Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Annual CNSC Staff Report for 2006 on the Safety Performance of the Canadian Nuclear Power Industry

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SUMMARY

This report summarizes the Canadian Nuclear Safety Commission (CNSC) staff's assessment of the Canadian nuclear power industry's safety performance in 2006 and describes licensee programs and implementation in nine safety areas. This document serves as a mid-term report for the Bruce A and B stations, which are currently in the middle of the five-year period covered by their operating licences.

A new feature of the 2006 report is the inclusion of performance objectives for each safety area and program. These objectives were developed by CNSC staff to describe the overarching outcome or objective of each of the nine principal safety areas and their associated programs.

In addition to assessing the safety areas and programs for each station, the report compares performance among stations, shows year-to-year trends and highlights significant issues that pertain to the industry at large.

Through inspections and reviews, CNSC staff observed that the nuclear power industry operated safely during 2006. No worker at any nuclear power station or member of the public received a radiation dose in excess of the regulatory limits. Emissions from all plants were also below regulatory limits.

In 2006, the industry met the CNSC's expectations of most safety areas. The assessment of all safety areas confirmed that, in general, the stations had adequate programs in place for ongoing safe operation. Various performance indicators further supported these conclusions.

As in previous years, the industry continued to have well developed and well implemented programs for the Emergency Preparedness, Environmental Protection, Radiation Protection and Safeguards safety areas. There remains room for considerable improvement in the area of Performance Assurance. Progress was made at Darlington and Pickering A and B, where all the programs under this safety area, and their implementation, now meet CNSC expectations. More work remains before all the programs under Performance Assurance can meet requirements and be adequately implemented at Bruce A and B and Point Lepreau.

INTRODUCTION

To meet the legal requirements of the *Nuclear Safety and Control Act* (NSCA) and *Nuclear Safety and Control Regulations*, licensees must implement programs that provide adequate provisions for protection of the environment, health and safety of persons, maintenance of national security, and the measures required to implement Canada's international obligations.

This report summarizes the Canadian Nuclear Safety Commission (CNSC) staff's assessment of the safety performance of nuclear power plant licensees in the Canadian nuclear power industry in 2006. The assessment is based on the legal requirements of the NSCA and regulations as well as the conditions of operating licences and applicable standards.

Licensee programs necessary for the safe operation of the nuclear power facilities are grouped into nine safety areas developed by CNSC staff (see Figure 1). The programs evaluated are consistent with the criteria found in the *International Atomic Energy Agency's* (IAEA) Safety Standard Series NS-R-2 *Safety of Nuclear Power Plants: Operation*.[1] The programs and their implementation are evaluated using a rating system established by CNSC staff in CMD 02-M5[2]. Appendix A provides general descriptions of the safety areas and their constituent programs.

The evaluations in this report are supported by information gathered through CNSC staff inspections, on-site presence, document assessments, event reviews, and performance indicators.

Section 1 focuses on individual power reactor sites and provides detailed assessments of the safety areas and programs, highlighting areas where programs or performance fell below CNSC staff expectations.

This report introduces, where applicable to each facility, a new subsection 10, "Update on Other Major Projects and Initiatives" in Section 1. This subsection discusses refurbishment, safe storage and radioactive waste management, where appropriate.

The Bruce A and B stations are in the middle of their five-year operating licence periods. This report is a mid-term report for Bruce A and B. Additional details specific to those stations are provided throughout Section 1.1 and are followed with a brief conclusion in subsection 1.1.11.

[1] IAEA Safety Standard Series NS-R-2 *Safety of Nuclear Power Plants: Operation* STI/PUB/1096, International Atomic Energy Agency, Austria, September 2000.

[2] CMD 02-M5 *Information from Canadian Nuclear Safety Commission staff regarding recommended approach and terminology to be used to rate CNSC licensee programs, performance and qualification in annual reports and licensing Commission Member Documents*, Canadian Nuclear Safety Commission, Ottawa, January 17, 2002.

Section 2 makes comparisons among stations, shows year-to-year trends, and highlights significant issues that pertain to the industry at large. It also contains tables of performance indicator data and tables that summarize licensee grades for 2006.

Definitions of the safety areas and programs are found in Appendix A. The grades assigned for each program and safety area are based on the rating system described in Appendix B.

Some specialized and technical terms are defined in Appendix C and are italicized throughout the text. The acronyms used in this document are listed in Appendix D.

Important events or developments at the licensed sites in 2006 were reported to the *Commission* in significant development reports (SDRs) via *Commission Member Documents* (CMDs). Appendix E, which is based on the SDRs, describes the significant developments relevant to power reactors in 2006 and related follow-up activities.

Finally, Appendix F describes the current status of the generic action items (GAIs) related to each licensee.

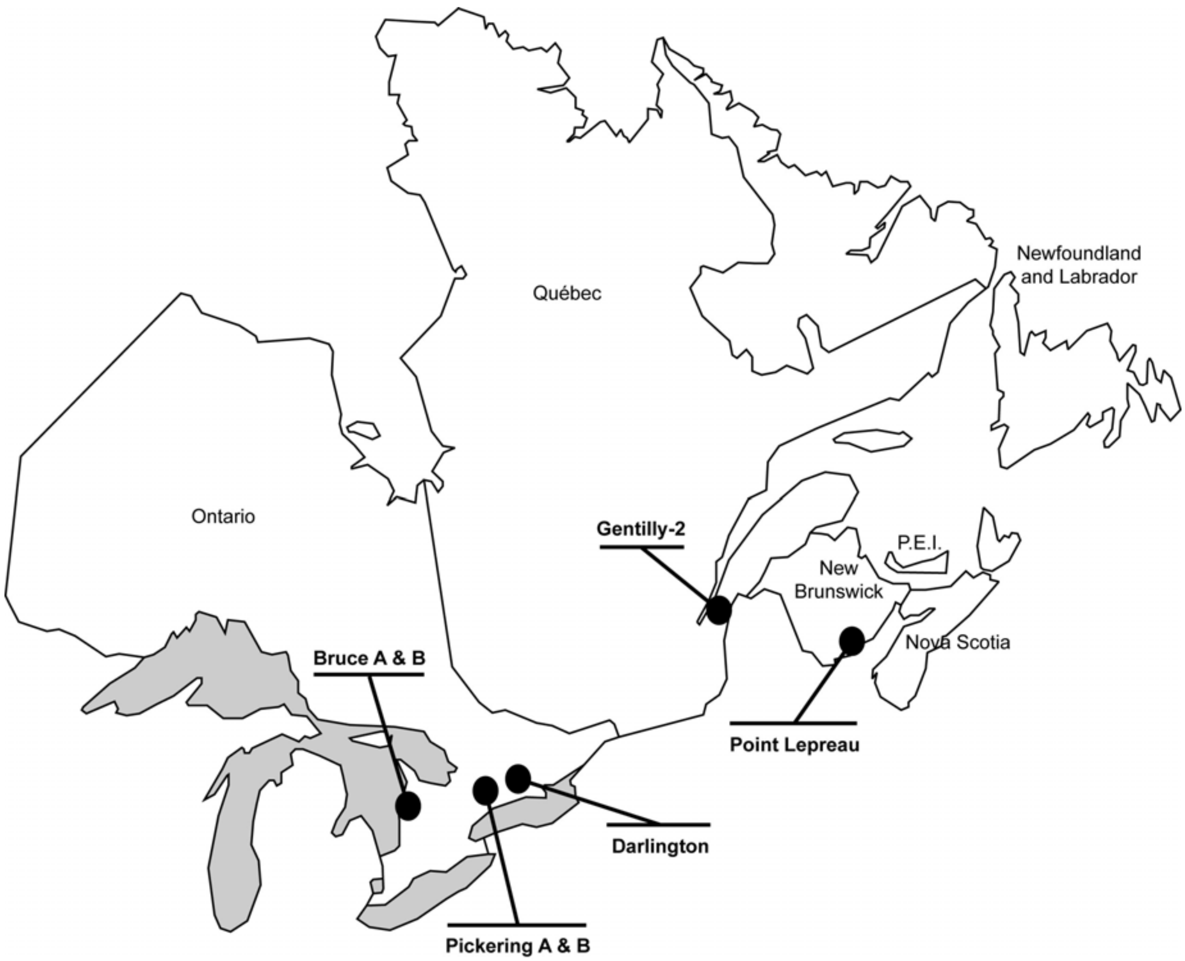
Figure 2 shows the locations of power reactor sites in Canada, the number and generating capacity of their reactors, their initial start-up dates, the names of the licence holders, and the expiry dates of current licences. Of the 22 CANDU reactors with operating licences issued by the *Commission*, 18 provided power to the electrical grid in 2006. In 2006, Ontario Power Generation (OPG) announced that Units 2 and 3 at Pickering A, which are currently in a long-term *lay-up state* will be de-fuelled, de-watered and placed in a safe storage state until the station is decommissioned. Bruce A Units 1 and 2 are undergoing refurbishment for the purpose of life extension, with a scheduled restart in 2009 subject to *Commission* approval.

Figure 1: Safety Areas and Programs

SAFETY AREA	Program
OPERATING PERFORMANCE	
	Organization and Plant Management
	Operations
	Occupational Health and Safety (Non-radiological)
PERFORMANCE ASSURANCE	
	Quality Management
	Human Factors
	Training, Examination, and Certification
DESIGN AND ANALYSIS	
	Safety Analysis
	Safety Issues
	Design
EQUIPMENT FITNESS FOR SERVICE	
	Maintenance
	Structural Integrity
	Reliability
	Equipment Qualification
EMERGENCY PREPAREDNESS	
ENVIRONMENTAL PROTECTION	
RADIATION PROTECTION	
SITE SECURITY	
SAFEGUARDS	

For a complete definition of each safety area and program, including the performance objective, please refer to Appendix A.

Figure 2: Locations and Data for Nuclear Power Plants in Canada



PLANT DATA							
Plant	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau
Licensee	Bruce Power	Bruce Power	Ontario Power Generation	Ontario Power Generation	Ontario Power Generation	Hydro-Québec	New Brunswick Power Nuclear
Reactor Units	4	4	4	4	4	1	1
Gross Electrical Capacity/Reactor (MW)	904	915	935	542	540	675	680
Start-Up	1976	1984	1989	1971	1982	1982	1982
Licence Expiry	2009/03/31	2009/03/31	2008/02/29	2010/06/30	2008/06/30	2010/12/31	2011//06/30

SECTION 1

SAFETY PERFORMANCE AT THE POWER REACTOR SITES

This section is organized by power reactor site, with grades provided for safety areas and programs for each site. The grades for all sites are also summarized in the tables at the end of Section 2. Appendix A defines safety areas and programs and outlines the overall performance objectives.

The grades assigned for each program and safety area are based on the rating system defined in Appendix B. The grades are supported by information gathered through inspections by Canadian Nuclear Safety Commission (CNSC) staff, general surveillance, correspondence, and document and event reviews.

The sub-section for Bruce A and B also serves as a mid-term report for the current term of those operating licences. As such, that sub-section contains detailed discussions of programs and safety areas requiring attention from the licensee and presents brief conclusions.

1.1 BRUCE A and BRUCE B

1.1.1 Operating Performance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Bruce A	OPERATING PERFORMANCE	B	B
	Organization and Plant Management	B	A
	Operations	B	B
	Occupational Health and Safety (Non-radiological)	B	A
Bruce B	OPERATING PERFORMANCE	B	B
	Organization and Plant Management	B	A
	Operations	B	B
	Occupational Health and Safety (Non-radiological)	B	B

Both the program and implementation of the Operating Performance safety area at Bruce A and Bruce B met the expectations of Canadian Nuclear Safety Commission (CNSC) staff. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC's desired outcomes. Bruce A and B improved their performance in reducing transients and shutdowns and continued to meet high standards of conventional safety, remaining in line with international nuclear industry safety developments.

1.1.1.1 Organization and Plant Management

The management of Bruce Power continued to provide leadership to its staff and to promote safety in 2006. Bruce Power continued to improve integration of the Bruce site and its processes.

CNSC staff observed no negative issues in this area during 2006. The inspections, surveillance and monitoring carried out by CNSC staff found no significant changes to the program over the past year, so the grade from the previous year remains valid.

In 2006, Bruce A had no reactor trips, 1 *stepback* and 5 *setbacks*. Bruce B had 1 reactor trip, no *stepbacks* and 7 *setbacks* (see Table 1). Overall, this represents improvement in all three performance indicators.

The implementation, ranked as "A," exceeds expectations — due mainly to improvements to the number of trips and *stepbacks*. The number of trips and *stepbacks* is significantly better than the world average and has improved over the last few years. This is considered an indicator of the state of the plant and therefore demonstrates improvement.

1.1.1.2 Operations

Based on inspections, surveillance and monitoring by CNSC staff, there was no indication of degraded performance or changes to the program. The program grading from the previous year continues.

In the area of communications, configuration management and outage management, CNSC staff concluded that performance met expectations.

1.1.1.3 Occupational Health and Safety (Non-radiological)

The conventional safety record at Bruce Power continues to reflect a strong conventional safety program, leadership, and continuous safety training. Bruce Power has an effective worker health and safety committee that is actively involved in plant operation.

Based on the performance indicators, the accident frequency is very good (low) and has resulted in an "A" rating; however, their severity was significant and was rated as a "B" (see Tables 9 and 10). Assessed separately, Bruce A is operating at an "A" grade and Bruce B is operating at a "B" grade.

Overall, the occupational health and safety program and implementation met CNSC performance expectations.

1.1.2 Performance Assurance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Bruce A	PERFORMANCE ASSURANCE	B	B
	Quality Management	C	C
	Human Factors	B	B
	Training, Examination, and Certification	B	B
Bruce B	PERFORMANCE ASSURANCE	B	B
	Quality Management	C	B
	Human Factors	B	B
	Training, Examination, and Certification	B	B

At Bruce A and B, the design of the programs and implementation in the Performance Assurance safety area met CNSC staff's overall expectations.

1.1.2.1 Quality Management

Bruce Power is still moving from a traditional quality assurance style of oversight to a more modern integrated management system approach. Significant resources have been spent on this management system modernization project, the largest current endeavour being the Process and Document Enhancement Project (PDEP). CNSC staff is monitoring the progress of the PDEP and has reviewed many of the key policy and program documents produced. The quality of the documents reviewed to date has been high. CNSC staff is waiting for the submission of a few key programs to complete the review of this project. The project is expected to be completed in 2007.

Although Bruce Power has put considerable effort into improving its quality management and oversight, the project is incomplete. Thus, the quality management programs of Bruce A and B did not meet CNSC requirements and the “C” grade remains unchanged from 2005.

A contractor management inspection revealed shortcomings in the program for the oversight of contracts: the findings included missing or inadequate processes and/or procedures.

The report on the Unit 3 Loss of Regulation event of 2005 was closed and presented to the *Commission* in 2006. CNSC staff is continuing to monitor the effectiveness of the corrective actions.

Despite the incomplete implementation of the PDEP project at Bruce B, improvements in processes have been observed. The licensee’s highly dedicated and trained staff adequately implements the quality management program at Bruce B. Thus, the program’s implementation at Bruce B met expectations.

Bruce A has not performed to the same level as Bruce B. The existing quality management implementation at Bruce A is less mature than at Bruce B, partly because it was not subject to a number of past improvement projects initiated while the station was laid up. Consequently, implementation of quality management at Bruce A does not meet CNSC requirements, and the grade of “C” is unchanged from 2005.

1.1.2.2 Human Factors

The performance of Bruce Power’s Human Factors program in 2006 has met expectations. Bruce Power has made significant progress related to the backlog of procedural changes identified in 2005, which has enabled the program and implementation to be given “B” grades.

During re-licensing, the *Commission* asked staff to report on staffing levels and the sustainability of a qualified workforce at the mid-term report. Additional information on these areas can also be found in the Training, Examination, and Certification section.

Bruce Power has reported minimum complement non-compliances — that is, there are times when it has been operating with insufficient staff — and is conducting an internal review to identify the causes. Another concern with minimum complement is Bruce Power's request to amend the Bruce A and B station shift complement document, which CNSC staff will review in 2007.

During the last half of 2006, Bruce A operated with the minimum complement of authorized nuclear operators (ANOs) 46% of the time, compared to 12% of the time at Bruce B. Based upon staffing projections, Bruce Power will be able to meet the date committed to in its licence for ANO staffing at Bruce B, whereas it does not appear that it will be able to do so at Bruce A before 2009. A shortage of certified staff has been a persistent problem at Bruce A since the restart of Units 3 and 4.

CNSC staff will continue to closely monitor staffing issues in 2007, including minimum complement, hours of work and progress on certified operator staffing levels.

Bruce Power has revised its procedure to systematically incorporate human factors processes under the engineering modifications procedures to include human factors integration across larger projects. CNSC staff will conduct compliance activities in 2007 to address human factors in design. .

1.1.2.3 Training, Examination, and Certification

Beginning in 2006, Bruce Power implemented the re-qualification testing program at Bruce A and continued to conduct re-qualification tests at Bruce B for all certified shift personnel, except the Unit 0 control room operators. In 2006, CNSC staff observed pilot Unit 0 control room operator re-qualification simulator examinations at Bruce A. Some findings were noted and identified to the licensee as part of the pilot phase of the program. At Bruce B, the ANO re-qualification comprehensive simulator testing was evaluated, and the testing was found to comply with CNSC requirements. Full implementation of the re-qualification testing program for Unit 0 control room operators is planned for 2007.

As part of the series of the training program evaluations being conducted to support the transfer of certification examinations to the licensee, CNSC staff evaluated the ANO specifics training program and the ANO simulator training program at Bruce A. Some deficiencies and recommendations were noted for each program. In addition, the training programs for shift manager simulator training and Unit 0 control room operator training were evaluated at Bruce B, and some deficiencies were noted and communicated verbally to the licensee. CNSC staff is formulating the written reports on these evaluations. Also, in support of examination transfer, Bruce Power submitted written notification that it has implemented the new station-specific program objective template for the Unit 0 control room operator training at the Bruce site.

As part of follow-up activities to support examination transfer, CNSC staff closed out the evaluation of the Bruce A Unit 0 control room operator simulator training. In addition, Bruce Power submitted a request for closure on a previously evaluated training program for the ANO-specific training program at Bruce B.

In training areas not associated with certification or examination transfer, Bruce Power submitted updates on the 2006 status of continuing training for mechanical maintainers and control maintainers. CNSC staff is reviewing the documents provided.

CNSC staff is monitoring the continuing training and timely special training of certified staff for the restart of Units 1 and 2. Bruce Power has provided the initial information on their planned training programs, which the CNSC staff has deemed acceptable. Bruce Power will submit further routine reports for CNSC staff assessment as the program develops.

During 2006, work progressed on the addition of a second unit to the Bruce A full scope simulator. This will assist in training and certifying the staff required for the restart of Units 1 and 2, as well as training current staff on the modifications to the refurbished units.

The overall success rate in certification examinations at Bruce Power was adequate during the year. CNSC staff concluded that these programs and their implementation met CNSC staff expectations. The CNSC staff will continue to verify that adequate numbers of certified staff are assigned to operating units (those that have fuel in the core) and pay special attention to staffing of the restart units.

1.1.3 Design and Analysis

Site	SAFETY AREA Program	Grades Program	 Implementation
Bruce A	DESIGN AND ANALYSIS	B	B
	Safety Analysis	B	B
	Safety Issues	B	B
	Design	B	B
Bruce B	DESIGN AND ANALYSIS	B	B
	Safety Analysis	B	B
	Safety Issues	B	B
	Design	B	B

Both the program and implementation of the Design and Analysis safety area at Bruce A and B met CNSC staff's expectations. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC's desired outcomes. CNSC staff reviews, which included evaluation of the work performed towards a plant-specific probabilistic safety assessment, concluded that the licensee continued to provide acceptable safety analyses and responses to new design and safety issues.

1.1.3.1 Safety Analysis

During the re-licensing hearing, the *Commission* requested staff to report on the progress of the specific issues, endeavours and accident scenario analyses listed below, as part of the mid-term report.

- Sustained Loss of All Heat Sinks
- Safe Operating Envelope
- Large Break Loss of Coolant Accident
- Shutdown Systems 1 and 2 (SDS1 and SDS2) Neutron Over-Power Protection System
- Operating Policies and Principles (OP&P)
- Bruce A Probabilistic Risk Assessment (BAPRA)
- Bruce B Risk Assessment (BBRA)

1.1.3.1.1 Sustained Loss of All Heat Sinks

In the design of the CANDU reactors, a number of alternate heat sink systems have been provided to adequately cool the fuel in case the normal heat sink fails. The sustained failure of all the heat sinks has been considered a very low probability event because of their physical and functional separation. However, if such an unlikely event took place and no heat sink could be restarted, core damage would occur. If the relief capacity of the primary heat transport system was inadequate, such that the system pressurized beyond its design limits and if the boiler tubes were the first point of failure, then a release of fission products outside containment could result.

CNSC staff asked licensees to provide assurance that such an event was very unlikely, that the pressure relief was adequate and that boiler tube failure would not occur.

Based on information provided by Bruce Power, CNSC staff is satisfied that the event would be very unlikely and that the capacity of the current relief valves is adequate to meet the requirements of Canadian Standards Association (CSA) Standard N285.0-95. Furthermore, staff is satisfied that if the event did occur and the relief capacity proved insufficient, the *pressure tubes* (PT) would fail before significant pressure increase or significant core damage occurred. This would ensure that any fission product release would be contained.

The issue was therefore closed because staff concluded that it presented no significant risk to the public and that no further action was required.

1.1.3.1.2 Safe Operating Envelope

Ontario Power Generation (OPG) began the Safe Operating Envelope (SOE) project at Bruce A and B, which was later adopted by Bruce Power to ensure a robust link among design, safety analysis and operating documentation.

Completion of the SOE project was a commitment for the refurbishment of Bruce A. The Bruce A systematic review of safety included reviews against modern standards. Compliance with a number of clauses was conditional on successful completion of the SOE project.

For Bruce B, completion of the SOE was a commitment from the Ontario Hydro Integrated Improvement Program that Bruce Power adopted when it took control of the station.

CNSC staff recognizes the importance of the SOE project and commends Bruce Power's earlier commitment to it. However, staff considered that insufficient progress was being made and wrote to Bruce Power to express this concern. Bruce Power has recently provided assurance that the commitment to complete the SOE project for safety systems will be met for Bruce A's return to service. CNSC staff has accepted Bruce Power's plan, but has not received a response for Bruce B.

1.1.3.1.3 Large Break Loss of Coolant Accident

In a postulated large break loss of coolant accident (LBLOCA) in CANDU reactors, reactor power will increase rapidly due to the positive reactivity feedback caused by the voiding of reactor coolant. The safety analyses should demonstrate that each shutdown system would be capable of limiting the power increase to an acceptable level and that appropriate regulatory requirements would be met.

Several developments in recent years indicated that the original licensing analyses did not account for all phenomena or did not rely on sufficiently validated data. As a consequence, certain compensatory measures have been taken, including reduction of power levels, implementation of more restricting operational limits, implementation of design changes or conducting more detailed analyses. Although these developments had an impact on all nuclear power reactors in Canada, the Bruce A and B reactors were the most affected due to their design characteristics.

Bruce Power is addressing the issue of improvement of LBLOCA safety margins in several ways:

- Core conversion is ongoing at Bruce B units, which will see reactors fuelled with the flow, as opposed to the original scheme of fuelling against the flow; this design change will eliminate a positive reactivity insertion in a LBLOCA caused by the fuel relocation. Bruce A units had already been converted.
- New fuel design, CANFLEX-LVRF, is nearing implementation. Demonstration irradiation is in progress, and two channels in Unit 7 are currently fuelled with the new fuel bundles. The new fuel design will significantly reduce the positive void reactivity coefficient of the core and thus reduce the power pulse in case of a LBLOCA.
- Several projects are underway to address technical requests identified by CNSC staff, most notably Generic Action Items (GAIs) 99G02, 00G01 and 01G01. Most of these requests are common to all stations and are addressed through coordinated efforts of CANDU licensees.

While acknowledging Bruce Power's ongoing efforts, CNSC staff remains concerned about LBLOCA margins for all Bruce units due to the long time frame and difficulties associated with implementation of the above-mentioned projects. Staff has therefore requested Bruce Power to provide an updated strategy that will restore LBLOCA margins.

1.1.3.1.4 Shutdown Systems 1 and 2 (SDS1 and SDS2) Neutron Over-Power Protection Systems

The Neutron Over-Power Protection (NOP) System is a detection component of the Shutdown Systems, which consists of a number of in-core detectors. The Bruce A Shutdown System1 (SDS1) NOP system consists of 39 detectors in 12 vertical detector assemblies located to detect various bulk Loss of Regulation (LOR), spatial LOR events and Loss of Coolant Accidents (LOCA). The SDS2 NOP, which was added late in the design stage of Bruce A, consists of 12 detectors in 2 horizontal detector assemblies and was designed to detect bulk LOR accidents and LOCA.

As part the restart of Units 3 and 4 at Bruce A, CNSC staff raised the issue of effectiveness of the SDS1 and SDS2 NOP systems and improvement to SDS2 NOP system. They requested additional information to confirm the adequacy of the trip setpoints and operating restrictions, including:

- a confirmatory analysis of SDS1 NOP trip setpoint for an increased design flux shape set
- an assessment of the Bruce A relevant Liquid Zone Controllers (LZC) failure events in CANDU operating experience data base
- feasibility study and benefit-cost analysis (BCA) of design options to improve the SDS2 NOP system

The information provided by Bruce Power showed that effectiveness of the Bruce A SDS1 NOP system is close to that of the Bruce B SDS1 NOP system, given the differences in core design. Adequate provisions are in place to address LZC failure. Bruce Power studies covered three feasible design options for SDS2 NOP enhancement. The BCA included an assessment of the improvement in coverage, the examination of worker dose, the cost and timeliness of the improvement given the expected lifetimes of Bruce A's Units 3 and 4, and an assessment of the impact on diversity and separation. Bruce Power concluded that the benefits from the averted risk over the remaining life of Bruce A's Units 3 and 4 are very low compared to the costs of implementing and maintaining/testing SDS2 NOP changes. The SDS enhancements are now planned as part of unit refurbishment activities at Bruce A's Units 1 and 2.

1.1.3.1.5 Operating Policies and Principles

The Operating Policies and Principles (OP&P) document identifies key principles and limits that govern the nuclear plant operation and is prepared by the licensee in accordance with a power reactor operating licence condition. Bruce Power had requested CNSC approval to make certain revisions to the document. These revisions are related to the channel and bundle power limits and trip set-points for SDS 1 and SDS 2.

The revision of the OP&P channel and bundle power limits and trip set-points was implemented in combination with new, lower limits on the Reactor Inlet Header (RIH) temperatures. In practice, if the RIH temperatures reach the new limits, then operation would revert to the current more restrictive channel and bundle powers. This was further reinforced by physical changes to the plant to reduce RIH temperatures, maintaining existing internal maximum bundle and channel power action limits, and additional improvements to enhance loss-of-flow trip coverage.

In December 2004 and December 2005, Bruce Power provided the CNSC with status updates with respect to the available operating margins to the maximum channel and bundle power limits. The updates also included separate flow calibration records of SDS 1 and SDS 2 safety channels for Units 3 and 4.

CNSC staff reviewed the assessments and follow up monitoring by Bruce Power and found that it met expectations.

1.1.3.1.6 Bruce A Probabilistic Risk Assessment (BAPRA)

In November 2006, CNSC staff completed the review of the BAPRA version 16B report and identified several areas for improvements. The BAPRA 16B reflects the plant as built and operated, as closely as reasonable achievable given the time constraints, but not at the desired level intended in the CNSC's new regulatory standard, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants,* S-294. Bruce A-specific models, data, assumptions, testing and maintenance practices, and plant configuration need further development to become a more realistic representation of the design and operation of Units 3 and 4.

The review revealed no major weakness that would invalidate the model or necessitate design changes. The review did identify some sources of uncertainty regarding the validity of the insights and their utility as input in the decision-making process.

CNSC staff believes that the implementation of proposed recommendations would bring the updated BAPRAs closer to compliance with the regulatory requirements stated in S-294 and enhance the confidence of the BAPRA users in the model and the resulting insights.

1.1.3.1.7 Bruce B Risk Assessment (BBRA)

Bruce Power submitted the Bruce B Risk Assessment (BBRA) report to the CNSC in 1999, and the report has since been updated in accordance with CNSC review. The existing probabilistic safety assessment (PSA) code and model is being migrated to develop user-friendly PSA applications to support plant decision making. CNSC staff is monitoring the migration and finds that, to date, it meets expectations. The risk indices presented in the Annual Reliability Report for 2006 meet the Bruce Power risk target and show no change from the 2005 results.

CNSC staff reviews confirmed that, overall, Bruce Power performed acceptable safety analysis in 2006.

The CNSC evaluated Bruce Power's monitoring and assessment of new information obtained in 2006, to ensure the validity of the safety analysis documented in the *safety report* for the Bruce A and B power station. The assessment of the safety analysis area confirmed that, in general, both stations have adequate programs in place to support ongoing safe operation.

1.1.3.2 Safety Issues

During the re-licensing hearing, the *Commission* requested staff to report on the progress of GAIs as part of its mid-term report.

CNSC staff reviewed the progress made by the CANDU industry and utilities to resolve the GAIs. Bruce Power continued its work, including participation in the industry efforts, toward resolution of the GAIs. The overall progress was judged satisfactory. For more information on particular safety issues, see Appendix F for developments regarding each GAI during 2006.

1.1.3.3 Design

Bruce Power's documentation of equipment qualification and equipment classification was judged to be adequate in 2006. Bruce A and Bruce B both experienced minor situations in 2006 that revealed legacy design issues, which are being reviewed. No deficiencies with respect to design changes were identified, and the licensee continued to pursue safety enhancement programs.

Improvements to the fire protection program at Bruce A have been made and, in general, there has been a considerable reduction in combustible loading at the facility. However, inspection and testing of fire protection equipment, housekeeping and transient material control remain weaknesses at both facilities. Regulatory oversight has been increased to ensure appropriate corrective actions are implemented. CNSC staff concluded that the implementation of fire protection program at Bruce A and B did not meet requirements, but is improving.

However, CNSC staff concluded that the overall design and implementation of the Design program at Bruce A and Bruce B meet CNSC expectations.

1.1.4 Equipment Fitness for Service

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Bruce A	EQUIPMENT FITNESS FOR SERVICE	B	B
	Maintenance	B	C
	Structural Integrity	B	B
	Reliability	B	B
	Equipment Qualification	B	B
Bruce B	EQUIPMENT FITNESS FOR SERVICE	B	B
	Maintenance	B	B
	Structural Integrity	B	B
	Reliability	B	B
	Equipment Qualification	B	B

The Bruce A and B programs in the Equipment Fitness for Service safety area, and their implementation, met CNSC staff's expectations and contributed to safe facility operation in 2006. However, the implementation of the maintenance program at Bruce A continues to be a challenge.

1.1.4.1 Maintenance

Bruce Power has policies, processes and procedures in place that provide direction and support for its maintenance program.

At Bruce A, the overall program met CNSC expectations. However, due to continued high maintenance backlog levels, the implementation of the program remains below performance expectations. Bruce Power has taken a number of initiatives to deal with this challenge and, as a result, has shown an improving trend.

At Bruce B, the maintenance program is supported by a significant organization with established goals. Continuous status reporting is done to track whether the goals are being met and to look for areas of improvement.

CNSC staff rates the implementation of the Bruce B maintenance program as meeting requirements. Bruce Power has controlled the age and quantity of the operating corrective maintenance backlog. Initiatives have been taken that should result in lower maintenance backlog levels.

1.1.4.2 Structural Integrity

The scope and schedule of in-service inspections at both Bruce A and Bruce B were based on the most recent revision of Bruce Power's periodic inspection program (PIP) and management plans for the life cycle and the aging of components. The programs are up to date. CNSC staff is satisfied both with the basis for these plans and the adequacy of documentation.

Both stations are meeting requirements for the pressure retaining components program. In accordance with scope and schedule defined in both Bruce A's and Bruce B's PIP and aging and life cycle management strategy and plans, both stations performed in-service inspections during 2006 planned outage. CNSC staff is satisfied with the inspection work and the assessment of the inspection findings.

Bruce Power has established two proactive initiatives concerning fuel channel fitness for service: a comprehensive program to address issues related to tight-fitting annulus spacers and the decision to complete post-irradiation examinations of a removed pressure tube. CNSC staff is satisfied with both the inspection work and the assessment of the inspection findings.

Bruce Power has proposed updating its procedures to facilitate implementation of certain improvements to the pressure boundary regulatory process according to CSA N285.0-06, beginning with a limited trial application for work associated with the return to service of Units 1 and 2.

1.1.4.3 Reliability

In 2006, Bruce Power applied to have the licences for both Bruce A and Bruce B amended to include the CNSC regulatory standard S-98, *Reliability Programs for Nuclear Power Plants*, as did all other power reactor licensees. Bruce Power is following industry-wide guidance for its revised reliability programs. CNSC staff considers the industry approach to be generally acceptable although some generic issues still need to be resolved. CNSC staff has planned a workshop with the industry in June 2007 to discuss these generic issues. CNSC staff will conduct a more detailed review of the reliability programs once these issues are resolved.

A CNSC staff inspection in 2005 observed a shortage of staffing in the reliability area. While Bruce Power has taken corrective actions to address this issue, CNSC staff remains concerned about the pace at which Bruce Power is producing the documentation associated with its reliability program. Therefore, CNSC staff will continue to monitor Bruce Power's progress closely during the coming year.

For both Bruce A and Bruce B, the performance of systems important to safety met their targets in 2006. However, not all the faults on systems were analyzed in detail, due to lack of staffing mentioned above. Once all the faults are analyzed, the actual performance of the systems may be changed. As noted above, CNSC staff is monitoring Bruce Power's corrective actions related to staffing of reliability.

During 2006, 9 out of 11 safety-related systems at Bruce A met reliability targets. The equipment qualification issue related to the steam barrier protected program, discussed further in the next section, affected the calculated past availability of many systems. Bruce Power has taken actions to address this issue, which is not expected to have significantly affected future system performance.

With respect to Bruce B, CNSC staff will be following up with Bruce Power on the number of minor impairments, and the long duration of some of these impairments, to the negative pressure containment system. While the system met its overall reliability target in 2006, CNSC staff is concerned of a reduction in the system redundancy caused by these minor impairments.

1.1.4.4 Equipment Qualification

A 2006 CNSC inspection of the Bruce A *environmental qualification* (EQ) program determined that the station is environmentally qualified for the short term. CNSC staff had identified some areas for improvements to advance the sustainability of EQ in the long term. In response to the inspection findings, Bruce A put in place the necessary corrective actions to address the issues. CNSC staff generally found that the licensee implemented appropriate measures to correct the deficiencies**.**

In 2006, there were several reportable events at both Bruce A and Bruce B related to the steam protection barrier program. Of particular note is that Bruce Power identified the EQ non-compliances that could have compromised the EQ requirements of the main control room (MCR) due to design deficiencies in the MCR room structure and unqualified status of associated heating, ventilation and air-conditioning ducts penetrations. As an interim compensatory measure in order to maintain operability of the station 75% of the upper power house emergency venting system panels have been opened to decrease the maximum pressure pulse resulting from a secondary line break. Bruce Power continues to analyze the new requirements for the MCR complex and associate penetrations.

1.1.5 Emergency Preparedness

Site	SAFETY AREA	Grades	
		Program	Implementation
Bruce A	EMERGENCY PREPAREDNESS	A	A
Bruce B	EMERGENCY PREPAREDNESS	A	A

From the observation of a corporate site exercise at Bruce B, the inspection team concluded that Bruce Power has demonstrated its ability to effectively manage and implement its emergency response plan.

Bruce B's emergency preparedness program is analogous to that of Bruce A. CNSC staff did not identify any changes suggesting degradation in the program or weaknesses in its implementation.

Bruce A and Bruce B continue to meet all the requirements and expectations of the CNSC with regard to emergency preparedness and response. As in previous industry reports, no unreasonable risk to the effectiveness of the emergency response capability was noted. Program and implementation at Bruce A and B are judged to exceed expectations.

1.1.6 Environmental Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Bruce A	ENVIRONMENTAL PROTECTION	B	B
Bruce B	ENVIRONMENTAL PROTECTION	B	B

The implementation of the environmental protection programs at Bruce A and Bruce B met the CNSC expectations in 2006. Both airborne emissions and liquid releases of nuclear substances to the environment were less than 1% of the *derived release limit* for Bruce A and Bruce B, and there were no reports of environmental action levels being exceeded. In 2006, the reported dose to the public was 2.45 μSv for the Bruce site (A and B).

There were no reported unplanned releases of nuclear substances or hazardous substances from either Bruce A or Bruce B in 2006 that posed a significant risk to the environment.

1.1.7 Radiation Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Bruce A	RADIATION PROTECTION	B	B
Bruce B	RADIATION PROTECTION	B	B

There were no radiation exposures that exceeded regulatory limits.

Outstanding issues from a 2005 inspection were resolved and the action notices were closed.

Bruce Power has implemented an aggressive program to ensure that radiation exposures during the refurbishment and the subsequent plant operation will be as low as reasonably achievable.

Major efforts in tritium reduction have been successful: They will result in eliminating tritium as a major hazard during the refurbishment process and will reduce external exposures, as cumbersome protective equipment will not have to be worn.

In 2006, Bruce A and B continued to meet the implementation requirements for all radiation protection program elements. Any identified deficiencies were considered to be minor and did not pose a threat to the health and safety of workers.

1.1.8 Site Security

The assessment of the Site Security safety area for Bruce A and B is documented in a separate (secret) *Commission Member Document* (CMD 07-M19.A).

1.1.9 Safeguards

Site	SAFETY AREA	Grades	
		Program	Implementation
Bruce A	SAFEGUARDS	B	B
Bruce B	SAFEGUARDS	B	B

In 2006, the *safeguards* program at Bruce A and Bruce B continued to meet CNSC expectations with respect to all *safeguards* requirements.

1.1.10 Update on Other Major Projects and Initiatives

1.1.10.1 Life Extension of Bruce A Units 1 and 2

In June 2006, the *Commission* accepted the results of the environmental assessment screening report for the Bruce A Refurbishment for Life Extension and Continued Operations Project. Bruce Power commenced physical work subsequent to the *Commission* decision. Work is well underway in removing existing components for installation of new replacements.

Since then, Bruce Power has made various submissions to the CNSC in general conformity with the process described by draft regulatory document on life extension, G-360. Review of these submissions is ongoing with the objective of reaching agreement on the scope of work required for life extension. This aspect of the project (reaching agreement) is behind schedule and may affect the timeline for future licence amendment(s). Additional effort is required of both licensee and CNSC staff.

The Human Factors aspect of the Integrated Safety Review (ISR) submissions for the Bruce A Units 1 and 1 life extension project were reviewed. CNSC staff found that Bruce Power's review against modern standards in the ISR was insufficient with regard to human factors considerations. The adequacy of the scope for human factors in design for the life extension project as a whole cannot be determined, because the gaps between the current systems and modern standards have not been identified in the ISR submissions received in 2006. This issue will be addressed in 2007.

1.1.10.2 Low Void Reactivity Fuel

In a postulated large loss of coolant accident (LLOCA) in CANDU reactors, reactor power would increase rapidly due to the positive reactivity feedback caused by reactor coolant voiding (see Section 1.1.3.1.3). A significant power increase may lead to fuel and channel failures. The Low Void Reactivity Fuel (LVRF) is a design-based solution to this safety issue, whereby the new fuel uses slightly enriched uranium oxide and is characterized by a substantially reduced void reactivity coefficient.

Bruce Power is currently performing a demonstration irradiation (DI) of two channels worth of LVRF fuel in Unit 7. The DI is expected to be completed in the winter of 2008 with the subsequent inspection of fuel channels and discharged fuel to confirm fuel performance. All indications are that the new fuel is behaving as expected.

The current proposed strategy is to implement full core LVRF fuel in the refurbished Units 1 and 2, after they have been returned to service and reached an equilibrium core. Units 3 and 4 will be fuelled with LVRF after their refurbishment. Units 5 to 8 will then be fuelled as Bruce Power accumulates sufficient reserves of new fuel.

The LVRF implementation timelines have slipped in the past few years, partly due to manufacturability issues and a supply issue related to a change in regulatory requirements for the manufacturing plant. CNSC staff continues to closely monitor this situation and will brief the *Commission* on any significant developments in the project.

Documents concerning human factors of fuel production for the LVRF project were reviewed in 2006. Although the human factors work was found to be acceptable for the demonstration irradiation, more formalised and rigorous human factors work is needed for the full-scope fuel production.

1.1.11 Conclusion

Bruce Power operated both the Bruce A and B plants safely in 2006 and continues to work on integrating and harmonizing its programs and procedures across the Bruce site. Significant progress has been made in the development and implementation of its management system.
Based upon staffing projections, Bruce B will be able to meet the date committed to in its licence for ANO staffing, whereas it does not appear that Bruce A will be able to do so before 2009. A shortage of certified staff has been a persistent problem at Bruce A since the restart of Units 3 and 4.

Safety analysis issues reported during the licensing of the Bruce plants in 2003 have either been closed out to staff's satisfaction or have made good progress towards resolution. Bruce Power continued its work, including participation in the industry efforts, toward resolving the GAIs.

Although Bruce Power's current aging management program is seen as adequate, it is expected that aging management will become more challenging as the units approach the end of their operating lives. Accordingly, the CNSC anticipates more verification activities will be required with respect to equipment fitness for service at Units 3 and 4 at Bruce over the remainder of the licensing period.

Overall staff is satisfied with the performance of Bruce Power as a qualified operator of the Bruce nuclear power plants. Worker and public health and safety continue to be a priority to the licensee. Environmental releases are maintained well below release limits and regulatory requirements are met. Bruce Power continues to improve its programs and implementation, which are reflected by an improvement in its 2006 industry report ratings.

1.2 DARLINGTON

1.2.1 Operating Performance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Darlington	OPERATING PERFORMANCE	B	B
	Organization and Plant Management	B	B
	Operations	B	B
	Occupational Health and Safety (Non-radiological)	B	B

Darlington operated safely in 2006: The Operating Performance safety area at Darlington met the expectations of Canadian Nuclear Safety Commission (CNSC) staff. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC's desired outcomes.

The Occupational Health and Safety area met staff's expectations.

1.2.1.1 Organization and Plant Management

There were no significant events at Darlington in 2006 related to process failures.

CNSC staff observed no negative issues in this area. However, there were indications that plant aging and spare part availability were affecting plant operation. Ontario Power Generation (OPG) is developing a plan to resolve the aging management issue.

The inspections, surveillance and monitoring carried out by CNSC staff have found no significant changes to the program or the implementation over the past year, so the grade from the previous year remains valid.

1.2.1.2 Operations

CNSC staff conducted several field and control room inspections during 2006 and reported no major findings.

Based on CNSC *Type II inspections* and surveillance and monitoring by CNSC staff, there were no indications of degraded performance or changes to the program. The program grade from the previous year remains valid.

In the areas of communications, configuration management and outage management, CNSC staff observed that safety performance met requirements.

1.2.1.3 Occupational Health and Safety (Non-Radiological)

Ontario Power Generation (OPG) uses the Canadian Electricity Association (CEA) safety measures to report safety performance and to compare itself with similar top-quartile industry performers.

The CEA does not set annual targets for either of these indicators but reports on a three-year rolling average. The CEA industry three-year rolling averages in 2006 for the all accident injury rate (AIR) and accident severity rate (ASR) were 1.42 and 4.80, respectively. In 2006, Darlington's three-year rolling averages for the AIR and ASR were 1.05 and 3.75, respectively, and below the top quartile of industry performers.

In 2006, Darlington's AIR was 1.34, which was very close to the year-end target of 1.30.

In 2006, Darlington's ASR was 5.43, which exceeded the year-end target of 3.75. Five Lost Time Accidents and 15 medically treated injuries occurred in 2006. Of these, 12 injuries occurred between January and May. Most of the injuries were musculoskeletal injuries, slip/trip and hand injuries. One of the lost time accidents during the Unit 3 outage was reported to the *Commission* in Significant Development Report No. 2006-4 (*Commission Member Document* 06-M28.B).

The aforementioned five accidents accounted for 135 days of lost time. The most significant of these was an injury sustained by a maintenance worker who slipped in the shower, resulting in 76 lost days. In May, a recovery plan was implemented and the ASR improved steadily for the remainder of the year. Additionally, as part of the station overall improvement plan, OPG has introduced several conventional safety initiatives to improve on safety performance by monitoring worker performance, management/ supervisory oversight and, effective planning, scheduling and execution of work.

Given the improvement seen following OPG's initiative to correct the higher-than-expected AIR and ASR, CNSC staff rates the Occupational Health and Safety program and implementation as adequate. Staff will continue to monitor progress made in the injury rate.

1.2.2 Performance Assurance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Darlington	PERFORMANCE ASSURANCE	B	B
	Quality Management	B	B
	Human Factors	B	B
	Training, Examination, and Certification	B	B

Both the program and implementation of the Performance Assurance safety area at Darlington met CNSC staff's expectations. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC's desired outcomes.

1.2.2.1 Quality Management

The S-99 events reported by the licensee relevant to the Quality Management area were analyzed. Staff's analysis did not identify any issues affecting Darlington's documented quality management program. For 2006, Darlington's quality management program met CNSC expectations.

1.2.2.2 Human Factors

Based on compliance activities carried out in 2006, Darlington meets CNSC expectations for its human factors program and its implementation. CNSC staff will continue to closely monitor the completion of outstanding enforcement actions in the different review areas, as well as emerging trends in performance observed through S-99 event reports and information in the facility's quarterly operations reports.

CNSC staff conducted a *Type I inspection* to verify OPG's compliance with the station shift complement document in 2005. This inspection was combined with another *Type I inspection* to verify limits of hours of work. CNSC staff noted strengths and areas for improvement in OPG's process to comply with the station shift complement and limits of hours of work. The licensee committed to address the action notices and recommendation identified in the inspection report and is progressing well towards completing these activities.

In 2006, Darlington submitted a request to reduce the emergency response team minimum complement as documented in the station shift complement document. A multi-disciplinary review by CNSC staff concluded that the proposed reduction was not justified and turned down Darlington's request.

OPG has committed to meeting the requirement to have an authorized nuclear operator (ANO) at the Darlington reactor panel at all times, on a schedule that maintains the safe operation of its nuclear stations. During 2006, OPG provided information to the CNSC with respect to the main control room operator and shift supervisor/shift operating supervisor staffing plan. OPG has conveyed to the CNSC that the commitment for Darlington will be met by July 31, 2009.

As part of its continuing training program OPG held workshops entitled "Human Performance Event-Free Tools for Knowledge Work" for all OPG engineering staff. CNSC staff observed one of the training sessions in May 2006 and provided informal feedback after the session. The presence of senior management facilitating the session, the discussion of how engineering staff should use event-free tools, and relevant examples provided led to an effective workshop. OPG is to be commended on this initiative and is encouraged to continue this program.

1.2.2.3 Training, Examination, and Certification

Darlington continued to conduct re-qualification testing for all certified shift personnel, except Unit 0 control room operators. Full implementation of the re-qualification testing program for Unit 0 control room operators is planned for 2007. Further to an inspection of the ANO re-qualification diagnostic simulator testing, some deficiencies were identified and recommendations were issued. CNSC staff is reviewing the submitted response.

There were no evaluations of training programs for certified staff conducted in 2006 at Darlington. Follow-up activities to support examination transfer continued.

Darlington continued to incorporate the station-specific program objectives into its specifics training program for ANOs and Unit 0 control room operators. The incorporation of station specific program objectives is a major element of OPG's readiness to assume responsibility for certification examinations. CNSC staff is reviewing milestone submissions related to this initiative. In addition, OPG submitted a request to close the evaluation of the ANO initial simulator skills training program. CNSC staff is reviewing the submitted documents.

The overall success rate of certification examinations at Darlington was adequate during the year. CNSC staff concluded that this program and implementation met CNSC expectations, but that staff will have to closely verify that the licensee maintains adequate levels of certified staff.

1.2.3 Design and Analysis

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Darlington	DESIGN AND ANALYSIS	B	B
	Safety Analysis	B	B
	Safety Issues	B	B
	Design	B	B

Both the program and implementation of the Design and Analysis safety area at Darlington met CNSC staff's expectations. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC's desired outcomes. CNSC staff reviews, which included evaluation of the work performed towards a plant-specific probabilistic safety assessment, concluded that the licensee continued to provide acceptable safety analyses and responses to new design and safety issues.

Safety Analysis

CNSC staff reviews confirmed that OPG performed acceptable safety analysis in 2006.

CNSC staff evaluated OPG's ability to monitor and assess new information obtained in 2006 to ensure the validity of the safety analysis documented in the *safety report* for Darlington. The major contributors to the acceptable rating in safety analysis included adequate monitoring and performance in the following areas:

- monitoring and assessment of the *Darlington Request for Trial Use of Shutdown Cooling (SDC) System as Primary and Backup Heat Sinks* during the Fall 2006 Outage
- monitoring the *Best Estimate Analysis and Uncertainty (BEAU)* methodology
- performance of the *safety report* update once every three years (a condition in the operating licence)
- funding of ongoing research and development programs in nuclear safety under the CANDU Owners Group (COG) and assessment of potential impact of research findings
- monitoring and assessment of the impact of plant changes due to aging on safety analysis
- monitoring of operating transients at Darlington and assessment of their potential impact on safety

OPG has developed a new analysis methodology to resolve the impact of heat transport system aging. However, OPG has yet to provide sufficient information based on current licensing tools to address staff concerns on plant aging. An in-depth review of this methodology will be performed in the upcoming year to ensure that its analysis is valid. In the meantime, CNSC staff is evaluating the nature and type of conservative measures, if any, that the licensee may need to take until the new methodology is accepted.

1.2.3.2 Safety Issues

CNSC staff reviewed the progress of the CANDU industry and utilities in resolving issues related to Generic Action Items (GAIs). OPG continued its work, including participation in the industry efforts, toward resolution of the GAIs. The overall progress was judged to be satisfactory. For more information on particular safety issues, see Appendix F for developments regarding each GAI in 2006.

1.2.3.3 Design

In the area of fire protection, CNSC staff concluded from its review and assessment that OPG is operating its Darlington facility in general compliance with licence requirements. There were several issues requiring corrective action but that were not considered to present unreasonable risk to persons and the environment from fires at the facility.

CNSC staff concluded that the overall Design program and its implementation at Darlington met expectations.

1.2.4 Equipment Fitness for Service

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Darlington	EQUIPMENT FITNESS FOR SERVICE	B	B
	Maintenance	B	B
	Structural Integrity	B	B
	Reliability	B	B
	Equipment Qualification	B	C

Both the program and implementation of the Equipment Fitness for Service safety area at Darlington met CNSC staff's expectations and contributed adequately to safe facility operation and the achievement of the CNSC's desired outcomes in 2006. However, the equipment qualification program implementation continued to concern CNSC staff.

1.2.4.1 Maintenance

OPG has policies, processes and procedures in place that provide direction and support for the Darlington maintenance program. The program is supported by a significant organization with established goals. Continuous status reporting is completed to track whether the goals are being met and to look for areas of improvement.

CNSC staff concluded that the Darlington maintenance program implementation met expectations and is improving.

1.2.4.2 Structural Integrity

The structural integrity program and its implementation at Darlington continued to meet CNSC expectations.

OPG obtained its certificates of authorization for pressure boundary work several years ago. In 2006, OPG was granted a temporary licence deviation for the use of CSA standard N285.0-06, *General Requirements for Pressure Retaining Systems and Components in CANDU Nuclear Power Plants*. OPG is working towards updating procedures before requesting a licence amendment.

OPG performed in-service inspections of Unit 3 *feeders*, fuel channels and *steam generators* in accordance with its strategy for aging and life cycle management. The scope and schedule for in-service inspections at Darlington were based on the most recent revision of these plans. CNSC staff is satisfied both with the basis for these plans and the adequacy of documentation, as well as with the inspection work and OPG's assessment of the results.

OPG's strategy for fuel channel aging and life cycle management summarizes the current understanding of degradation mechanisms affecting Darlington *pressure tubes*, based on research and development programs and assessments of earlier inspection data collected at Darlington and other CANDU reactors. As such, it aims to identify both present and potential fitness-for-service issues affecting Darlington *pressure tubes*. CNSC staff is satisfied that OPG has implemented a managed process and a firm technical basis for assessing *pressure tube* fitness for service.

In 2006, several *feeders* were replaced in Unit 1 as part of OPG's *feeder* fitness-for-service guideline. It is OPG's strategy to repair *feeders* as necessary to allow station operation until the fuel channels need replacing.

As part of Darlington's fitness-for-service guidelines, supports and fittings that did not meet code requirements were repaired before the unit was returned to service.

CNSC staff concluded that Darlington met CNSC expectations for program and implementation.

1.2.4.3 Reliability

OPG has developed the Darlington reliability program consistent with the industry approach. CNSC staff considers the industry approach to be generally acceptable, although some generic issues still need to be resolved. CNSC staff has planned a workshop with the industry in June 2007 (and other meetings if needed) to resolve remaining issues. Overall, CNSC staff considers the reliability program at Darlington to be acceptable.

An inspection of the process of collecting and treating reliability data was conducted and revealed a need for improvement in terms of process documentation and tool development. Darlington provided a proper response to the findings and has developed a corrective action plan.

OPG continued to implement the reliability program at Darlington in 2006, which includes developing reliability models for all systems important to safety and improving reliability data. The ability of systems important to safety to perform as intended met the regulatory requirements.

CNSC staff is generally satisfied with progress in implementing the reliability program at Darlington in 2006 and will continue to monitor it in 2007.

1.2.4.4 Equipment Qualification

Fewer S-99 events associated with steam-protected rooms (for example, doors left open) were reported in 2006 than in 2005. These rooms (approximately 350) protect contained sensitive electrical equipment from harsh environment conditions in the event of a main steam line break. OPG is to be commended for promoting environmental qualification (EQ) awareness to its staff in 2006.

On December 5, 2006, OPG presented CNSC staff with an annual update of its EQ program. The update provided staff with the status of several outstanding actions. These include completion of EQ documentation, replacement of EQ-related components and testing of steam-protected rooms.

Completion of EQ documentation was recognized as an outstanding requirement of the program. As part of the documentation update, the licensee had to rebuild its environment qualification safety related components list, which is vital to maintaining the EQ envelope. Staff will monitor this issue closely in 2007 as updates to this list are still in progress.

In 2006, OPG replaced all EQ components at Darlington as scheduled, with some minor exceptions.

A leakage test on the Unit 1 steam-protected room was conducted in 2006 to validate that safety related equipment would not be damaged in accident situations. The result showed the as-found steam leak rate was slightly exceeded. CNSC staff is evaluating the final test report.

While implementation of the EQ program is evolving, it has yet to meet CNSC staff's expectations. CNSC staff will continue to closely monitor the Darlington EQ program implementation in the upcoming year.

1.2.5 Emergency Preparedness

Site	SAFETY AREA	Grades	
		Program	Implementation
Darlington	EMERGENCY PREPAREDNESS	A	A

The emergency preparedness program and its implementation at Darlington continued to exceed CNSC expectations.

During a *Type II* inspection of an off-site public emergency evacuation exercise, Darlington staff demonstrated the ability to deal with contaminated members of the public.

Darlington continued to meet regulatory requirements for emergency preparedness and response capability. Consistent with the previous industry report, the licensee continued to demonstrate effective emergency response capability.

1.2.6 Environmental Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Darlington	ENVIRONMENTAL PROTECTION	B	B

The implementation of the environmental protection program at Darlington met the CNSC expectations in 2006.

Both airborne emissions and liquid releases of nuclear substances to the environment were less than 1% of the *derived release limit* for Darlington, and there were no reports of environmental action levels being exceeded. In 2006, the reported dose to the public was 1.1 µSv for Darlington.

There were no reported unplanned releases of nuclear substances or hazardous substances from Darlington in 2006 that posed a significant risk to the environment.

CNSC staff conducted a *Type I inspection* of the OPG nuclear environmental management system in 2006 and identified no significant issues.

1.2.7 Radiation Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Darlington	RADIATION PROTECTION	B	A

There were no radiation exposures that exceeded regulatory limits.

In 2006, CNSC staff evaluated the Darlington station radiation protection program and rated it as meeting expectations and assigned a “B” grade. The Darlington radiation protection program is part of the OPG’s overall radiation protection program, which met CNSC staff expectations. Implementation of the radiation protection program at Darlington, which exceeded expectations, was rated an “A.”

During the past few years, the Darlington radiation protection Department’s implementation of its radiation protection program exceeded CNSC expectations. The station has applied the as low as reasonably achievable (ALARA) principles effectively over the years and has seen a decrease on its collective dose in operations situations. The high-technology approach of its ALARA group during outages was also noted as a good example of *best practices* in the industry.

In 2006, five in-depth reviews of radiation protection were performed during periods of operations and outages. This increase in surveillance was in anticipation of the Darlington 2008 licence renewal. Different areas of the radiation protection program were reviewed against CNSC inspection criteria and have exceeded requirements. Criteria reviewed included the radiation protection management, dosimetry, contamination control and the site's compliance with ALARA principles.

More importantly, Darlington radiation protection management has demonstrated to the CNSC a high degree of professionalism. For example, radiation protection events reported at the site were corrected immediately.

These facts and the Darlington radiation protection program's positive long-term trend have allowed the program to exceed expectations of CNSC staff. However, room for improvement remains, for example with respect to an OPG corporate issue related to procedural adherence in the use of respirators and medical surveillance for respirator users.

1.2.8 Site Security

The assessment of the Site Security safety area for Darlington is documented in a separate (secret) *Commission Member Document* (CMD 07-M19.A).

1.2.9 Safeguards

Site	SAFETY AREA	Grades	
		Program	Implementation
Darlington	SAFEGUARDS	B	B

In 2006, the *safeguards* program at Darlington continued to meet CNSC expectations with respect to all *safeguards* requirements.

1.3 PICKERING A

1.3.1 Operating Performance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Pickering A	OPERATING PERFORMANCE	B	B
	Organization and Plant Management	B	C
	Operations	B	B
	Occupational Health & Safety (Non-radiological)	B	B

Both the program and implementation of the Operating Performance safety area at Pickering A met the expectations of CNSC staff. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the desired outcomes. Organization and Plant Management implementation was rated a "C," Operations was rated a "B," and Occupational Health and Safety was rated a "B."

1.3.1.1 Organization and Plant Management

Pickering A experienced eight forced shutdowns due to equipment failures during the year. Three of the eight forced shutdowns were due to problems with the liquid zone control system. In some cases, the outages resulted from past inadequate resolution of known problems. There were six reactor trips on Pickering A, all on Unit 1, with one automatic and five manually initiated.

Ontario Power Generation (OPG) station condition records identified management deficiencies as the root cause of several events, such as:

- lack of direction regarding responsibility for core reactivity management
- lack of use of in-house operating experience on Units 1 and 4 on the dissolved oxygen and megawatt loss investigations
- lack of oversight during troubleshooting activities that led to condensate system piping over-pressurization

Reactivity control issues led to adjuster rod withdrawal on Unit 4 on one occasion and numerous instances of extended operation at reduced power levels due to lack of fuel.

In late December, demineralised water was contaminated with ion-exchange resin, which led directly to the shutdown of one unit at Pickering B and operating restrictions on all other units at Pickering A and B. Investigation into the cause was still in progress at year end.

There were numerous unresolved, repetitive or persistent equipment deficiencies that led to repeat events:

- opening of the powerhouse environment ventilation panels during adverse weather conditions (high winds)
- thinning of service water piping downstream of the moderator temperature control valves
- limit switch deficiencies on steam release valves that generated spurious *setback* signals and on moderator valves required for emergency coolant injection system recovery operation
- fuel handling equipment failures that resulted in adjuster rod withdrawals, several unit de-ratings, liquid zone level control problems, and the inability to locate and remove defect fuel in Unit 1, which led to frequent personnel contamination events and one instance of internal uptakes
- issues with inadequate engineering change control, which delayed replacement of obsolete process and protective system meters
- inadvertent boron addition to the moderator system, which was due to equipment deficiencies that also led to reactivity deficiencies
- several equipment failures that led to periods where safety-related systems were unavailable

In several cases, past investigations and actions failed to correct these problems.

A review of the unscheduled reports required by S-99 identified that the time between the discovery of the event and receipt of the preliminary event report was significantly longer than it has been in the past and compared to other nuclear power plants. Station processes need to be changed to improve licensee performance in this area. In addition, on some occasions CNSC staff had to advise OPG to report events. Furthermore, OPG should limit the use of additional reports only to those occasions where absolutely necessary, and these should be produced in a timely manner.

Overall, OPG required improvement in this area and its implementation was therefore rated a “C.”

1.3.1.2 Operations

CNSC staff assessed Operations from information collected through inspections, review of operations and S-99 reports.

CNSC staff conducted a series of field compliance inspections at Pickering A during 2006. While many housekeeping or plant status deficiencies were noted, they were generally minor and easily corrected. Overall housekeeping performance in the operating units (Units 1 and 4) was improved, but areas in Units 2 and 3 were deficient because return-to-service equipment and materials were being stored in these areas.

The planned Unit 4 outage was originally scheduled for 60 days and to be completed in mid-December, but extended significantly beyond year end due to a broken adjuster rod cable causing the rod to drop in core with subsequent investigation and recovery activities.

1.3.1.3 Occupational Health and Safety (Non-radiological)

The Pickering A and B combined accident severity rate was higher than that of the whole industry average (see Table 9). However, most of the contribution to this indicator was from Pickering B. Overall, the occupational health and safety program and implementation for Pickering A, met CNSC's performance expectations.

1.3.2 Performance Assurance

Site	SAFETY AREA	Grades	
	Program	Program	Implementation
Pickering A	PERFORMANCE ASSURANCE	B	B
	Quality Management	B	B
	Human Factors	B	C
	Training, Examination, and Certification	B	B

Both the program and implementation of the Performance Assurance safety area at Pickering A met CNSC staff's expectations. The programs under this safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC's expectations.

The implementation of the quality management program and the training, examination and certification program met CNSC staff expectations. The implementation of the Human Factors program did not meet CNSC staff expectations.

1.3.2.1 Quality Management

No *Type I inspections* for quality management activities were carried out at Pickering A in 2006. A *Type I inspection* regarding engineering change control is scheduled for early 2007, as part of an effort to evaluate OPG's engineering change control at all three OPG stations.

A number of S-99 events identified issues regarding non-adherence to the licensee's documented quality management program in the areas of work control, verification, design, and maintenance. The apparent causes of these events occurred several times throughout the year and are significant indicators of potential degradation to Pickering A's implemented quality management program.

For 2006, Pickering A's quality management program met CNSC expectations, although some negative precursors did occur. Although the events reviewed were not directly associated with unsafe conditions, increased oversight is needed to ensure that identified precursors are evaluated and corrected to prevent major issues with Pickering A's implemented quality management program.

1.3.2.2 Human Factors

CNSC staff conducted a *Type I inspection* at Pickering to verify compliance with the shift station complement document. This inspection was combined with the *Type I inspection* to verify compliance with the Limits to Hours of Work document. Pickering A and Pickering B share a shift station complement document, so this was a combined inspection assessing compliance at both stations. As a result of the inspection, the CNSC issued a directive requiring OPG to generate evidence demonstrating compliance with condition 2.2 of the power reactor operating licences. CNSC staff also issued two action notices requiring OPG to document and implement a process to ensure each minimum shift complement is met. The licensee has provided preliminary information identifying interim actions and proposed plans to address the enforcement actions in the inspection report. OPG is also reviewing alternatives to determine a minimum complement and a recommendation on the most effective method.

A review of station performance information, submitted S-99 reports and CNSC inspection reports have identified a number of human performance issues at Pickering A that indicate a downward trend in the area of human performance. These issues concerned the following areas:

- non-conservative decision making (during responses to a liquid zone event on Unit 1)
- lack of oversight (during Unit 4 condensate piping over-pressurization and the investigation of oxygen leak and megawatt loss at Units 1 and 4)
- procedural non-compliances and deviations (during response to Unit 1 liquid zone problems and in radiation protection events)
- lack of dedicated authorized nuclear operators to perform tasks (one instance leading to a Unit 1 automatic reactor trip during start-up activities)

As part of its continuing training program, OPG held workshops entitled "Human Performance Event-Free Tools for Knowledge Work" for all OPG engineering staff. CNSC staff observed one of the training sessions in May 2006, and provided informal feedback after the session. The presence of senior management facilitating the session, the discussion of how engineering staff should use event-free tools, and relevant examples led to an effective workshop. OPG is to be commended on this initiative and is encouraged to continue.

Based on compliance activities carried out in 2006, and information collected from the review of licensee reports, Pickering A met CNSC expectations for its human factors program and was given a “B” rating; however, the implementation did not meet CNSC expectations and was therefore assigned a “C” rating. CNSC staff will continue to closely monitor the completion of outstanding regulatory actions in the different review areas, as well as emerging trends in performance observed through S-99 event reports and information the facility’s quarterly operations reports.

1.3.2.3 Training, Examination, and Certification

During 2006, there were a number of station events involving operating and certified staff, such as the simultaneous shutdown of the Class 2 inverters of Unit 4. The detailed reports on these events will be used to review the performance of certified staff and to examine the adequacy of procedures to cover these types of events.

There were no evaluations of re-qualification testing programs or of training programs for certified staff conducted in 2006 at Pickering A.

OPG continued working to incorporate the station specific program objectives into the training program for authorized nuclear operators (ANOs). CNSC staff is reviewing milestone submissions. The incorporation of station-specific learning objectives is a major element of OPG’s preparation to assume responsibility for certification examinations.

The overall success rate in certification examinations at Pickering A was adequate during the year. CNSC staff concluded that this program and implementation met expectations. The CNSC continued to monitor that the required number of certified staff assigned to work on all units was adequate, with focus on staffing of the de-fuelled Units 2 and 3. There must be an adequate number of certified staff assigned to the de-fuelled units in order to operate the common and safety systems equipment controlled from the panels of these units. These operators must be in addition to those assigned to the operating Units 1 and 4.

1.3.3 Design and Analysis

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Pickering A	DESIGN AND ANALYSIS	B	B
	Safety Analysis	B	B
	Safety Issues	B	B
	Design	B	B

Both the program and implementation of the Design and Analysis safety area at Pickering A met CNSC staff’s expectations. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC’s required outcomes. CNSC staff reviews, which included evaluation of the work performed towards a plant-specific probabilistic safety assessment, concluded that the licensee continued to provide acceptable safety analyses and responses to new design and safety issues.

1.3.3.1 Safety Analysis

CNSC staff reviews confirmed that OPG performed acceptable safety analysis in 2006.

The CNSC assessed OPG's performance in monitoring and assessing new information obtained in 2006, to ensure the validity of the safety analysis documented in the *safety report* for the Pickering A power station. The major contributors to the acceptable rating in safety analysis included:

- monitoring the *Best Estimate Analysis and Uncertainty (BEAU)* methodology
- funding of ongoing research and development programs in nuclear safety under COG and assessment of potential impact of research findings
- performance of the *safety report* update every three years (a condition in the operating licence)
- monitoring and assessment of the impact of plant aging on safety analysis
- monitoring of operating transients at Pickering A and assessment of their potential impact on safety
- OPG's efforts to date in meeting the intent of S-294 with respect to probabilistic safety assessment, although the *Pickering A Risk Assessment* did not yet meet all the S-294 requirements.

The assessment of the safety analysis area confirmed that, in general, the station has adequate programs in place to support ongoing safe operation.

1.3.3.2 Safety Issues

CNSC staff reviewed the progress made by the CANDU industry and utilities to resolve the generic action items (GAIs). OPG continued its work, including participation in the industry efforts, toward resolution of the GAIs. The overall progress was judged satisfactory. For more information on particular safety issues, see Appendix F for developments regarding each GAI in 2006.

1.3.3.3 Design

Although some minor deficiencies were identified in the design of certain systems at Pickering A, the overall Design program and its implementation at Pickering A met CNSC expectations in 2006.

1.3.4 Equipment Fitness For Service

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Pickering A	EQUIPMENT FITNESS FOR SERVICE	B	B
	Maintenance	B	B
	Structural Integrity	B	B
	Reliability	B	B
	Equipment Qualification	B	B

Both the program and implementation of the Equipment Fitness for Service safety area at Pickering A met CNSC staff's expectations. The programs under this safety area met CNSC's expectations in 2006.

1.3.4.1 Maintenance

CNSC staff concluded that Pickering A had policies, processes and procedures in place that provide direction and support for its maintenance program. The program was supported by a significant organization with established goals. Continuous status reporting was done to track whether or not the goals were being met and to look for areas of improvement. CNSC staff considered that the Pickering A maintenance program met requirements.

Pickering A Units 1 and 4 recently underwent extensive upgrades due to return-to-service activities and met all maintenance related commitments. On this basis, Pickering A's maintenance program met CNSC staff's expectations.

1.3.4.2 Structural Integrity

OPG obtained certificates of authorization for pressure boundary work several years ago, and had been working towards updating procedures to the latest revision of CSA N285.0-06 before submitting a request for licence amendment.

In accordance with Pickering A's periodic inspection program and strategy for aging and life cycle management, Pickering A performed in-service inspections during the 2006 planned outage. The scope and schedule for in-service inspections at Pickering A were based on the most recent revision of OPG's strategy for components aging and life cycle management. The programs were up to date. CNSC staff was satisfied both with the basis for these plans and the adequacy of documentation, as well as with the inspection work and the assessment of inspection findings.
Since Units 1 and 4 at Pickering A were restarted recently, inspections of the steam generator, *pressure tubes* and *feeders* were completed prior the restart. The program and its implementation of the Structural Integrity program met CNSC requirements.

1.3.4.3 Reliability

OPG has developed the Pickering A reliability program consistent with the industry approach. CNSC staff considered the industry approach generally acceptable although some generic issues still needed to be resolved. CNSC staff planned a workshop in June 2007 (and other meetings if needed) with the industry to resolve the remaining issues. Overall, CNSC staff considered the reliability program at Pickering A to be acceptable.

OPG continued to implement the reliability program at Pickering A in 2006, such as developing reliability models for all the systems important to safety and improving reliability data, etc. CNSC staff was satisfied in general with the progress in implementation of the reliability program at Pickering A in 2006 and will keep monitoring progress in 2007.

In general, most safety-related systems performed as intended in 2006; however, the number of incidents where safety-related systems were unavailable was higher in 2006 than in the previous year. Overall, CNSC staff was satisfied with the implementation of the reliability program at Pickering A in 2006.

1.3.4.4 Equipment Qualification

In 2006, CNSC staff did not identify any significant changes suggesting degradation in the Pickering A equipment qualification program or weaknesses in its implementation.

1.3.5 Emergency Preparedness

Site	SAFETY AREA	Grades	
		Program	Implementation
Pickering A	EMERGENCY PREPAREDNESS	A	A

A *Type II inspection* was conducted at Pickering B in September 2006, concluding that "within the scope of the inspection, Pickering has demonstrated its ability to effectively respond to and manage an emergency". Pickering A and Pickering B share corporate resources for emergency response, so this conclusion also applied to Pickering A.

Pickering A continued to meet all regulatory requirements for emergency preparedness and response capability. Consistent with the previous industry report, no unreasonable risk to the effectiveness of the emergency response capability was determined. The Pickering A emergency preparedness program and its implementation continued to exceed expectations.

1.3.6 Environmental Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Pickering A	ENVIRONMENTAL PROTECTION	B	B

The implementation of the environmental protection program at Pickering A met the CNSC expectations in 2006. Both airborne emissions and liquid releases of nuclear substances to the environment were less than 1% of the *derived release limit* for Pickering A. There were no reports of environmental action levels being exceeded. In 2006, the reported dose to the public was 2.8 µSv for the Pickering site (A and B).

There were no reported unplanned releases of nuclear substances or hazardous substances from Pickering A in 2006 that posed a significant risk to the environment.

CNSC staff conducted a *Type I inspection* of the OPG nuclear environmental management system in 2006 and no significant issues were identified.

1.3.7 Radiation Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Pickering A	RADIATION PROTECTION	B	B

There were no radiation exposures that exceeded regulatory limits.

CNSC staff performed a *Type I inspection* of the Pickering A radiation protection program in March 2006. Two respirator-related deficiencies were noted, and OPG agreed to undertake actions to correct them. OPG has committed to implementing a medical surveillance program to ensure employees are physically fit to safely use respiratory protection equipment. The licensee has also committed to enforcing procedural respirator use. Specifically, it will ensure that users are clean shaven.

During the year, one incident resulted in one individual receiving a tritium dose in excess of an action level. The licensee took all required steps, and this incident did not represent a loss of control of the licensee’s radiation protection program.

In 2006, OPG continued to meet implementation requirements for all elements of its radiation protection program at Pickering A. Identified deficiencies were considered to be minor and did not pose a threat to the health and safety of workers.

1.3.8 Site Security

The assessment of the Site Security safety area for Pickering A and Pickering B is documented in a separate (secret) *Commission Member Document* (CMD 06-35.A).

1.3.9 Safeguards

Site	SAFETY AREA	Grades	
		Program	Implementation
Pickering A	SAFEGUARDS	B	B

In 2006, the *safeguards* program at Pickering A continued to meet CNSC expectations with respect to all *safeguards* requirements.

1.3.10 Update on Other Major Projects and Initiatives

1.3.10.1 Pickering A Units 2 and 3 Safe Storage Project

In November 2005, OPG advised the CNSC of its decision not to return Pickering A Units 2 and 3 to service as previously planned after its Board of Directors accepted management's recommendation not to proceed with the restart of these units. The safe return to service of these units would have been technically feasible; the decision not to proceed with refurbishment was made in consideration of the business case. Instead of returning to operation, Units 2 and 3 will be placed in long-term safe storage.

The units are currently in a *guaranteed shutdown state*. They contain nuclear fuel and heavy water and are capable of sustaining a nuclear chain reaction. Due to the many interconnections that existed between the systems in all four units to support their operation, some Unit 2 and 3 systems will still be required to operate in support of Units 1 and 4.

The preliminary decommissioning plan for Pickering A calls for units to be placed in a safe storage state after they are permanently shut down and before they are dismantled. Accordingly, the goal of the safe storage project is to remove the fuel and heavy water from Units 2 and 3, maintain them in safe storage until Units 1 and 4 are permanently shut down and until decommission activities have begun.

According to OPG, all activities required to place the units in safe storage (removal of fuel and heavy water) can be performed under the existing operating licence. As a result, OPG does not intend to apply for a different licence for Units 2 and 3 while they are being placed in or while they are in the safe storage state.

The project execution plan, Governance in Support of Safe Storage, and a letter indicating submissions in support of safe storage project have been formally submitted. The latter indicates that several amendments to the current licence will be required.

These amendments include revision to certain documents to reflect the safe storage state, changes to operation, and design.

1.4 PICKERING B

1.4.1 Operating Performance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Pickering B	OPERATING PERFORMANCE	B	B
	Organization and Plant Management	B	B
	Operations	B	B
	Occupational Health and Safety (Non-radiological)	B	B

Both the program and implementation of the Operating Performance safety area at Pickering B met the expectations of CNSC staff. The programs under the safety area met CNSC's expectations in 2006.

1.4.1.1 Organization and Plant Management

There were five forced outages including one reactor trip due to equipment problems, some due to historically known problems. There were three major planned outages that occurred during the year. All unit planned outages were significantly extended. Repetitive equipment failures caused some of these extensions.

There were three *setbacks* initiated due to equipment problems, with one leading to a forced outage. In the other two cases, the equipment deficiencies were resolved and the units returned to full-power operation.

Equipment deficiencies led to repeat events such as quality issues with new components such as steam release valve transducers and alarm units, shutdown cooling pump seals, heat transport and emergency coolant injection valve packing leakage, and trips of emergency low- and high-pressure service water pumps. In some cases, these were repeat events and past investigations and corrective actions failed to correct these problems.

Algae clogging of the intake cooling water system necessitated unit de-ratings. While corrective actions were taken on these situations, it will be some time before all actions are implemented and their effectiveness can be determined.

There were two notable events that arose from interactions with outside service providers. In one case, work on safety-related equipment was being performed by an unqualified service provider. Interim actions were implemented to address immediate quality issues. In the other case, demineralised water was contaminated with ion-exchange resin, leading directly to the shutdown of one unit and operating restrictions on all other units.

A review of the unscheduled reports required by S-99, *Reporting Requirements for Operating Nuclear Power Plants*, identified that the time between the discovery of events and receipt of the preliminary event reports was significantly longer than in the past and compared to other nuclear power plants. Station processes need to be changed to improve licensee performance in this area. In addition, on many occasions, CNSC staff had to advise OPG to report events. Furthermore, OPG should limit the use of additional reports only to those occasions where absolutely necessary, and these should be produced in a timely manner.

While some deficiencies have been identified in the implementation of Organization and Plant Management, it is rated a “B.”

1.4.1.2 Operations

CNSC staff assessed Operations from information collected through inspections, review of operations and S-99 reports.

CNSC staff conducted a series of field compliance inspections at Pickering B during 2006. While many issues were noted, they were generally minor. CNSC staff considered overall housekeeping performance to be acceptable, but noted several issues in temporary equipment tagging and non-compliance with seismic route requirements.

The Operations program and its implementation have been rated a “B” for 2006; however, there were incidents that resulted in a transient and equipment unavailability, which will require closer oversight in 2007.

1.4.1.3 Occupational Health and Safety (Non-radiological)

At Pickering B, there were 5 disabling injuries during 2006, resulting in 120 days of lost time. This resulted in an accident severity rate of 7.76. The accident severity rate, which was influenced by a single accident involving an ankle sprain, is well above the target of 3.75, but does not indicate an adverse trend. This program was given a “B” rating, but will be monitored to identify trends.

1.4.2 Performance Assurance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Pickering B	PERFORMANCE ASSURANCE	B	B
	Quality Management	B	B
	Human Factors	B	B
	Training, Examination, and Certification	B	B

The Performance Assurance safety area at Pickering B met CNSC staff’s expectations. The programs under this safety area adequately contribute to safe facility operation.

Deficiencies were identified with the implementation of the quality management and the human factors programs; however, they were given a “B” rating and will require additional oversight for the next year.

1.4.2.1 Quality Management

A *Type I inspection* regarding engineering change control was carried out at Pickering B. The final analysis and reports will be prepared in 2007. To date, no serious deficiencies leading to unsafe operation have been detected by the inspections.”

A number of events reported under S-99 identified issues regarding non adherence to the licensee’s documented quality management program, in the areas of work control, verification, design, and maintenance. The event’s apparent causes occurred multiple times throughout the year and may indicate an adverse trend in the implementation of the quality management program.

Overall the events reviewed were not directly associated with any unsafe conditions for the facility. For 2006, Pickering B’s quality management program met CNSC expectations although the issues identified will require further oversight.

1.4.2.2 Human Factors

CNSC staff conducted a *Type I inspection* at Pickering to verify compliance with the shift station complement document. This inspection was combined with the *Type I inspection* to verify compliance with the Limits to Hours of Work document. Since Pickering A and Pickering B share a shift station complement document, this was a combined inspection assessing compliance at both stations. As a result of the inspection, the CNSC issued a directive requiring that OPG generate evidence to demonstrate compliance with condition 2.2 of the power reactor operating licences. CNSC staff also issued two action notices requiring OPG to document and implement a process to meet each minimum shift complement. OPG has provided preliminary information identifying interim actions and proposed plans to address the enforcement actions identified in the inspection report. The licensee is reviewing alternatives to determine the minimum complement and to recommend the most effective method.

OPG has committed to addressing action notices and recommendations identified with respect to procedural compliance and have provided an update on its initial responses to the results of the inspection in 2006. CNSC staff’s review of the information provided, combined with inspection, station performance information and submitted S-99 reports conclude that further effort is required to see sustained improvements in compliance with procedures.

As part of its continuing training program, OPG held workshops entitled “Human Performance Event-Free Tools for Knowledge Work” for all OPG engineering staff. CNSC staff observed one of the training sessions in May 2006 and provided informal feedback after the session. The presence of senior management facilitating the session, the discussion of how engineering staff should use event-free tools, and relevant examples led to an effective workshop. OPG is to be commended on this initiative and is encouraged to continue it.

The Human Factors program and its implementation, while indicating some problems, were assigned a “B” rating.

1.4.2.3 Training, Examination, and Certification

In December 2006, a multi-unit outage occurred due to a demineralised water supply problem from an externally contracted water treatment plant. CNSC staff will use the detailed event report to review the performance of the plant’s certified staff to this type of event. No evaluations of re-qualification testing programs or of training programs for certified staff were conducted in 2006 at Pickering B.

OPG continued working to incorporate the station-specific program objectives into the training program for ANOs. Milestone submissions are being reviewed by CNSC staff. The incorporation of station-specific learning objectives is a major element of Pickering B’s preparation for readiness to assume responsibility for certification examinations.

In addition, CNSC staff is reviewing submitted documents in request for closure of a previously conducted training program evaluation of the shift manager/control room shift supervisor initial simulator skills phase training program.

The overall success rate in certification examinations at Pickering B was adequate during the year. This program and implementation met CNSC’s expectations for adequate levels of certified staff.

1.4.3 Design and Analysis

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Pickering B	DESIGN AND ANALYSIS	B	B
	Safety Analysis	B	B
	Safety Issues	B	B
	Design	B	C

Both the program and implementation of the Design and Analysis safety area at Pickering B met CNSC staff expectations. The programs under the safety area contributed adequately to safe facility operation in 2006; however, implementation of the Design program at Pickering B will continue to be rated below requirements until the units can be cooled if all power to the units is lost. CNSC staff reviews, which included a review of the work performed towards a plant-specific probabilistic safety assessment (PSA), concluded that the licensee continued to provide acceptable safety analyses and responses to new design and safety issues.

1.4.3.1 Safety Analysis

CNSC staff reviews confirmed that OPG performed acceptable safety analysis in 2006.

The performance of OPG to monitor and assess new information obtained in 2006 to ensure the validity of the safety analysis documented in the *safety report* for Pickering B power station was assessed. The major contributors to the acceptable rating in safety analysis include:

- performance of the *safety report* update every three years (a condition in the operating licence)
- assessment of the *Thermo-syphoning Operating Procedures and Their Technical Basis for Long Term Operation*
- monitoring and assessment of the *Adequacy of Emergency Power Supply and Emergency Water Supply*
- monitoring of *Low Level Drain State for Unit 6 Outage P561*
- monitoring the Best *Estimate Analysis and Uncertainty (BEAU)* methodology
- monitoring and assessment of the impact of plant aging on safety analysis
- funding of ongoing research and development programs in nuclear safety under COG and assessment of potential impact of research findings
- monitoring of operating transients at Pickering B and assessment of their potential impact on safety
- OPG's efforts to date in meeting the intent of S-294 with respect to PSA, although the *Pickering B Risk Assessment* does not yet meet all the S-294 requirements

The assessment of the safety analysis area confirmed that, in general, the station has adequate programs in place to support ongoing safe operation. However, it appears that a correction to the Neutron Over-Power Protection System trip setpoints, and possibly to other trips, may be needed at Pickering B to address the impact of plant aging.

1.4.3.2 Safety Issues

CNSC staff reviewed the progress made by the CANDU industry and utilities to resolve the GAIs. OPG continued its work, including participation in industry efforts, toward resolution of the GAIs and overall progress was judged satisfactory. For more information on particular safety issues, see Appendix F for developments regarding each GAI in 2006.

1.4.3.3 Design

The August 2003 blackout revealed deficiencies in the design of some of the systems at Pickering B. The deficiencies affected the overall defence-in-depth of the station. The main deficiency was the inability to cool down the reactor after a loss of the electricity grid, requiring the units to remain hot and dependent on thermo-syphoning to remove the decay heat. Among the corrective actions required, OPG is installing permanent large combustion turbine units to provide sufficient power to all units in case of a loss of off-site power in combination with units failing to survive and the need arises for cooling down of a single unit. The auxiliary power system will be commissioned in the third quarter of 2007.

In 2006, CNSC staff reviewed selected elements of fire protection implementation and concluded that overall the program met CNSC expectations. However, the fire protection program implementation was rated below expectations due to unresolved fire water supply deficiencies revealed during the August 2003 blackout. Pickering B has proposed a solution to address this issue, which would address staff's concerns if implemented.

CNSC staff completed a functional inspection of Pickering B's electrical distribution system and found evidence of technical and operational support to operate the system safely under normal operation conditions. However, the inspection found areas for which additional information is required which are being addressed by OPG.

During 2006, CNSC staff judged that the overall design program at Pickering B met CNSC's expectations. However implementation of this program will continue to be rated below requirements until the units can be cooled down in the absence of Class IV power to all units.

1.4.4 Equipment Fitness For Service

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Pickering B	EQUIPMENT FITNESS FOR SERVICE	B	B
	Maintenance	B	C
	Structural Integrity	B	B
	Reliability	B	B
	Equipment Qualification	B	B

At Pickering B, the implementation of the Equipment Fitness for Service safety area met expectations.

OPG has initiated an improvement program for equipment called "85/5," which indicates a target capacity factor of 85% and a 5% forced-loss rate. While these values are aimed at production, the improvements to meet these targets also affect the safety performance of the plant. CNSC staff recognizes the need for such an improvement program and is monitoring progress toward the targets.

1.4.4.1 Maintenance

CNSC staff concluded that OPG has policies, processes and procedures in place at Pickering B that provide direction and support for its maintenance program. The program is supported by a significant organization with established goals. Continuous status reporting is done to track whether goals are being met and to identify areas of improvement. The Pickering B maintenance program met CNSC requirements.

OPG provided an update on maintenance performance issues, indicating progress in reducing maintenance backlog. Reduction targets for the next two years were provided. Nevertheless, the backlog levels remain high, and CNSC staff continued to rate the implementation of the program as a “C” or below requirements.

1.4.4.2 Structural Integrity

OPG obtained certificates of authorization for pressure boundary work several years ago and has been working towards updating procedures to the latest revision of CSA N285.0-06 before submitting a request for licence amendment.

In accordance with Pickering B’s periodic inspection program and strategy for aging and life cycle management, OPG performed in-service inspections during the 2006 planned outage. The scope of and schedule for in-service inspections at Pickering B were based on the most recent revision of OPG’s strategy for components aging and life cycle management.

The programs are up to date. CNSC staff is satisfied both with the basis for these plans, and the adequacy of documentation, as well as with the inspection work and OPG’s assessment of the inspection findings.

1.4.4.3 Reliability

In 2006, Pickering B submitted its reliability program, developed in accordance with the industry approach, to the CNSC. CNSC staff considered the industry approach as generally acceptable, although some generic issues still needed to be resolved. CNSC staff has planned a workshop in June 2007 (and other meetings if needed) with the industry to resolve remaining issues. Overall, CNSC staff considered the reliability program at Pickering to be acceptable.

Based on review of Pickering B programs and procedures covering different areas of plant operation and results of plant inspections, CNSC staff believed that the reliability program had been implemented at Pickering B. There were areas for improvement and CNSC staff will continue its oversight of the program.

CNSC staff noted improvement in plant systems performance during 2006. There were fewer events involving unavailability of safety-related systems compared to 2005, and all systems important to safety met their unavailability targets. Several inspections held at Pickering B on different systems did not identify any major issue that would adversely impact the plant systems reliability. CNSC staff will continue to monitor OPG's implementation of the reliability program to ensure sustained improvement.

1.4.4.4 Equipment Qualification

A CNSC *Type I inspection* of Pickering B's *environmental qualification* (EQ) conducted in 2005 determined that the program and its implementation met the intent of the CNSC acceptance criteria. The inspection found a satisfactory level of EQ awareness among station management and staff. OPG's new sustaining plan for EQ was found to be acceptable. The inspection identified some area for improvements. The CNSC raised five action notices and five recommendations following the inspection.

In 2006, OPG responded to the inspection's finding providing the status of activities undertaken to address the action notices and recommendations. All findings, except the implementation of the cable monitoring subprogram, have been addressed.

In 2006, there was one noteworthy event at Pickering B with respect to the EQ requirements. Per the Pickering B EQ design guide, the Class III power and the instrument air compressors are not qualified for harsh environments. If operability of instrument air cannot be assured for design basis accidents resulting in harsh environments, then opening of steam reject valves from the main control room will be compromised for these events. OPG is currently assessing options to resolve this issue.

1.4.5 Emergency Preparedness

Site	SAFETY AREA	Grades	
		Program	Implementation
Pickering B	EMERGENCY PREPAREDNESS	A	A

A *Type II inspection* was conducted at Pickering B in September 2006, concluding that "within the scope of the inspection, OPG has demonstrated its ability to effectively respond to and manage an emergency." Because both Pickering A and Pickering B share corporate resources for emergency response, the same conclusion for corporate emergency response applies to Pickering A.

Pickering B continued to meet all of the regulatory requirements for emergency preparedness and response capability. Consistent with the previous industry report, no unreasonable risk to the effectiveness of the emergency response capability was determined and that the emergency preparedness program and its implementation at Pickering B continued to exceed expectations.

1.4.6 Environmental Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Pickering B	ENVIRONMENTAL PROTECTION	B	B

The implementation of the environmental protection program at Pickering B met CNSC expectations in 2006. Both airborne emissions and liquid releases of nuclear substances to the environment were less than 1% of the *derived release limit* for Pickering B. There were no reports of environmental action levels being exceeded. In 2006, the reported dose to the public was 2.8 µSv for the Pickering site (A and B).

There were no reported unplanned releases of nuclear substances or hazardous substances from Pickering B in 2006 that posed a significant risk to the environment.

CNSC staff conducted a *Type I inspection* of the OPG nuclear environmental management system in 2006 and no significant issues were identified.

1.4.7 Radiation Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Pickering B	RADIATION PROTECTION	B	B

There were no radiation exposures that exceeded regulatory limits.

CNSC staff was satisfied with OPG's changes and updates in response to radiation protection inspections performed in past years. Five actions remain from a 2005 radiation protection inspection in the areas of oversight, Carbon-14 surveys, neutron monitoring, respiratory protection, and job and task analysis. OPG has committed to resolving these issues.

During the year, one incident resulted in two individuals receiving tritium doses in excess of an action level. The licensee took all required steps, and these action levels did not represent a loss of control of the licensee's radiation protection program.

In 2006, Pickering B continued to meet the implementation requirements for all elements of its radiation protection programs. Identified deficiencies were considered to be minor and did not pose a threat to the health and safety of workers.

1.4.8 Site Security

The assessment of the Site Security safety area for Pickering A and Pickering B is documented in a separate (secret) *Commission Member Document* (CMD 07-M19.A).

1.4.9 Safeguards

Site	SAFETY AREA	Grades	
		Program	Implementation
Pickering B	SAFEGUARDS	B	B

In 2006, the *safeguards* program at Pickering B continued to meet CNSC expectations with respect to all *safeguards* requirements.

1.4.10 Update on Other Major Projects and Initiatives

1.4.10.1 Refurbishment

Pickering B has operated continuously since 1983. Mid-life *pressure tube* refurbishment of CANDU nuclear generating stations is an element of the plant design assumed to be required at some point in the life of the plant, generally after 25 to 30 years of operation. Refurbishment would allow Pickering B to continue to operate for another 25 to 30 years, to approximately 2060.

OPG initially informed the CNSC of its intent to refurbish Pickering B in 2005. Since then the OPG Board of Directors has approved a project to undertake a feasibility study for the Pickering B Refurbishment. This includes an Environmental Assessment (EA) and an integrated safety review (ISR). The results of the EA studies and the ISR will make an important contribution to OPG's business decision on whether to refurbish the Pickering B units. Results of the ISR and the EA study may be incorporated in future licences for the continued operation of Pickering B after refurbishment.

1.4.10.1.1 Environmental Assessment (EA)

In June 2006, OPG submitted a project description for the refurbishment of the units at Pickering B. CNSC staff reviewed this project description and determined that the project description was acceptable and that the content was sufficient to enable a determination on the application of the *Canadian Environmental Assessment Act*. At that time, it was decided that a screening-level environmental assessment (EA) was appropriate for this project. Consequently, CNSC staff has prepared draft EA guidelines that were issued for review by public and federal authorities. The draft guidelines and comments from these reviews were dispositioned in the *Commission Member Document* 07-H2. The draft EA guidelines were presented at the January 24, 2007 *Commission* hearing for approval.

In accordance with the draft EA Guidelines, OPG has submitted its proposed valued ecosystem components, criteria for evaluating significance of environmental effects, the public involvement program, and bounding malfunctions and accidents, which must be accepted by the CNSC in accordance with the EA guidelines. At the end of 2006, these documents were still under review. The EA work is continuing and the study report is expected to be submitted on June 30, 2007.

1.4.10.1.2 Integrated Safety Review (ISR)

After receiving comments from CNSC staff, OPG submitted an ISR document along with a benefit-cost analysis process for the proposed Pickering B refurbishment.

Completion of the ISR basis scope and benefit-cost analysis was proceeding in 2006, OPG was addressing the CNSC comments and the final documents are expected to comply with G-360 guidance.

In 2006, CNSC staff began the review of the Pickering B Risk Assessment (PBRA), which is also an important component of an ISR. The CNSC staff's reviews of PBRA are progressing.

1.5 GENTILLY-2

1.5.1 Operating Performance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Gentilly-2	OPERATING PERFORMANCE	B	B
	Organization and Plant Management	B	B
	Operations	B	B
	Occupational Health and Safety (Non-radiological)	B	B

As reported to the *Commission* in *Commission Member Document* (CMD) 06-H15, “Renewal of the Operating Licence for the Gentilly-2 Nuclear Generating Station,” on August 16, 2006, CNSC staff concluded that the Operating Performance safety area met expectations. There have been no new safety area program evaluations since that time.

CNSC inspectors concluded that the safety areas of Station Operations, Organization and Plant Management, and Occupational Health and Safety (non-radiological) at Gentilly-2 were acceptable in 2006, both from a programmatic and implementation perspective. Although performance in most review topics met expectations, there were some weaknesses in procedural adherence particularly with respect to seismic area housekeeping. Also regarding seismic requirements, inspections revealed a backlog in modifications required to seismically qualify the emergency power supply system.

Finally, concern remains about actions taken by Hydro-Québec to prevent recurrence of difficulties encountered during boiler cleaning work in 2005.

1.5.1.1 Organization and Plant Management

CNSC staff concluded that the programs for the following areas met expectations in 2006: global program integration; *serious process failures* and transients, plant status and material condition; and public information program. CNSC staff is reviewing Hydro-Québec’s financial guarantees.

For the 2006 calendar year, Hydro-Québec’s safety performance in Organization and Plant Management at Gentilly-2 was acceptable. Although inspections, events and site surveillance revealed several points requiring follow-up, no distinct trend emerged. Immediate and definitive action on the part of Hydro-Québec is required to seismically qualify several components of the emergency power supply given a backlog of modifications revealed during a system inspection.

CNSC staff has yet to formally assess the implementation of the public information program.

1.5.1.2 Operations

In 2006, CNSC staff concluded that the operations program met expectations.

Overall, CNSC inspectors concluded that Hydro-Québec performance in implementing station operations was acceptable. From the references and documents gathered, the inspectors judged that Hydro-Québec met expectations in terms of communications, change control and outage management. Nevertheless, the inspectors noted weaknesses in the procedural adherence sub-topic, especially with respect to housekeeping practices in designated seismic areas.

1.5.1.3 Occupational Health and Safety (Non-radiological)

CNSC staff concluded that the occupational health and safety program and its implementation met expectations in 2006.

There was general improvement in performance over that observed in 2005, although concern remains about Hydro-Québec's actions to prevent recurrence of difficulties encountered during boiler cleaning work that year.

1.5.2 Performance Assurance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Gentilly-2	PERFORMANCE ASSURANCE	B	B
	Quality Management	B	B
	Human Factors	B	B
	Training, Examination, and Certification	B	B

As reported to the *Commission* in CMD-06-H15, *Renewal of the Operating Licence for the Gentilly-2 Nuclear Generating Station*, on August 16, 2006, CNSC staff concluded that the Performance Assurance safety area met expectations. Significant improvements occurred in 2006 in the implementation of a *systematic approach to training* (SAT) program at Gentilly-2. However, weaknesses in the implementation of quality management and human factors programs were found, which the licensee will need to address.

1.5.2.1 Quality Management

Hydro-Québec maintains a quality assurance (QA) program that links its processes. CNSC staff found some deficiencies in 2006 through inspections and follow ups, but identified no serious gaps. All details of these deficiencies were discussed with Hydro-Québec and are being corrected to conform to related standards. Overall, the program documentation met the requirements of applicable standards.

A *Type I inspection* conducted in 2006 revealed that the performance evaluation of service suppliers and the documented process were not completed. Deficiencies were also found in the documented environmental management process, and *Type II inspections* found incoherent information within technical documents used in the field.

The Gentilly-2 licence renewal CMD 06-H15 stated that the implementation of the QA program was found to meet requirements. This rating remains the same for this report. However, recent inspections and follow-ups revealed deficiencies in the implementation of the environmental program, the update of the quality documents and the correction of enforcements on the corrective action program and self-assessment process.

1.5.2.2 Human Factors

During this review period, CNSC staff focused attention on conservative decision making, procedure use and adherence as well as event reviews.

Conservative decision making had been noted as an issue at Gentilly-2. The licensee has undertaken a series of activities to improve the situation, and CNSC staff carried out follow-up interviews with station staff to determine progress to date. Findings indicated that management expectations with respect to strict adherences with documented practices were not made clear to all managers and that coaching was not widely practised, even though efforts were being made to implement it. On the other hand, it was also determined that progress had been made and continued to be made on the implementation of a plan to enhance conservative decision-making by control room staff. An example of enhancement was the decision to open a service counter outside the control room to continue to provide required services to other plant staff, while restricting non-essential personnel access to the control room. A further enhancement is the work towards clarifying expectations and fundamental values in a draft procedure (NAC-47).

A *Type II inspection* was carried out at Gentilly-2 in 2006 on adherence to procedures. The inspection highlighted positive points regarding housekeeping and foreign material exclusion. However, findings indicated that expectations for adherence to procedures were insufficiently clear and implemented. Also, event reviews indicated a lack of identification of the underlying human causes to reportable events.

The Gentilly-2 licence renewal CMD 06-H15 states that overall, both the program and implementation of the human factors program met requirements. The “B” ratings remain for the 2006 Industry Report, but weaknesses were found, indicating shortcomings in the implementation.

1.5.2.3 Training, Examination, and Certification

CNSC staff routinely assesses the performance and programs in place to ensure the continuing competence of certified staff. One requirement is that each staff member works a minimum number of shifts per quarter in their certified positions. At Gentilly-2, this is identified in NAC-24 as working three shifts per quarter in the certified positions. During 2006, CNSC staff found that a number of certified staff were not meeting this requirement, with one individual working only one shift in the first three quarters of the year. The licensee made a commitment that, commencing November 2006, all staff would work the minimum of three shifts per quarter. CNSC staff is monitoring the situation, and it appears that certified staff are now working the minimum required number of shifts.

The “C” rating in the 2005 Industry Report (and in the 2006 licensing CMD) for training implementation was due to a lack of *systematic approach to training* (SAT) programs. Gentilly-2 continued working on its approved action plan to develop and incorporate SAT principles into its certification training programs. Good progress towards this end was made in 2006. CNSC staff continued to monitor progress against the plan. The creation and implementation of SAT-based training programs for certified staff is a major element of Gentilly-2’s preparation for the transfer of certification examinations to the licensee. This rating has been upgraded to a “B” for 2006, due to progress improvements on approved action plans to implement SAT for certified staff.

Training programs for certified staff at Gentilly-2 were not evaluated during 2006. One written certification examination was conducted at the end of the year and the results are not yet available.

1.5.3 Design and Analysis

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Gentilly-2	DESIGN AND ANALYSIS	B	B
	Safety Analysis	B	B
	Safety Issues	B	B
	Design	B	B

Both the program and implementation of the Design and Analysis safety area at Gentilly-2 met CNSC staff’s expectations. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC’s desired outcomes. CNSC staff reviews, which included evaluation of the work performed towards a plant-specific probabilistic safety assessment, concluded that the licensee continued to provide acceptable safety analyses and responses to new design and safety issues.

1.5.3.1 Safety Analysis

CNSC staff reviews confirmed that Hydro-Québec performed acceptable safety analysis in 2006.

The performance of Hydro-Québec in monitoring and assessing new information obtained in 2006 to ensure the validity of the safety analysis documented in the *safety report* for Gentilly-2 was assessed. The major contributors to the acceptable rating in safety analysis include the following:

- monitoring of the *Best Estimate Analysis and Uncertainty (BEAU)* methodology
- monitoring of the Regional Overpower Protection Trip setpoint, which changes as a result of plant aging
- funding of ongoing research and development programs in nuclear safety under the CANDU Owners Group and assessment of potential impact of research findings
- update of the *safety report* every three years (a condition in the operating licence)

- monitoring and assessment of the impact of plant aging on safety analysis
- monitoring of operating transients at Gentilly-2 and assessment of their potential impact on safety

In April 2005, CNSC issued regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. This regulatory standard requires that a plant-specific PSA be performed, and sets high-level requirements for it. The requirements of S-294 are now a licence condition for Gentilly-2. CNSC staff is reviewing Hydro-Québec's plan to perform a PSA.

1.5.3.2 Safety Issues

CNSC staff reviewed the progress made by the CANDU industry and utilities to resolve the generic action items (GAIs). Hydro-Québec continued its work, including participation in the industry efforts, toward resolution of the GAIs. Overall progress was judged satisfactory. For more information on particular safety issues, see Appendix F for developments regarding each GAI in 2006.

1.5.3.3 Design

CNSC staff concluded from their review and assessment that the fire protection program at Gentilly-2 is incomplete. . As a result of the non-compliance issues, the licensee has been requested to submit a corrective action plan with implementation dates to address the deficiencies in the program and the related action items.

Reviews and assessments of event reports and the individual elements also indicated some weaknesses in the implementation of the program. However, these issues were not considered to present unreasonable risk to persons and the environment — for example, due to potential fires at the facility.

Aside from the deficiencies in fire protection, which is only one element of the Design program, CNSC staff judged that the overall Design program and implementation at Gentilly-2 met expectations.

1.5.4 Equipment Fitness for Service

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Gentilly-2	EQUIPMENT FITNESS FOR SERVICE	B	B
	Maintenance	B	B
	Structural Integrity	B	B
	Reliability	B	B
	Equipment Qualification	B	B

Both the program and implementation of the Equipment Fitness for Service safety area at Gentilly-2 met CNSC staff's expectations. The programs under the safety area contributed to safe facility operation in 2006 and to the achievement of the CNSC's desired outcomes.

1.5.4.1 Maintenance

Gentilly-2 has established policies, processes and procedures in place that provide direction and support for its maintenance program. The program is supported by a significant organization with well established goals. Continuous status reporting and internal audits are ongoing to monitor whether goals are being achieved and to identify areas needing improvement.

Inspections have shown that timely work completion is a challenge for Gentilly-2. If this challenge is not adequately dealt with, there is potential for increased risk.

Overall, CNSC staff rates the Gentilly-2 maintenance program and its implementation as meeting requirements.

1.5.4.2 Structural Integrity

Hydro-Québec's fuel channel aging and life cycle management plan summarizes the current understanding of degradation mechanisms affecting Gentilly-2 pressure tubes, based on research and development programs, and assessments of earlier inspection data collected at Gentilly-2 and other CANDU reactors. As such, the plan aims to identify both present and potential fitness-for-service issues affecting Gentilly-2 pressure tubes.

CNSC staff is satisfied that Hydro-Québec has implemented a managed process and a firm technical basis for assessing pressure tube fitness for service. Hydro-Québec has demonstrated that, to date, the Gentilly-2 *steam generators* have experienced only minor degradation and have not been yet been affected by degradation mechanisms found at other CANDU reactors. However, the *steam generator* life cycle management program is not adequately documented. CNSC staff noted that Hydro-Québec has made initial progress in documenting its submissions regarding *steam generator* life cycle management.

CNSC staff concluded that Hydro-Québec met CNSC expectations for managing structural integrity of systems and components.

1.5.4.3 Reliability

Hydro-Québec submitted a reliability program for Gentilly-2 to the CNSC in 2006, as required by S-98. This program is consistent with the industry approach. Hydro-Québec continued to implement the S-98 requirements at Gentilly-2, such as developing reliability models for all systems important to safety. Currently, CNSC staff is discussing generic reliability program issues with the industry to ensure that all licensees meet CNSC expectations specified in S-98.

A *Type I inspection* on the process of collecting and treating reliability data was conducted at Gentilly-2 in 2006 and revealed a need for improvement in terms of process documentation and tool development.

In general, Hydro-Québec's reliability program is, well planned and maintained. The performance of systems important to safety met regulatory requirements in 2006, although CNSC staff is following up on some instances of unavailability of certain safety systems.

1.5.4.4 Equipment Qualification

In 2004, Hydro-Québec identified a number of corrective actions required to demonstrate Gentilly-2's compliance with its licence condition on *environmental qualification* (EQ) and the associated acceptance criteria. Throughout 2005, Hydro-Québec submitted a number of technical reports related to these actions. CNSC staff reviewed most of these submissions and found that Hydro-Québec has made good progress in resolving the outstanding issues. However, to ensure completion of required corrective actions, Hydro-Québec will still issue several documents and implement field modifications.

From November 26 to December 1, 2006, CNSC staff conducted a *Type I inspection* of the EQ program at Gentilly-2. CNSC staff is preparing the inspection report. Based on the inspection, both the EQ program and its implementation met the intent of the CNSC acceptance criteria."

1.5.5 Emergency Preparedness

Site	SAFETY AREA	Grades	
		Program	Implementation
Gentilly-2	EMERGENCY PREPAREDNESS	A	B

During a *Type II inspection* to evaluate emergency preparedness, Hydro-Québec demonstrated its capability to effectively manage its emergency program and to meet CNSC expectations with regard to emergency preparedness.

New initiatives from Hydro-Québec to further improve its response capability, such as the increase in quantity of the off-site telemetric survey equipment (*balises télémétriques*), were also planned for the next few years.

Gentilly-2 continues to meet all the requirements and expectations of the CNSC with regard to its emergency preparedness and response programs. As in previous industry reports, the emergency response capability presented no unreasonable risk, nor was any degradation in the performance of the program recorded for the past year.

Consequently, no change in the grading for Gentilly-2 is justified and the program retained an “A” rating. Implementation received a “B” rating for 2006.

1.5.6 Environmental Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Gentilly-2	ENVIRONMENTAL PROTECTION	B	B

The environmental protection program and its implementation at Gentilly-2 met CNSC expectations. Both airborne emissions and liquid releases of nuclear substances to the environment were less than 1% of the *derived release limit* for Gentilly-2, and there were no reports of environmental action levels being exceeded. In 2006, the reported dose to the public was 5.69 μSv for Gentilly-2.

There were no reported unplanned releases of nuclear substances or hazardous substances from Gentilly-2 in 2006 that posed a significant risk to the environment.

1.5.7 Radiation Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Gentilly-2	RADIATION PROTECTION	B	B

There were no radiation exposures that exceeded regulatory limits.

Since 2004, Hydro-Québec conducted several initiatives to address ongoing issues with the radiation protection program. In 2006, CNSC staff continued follow-up with Gentilly-2 by focusing on the action items raised from the *Type I inspection* in 2004 and follow-up *Type II inspections*.

Based on document reviews, observations, and information exchanges with personnel at Hydro-Quebec, the implementation of radiation protection at Gentilly-2 continued to meet CNSC expectations in 2006.

1.5.8 Site Security

The assessment of the Site Security safety area for Gentilly-2 is documented in a separate (secret) *Commission Member Document* (CMD 06-M19.A).

1.5.9 Safeguards

Site	SAFETY AREA	Grades	
		Program	Implementation
Gentilly-2	SAFEGUARDS	B	B

In 2006, the *safeguards* program at Gentilly-2 continued to meet CNSC expectations with respect to all *safeguards* requirements.

1.5.10 Update on Other Major Projects and Initiatives

1.5.10.1 Gentilly-2 Waste Management Facility – Reserve Space at the Radioactive Waste Storage Area (ASDR)

Hydro-Québec advised CNSC staff that as of the end of 2006, it expects to make use of part of the reserved space at the Radioactive Waste Storage Area (ASDR). This area is currently receiving all low- and intermediate-level waste from the Gentilly-2 nuclear power plant and, in the past, reserved sufficient space for spent fuel bundles from at least one year of full power operation.

As of the end of 2006, the available volume at the ASDR was estimated at less than 100 m^3. Hydro-Québec expects that sufficient space remains available to meet operational needs until at least the end of 2007.

In order to meet the Gentilly-2 plant's operational waste storage needs after 2007, Hydro-Québec requested an amendment to its waste facility operating licence to allow construction of a new solid radioactive waste storage facility.

CNSC staff continues to closely monitor this situation to ensure safe management and storage of all wastes produced by the Gentilly-2 nuclear power plant.

1.6 POINT LEPREAU

1.6.1 Operating Performance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Point Lepreau	OPERATING PERFORMANCE	B	B
	Organization and Plant Management	B	B
	Operations	B	B
	Occupational Health and Safety (Non-radiological)	B	B

Both the program and implementation of the Operating Performance safety area at Point Lepreau met the expectations of Canadian Nuclear Safety Commission staff and contributed adequately to the achievement of CNSC's desired outcomes. Point Lepreau operated safely in 2006.

1.6.1.1 Organization and Plant Management

There were no *serious process failures* at Point Lepreau in 2006. The station experienced one reportable spurious activation of a shutdown system in 2006 (see Table 1).

The financial guarantees provided by New Brunswick Power Nuclear (NBPN) were considered to be adequate. The various programs established by NBPN to manage its activities were adequately integrated.

1.6.1.2 Operations

CNSC staff conducted 17 field and 12 main control room inspections during 2006. There were no major findings, and all minor findings were reported to the duty shift supervisor for correction.

A CNSC inspection report on the 2006 outage identified that the outage planning process needed improvement. The foreign material exclusion practices needed improvement to protect the emergency core cooling strainers.

Plant status and material condition remain acceptable. Several events were caused by problems with the standby generators. NBPN is planning to add a third standby generator during the refurbishment outage in 2008–2009.

1.6.1.3 Occupational Health and Safety (Non-radiological)

Point Lepreau's accident severity rate (0.0 in 2006) compared very favourably with that of the rest of the industry (see Tables 9, 10 and 11). This marked a return to the historically low value of the performance indicator at Point Lepreau. Overall, the Occupational Health and Safety program and its implementation met CNSC performance expectations.

Performance indicators under health and safety submitted by the station are acceptable.

1.6.2 Performance Assurance

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Point Lepreau	PERFORMANCE ASSURANCE	B	B
	Quality Management	B	B
	Human Factors	C	C
	Training, Examination, and Certification	B	B

Both the program and implementation of the Performance Assurance safety area at Point Lepreau met CNSC staff's expectations and contributed adequately to the achievement of the CNSC's desired outcomes in 2006.

1.6.2.1 Quality Management

A *Type I inspection* of the supplier performance evaluation process carried out in 2006 found that, overall, the Point Lepreau process is effective in evaluating the performance of the vendors. The inspection also revealed some deficiencies in the supplier performance evaluation process: it was not fully documented and controlled, the service performance evaluation data entry was not consistent, and NBPN received services from some external organizations without controlling external processes within its quality management system or including those on the approved vendor list. However, all deficiencies were being properly managed and corrected by the licensee.

Point Lepreau now uses a three-year cycle for internal assessment of CSA N286 requirements and reviews some elements annually. NBPN is also grading its processes and elements to target those most important to safety in its internal audit. Once developed, CNSC will review the plan before it is implemented.

The general conclusion from the inspections was that quality management was properly documented and implemented as documented, and that the overall performance of the processes was satisfactory. NBPN's quality assurance program and its implementation met CNSC staff's expectations in 2006

1.6.2.2 Human Factors

NBPN's human factors program continued to evolve in 2006. A particular strength of the program is the variety of reports that include indicators related to human performance. Although CNSC staff recognizes progress made by NBPN in 2006, some concerns were also identified. Concerns in the areas of overall staffing and hours of work led to a "C" rating.

Like the rest of the nuclear industry, NBPN has an aging workforce with many employees expected to retire in the next few years. During an inspection in 2004, CNSC staff raised concerns about the justification and documentation of engineering and technically based skills required for safe station operations. This basis is required to support succession planning. NBPN made progress in addressing this issue in 2006, but further work is required.

Nuclear power plants limit the number of hours that can be worked by staff to reduce the risk of performance impairments due to fatigue. During an inspection, CNSC staff identified deficiencies in NBPN's process for monitoring compliance with limits on hours of work. Based on initial feedback from NBPN, CNSC staff expects improvements to be made in 2007 in its system for monitoring compliance with these limits.

1.6.2.3 Training, Examination, and Certification

NBPN has presented a plan for the continuing training and start-up training of staff that CNSC staff have reviewed and found acceptable.

There were no evaluations of re-qualification testing programs or training programs at Point Lepreau in 2006. A request for closure was received for a previously conducted training program evaluation of the control room operator initial simulator training program. CNSC staff is reviewing documents to support this request for closure.

The overall success rate of certification examinations at Point Lepreau was adequate during the year. CNSC staff concluded that this program and implementation met CNSC expectations. CNSC staff will continue to assess the number of certified staff at the station.

1.6.3 Design and Analysis

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Point Lepreau	DESIGN AND ANALYSIS	B	B
	Safety Analysis	B	B
	Safety Issues	B	B
	Design	B	B

Both the program and implementation of the Design and Analysis safety area at Point Lepreau met CNSC staff's expectations. The programs under the safety area contributed adequately to safe facility operation in 2006 and, in general, to the achievement of the CNSC's desired outcomes. CNSC staff reviews, which included evaluation of the work performed towards a plant-specific probabilistic safety assessment, concluded that the licensee continued to provide acceptable safety analyses and responses to new design and safety issues.

1.6.3.1 Safety Analysis

CNSC staff reviews confirmed that NBPN performed acceptable safety analysis in 2006.

CNSC staff assessed the performance of NBPN in maintaining the validity of plant safety analysis and in documenting new information in 2006. The major contributors to this acceptable rating in safety analysis included the following accomplishments:

- monitoring the *Best Estimate Analysis and Uncertainty (BEAU)* methodology
- monitoring of the Regional Overpower Protection Trip setpoint, which changes as a result of plant aging
- monitoring the containment system as a *special safety system* to meet the requirements
- verification of the adequacy of the safety findings to confirm the acceptability of the planned refurbishment activities and safety upgrades
- performance of the *safety report* update every three years (a condition in the operating licence)
- funding of ongoing research and development programs in nuclear safety under the CANDU Owners Group and assessment of potential impact of research findings
- monitoring and assessment of the impact of plant aging on safety analysis,
- monitoring of operating transients at Point Lepreau and assessment of their potential impact on safety
- developing the probabilistic safety assessment as planned for the refurbishment project

1.6.3.2 Safety Issues

CNSC staff reviewed the progress made by the CANDU industry and utilities to resolve the generic action items (GAIs). NBPN continued its work, including participation in the industry efforts, toward resolution of the GAIs, and overall progress was judged satisfactory. For more information on particular safety issues, see Appendix F for developments regarding each GAI in 2006.

1.6.3.3 Design

In 2006, CNSC staff judged that, aside from the deficiencies in fire protection, which is only one element of the program, the overall Design program and its implementation at Point Lepreau met expectations.

Based on CNSC staff assessment in 2006, the fire protection program and its implementation at Point Lepreau was rated as being below requirements. However, staff acknowledged an improving trend due to commitments and progress made to address fire protection issues.

Although significant work remains, the compliance strategy updates confirm that improvements to fire protection issues are being implemented at the facility.

In 2006, NB Power Nuclear updated CNSC staff on progress toward implementing corrective measures identified in previous electrical distribution systems inspections. In general, CNSC staff was satisfied with the progress made at Point Lepreau.

1.6.4 Equipment Fitness for Service

Site	SAFETY AREA Program	Grades	
		Program	Implementation
Point Lepreau	EQUIPMENT FITNESS FOR SERVICE	B	B
	Maintenance	B	B
	Structural Integrity	B	B
	Reliability	B	B
	Equipment Qualification	B	B

Both the program and implementation of the Equipment Fitness for Service safety area at Point Lepreau met CNSC staff's expectations and contributed adequately to the achievement of the CNSC's desired outcomes in 2006.

1.6.4.1 Maintenance

NBPN has established policies, processes and procedures in place that provide direction and support for its maintenance program. The program is supported by a significant organization with well established goals. Continuous status reporting and internal audits are ongoing to monitor whether goals are being achieved and to identify areas of improvement.

There are some difficulties with standby generator maintenance and this is a challenge for NBPN. However, an action plan is in place to install a third standby generator during the refurbishment project outage. CNSC staff will continue to monitor this issue.

Overall, CNSC staff rates the Point Lepreau maintenance program and its implementation as meeting requirements.

1.6.4.2 Structural Integrity

Updates provided in 2006 suggest an improving trend. NBPN is planning to further modify its periodic inspection program (PIP). The scope and schedule for in-service inspections of main components were based on the most recent revision of plans for components aging and life cycle management. The programs are up to date. CNSC staff is satisfied both with the basis for these plans and the adequacy of documentation.

NBPN met the requirements for its pressure retaining components program based upon the strategy and plans defined in its PIP and aging and life cycle management. During the 2006 planned outage, NBPN performed in-service inspections. CNSC staff is satisfied with both the inspection work and the assessment of the inspection findings.

CNSC staff noted that NBPN has made significant progress in developing a formal, well documented *steam generator* management program.

1.6.4.3 Reliability

The reliability program developed for Point Lepreau station has been consistent with the industry approach. NBPN continued to implement the S-98 requirements, such as developing reliability models for all the systems important to safety. Currently, CNSC staff is discussing with the industry the generic issues involved in the reliability program to ensure that all the licensees meet CNSC expectations specified in S-98.

NBPN’s reliability program is well planned and maintained. The performance of systems that are important to safety met regulatory requirements and CNSC staff expectations 2006.

1.6.4.4 Equipment Qualification

In 2005, CNSC staff inspected the Point Lepreau *environmental qualification* (EQ) program. Both the program and its implementation met the intent associated with CNSC's acceptance criteria. The inspection team identified some areas that require improvement: updating of EQ-related documents (including governing documents, EQ assessments, etc.); definition of roles and responsibilities of EQ and system specialists; development and implementation of environmental and condition monitoring subprograms; and timely completion of corrective actions. Seven action notices, eight recommendations and three incidental findings were issued as a result of the inspection.

In December 2006, NBPN provided the status of activities undertaken to address the action notices, recommendations and incidental findings. Currently, CNSC staff is performing a detailed review to disposition the NBPN responses. It appears that all enforcement actions, recommendations and incidental findings have been addressed.

1.6.5 Emergency Preparedness

Site	SAFETY AREA	Grades	
		Program	Implementation
Point Lepreau	EMERGENCY PREPAREDNESS	A	B

During 2006 both a program audit and an emergency preparedness exercise audit were conducted at Point Lepreau. These two inspections identified no significant findings that would affect the previous year's ratings. Therefore, the Point Lepreau emergency preparedness program met CNSC requirements, with a rating of "A" for the program and "B" for the implementation.

1.6.6 Environmental Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Point Lepreau	ENVIRONMENTAL PROTECTION	B	B

The implementation of the environmental protection program at Point Lepreau met the CNSC expectations in 2006. Both airborne emissions and liquid releases of nuclear substances to the environment were less than 1% of the *derived release limit* for Point Lepreau, and there were no reports of environmental action levels being exceeded.
In 2006, the reported dose to the public was 0.57 µSv for Point Lepreau.

There were no reported unplanned releases of nuclear substances or hazardous substances from Point Lepreau in 2006 that posed a significant risk to the environment.

1.6.7 Radiation Protection

Site	SAFETY AREA	Grades	
		Program	Implementation
Point Lepreau	RADIATION PROTECTION	B	B

There were no radiation exposures that exceeded regulatory limits.

An inspection of the radiation protection program in March of 2006 revealed that previous concerns identified in the ALARA program had not been resolved. Four *action items* were issued and NBPN undertook significant measures during the year towards resolving the deficiencies.

NBPN also undertook actions, based on experience from CANDU operations during refurbishment, to ensure that radiation exposure during refurbishment and subsequent operations will adhere to the ALARA principle.

1.6.8 Site Security

The assessment of the Site Security safety area for Point Lepreau is documented in a separate (secret) *Commission Member Document* (CMD 07-M19.A).

1.6.9 Safeguards

Site	SAFETY AREA	Grades	
		Program	Implementation
Point Lepreau	SAFEGUARDS	B	B

In 2006, the *safeguards* program at Point Lepreau continued to meet CNSC expectations with respect to all *safeguards* requirements.

1.6.10 Update on Other Major Projects and Initiatives

In its licence renewal decision of May 18, 2006, the *Commission* requested CNSC staff to provide, as part of the *CNSC Staff Annual Report on the Canadian Nuclear Power Industry*, a detailed progress report related to the authorized activities associated with the re-tube and the refurbishment of the Point Lepreau.

1.6.10.1 Point Lepreau Refurbishment

In general, work on Point Lepreau refurbishment project is on schedule and on budget, and progress has been made in the following areas:

1.6.10.1.1 Procurement and Design Review

Procurement and manufacture of long lead items are underway and all major equipment has been procured. Re-tube activities and engineering design reviews are continuing. All fault trees for probabilistic safety assessment (PSA) for Level 1 (internal events) are finalized. The "high-probability" outcomes of the analysis will be addressed through operator recovery actions to appropriate event sequences or the performance of any potential design changes.

The accident sequence quantification (ASQ) analysis for internal events is progressing well, and no major issues were identified as of the end of 2006. Completion of the ASQ analyses for Level 1 internal events and Level 1 external events is planned for May 2007 and June 2007, respectively. As established under the auspices of the refurbishment project, NBPN will perform a full Level 2 PSA scheduled for completion in September 2007. NBPN will implement additional provisions to improve containment performance for severe accident conditions in order to meet PSA safety goals.

1.6.10.1.2 Planning Activities

Following the completion of the 2008 Refurbishment Outage-Scope-Freeze at the end of November 2006, NBPN developed the first Integrated Schedule As Planned by the end of January 2007. This integrated schedule will reflect work being undertaken by NBPN and its contractors for the refurbishment project execution. It will also define measures put in place to control potential modifications to the project's scope

1.6.10.1.3 Integrated Safety Review

NBPN has submitted two updates in response to CNSC staff review comments on the integrated safety review (ISR) results. Given the number of issues to be addressed as part of this review, a reporting strategy has been developed to facilitate communications between both parties.

1.6.10.1.3.1 Technical Reviews Completed by CNSC Staff

The technical reviews of NBPN submissions under the auspices of the Point Lepreau refurbishment project focused on the following areas and/or established programs:

- probabilistic safety assessment
- design requirements for programmable digital comparators in both shutdown safety systems (SDS 1 & SDS 2)
- safety analyses in support of design upgrades under the refurbishment project that comprise significant improvements to the trip coverage.
- human factors engineering program plan
- health safety and environmental protection updated plan activities
- programs for training, system *lay-up*, commissioning and return to service

1.6.10.1.3.2 International Practices

In its May 18, 2006 licensing decision, the *Commission* also requested staff to report as appropriate on international practices for radiation protection during the refurbishment activities, to ensure all possible means are taken to keep doses to workers as low as reasonably achievable.

Subsequently, NBPN invited the World Association of Nuclear Operators to conduct an assist visit at Point Lepreau in January 2007. The objective of the visit was to inspect NBPN's radiation protection best practices and international practices applied during the refurbishment project. Outcomes of the visit will be shared with CNSC staff.

1.6.10.1.4 Solid Radioactive Waste Management Facility

All civil work for the construction of new vaults to house low and medium level waste for extended operation (Phase I) and refurbishment activities (Phase III), as well as for the construction of newly built canisters for managing high-level re-tube waste generated during the refurbishment outage (Phase III) has been completed. The installation of the crane and mechanical equipment required for the canisters is complete. Commissioning activities for Phase I were initiated in April, Phase III facilities are planned for May 2007, and Phase III is planned for August 2007. NB Power Nuclear (NBPN) has initiated revisions of documents referenced in both the waste facility operating licence and the power reactor operating licence to reflect the new structures.

SECTION 2

SAFETY PERFORMANCE AND TRENDS ACROSS THE INDUSTRY

This section of the report discusses overall safety performance at each generating station, according to safety areas and programs defined in Section 1 of this report. Year-to-year trends are illustrated and significant issues that pertain to the industry at large are highlighted. CNSC performance indicators illustrate various trends and issues. Their definitions are taken from regulatory standard S-99, *Reporting Requirements for Operating Nuclear Power Plants*.

2.1 OPERATING PERFORMANCE

There were 18 reactors operating in 2006. Having announced in 2005 that it would not proceed with the restart of Pickering Units 2 and 3, OPG placed them in a de-fuelled safe shutdown state. Bruce A Units 1 and 2 are currently in a *lay-up state.* The environmental assessment of Bruce A Units 1 and 2 was completed and accepted by the *Commission*. A number of projects are underway in anticipation of restarting the units.

2.1.1 Organization and Plant Management

Licensees had appropriate organizations to manage and safely operate their stations in 2006.

No worker at any station or member of the public received a radiation dose in excess of the regulatory limits in 2006. Emissions from all plants were also well below regulatory limits. Low personnel radiation exposures and environmental emissions continued to be the norm for the industry in 2006. These results are general reflections of adequate controls employed by the organizations at the sites. CNSC staff has noted that, compared to the performance of other reactors world-wide, the CANDU plants now have relatively higher occupational radiation exposures.

There were no *serious process failures* at any station in 2006 and this was a positive outcome.

CNSC staff uses *action items* to bring issues that require timely, corrective action to the attention of licensees. In 2006, CNSC staff was satisfied with licensees' *action item* management, event reporting, plant system performance analysis, and follow-up. There were also 463 reportable events at the stations in 2006. The most important ones are among the significant developments described in Appendix E. CNSC staff continued to observe a low self-reporting threshold, indicating a positive, questioning attitude of licensee staff.

The "Number of Unplanned Transients" performance indicator (PI) denotes the unplanned reactor power transients due to all sources while the reactor was not in a GSS. This PI, illustrated in Tables 1 through 3, shows the number of manual or automatic power reductions from actuation of the shutdown, *stepback* or *setback* systems (note that Pickering A does not have a *stepback* system). Unexpected power reductions may indicate problems within the plant and place unnecessary strain on systems. Most of the unplanned transients in 2006 were *setbacks*, which typically pose little risk to plant operations. The significant transients are described in the *Commission Member Documents* (CMDs) known as significant development reports (see Appendix E).

The indicator also includes the number of hours that the reactors were in a GSS. Note that these hours are only reported in Tables 1 and 2 in 2004 and 2005 for reactors that were not in the *lay-up state*. For the years 2002 to 2003, hours are summed for all reactors, including those in a *lay-up state*.

Table 1: Number of Unplanned Transients for 2006

Station	GSS Hours	Unplanned Transients at Sites in 2006			
		Trips	*Stepbacks*	*Setbacks*	Total
Bruce A	2,386	0	1	5	6
Bruce B	1,534	1	0	7	8
Darlington	2,828	0	4	4	8
Pickering A	3,160	6	0	3	9
Pickering B	5,475	1	1	3	5
Gentilly-2	922	1	1	0	2
Point Lepreau	832	0	0	0	0
Industry Total	17,137	9	7	22	38

Tables 2 and 3 show the trends of this PI for the industry since 2002. For the entire industry in 2006, the number of transients returned to levels seen in previous years. The decrease can be attributed to a significant reduction in the number of unplanned trips and the number of *setbacks* at Bruce A. This was despite a slight increase in the number of *setbacks* at Bruce B. In 2006, there was an industry average of 8,784 hours of non-GSS time between reactor trips or *stepbacks*. This is considered good when compared with the international performance target of one reactor trip per 7,000 hours of operation.

Table 2: Trend Details of Number of Unplanned Transients for Industry

Year	GSS Hours	Unplanned Transients in Industry			
		Trips	*Stepbacks*	*Setbacks*	Total
2002	51,503	3	1	13	17
2003	47,922	19	13	11	43
2004	20,424 *	10	5	22	37
2005	25,533 *	13	5	35	53
2006	32,524 *	9	7	22	38

*For 2004 to 2006, GSS hours were only tabulated for reactors not in a *lay-up state*.

Table 3: Trends of Number of Unplanned Transients for Stations

Station	Unplanned Transients				
	2002	2003	2004	2005	2006
Bruce A	NA	1	17	25	6
Bruce B	6	8	4	7	8
Darlington	1	10	6	4	8
Pickering A	NA	7	4	3	9
Pickering B	6	14	3	9	5
Gentilly-2	2	2	1	3	2
Point Lepreau	2	1	2	2	0
Industry Total	17	43	37	53	38

2.1.2 Operations

Most CNSC staff inspections conducted at the stations in 2006 confirmed compliance with CNSC requirements and the licensees' governing procedures and documents, and did not require any remedial action. For those inspections that did require remedial action, CNSC staff generally found that the licensees implemented appropriate measures to correct the deficiencies immediately.

The "Unplanned Capability Loss Factor" PI in Tables 4 and 5 reflects overall plant management by indicating how a unit is managed, operated, and maintained in order to avoid unplanned outages. The indicator is the percentage of the reference electrical output for the station lost during the period due to unplanned circumstances. Some of the unplanned shutdowns for the stations are described in Appendix E.

At Pickering A and B, the unplanned capability loss factor has remained higher than the industry average over most of the past five years. CNSC staff notes that a relatively high loss factor is typical of units at stations that have retuned from long *lay-ups* and this was the case for Pickering Unit 4. At Darlington, the factor has remained fairly consistent, while at Gentilly and Point Lepreau the trend has been markedly downward over the past three years. Bruce A showed a small increase while Bruce B and Pickering A showed marked decreases. Pickering B had the largest increase.

Table 4: Unplanned Capability Loss Factor for 2006

Station	Unplanned Capability Loss Factor (%)				
	Quarter				For Year
	Q1	Q2	Q3	Q4	
Bruce A	3.8	7.9	13.9	3.4	7.4
Bruce B	4.6	4.9	1.0	3.0	3.4
Pickering A	8.8	7.8	17.8	37.2	17.9
Pickering B	12.1	11.5	8.4	24.1	14.0
Darlington	3.1	8.2	7.6	2.8	5.4
Gentilly-2	0	0	3.7	0	0.9
Point Lepreau	0	6.3	0	0	1.6

Table 5: Trend Details of Unplanned Capability Loss Factor for Industry

Station	Unplanned Capability Loss Factor (%)				
	Year				
	2002	2003	2004	2005	2006
Bruce A			11.4	5.7	7.4
Bruce B	6.4	3.8	4.9	8.5	3.4
Pickering A	n/a	10.2	18.5	30.1	17.9
Pickering B	7.2	19.1	12.2	5.1	14.0
Darlington	4.9	4.3	6.7	3.4	5.4
Gentilly-2	0.0	0.2	10.2	1.3	0.9
Point Lepreau	9.2	3.9	6.9	6.6	1.6

In general, CNSC staff found that the planning and performance of outages was acceptable in 2006.

The “Non-Compliance Index” PI indicates the number of occurrences where the operation of the station failed to comply with licence conditions or with the *Nuclear Safety and Control* Act (NSCA) and regulations. CNSC staff evaluates all non-compliances, which are categorized as follows:

- a = number of non-compliances with the operating policies and principles referred to in the licence
- b = number of non-compliances with the radiation protection requirements referred to in the licence
- c = number of non-compliances with the minimum shift complement referred to in the licence
- d = number of other non-compliances with the licence
- e = number of non-compliances with the NSCA and regulations

Tables 6, 7 and 8 illustrate the Non-Compliance Index for the industry. The stations had comparable numbers of non-compliances in 2006 (see Table 6). The total number of non-compliances for the industry continued to decrease in 2006 (see Table 7), which is a positive outcome. The largest decreases were at Pickering and Darlington (see Table 8). (Before 2004, this indicator was not reported separately for Pickering A and B.) Gentilly posted a significant increase, but the number is in line with previous years. Note that the variation in non-compliance rates is relative to different site requirements, including operating policies and principles, radiation requirements, designs, licence conditions, and practices.

This performance indicator is not given a rating, as the CNSC promotes self-reporting by licensees. Individual events or issues are dealt with on their merit and appropriate regulatory action is taken when an issue occurs.

Table 6: Non-Compliance Index for 2006

Station	Non-Compliances by Type					
	A	B	C	D	D	Total
Bruce A	3	23	3	42	0	71
Bruce B	1	25	11	40	0	77
Pickering A	28	11	0	26	0	65
Pickering B	28	11	1	30	1	71
Darlington	20	23	0	11	0	54
Gentilly-2	11	0	0	13	0	24
Point Lepreau	4	3	0	2	12	21

Table 7: Trend Details of Non-Compliance Index for Industry

Year	Non-Compliances by Type					
	A	B	C	D	E	Total
2002	219	140	13	222	24	618
2003	142	186	10	203	50	591
2004	108	167	20	142	36	473
2005	95	144	24	156	19	438
2006	95	96	15	164	13	383

Table 8: Trends of Non-Compliance Index for Stations

Station	Total Non-Compliances				
	2002	2003	2004	2005	2006
Bruce A	24	120	81	69	71
Bruce B	124	79	72	86	77
Pickering	337	282	202	173	136
Darlington	58	70	71	82	54
Gentilly-2	20	13	23	6	24
Point Lepreau	55	27	24	22	21
Industry Total	618	591	473	438	383

2.1.3 Occupational Health and Safety (Non-radiological)

Overall, all licensees met the expectations for Occupational Health and Safety at all sites in 2006. The "Accident Severity Rate" indicator is used to monitor licensee performance in meeting nuclear industry standards in the area of worker safety (see Tables 9, 10 and 11). The indicator measures the total number of days lost to injury for every 200,000 person-hours worked at the site. (Caution is advised when comparing licensees due to the differences among organizations, including the definitions of industrial accidents, jurisdiction of worker safety, and the interpretation of lost time associated with chronic health problems.)

Licensee accident severity rates in 2006 increased over the previous year at the Bruce, Darlington and Pickering sites and decreased at Gentilly-2 and Point Lepreau. (Table 11) Overall, the rate returned to levels seen two to three years ago. Nevertheless, the number of lost time accidents at the various sites remained well below that of other comparable industries, of the world nuclear reactor performance as well as the latest published statistical average (2002) for federal public service departments. CNSC staff considers that the occupational safety statistics of the industry as a whole continued to be strong in 2006.

Table 9: Accident Severity Rate for 2006

Site	Days Lost	Person Hours	Accident Severity Rate
Bruce A and B	60	7,308,436	1.64
Pickering A and B	187	7,874,588	4.75
Darlington	128	4,975,304	5.15
Gentilly-2	9	1,339,767	1.34
Point Lepreau	0	1,428,083	0.00
Industry Average	384	22,926,178	3.35

Table 10: Trend Details of Accident Severity Rate for Industry

Year	Days Lost	Person Hours	Accident Severity Rate
2002	350	17,579,865	3.98
2003	372	16,612,884	4.48
2004	145	16,447,399	1.76
2005	170	22,698,360	1.50
2006	384	22,926,178	3.35

Table 11: Trends of Accident Severity Rate for Stations

Site	Accident Severity Rate				
	2002	2003	2004	2005	2006
Bruce A and B	4.8	4.2	0.0	0.9	1.6
Pickering A and B	1.4	3.7	0.0	2.0	4.8
Darlington	0.0	0.6	3.0	1.0	5.2
Gentilly-2	25.2	20.4	1.2	3.6	1.3
Point Lepreau	0.0	0.1	14.2	0.7	0.0

2.2 PERFORMANCE ASSURANCE

Overall, the Performance Assurance safety area met CNSC staff's expectations for all licensees of Nuclear Generating Stations. The programs under this safety area continue to be adequately implemented, contributing to safe facility operation in 2006 and, in general, the achievement of the CNSC's desired outcomes.

A negative trend has been observed regarding licensees' performance for the Quality Management and Human Factors programs. Though the observations made could not be directly associated with unsafe operating conditions for the stations, increased CNSC oversight of these licensee programs is warranted for 2007.

2.2.1 Quality Management

The multi-unit OPG stations (Darlington and Pickering A and B) have a documented quality management program that continued to meet requirements in 2006. At 2006 year end, CNSC staff carried out a *Type I inspection* at Darlington regarding engineering change control. A similar inspection is scheduled for early 2007 at Pickering A. The analysis for the inspections will be completed in 2007.

Analysis of OPG's event reports did not directly associate any events with any unsafe conditions at the facility, although a negative trend has been observed for Pickering A and B. This warrants an increase in CNSC staff oversight of OPG management.

The multi-unit Bruce Power stations (Bruce A and B) have made progress in documenting their quality management program. However, a significant amount of documentation is not yet complete for key areas of a quality management program. CNSC noted that Bruce B's implementation of the quality management program met expectations, a notable improvement over 2005. Bruce A's performance needs improvement and is rated a "C," unchanged from 2005.

The single-unit stations, Gentilly-2 and Point Lepreau, have documented quality management programs that continued to meet requirements in 2006. Deficiencies have been identified with program implementation. The deficiencies are being reviewed with the Gentilly-2 licensee and have been corrected by the Point Lepreau licensee.

Overall CNSC staff evaluated the quality management programs and found that they were adequately documented and implemented in 2006. There are indications of negative trends regarding the implementation of the program that will bring about increased oversight by CNSC staff.

2.2.2 Human Factors

The state of the processes required to meet CNSC staff's expectations for human factors programs across the industry ranges from currently acceptable to progressing towards an acceptable state. All facilities remained unchanged in meeting expectations with the exception of Bruce A and B, where implementation of programs improved to an acceptable level and Pickering A for which a decline was noted.

In 2005, the CNSC staff carried out a *Type I inspection* of procedural adherence at the Bruce Power site, which identified deficiencies relating to the backlog of procedural changes and performance indicators that enable management to oversee procedural updates. In 2006, Bruce Power made significant progress in improving processes relating to the backlog of procedural changes identified in 2005, which enabled the CNSC to give a "B" grade for implementation.

In 1997, Ontario Hydro's integrated improvement program recommended eliminating the use of non-certified staff to monitor the control panels of the reactor units. Pickering A has addressed this recommendation and currently has an authorized nuclear operator (ANO) at the control panels at all times for each of the two operating reactor units. Pickering B and Bruce B will have an ANO at the control panels of each reactor unit at all times by July 31, 2007, and October 1, 2007, respectively. At Bruce A and Darlington, there will not be adequate staffing to have an ANO at the control panels of each reactor unit at all times until 2009. As an interim measure, the licences for Bruce A, Bruce B, Pickering B and Darlington include conditions that limit and control the use of non-certified operators operating reactor control panels. Based on staffing projections submitted biannually, Pickering B, Bruce B, and Darlington should be able to meet the dates committed to in their licences for ANO staffing.

In 1998, Ontario Hydro initiated a shift re-organization at its stations by introducing the position of control room shift supervisor to replace the control room shift operating supervisor. Pickering A and B are the only multi-unit stations that have not yet completed this initiative. OPG has committed to complete this change at Pickering by the end of 2009.

2.2.3 Safety Culture and Safety Management

A draft copy of the document "Guidance for Safety Culture Self-Assessment of Licensee Facilities" was developed and the Purpose and Scope sections of the document were placed on the CNSC Web site for public comment. The CNSC intends to finalize the guide for use at all facilities.

In May 2006, the CNSC was asked to provide delegates at the Women in Nuclear Conference with information about safety culture. A presentation was made describing the importance of organizational influences on safety performance and the research outcomes that led to the recognition of safety culture's importance as an overriding influence on all organizational processes.

In May 2006, safety culture was one of the topics discussed at the Nuclear Energy Association's Committee on Nuclear Regulatory Activities Working Group on Inspection Practices 8th International Nuclear Regulatory Inspection Workshop. A CNSC delegate participated in the workshop on how regulatory inspections can promote or not promote good safety culture.

The CNSC has a representative who is part of the Nuclear Energy Association's Working Group on Human and Organizational Factors, which meets biannually to discuss issues common to member countries.

2.2.4 Training, Examination, and Certification

A number of licensee facilities are in various stages of unit refurbishment. In all of these cases, CNSC staff is monitoring the programs for certified staff continuing training and re-qualification testing during the refurbishment outages, as well as reviewing and monitoring the training on modified systems and for unit restart.

Significant progress is being made on the project to establish and implement training and examination programs for certified shift personnel in support of examination transfer to licensees. This project is being managed by the CNSC in consultation with industry members. In 2006, evaluations of certification training programs across the industry continued as scheduled. In parallel, follow-up work to correct previously identified deficiencies continued at all licensee facilities. CNSC staff continues to monitor and review individual licensee progress.

In addition, most licensees are facing an industry-wide challenge to maintain the required number of qualified staff. This area is continuing to receive special review by CNSC staff, by such means as a semi-annual licensee report of the status in key areas.

2.3 DESIGN AND ANALYSIS

2.3.1 Safety Analysis

Updates of the *safety report* for each site are required every three years in accordance with the operating licences. The most important performance expectation is evaluated by monitoring and considering the impact on safety analysis of operating transients, plant changes due to aging, and sustained loss of heat sink scenarios. For the year 2006, CNSC staff reviews concluded that the safety assessments submitted by the licensees in the past year showed acceptable margins. CNSC staff is performing a more detailed review of computer code validation and analysis methodology for the assessments documented in the licensees' *safety reports*. CNSC staff has concerns about the industry progress rate on code validation. Staff will update the rating during next reporting cycle according to resolution of the remaining issues.

CNSC issued a new regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* in April 2005. This regulatory standard requires a plant-specific PSA to be performed and sets high-level requirements for PSAs. Although the standard was published in 2005, the requirement to comply with the standard is being added to each nuclear power reactor operating licence at the time of renewal because PSAs for most stations have already been submitted to the CNSC. In 2006, a condition requesting the licensee to perform a plant-specific PSA in accordance with S-294 was added to the licences for Point Lepreau and Gentilly-2. While other nuclear generating stations do not yet have this licence condition, they have nevertheless submitted plant-specific PSAs to the CNSC. Recognizing that production of PSA is a normally a multi-year project, CNSC staff is discussing with all licensees specific requirements and schedule to bring all the PSAs to the meet the CNSC standard.

2.3.2 Safety Issues

There has been progress on some outstanding safety issues in 2006, while progress on others proved to be slower than anticipated. Thirteen GAIs were active in 2006; during the year:

- GAI 91G01 was closed for NB Power Nuclear (NBPN), and is now closed for all stations
- GAI 94G02 was closed for NBPN
- GAI 98G02 was closed for Hydro-Québec and is now closed for all stations
- GAI 99G01 was closed for OPG
- GAI 06G01 was created for all stations

Progress on each of the GAIs is described in Appendix F. CNSC staff is satisfied that all licensees made adequate progress on the remaining safety issues.

2.3.3 Design

In 2006, CNSC staff reviews indicated that the fire protection program and implementation at some plants have weaknesses. CNSC staff identified findings from previous inspections that were not addressed, resulting in non-compliance with the fire protection requirements of the operating licences. Other aspects of the Design program were satisfactory at the stations in 2006, with the exception of the lack of resolution of Design issues identified at Pickering B following the August 2003 blackout.

2.4 EQUIPMENT FITNESS FOR SERVICE

In 2006, CNSC staff reviews showed that, in principle, the licensees met requirements for programs in the area of Equipment Fitness for Service. However, implementation of those programs did not meet requirements in some cases.

2.4.1 Maintenance

All licensees have established maintenance programs to meet their maintenance program licence conditions. The general objective of these programs is to ensure that systems, structures and components continue to be capable of fulfilling their design intent. A major element of these programs is work management including preventive, elective and corrective maintenance work orders.

In 2006, initiatives were taken and overall backlog levels are reducing. Reported corrective maintenance on safety related systems decreased as an overall trend.

2.4.2 Structural Integrity

In 2003, CNSC staff requested Bruce Power to upgrade its quality assurance (QA) program manual and to acquire certificates of authorization, which includes plans and procedures to implement QA programs for pressure boundaries according to applicable standards. Bruce Power obtained approval for its upgraded QA program manual later in 2005. The licensee requested an extension for the ‘plans and procedures certificates’ portion of the QA program until December 2006 and also requested one additional authorized nuclear inspector at site. Since November 2005, CNSC staff and Bruce Power staff have met quarterly to discuss progress in the implementation of the pressure boundary program. The certificate of authorization audit was scheduled for May 2007.

The licensees have aging and life-cycle management strategies and plans for fuel channels to help manage risk of failure. These plans summarize the current understanding of degradation mechanisms that affect *pressure tubes* (PT), based on research and development programs and assessments of earlier data collected at CANDU reactors. The plans describe the inspection and maintenance activities intended to manage observed degradation and detect possible future degradation.

CNSC staff is satisfied that Bruce Power, OPG, and Hydro-Québec have implemented a managed process and a firm technical basis for assessing PT fitness for service. CNSC staff is also satisfied that Bruce Power and OPG view their plans as triggers for future action.

The fuel channel life management and inspection program for Point Lepreau was issued in 2000; this continues to form the basis for its inspection practises. NBPN recently initiated a heat transport system life cycle management improvement project to systematically review all programs and procedures relevant to maintaining the structural integrity of fuel channels, as well as *feeders* and *steam generators*. The licensee intends to issue an updated plan for fuel channels by September 2007.

During the Unit 2 inspection outage, Darlington voluntarily removed a PT to support the industry assessment of the impact of irradiation on critical material properties. Darlington submitted the acceptance criteria it intended to apply to the destructive examination of this tube to CNSC staff.

In 2005, CNSC staff raised a concern regarding the increased number and severity of PT crevice corrosion flaws revealed in recent PT inspections at numerous OPG units. To ensure that OPG has made adequate provisions to effectively manage this form of degradation, CNSC staff requested OPG to conduct a thorough review of all related issues, in cooperation with all other affected utilities, and research and development organizations.

Licensees, through the CANDU Owners Group, have been developing new fitness-for-service guidelines to deal with the highly localized *feeder* wall thinning near welds. The new guidelines were submitted to CNSC for review in 2006.

The “Number of Pressure Boundary Degradations” PI demonstrates the number of pressure boundary degradations that occurred at the stations and monitors the performance in meeting nuclear industry codes and standards. Degradations are defined as instances where limits in relevant design or inspection criteria are exceeded. The “class” that is referred to is the code classification of nuclear systems, whereas “conventional” refers to non-nuclear systems. Industry data for this indicator is shown in Tables 12, 13 and 14. The total number of degradations in 2006 was elevated from previous years suggesting an increasing trend. However, the vast majority of the degradations occurred in the conventional systems.

Table 12: Pressure Boundary Degradations for 2006

Station	Number of Pressure Boundary Degradations by Type					
	Class 1	Class 2	Class 3	Class 4	Conv	Total
Bruce A	8	2	12	1	131	154
Bruce B	7	1	12	0	140	160
Darlington	17	3	9	0	64	93
Pickering A	1	1	6	0	15	23*
Pickering B	0	0	7	0	29	36
Gentilly-2	0	0	0	0	1	1
Point Lepreau	2	0	0	0	1	3

*Due to legacy issues with the system pressure boundary registration at Pickering A, certain features are not required to be reported.

Table 13: Trend Details of Pressure Boundary Degradations for Industry

Year	Number of Pressure Boundary Degradations by Type					
	Class 1	Class 2	Class 3	Class 4	Conv	Total
2002	18	11	37	0	261	327
2003	37	10	28	1	333	409
2004	21	4	23	0	292	340
2005	47	13	27	1	352	440
2006	35	7	46	1	381	470

Table 14: Trends of Pressure Boundary Degradations for Stations

Station	Total Number of Pressure Boundary Degradations				
	2002	2003	2004	2005	2006
Bruce A	18	131	68	92	131
Bruce B	71	109	134	206	140
Darlington	91	59	66	92	64
Pickering A and B	109	100	64	47	59
Gentilly-2	3	0	0	0	1
Point Lepreau	35	10	8	3	3

2.4.3 Reliability

In early 2006, licensees applied for licence amendments to include a new condition requiring compliance with regulatory standard S-98, *Reliability Programs for Nuclear Power Plants*, which was issued in 2005. Each licensee has developed a reliability program consistent with the industry approach. CNSC staff considers the industry approach as generally acceptable although some generic issues still need to be resolved. CNSC staff has planned a workshop in June of 2007 (and other meetings if needed) with the industry to resolve all the remaining issues.

Overall, the systems important to safety performed well in terms of reliability, although there were events in 2006 that challenged the reliability of some of the *special safety systems*.

The “Number of Missed Mandatory Safety System Tests” performance indicator demonstrates successful completion of tests required by licence conditions, including those referenced in documents submitted in support of a licence application. This indicator represents the ability of licensees to successfully complete routine tests on systems related to safety. Data is shown in Tables 15, 16 and 17. Approximately 90,000 of these tests were performed throughout the industry in 2006. The total number of missed tests was lower in 2006 than in 2005 (see Table 16), The total number of missed tests of the *special safety systems* was lower compared with that of last year (see Table 16), and represented only an insignificant percentage of the tens of thousands of tests performed in 2006. This indicated a consistent industry commitment to test its safety systems on a regular basis.

Table 15: Missed Mandatory Safety System Tests for 2006

Station	Total # Tests	Missed Mandatory Safety System Tests			
		Special	Standby	Safety Related	Total
Bruce A	17,330	3	0	3	6
Bruce B	30,113	0	0	0	0
Darlington	10,800	0	0	1	1
Pickering A	12,188	0	0	0	0
Pickering B	10,984	1	0	0	1
Gentilly-2	4,955	0	2	3	5
Point Lepreau	4,289	0	0	0	0
Industry Total	90,659	4	2	7	13

Table 16: Trend Details of Missed Mandatory Safety System Tests for Industry

Year	Total # Tests	Total Number of Missed Mandatory Safety System Tests			
		Special	Standby	Safety Related	Total
2002	63,864	3	1	0	4
2003	64,303	2	2	3	7
2004	84,471	18	3	6	27
2005	84,099	11	2	4	17
2006	85,702	4	2	7	13

Table 17: Trend of Missed Mandatory Safety System Tests for Stations

Station	Total Number of Missed Mandatory Safety System Tests				
	2002	2003	2004	2005	2006
Bruce A			2	4	6
Bruce B	0	0	1	7	0
Darlington	0	0	1	3	1
Pickering A	0	0	0	0	0
Pickering B	1	5	19	2	1
Gentilly-2	1	2	2	1	5
Point Lepreau	2	0	2	0	0
Industry Total	4	7	27	17	12

2.4.4 Equipment Qualification

The licensees were required by a licence condition on *environmental qualification* (EQ) to establish by June 30, 2004, that all *special safety systems* and safety support systems were qualified to perform their safety functions under environmental conditions resulting from design basis accidents.

In 2006, CNSC staff found that, in principle, the EQ programs and their implementation met the intent of the CNSC criteria. However, some of the licensees reported a few unresolved EQ issues related to the steam-protected rooms.

2.5 EMERGENCY PREPAREDNESS

Overall, the industry continued to exceed CNSC requirements and consistently meet CNSC performance expectations for emergency preparedness programs. No reportable events had any significant bearing on any of the industry's emergency preparedness programs or their implementation.

2.6 ENVIRONMENTAL PROTECTION

In 2006, monitoring data on airborne emissions and liquid releases of radioactive substances for all plants showed releases to the environment less than 1% of the *derived release limit* and there were no reports of environmental action levels being exceeded. In 2006, reported doses (μSv/year) to the public at Point Lepreau, Darlington, Pickering, Bruce and Gentilly-2 were 0.57, 1.1, 2.8, 2.45 and 5.69, respectively.

Licensees are required to report to the CNSC any unplanned releases of radioactive material or other hazardous substances to the environment. There were no reported unplanned releases of nuclear substances or hazardous substances from any power reactor sites in 2006 that posed a significant risk to the environment.

2.7 RADIATION PROTECTION

In 2006, CNSC staff carried out regular reviews of most aspects of radiation protection programs at all facilities and found that, in general, licensees continued to adequately manage radiation doses.

Stations also met regulatory requirements and CNSC staff expectations for implementation of their radiation protection programs.

The "Radiation Occurrence Index" performance indicator represents the number and weighted severity of radiation occurrences at a station, thus monitoring the performance in meeting the CNSC's expectations in the area of worker radiation protection. The index and its components are defined and calculated as follows:

a = number of occurrences, after decontamination attempts, of fixed body contamination > 50 kBq/m^2
b = number of occurrences of unplanned acute whole body doses from external exposure > 5 mSv
c = number of occurrences of intake of radioactive material with effective dose > 2 mSv (normalized to 2 mSv)
d = number of occurrences of acute or committed dose in excess of specified limits

Radiation Occurrence Index = a + 5b + 5c + 50d

The weight of each component in the formula indicates the relative safety significance of the various types of occurrences. Tables 18, 19 and 20 show the industry's Radiation Occurrence Index. In 2006, there were no doses in excess of specified limits (see the value of "d" in Table 18). Bruce A and B, Darlington, Gentilly-2 and Point Lepreau had no occurrences of any type. For Pickering A and B the index for 2006 (see Table 20) can be attributed entirely to type "c" occurrences (see Tables 18 and 19). In both cases, the licensee took all required actions, and these occurrences did not represent a loss of control of the licensee's radiation protection program.

Table 18: Radiation Occurrence Index for 2006

Station	Radiation Occurrence				
	a	b	c	d	Index
Bruce A	0	0	0	0	0
Bruce B	0	0	0	0	0
Darlington	0	0	0	0	0
Pickering A	0	0	2.52	0	12.6
Pickering B	0	0	2.99	0	15.0
Gentilly-2	0	0	0	0	0
Point Lepreau	0	0	0	0	0

Table 19: Trend Details of Radiation Occurrence Index for Industry

Year	Radiation Occurrence				
	a	b	c	d	Index
2002	0	0	4.4	0	22.0
2003	2	0	6.7	0	35.5
2004	0	0	2.1	0	10.4
2005	0	0	11.4	0	56.8
2006	0	0	5.5	0	27.6

Table 20: Trends of Radiation Occurrence Index for Stations

Station	Radiation Occurrence Index				
	2002	2003	2004	2005	2006
Bruce A	0	0	0	0	0
Bruce B	13.2	0	5	0	0
Darlington	0	0	0	0	0
Pickering A	0	0	5.4	0	12.6
Pickering B	8.8	0	0	18.0	15.0
Gentilly-2	0	35	0	17.1	0
Point Lepreau	0	0	0	21.8	0

2.8 SITE SECURITY

The assessment of the Site Security safety area for the industry is documented in a separate (secret) *Commission Member Document* (CMD 07-M19.A).

2.9 SAFEGUARDS

In 2006, pursuant to the *safeguards* agreements between the Government of Canada and the *International Atomic Energy Agency* (IAEA), IAEA staff performed *safeguards* inspections and other verification activities at all power reactor sites in Canada. In a timely manner, all licensees provided all information necessary for the CNSC to meet its reporting commitments to the IAEA. All licensees cooperated with the CNSC and the IAEA to successfully accomplish routine inspection activities, including design information verification, the annual simultaneous physical inventory verification, complementary accesses, and equipment installations. All licensees promptly addressed any problems or issues that arose. The IAEA has yet to report its final conclusion on the *safeguards* results in Canada for 2006; however, CNSC staff expects a positive result.

2.10 CONCLUSION

The review of the Operating Performance safety area supported the conclusion that the Canadian power reactor industry operated safely in 2006. Performance indicator data for the stations provided further evidence to uphold this conclusion. The review of the programs in the safety areas covered by this report confirmed that licensees had adequate programs and implementation to support the safe performance of the industry in 2006.

The grades assigned to the licensees for the various safety areas and programs are summarized in Tables 21 through 23. Table 21 shows the program portion of the safety area grades, and Table 22 shows the implementation portion of the safety area grades.
In both tables, the grades from the two previous annual reports are shown for comparison. Table 23 repeats all the grades for all safety areas in 2006, as well as the grades for all the programs under each safety area.

The absence of “C” grades in 2006 in Table 21 and Table 22 suggests that, overall, licensees had good programs and implementation for the various safety areas. However, certain constituent programs may not have met CNSC staff expectations in terms of the program development or implementation as indicated in Table 23.

As in previous years, the industry continued to have well developed and well implemented programs in the Emergency Preparedness, Environmental Protection, Radiation Protection and *Safeguards* safety areas.

Implementation of Organization and Plant Management at Pickering A was rated as not meeting CNSC staff expectations because of the high number of reactor trips and transients and unresolved, repetitive or persistent equipment deficiencies which led to numerous events.

Although all licensees continued to work toward developing, maintaining, and implementing adequate programs in the Performance Assurance safety area, CNSC staff identified a number of weaknesses in the individual programs. Despite Bruce Power’s considerable effort to improve its Quality Management program at Bruce A and B, the project remains incomplete. Meanwhile, Human Factors is an area of weakness at Pickering A, where CNSC staff continue to closely monitor the completion of outstanding regulatory actions in a number of review areas, and at Point Lepreau due to issues involving overall staffing and hours of work.

Implementation of the Design safety program at Pickering B will continue to be rated below requirements until it can be demonstrated that all units can be cooled down in the event of a loss of Class IV power.

In the Equipment Fitness for Service area, CNSC staff rated implementation of the Maintenance programs at Bruce A and Pickering B as not meeting expectations due to continued high maintenance backlog levels at those facilities. The Equipment Qualification program at Darlington was rated below expectations due to issues involving completion of *environmental qualification (EQ)* documentation, replacement of EQ related components and testing of steam-protected rooms.

Table 21: Trends of Program Grades from Annual Reports for the Nine Safety Areas at all Sites

Safety Area	Year of Report	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau
		A	B		A	B		
Operating Performance	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Performance Assurance	2004	B	B	B	B	B	C	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Design and Analysis	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Equipment Fitness for Service	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Emergency Preparedness	2004	A	A	A	A	A	A	A
	2005	A	A	A	A	A	A	A
	2006	**A**	**A**	**A**	**A**	**A**	**A**	**A**
Environmental Protection	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Radiation Protection	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Site Security	2004	Protected						
	2005							
	2006							
Safeguards	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**

Program grades for 2006 that changed since the 2005 annual report are highlighted.

Legend:

A = Exceeds requirements	B = Meets requirements	C = Below requirements	D = Significantly below requirements	E = Unacceptable

Table 22: Trends of Implementation Grades from Annual Reports for the Nine Safety Areas at All Sites

Safety Area	Year of Report	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau
		A	B		A	B		
Operating Performance	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Performance Assurance	2004	B	B	B	B	B	C	B
	2005	C	B	B	B	B	C	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Design and Analysis	2004	B	B	B	B	C	B	B
	2005	B	B	B	B	C	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Equipment Fitness for Service	2004	B	B	B.	B	B	B	C
	2005	B	B	B	B	C	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Emergency Preparedness	2004	A	A	A	A	A	B	C
	2005	A	A	A	A	A	B	B
	2006	**A**	**A**	**A**	**A**	**A**	**B**	**B**
Environmental Protection	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Radiation Protection	2004	B	B	B	B	B	C	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**A**	**B**	**B**	**B**	**B**
Site Security	2004	Protected						
	2005							
	2006							
Safeguards	2004	B	B	B	B	B	B	B
	2005	B	B	B	B	B	B	B
	2006	**B**	**B**	**B**	**B**	**B**	**B**	**B**

Implementation grades for 2006 that changed since the 2005 annual report are highlighted.

Legend:

A = Exceeds requirements	B = Meets requirements	C = Below requirements	D = Significantly below requirements	E = Unacceptable

Table 23: Summary Table of Program and Implementation Grades for all Safety Areas and Programs at all Sites

Safety Area/Program	P or I	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau
		A	B		A	B		
Operating Performance	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Organization and Plant Management	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**A**	**A**	**B**	**C**	**B**	**B**	**B**
Operations	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Occupational Health and Safety (non-radiological)	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**A**	**B**	**B**	**B**	**B**	**B**	**B**
Performance Assurance	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Quality Management	P	**C**	**C**	**B**	**B**	**B**	**B**	**B**
	I	**C**	**B**	**B**	**B**	**B**	**B**	**B**
Human Factors	P	**B**	**B**	**B**	**B**	**B**	**B**	**C**
	I	**B**	**B**	**B**	**C**	**B**	**B**	**C**
Training, Examination, and Certification	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Design and Analysis	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Safety Analysis	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Safety Issues	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Design	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**C**	**B**	**B**
Equipment Fitness for Service	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Maintenance	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**C**	**B**	**B**	**B**	**C**	**B**	**B**
Structural Integrity	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Reliability	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Equipment Qualification	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**C**	**B**	**B**	**B**	**B**
Emergency Preparedness	P	**A**	**A**	**A**	**A**	**A**	**A**	**A**
	I	**A**	**A**	**A**	**A**	**A**	**B**	**B**

Safety Area/Program	P or I	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau
		A	B		A	B		
Environmental Protection	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Radiation Protection	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**A**	**B**	**B**	**B**	**B**
Site Security	P	**Secret**						
	I	**Secret**						
Safeguards	P	**B**	**B**	**B**	**B**	**B**	**B**	**B**
	I	**B**	**B**	**B**	**B**	**B**	**B**	**B**

“C” grades are highlighted.

APPENDIX A - DEFINITIONS OF SAFETY AREAS AND PROGRAMS

OPERATING PERFORMANCE

Operating Performance relates to organization and plant management and overall station operation.

Operating Performance is a cross-cutting safety area that takes into account findings from all safety areas applicable to overall plant performance, such as safety culture and review of the reactor transients. This safety area also includes non-radiological occupational health and safety.

Performance Objective

Safe and secure operation of the facility solely for peaceful purposes and public confidence in the operator's ability to achieve this outcome

Organization and Plant Management

Organization and Plant Management relates to the overall review of plant management.

This program covers high-level review topics and information from individual programs applicable to overall performance, as well as topics that fall under the direct responsibility of plant management. Indicators would include, inter alia, evidence of configuration management, management self assessment, prompt reporting to the CNSC, corrective action program, and defence-in-depth risk approaches as well as minimization of process failures and unplanned transients.

Performance Objective

Capable organization and management of safety programs that provide adequate attention to health, safety, security, environmental protection and international obligations

Operations

The Operations program relates to the performance of a plant's operating staff. It covers activities that operators perform to demonstrate the safe operation of plant systems and awareness of the "cool, control and contain" philosophy.

This area covers licensees' programs for operational inspections, procedural adherence, communications, approvals, change control and outage management. To verify these programs, CNSC staff carries out document reviews and field inspections of systems and operational practices. CNSC staff also monitors maintenance outages to ensure reactor safety principles are maintained and that licensee programs such as maintenance, radiation protection and dose control are effectively managed.

Performance Objective

Safe and secure plant operation with adequate regard for health, safety, security, environmental protection and international obligations

Occupational Health and Safety (Non-radiological)

The Occupational Health and Safety program is mandated of all employers and employees by federal and, in most cases, provincial statutes, to minimize risk to the health and safety of workers posed by conventional (non-radiological) hazards in the workplace.

Performance indicators include lost time injuries and accident severity rate.

Performance Objective

Adequate protection of workers against non-radiological hazards

PERFORMANCE ASSURANCE

Performance Assurance assures the safe performance of the facility through the continuous improvement of policies, programs, standards, and procedures required to manage the facility

Quality management, Human Factors and Training, Examination, and Certification are cross-cutting programs; that is, their performance affects that of other programs and the effectiveness of overall plant management.

Performance Objective

Continued and consistent safe operation of the facility through a system of programs, policies, standards and procedures

Quality Management

Quality Management is the program of coordinated activities to direct and control an organization with regard to quality and safety.

Quality Management focuses on the achievement of results, in relation to the quality objectives, to satisfy the needs, expectations and requirements of interested parties as appropriate. An operational quality management program requires the series of processes necessary for the safe operation of the plant to be integrated and documented in manuals, policies, standards, and procedures.

Performance Objective

Adequate management oversight of the direction and control of quality- and safety-related activities

Human Factors

Human Factors programs are intended to reduce the likelihood of human error by addressing factors that may affect human performance.
CNSC staff currently reviews the following human factors areas to ensure licensee compliance with regulatory expectations:

- human factors in design
- human reliability analysis
- work organization and job design (for example, staffing levels, hours of work)
- procedures
- human performance
- performance measurement
- performance improvement
- organization and management

Performance Objective

Reduced likelihood of human error by effectively addressing factors that may affect human performance

Training, Examination and Certification

Training, Examination and Certification programs ensure a sufficient number of qualified workers to carry out the licensed activities.

These programs must provide licensee staff members in all relevant job areas with the necessary knowledge and skills to safely carry out their duties. Grades for Training, Examination and Certification are based on the review of training programs and use criteria based on the methodology called a *systematic approach to training*, not the performance of licensee candidates in certification exams. However, ongoing satisfactory certification of workers is a requirement for all stations.

Performance Objective

Sufficient numbers of qualified workers to carry out the licensed activities

DESIGN AND ANALYSIS

The Design and Analysis safety area relates to the organization's activities to confirm that systems in a nuclear power plant continually meet design requirements, given new information resulting from operating experience, safety analysis or the resolution of safety issues.

CNSC staff evaluates the documentation of plant systems and assessment of system performance under normal and upset conditions. CNSC staff will raise an *action item* with the licensee if system performance does not meet specifications or if a new failure or degradation mechanism is discovered. The licensee must then take interim compensatory measures to maintain safe reactor operation. The issue will be monitored until it has been satisfactorily and permanently resolved.

Performance Objective

Continued safe operation of the nuclear facility through the identification and resolution of safety related issues of design and analysis

Safety Analysis

Safety Analysis relates to the confirmation that the probability and consequences of a range of events are acceptable. It also includes an integrated review of the adequacy of the plant. Analysis results are used to define safe operational limits.

Power reactor licensees routinely carry out safety analyses to confirm that plant design changes would allow potential consequences of design basis accidents to meet CNSC requirements. In addition, probabilistic safety assessments are performed to identify and better manage all important contributors to public risk. CNSC staff will review safety analyses primarily to verify that licensees employ reasonably adequate assumptions, use validated models, have appropriate scope, and demonstrate acceptable results.

***Performance Objective*s**

Demonstrated acceptability of the consequences of design basis events, the capability of protective systems to adequately control power, cool the fuel and contain any radioactivity that is released from the fuel and the capability to adequately manage the risk contributors identified by the probabilistic safety assessment

Safety Issues

The Safety Issues program relates to the identification and resolution of safety-related concerns arising from operational experience, analysis, research and incorporation of new knowledge or requirements. A safety-related concern that cannot be resolved based on current knowledge is referred to as an outstanding safety issue.

CNSC staff has formally documented those outstanding safety issues that are common to more than one station and complex in nature as generic action items (GAIs). GAIs identify areas where there is uncertainty in the knowledge basis of the safety assessment or where regulatory decisions need to be confirmed. Further work or experimental research is required to more accurately determine the overall safety impact on the facility. CNSC staff allows station operation because GAIs deal with situations where safety margins still exist. Issues with confirmed, immediate safety significance are addressed by other means on a priority basis.

Performance Objective

Timely identification and resolution of safety related issues arising from operational experience, analysis, research and incorporation of new knowledge or requirements

Design

Design relates to the upkeep of the initial plant specifications to align with modern standards, improved practices, or correction of past deficiencies.

CNSC staff reviews plant design to ensure licensees maintain a documented description of equipment, including equipment qualification and classification requirements. CNSC staff reviews licensees' design changes and safety enhancement programs, as well as programs that affect the overall safe operation of the plant, such as fire protection.

Performance Objective

Up-to-date plant specifications aligned to applicable standards

EQUIPMENT FITNESS FOR SERVICE

Equipment Fitness for Service includes those programs that have an impact on the physical condition of structures, systems and components (SSC) in the plant.

This safety area covers maintenance, structural integrity, reliability, and equipment qualification programs. To ensure that safety-significant SSCs are effective and remain so as the plant ages, licensees must establish adequate *environmental qualification* (EQ) programs and integrate the results of inspection and reliability programs into their plant maintenance activities.

Performance Objective

Continued safe operation of the nuclear facility through the identification and resolution of safety-related issues involving structures, systems and components

Maintenance

Licensees are required to maintain their SSCs in a state that conforms to current design requirements and analysis results.

Licensees are required to implement a maintenance program that includes adequate organization, tools and procedures. Licensees must also demonstrate that related programs involving reliability, EQ, training, technical surveillance, procurement, and planning effectively support this maintenance program.

Performance Objective

Structures, systems, and components whose performance may affect safe operations or security remain available, reliable and effective, consistent with the design and analysis documents

Structural Integrity

Structural Integrity relates to the periodic inspections of major components to ensure they remain fit for service.

CNSC staff requires licensees to establish strategies to manage structural integrity problems, including monitoring, assessing, mitigating, and, if appropriate, replacing degraded components. Licensees carry out periodic inspections to confirm that major primary heat transport systems and safety system components — important to worker and public health and safety and the protection of the environment — remain fit for service. These inspections emphasize *pressure tubes, feeder* piping and *steam generator* tubes.

Performance Objective

Safety-significant structural components remain fit for service

Reliability

Licensees must establish a program that includes setting reliability targets, performing reliability assessments, testing and monitoring, and reporting for plant systems whose failure affect the risk of a release of radioactive or hazardous material.

CNSC staff reviews of licensees' reliability programs mainly cover the following:

- reliability models and data verification
- safety system availability
- testing program
- reporting

Performance Objective

Systems important to safety can and will meet their defined design and performance specifications at acceptable levels of reliability throughout the lifetime of the facility

Equipment Qualification

Equipment Qualification relates to plant-specific functional and performance requirements that ensure that SSCs are suitable for operation.

An important component of the Equipment Qualification program is *Environmental Qualification*, (EQ) to ensure that equipment can perform its intended safety function in an aged condition and under extreme environmental conditions resulting from design basis accidents. To be deemed effective, EQ programs must meet a number of acceptance criteria developed by CNSC staff. The licensees must:

- have a documented EQ program and associated processes in place
- ensure that EQ processes and procedures meet recognized industry standards
- install (or replace) the required equipment and have evidence that it is qualified to perform its intended safety function
- have all EQ-related documentation available at the station
- develop a program to assess degradation and failures of qualified equipment during normal operation
- ensure that EQ-related processes comply with the station quality assurance program
- train operations and maintenance staff on EQ principles and processes

Other review topics under Equipment Qualification include chemistry control and fire protection.

Performance Objective

Safety and safety-related systems, equipment, components, protective barriers and structures are qualified to perform their safety functions under environmental conditions resulting from design-basis accidents

EMERGENCY PREPAREDNESS

Emergency Preparedness relates to the consolidated emergency plan and the emergency preparedness program, as well as the results of all emergency exercises.

To be able to respond effectively to an emergency, licensees must establish a consolidated emergency plan with an associated emergency preparedness program and must conduct simulated emergencies to ensure their staff is capable of responding. To evaluate the emergency preparedness of a licensee, CNSC staff assesses its emergency plan and preparedness program as well as the results of simulated emergency exercises. The assessment of the emergency plan indicates the effectiveness of the emergency response strategy. The review of the emergency preparedness program verifies that all components of the emergency response plan are in place and in a state of readiness. Finally, the evaluation of the facility's staff during a simulated nuclear accident assesses their emergency response capability.

Performance Objective

Adequate provisions for preparedness and response capability that would sustain adequate protection of the environment and the health and safety of Canadians during an emergency

ENVIRONMENTAL PROTECTION

Environmental Protection relates to the programs that identify, control and monitor all releases of radioactive and hazardous substances from facilities. This safety area includes effluent and environmental monitoring, emission data, and unplanned releases.

CNSC regulations require that each licensee take all reasonable precautions to protect the environment and the health and safety of persons, including controlling the release of radioactive and hazardous substances to the environment. CNSC staff verifies that licensees have programs in place to identify, control and monitor all releases of nuclear and hazardous substances from their plants. CNSC staff reviews of environmental performance include:

- public doses
- emission data
- effluent and environmental monitoring
- unplanned releases

Performance Objective

Protection of the environment and the health and safety of persons by taking all reasonable precautions, including identifying, controlling, and monitoring the release of radioactive substances and hazardous substances to the environment

RADIATION PROTECTION

Radiation Protection relates to the program in place to protect persons inside a nuclear facility from unnecessary exposure to ionizing radiation.

The *Radiation Protection Regulations* prescribe dose limits for workers who may be exposed to radioactive material. In addition, the regulations require licensees to establish a radiation protection program with part of it devoted to keeping exposures to radiation as low as reasonably achievable (the ALARA principle) through the implementation of a number of control programs including:

- management control over work practices, personnel qualification and training
- control of occupational and public exposures to radiation
- planning for unusual situations
- verifying the quantity and concentration of any nuclear substance released as a result of the licensed activity

Performance Objective

Adequate protection of the health and safety of persons inside the facility with respect to ionizing radiation

SITE SECURITY

Site Security relates to the program required to implement and support the security requirements stipulated in the *Nuclear Security Regulations* and any site-specific orders.

To obtain assurance of compliance with these requirements, CNSC staff assesses licensees':

- security guard service, including duties, responsibilities and training
- nuclear response force, including equipment, training and deployment
- protection arrangements with off-site response forces and testing of response plans
- procedures to assess and respond to potential breaches of security
- security monitoring, assessment, detection, communication, access control systems, hardware and software

Licensees are required to have a sufficient number of trained and properly-equipped security staff available at all times. Their sites must be continuously monitored and licensees must take appropriate action in the event of a security breach. In addition, while not directly specified by the regulations, CNSC staff expects all licensees to conduct joint security exercises with their respective off-site response forces.

Performance Objective

Provision of a physical protection program to provide the required security for a facility and its operations

SAFEGUARDS

The CNSC's regulatory mandate includes ensuring conformity with measures required to implement Canada's international obligations under the Treaty on the Non-Proliferation of Nuclear Weapons. Pursuant to the treaty, Canada has entered into a *safeguards* agreement and a protocol additional to the agreement with the *International Atomic Energy Agency* (IAEA). These agreements provide the IAEA with the right and the responsibility to verify that Canada is fulfilling its international commitment on the peaceful use of nuclear energy.

The CNSC provides the mechanism, through the *Nuclear Safety and Control Act* and *Nuclear Safety and Control Regulations* as well as licence conditions, for the IAEA to implement the *safeguards* agreements. Conditions for the application of IAEA *safeguards* are contained in power reactor operating licences. Compliance includes:

- timely and accurate provision of reports on activities and on the movement and location of all nuclear materials
- provision of measures and services for the application of *safeguards*
- development and satisfactory implementation of appropriate operational processes and procedures

Performance Objective

A positive annual safeguards conclusion by the IAEA by ensuring that international safeguards obligations are attained

APPENDIX B - RATING SYSTEM

Grades are assigned for both design of the program and its implementation and performance for each safety area and for programs within the safety area

A - Exceeds requirements Assessment topics or programs meet and consistently exceed applicable CNSC requirements and performance expectations. Performance is stable or improving. Any problems or issues that arise are promptly addressed, such that they do not pose an unreasonable risk to the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed.
B - Meets requirements Assessment topics or programs meet the intent or objectives of CNSC requirements and performance expectations. There is only minor deviation from requirements or the expectations for the design and/or execution of the programs, but these deviations do not represent an unreasonable risk to the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed. That is, there is some slippage with respect to the requirements and expectations for program design and execution. However those issues are considered to pose a low risk to the achievement of regulatory performance requirements and expectations of the CNSC.
C – Below requirements Performance deteriorates and falls below expectations, or assessment topics or programs deviate from the intent or objectives of CNSC requirements, to the extent that there is a moderate risk that the programs will ultimately fail to achieve expectations for the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed. Although the risk of failing to meet regulatory requirements in the short term remains low, improvements in performance or programs are required to address identified weaknesses. The licensee or applicant has taken, or is taking appropriate action.
D – Significantly below requirements Assessment topics or programs are significantly below requirements, or there is evidence of continued poor performance, to the extent that whole programs are undermined. This area is compromised. Without corrective action, there is a high probability that the deficiencies will lead to an unreasonable risk to the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed. Issues are not being addressed effectively by the licensee or applicant. The licensee or applicant has neither taken appropriate compensating measures nor provided an alternative plan of action.
E – Unacceptable Evidence of either an absence, total inadequacy, breakdown, or loss of control of an assessment topic or a program. There is a very high probability of an unreasonable risk to the maintenance of health, safety, security, environmental protection, or conformance with international obligations to which Canada has agreed. An appropriate regulatory response, such as an order or restrictive licensing action has been or is being implemented to rectify the situation.

APPENDIX C - GLOSSARY OF TERMS

These terms are italicized when used in the text:

action item
A numbered tracking system used by CNSC staff to control issues requiring licensee attention.

calandria tubes
Tubes that span the calandria and separate the *pressure tubes* from the moderator. Each *calandria tube* contains one *pressure tube*.

Commission
A corporate body of not more than seven members, established under the *Nuclear Safety and Control Act* and appointed by the Governor in Council, to perform the following functions:

- regulate the development, production and use of nuclear energy and the production, possession, use and transport of nuclear substances
- regulate the production, possession and use of prescribed equipment and prescribed information
- implement measures respecting international control of the development, production, transport and use of nuclear energy and nuclear substances, including those respecting the non-proliferation of nuclear weapons and nuclear explosive devices
- disseminate scientific, technical and regulatory information concerning the activities of the CNSC and the effects on the environment and on the health and safety of persons, of the development, production, possession, transport and uses referred to above

Commission Member Documents (CMD)
Documents prepared for *Commission* hearings and meetings by CNSC staff, proponents and intervenors. Each CMD is assigned a specific identification number.

derived release limit
A limit imposed by the CNSC on the release of a radioactive substance from a licensed nuclear facility such that compliance with the *derived release limit* gives reasonable assurance that the regulatory dose limit is not exceeded.

environmental qualification (EQ)
A program that establishes an integrated and comprehensive set of requirements that provide assurance that essential equipment can perform as required if exposed to harsh conditions, and that this capability is maintained over the lifespan of the plant.

feeder
There are several hundred channels in the reactor that contain fuel. The *feeders* are pipes attached to each end of the channels used to circulate heavy water coolant from the fuel channels to the *steam generators*.

guaranteed shutdown state (GSS)
A method for ensuring that a reactor is shut down. It includes adding a substance to the reactor moderator, which absorbs neutrons and removes them from the fission chain reaction, or draining the moderator from the reactor.

International Atomic Energy Agency (IAEA)
A United Nations agency that establishes a system of *safeguards* to ensure that member states do not divert nuclear materials to non-peaceful activities. It also provides an international forum for nuclear safety.

lay-up state
A special configuration into which a plant is placed to prevent system and component degradation during extended periods of shutdown.

pressure tubes
Tubes that pass through the calandria and contain 12 or 13 fuel bundles. Pressurized heavy water flows through the tubes, cooling the fuel.

root cause analysis
An objective, structured, systematic and comprehensive analysis designed to determine the underlying reason(s) for a situation or event, which is conducted with a level of effort consistent with the safety significance of the event.

safeguards
A system of international inspection and other verification activities undertaken by staff of the *International Atomic Energy Agency* (IAEA) in order to evaluate, on an annual basis, Canada's compliance with its obligations pursuant to the *safeguards* agreements between the Government of Canada and the IAEA. In the case of Canada, the objective is for the IAEA to provide credible assurance to Canada and to the international community that all declared nuclear material is in peaceful, non-explosive uses and that there are no undeclared nuclear material or activities in this country.

safety report
The safety report, described in Regulatory Standard S-99 *Reporting Requirements for Operating Nuclear Power Plants* provides descriptions of the systems, structures, and equipment of a facility including their design and operating conditions. It includes a final safety analysis report demonstrating the adequacy of the design of the nuclear facility.

serious process failure
A failure of a process system, component or structure:
(a) that leads to a systematic fuel failure or a significant release from the nuclear power plant, or
(b) that could lead to a systematic fuel failure or a significant release in the absence of action by any *special safety system*

setback
A system designed to automatically reduce reactor power at a slow rate if a problem occurs. The *setback* system is part of the reactor-regulating system.

special safety system
The shutdown system #1, the shutdown system #2, the containment system, or the emergency core cooling system, of a nuclear power plant.

steam generator
A heat exchanger that transfers heat from the heavy water coolant to ordinary water. The ordinary water boils, producing steam to drive the turbine. The *steam generator* tubes separate the reactor coolant from the rest of the power-generating system.

stepback
A system designed to automatically reduce reactor power at a fast rate if a problem occurs. The *stepback* system is part of the reactor-regulating system.

systematic approach to training
A logical progression from the identification of training needs and competencies required to perform a job, to the development and implementation of training to achieve these competencies and to the subsequent evaluation of this training.

Type I inspection
An audit or evaluation carried out by CNSC staff of a licensee's programs, processes and practices.

Type II inspection
An equipment or system inspection or operating practice assessment carried out by CNSC staff, which includes item-by-item checks and rounds that focus on outputs or performance of licensee programs, processes and practices. Findings play a key role in identifying where a *Type I inspection* may be required to determine systemic problems in programs, processes or practices.

APPENDIX D - ACRONYMS

These acronyms are also defined when first used in the text.

AECL	Atomic Energy of Canada Limited
AIR	accident injury rate
ALARA	as low as reasonably achievable
ANO	authorized nuclear operator
ASR	accident severity rate
ASDR	Radioactive Waste Storage Area (at Gentilly-2)
ASQ	Accident Sequence Quantification
BAPRA	Bruce A Probabilistic Risk Assessment
BBRA	Bruce B Risk Assessment
BCA	benefit-cost analysis
BDBA	beyond design basis accident
BEAU	Best Estimate Analysis and Uncertainty
CMD	Commission Member Document
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
CSA	Canadian Standards Association
CT	calandria tube
DI	demonstration irradiation
EA	environmental assessment
ECC	emergency core coolant
ECI	emergency cooling injection
EQ	environmental qualification
GAI	generic action item
GSS	guaranteed shutdown state
HPECI	high pressure emergency coolant injection
HTS	heat transport system
IAEA	International Atomic Energy Agency
ICET	Integrated Chemical Effects Test
ISR	Integrated Safety Review
IST	industry standard toolset
LBLOCA	large break loss of coolant accident
LLOCA	large loss of coolant accident
LOCA	loss of coolant accident
LOR	loss of regulation
LVRF	low void reactivity fuel
MCR	main control room
NBPN	New Brunswick Power Nuclear
NOP	Neutron Over-Power Protection System
NSCA	*Nuclear Safety and Control Act*
NRV	non-return valve
OP&P	operating policies and principles
OPG	Ontario Power Generation

PI	performance indicator
PIP	periodic inspection program
PRA	probabilistic risk assessment
PT	pressure tube
QA	quality assurance
PSA	probabilistic safety assessment
RIH	reactor inlet header
SAT	systematic approach to training
SDR	Significant Development Report
SDS	shutdown system
SOE	safe operating envelope
SSC	structures, systems and components
TSP	tri-sodium phosphate

APPENDIX E - SIGNIFICANT DEVELOPMENTS AND FOLLOW-UP FOR POWER REACTORS

The descriptions of significant developments are organized by site and date. Most of the information is from *Commission Member Documents* (CMDs) called significant development reports (SDR). For late-breaking developments that were reported orally to the *Commission*, the information is from the transcripts of the *Commission* meetings.

E.1 Significant Development Reports for Bruce A

There were no SDRs for Bruce A in 2006.

E.2 Significant Development Reports for Bruce B

E.2.1 Bruce B Unit 8: Contamination Found On Material Released (CMD 06-M58)

E.2.1.1 Original Description (CMD 06-M58)

On October 19, 2006 at 7:00 a.m., Bruce Power was notified by Millstone Nuclear Generating Station that contamination was found on material which had been released on an unconditional transfer permit. Millstone received 15 boxes of material in which 7 items were contaminated. The total activity of contaminated items in the shipment was approximately 125nCi.

E.2.1.2 Follow-Up (CMD 06-M58)

Bruce Power had monitored that material with external radiation monitors (detection threshold 10µCi) before it left the site. The contamination found was on the inside of the component that shielded it from the external radiation monitors. Because the items were contained in boxes that had not been opened during transportation, no contamination spread to public or facility areas and it did not present an external hazard to people in the vicinity. Bruce Power has revised its procedures and reinforced with staff the need to comply. CNSC staff is satisfied that corrective actions are appropriate and will reduce the probability of recurrence.

E.2.2 Bruce B Unit 7: Unplanned Shutdown System 2 (SDS2) Trip (CMD 06-M33.C)

E.2.2.1 Original Description (CMD 06-M33.C)

On June 13, 2006, Bruce B Unit 7 experienced an SDS2 trip from 30% power on low core delta P (that is, low reactor inlet header to outlet header pressure differential).

This occurred just after primary heat transport pump P4 was shut down by the operators on indication of seal leakage, using a procedure that had been followed many times without incident. The unanticipated trip appears to have been caused by reduction in core delta P over time due to circumferential *pressure tube* creep and *steam generator* tube fouling. The reordering of fuel bundles in the core may have played a role, as one fuel bundle was removed from each fuel channel, further reducing pressure drop.

E.2.2.2 Initial Follow-up (CMD 06-M33.C)

This event had no consequences in that SDS2 functioned as designed and as expected and fuel cooling was maintained at all times.

Unit 7 has since been restarted. Bruce Power continues to investigate the event to ensure that its causes are well understood. CNSC staff will oversee this investigation and will consider implications for the remainder of the reactor fleet.

E.2.2.3 Additional Follow-up

Bruce Power has performed a *root cause analysis* and submitted a corrective action plan as part of S-99 report B-2006-03895-A0. The interim preventative actions have been completed, and work on the longer term corrective actions is in progress. CNSC staff is satisfied with the corrective action plan and progress to date.

E.3 Significant Development Reports from Darlington

E.3.1 Worker Injured During Unit 3 Outage

E.3.1.1 Original Description (CMD 06-M28.B)

On May 4, 2006 at approximately 16:00 hrs, a mechanical maintenance worker employed by OPG was injured while performing Unit 3 outage work related to the testing of an emergency cooling injection (ECI) non-return valve (NRV). An air impact wrench was required to remove the nuts from the ECI NRV. As the nut was rotating up the bolt, the handle of the wrench moved upwards and crushed the employee's hand between the wrench and a nearby guardrail pipe. As a result, the worker lost a portion of the right little finger up to the second knuckle and had the ring finger crushed. The worker was transported immediately to the Bowmanville hospital.

E.3.1.2 Follow-up (CMD 06-M28.B)

OPG has completed a full investigation into the event. CNSC staff is satisfied with the actions that were taken to prevent similar injuries in the future.

E.4 Significant Development Reports from Pickering A

E.4.1. Multi-Unit Forced Outage at Pickering Nuclear Generating Stations A and B

E.4.1.1 Original Description (CMD 07-M4.A)

On December 21, 2006, Unit 6 of Pickering B was shut down after OPG discovered impurities in the boiler feedwater system. The boiler feedwater must be pure de-mineralized water to prevent long-term degradation of the boiler tubes.
On January 6, 2007, Unit 8 was shut down due to the same boiler chemistry issue.
In addition to the forced shutdown of Units 6 and 8, the station-wide impact of this issue delayed the restart of Unit 7 (which had just completed a planned outage) so that from January 6 until January 16 only Unit 5 was operating at Pickering B.

A condition of the Pickering operating licences requires CNSC approval for continued operation beyond four days if only one unit of the station is operating. In this configuration (single unit operation) a high pressure emergency coolant injection (HPECI) pump must be kept running with its electrical supply from a dedicated standby generator. CNSC staff approved the continued operation of Pickering A and B stations with a standby generator supplying the running HPECI pump until a second unit could be restarted.

OPG's investigation determined that the cause of the boiler chemistry problems was resin in the de-mineralized water supply. The release of resin was caused by an equipment failure in the station water treatment plant which supplies the de-mineralized water system. Resin breakdown at high temperatures, such as those in the boilers, contributes to high sulphates that can damage tubes over the long term. For these reasons, OPG undertook a thorough clean up of the boiler water supply system, including the de-mineralized water header, tank and feedwater supply in those units affected by the resin contamination. OPG is also conducting an investigation to ensure that the causes of this event are understood so that a repeat does not occur.

While the event resulted in the release of some resin to the lake, the impact on the environment was below the levels requiring CNSC notification. (OPG has notified the Ontario Ministry of the Environment, however.) CNSC staff is satisfied that OPG has taken adequate corrective actions to ensure safe continued operation of the stations during this event and that there was no adverse impact to OPG staff or public safety or the environment.

E.4.1.2 Follow-up (CMD 07-M4.A)

CNSC staff will review and evaluate, upon the licensee's submission of the additional reports and the *root cause analysis,* the long-term corrective actions proposed to ensure safe continued operation of the stations and prevent recurrence of such events.

E.5 Significant Development Reports from Pickering B

E.5.1 Multi-Unit Forced Outage at Pickering Nuclear Generating Stations A and B

Please refer to Section E.4.1.1 and E.4.1.2 for details related to this forced outage.

E.6 Significant Development Reports from Gentilly-2

E.6.1 Activation of Emergency Plans at Gentilly-2 (CMD 06-M16.A)

E.6.1.1 Original Description (CMD 06-M16.A)

At approximately 11:30 am on March 22, 2006, the licensee reported that a failure in the process of transferring fuel from the reactor resulted in a release of radioactivity into the reactor building. The licensee activated its emergency response plan and evacuated the reactor building. The incident was resolved by Hydro-Québec staff and was declared closed shortly afterwards at 11:55 am.

Initial data indicates that no workers received any significant exposure and there was no release off-site beyond regulatory limits as a result of the incident. CNSC staff on site monitored Hydro-Québec's response and are satisfied that it responded effectively and took all reasonable precautions to protect health, safety and the environment.

E.6.1.2 Follow-up (CMD 06-M16.A)

Corrective actions identified in the detailed event report submitted by Hydro-Québec include modifications to applicable procedures and a change in the frequency of ventilation system configuration testing. Monitoring of the completion of these corrective actions is continuing.

E.6.2 Station Alert at Gentilly-2 (CMD 06-M43.A)

E.6.2.1 Original Description (CMD 06-M43.A)

At approximately 16:00 on July 18, 2006, Canadian Nuclear Safety Commission staff was advised of Hydro-Québec's decision to activate its emergency plan at Gentilly-2 in Bécancour, Quebec.

The licensee declared that a steam leak was detected in the turbine building following activation of alarms in the control room and a decrease in electrical power. The licensee tripped the reactor and turbine, activated its emergency plan and initiated a station alert as required under its procedures. The operation buildings were evacuated and personnel accounting revealed that no staff members were missing. The station alert was downgraded subsequently to a sectorial alert, which was lifted a little later that evening. It was later confirmed that the steam leak originated from valves on the gland seal system, which opened as a result of excess steam originating from the steam generator. These valves unexpectedly sent steam into the turbine building. Following inspections, Gentilly-2 staff determined that it was safe to restart the reactor. The reactor returned to full power on Saturday, July 22.

The fuel remained cooled during the event. There was no occurrence of radioactive release or injury. CNSC staff monitored Hydro-Québec's response and concluded that it responded effectively and took the measures necessary to protect the health and safety of persons and the environment.

E.6.2.2 Follow-up (CMD 06-M43.A)

Hydro-Québec submitted a detailed event report. CNSC staff is awaiting a *root cause analysis* of the event.

E.6.3 Station Alert at Gentilly-2 (CMD 06-M53.A)

E.6.3.1 Original Description (CMD 06-M53.A)

On November 23, 2006, Canadian Nuclear Safety Commission staff was advised of Hydro-Québec's decision to declare a sectorial alert at the reactor building. The alert was activated at approximately 10:05 a.m.

The alert was declared after tritiated heavy water was mistakenly sent into a ventilation stack while performing tank-drying procedures. Four people were present in the reactor building when the event occurred, three of whom were exposed to low doses of tritium (1 to 3 millirem). The sectorial alert was lifted at approximately 10:52, and the heavy water was recovered.

Staff monitored Hydro-Québec's response and concluded that it had taken the measures necessary to protect the health and safety of persons and the environment. Staff will continue to monitor the examination of the event by the licensee, and will verify the implementation of any necessary corrective action.

Staff considers this event as minor as the release was small (1 to 2 L) and took place inside containment. The decision to produce this report was made solely as a result of this event appearing in the news in the subsequent few days. The event does not meet any of the other criteria for the production of a Significant Development Report.

E.6.3.2 Follow-up (CMD 06-M53.A)

A detailed event report including four corrective actions was produced. One of them states to verify if it is possible to dry the tank without using the ventilation system to prevent recurrence.

E.7 Significant Development Reports from Point Lepreau

There were no SDRs from Point Lepreau in 2006.

APPENDIX F - GENERIC ACTION ITEMS

Safety Issues relate to the identification and resolution of issues arising from research, incorporation of new knowledge, hazard analysis or accident mitigation strategies.
A safety-related concern that cannot be resolved based on the currently available knowledge is referred to as an outstanding safety issue. Canadian Nuclear Safety Commission (CNSC) staff has formally documented those outstanding safety issues that are common to more than one station and complex in nature as GAI. Further work, occasionally including experimental research, is required to more accurately determine the overall effect of a GAI on the safety of the facility. To ensure that CNSC expectations are clear for each GAI, CNSC staff has developed position statements that include closure criteria and an expected timeframe for closure.

Nevertheless, CNSC staff judges that continued station operation is permissible, because the majority of GAIs deal with situations where safety margins still exist but may be subject to potential degradation. Issues with confirmed, immediate safety significance are addressed by other means on a priority basis.

The following describes the progress for each GAI in 2006.

GAI 88G02 - Hydrogen Behaviour in CANDU Nuclear Generating Stations

Loss of coolant accidents (LOCA) can lead to substantial hydrogen releases to containment. Radiolysis of the water in the primary heat transport system by radiation fields from intact fuel in the core is recognized as the primary source for hydrogen generation. Radiolysis of the water collected in the containment by radio-nuclides released from failed fuel bundles can also lead to release of appreciable amount of hydrogen to the containment in the long term. In addition, for LOCA scenarios where emergency core coolant (ECC) initiation cannot be credited, oxidation of over-heated fuel sheath is expected to result in considerable short-term releases of hydrogen into the containment. The more significant long term hydrogen releases have been shown to induce flammable and potentially explosive gas mixtures in entire containment compartments, while the short term releases can have similar local impact in certain regions of the affected compartments. Sensitivity studies on post-blow-down steam flows through the core have indicated an escalation in hydrogen and radionuclide releases for fuel channel flow rates below 100 g/s, with a peak around 10 to 20 g/s.

A significant safety issue, unless appropriate mitigation is provided, is the challenge posed to the integrity of the containment systems and the necessary (or credited) post-accident structures, systems and components (SSC) inside containment by the large combustion and potentially explosive loads from hydrogen ignition. A second significant safety issue is related to the challenge posed to the post-accident performance of containment and its necessary/credited SSCs by inadequate *environmental qualification* to the induced harsh radiological and potential combustion conditions. Mitigation of the long term hydrogen releases is also needed for viable severe accident management.

These safety issues will now be resolved as part of the implementation of the proposed requirements contained in S-337 and S-310 regulatory documents which, in a manner consistent with international practice, define the safety requirements to be met by the containment system in design basis accidents and in beyond design basis accidents (BDBA), and the analysis methodology to be used in the corresponding safety analyses. Implementation of these documents will further allow BDBA to be consistently addressed for reactor units undergoing refurbishment and units approaching their end of life.

GAI 91G01 - Post-Accident Filter Effectiveness

In certain postulated accidents, venting of containment may be needed to reduce the risk of an uncontrolled release of radioactive material. The licensees have been required to demonstrate that the filters are capable of performing their design function and that adequate testing and maintenance activities for them are in place. The filters covered by this GAI included containment emergency filtered air discharge system filters and other filters that are credited in safety analyses. This GAI was closed for the Hydro-Québec (Gentilly-2), OPG (Pickering A and B and Darlington), and Bruce Power (Bruce A and B) plants in previous years. In 2006, CNSC staff closed GAI 91G01 for NBPN (Point Lepreau) based on a number of activities, including the development of an additional post-accident venting procedure as well as detailed analyses to demonstrate that hydrogen burns within the filtering systems are precluded.

GAI 94G02 - Impact of Fuel Bundle Condition on Reactor Safety

The condition of certain fuel bundles irradiated in CANDU reactors has been observed to differ from that predicted and accounted for in design, operation, and safety analysis documentation. The fuel bundles in question have shown signs of more-than-expected degradation such as end plate cracking, spacer pad wear, element bowing, sheath wear, bearing pad wear, sheath strain, disappearance of the CANLUB layer, oxidation of defective fuel and fission product release.

Fuel bundle degradation depends on the reactor, fuel channel and fuel designs, fuel manufacture and operating conditions. The effects of bundle degradation on reactor safety are not fully known, partially because limitations of safety analysis methods. Since theoretical models have been unable to correlate these factors adequately to the fuel condition, fuel and PT inspections are necessary. It is also necessary to conduct an integrated evaluation of information obtained from inspections and examinations, research and safety analyses. Although in the past some fuel inspections were conducted and the results submitted to the CNSC, licensees did not have a formal process to ensure that the fuel and fuel channel conditions were identified and accounted for.
Consequently, the licensees have been required to:

- implement an action plan to eliminate excessive fuel and fuel channel degradation in acoustically active channels; and
- implement an effective, formal, and systematic process for integrating fuel design, fuel and channel inspection and examination, research, operating experience and safety analysis.

This GAI was closed for OPG and Bruce Power in 2001 and 2002 respectively. In 2006, GAI 94G02 was also closed for NBPN based on the information describing the processes implemented at Point Lepreau and results of CNSC evaluation of fuel performance. Request for closure of this GAI for Hydro-Québec is under review by CNSC staff.

GAI 95G01 - Molten Fuel-Moderator Interaction

A severe flow blockage in a fuel channel, or an inlet *feeder* stagnation break, could potentially lead to fuel melting, channel rupture and ejection of molten fuel into the moderator. Potentially the resulting molten fuel/moderator interaction could damage the shut-off rod guide tubes and prevent SDS1 from functioning properly. It could also damage other fuel channels, or the calandria vessel itself.

There has been a long-standing difference of opinion between CNSC staff and licensees and their respective consultants on the severity of the molten fuel/moderator interaction. Beginning in 2000, licensees initiated an experimental program to resolve this safety concern. A panel of three independent fuel-coolant interaction experts was set up to review the experimental program and the industry's proposed resolution criteria. CNSC staff and industry accepted the panel's recommendations. CNSC staff also accepted the industry's proposed closure criteria and experimental program schedule.

Due to technical challenges and problems in obtaining the code classification approval for the test facility, some delays were encountered in the implementation of the experimental program. The first of the planned four tests was carried out successfully in December 2004. By the end of 2006, one 5-kg and two 25-kg melt ejection tests had been performed. The industry is assessing the results from these tests to determine the need for further tests or modifications of the overall plan.

Experience from the tests indicated that the time required to perform post-test analyses is longer than expected. The schedule for closing this GAI has been revised to June 2008.

GAI 95G02 - *Pressure Tube* Failure with Consequential Loss of Moderator

The single and dual failure concept requires analyses of events caused by failures of process systems, plus analyses of initiating events coupled with failure of one of the *special safety systems.* For the postulated scenario of LOCA plus loss of ECC, the moderator system has been credited in the analysis as a heat sink. Heat transfer to the moderator is assumed to be via PT contact with *calandria tubes* (CTs) following PT deformation due to heat-up. This mode of heat transfer has been accepted by CNSC staff, since the moderator was considered to be independent of postulated initiating events and ECC failures.

For dual failures involving PT rupture plus loss of ECC injection, however, experiments have suggested that the moderator may not be available to provide cooling for the fuel channels. The reason is that PT failures may lead to the end-fitting ejection, and as a result, the draining of the moderator water. In that case, the event involving a PT rupture and loss of ECC injection could result in severe damage to a large number of channels, with consequences in excess of those anticipated in the *safety report*.

To achieve closure of this GAI, licensees were requested to provide proposals for a course of action, including possible design changes that would result in the mitigation of, or at least a significant reduction in, the impact of the consequences of such an event.
In response to this GAI the industry presented evaluation criteria for selection of practicable corrective actions, including a proposed cost-benefit methodology. Subsequently, CNSC staff has modified its position statement to refer to the CNSC policy on the use of cost-benefit arguments, and to modify the closure criteria and the completion schedule to reflect recent CNSC staff and industry discussions.

More recently, the industry has submitted the plans of actions to reduce the potential risk associated with this postulated event, and requested closure of this GAI. CNSC staff has, in principle, agreed with the measures taken to mitigate the potential consequences of this event, and also agreed that implementation of any substantial design changes to reduce the likelihood of the event could be done during plant refurbishment and replacement of fuel channels.

As part of its refurbishment plan, NBPN considered the replacement of existing seam-welded CT by more robust seamless CT to address the concern identified in this GAI. However, results of design qualification tests revealed that the anticipated performance improvements of the seamless CT design could not be realized without redesigning the CT-to-tubesheet rolled-joint. NBPN presented arguments that engineering design changes would not be justified based on a more detailed evaluation of the frequency of severe core damage due to a pressure tube rupture (currently under review).

CNSC staff review of this issue is therefore on-going. Other licensees have been requested to address the impact of this development for their facilities.

GAI 95G04 - Positive Void Reactivity Uncertainty – Treatment in Large LOCA Analysis

Accuracy of void reactivity calculations is a significant safety issue in the analyses of design basis accidents involving channel voiding, especially for large break LOCAs (LBLOCA). In 1995, CNSC staff raised concerns about the adequacy of available evidence in support of best-estimate predictions of void reactivity, and subsequently requested all licensees to complete a suitable experimental program to improve related safety analyses, and to undertake adequate interim measures.

In 2001, a CANDU Owners Group report on void reactivity error assessment for CANDU reactors was issued. It summarized the results arising from the overall industry program to address GAI 95G04. It was concluded that the new industry standard toolset (IST) reactor physics suite of computer codes over-predicts the void reactivity of CANDU fuel when compared to the ZED-2 research reactor measurements. The report recommended fuel-type specific values for the errors to be applied in void reactivity calculations by IST reactor physics codes for operating CANDU conditions at all fuel burn-ups. This recommended value of over prediction of void reactivity has been credited in the recent LBLOCA safety analyses with the new IST reactor physics suite of codes.

The acceptability of the estimate of uncertainty in the IST reactor physics codes' prediction of void reactivity for operating CANDU conditions has also been discussed in an industry-proposed independent panel assessment. The panel report was completed and issued in January 2003. The industry dispositioned the recommendations that were made and proposed further research and development activities. The bulk of proposed activities has been completed in 2004 and all licensees requested the closure of this GAI in December 2004. CNSC staff's preliminary review findings and conclusions were discussed with the licensees during a technical meeting in May 2006. CNSC staff indicated that completion of the review and formal responses are planned for 2007.

GAI 95G05 - Moderator Temperature Predictions

In some LLOCA events, the integrity of fuel channels depends on the capability of the moderator to act as the ultimate heat sink. As fuel channels heat up, pressure tubes radially balloon and come into contact with the CTs. Fuel channels remain intact upon contact if the moderator fluid outside the CTs is cold enough to provide good heat removal capability. Channels may fail, however, if the moderator temperature is too high to prevent the outside of the CTs from drying out following contact on the inside with the pressure tubes.

CNSC staff has requested the validation of the computer code used to calculate the moderator temperature distribution against 3-D experimental data representative of reactor conditions. A 3-D test was completed in 2001 to the satisfaction of CNSC staff, and the validation of the computer code MODTURC-CLAS was performed against both separate effect testing and the results of the 3-D integral test. This work has been carried out by an industry team representing all Canadian utilities. The team has made a final submission on code validation to CNSC in December 2005 with a request to close this GAI.

CNSC staff has developed a plan to review the industry submission in detail, and to identify factors that would lead to acceptance or rejection of the request for GAI closure. The review has started in 2006, and is scheduled to continue to the end of 2007 in view of the large size of the submission that includes 17 individual assessment reports.

GAI 98G02 - Validation of Computer Programs Used in Safety Analysis of Power Reactors

In the past, CNSC staff assessed licensees' computer programs and safety analysis methods and identified several inadequate practices with respect to computer program validation. Examples of poor practices include lack of a managed process in performing validation, poor documentation of computer program validation, poor applicability of validation due to the limited range of conditions in the validation experiments in comparison with the reactor analysis, and inadequate assessment of the impact of dimensional scaling and important phenomena for which adequate validation data do not exist. CNSC staff concluded that these inadequate practices eroded overall confidence in the safety analyses results.

The industry has responded to this GAI favorably by establishing a quality control process to improve the computer code validation, and by achieving an overall level of baseline validation for a specific set of major computer codes used in safety analyses. These efforts, once confirmed by CNSC staff's reviews and audits of relevant licensees' programs, are considered to be sufficient to warrant the closure of this GAI. This GAI had been closed for Bruce Power, OPG, and NBPN in 2005. Based on the satisfactory results of CNSC staff evaluation at Hydro-Québec carried out in 2005, this GAI was closed for Hydro-Québec in 2006.

GAI 99G01 - Quality Assurance of Safety Analysis

The CNSC expects power reactor licensees to conduct operations in accordance with a quality assurance (QA) program. This program includes requirements for various safety-related activities, including safety analyses. The acceptability of the safety-related information established by safety analyses depends on the degree of conservatism incorporated into the analyses. It also relies on the credibility of the analytical tools and activities, such as computer codes, methods and input information. Licensees need to perform safety analyses in a systematic manner, using QA principles, to ensure confidence in the licensing basis and safe operating envelope for each facility.

CNSC staff had become aware of an increasing number of occurrences of poor safety analysis practices by power reactor licensees caused by inadequate QA. These poor practices were identified through audits and assessments. The initiation of this GAI in 1999 was due to the CNSC staff conclusion that inadequate QA of safety analyses had caused a reduction in the overall confidence in the safety analysis results.

The industry has responded by establishing QA frameworks and procedures related to safety analysis, and by taking actions to satisfy all relevant closure criteria. This GAI for Bruce Power had been closed earlier.

The results of the audit at OPG were also satisfactory. Based on results of CNSC staff reviews of the new QA program, CNSC staff closed this GAI for OPG in 2006.

The results of the audit at NBPN were satisfactory, but closure of this GAI is contingent on the compatibility of the newly established procedures with the overall QA program being developed at NBPN.

A relevant audit was carried out for Hydro-Québec in 2005 with satisfactory results, and closure of this GAI is expected in the near future.

GAI 99G02 – Replacement of Reactor Physics Computer Codes Used in Safety Analysis of CANDU Reactors

Licensees use reactor physics methods and computer codes to support nuclear design, operation and compliance with the safe operating envelope. There are stringent requirements on accuracy and validation of these methods and codes due to their role in the confirmation of safe operation. Recent experimental data, as well as reviews of key computer codes, identified several shortcomings. These deficiencies are related to inaccurate predictions of key parameters for accident conditions, lack of proper validation and a significant lag of licensees' methods and codes behind the current state of knowledge in this area. These shortcomings had a negative effect on the overall confidence in the results of reactor physics analyses, especially for those analyses where safety margins are small.

Under this GAI, licensees are required to carry out a structured program of replacement of reactor physics computer codes. In February 2001, an industry project to analyze a power pulse following a LLOCA with the new set of reactor physics codes resulted in the prediction of more severe consequences than those presented in earlier licensing submissions. To mitigate the potential effects of this, the licensees implemented more restrictive operating limits, such as flux tilt limit, moderator and coolant purity limits, and moderator poison load limit to compensate the increase in the predicted power pulse. Following imposition of those restrictions, licensees continued implementation of their programs to replace reactor physics computer codes.

A report of an independent expert panel (see GAI 95G04) assessed the adequacy of estimated uncertainties of certain key parameters predicted by the codes. Two licensees (Bruce Power and OPG) completed an agreed set of activities and declared the new reactor physics toolset in service for future accident analysis. The new reactor physics toolset was applied in licensing safety analysis and commissioning of the Bruce A Units 3 and 4 restart. Work on a second set of activities on code validation has been completed in 2004 and Bruce Power and OPG requested the closure of this GAI. CNSC staff's preliminary review findings and conclusions were discussed with all licensees during a technical meeting in May 2006. CNSC staff indicated that completion of the review and formal responses are planned for 2007.

GAI 00G01—Channel Voiding During a LLOCA

CNSC staff has a concern that the computer codes used for prediction of overpower transients for CANDU reactors with a positive coolant void reactivity coefficient have not been adequately validated. This GAI requires the licensees to carry out direct void fraction measurements, provide an assessment of the scaling of the results to the phenomena expected in the reactor, perform validation exercises using these data and complete an impact assessment on the safety margins.

Tests with void fraction measurements in Atomic Energy of Canada Limited (AECL)'s RD-14M facility have been completed, and data analysis reports have been submitted to the CNSC. The industry has provided information on the computer code validation exercises and the scaling assessment.

After reviewing the information submitted by the industry, CNSC staff requested each licensee to provide a plan to address the following outstanding issues:

- perform scaling analysis work to document the scaling rationale for the RD-14M simulated large LOCA experiments and demonstrate the relevance of the channel void measurements in these RD-14M experiments to the reactor situation
- provide estimates of the simulation uncertainty of the system thermalhydraulic code for predicting the channel void fraction during the rapid voiding phase following a LLOCA using the simulation and experimental results on the channel voiding behaviour in the RD-14M simulated large break LOCA tests
- provide confirmation that the system thermalhydraulic code, when simulating the channel voiding behaviour in a large break LOCA, is used in the same way as in the validation exercises. Any deviations in the usage of the computer code in safety analysis are to be identified, explained and justified
- perform sensitivity calculations to examine the effect of uncertainty in the channel void predictions from the system thermalhydraulic code during the early blowdown phase on key safety parameters (for example, peak fuel centreline and sheath temperatures) of a large break LOCA

A progress meeting was held in April 2006 to discuss the industry's progress on the scaling assessment. In June 2006, the industry submitted a scaling assessment of RD-14M large break LOCA tests for the channel voiding behaviour during the power pulse phase. This assessment is under review by CNSC staff. A progress meeting was held in December 2006 to discuss the status of the remaining issues under this GAI. Discussions between CNSC and industry staff continue to address the outstanding issues.

GAI 01G01 - Fuel Management and Surveillance Software Upgrade

This GAI was initiated as a follow-up to the closure of GAI 95G03. The GAI only related to Bruce Power and OPG.

Compliance with reactor physics safety limits that define the safe operating envelope, such as channel and bundle power limits, is based on analyses performed with a fuel management computer code. Recent, more rigorous, scrutiny of the accuracy of methods, acceptance criteria, assumptions and results of safety analyses of various design basis accidents led to significant restrictions of operating parameters, including channel and bundle powers, and introduction of additional physics parameters for compliance purposes, such as fuel string relocation reactivity and minimum margin to axial constraint. As such, the significance of compliance with safety-related reactor physics limits has increased. This has enhanced the need for an improved analytical model, validated over a broader range of applications and conditions as well as better-defined compliance allowances and more consistent procedures.

To achieve closure of this GAI, licensees were required to implement a structured program for reactor core surveillance that covers the fuel management software upgrade and validation as well as validation and qualification of the error compliance methodology.

Bruce Power and OPG submitted detailed work plans and schedules, as well as semi-annual progress reports. Work is divided into two main phases. Phase I deals with modeling improvements to the SORO computer code and Phase II deals with estimation of error allowances.

A significant milestone was achieved in December 2003 with the implementation of the first improved version of the computer code WIMS-IST-SORO. Significant progress has been made during 2005 with the completion of work related to validation of WIMS-SORO version against flux measurements in a CANDU 6 reactor. CNSC staff is closely monitoring the progress of this GAI. CNSC staff's preliminary review findings and conclusions were discussed with all licensees during a technical meeting in May 2006. CNSC staff indicated that completion of the review and formal responses are planned for 2007.

GAI 06G01 – ECC Strainer Deposits

Preliminary research findings of the Integrated Chemical Effects Test (ICET) program in the United States have raised concerns about the formation of deposits on ECC system strainers. A new GAI, 06G01 *ECC Strainer Deposits*, was created in 2006 to address the impact of this concern for CANDU reactors.

A postulated LOCA would dislodge significant quantities of insulation material, both fibrous and particulate. Much of this debris is expected to be transported to the reactor building sump with the coolant lost from the reactor through the break. ECC recirculation recovers water from the sump, cools it and returns it to the reactor to cool the core. The ECC strainers are located in the sump and protect the ECC recirculation flow path by preventing the debris from entering the ECC system. As a result, a layer builds up over the strainer surface. The strainers are designed with sufficient surface area that the debris bed does not impede flow.

The ICET program looks at the impact of reactor building sump chemistry following a LOCA and possible implications for ECC strainers during recirculation following a LOCA. In some of the ICET tests a gelatinous deposit was discovered on the fibre samples in the tank. There is a concern that such chemical deposits could lead to a partial blockage of the strainer thereby impairing the ECC recirculation.

Industry was advised of CNSC staff's concerns and immediately established a CANDU Owners Group research program to address it. CNSC staff raised GAI 06G01 to track the issue. Up to date, licensees have submitted information giving confidence that the chemical environment in CANDU reactors does not include the features that led to possibly harmful deposits in the ICET tests. In particular, the study showed that addition of tri-sodium phosphate (TSP) to the water in the ICET tests led to accelerated aluminium corrosion and the formation of the deposits. CANDU reactors do not make use of TSP to raise sump pH after a LOCA. CNSC staff accepted the conclusions of this study.

However, licensees could not completely exclude chemical effects under CANDU sump conditions. Therefore an experimental program was established to close this gap in knowledge. CNSC has been consulted on the test plan and methods and staff's views have been taken into account. The program is scheduled to be completed in 2007. Early results are encouraging.

Progress by industry in addressing this GAI has been excellent. The research program was established quickly and the work is proceeding on schedule.