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Report Rapport

Atomic Energy Control Board

Commission de contrôle de l'énergie atomique

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AECB STAFF REVIEW OF BRUCE NGS 'A' OPERATION FOR THE YEAR 1989

June 1990

Canada

Report

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1. INTRODUCTION

AECB staff resident at Bruce NGS"A" ensures that the station operation is monitored and licensing requirements are enforced. This process requires that the project staff, in co-operation with AECB staff in Ottawa, monitors reactor operations, conducts audits and inspections, witnesses important activities, and reviews station documents and reports from the licensee.

A formal Annual Review Meeting is held with the station management and senior staff in order to discuss safety-related issues and to present to Ontario Hydro an assessment of station operation during the year. This meeting is convened following the preparation, in draft form, of an AECB Staff Review of Station Operation. The report is compiled using, amongst other information, Ontario Hydro Quarterly Reports. These are a requirement of the licence and summarize key features of station operation during the year.

This report presents AECB project staff review of major licensing issues and of the operational performance of the station during 1989. In addition to the reports mentioned above, other Ontario Hydro reports, official correspondence, and observations of AECB site staff have been taken into consideration. The report is limited to those aspects of station performance that AECB staff considers to have some safety significance. Where developments of significance, associated with issues addressed in the report, occurred in the early part of 1990 these are also mentioned.

2. STATION OPERATION

2.1 Station Performance

The station net capacity factor for 1989 was 53.55%. This compares with a "since in-service" average capacity factor of 77.12% and last year's 58.68%. Again, as last year, the below average value is attributable to lengthy unit outages. The boiler level oscillations* which affected Unit 2 in 1988 resulted in a unit shutdown from May onwards and, as the year progressed, this phenomenon increasingly affected Unit 1, maximum power from this unit being limited to 78% at year's end.

The following major unit outages occurred during the year:

All Units, 89-05-12 to 89-05-31, 19 days

Station outage for containment and vacuum building testing and modifications.

Unit 2, 89-03-30 to 89-12-31, 287 days

Outage to inspect and clean boilers, perform maintenance work on pressure tubes and moderator heat exchanger work (unit remained shutdown at end of year).

Unit 3, 89-01-01 to 89-02-05, 36 days

Continuation and completion of pressure tube end bearing repositioning outage that commenced in 1989.

* Boiler level oscillations are discussed in detail in Section 2.2

Unit 3, 89-05-31 to 89-06-27, 27 days

Unit remained shutdown following the station outage due to an indicated, but unconfirmed, leak on a moderator heat exchanger.

Unit 3, 89-08-25 to 89-10-04, 40 days

Planned outage to replace pressure tube.

Unit 4, 89-05-31 to 89-06-15, 15 days

Unit remained shutdown following station outage to repair electrical generator seals.

Unit 4, 89-08-14 to 89-08-24, 10 days

Forced Outage to repair leaks in boiler feed and pressurizer systems.

In addition to these outages, Bruce NGS"A" overall performance was still affected by transmission line limitations. These restrictions, over the course of the year, equated to a single unit shutdown of 23 days. The limitations will remain until the 500 kV transmission line, currently under construction, is brought into service (currently scheduled for December 1990).

2.2 Unit Operation at High Power

Throughout the year all units were licensed to operate at full power. However, as a result of imposed power limits and transmission line restrictions, as in 1988, very little operation took place at above 95% full power on any unit. Full power operation is limited due to a deficiency in back-up trip coverage (see Section 4.5) and an adjustment in the Simulation Of Reactor Operation (SORO) code. This code is used to ensure that fuel is operated within limits specified in the operating licence. No allowance had been made previously to take account of any impreciseness in the modelling. A tolerance band of approximately 5% has now been added to the code with the result that channel power limits have been reduced, limiting unit output to about 95% full power.

Boiler Level Oscillations

This problem, caused by blockage of the upper boiler tube support plates, was first identified in 1988 and is described in the Annual Report for that year. A major effort was made by Ontario Hydro in 1989 to remove the blockages from Unit 2 boilers. Mechanical methods, water lancing and "water slap" (impact) were successful on all except two of Unit 2 boilers. Despite a three fold increase in lancing pressure, it was not possible to remove all the scale from the two offending boilers. A proprietary chemical additive was added to the lancing water and a significant improvement was noted. However, considerable blockage of the tube support plates remains and total clearing is unlikely using the methods described above.

Unit 1 boilers will be cleaned later this year using the "water lance" technique developed for Unit 2. However, Ontario Hydro considers that completely satisfactory cleaning will only be achieved by using chemical methods to remove scale. This major operation is planned for the pressure tube replacement outages on Unit 1 in 1993 and Unit 2 in 1997. AECB staff will continue to monitor this cleaning program which is being run in parallel with efforts to improve the quality of the feedwater by an upgrading of the water treatment plant and the replacement of copper components in the feed system. The presence of copper is a large contributor to the extremely tenacious nature of the scale.

3. AECB STAFF REVIEW OF OPERATIONAL SAFETY ASPECTS

3.1 Station Compliance

The operation of the station must comply with various regulations, the principal of these for nuclear stations being the Atomic Energy Control Regulations. The Atomic Energy Control Regulations state that the operation of the station must be in accordance with the Operating Licence, to which the AECB can attach such conditions as deemed necessary. The first condition of the licence states that the operation of the facility shall be governed by, and be in accordance with, the document entitled "Operating Policies and Principles" (OP&P). Finally, the OP&P refer to various operating and maintenance procedures that are carried out in the operation of the station. In practice, AECB staff usually refers to station compliance as measured against a licence condition or a section of the OP&P.

3.1.1 Compliance with Regulations

There was one infraction in 1989 of section 23 of the Atomic Energy Control Regulations. In July it was discovered, at Pickering NGS"A", that ice plugging equipment belonging to a private contractor, under contract to Ontario Hydro, was contaminated with radioactive material. Subsequent investigation showed that this contamination originated at Bruce NGS"A" and that the equipment had been erroneously released. Other items of equipment used at Bruce NGS"A" were discovered, still contaminated, at the company's premises in Sarnia.

This breach of regulations by Ontario Hydro also placed the contracting company in violation of the regulations under both section 23, as above, and section

AECB staff considers this incident to require positive and timely action from Ontario Hydro to prevent a recurrence. This instance was the third such incorrect release of radioactive or potentially radioactive material from Bruce NGS"A" since 1982. Documentation and monitoring procedures are currently under review by Ontario Hydro but at this time no definite proposals have been forthcoming. AECB has expressed its dissatisfaction with this situation and is expecting proposals to be presented in the near future.

3.1.2 Compliance with the Licence

Ontario Hydro has generally complied with the conditions of its reactor operating licence (ROL 8/88 until 11 November 1989 and subsequently ROL 7/89). Some of the exceptions are discussed below:

3.1.2.1 Compliance with Operating Policies and Principles (Condition A.A.1)

Ten events were reported which represented breaches of the station Operating Policies and Principles. These events are discussed further in Section 3.7.

3.1.2.2 Compliance with Ontario Hydro's Radiation Procedure Regulations (Condition A.A.1)

A shipment of prescribed substances incident has already been discussed in Section 3.1.1. AECB staff review of other radiation control related significant events has concluded that none of them represented a breach of this condition. There were no incidents of personnel receiving doses in excess of regulatory limits during the year.

3.1.2.3 Maintenance (Condition A.A.11)

As discussed elsewhere in this report and in the two previous annual reports, AECB staff was not satisfied that maintenance standards for Bruce NGS"A" met the requirements of the licence condition:

"A.A.11 Maintenance at the nuclear facility shall be of such a standard that, in the opinion of the Board, the reliability and effectiveness of all equipment and systems as claimed in the Safety Report and documents listed in the application are assured."

Ontario Hydro is continuing its efforts to provide the necessary resources to rectify this situation. This topic is discussed further in Sections 3.9 and 4.1.

3.1.2.4 Testing (Condition A.A.13)

Bruce NGS"A" continued its good record of completing safety system tests on time in 1989. The only area where testing failed to meet targets was in respect to auxiliary pressure relief valves (APRV) (part of the negative pressure containment system) where one test was unable to be completed for a ten-week period due to the failure of an associated isolating valve. AECB staff was kept fully informed of this situation while it existed.

3.1.3 AECB Staff Comment on Compliance with Bruce NGS"A" Reactor Operating Licence During 1989

AECB staff considers that station management, once again, made a determined effort to comply with the requirements of the licence during 1989. All of the identified cases where licence conditions were breached were accidental and appropriate steps were taken promptly to prevent reoccurrence.

Improvements observed in 1988, in timeliness of technical report submissions and prompt completion of reports, tests, inspections, modification and analyses required by the AECB (Condition A.A.12) were, in general, maintained in 1989. This was in spite of the continuing constraints in resources. This situation is showing signs of improvement as new staff is progressing through the training phase. AECB staff is being kept informed of resource progress. However, AECB staff is not satisfied with the continuing delays in submission of safety report updates.

AECB staff believes that the following areas of compliance require the particular attention of station management and will look for evidence of improvement during 1990:

1) control of radioactive material shipments off site.

2) compliance with the requirements of the station Operating Policies and Principles. There were ten reported breaches of OP&P requirements in 1989. Most of these could have been avoided had the station personnel involved been better acquainted with OP&P requirements or had appropriate operating/maintenance procedures and practices been of a satisfactory standard.

3.2 Quarterly Reports

The four Quarterly Reports were produced in a timely manner and were reviewed by AECB project staff. These reports contained detailed information on performance of station reactor units, safety systems and safety related activities, such as chemical and radiation control, and the handling of prescribed substances. Also included are data relating to safety reliability assessments, faults, and predictions for future unavailability of safety systems. In its review, AECB staff found the reports to be clear in content and, as far as could be ascertained, accurate records of station performance and events.

AECB has recently been in discussion with Ontario Hydro regarding modifications to the format of these reports in an effort to remove certain extraneous information and to present more data in a graphic rather than tabular format.

3.3 Radiation Protection

No member of station staff received a radiation exposure in excess of the legal limits during 1989. Accumulated doses for station staff were lower than in 1988. This is a creditable achievement in view of the high level of maintenance work, with the increased potential for exposure, that was ongoing during the year. The total neutron dose, which increased during 1988, was substantially reduced in 1989 to 0.14 Sv from a figure of 1.15 Sv in the previous year.

However, there were several instances during the year when careless activities could have resulted in large doses of radiation to personnel. An example of this was highlighted by SER 89-84 when a bucket of highly active moderator heavy water was found "abandoned" in a construction storage area. Fortunately, the construction personnel acted correctly in reporting the matter to Operations who took immediate and effective action.

Again in 1989, forty-three (the same number as in 1988) supervisor investigations into radiation incidents were carried out. This number indicates that radiation control procedures are still not being fully adhered to and this remains a concern. The ongoing, extensive, maintenance programs planned for the foreseeable future involving staff from other areas of Ontario Hydro and outside contractors will require continued, and probably increased, vigilance and control in this area.

It was also encouraging to see that procedures have been put in place to cover the detection and handling of "hot particles". It is hoped that these will avoid such incidents as that which occurred in 1988 (refer to this section in last year's report). AECB staff has also noted a marked improvement in the maintenance of radiation survey boards posted around the plant.

The involvement of Health Physics staff in presentations of information to staff, particularly in the area of new tritium dose limits and "hot particle" procedures, is to be commended.

3.4 Station Effluents and Environmental Monitoring

The station gaseous and waterborne emissions and environmental monitoring measurements are shown in Appendix II, Objective Measures. There were no emissions from the station during 1989 which approached the Derived Emission Limits (DEL). The 1% DEL weekly target was exceeded on eight occasions, once for a period of five consecutive weeks when the integrated figure was 1.36% of DEL. The problem on this occasion was the continuous purging of driers due to an instrument air failure. This problem was complicated by several other drier related problems which masked the root cause of the problem. However, it is of concern to AECB staff that the situation persisted for as long as it did.

The commitments made by the licensee to install improved gaseous effluent monitors and a new liquid effluent monitor have not been completed. AECB staff finds this unsatisfactory since, with regard to the liquid effluent monitoring, no effective on-line monitoring method is in-service. For the gaseous effluents, the current in-service equipment does not provide the degree of resolution desirable. The installation of the heavy water in light water monitoring system, also committed by the licensee, is not yet complete on two units. AECB staff has asked for a firm commitment from Ontario Hydro that these issues are more rigorously addressed and that a firm in-service date, in the near future, is set and adhered to.

The proposed changes in Derived Emission Limits (DELs), as reported in 1989, have been approved on a temporary basis. Final approval is subject to the receipt of more viable data for the concentration, in particular, of Cesium 137 in locally caught fish.

3.5.1 Reactor Process, Control and Fuel Handling Systems

Nineteen (19) of the fifty-eight (58) events reported in 1989 pursuant to the operating licence involved reactor process systems. Again, as in 1988, the high level of maintenance activity on moderator and heat transport systems and the reactor fuel channels was a major contributor.

In February an event occurred which clearly demonstrated the need for proper identification of components requiring environmental protection. Due to failure, by wetting, of a fuelling machine heavy water level detection instrument, two irradiated fuel bundles recently removed from a reactor were left dry, and therefore uncooled, for more than an hour. This could have resulted in failure of the fuel due to overheating and subsequent release of radioactive materials inside containment. AECB staff considers that Ontario Hydro has taken appropriate steps to avoid reoccurrence.

A serious malfunction of one of the Unit 2 control computers occurred in September. Fortunately the unit was in the guaranteed shutdown state at the time. The protected memory of the computer was suddenly altered by what has been termed a "core blast" resulting in reactor power limit setpoints being changed from very low values (< 1%) to very high values (>60%). This hardware failure has been attributed to excessively high computer room ambient temperatures. It is entirely possible that an incident of this type when the reactor is at power, could lead to a loss of regulation, which would require a reactor trip. Ontario Hydro has taken steps to enhance the reliability of the computer room air conditioning system and to minimize the effects of temperature changes on the unit control computers.

An event occurred in October as a result of poor procedural control of computer software changes. A temporary change had been made to maintain normal function of the reactor regulating system while some wiring changes were being made during a unit shutdown. This temporary change was not removed, and later, when the unit was operating at 29% Full Power, replacement of a failed fuse in a control circuit power supply lead to a spatial control upset. Although the event itself was not of great safety significance, since the reactor control system is designed to cope with such upsets, the inadequacy of software change control procedures that this event revealed is important. Ontario Hydro has since taken appropriate steps to correct the shortcomings that were identified as the cause of this particular event. However, AECB is not satisfied that software change control in the broader generic sense is adequate.

In October, due to a misinterpretation of information on a drawing by a mechanical maintainer, some bolts securing the bonnets on two check valves in the heat transport system of Unit 1 were grossly over torqued. The error was discovered later when unit heat-up was underway for return to power. The shift supervisor decided to continue the unit start-up despite the risk that the bolts might fail. Subsequent inspection of the bolts and analysis indicated that no damage or overstressing had occurred. AECB staff ascertained that appropriate follow-up action had been taken.

There was one heat transport pump seal failure during 1989. This occurred on start-up of Unit 3 after a long outage and may have been attributable to damage sustained by the seal assembly during installation of heavy steelwork for pump vibration restraint.

3.5.2 Secondary Systems

As in 1988, there were a number of significant events resulting in steam drum/heat transport temperature excursions which exceeded the limits imposed by the Steam Drum Operating Diagram (SOD) control program. In most cases these excursions were a secondary result of another event or connected with unit cooldowns and start-ups. As in 1988, ten such instances were reported. Each event was subjected to analysis to determine whether code allowable stress levels had been exceeded. In all cases, it was shown that stresses were within limits.

It is the opinion of the AECB staff that, due to the combination of boiler design and system interaction, that this type of event will continue to be an operational problem. Operators must therefore be continually aware of the potential consequences of this type of event or an event which will cause such a secondary effect.

3.6 Special Safety Systems

3.6.1 Shutdown Systems (SDS)

SDS1 was available, on all units not in a guaranteed shutdown state, at all times through the year. This record was duplicated by SDS2 although there was a technical impairment in Unit 4 due to flooding of the helium balance header. However, the unit was in a guaranteed shutdown state at the time and the flooding was as a result of work in progress. The duration of the impairment was only six minutes.

Ten of the fifty-eight (58) significant events reported pursuant to the operating licence in 1989 were attributable to the shutdown systems. This is an increase from 1988 when the total number was seven.

There was a total of five completed SDS1 trips during the year but none of these were due to process system failures. All were attributable to testing and minor component failure. There were also two completed trips on high rate of increase of power on Unit 2 whilst in the guaranteed shutdown state. These trips are not considered "safety" significant and the cause is likely the same as reported in last year's report - electrical "noise" created by maintenance activities.

SDS2 had a single completed trip during the year on Unit 4 due to accidentally pressed manual trip pushbuttons by the authorized first operator who was pointing out panel features to operational staff. This event was reported in SER 89-118.

A program for replacement of the mercury-wetted relays, which open to allow the fall of the SDS1 shutoff rods, has been put in place by Ontario Hydro. Poor performance of these relays is a generic problem throughout the nuclear industry. After extended periods in the closed condition, the relay contacts may fail to open on demand. A new "tin doped" version of these relays is being installed as a replacement and to-date there have been no failures of these relays.

An additional recorded impairment on SDS2 was classified, by Ontario Hydro, as a "special case" level 3 impairment. This was found to exist on all four units going back to the time of original unit start-ups. During a recalibration of flux detectors to reduce neutron overpower trip setpoints from 118.5% to 118% FP it was discovered that the calibration procedure introduced an error of 0.6% in the unsafe direction due to a misrepresentation of actual trip parameters at the test position. The deficient procedure was immediately corrected and all units were recalibrated.

This event raises some doubt about the adequacy of maintenance procedures review and approval process. AECB staff is pursuing this matter with Ontario Hydro.

3.6.2 Emergency Coolant Injection (ECI)

The reported unavailability of this system for 1989 was 331.6×10^{-3} yr/yr (121 days). This figure grossly exceeds the design target level of 1×10^{-3} yr/yr (8 hrs/yr) and was due to a level 2 impairment which existed for 102.8 days when both accumulator gas isolation valves (MV303/304) were slow to open. In late June a further impairment of these valves contributed another 18.3 days of level 2 impairment. These two impairments were reported in SER 89-66 and 89-101. These impairments were largely due to the failure of the valve stem bearing material. The valves have since been rebuilt using a new bearing material less susceptible to "galling".

An analysis has been prepared by Ontario Hydro which suggests that the allowable opening time for the gas isolation valves can be increased by a factor of two (to 40 seconds) without affecting ECI effectiveness. This has not yet been accepted by the AECB. If accepted, this impairment will be downgraded from a level 2 and unavailability for ECI would, retroactively, be reduced to zero.

A further level 2 impairment occurred on Unit 4 when all moderator level transmitters, which provide a conditioning parameter for ECI, were found to be reading low due to a common fault which simultaneously affected all three channels. This event was recorded by SER 89-127, and is now the subject of an AECB Action Item since this system provides level measurement for both ECI, a safety system, and moderator level control, a process system. This is contrary to the principle of separation of safety and process systems.

The problem with oversized drive motors on the injection valves reported in last year's report is being addressed by Ontario Hydro. It is anticipated that the conversion, which should improve ECI availability, will be completed by mid-1991.

3.6.3 Negative Pressure Containment (NPC)

Once again in 1989, NPC failed to meet its design unavailability target of 1×10^{-3} yr/yr. The figure achieved was 383.6×10^{-3} yr/yr (140 days). This high level of unavailability was caused by a defective transfer chamber in Unit 0. The fault was primarily due to an inflatable seal blow-out due to excessive door gaps and some distortion of the door structure when the seals have inflated. The temporary solution adopted was to equalize the airlock to the service (outer) side and strengthen the service side door structure. A permanent design solution, in addition to door stiffening, will eliminate the equalizing valves.

A further 14 minute breach of containment also occurred when staff incorrectly operated a transfer chamber whilst it was being maintained (SER 89-41).

In-service containment leak testing was carried out during the year. Results showed that the 2% vol/hr design limit assumed in the safety analysis could barely be met. To enable more consistent leak rate data to be gathered, a permanent leak rate measurement system was installed. Ontario Hydro had made efforts during the year to reduce instrument air in-leakage to containment and this goal now seems to have been achieved. Air in-leakage was, at the last leak test, below the design limit of 208 kg/hr. It is hoped that this standard can be maintained.

Ontario Hydro continues to claim that a 3% mass/hr leak rate would not exceed the single failure dose limit in the event of an accident and that much higher air in-leakage rates can be tolerated. AECB staff has not accepted these claims and review of the Ontario Hydro position is continuing.

The installation and commissioning of the hydrogen ignitors has now been completed and they are now able to operate automatically. This feature reduces the risk of hydrogen explosions inside containment.

AECB is of the opinion that Ontario Hydro needs to make additional efforts to improve negative pressure containment performance.

3.7 Significant Events

One hundred and twenty-seven (127) significant events were reported in 1989; none of these were attributable to serious process failures but 58 reports were pursuant to the Bruce NGS"A" operating licence. The total number of events is less than that of the previous year (143) but the reportable events are essentially the same, fifty-eight, as compared with fifty-seven in 1988.

A comparison of events for the two years shows where the differences have occurred.

Event Category	Number of Reportable Events 1988	1989
Radiation Control	15	20
Shutdown Systems	7	10
Containment	5	3
Emergency Coolant Injection	1	2
Reactor Process Systems	16	19
Secondary Systems	8	-
Miscellaneous	5	4

As noted in Section 3.1.2.1, 10 events were designated as contravening Operating Policies and Principles (OP&P). A brief summary of these events follows:

1. February 1989 - Two irradiated fuel bundles were without cooling in the fuelling machine head for a period of up to 1.5 hours. This was the result of an electrical failure caused by the spraying of heavy water from a leaking connection onto a junction box with a defective gasket. It was fortuitous that the fault occurred with only two irradiated fuel bundles in the fuelling machine head. OP&P 35.4 requires irradiated fuel to be cooled at all times.

   This event is further discussed in Section 3.5.1.

2. March 1989 - Unit 3 was without moderator high temperature alarms for a period of 51 days. This fact was discovered during "routine" panel checks and, upon correction of the fault, it was found that the moderator

temperature was above its limit. A reactor derating was required to bring temperature into its normal range. This event violated the OP&P requirements for the moderator as an ultimate heat sink.

3. April 1989 - A fault in an electric boiler was such that power to plant security devices (monitoring and outside lighting) was interrupted for a period of 10 minutes. Subsequent restart problems caused a surveillance disruption in excess of two hours. The interruption violated OP&P 10.2.

4 and 5 April 1989 - October 1989 These were technical violations of OP&P due to the lack of capability to distinguish between the two isotopes of boron which may be present in the moderator. In these instances the excess was Boron 11 which has a low neutron absorption factor. The OP&P has since been amended to take account of this and similar instances in future will not generate a SER.

6. May 1989 - planned Moderator level on Unit 4 went high following a

120V bus outage. The high moderator level resulted in a temporary impairment, level 2, of SDS2. The incident resulted from a poor understanding of the loads supplied from that electrical bus. OP&P 32.2 applies.

7. July 1989 - This event highlighted a discrepancy between the valve timing requirements of the safety system test (SST) and those required by the OP&P Appendix. This situation is currently being analyzed with a view to increasing the allowable opening times for the valves in question.

8. September 1989 - This event was related to the previous event. The slow opening times of the ECI nitrogen injection valves was traced to an unsuitable choice of valve stem bearing material.

9. October 1989 - The OP&P which requires the keeping of records of operating, maintenance and testing was violated by this event. The actual event was caused by a patch in the control computer substituting an incorrect parameter value under fault conditions. This, fortunately, resulted in a decrease in reactor power.

10. November 1989 - This event revealed that a level 3 impairment of SDS2 existed due to the excessive opening time of an injection valve. The channel should have been, but was not, rejected at the time of discovery.

Events in which human factors played a role totalled 53 in 1989. This is a decrease from those noted in 1988 (69) and represents as a fraction of the total number of event reported, a decrease from 48% in 1988 to 42% in 1989. AECB project staff considers that this further reduction is a positive sign that quality in the plant continues to show some improvement. The 33% increase in radiation control type events does, however, need attention. Some of these events can be attributed to the greater amount of maintenance work which has taken place on shutdown units, however, as already mentioned in section 3.3, indications are that radiation control procedures are not always followed.

Events which are considered to be of most significance are discussed in the various subsections of this report under headings which correspond with the event categories.

3.8 Quality Assurance

One quality Assurance (QA) audit was conducted by AECB staff during 1989 in the month of April. The audit was designed to reassess performance in areas where problems had been identified in the February 1988 audit, i.e., safety system call-ups, jumper records, shift turnovers, measurement and test equipment calibration and operator field routines. Significant improvements were observed in all areas except "jumper records". In this area it was found that despite the existence of an improved procedure implementation of the procedure was poor; numerous examples of procedure violations were found. Also, a very large backlog of jumpers was found to exist. An action was placed on the station's management to effect improvements in the control of jumpers and to reduce the backlog.

The AECB audit process requires that the licensee respond in writing to documented audit action notices within 40 days. It took Ontario Hydro more than three months to respond to the April audit report.

At the end of the year, the two most important QA issues were: i) the Bruce NGS"A" QA Manual, and ii) the size and role of the station's QA organization. AECB staff views were communicated to Ontario Hydro but at the time of writing, the status remains unchanged.

i) Bruce NGS"A" Quality Assurance Manual

Revision 2 of the station's Quality Assurance (QA) manual was formally issued in May 1989. This manual described the QA program and identified its requirements. AECB staff has carried out a detailed review of the manual and has found it to be unsatisfactory on several counts. Its major criticisms are that it is not in compliance with the appropriate Canadian Standards Association standard (CSA N286.5), does not contain many of the changes agreed to by the licensee following earlier assessments by AECB staff and for the most part does not reflect the recommendations, which AECB staff consider important, made by Ontario Hydro's own Nuclear Operating Standards Division.

ii) Bruce NGS"A" Quality Assurance Organization

AECB staff reviewed Ontario Hydro's submission in support of a proposal to reduce the station QA organization staff numbers and found it unacceptable. The AECB response to Ontario Hydro on this issue has been made as a generic letter (the issue concerns both Bruce and Pickering stations) indicating dissatisfaction with Ontario Hydro's proposal and explaining the AECB position on the role of the station QA group. AECB project staff has advised the licensee that until such time as proposed changes to the station QA organization are acceptable to the AECB, its approval of the station organization as a whole cannot be given. AECB staff expects this matter to be resolved shortly.

3.9 Maintenance

Ontario Hydro's station management committed a significant work program in 1989 to improve the standards of operations and maintenance work and achieved some success. Notable improvements were seen in the following areas:

- field operations supervision
- shift turnovers
- safety system testing program
- operator routines including the introduction of a new operator Rounds system
- outage work control

Progress has been hampered by the prodigious outage work load and the lack of fully trained resources.

AECB staff conducted a broad scope assessment program in 1989 designed to cover all significant station functions that affect standards of operations and maintenance work. Activities that were found to be i) unsatisfactory but with evidence of improvement, and ii) unsatisfactory with little or no sign or improvement are noted below:

i)
- preventative maintenance call-ups
- housekeeping
- field operations supervision
- effectiveness of maintenance management structure
- chemistry control
- liquid and gaseous effluent monitoring

ii)
- jumper system
- radiation protection practices
- verification and supervision of maintenance work
- access control
- reduction of maintenance backlog

An event involving movement of a fuelling machine whilst attached to a channel, occurred in January 1990 on Unit 4. During shutdown of the unit and subsequent recovery operations following the event, numerous component malfunctions occurred, that clearly illustrated the effects of a high maintenance backlog.

At the end of March 1990, Ontario Hydro submitted the first part of a Nuclear Generating Division wide Quality Improvement Plan. The plan is very thorough and covers most of the activities associated with operation of their nuclear plants including support functions. It is clear that the plan has the support of Ontario Hydro's corporate management and it is to be hoped that the objective, to meet world class standards of operation by the mid 1990s, will be achieved. AECB staff has yet to be informed how this plan will be implemented at Bruce NGS"A".

3.10 Chemistry Control

The average overall station chemical control performance achieved throughout 1989 was 75% as assessed against a target of 90%. This figure shows only a small increase (4%) over the figure for 1988. The size of this increase would suggest that the changes outlined in last year's report have not yet produced the results expected. The appointment of a Chemical Superintendent is, however, seen as a positive move.

AECB staff is expecting to see further improvements in performance in this area during the coming year since sub-standard chemistry control is inconsistent with Section 2.4 of Operating Policies and Principles.

3.11 Station Management

It was noted in last year's report that a significant improvement in the management and control of station operation had been observed in 1988. A further improvement was noted in 1989 attributable to the continued efforts of station management to solve identified problems. In the latter part of 1989, a change in focus of these efforts was noted. More emphasis was placed on "people management" and the fostering of a work ethic and safety culture. However, AECB staff has not as yet observed any positive results from these new initiatives.

AECB staff has continued to receive good co-operation from Ontario Hydro staff at all levels. Communications have been effective. Advance notification of potential safety concerns and licensing issues and prompt notice of safety significant events or planned activities has been consistently provided by station management. This excellent cooperation continues to be appreciated by the AECB project staff.

3.12 Training

Bruce NGS"A" shift supervisor and first operator candidates achieved a significant increase in their pass rates in AECB examinations in 1989.

The refresher training program has received further attention from Ontario Hydro during the year; the addition of a 3-day Radiation Protection Update Package is an example. The program has now reached a point where spare shift days are fully employed for training and a further increase may only be achievable by the provision of extra training resources, e.g., shift use of simulators, or the introduction of an extra shift crew to allow extra time for training.

3.13 Emergency Drills

During 1989 various drills and practices were held to test emergency preparedness both on a station and site wide basis. The schedule is arranged such that each crew participates in a more or less equal number of exercises. A total of 41 such drills were held during the year.

In addition to the above, a total of 50 (10 per crew) crew drills and practices were scheduled. Forty-five (90%) of these were completed, however one crew actually completed more drills than scheduled and three crews failed to complete their scheduled quantity.

Each operator is also required to complete sixteen emergency check sheets during the course of the year. This program was 98% completed - only one shift coming up short of the target number.

AECB staff considers that the attention paid to emergency preparedness by Bruce NGS"A" management, during a period when maintenance activity was at a high level, was highly creditable.

3.14 Security

There were no security incidents during 1989. The temporary loss of surveillance equipment due to a plant electrical failure (SER 89-042) has been already described in section 3.7. During the course of the year, security staff carried out three intrusion drills. As a result of these drills, procedures are being modified, particularly with respect to control room security and public address announcements. AECB Safeguards and Security Division inspected Bruce Nuclear Power Development Security Services and found the organization to be effective.

3.15 AECB Staff Inspections

The AECB project staff was not able to fully maintain its plant "Rounds" inspection schedule in 1989 due to the large number of major licensing issues and safety significant station activities requiring attention. However, sufficient plant and system inspections were performed as part of a preplanned broad scope assessment program to assess performance of operations and maintenance activities (see Section 3.9). Housekeeping standards were observed to have further improved over 1988 levels.

3.16 Measures of Station Performance

The 1989 performance indicators and other objective measures are presented in Appendix II. Comparisons with the previous year's figures are made and an assessment is made by AECB staff as either "acceptable" or "needs action". Most of the indicators are supported by comments in the appropriate section of this report. It should be noted that the assessment arrived at may not be based on any established criteria but represents a "consensus" view of AECB staff members who were most closely involved with the operation of the plant in 1989.

4. SIGNIFICANT LICENSING MATTERS

The AECB staff recommendation to the Board for renewal of the Bruce NGS"A" Operating Licence in November 1989, BMD-151, identified nine significant licensing issues. Those which remain are briefly reviewed below:

4.1 Standards of Operation and Maintenance

This topic is discussed in Section 3.9 of this report. Outstanding AECB staff criticisms are as listed in that section as "unsatisfactory".

In its covering letter accompanying the operating licence No. 7/89, issued to Ontario Hydro in November 1989, AECB staff advised that Ontario Hydro is expected to prepare and issue a plan of action for the establishment of satisfactory standards of operation and maintenance at Bruce NGS"A". In addition, Dr. R. Lévesque, President of the Board, wrote to Mr. R. Franklin, President of Ontario Hydro, later in November 1989 and reiterated the requirement for such a plan of action, stating that the plan was to identify, for each nuclear station, specific quantifiable factors that can be measured and readily recognized as indicators of standards of operation and maintenance.

Ontario Hydro has submitted to the AECB Volume 1 of its Quality Improvement Plan (QIP) referred to in Section 3.9. This is a complex, though well-constructed, multi-tiered plan for improvement that will require a major resource commitment to achieve and to sustain. The plan does not, as yet, contain any information on performance indicators nor does it contain a detailed milestone schedule for development and implementation of the plan.

It remains to be seen whether the QIP will be successful in effecting a "culture change" in the Nuclear Generating Division which will establish a satisfactory level of acceptance of "accountability" by personnel for their work and its results. This is an objective of the enabling program section of the plan and in the view of AECB staff one of the most important and difficult objectives to fulfill.

A short term objective of QIP is to be able to demonstrate improvement in performance in 1990.

4.2 Quality Assurance

This issue is discussed in Section 3.8. AECB staff is awaiting Ontario Hydro's response to its letter concerning the size and role of the station QA group. It is also awaiting submission of the revised station QA manual, the current version of which is unacceptable to the AECB.

4.3 Pressure Tube Integrity

Ontario Hydro carried out an extensive fuel channel inspection program on Unit 2 during the latter part of the year. The inspection program involved taking scrape samples from twenty channels to determine the concentration of zirconium hydride, and performing a full length internal inspection of some sixty tubes to establish the location of the garter springs[1] and the presence of any significant flaws. The results of this inspection program were that fourteen flaws found in eight pressure tubes were reportable to the jurisdictions (AECB and Ontario Ministry of Consumer and Corporate Relations) for their approval of the proposed disposition and four pressure tubes were found to be in a condition of potential risk of failure because of the predicted presence of small hydride blisters[1] and contact between the pressure tube and calandria tube. Removal of these four pressure tubes from contact with their calandria tubes was made a pre-condition for return to service of Unit 2.

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[1] These terms are explained in BMD 89-151 which summarizes and records AECB staff views on the pressure tube issue in August of 1989.

Using a specially designed tool known as "SLARETTE", the garter springs in these four pressure tubes were relocated to remove the pressure tubes from contact.

The issue of pressure tube fitness for continued service is the subject of ongoing discussions between Ontario Hydro and the AECB. It is a generic issue and effects all CANDU reactors. AECB staff has not accepted the proposed criteria for pressure tube fitness for service submitted by Ontario Hydro but has agreed to defer any action for a short period of time in order to allow Ontario Hydro to implement an appropriate program to demonstrate the conservative nature of its assumptions.

4.4 Containment

4.4.1 Containment Integrity

This topic is also discussed in Section 3.6.3.

Ontario Hydro voluntarily shutdown all four reactor units in May to conduct a containment leak rate test and to install covers over four of the pressure relief ducts inside the vacuum building to prevent them from filling with water during a douse. (This modification was found necessary following a commissioning test at Darlington NGS and is described in BMD 89-151.) The leakage tests were successfully completed and demonstrated that the isolation of the vault vapour recovery systems from containment was effective in reducing the leakage rate to an acceptable level. The commissioning of the automatic dampers which had been installed prior to the test was completed later in the year. In addition, a major effort to substantially reduce instrument air ingress to containment proved successful.

As is discussed in section 3.6.3, the issue of containment leak tightness criteria is not yet resolved to the satisfaction of AECB staff.

4.4.2 Containment Modifications

In addition to the Vapour Recovery isolation damper installation and instrument air ingress reduction a number of design modifications intended to improve containment performance under accident conditions are now complete:

i) installation of hydrogen ignitors
ii) installation of the Emergency Filtered Air Discharge System (EFADS) and Post Accident Radiation Monitoring System (PARMS)
iii) installation of airlock inflatable seal gap reduction devices

The station management at Bruce NGS"A" actively pursued these work items during 1989 and deserves credit for giving these important safety related modifications the necessary priority to complete them. It should be noted that further design changes to the EFADS system may be necessary to ensure that the system can effectively satisfy its design requirements.

4.5 Shutdown System Effectiveness

Installation of automatic reduction of shutdown system no. 2 (SDS2) neutron overpower (NOP) trip setpoints to improve reactor protection was completed on all units but has not yet been placed in-service pending recalibration of fuel channel flow orifices which generate the signal to lower the trip setpoints.

To compensate, Ontario Hydro has lowered the maximum fuel channel power limits by approximately 5%. Discussions are ongoing between Ontario Hydro and AECB staff to reach agreement on a satisfactory method for recalibration of the flow orifices.

Another issue under active discussion at the time of writing is loss of moderator inventory trip coverage. Ontario Hydro has proposed to the AECB that such additional trip coverage is not justified on the grounds that the event for which it may provide additional protection has a very low probability of occurrence and its provision would be costly and add unwanted additional complexity to the operation of the reactors. AECB staff has reviewed the arguments presented and has asked for a meeting with Ontario Hydro staff to discuss the topic.

4.6 Steam Generator Secondary Side Blockage

This topic is discussed in section 2.2 under the heading "Boiler Level Oscillations".

The steam generator scale removal program carried out during the Unit 2 outage was largely developmental and the most effective method found, high pressure "water lancing" using the proprietary chemical additive, will be used for scale removal on the Unit 1 steam generators during its upcoming maintenance outage later this year.

Having carefully monitored the scale removal techniques used during the Unit 2 outage, AECB staff is satisfied that Ontario Hydro has taken adequate precautions to avoid any undue risk to the integrity of the steam generator pressure boundaries. However, AECB staff is not convinced that Ontario Hydro has found the solution to effectively minimizing scale build-up in the steam generators.

4.7 Complexity of Station Design and Operation

In its 1987 and 1988 Annual Reports on Station Operation, AECB staff commented on the increasing complexity of Bruce NGS"A" reactors and the consequent increasing difficulty of their safe operation. Ontario Hydro has advised AECB staff that it is currently undertaking a design review to assess and establish means by which reactor operation may be simplified. It is apparent that major changes are being contemplated and that these may be carried out during the unit outages planned for pressure tube replacement. AECB staff expects to receive more information on these proposals in the near future.

5. CONCLUSIONS

It is the opinion of AECB staff that, overall, the operation of the station by Ontario Hydro during 1989 met acceptable safety standards. Despite the numerous problems and technical difficulties encountered during the year, AECB staff believes that station management and supervisory personnel have, on the whole, acted with due caution and made decisions in the interests of safety as a primary consideration. There was evidence of improvement in a number of key areas during 1989. These are noted in section 3.9 and elsewhere in this report. The noted improvements in operation and maintenance activities are supported by pertinent indicators in the Objective Measures table, for example, the number of outstanding call-ups is down to approximately one third of the number existing at the end of 1988, the number of events attributable or contributed to by human error is down from 69 in 1988 to 53 in 1989.

The extensive inspection and maintenance programs carried out during the year revealed the extent of component deterioration due to aging to be larger than expected. Hydrogen embrittlement of pressure tubes, erosion/corrosion of steam and feedwater valves, heat exchanger tubes and piping, fouling of boilers and heat exchangers, and environmental damage of electrical equipment are examples of such deterioration.

AECB staff believes and Ontario Hydro agrees that the continued aging of plant equipment and its potential for reducing the margins for safe operation must be taken into account by Ontario Hydro in its decisions that establish priorities and target dates for completion of actions to resolve identified problems at Bruce NGS"A".

APPENDIX I

1989 SIGNIFICANT EVENTS PURSUANT TO THE OPERATING LICENCE

89- 6	Unit Alert D_2O Spill in ASB
89- 7	Unit Alert High Gamma Fields at Annulus Gas Compressors
89- 8	Unit Alert H3 Hazard
89- 11	SDS1 Trip During P Trip Testing
89- 12	Reactor Setback and Turbine Trip on DA Low Level
89- 13	Forced Outage - PHT Pumps Primary Seal Failure
89- 14	Main HT Pump Motor Trip, Steam Drum 1 SOD Alarm
89- 15	Operation of Overcurrent Protection on 5510-BUB1 Level 1 Impairment PTrip
89- 16	Violation of Work Authorization
89- 21	Irradiated Fuel Uncooled
89- 23	Level 1 Impairment Failure of PTrip on P3
89- 27	Steam Drum 2 SOD Danger Limit Exceeded
89- 28	Delay in Unit Start-up Due to 3312-P1 Seal Replacement
89- 29	Level 1 P Trip Impairment Due to Loss of 5510 BUA1
89- 32	PHT Thermowell Seal Weld Repair
89- 34	HPECI Ch K Level 3 Impairment Due to Severed Cable
89- 36	Loss of Moderator Outlet Temperature Hi Temp Alarm
89- 37	Hydrazine Spill
89- 38	Level 1 Impairment of P Trip During Start-up
89- 41	Breach of Containment TC5
89- 42	Loss of Electrical Power to Security Devices
89- 44	High Boron Concentration in Moderator
89- 45	Unit Alert D_2O Spill
89- 49	Main HTS Pump Trip with Resultant SOD Incidents
89- 50	Unit Alert TC Seals Failed During Containment Pressure Test
89- 52	Class II 120V Bus Outage
89- 55	Unit Alert D_2O Spill
89- 63	Level 1 Impairment of PHT Pump P Trip Logic
89- 66	HPECI Gas Isolation Valve Timing Error
89- 67	Unit Alert Moderator Cover Gas Leaks
89- 68	Unit Alert - Event in Inc Services Bldg
89- 69	Unit 0 Alert Leaking Mod Upgrader Pump
89- 73	Unit Alert High H3 Levels Near Gas Chromatograph
89- 79	Unit Alert High H3 Levels
89- 86	SDS2 Low Delta T Alarm
89- 91	Unit Alert Due to H3 Release
89- 94	Uncontrolled Radiation Hazard
89- 95	Unit Alert Button Up Caused by Annulus Gas CO2
89- 96	Unit Alert Cover Gas Compressor Leak
89- 97	Leak at Weld MV10B
89- 99	Near Miss Uptake of H3 Due Wetting
89-100	Spurious Button-up
89-101	Unavailability of Both ECI N2 Isolation Valves
89-103	Pressure Tube Transfer
89-104	Unplanned H3 Exposure Due to Mod Upgrader Upset
89-106	Level 3 Impairment of NPC - 6 PRVs Unavailable

89-108	Incorrect Patch on RRSSLO
89-110	Unit Alert ASB - D_2O Spill
89-111	Fractured Piping in SDC
89-112	Incorrect Boron Levels in Moderator
89-115	Level 3 Impairment of SDS2
89-117	Incorrect SDS2 NOP Calibration
89-119	Overtorqued Bolts on NVs
89-125	Unit Alert Moderator Cover Gas Compressors
89-127	Loss of HPECI Mod HI Level Conditioning Signal - Unit Shutdown

3. Plant Maintenance

		LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
3.1 Number of Unplanned Outages/Unit	1.25	2.5	[X]	[ ]
3.2 Number of Call-ups Outstanding at end year	431	861	[X]	[ ]
3.3 Average of Monthly DRs Outstanding/Unit	1360	1125	[X]	[ ]

4. Plant Administration

4.1 Documentation

4.1.1 Average No. of Operating Memos in force/unit on 31 December	55	66	[X]	[ ]
4.1.2 Number of memos extant > 6 months	88	111	[ ]	[X]
4.1.3 No. of systems (USI) with >1 Op. Memo Extant	15	32	[X]	[ ]
4.1.4 No of Operating Memos behind schedule for review	18	15	[X]	[ ]

4.2 Training

4.2.1 % Scheduled drills completed	90%	100%	[X]	[ ]
4.2.2 % Candidates passing AECB exams	95	79	[X]	[ ]

4.3 Security

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

4.4 Quality Assurance

4.4.1 Results of AECB Audits

	ACCEPTABLE	NEEDS ACTION
1) Date April 3-7, 1990	[X]	[ ]
2) Date ____________	[ ]	[ ]
3) Date ____________	[ ]	[ ]

1.2.2 Continued

	LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
Average C14 in Milk (+) 230 Bq/l	240 Bq/l	[X]	[ ]
Average I131 in Milk (+) 118 Bq/l	141 Bq/l	[X]	[ ]
Average Tritium in drinking water (+) 37.5 kBq/l	26 Bq/l	[X]	[ ]
Average gross β in drinking water (+) 118 Bq/l	85 Bq/l	[X]	[ ]
Local water and fish samples		[X]	[ ]

Specific items for comment:

Some more extensive data for fish required.

Terrestrial Samples

Specific items for comment:

N/A

2. <u>Plant Control</u>

	This Year	Last Year's Value	Acceptable	Needs Action
2.1 Number of Genuine Reactor Trips/Unit	1.25	1.5	[X]	[ ]
2.2 Number of Serious Process Failures/Unit	0	0	[X]	[ ]

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

	This Year U1	This Year U2	This Year U3	This Year U4	Last Year U1	Last Year U2	Last Year U3	Last Year U4	Acceptable	Needs Action
SDS1	0	0	0	0	0	0	0	0	[X]	[ ]
SDS2	0	0	0	0	0.11	0	0	3.44	[X]	[ ]
Containment	383.6	383.6	383.6	383.6	385.6	385.6	385.6	385.6	[ ]	[X]
ECI	331.6	331.6	331.6	331.6	0	.43	0	0	[ ]	[X]

	This Year	Last Year's Value	Acceptable	Needs Action
2.4 Number of Reportable Incidents/Unit	14.5	14.5	[X]	[ ]
2.5 Number of fires *	4	8	[X]	[ ]
2.6 Number of significant human errors reported	53	69	[ ]	[X]
2.7 Plant Capacity Factor	53.55%	58.65 %	[ ]	[X]
2.8 % AECB compliance inspections "unsatisfactory" **	48 %	N/A	[ ]	[X]

* none major
** denotes percentage of inspections when some deviation from expected condition was found

OBJECTIVE MEASURES OF STATION PERFORMANCE
BRUCE NGS"A"

1. Radiation Control

1.1 Occupational Safety

Item		This year	Last year's value	Acceptable	Needs action
1.1.1	Total Whole Body Dose	4.26 Sv	5.2 Sv	[X]	[ ]
1.1.2	Total Extremity Dose	5.07 Sv	5.5 Sv	[X]	[ ]
1.1.3	Total F/H Extremity Dose	1.13 rem	1.37 Sv	[X]	[ ]
1.1.4	Total Neutron Dose	.14 mSv	1.2 Sv	[X]	[ ]
1.1.5	Number of Exposures > Regulatory Limits	0	0	[X]	[ ]
1.1.6	Number of radiation related supervisor's investigations	43	43	[ ]	[X]

1.2 Public Safety

1.2.1 Releases from the Station

a) Airborne

Release	Measure	This year	Last year's value	Acceptable	Needs action
Tritium	No of weeks >1% DEL	8	2	[ ]	[X]
	Average % DEL for year	0.6 %	0.55%	[X]	[ ]
Noble Gas	No of weeks >1% DEL	1	1	[X]	[ ]
	Average % DEL for year	0.59 %	0.61%	[X]	[ ]
Iodine 131	No of weeks >1% DEL	0	0	[X]	[ ]
	Average % DEL for year	0.015 %	0.019%	[X]	[ ]
Particulates	No of weeks >1% DEL	0	0	[X]	[ ]
	Average % DEL for year	.0001 %	0.012%	[X]	[ ]

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 0.34 %	0.33	[X]	[ ]
Gross β — No of months >1% DEL 0	1	[X]	[ ]
Gross β — Average % DEL for year 0.09 %	0.55%	[X]	[ ]
c) Total Heavy Water Loss 15563 kg (if excessive, should be reflected in higher tritium releases)	19202	[X]	[ ]
d) Critical Adult Dose 8.6 μSv	N/A	[X]	[ ]
1.2.2 Environmental Measurements			
Average Boundary dose rate 37 nGy/hr (Acceptable if within range of provincial reference sites value and not a significant increase from previous years)	55 nGy/hr	[X]	[ ]
Average Boundary Tritium in Air .052 %MPCa (> .1% MPCa would indicate a marked increase and would require investigation)	.044	[X]	[ ]
Average Tritium Concentration in Precipitation 484 Bq/l (average of all measurement sites)	440	[X]	[ ]
Average Gross β in Precipitation (+) 36 MBq/km^{-2}/mth	28	[X]	[ ]
Average Tritium in Milk 32 Bq/l	18	[X]	[ ]