Report Rapport

Atomic Energy Control Board

Commission de contrôle de l'énergie atomique

AECB STAFF REVIEW OF
BRUCE NGS'A' OPERATION
FOR THE YEAR 1987

Canada

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1. INTRODUCTION

The operation of Bruce NGS"A" is monitored and the licensing requirements are enforced by AECB project staff resident at the station. To assess operation in accordance with licensing requirements, the project staff, with appropriate support from other AECB personnel, monitors operation of the four reactors, witnesses important activities, conducts audits, carries out inspections, and reviews station documents and reports as appropriate.

To comply with the requirements of the license, Ontario Hydro issues Quarterly Technical Reports which summarize key features of station operation during the year. Following AECB staff review of these reports, a formal Annual Review Meeting is held with the station management to discuss safety related issues and to convey to Ontario Hydro the AECB's assessment of station operation during the year.

This report presents AECB project staff's review of major licensing issues and of the operational performance of the station during 1987. Ontario Hydro reports and official correspondence and observations of AECB staff at site have been taken into consideration. The report is limited to aspects of the station performance that AECB staff considers to have safety significance. Where significant developments associated with issues addressed in the report occurred in the early part of 1988 (up to the time of writing), these are mentioned where appropriate. Ontario Hydro's Quarterly Reports for 1987 contain detailed technical information on the performance of the station, individual units and unit systems.

2. CONCLUSIONS

It is the opinion of AECB project staff that despite a number of commendable actions and achievements which are identified in this report, the performance of the station in 1987 was only marginally satisfactory and less satisfactory than in 1986. This assessment is supported by key performance indicators such as the number of reportable significant events, the number of events caused by or influenced by human error and the reactor trip frequency, all of which exceeded 1986 levels, and also by the lack of satisfactory progress made during the year on actions to address the findings of the Fall '86 AECB Assessment of Operating Practices. AECB staff considers that the outstanding operations and maintenance problems that were identified in the 1986 Assessment are due, in part, to an ineffective quality assurance program, and in part to a shortage of resources.

3. REVIEW

3.1 Overview of Station Performance

The station net capacity factor for 1987 was 64.98%. This compares to its overall lifetime average of 81.81% and last year's 74.8%. The below average value was primarily due to three major unit outages and a one-month long station outage (all four units shutdown) for containment tests. The unit outages comprised completion of west shift outage on unit 1 (17 weeks), a west shift outage to adjust fuel channel position to allow for creep of pressure tubes on unit 2 (18 weeks) and an engineering change outage on unit 4 (9 weeks). The station outage is discussed in more detail in section 3.2, Significant Licensing Activities.

Transmission line limitations contributed significantly to the low station capacity factor, as was anticipated with all four Bruce NGS"B" reactors now in-service.

3.1.1 Operation at High Power

Since the return to service of unit 1 in the first quarter of 1987, all four units have been licensed to operate at their maximum design power. As was reported last year some problems associated with stability at high power have continued to occur.

Low Frequency Oscillation

Low frequency oscillation of major unit parameters such as reactor power, heat transport pressure, pressurizer level, feed and bleed flows, was reported last year. This phenomenon, which was most significant on unit 2, has continued. However, design modification to improve pressurizer level control at high power was installed in the third quarter of 1987. This modification was successful in substantially eliminating the oscillation after extensive tuning of the level control logic elements. The same modification is planned for units 4, 1, and 3 during the scheduled outages of these units in 1988.

Unit 2 Boiler 3 Level Oscillation

Little progress was made in determining the cause of this phenomenon which has gradually become more severe since it was first recognized in the fall of 1986. The oscillations in boiler level indication now begin at a lower power level (approximately 70% reactor power) than was the case a year ago. The cause is now believed to be a restriction in one of the tube bundle baffle plates.

To avoid spurious trips on the most sensitive shutdown system boiler low level channel, unit 2 has been operated at reduced power since returning to service after the outage in the Fall of 1987. Further inspection of boiler internals is planned for the next scheduled outage of this unit in November 1988. An inspection conducted in mid-1987 revealed no findings that could have contributed significantly to the oscillation.

Ontario Hydro has stated that this oscillation does not represent a threat to the integrity of the heat transport system pressure boundary nor to the control of the reactor. AECB staff is observing developments and, at the present time, is of the opinion that the actions taken and planned by Ontario Hydro are appropriate.

Reactor Trips on Minor Reactivity Changes

In 1986, five reactor trips were attributed to the inability of the reactor regulating system (RRS) to control spacial flux disturbances at high power. In 1987 there were no such reactor trips. The changes made to the RRS program to reduce reactor power control limit to 100.5%, and the high power setpoints for Stepback and Setback routines, appear to have been effective in resolving this problem. Two power setbacks occurred as a result of localized reactivity changes at high power.

3.2 Significant Licensing Activities

The following major licensing activities took place during 1987.

3.2.1 Containment Testing

In compliance with a licence condition, all units at Bruce NGS"A" were shut down in May to conduct an in-service test of the containment structure and the vacuum building. These tests revealed that leakage from the containment boundary could exceed that assumed in the Safety Analysis. Ontario Hydro is committed to install modifications to alleviate this problem by 1990. In the meantime, enhanced maintenance activity has reduced the leakage rate. AECB staff approved the station re-start on the basis of the commitments made.

3.2.2 Primary Heat Transport Pump Trips

Late in 1987, Ontario Hydro reported that recent analysis had shown that, under particular post-accident conditions in which there is two-phase flow at the pump suction, vibrations in the heat transport system could be created, by its large electrically driven pumps, to an extent where its integrity and that of adjacent containment boundary seals could not be assured. A temporary pump tripping arrangement was rapidly devised and installed and Ontario Hydro is required to install an approved permanent arrangement by 30 September 1988. During review of this matter, members of the Board requested that Ontario Hydro pursue strengthening of the pump supports to prevent their failure under accident conditions. This request was communicated to Ontario Hydro. AECB staff has yet to receive substantive proposals to address this request.

3.2.3 Pressure Tube Integrity

Ontario Hydro undertook extensive pressure tube inspections during 1987 as part of a continuing in-service inspection program and to comply with AECB requirements imposed following the failure of a pressure and calandria tube in unit 2 in 1986. This program is continuing.

3.2.4 Other Significant Topics

These include completion of the submission of safety analysis sections by Ontario Hydro, installation of modifications to ensure full trip coverage for loss of a single heat transport pump, and review of proposals to modify fuelling machines. The last two items are still in progress.

3.3 Station Compliance

3.3.1 Compliance with Regulations

AECB staff considers that, in general, Ontario Hydro has complied with relevant regulations during 1987. A question of interpretation of the Physical Security Regulations with respect to the required frequency of security alarm drills at both Bruce nuclear stations has yet to be formally resolved. In addition, there was a violation of the Transport Packaging of Radioactive Materials Regulations when a shipping flask was dispatched from the station without being properly secured to its transporter. No incident resulted from this omission.

3.3.2 Compliance With the Licence

Ontario Hydro has generally complied with the 34 conditions of the current Reactor Operating Licence (ROL 10/86), with the following exceptions.

3.3.2.1 Compliance with Operating Policies and Principles Condition A.A.1)

Three events were reported which represented breaches of the station Operating Policies and Principles. These events concerned control of moderator cover gas pressure, testing of a shutdown system, and operation of the minimum number of standby generators. They are discussed further in section 3.4.3 of this report.

3.3.2.2 Compliance with Ontario Hydro's "Radiation Protection Regulations, Part 1" (Condition A.A.1)

Four events during 1987 are construed by AECB staff to represent breaches of these regulations. These events involved a shipment of radioactive equipment without a transfer permit, contamination of a contract worker, an unexpected tritium uptake which disclosed failure to use proper radiation procedures, and an injury to a construction technician. None of these events resulted in significant consequences. However, the injury to construction technician (being rendered unconscious by breathing nitrogen) could have proved fatal.

3.3.2.3 Maintenance of Shutdown System Trip Setpoints (Condition A.A.6)

An event involving failure to properly implement a design change to disconnect trip setpoint switching logic on booster insertion occurred in 1987. Analysis showed that there was no direct safety implication, but the event indicated lack of control of an important safety system change.

3.3.2.4 Compliance with Laws of General Application in the Province of Ontario (Condition A.A.8)

A minor case of non-compliance was reported with respect to a violation of the Ontario Building Code, in that a fire barrier was inadvertently removed during an office modification. The Code requirements have been restored.

3.3.2.5 Standards of Maintenance (Condition A.A.11)

Condition A.A.11 of the licence requires that the standard of maintenance be at a level satisfactory to the Board. Assessment of this condition accordingly requires exercise of judgement. However, it is the opinion of AECB staff that standards of maintenance at Bruce NGS"A" were not satisfactory during 1987 in a number of ways.

a) Review of Outstanding Maintenance by the Technical Unit

In 1987, AECB staff could see little evidence that this important task was being done, although a recommendation to this effect was made during an AECB assessment in late 1986. In early 1988, there was evidence that the station technical unit had started a review of outstanding maintenance.

b) Backlog of Maintenance

The backlog of maintenance appeared to increase during 1987 from an existing high level. (The decrease in Call-Up backlog was more than offset by the large increase in the reported deficiency backlog.) The station was involved in major testing, maintenance and engineering change programs during the year, and will continue to be in the near future. It is evident that station management is taking action to improve the management of maintenance and to attempt to deploy more resources in this area.

c) Maintenance Standards

While AECB staff believes that Bruce NGS"A" standards are generally high, there have been a number of events where deficient maintenance has caused avoidable delays in returning the reactors to power. These incidents were associated more with plant process systems rather than with safety systems. They have, however, caused AECB staff to doubt the adequacy of Ontario Hydro's quality assurance program, and to conclude that lack of field supervision may apply to maintenance work as well as field operations. At the time of writing, it is evident that Ontario Hydro has recognized this problem and is taking steps to resolve it.

d) Housekeeping

Standards of housekeeping fell during the early part of 1987, although some effort was made later in the year to effect improvement. Substantial improvement was achieved early in 1988.

3.3.2.6 Expeditious Completion of Reports, Tests, Inspections, Modifications, and Analyses Requested by the Board (Condition A.A.12)

A number of safety-related modifications to the plant, either requested by or committed to the AECB remained outstanding during 1987. These included modifications to mitigate the effects of a steam or feed system failure in the powerhouse, some modifications to reduce the impact of a loss of coolant accident on subsequent plant operation (the bulk of these modifications committed in 1980 have been completed), modifications to the system monitoring the presence of heavy water in moderator heat exchanger cooling water, and a number of modifications relating to the effectiveness of the containment system. In the case of an important modification required to trip heat transport pumps under certain accident conditions, the Board has made timely installation a condition of the Reactor Operating Licence.

In addition, it is clear that the limited resources of Ontario Hydro's safety analysis group are being committed to major tasks and that a number of lesser but still important issues are receiving little attention.

3.3.2.7 Safety Report Updates (Condition A.A.18)

This condition requires that the Safety Report shall be reviewed and brought up-to-date once in any three year period during the operating life of the facility. The last formal issue is dated August 1984. Since that time, the Safety Analysis component of the Safety Report has been revised and submitted, although not in a complete formal package. An agreement now exists for part of the analysis to be updated each year.

However, the descriptive (Volumes I and II) component has not been updated, although a number of changes have been made to the plant, rendering the current report out-of-date. While this may not have a direct safety implication for plant operation, it does constitute a formal breach of the licence condition.

3.3.2.8 AECB Staff Position With Respect to Licence Compliance

Some of the non-compliances mentioned above may be considered to be largely "technical" failures (e.g., 3.3.2.4, 3.3.2.7) with respect to nuclear safety. They reflect primarily on Ontario Hydro's administrative controls. Moreover, it should be noted that Ontario Hydro faithfully met the conditions of the licence that impose reporting requirements, and generally strove to meet the other licence conditions.

However, other items reported above, notably those pertaining to operating and maintenance standards and to the timely installation of safety related modifications have a direct bearing on safety. These areas need to be improved promptly. AECB staff believes that station management is well aware of these concerns and that there is a structured approach to achieving improvement. AECB staff will be conducting a comprehensive auditing program to satisfy itself that the planned improvements are realized.

3.4 Review of Station Operation

3.4.1 Radiation Control

3.4.1.1 Occupational Safety

There were no whole body exposures of station personnel in excess of the legal limits during the year. The station commenced dose control measures using 2 rem (averaged over an employee's career) per year guidelines, in the Fall. Previously the figure was 4. AECB staff regards this as a positive step. Early indications are that it will result in lower doses. Despite record levels of tritium (up to 38 Ci/kg) in the moderator systems and an increase in the level of moderator maintenance work during the year, the number of tritium related supervisor investigations was lower than in previous years. This can be attributed in part to the effectiveness of a stepped up tritium work educational program. There were, however, forty-seven supervisor investigations into radiation incidents which shows that infringements of the radiation control procedures and working practices remain a concern. Section 1.1 of the Objective Measures, Appendix I shows dose values which compare favorably with the previous year. The significant reductions in extremity dose levels are noteworthy. AECB staff is of the view that these results reflect effective control over the high hazard work activities undertaken during the year.

In the fall of 1987, a routine floor survey for loose contamination immediately outside the station office area detected the presence of a high activity level small particle (termed "hot particle"). This was not the first occasion that a "hot particle" has escaped detection at the inter-zone boundary monitors. Ontario Hydro is aware of the situation and AECB staff is monitoring it.

3.4.1.2 Radioactive Emissions

Appendix 1 indicates that station gaseous and waterborne emissions were acceptable during 1987. The five occasions that tritium emissions exceeded 1% DEL were as a result of inadvertent releases during moderator maintenance. AECB staff, however, remains concerned with the unsatisfactory state of some of the station's radiation monitoring facilities which might jeopardize the station's ability to correctly monitor unexpected releases. These systems include the Active Liquid Waste Management System, where proven on-line effluent monitoring is still unavailable, the D_2O in H_2O monitoring system, and the off-gas management system. While none of these systems is considered unacceptable, AECB staff is of the opinion that planned action to restore the systems to meet the design intent should be given a higher priority by Ontario Hydro.

3.4.2 Significant Events

During 1987, no serious process failures were reported. Of the one hundred and fifteen (115) significant events reported, thirty-six (36) were pursuant to the Bruce NGS"A" Operating Licence. This represents a significant increase from the number of reportable events in 1986 (twenty [20]). Also, showing a significant increase over 1986 was the number of events in which human error was a contributing factor (up from forty-two [42] to sixty-three [63]). These trends are of concern to AECB staff and it is expected that Ontario Hydro will be taking appropriate corrective action to reverse them.

While AECB staff considers that Ontario Hydro has consistently and accurately reported all events of safety significance and that appropriate remedial actions are usually taken, it was evident in 1987 from the tardiness of many Follow-Up Reports that they were not always assigned the priority they would appear to merit.

A list of the reportable significant events is included as Appendix 2. A breakdown of these events into station system/area category is given below.

Event Category	No. of Reportable Events
Radiation Control	10
Shutdown Systems	6
Containment	1
Emergency Cooling Injection	1
Reactor Process Systems	10
Secondary Systems	5
Miscellaneous	3

The more significant of the above events in each category are summarized below.

3.4.2.1 Radiation Control

Of the ten reportable events, six were due to tritiated heavy water leaks or spills, some resulting in worker uptakes exceeding 1 MPBB (Maximum Permissible Body Burden) and others in unit alerts due to tritium concentrations exceeding 200 MPCa (Maximum Permissible Concentration in Air). One event, due to a procedure violation and lack of communication, involved the shipment off-site of a heat transport pump motor without a radioactive materials transfer permit. Another event, again due to deviations from procedure and communications problems, occurred when a shipping flask, containing a radioactive horizontal flux detector unit, was shipped to Chalk River Nuclear Laboratories without being bolted down, as called for in the procedure. This event was a violation of the "Transport Packaging of Radioactive Materials" regulations.

3.4.2.2 Shutdown Systems

An unsafe condition, reported as an event in June 1987, and considered to be serious by AECB staff, was discovered on unit 1 during booster use for early start-up from a poison outage. It was found that the neutron overpower (NOP) trip setpoints had switched to the "booster conditioning" position even though the switching logic was supposed to have been disconnected as part of a design change. A subsequent study carried out by Ontario Hydro showed that this error had not impaired the shutdown system.

Two events that occurred in June/July 1987 involved the impairment of shutdown system 2 (SDS2) as a result of malfunction of a relief valve which would not reclose after lifting, allowing the helium tank pressure to drop below the minimum acceptable level. Ontario Hydro have determined that the relief valve was defective and that this was an isolated case.

In another event, the malfunction of two mercury-wetted relays prevented two SDS2 channels from tripping during a safety system test while the unit was shutdown. These relays have been a known problem area for some time but this was the first time that two have failed simultaneously. Ontario Hydro plans to replace this type of relay with new "Tin-Doped" relays as the former are found to be no longer serviceable.

3.4.2.3 Containment

During the station outage, a vacuum building douse test was performed. Water on the vacuum building floor backed up through a stuck-open check valve onto the VB basement floor and thence to the inactive draining system. This event was of concern to AECB staff since it revealed a potential unmonitored and uncontrolled leakage path for radioactive materials out of the plant and a hitherto unknown breach in the containment boundary. Early and appropriate action was taken by Ontario Hydro to correct the situation.

3.4.2.4 Emergency Cooling Injection

An operator error resulted in impairment of the emergency coolant injection (ECI) system for approximately four hours. The event occurred as a result of field valving actions being carried out to isolate the wrong valve. Test stroking of the valve believed to be isolated then caused partial drainage of the low pressure recovery system. AECB staff regarded this as a serious event and are not yet satisfied that Ontario Hydro has adequately demonstrated that the event was not a full "level 1" impairment.

3.4.2.5 Reactor Process Systems

In-service inspection revealed severe fretting on the 6" diameter heat transport system feed line on two units (1 and 4). On unit 1 the fret mark had penetrated 48% through the pipe wall and on unit 4 it had penetrated 85% through the wall. Had this damage gone unnoticed for much longer, a loss-of-coolant accident could have occurred. The cause of the fretting was determined to be "rubbing" by a stainless steel insulation strap on a 12" diameter boiler cross-over pipe immediately overhead. Inspection of this location on units 2 and 3 revealed no fretting damage. Ontario Hydro repaired the defective pipes on units 1 and 4 following approval of the proposed repair procedures by Ontario Ministry of Consumer and Commercial Relations and AECB representatives. Ontario Hydro Design Department are reviewing the design of the feed line piping supports.

An AECB staff member, while conducting a routine inspection in the plant, discovered moderator cover gas pressure to be reading low on unit 1 and reported this to the shift supervisor. Subsequent investigation determined that the pressure transmitter which should have alerted the unit 1 operator to this condition was out of calibration and reading 15% high. As a result, the operating parameters of the moderator were outside the limits permitted by Operating Policies and Principles and the operator was unaware of it. Although subsequent analysis showed that the moderator margin of subcooling was within safety analysis limits, AECB staff was concerned with the implications of this event:

i) the unit operators may not be aware that their unit is operating outside Operating Policies and Principles limits
ii) that there is no station procedure that ensures that all field instruments that provide important signals to the control room are routinely calibrated.

AECB staff is pursuing these concerns with the station Technical and QA sections.

3.4.2.6 Secondary Systems

In August 1987, Unit 1 was shut down because of a steam leak from a crack in the main feedwater line at the deaerator outlet. This event was considered to be serious by AECB staff because of the potential consequences of a feedwater line break and because the unit was permitted to continue operating for more than 24 hours following the discovery that a crack in the feedwater line was the cause of the steam leak. Since Ontario Hydro did not propose to take early action on the detection of this crack, AECB staff decided to instruct Ontario Hydro to shut the reactor down immediately. On being advised of this decision, Ontario Hydro shut the reactor down before the instruction was formally issued. Inspection of other units revealed surface cracks in a similar location on the feedline on units 3 and 4. The cracks were repaired and a subsequent analysis revealed their cause to be fatigue failure of a gusset weld due to high vibration. A design modification is presently being implemented to stiffen the feedwater line in this area.

In September 1987, an event occurred in which the failure to start of a standby generator (SG) prompted an investigation which revealed that fewer than the required number of SGs were available as defined in the Operating Policies and Principles. It is believed that this condition existed for 43 hours. A similar event occurred in November 1987 when lack of availability of the same two SGs resulted in violation of the Operating Policies and Principles requirements for a minimum number of available SGs. In this case, the condition existed for less than one hour and was primarily due to the time taken by an assistant operator to reset a reverse power relay. Ontario Hydro has taken appropriate action to minimize the likelihood of a recurrence of such events.

3.4.2.7 Miscellaneous

During the station outage in May 1987, a construction worker came close to being asphyxiated as a result of a communications breakdown and an approved work plan not being followed. The worker was rendered unconscious after connecting up his air supply hose to a breathing air line containing nitrogen. A thorough investigation of the accident by Ontario Hydro revealed the need for improvements in the administration and implementation of work plans prepared by station operations and carried out by construction.

An event which had potentially serious consequences occurred late in the year. On investigating why one of the fuelling machine's "jaw closed position" switches would not actuate properly, the jaws were found to be distorted and cracks were detected showing that the jaws had been significantly overstressed. An investigation of the incident revealed that the jaws on two fuelling machines had been cracked due to over torquing when driven manually from the fuelling machine console rather than automatically by the fuelling machine computer as is normal. The over torquing had occurred as a result of a malfunctioning inverter monitor which should have been recalibrated six months prior to the event.

3.4.3 Quality Assurance

There were no AECB Quality Assurance (QA) audits carried out during 1987. However, an AECB assessment of the station QA manual was carried out and a report submitted to Ontario Hydro station management. AECB staff found the QA manual to be lacking in authority and deficient in meeting the requirements of the CSA standard N286.5 (Operations Quality Assurance Program Requirements) in a number of areas. Revisions to the manual are underway and its reissue is targeted in June, 1988.

Two reports were made to AECB staff during 1987 on the status of work to address the findings of the Fall 1986 AECB Assessment of Operating Practices. The second report delivered in November clearly indicated that, although plans were made, very little implementation of these plans had occurred. This remained the situation through the first three months of 1988. AECB staff is of the view that many of the operating and maintenance problems identified elsewhere in this report are a reflection of an ineffective quality assurance program.

A peer group audit, carried out by Ontario Hydro, was conducted at Bruce NGS"A" in the latter part of 1987. The auditors reported their findings to the station management and made numerous recommendations. A program has been established by the station for addressing the audit findings and a commitment made by the management to complete the program by the end of 1988. AECB staff considers the decision to conduct the audit, and the commitment to satisfy the concerns identified at an early date, to be commendable management initiatives by Ontario Hydro.

3.4.4 Station Maintenance

This subject is addressed in Section 3.3.5 of this report. Although there was a significant reduction of the backlog of maintenance call-ups achieved during 1987, there was little evidence of the Technical Units' involvement in reviewing this backlog and recommending priorities commensurate with safety concerns. Also, there was a very significant increase in the number of outstanding Deficiency Reports.

Approximately 13% of the 115 reported significant events were caused by, or contributed to by, maintenance errors. It is the opinion of AECB staff that this number would be substantially lower with adequate field supervision and verification of maintenance work. One event was caused by the electrical connector to one of the shutdown system's in-core flux detector assemblies being left disconnected following maintenance work on the reactivity mechanisms deck during a unit shutdown. Such errors can have serious consequences.

3.4.5 Reactor Control

The number of reactor trips in 1987 showed an increase from the previous year as did the number of significant events contributed to by human error, as assessed by AECB staff. Additionally, the number of events reportable under licence conditions showed a significant increase. A contributing factor to the increased number of human errors may have been the larger than normal number of major unit outages (7) that took place during the year and the increased workload for both operations and maintenance staff. The increased number of reactor trips may also be, to some extent, attributable to the unit outages as the majority of them occurred during unit start-up, at low power or shortly after returning to high power.

AECB staff accept Ontario Hydro's assessment that none of the significant events in 1987 constituted a "serious process failure" (i.e., an event for which significant fuel failures would have occurred in the absence of shutdown system action). However, it is evident that the demands made on the safety systems remain high and this indicates that either the operator or the regulating system are having difficulty keeping the plant inside its normal operating envelope. The increasing number and complexity of operating memos are believed to be a contributing factor as is the complexity of the units themselves.

During 1987 several design changes were implemented on one or more of the reactor units involving process and safety system control and trip parameters. One of the modifications made late in the year was to add a heat transport pump trip function. These changes have added to the design complexity of the units and to the responsibilities placed on the unit operators. AECB staff believes that the rising level of complexity of the plant design and of the concomitant operating requirements, make the safety of the plant very susceptible to operator performance. For this reason, AECB staff restates its opinion that a careful review of Bruce NGS"A" plant design and operating procedures is warranted, to ensure that Ontario Hydro's safety objectives are and will continue to be met.

3.4.6 Chemistry Control

An increase in the amount of time that the primary heat transport system has been operated outside chemistry specification limits has again been reported. Dissolved deuterium and pH were the parameters of most concern. The station chemistry section attributed this poor performance, in part, to the heavy unit outage program and unavailability of the hydrogen addition system on unit 4 for a 2-week period.

AECB staff is concerned that this performance is not consistent with the requirements of paragraph 02.4 of the Operating Policies and Principles. AECB staff also question the potential impact, of out-of-specification limits operation of the system, on pressure tube integrity. Performance of the station in the control of heat transport chemistry will be monitored more closely by AECB staff in future.

It is understood that Ontario Hydro has established a Nuclear Generation Division task force to investigate and resolve chemistry control problems.

3.4.7 Special Safety System Performance

3.4.7.1 Shutdown System One (SDS1)

At no time during 1987 was SDS1 unavailable on any unit while not in the guaranteed shutdown state. However, AECB staff was concerned to note a sharp increase in the frequency of shut-off rods failing to drop during testing. Out of a total of 18 such incidents over the past five years, 14 occurred in 1987. Ontario Hydro can offer no explanation for this but is in the process of investigating. It is to be noted that on no occasion did more than one rod fail to drop during an actual system trip (at least three out of the 30 rods must fail in order to impair the system).

3.4.7.2 Shutdown System Two (SDS2)

The two events referred to in section 3.4.3.2 of this report were the only occasions during which SDS2 was reported as unavailable during 1987. The unavailability target of 1×10^{-3} y/y for the year was comfortably met. A modification to prevent the possibility of "waterhammer" when the system is operated, was installed in unit two and will be added to the remaining units during their next planned outages in 1988/1989.

3.4.7.3 Containment

Due to the finding of the "stuck open check valve" during the dousing test in May '87 reported in section 3.4.3.3, the system was conservatively declared unavailable by Ontario Hydro for the four preceding months of the year. The unavailability target of 1×10^{-3} y/y was thus not met by a significant margin. In addition, in-service containment leak tests conducted immediately after the station outage for containment testing at positive pressure, indicated total containment leakage just in excess of the 2% mass/hr design limit. Ontario Hydro contends that a leak of 3% mass/hour would not exceed the single failure dose limit set by the AECB and that a "single equivalent hole" in containment may be credited for any margin that exists between the current measured leak rate and the single failure dose limit. AECB staff has stated its disagreement with this concept. Vault vapor recovery system leaks were known to be the major contributor to this leakage and improved maintenance following this test resulted in significantly lower leakage results in subsequent on-power tests conducted towards the end of the year.

Ontario Hydro is planning to fit motorized dampers on all four reactor unit vapor recovery systems by early in 1989. These will allow complete isolation of the recovery system from containment in the event of a loss-of-coolant accident. As a result, leakage from the vault vapour recovery system will no longer constitute a leak from containment.

Another containment concern that emerged during 1987 was the possibility of "J" tube flooding. J tubes provide the pathway from containment into the vacuum building and during operation of the dousing system some of the tubes may be flooded, thus restricting the flow path. Ontario Hydro has undertaken to resolve this issue expeditiously. Ontario Hydro has recently committed to carry-out a repeat positive pressure containment leak test and to install J tube covers in 1989.

3.4.7.4 Emergency Cooling Injection System

The High Pressure Emergency Injection System (HPECI) was declared in-service on Unit 1 in March 1987 and is now in-service on all units. Ontario Hydro has reported the system to be 100% available during 1987. The event involving isolation of the wrong valve for testing described in section 3.4.3.4 may have impaired the system for a short period of time. Ontario Hydro has yet to answer AECB staff questions on this matter.

Problems with the actuators on the main system isolating valves occurred from time to time during the year. These were related to a design weakness which was recognized several years ago and AECB staff is satisfied that Ontario Hydro is taking appropriace action.

3.4.8 Objective Measures

Using data from the station Quarterly Technical Reports, other Ontario Hydro reports, station records, and also AECB data on significant events, AECB staff has prepared a set of Objective Measures of the station's performance which is attached to this report as Appendix 1. The purpose of this information is to attempt to present a quantitative assessment of the station performance and a basis of comparison with performance in the previous year.

3.5 Fire Incidents

Seven fires were reported during 1987, three more than in the previous year. Although none of these fires was serious, some were caused by inattention to basic safety rules. Improved housekeeping should help to reduce this number.

3.6 Station Management and Administration

With due consideration for the appreciable difficulties caused by a high station work load and apparent understaffing, AECB staff is generally satisfied that the station is being adequately managed.

During 1987 it was apparent to AECB staff that Ontario Hydro had recognized significant problems at Bruce NGS"A". A new station manager, appointed in September, introduced a determined attempt to resolve these problems.

AECB staff views the decision of Ontario Hydro management to conduct the peer audit, and their commitment to resolve the problems identified expeditiously, as commendable initiatives. Also considered commendable is the newly appointed Station Manager's initiative to have installed an intertie steam line between the units to permit the turbine generator of a shutdown reactor unit to be run at low power ($\leq$ 50 MW) using steam supplied from an adjacent unit. This modification was completed for the unit 3/4 intertie before the end of 1987 and will be installed for units 1/2 in 1988. In addition to allowing more power to be exported from the Bruce site, it will permit longer unit outages to perform outstanding maintenance work.

Areas in which AECB staff consider improvements desirable are the timely review of operating memos and significant event follow-up reports and the demonstration to station staff of management's commitment to high standards of excellence in quality and safety of work. There is evidence that the station organization is taking steps to effect improvements in these areas.

AECB staff has once again received good cooperation from, and maintained open communications with, station management, technical, operations, and administrative staff.

3.7 Training and Emergency Drills

The pass rate of the station's first operator and shift supervisor candidates in AECB examinations during 1987 showed a drop compared with the previous year (76% pass rate compared with 83%) and fell appreciably during the latter part of 1987 placing this station well below the average when compared with the pass rates of other Canadian CANDU stations. Although this performance is not of immediate concern to AECB staff, it is believed to indicate some difficulties in the station's training program and in the quality of operating procedures. AECB staff is not able to comment on the training of station operations and maintenance staff in general due to lack of objective measures. The large number of significant events contributed to by human error may be of some significance in this regard.

Emergency drill performance was reported as 73% drills completed in 1987 compared with 90% in 1986. This is considered less than satisfactory. The station safety group intends to improve on this performance by monitoring more closely and occasionally auditing shift crew safety drills in future.

3.8 Security

There were no security incidents during 1987. Plant security is considered to be satisfactory by AECB staff.

4. SUMMARY OF AECB STAFF COMMENTS ON STATION PERFORMANCE IN 1987

After careful review of the operation of Bruce NGS"A" during 1987, AECB staff has assessed station performance as only marginally satisfactory in overall terms. There was, however, evidence of improvement towards the end of the year.

Notably, positive factors of the station performance include high radiation hazard work control, the change to 2 rem average annual limit administrative control, the peer audit and commitment to resolve identified problems and continued good co-operation and communication with AECB staff.

Aspects of station performance in 1987 which AECB staff considers to be of significant concern and which it is considered require prompt action from Ontario Hydro to improve or resolve are the following:

- operating and maintenance practices
- heat transport system operation under conditions of void
- station quality assurance program
- technical monitoring of station system performance
- negative pressure containment system integrity

In section 4.7 of the Annual Report of Station Operation for 1986, AECB staff commented on the increasing complexity of the plant and in section 5.0 expressed the opinion that a careful design and operations review was warranted. It is not evident to AECB staff that such a review has been undertaken although significant work has been done on the Abnormal Incidents Manual to take account of recent changes. During the reported year, a number of design changes were made to some or all of the units including modifications to shutdown system reactor trip coverage, the addition of an automatic heat transport system pump trip, and the identification of additional constraints during cooldown and heat-up to avoid increasing the risk of pressure tube failure by fast fracture. AECB staff believes that these changes have added significantly to the complexity of the plant and to its vulnerability to operator error and once again recommends that Ontario Hydro conduct an overall review of reactor design and operation.

APPENDIX I

OBJECTIVE MEASURES OF STATION PERFORMANCE
1987

1. Radiation Control

1.1 Occupational Safety	LAST YEAR'S VALUE	GOOD	ACCEPTABLE	NEEDS ACTION
1.1.1 Total Whole Body Dose 547 man-rem	546 rem	☐	XX	☐
1.1.2 Total Extremity Dose 759 rem	1341	☐	XX	☐
1.1.3 Total F/H Extremity Dose 212 rem	470	X	☐	☐
1.1.4 Total Neutron Dose .065 rem	.060	X	☐	☐
1.1.5 Number of Exposures > Regulatory Limits 0	0	X	☐	☐
1.1.6 Number of Radiation related supervisor's investigations 47*	50*	☐	☐	X

1.2 Public Safety

1.2.1 Releases from the Station

a) Airborne

		LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
Tritium	No of weeks >1% DEL 5	2	X	☐
	Average % DEL for year .56 %	.47	X	☐
Noble Gas	No of weeks >1% DEL 1	2	X	☐
	Average % DEL for year .61 %	.68	X	☐
Iodine 131	No of weeks >1% DEL 0	0	X	☐
	Average % DEL for year .002 %	.32	X	☐
Particulates	No of weeks >1% DEL 0	0	X	☐
	Average % DEL for year .01 %	.49	X	☐

* These figures, which are at variace with those of the Quarterly Technical Report, are correct, cancelled meetings having been discounted.

1.2.1 Continued

	LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
b) Waterborne			
Tritium — No of months >1% DEL 0	0	[X]	[ ]
Tritium — Average % DEL for year .24 %	.26	[X]	[ ]
Gross β — No of months >1% DEL 0	1	[X]	[ ]
Gross β — Average % DEL for year .16 %	.42	[X]	[ ]
c) Total Heavy Water Loss 18 284 kg (if excessive, should be reflected in higher tritium releases)	20 2	[X]	[ ]

1.2.2 Environmental Measurements

	LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
Average Boundary dose rate 5.4 μR/hr (Acceptable if within range of provincial reference sites value and not a significant increase from previous years)	4.4 μ R/hr	[X]	[ ]
Average Boundary Tritium in Air .048 %MPCa (> .1% MPCa would indicate a marked increase and would require investigation)	.049	[X]	[ ]
Average Tritium Concentration in Precipitation 8.4 nCi/L (average of all measurement sites) (+)	30.2	[X]	[ ]
Average Gross β in Precipitation (+) 0.75 mCi.km^{-2}.months^{-1}	.53	[X]	[ ]
Average Tritium in Milk (+) 733 pCi/L	712	[X]	[ ]

1.2.2 Continued

	LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
Average C14 in Milk (+) 6.3 pCi/g of C	6.8	[X]	[ ]
Average I131 in Milk (+) 3.8 pCi/ l	5.3	[X]	[ ]
Average Tritium in drinking water (+) 836 pCi/L	775	[X]	[ ]
Average gross ß in drinking water (+) 1.7 pCi/L	2.1	[X]	[ ]
Local water and fish samples (++)		[ ]	[ ]

Specific items for comment:

____

____

____

	ACCEPTABLE	NEEDS ACTION
Terrestrial Samples (++)	[ ]	[ ]

Specific items for comment:

____

____

____

Notes: (+) - marked increase from previous acceptable levels warrants investigation

(++) - review in detail and identify any specific problems

2. Plant Control

	This Year	Last Year's Value	Good	Acceptable	Needs Action
2.1 Number of Genuine Reactor Trips/Unit	2.25*	1.75 (1.50 SDS1, .25 SDS2)	☐	☒	☐
2.2 Number of Serious Process Failures/Unit	0	0	☒	☐	☐

2.3 Special Safety System Unavailability (10^{-3} Years/Year)

	This Year U0	This Year U1	This Year U2	This Year U3	This Year U4	Last Year U0	Last Year U1	Last Year U2	Last Year U3	Last Year U4	Good	Acceptable	Needs Action
SDS1		0	0	0	0		0	1.07	0	0	☒	☐	☐
SDS2		.052	0	0	0		0	2.79	0	0	☐	☒	☐
Containment		385.6	385.6	385.6	385.6		402.8	0	0	0	☐	☐	☒
ECI		0	0	0	0		0	0	0	0	☒	☐	☐

	This Year	Last Year's Value	Good	Acceptable	Needs Action
2.4 Number of Reportable Incidents/Unit	10	5	☐	☒	☐
2.5 Number of fires	7	4	☐	☒	☐
2.6 Number of Significant Human errors reported (via Significant Event Reports)	72 (63)**	42	☐	☐	☒
2.7 Plant Capacity Factor	65 %	75%	☐	☒	☐
2.8 % AECB compliance inspections "unsatisfactory" #	#		☐	☐	☐

* This figure is at variance with OH Quarterly Technical Report and is based on AECB SER data files. All completed trips where unit was not in guaranteed shutdown state are counted.

** 72 human errors were reported in 63 significant event reports.

None were carried out.

			LAST YEAR'S VALUE	GOOD	ACCEPTABLE	NEEDS ACTION
3.	**Plant Maintenance**					
3.1	Number of Unplanned Outages/Unit	5.5	7.25	☐	☒	☐
3.2	Number of Call-ups (Operational) Outstanding at end year	518	737	☐	☐	☒
3.3	Average of Monthly DRs Outstanding/Unit	935	283 *	☐	☐	☒
4.	**Plant Administration**					
4.1	**Documentation**					
4.1.1	Average No. of Op Memos in force/unit on 31 December	47	31	☐	☐	☒
4.1.2	No. Op. Memos extant > 6 months	69		☐	☐	☒
4.1.3	No. of systems (USI) with >1 Op. Memo Extant	32	5	☐	☐	☒
4.1.4	No of Operating Memos behind schedule for review	73	Approx. 35	☐	☐	☒
4.2	**Training**					
4.2.1	% Scheduled emergency drills completed	73	90	☐	☐	☒
4.2.2	% Candidates passing AECB exams	76	83	☐	☒	☐

* This represents last year's figure multiplied by 5/4. The figure is based on an estimate; this year's figure comes from the computer tally and is therefore more accurate.

4.3 Security

		LAST YEAR'S VALUE	GOOD	ACCEPTABLE	NEEDS ACTION
4.3.1 Number of reportable security events	0	0	[X]	[ ]	[ ]

4.4 Quality Assurance

	GOOD	ACCEPTABLE	NEEDS ACTION
4.4.1 Results of AECB Audits			
1) Date None conducted in 1987.	[ ]	[ ]	[ ]
2) Date ______	[ ]	[ ]	[ ]
3) Date ______	[ ]	[ ]	[ ]
4.4.2 AECB Assessment of Station Quality Assurance Manual	[ ]	[ ]	[X]

APPENDIX II

Reportable SERs

87-001	Possible Extremity Dose
87-004	HPECI Impairment (Pump Suction)
87-006	Shipment Without Transfer Permit (Breach of Ontario Hydro Health Physics Regulations)
87-008	Boiler Delta T Limit Exceeded
87-018	Contamination of a Contract Worker
87-020	Unexpected Tritium Uptake - Unmarked Pump
87-024	Moderator Cover Gas Compressor Leak
87-028	Unit Alert - VVRS Drier Leak on Test
87-033	Injury to Construction Technician
87-036	Breach of Containment System During Douse Test
87-038	Moderator Spill of Tritiated D_2O
87-044	Fretting of Heat Transport Feedline U1
87-045	Fretting of Heat Transport Feedline U4
87-046	Incorrect Booster Trip Setpoints
87-048	Impairment of SDS2 (Low Helium Pressure)
87-049	High Gamma Field Unit Alert (Air in Annulus Gas System)
87-053	Impairment of SDS2 (Low Helium Pressure)
87-054	SDS1 Trip Due to Low Moderator Level
87-056	Missing Holding Down Bolts for NAC Flask (Violation of transport packing regulations)
87-057	Dual Failure of Mercury-Wetted Relays Causes Impairment of SDS2
87-058	Poison Out Due to Inverter Failure

87-063	Unit Alert - Moderator Liquid Poison Spill
87-067	Deaerator Leak - Reactor Shutdown
87-073	Unit Alert - Moderator Spill
87-074	Insufficient Standby Generators Available (OP&P Violation)
87-077	D_2O Spill - HT
87-083	Unit Alert - Moderator Spill
87-093	Moderator Cover Gas Pressure Too Low (Violation of OP&P)
87-094	Incomplete Guaranteed Shutdown State Condition Guarantee
87-100	Failure to Comply with OP&P During Testing of SDS1 While Shutdown in Guaranteed Shutdown State
87-101	Ontario Building Code Violation (Fire Barrier)
87-102	OP&P Violation - Failure to Have Available Sufficient Standby Generators
87-108	Unit Alert - D_2O Spill
87-112	PHT Pump Stepback Impaired
87-114	Fuelling Machine Cracked "Jaws"