEA Safety Standards or proven, good international practices and addresses the root causes rather than the symptoms of the identified concern. It very often illustrates a proven method of striving for excellence, which reaches beyond minimum requirements. Recommendations are specific, realistic and designed to result in tangible improvements. Absence of recommendations can be interpreted as performance corresponding with proven international practices.

Suggestion

A suggestion is either an additional proposal in conjunction with a recommendation or may stand on its own following a discussion of the pertinent background. It may indirectly contribute to improvements in operational safety but is primarily intended to make a good performance more effective, to indicate useful expansions to existing programmes and to point out possible superior alternatives to ongoing work. In general, it is designed to stimulate the plant management and supporting staff to continue to consider ways and means for enhancing performance.

Note: if an item is not well based enough to meet the criteria of a 'suggestion', but the expert or the team feels that mentioning it is still desirable, the given topic may be described in the text of the report using the phrase 'encouragement' (e.g. The team encouraged the plant to…).

Good practice

A good practice is an outstanding and proven performance, programme, activity or equipment in use that contributes directly or indirectly to operational safety and sustained good performance. A good practice is markedly superior to that observed elsewhere, not just the fulfilment of current requirements or expectations. It should be superior enough and have broad application to be brought to the attention of other nuclear power plants and be worthy of their consideration in the general drive for excellence. A good practice has the following characteristics:

- novel;
- has a proven benefit;
- replicable (it can be used at other plants);
- does not contradict an issue.

The attributes of a given 'good practice' (e.g. whether it is well implemented, or cost effective, or creative, or it has good results) should be explicitly stated in the description of the 'good practice'.

Note: An item may not meet all the criteria of a 'good practice', but still be worthy to take note of. In this case it may be referred as a 'good performance', and may be documented in the text of the report. A good performance is a superior objective that has been achieved or a good technique or programme that contributes directly or indirectly to operational safety and sustained good performance, that works well at the plant. However, it might not be necessary to recommend its adoption by other nuclear power plants, because of financial considerations, differences in design or other reasons.

LIST OF IAEA REFERENCES (BASIS)

Safety Standards

- **SF-1**; Fundamental Safety Principles (Safety Fundamentals)
- **GSR Part 2**; Leadership and Management for Safety (General Safety Requirements)
- **GSR Part 3;** Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
- **SSR-2/1**; Safety of Nuclear Power Plants: Design (Specific Safety Requirements)
- **SSR-2/2**; Safety of Nuclear Power Plants: Commissioning and Operation (Specific Safety Requirements)
- **NS-G-1.1**; Software for Computer Based Systems Important to Safety in Nuclear Power Plants (Safety Guide)
- **NS-G-2.1**; Fire Safety in the Operation of Nuclear Power Plans (Safety Guide)
- **NS-G-2.2**; Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants (Safety Guide)
- **NS-G-2.3**; Modifications to Nuclear Power Plants (Safety Guide)
- **NS-G-2.4**; The Operating Organization for Nuclear Power Plants (Safety Guide)
- **NS-G-2.5**; Core Management and Fuel Handling for Nuclear Power Plants (Safety Guide)
- **NS-G-2.6**; Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants (Safety Guide)
- **NS-G-2.7**; Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants (Safety Guide)
- **NS-G-2.8**; Recruitment, Qualification and Training of Personnel for Nuclear Power Plants (Safety Guide)
- **NS-G-2.9**; Commissioning for Nuclear Power Plants (Safety Guide)
- **NS-G-2.11**; A System for the Feedback of Experience from Events in Nuclear Installations (Safety Guide)
- **NS-G-2.12**; Aging Management for Nuclear Power Plants (Safety Guide)
- **NS-G-2.13**; Evaluation of Seismic Safety for Existing Nuclear Installations (Safety Guide)
- **NS-G-2.14**; Conduct of Operations at Nuclear Power Plants (Safety Guide)

- **NS-G-2.15**; Severe Accident Management Programmes for Nuclear Power Plants (Safety Guide)
- **SSG-13**; Chemistry Programme for Water Cooled Nuclear Power Plants (Specific Safety Guide)
- **SSG-25**; Periodic Safety Review for Nuclear Power Plants (Specific Safety Guide)
- **GSR Part 1**; Governmental, Legal and Regulatory Framework for Safety (General Safety Requirements)
- **GSR Part 7**; Preparedness and Response for a Nuclear or Radiological Emergency (General Safety Requirements)
- **GS-R-3**; The Management System for Facilities and Activities (Safety Requirements)
- **GSR Part 4**; Safety Assessment for Facilities and Activities (General Safety Requirements)
- **GS-G-4.1**; Format and Content of the Safety Analysis report for Nuclear Power Plants (Safety Guide)
- **SSG-2**; Deterministic Safety Analysis for Nuclear Power Plants (Specific Safety Guide)
- **SSG-3**; Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants (Specific Safety Guide)
- **SSG-4**; Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants (Specific Safety Guide)
- **GSR Part 5**; Predisposal Management of Radioactive Waste (General Safety Requirements)
- **GS-G-2.1**; Arrangement for Preparedness for a Nuclear or Radiological Emergency (Safety Guide)
- **GSG-2**; Criteria for Use in Preparedness and Response for a Nuclear and Radiological Emergency (General Safety Guide)
- **GS-G-3.1**; Application of the Management System for Facilities and Activities (Safety Guide)
- **GS-G-3.5**; The Management System for Nuclear Installations (Safety Guide)
- **RS-G-1.1**; Occupational Radiation Protection (Safety Guide)
- **RS-G-1.2**; Assessment of Occupational Exposure Due to Intakes of Radionuclides (Safety Guide)
- **RS-G-1.3**; Assessment of Occupational Exposure Due to External Sources of Radiation (Safety Guide)

- **RS-G-1.8**; Environmental and Source Monitoring for Purposes of Radiation Protection (Safety Guide)
- **SSR-5;** Disposal of Radioactive Waste (Specific Safety Requirements)
- **GSG-1** Classification of Radioactive Waste (General Safety Guide)
- **WS-G-6.1**; Storage of Radioactive Waste (Safety Guide)
- **GSR Part 6**; Decommissioning of Facilities (General Safety Requirement)
- **WS-G-2.1;** Decommissioning of Nuclear Power Plants and Research Reactors (Safety Guide)
- **WS-G-2.5**; Predisposal Management of Low and Intermediate Level Radioactive Waste (Safety Guide)

▪ ***INSAG, Safety Report Series***

INSAG-4; Safety Culture

INSAG-10; Defence in Depth in Nuclear Safety

INSAG-12; Basic Safety Principles for Nuclear Power Plants, 75-INSAG-3 Rev.1

INSAG-13; Management of Operational Safety in Nuclear Power Plants

INSAG-14; Safe Management of the Operating Lifetimes of Nuclear Power Plants

INSAG-15; Key Practical Issues In Strengthening Safety Culture

INSAG-16; Maintaining Knowledge, Training and Infrastructure for Research and Development in Nuclear Safety

INSAG-17; Independence in Regulatory Decision Making

INSAG-18; Managing Change in the Nuclear Industry: The Effects on Safety

INSAG-19; Maintaining the Design Integrity of Nuclear Installations throughout their Operating Life

INSAG-20; Stakeholder Involvement in Nuclear Issues

INSAG-23; Improving the International System for Operating Experience Feedback

INSAG-25; A Framework for an Integrated Risk Informed Decision Making Process

Safety Report Series No.11; Developing Safety Culture in Nuclear Activities Practical Suggestions to Assist Progress

Safety Report Series No.21; Optimization of Radiation Protection in the Control of Occupational Exposure

Safety Report Series No.48; Development and Review of Plant Specific Emergency Operating Procedures

Safety Report Series No. 57; Safe Long Term Operation of Nuclear Power Plants

- ***Other IAEA Publications***

  - **IAEA Safety Glossary** Terminology used in nuclear safety and radiation protection 2007 Edition
  - **Services series No.12**; OSART Guidelines
  - **EPR-ENATOM-2002**; Emergency Notification and Assistance Technical Operations Manual
  - **EPR-METHOD-2003**; Method for developing arrangements for response to a nuclear or radiological emergency, (Updating IAEA-TECDOC-953)
  - **EPR-EXERCISE-2005**; Preparation, Conduct and Evaluation of Exercises to Test Preparedness for a Nuclear or Radiological Emergency
  - **EPR-NPP PPA 2013**; Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor

- ***International Labour Office publications on industrial safety***

  - **ILO-OSH 2001;** Guidelines on occupational safety and health management systems (ILO guideline)
  - Safety and health in construction (ILO code of practice)
  - Safety in the use of chemicals at work (ILO code of practice)

TEAM COMPOSITION OF THE OSART MISSION

JIANG, Fuming – IAEA
Team Leader
Years of experience: 19

MARTYNENKO, Yury – IAEA
Deputy Team Leader
Years of experience: 34

DOUMONT, Pierre – Belgium
Years of experience: 40
Review Area: Leadership and Management

GILLIS, Juergen – Belgium
Years of experience: 15
Review Area: Training and Qualification

MIHAI, Adrian – Romania
Years of experience: 27
Review Area: Operations 1

QIN, Guogiang – China
Years of experience: 12
Review Area: Operations 2

LYRSTEDT, Frederik – Sweden
Years of experience: 10
Review Area: Maintenance

BILIC ZABRIC, Tea – IAEA
Years of experience: 28
Review Area: Technical Support

BILA, Nadezda – Czech Republic
Years of experience: 21
Review Area: Operating Experience

DO AMARAL, Marcos Antonio – Brazil
Years of experience: 23
Review Area: Radiation Protection

BOLZ, Michael – Germany
Years of experience: 22
Review Area: Chemistry

KUSTER, Sandrine – France
Years of experience: 18
Review Area: Emergency Preparedness and Response

ELTER, Jozsef – Hungary
Years of experience: 29
Review Area: Severe Accident Management

BARNES, Joseph – United States of America
Years of experience: 39
Review Area: Human Technology and Organizations

MAKELA, Kari - IAEA
Years of experience: 27
Review Area: Long Term Operation

BETAK, Aladar – Slovakia
Years of experience: 32
Review Area: Transition from Operation to Decommissioning

KAINOV, Aleksandr – Russian Federation
Years of experience: 15
Review Area: Observer

BABYLON, Debra – United States of America
Years of experience: 7
Review Area: Observer