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- Focus on CANDU maintenance
- Fuel Channel Inspection
- Cernavoda and Embalse
- CNA 2004 Seminar
- W.B. Lewis Lecture
- Uranium Mining Update

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EDITORIAL

Ending the Secrecy

One of the lingering criticisms of the nuclear field is that of "secrecy".

For the first couple of decades of the "nuclear era", dating from the discovery of fission in 1939, secrecy was the norm. With the world immersed in the Second World War it was inevitable that the discovery would be directed to military uses. The Herculean effort of the Manhattan Project led to nuclear energy being introduced to the world by two "atomic bombs". The legacy of that traumatic beginning still haunts us.

Because of the continuing "Cold War" the development of nuclear weapons continued with the result that all nuclear activities, even those aimed at peaceful uses, were still shrouded in secrecy. In Canada, the Atomic Energy Control Act of 1946 focused on "security".

The speech by Eisenhower to the United Nations in December 1953, dubbed "Atoms for Peace", began a long process of declassifying the nuclear science and technology not specifically associated with nuclear weapons. Today there is extensive open literature and many open conferences around the world.

However, we seem to have replaced official secrecy with a widespread reluctance by leaders of our nuclear industry to acknowledge problems by pretending they do not exist.

Here in Canada the most glaring examples of this behaviour are related to the botched refurbishment of the four units of the Pickering A station and the never-ending saga of the MAPLE reactors. Even at "in-house" gatherings, such as the recent CNA 2004 Seminar, the pretense of "no problem" continues.

No wonder there is scepticism, even cynicism, among the media and the many members of the public who are aware of the situation.

Over the past couple of decades there has been much written on how to deal with a crisis or event that could have serious negative effects. The general consensus is that it is best to respond early, to be open and to be honest. This should be followed with plans for rectifying the situation.

In the cases of Pickering and MAPLE just the opposite has occurred. Either nothing was said or there was such obfuscation that even the most unknowing person could see through it.

The nuclear industry has been trying to gain acceptance of the public. Over the past few years a large sum has been spent on advertisements The polls show that this has been largely in vain. That is not surprising. When all credibility has been lost it is unlikely that acceptance can be gained by a few commercial messages.

It will not be easy to regain our credibility with the public but the attempt must be made and it must begin with "leaders" of the industry acknowledging the mistakes and presenting a realistic plan for correcting the situation. Unfortunately, many us believe the only way to correct the situation is to replace the leaders.

Fred Boyd

IN THIS ISSUE

First, we hope that you will notice two major changes, colour in the interior and more advertisements. The two go hand in hand. This is a significant change for us and has resulted in some technical challenges. We hope you will like the result.

This issue focuses on CANDU maintenance, with four papers from the 6th International Conference on CANDU Maintenance last November. (A report on the conference was in the December 2003 issue.) We have selected four papers from the many excellent ones presented; our choices being based on diversity and perceived broad interest. They are: **Fuel Channel Inspection; Refurbishment Programs; Steam Generator Maintenance and Life Management at Embalse;** and **Electrical and C&I at Cernavoda.**

For a change in pace there are two short items: **Atoms for Peace,** which presents excerpts from the memorable speech by US president Eisenhower to the UN in December 1953; and notes from a **Conversation with Murray Elston,** the new president of the Canadian Nuclear Association.

Next is our report on the **CNA 2004 Seminar,** followed by this year's **W. B. Lewis Lecture,** by William Magwood of the US Department of Energy, which was incorporated into the Seminar program for the first time. Then there are excerpts from another presentation to the Seminar, **Canada's Uranium Mining Industry.**

There follows the usual eclectic selection of items in **General News** and, of course, news of the Society in **CNS News.**

There is a couple of **Book Reviews,** an updated **Calendar,** and, of course, the imitable musings of Jeremy Whitlock in **Endpoint.**

Your suggestions and contributions are always welcomed, especially your reaction to our new look.

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Cover Photo

The photograph on the cover shows the Embalse generating station in Argentina.

Courtesy of Henry Chan of COG

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Refurbishment Programs

by Craig S. Irish[1]

Ed. Note: *The following paper was presented at the 6th CNS International Conference on CANDU Maintenance, held in Toronto, Ontario, November 2003*

Abstract

As nuclear plants age, equipment becomes obsolete, outdated or just simply unreliable. This puts a lot of emphasis on replacement of the subject equipment. This can be an expensive proposition for safety related equipment due to design changes, requalification charges and the cost of the new equipment, specifically when the original component is obsolete. The presentation will explain how comprehensive refurbishment programs on many different types of equipment can alleviate this situation. The refurbishment program is a systematic refurbishment of equipment to an as new condition by replacing all of the age sensitive components within the equipment. This is carried out on all of the same type of equipment in a scheduled program. For example the plant may to decide to refurbish all of their Lambda LME-24 power supplies, or all of their Bailey modules, or all of their Agastat DSC Series relays. Independent of the item the process is the same. Refurbish each piece of equipment to an as new condition by replacing all of the age sensitive equipment. The equipment is then returned to the client as safety related, existing qualification maintained and with a new service life/warranty. This is not a simple repair. It is a planned refurbishment to an as new condition of certain equipment types throughout the plant and then carried out from equipment piece to equipment piece. The refurbishment program may even include introducing new spares into the plant. This is normally performed by upgrading (dedicating for safety related use and refurbishing to an "as new" condition) surplus equipment and using these equipment pieces in the rotation of the plant equipment to refurbish the entire population of a selected piece of equipment at the plant. This process can be performed on many equipment types including power supplies, circuit boards, modules, relays, motors, breakers, and many more. The refurbishment program greatly increases the reliability of the equipment without the cost associated with a design change needed to replace an obsolete piece of safety related equipment.

Introduction

As nuclear plants age, equipment becomes obsolete, outdated or just simply unreliable. This puts a lot of emphasis on replacement of the subject equipment. This can be an expensive proposition for safety related equipment due to design changes, requalification charges and the cost of the new equipment, specifically when the original component is obsolete. Obsolescence covers all equipment types, electrical, mechanical and instrumentation in a nuclear power plant. There is such a large emphasis on keeping safety related equipment the same that nuclear power plants have not evolved with newer equipment types offered by OEM's over the years. Now nuclear power plants are faced with increasing reliability on very old equipment systems. In many cases the equipment is obsolete and has been obsolete for a very long time. The early answer to this problem was to stock all of the spare parts needed to maintain the equipment at the nuclear power plant. This led to very large inventories at the plants, which was also not desirable. Over the years this inventory has been reduced for business reasons and depleted due to use of the parts. This leaves the nuclear industry with the current state which is what do you do when an obsolete piece of equipment needs to be changed out and there is no direct replacement.

When an obsolete safety-related piece of equipment needs to be changed out there are a few options to consider:

1) Replacement of the piece of equipment with a form, fit and functional substitute.
2) Replacement of the piece of equipment with a new item, which requires a design change.
3) Establishing a "Refurbishment Program" to bring the existing inventory to an as new condition.

If it is decided that replacement is not possible due to technical or cost issues then a "Refurbishment Program" is a very good option to maintain and in some cases increase the reliability of the equipment in question. It

1 Nuclear Logistics, Inc., Chelmsford, Massachusetts 01824

should be noted that a "Refurbishment Program" is not a reactionary repair, but rather a systematic refurbishment of families of equipment within the nuclear power plant. The "Refurbishment Program" would be performed on a proactive basis prior to the equipment failing.

The "Refurbishment Program" consists of the replacement of all age sensitive components within the subject piece equipment with form, fit and functional equivalent components. The goal of the "Refurbishment Program" is to bring the original piece of equipment back to an as new condition as possible. In some cases the equipment performance (e.g. accuracy, repeatability, rating) can be increased with the use of newer components available today, which were not available at the time the original equipment was fabricated. Although this is possible, strict adherence to configuration control must be maintained when in the "Refurbishment Program". At no time in the "Refurbishment Program" should the original safety function of the piece of equipment be changed. In addition the "Refurbishment Program" should not introduce any new un-analyzed failure modes to the original piece of equipment.

Typical piece parts which are replaced in a "Refurbishment Program", but are not limited too are:

- Soft Parts (e.g. o-rings, gaskets, seats, etc.)
- Discrete Components (e.g. resistors, capacitors, diodes, etc.)
- Old Magnetics

At the beginning of the "Refurbishment Program" a detailed review of the design of the piece of equipment in question is performed. The review of the design determines which piece parts have aging mechanisms and need to be replaced in order to bring the original equipment back to an as new condition.

The piece of equipment is then refurbished to an "as new" condition using all new piece parts. New piece parts are chosen which have a proven or certified performance (e.g. MIL-SPEC discrete components). In many electrical component cases tantalum capacitors can be used in place of electrolytic capacitors removing the need for future capacitors change outs due to end of life conditions. Electrical equipment which has been refurbished is then burned-in to reduce any infant mortality.

All refurbished equipment is tested to completely verify that the safety function of the item is maintained. Critical characteristics of the piece of equipment are chosen which best represents the items safety function. The critical characteristics are then verified and accepted as part of the "Refurbishment Program".

The above process is performed on all of the equipment pieces within a given family at the nuclear power plant. For example the plant may to decide to refurbish all of their Lambda LME-24 power supplies, or all of their Bailey modules, or all of their Agastat DSC Series relays. Independent of the item the process is the same. Refurbish each piece of equipment to an as new condition by replacing all of the age sensitive equipment. The equipment is then returned to the client as safety related, existing qualification maintained and with a new service life/warranty.

To get the best value out of a "Refurbishment Program" the program needs to be initiated in a proactive manner on equipment within the nuclear power plant which is obsolete and has known aging mechanisms. This is not a simple repair. It is a planned refurbishment to an as new condition of certain equipment types throughout the plant and then carried out from equipment piece to equipment piece.

The refurbishment program may even include introducing new spares into the plant. This is normally performed by upgrading (dedicating for safety related use and refurbishing to an as new condition) surplus equipment and using these equipment pieces in the rotation of the plant equipment to refurbish the entire population of a selected piece of equipment at the plant.

Prior to beginning a refurbishment program the parts availability needs to be assessed.

In some cases the OEM may no longer support the parts or may have a stop support date posted. In these cases alternate parts need to be researched to determine if the commercial aspect of the program is still viable. Reverse engineering parts and or significant engineering to use alternate parts in the refurbishment program needs to be addressed.

The refurbishment process for safety-related equipment needs to include the following:

- Refurbishment done to detailed procedures.
- Trained (ESD, solder, FME, etc.) technicians used for refurbishment.
- In process and final assembly testing/dedication.
- Burn-in on electrical items.
- 10CFR50 App. B, and NQA-1 controls in place.

Refurbishment Examples

The refurbishment process is best illustrated with examples taken from actual programs in place at participating nuclear power plants.

Example #1: Power Mate/Power Designs Power Supplies

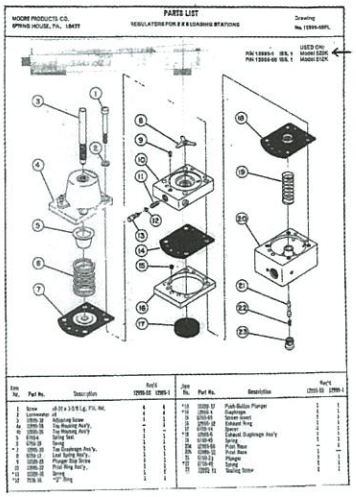
Independent of the type of nuclear power plant or original OEM all power plants rely on power supplies to power critical instrumentation. Many of the original power supply

OEM's used in the plant construction no longer support the original design for numerous reasons.

One such example is Power Mate/Power Design high voltage power supplies. These power supplies are used in high voltage applications with significant aging mechanisms. The design is very unique and is obsolete from the OEM. There is no direct replacement for this power supply allowing a one-for-one or even equivalent change out.

The plant had a "Refurbishment Program" performed on all of the subject high voltage power supplies used, brining the entire population to an as new condition. As a result the overall plant reliability has been increased with out the need of a costly safety related design change.

Example #2: Moore 522K Controllers

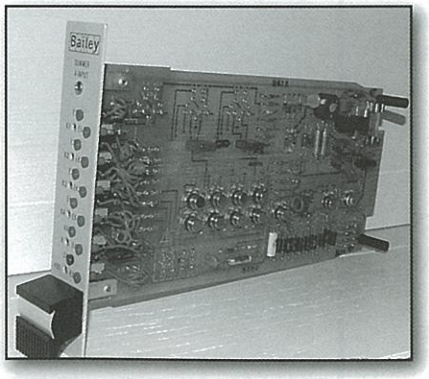


The second example is with a Moore 522K pneumatic controller. The unit is obsolete. There are no longer pneumatic controllers of this type offered by any OEM. As a result the plant had a "Refurbishment Program" performed on the entire inventory of Moore 522K controllers used at the site both safety related and non-safety related.

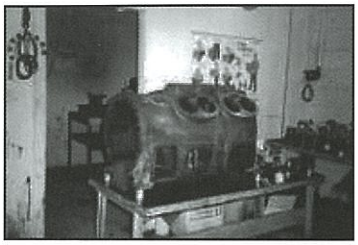
To compound problems with this unit, all of the piece parts needed to refurbish the unit are also obsolete. Therefore all of the "soft" parts had to be reverse engineered and fabricated. All of the "soft" parts were then replaced. The controllers were retested and certified verifying the safety function. The "Refurbishment Program" eliminated the need to replace pneumatic controllers with digital controllers at a significant cost savings.

Example #3: Bailey Modules

Many nuclear power plants use Bailey Modules in their instrumentation cabinets. These units are obsolete with no direct replacements. This program included the replacement of all age sensitive piece parts with new equivalent piece parts, each evaluated for their specific function in the original item. The units received a 100 hour burn-in. Each unit was tested to verify and accept the safety function. To help facilitate the "Refurbishment Program" units were purchased from the surplus industry, refurbished to an as new condition, burned-in and tested, allowing the plant to rotate spare units through the plant population. As a result the overall plant reliability has been increased with out the need of a costly safety related design change.

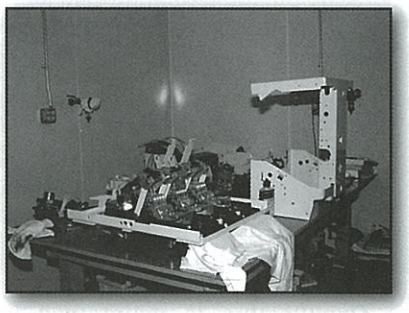


Example #4: Carrier Refrigeration Compressor

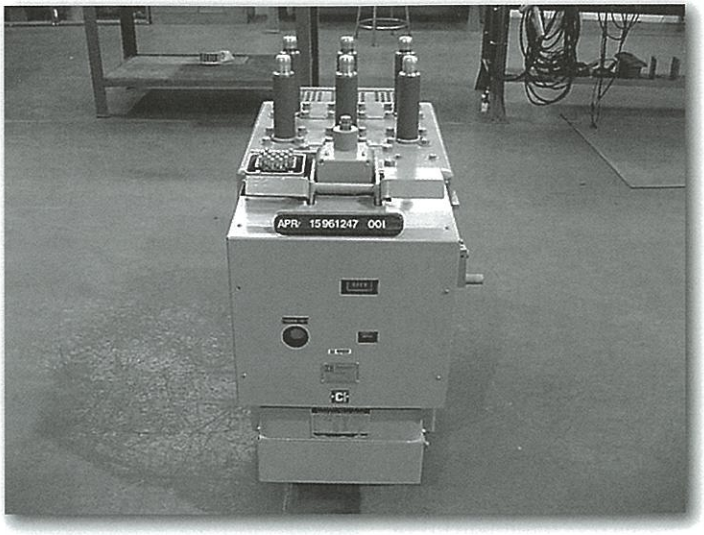


The fourth example is an example of an obsolete item as well as an item which is no longer supported by the OEM with a nuclear Quality Assurance Program. This program started with the purchase of a compressor from the surplus market providing the plant a needed spare to initiate the "Refurbishment Program". The reciprocating compressors were refurbished with a combination of new parts, reconditioned parts and equivalent new parts. Each compressor was then performance tested on a test stand simulating its safety function in the chiller. As a result the overall plant reliability has been increased with out the need of a costly safety related design change. This design change would have undoubtedly incurred significant field changes as well.

Example #5: GE AK and AM Switchgear Breakers



The fifth example is a border line case of using a "Refurbishment Program" or conducting a change out of the breakers with a new breaker. The GE AK and AM Series circuit breakers are obsolete from the OEM. Most of the parts are still available as new however more and more are becoming obsolete on a monthly basis. Like many "Refurbishment Programs", this program started with the purchase of a breaker from the surplus market, refurbished to an as new condition so the plant can have a unit to rotate through for a full refurbishment program. The refurbishment program consisted of the reuse/recondition surplus parts, purchase of new parts and use of equivalent parts in order to bring the breaker to an as new condition. The breaker was then fully electrically and mechanically tested to verify and accept the breakers safety function.



This is a border line case since the OEM has made so many parts obsolete that the refurbishment price is approaching and sometimes exceeding the replacement price. A replacement breaker can be provided which will replace the existing breaker without any field modifications which requires no or a significantly reduced maintenance program. A replacement breaker will require a design change package, however the reduced (or in some cases none) maintenance will quickly pay for the design change in the first 3 – 5 years.

Service Life:

For each "Refurbishment Program" a new service life is determined based on the item and application. The refurbished items are returned with documentation detailing:

- New service life
- Recommended maintenance/inspection intervals
- Recommended spare parts list

Safety Function and Qualification:

As stated above in the examples each "Refurbishment Program" will include verification of the safety function on 100% of the refurbished components in accordance with guidelines of EPRI NP-5652, Method 1, "Special Tests and Inspections".

Qualification is maintained in accordance with IEEE Std. 344 and 323 by analysis, engineering justification or additional testing as the specific component refurbishment dictates.

Documentation:

Typical refurbishment documentation includes:

- Verification Plan/Report in accordance with the guidelines of EPRI NP-5652 for piece parts and complete assembly.
- Test & Inspection Report identifying all replaced parts and testing performed.
- Item Equivalency Evaluation for replaced piece parts which were not the same as the original (as applicable) in accordance with the guidelines of EPRI NP-6406.
- Calculation Document addressing qualification (as necessary) in accordance with IEEE Std. 344 and IEEE Std. 323, at a minimum.
- Certificate of Conformance

Conclusion:

The concept is not new. It has been adopted for years on equipment types such as motors, metal clad switchgear breakers and pumps. The refurbishment process can be performed on many equipment types including power supplies, circuit boards, modules, relays, motors, breakers, and many more. The refurbishment program greatly increases the reliability of the equipment without the cost associated with a design change needed to replace an obsolete piece of safety related equipment.

Depending on the equipment in question, a planned systematic refurbishment program can be a viable, technically acceptable and cost conscious alternative to replacing old/obsolete equipment.

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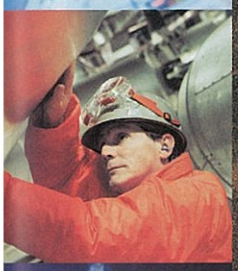
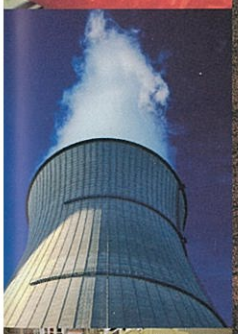
Safety-related expertise





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Fuel Channel Inspection
– using the AECL Fuel Channel Inspection System

by W.R. Mayo, G. Van Drunen, D. Kalenchuk, R. Gunn[1]

Ed. Note: *The following paper was presented at the 6th CNS CANDU Maintenance Conference in Toronto, Ontario, November 2003*

ABSTRACT

The AECL Fuel Channel Inspection System (AFCIS) is a "wet" system capable of storing a closure plug and delivering inspection tooling into flooded channels. The first system was used in 1999, and a second one was delivered to Korea in 2001. To date, over 80 CANDU fuel channels have been inspected with this equipment - in six different CANDU-6 reactors. Three types of inspection head tooling have been delivered by AFCIS:

1. The primary inspection head is capable of satisfying current and anticipated future requirements of Standard CAN/CSA-N285.4. It includes: a self-powered rotating inspection module that provides rapid inspection of 100% of the pressure tube volume, a direct pressure-to-calandria tube gap measurement capability, eddy current volumetric inspection to complement six-direction ultrasonic measurements.
2. A re-inspection head is available to help characterize significant internal pressure tube flaws. It includes capabilities for video examination in flooded channels and flaw replication.
3. A multi-head sampling tool permits the collection of micro-samples for deuterium/hydrogen analysis from four different axial locations in a pressure tube, during a single channel entry. It does not require any interface to station fuel handling equipment.

In addition to the inspection heads, AFCIS consists of a slightly modified Advanced Delivery Machine (ADM), originally developed for delivering Spacer Location and Repositioning (SLAR) tools, and a state-of-the-art Data Acquisition System (DAS). The ADM includes a calibration tube that enables calibration of inspection functions immediately before and after each channel entry. The DAS hardware is modular to simplify maintenance and minimize coping with instrument and computer obsolescence problems in the future. DAS software is (Microsoft) Windows-based.

This paper describes the AFCIS equipment and its capabilities. System performance is illustrated by typical inspection results.

INTRODUCTION

Historical Overview

AECL has been involved with the inspection of CANDU fuel channels (FC) since the pressure tube concept was adopted. Early work on inspection equipment at Chalk River Laboratories dates back to the 1960s; it primarily involved monitoring dimensional changes. Flaw detection and characterization became part of inspection requirements in the 1970s. Early "dry" inspection tooling was designed to operate in drained channels. This equipment satisfied CANDU inspection requirements until about 1985.

About 1980 it was recognized that dry in-service FC inspections were time-consuming and radiation dose intensive. Both problems could be alleviated through "wet" inspection equipment capable of operating in channels flooded with primary heat transport fluid. The first such system, CIGAR[2], was developed by Ontario Hydro; it became operational in the mid 1980's [1].

Over the past 15 years a number of CANDU reactors have moved well into the second-half of their original design life. With that development have come new and expanded requirements for fuel channel inspection (FCI) such as:

- faster inspection of 100% of the pressure tube volume,
- the need to inspect more channels during an inspection campaign,
- new inspection requirements (such as pressure-to-calandria tube gap and improved garter spring spacer location),
- monitoring deuterium uptake with minimum impact on station operations.

1 Atomic Energy of Canada Limited, Mississauga, Ontario, Canada

2 Channel Inspection and Gauging Appartus for Reactors

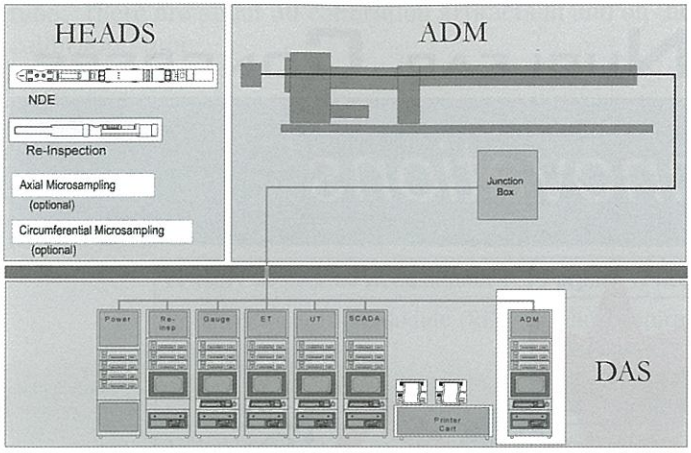

Figure 1: AFCIS Schematic Overview

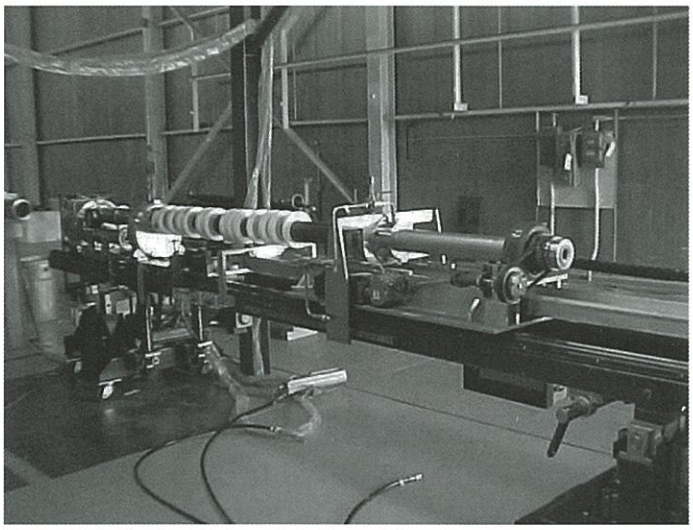

Figure 2: Photo of ADM viewed from the ram-end.

To address current and anticipated needs in FCI, and to take advantage of major advances in computer technology over the past decade, AECL developed and built a second-generation wet fuel channel inspection system named AFCIS[3]. Work on the first system was started in 1998, a second was built in 2000/2001. Over 80 channels have been successfully inspected with AFCIS in six different reactors since 1999.

AFCIS Requirements

Design requirements established at the start of AFCIS development were:

- portability between CANDU stations around the world,
- satisfy all existing and anticipated requirements of Standard CAN/CSA-N285.4 [2],
- minimize total channel inspection time,
- verify system performance through channel post- and pre-entry calibration checks.

Figure 3: The NDE Head. The RIM is on the far left, the Motor Module in the centre, and the Sag Module on the right-hand-side.

Additional requirements that could be classified as desirable included:

- build on proven inspection technology to the greatest extent possible,
- design to deal efficiently with future equipment obsolescence,
- design to accommodate new inspection requirements that may arise in future,
- achieve inspection of more than 10 channels with one inspection head during each inspection.

AFCIS Equipment

Figure 1 provides a schematic overview of the main AFCIS components. They are described in more detail below.

Delivery Machine

The machine used (see Figure 2) to manipulate the inspection heads (tools) is a modified Advanced Delivery Machine (ADM) originally developed for SLARette[4] operations in CANDU-6 reactors. It is a wet delivery system, capable of removing the closure plug and accessing the channel without isolation, once the channel has been defuelled, shield plugs have been removed, and the closure plug has been replaced at low force.

The ADM provides axial motion over the full length of the pressure tube for inspection tooling by means of three-stage telescopic ram tubes that are latched and unlatched under remote computer control. The ADM also provides limited (±360°) head rotation for some inspection scan patterns.

A prominent feature on the ADM is the calibration tube consisting of lengths of production pressure and calandria

3 AECL Fuel Channel Inspection System
4 Spacer Location And Repositioning
5 Linear Variable Differential Transformer

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tube. There are about 30 calibration artifacts in and on the calibration tube.

In-Channel Heads and Tooling

The (Primary) Inspection Head, shown in Figure 3, consists of three main modules. Each performs multiple inspection tasks:

Primary Inspection Head Modules	Purpose & Location	Key Components
Rotating Inspection Module (RIM)	Helical (Spiral) Scanning for flaw detection and diameter and wall thickness gauging. End of head furtherest from ADM	2 Eddy Current Flaw Probes 6 Ultrasonic Flaw Probes 1 Ultrasonic Wall Thickness Probe 1 Diameter (LVDT[4]) Probe
Motor Module	Provide RIM rotation, signal transfer. Located behind RIM.	Motor Drive Multi-Channel Slip Ring Assembly Resolver (Encoder)
Sag Module	Sag, Gap, ET Spacer, Temperature Located behind Motor Module	2 LVDT Curvature (Sag) Probes 2 Eddy Current Gap Probes 1 Eddy Current spacer Probe Resolver (Encoder) Temperature Probe (RTD)

The Re-inspection Head, Figure 4, collects additional information about significant pressure tube flaws by video examination and replication (for detailed flaw geometry determination). The head is comprised of the modules described below.

Re-Inspection Head Modules	Purpose & Location	Components
Video	Visual examination. At end furthest from ADM.	Radiation Resistant Video Camera with remote focusing, adjustable lighting.
NDE	Eddy Current and Ultrasonic Flaw Re-Location. Located behind video camera.	1 Eddy Current Probe 1 (20 MHz) Ultrasonic Probe
Replicating	Flaw Moulding. Located behind NDE Module.	1 Pneumatically Operated Plate Replicating Compound Holder

Pressure tube sampling is a direct and proven method for satisfying the requirement in CAN/CSA-N285.4 for measuring hydrogen isotope concentration in pressure tubes. A newly developed *Multi-Head Sampling Tool* significantly reduces sampling efforts by using one tool to sequentially sample at all four locations before removal from the reactor thus greatly increasing sampling efficiency. (Previous tools could only sample at one location each time.) Sampling is done in a flooded channel at normal maintenance flow conditions. Four sets of independent cutting heads (Figure 5), like those on the existing Damp or Wet tools and incorporating proven technology demonstrated in obtaining over 2300 in-reactor samples, are used to obtain a full set of four samples. After each actuation, the tool is repositioned to obtain the next sample. A small amount of light water (300 ml) is injected in each cut region to protect the sample from deuterium pick-up during the sampling operation.

Figure 4: Re-Inspection Head. The Video Module on the left, the NDE Module in the centre, and the Replication Module on the right-hand-side.

Data Acquisition System

The inspection heads are connected to an umbilical cable that runs through the center of the ADM ram tubes and from there to a junction box (JB) located on the ADM reactor-face platform. Trunk cables run from the JB to a reactor

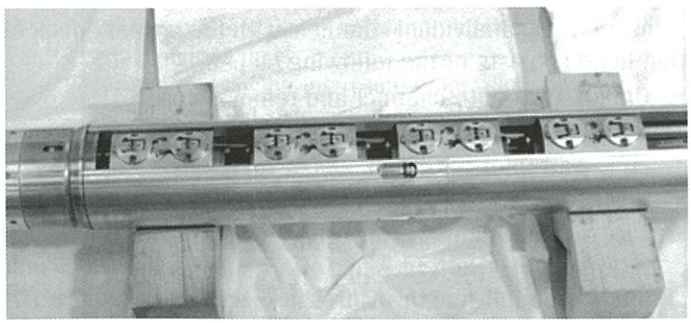

Figure 5: The AECL Multi-Head Sampling Tool showing the four sampling heads in the main module at the end of the tool. The module to the left houses the actuator, control mechanisms and connectors.

building penetration. A second set of trunk cables provides connections from the penetration to the Data Acquisition System (DAS) located outside the reactor building. Figure 6 shows a portion of the DAS.

The data acquisition and control system consists of eight stand-alone rack-carts that can be configured to fit the available space:

Rack (or Cart)	Purpose
ADM Control	Computer control of speed, direction, and position to the delivery machine.
Supervisory Computer and Data Acquisition (SCADA)	Automated control for RIM rotation. Position information to all the other racks
Ultrasonic Testing	Ultrasonic Flaw Detection and Characterization (including Re-Inspection); data acquisition.
Eddy Current Testing	Eddy Current: Flaw Detection (including Re-Inspection), "Loose" Spacer Detection, Gap Measurement; data acquisition.
Dimensional Gauging	Gauging: Wall Thickness, Diameter, Curvature (Sag); data acquisition.
Re-Inspection	Re-Inspection: Video, Flaw Replication.
Power	Adapts station power to requirements of racks/carts.
Printer (Cart)	Hard-Copy Print-Outs of inspection results.

Sequence of Operations

Typical AFCIS inspection consists of the following, with approximate time requirements:

- Unpack and set-up equipment for FC mock-up testing/ rehearsals/training (one week).
- Move equipment to reactor building, install ADM on reactor-face platform, final system checks and adjustments (2 days).
- Inspect channels with primary inspection head and analyze results (12 hours/channel).
- Install re-inspection head and re-inspect any significant flaws (1 day if required).
- Dismantle system and remove from reactor building (1 day).
- Perform initial decontamination, pack, prepare preliminary inspection report (5 days).

Inspection of individual channels with the primary inspection head consists of the following steps6:

- Clamp ADM onto channel and remove closure.
- Calibrate Pass #1 scan tests (UT & ET volumetric, diameter, wall thickness, and spacer location).
- Scan Pass #1 Insert – locate spacers and ends of pressure tube to define scan range (and measure pressure tube length); Retract – perform helical scan at 0.9 mm pitch over full length of pressure tube and acquire UT, ET, diameter and wall thickness data.
- Final calibration for Pass #1 measurements and initial calibration for Pass #2 and #3 measurements (curvature and pressure-to-calandria tube gap).
- Scan Pass #2 Insert – measure curvature and gap at 6: 00; Retract – measure curvature and gap at 12:00.
- Scan Pass #3 Insert – available - can be used to improve suspect data from Scan Pass #2; Retract – perform circumferential gap scans every 220 mm along channel.

Figure 6: AFCIS data acquisition system. The six racks along the right-hand side of the figure are (from back to front): ADM control, SCADA, UT rack, ET rack, gauging rack, and re-inspection rack.

- Final calibration for Pass #2 and #3 measurements.
- Rescan any suspect flaw regions and perform sufficient analysis to ensure all inspection data is acceptable. Back up all electronic inspection data.
- Re-install closure and unclamp ADM from channel.

The full-length spiral scan of a pressure tube requires two hours. It is made possible by the motor/slip-ring module in the inspection head and is the most notable AFCIS advance in pressure tube inspection technology.

AFCIS capabilities & performance

Inspection Speed

Inspection speed often dominates discussions about FC inspection systems. Despite the preference for simplicity, comparisons of AFCIS performance to other systems is complicated by several factors, such as:

- AFCIS provides measurements not possible with other inspection equipment, e.g., pressure-to-calandria tube gap and eddy current volumetric inspection. Deleting such measurements would reduce AFCIS inspection time by an hour or more per channel.
- AFCIS provides 100% volumetric inspection coverage. Increasing AFCIS spiral scan pitch to the 3 mm used during previous inspections at some CANDU stations would reduce AFCIS inspection time significantly – unfortunately, AECL believes it would also not satisfy the intent

5 It is assumed the channels have been de-fueled and shield-plugs removed prior to the start of inspection activities.

of the current version of standard CAN/CSA-N285.4.

- AFCIS procedures call for complete calibration of all test functions at the start and end of each channel. This consumes additional time, but is considered essential to assuring the collection of quality data.

Keeping the above factors in mind – with experienced AFCIS operators, a flaw-free channel can be inspected in less than 8 hours. That includes over an hour to move from channel to channel and ADM clamp-on/unclamp. This inspection rate has been demonstrated on a number of occasions. Channels with numerous flaws requiring rescans and considerable analysis can add 2 or 3 hours to total inspection time. With some contingency for equipment maintenance and station delays this adds up to the 12 hour per channel allowance recommended in Section 2.4. That speed is a factor of 2 or 3 faster than existing "wet" and "dry" FC inspection systems.

The last five AFCIS inspections were scheduled using the elapsed times given in Section 2.4. Each of those inspections was completed on or ahead of schedule.

Nondestructive Examination and Dimensional Gauging

Meeting the requirements of N285.4 necessitates the considerable nondestructive examination and dimensional gauging capabilities on AFCIS. Present capabilities are summarized in the following table.

NDE/Gauging Capability	Methods	Significant Features
Ultrasonic (UT) Volumetric Inspection	45-Degree angle beam transervse wave; four directions. Normal beam. 0.9 mm pitch = 100% coverage. High frequency surface profiling; example figure 7.	Principle flaw detection method. Same as CIGAR and manufacturing inspection [1,3]. Flaw depth accuracy: ±20 microns (estimated).
Eddy Current (ET) Volumetric Inspection	Surface-riding differential probes. Multi-frequency operation. C-scan of calibration tube: Figure 8	Particularly effective at detecting open ID flaws. Complements ultrasonic inspection [4].
Pressure-Calandria Tube Gap Measurement	Low frequency transmit-receive ET coils. Gap profile example: Figure 9.	Direct compensation for wall thickness variation. Normalization of gap values to known garter spring spacer diameter at confirmed spacer locations.
Garter Spring Spacer Location	Loose: Transmit-receive probe with field focusing [5]. Snug: Effects on PT seen in Diameter, Curvature, and UT	Reduces diameter-growth distortion. Processed diameter data: Figure 10. After 40,000 EFPH, expect to detect over 90% snug spacers: Figure 11.
Channel Deflection (Sag)	Curvature measured using two LVDT probes located at mid-span of two beams. Double-integrate curvature.	Curvature ∞ (LVDT) deflection. Typical cuvature and deflection profiles: Figure 12.
Pressure Tube Internal Diameter	Distance between diametrically opposed contact-points measured by LVDT.	Data presented as plots of maximum, average, and minimum diameter along the pressure tube; example: Figure 13.
Pressure Tube Wall Thickness	Pulse-echo normal beam ultrasonics. Independent of flaw detection normal beam.	Typical profiles of maximum, average and minimum wall thickness in PT operated >100,000 hours: Figure 14.
Pressure Tube Elgongation	Diameter probes and ADM axial travel. Length = distance between rolled joint burnish mark inboard ends: Figure 15. AFCIS (CANDU-6) data compared with other sources: Figure 16. Requires mock-up calibration.	Actual N285.4 requirement = channel position on bearings; length only provides part of information. Relatively simple; adds nothing to inspection equipment or time. Essential to comparing results from volumetric inspections and spacer positions between successive inspections.
Video	Video camera on Re-inspection head.	Only used for significant flaws; costs additional time and radiation dose. Better information on flaw origin than UT or ET; often supplies final information to decide if replication should be done.
Replication	Injection of moulding compound in Re-inspection head. Example of replica: Figure 17.	Best information on geometry and orientation without destructive examination. Depth and root tip radius obtained from replicas provide most convincing evidence used in flaw dispositioning.

Deuterium/Hydrogen Sampling

The Multi-Head Sampling Tool (MHST) delivered by the AFCIS ADM offers the same proven performance and demonstrated accuracy provided by earlier versions of sampling tools [6]. The main advantages of the MSHT are reduced sampling time and minimal impact on fuel handling equipment and station personnel. The following table compares the performance of the MHST with earlier versions.

	Damp Sampling	*Wet Sampling*	*Multi-Head Sampling*
Set up	0.5 day	2 days	0.5 day
Typical Sampling Rate (hr/chan.)	12-24	6-10	2-4
Fuel Handling Burden	Low	High	Low
Freeze Plugs in Feeders	Yes	No	No

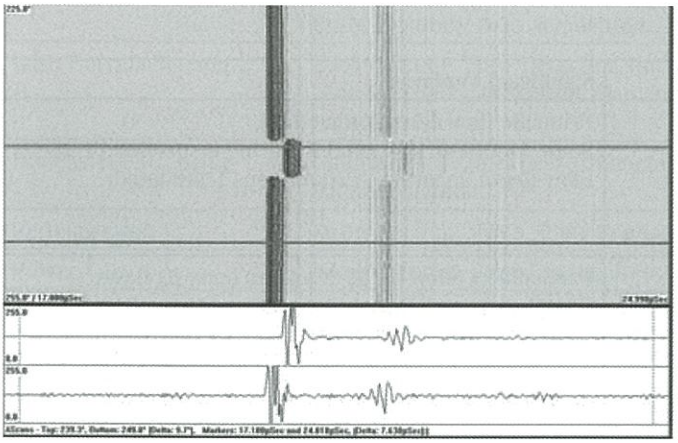

Figure 7: Ultrasonic B-scan (top) and the corresponding A-scans (bottom) of a 0.15 mm deep notch in the AFCIS calibration tube.

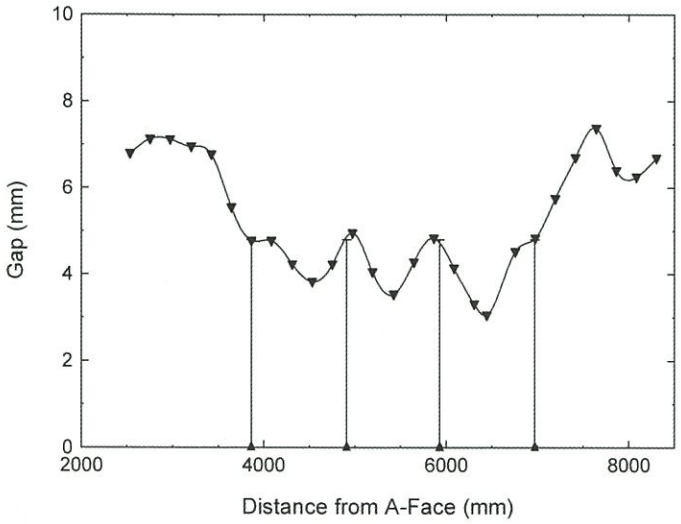

Figure 9: Pressure-to-calandria tube gap profile over the length of a fuel channel. Vertical lines indicate confirmed spacer locations.

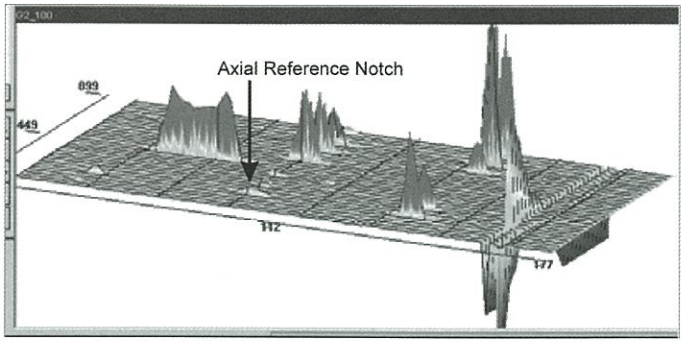

Figure 8: Eddy current isometric C-scan of a portion of the AFCIS calibration tube. The arrow indicates the response from a 6 mm long x 0.15 mm deep calibration notch.

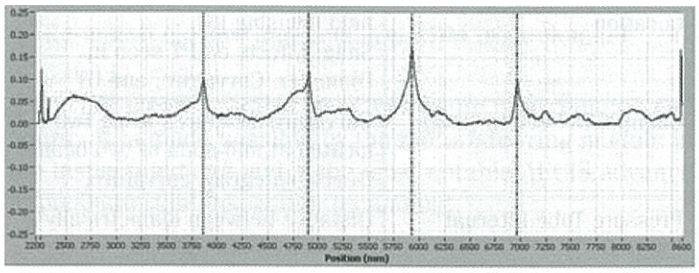

Figure 10: Plot of processed diameter data versus distance from channel E-face used to locate snug garter spring spacers.

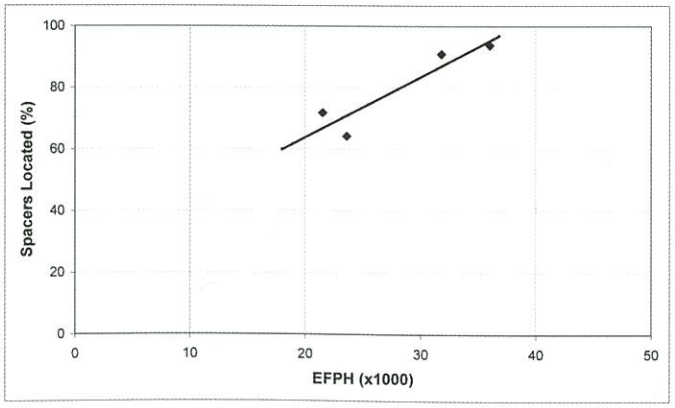

Figure 11: Fraction of snug spacers detected as a function of Effective Full Power Hours.

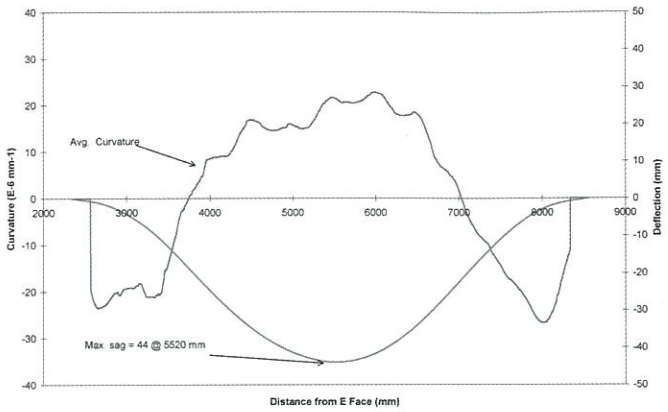

Figure 12: Average curvature and the derived sag profile of a fuel channel after more than 100,000 hours of operation.

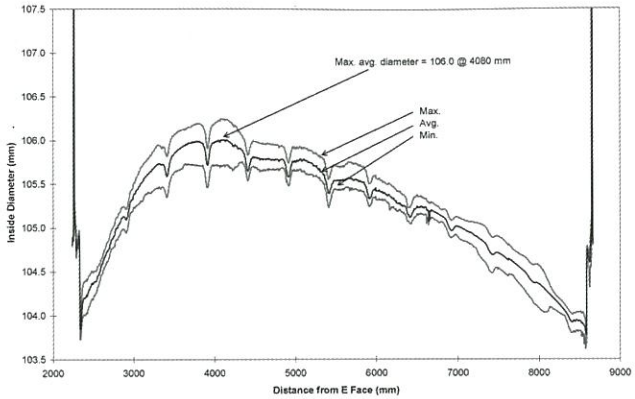

Figure 13: Diameter profiles along a pressure tube which has operated for about 100,000 hours.

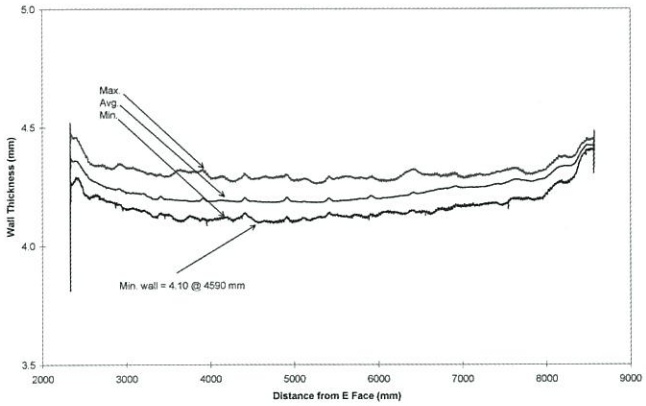

Figure 14: Typical pressure tube wall thickness profiles measured with AFCIS.

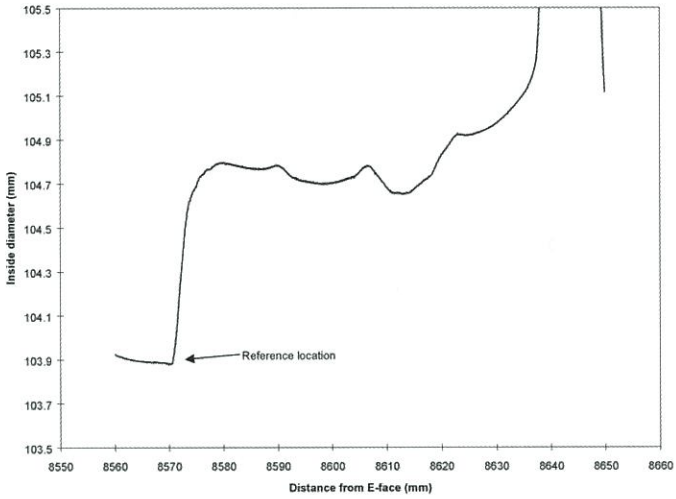

Figure 15: A rolled joint diameter profile and the end-point location for pressure tube length measurement.

Conclusions

1. AFCIS satisfies existing and anticipated CANDU fuel channel inspection requirements.
2. AFCIS provides 100% volumetric inspection of a pressure tube in reasonable time.
3. Quality of AFCIS inspection results is assured by calibration before and after each channel.
4. Inspection of ten channels with one AFCIS primary inspection head has been demonstrated.
5. Modular design of the AFCIS inspection heads and data acquisition system will make it feasible to deal with new inspection requirements and equipment obsolescence when necessary.
6. Eight AFCIS inspections have been completed in the past five years at CANDU sites located around the world.
7. A Multi-Head Sampling Tool delivered by the AFCIS delivery machine has been demonstrated to provide significant savings in time and reduced impact on station resources.

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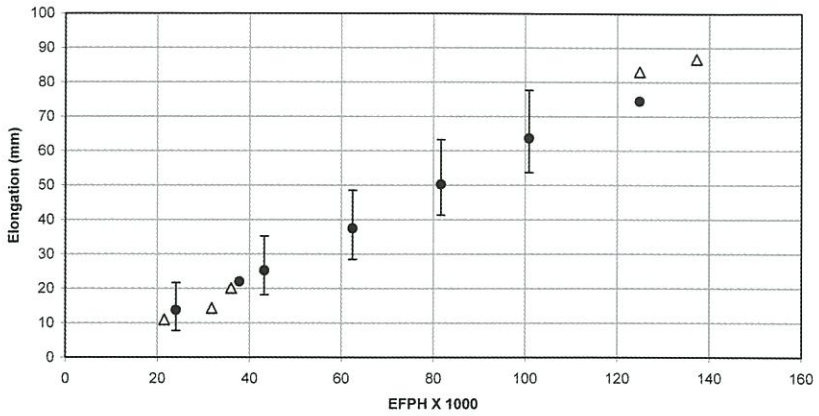


Figure 16: Average elongation of C-Type pressure tubes in CANDU-6 reactors. The triangular data points were obtained with AFCIS.

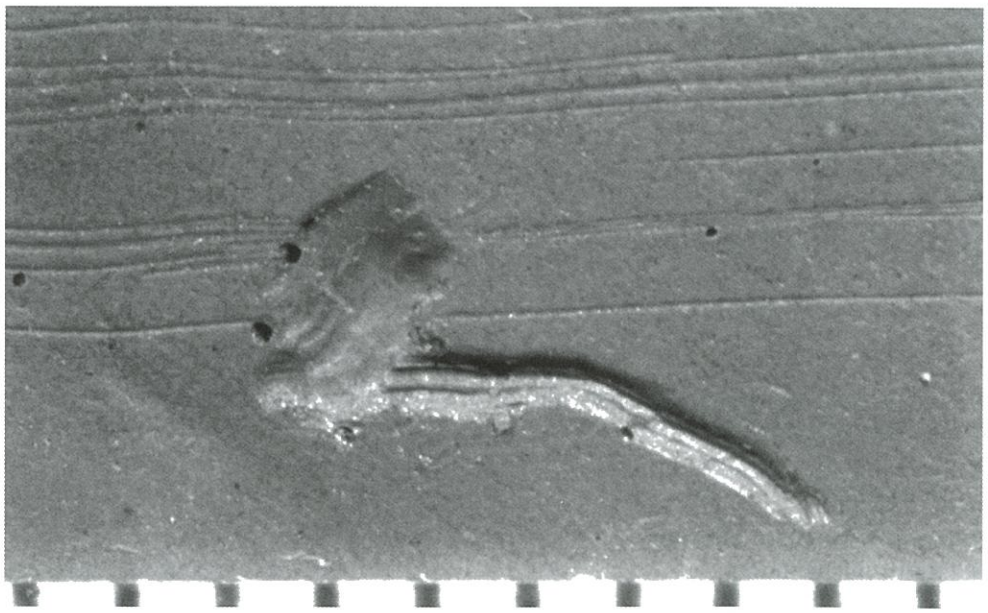


Figure 17: Macrophoto of a replica of a debris flaw obtained with AFCIS. The horizontal marks are fuelling tracks – they are slightly curved due to replica distortion. The flaw is about 6 mm long. The small circular objects are artifacts from debris or bubbles in the replicating compound.

Steam Generator Maintenance and Life Management at Embalse Nuclear Station

by R. Sainz, G. Diaz, H. Sveruga[1] and T.K. Ramakrishnan, S. Azeez[2]

Ed. Note: *The following paper was presented at the 6th CNS International Conference on CANDU Maintenance in Toronto, Ontario, November 2003. It has been slightly edited.*

Abstract

The Embalse Nuclear Station has four steam generators (SGs) with inverted vertical U tubes manufactured by Babcock & Wilcox Canada (B&W). These are main components, both from the operative point of view as the heat transfer from the Primary Heat Transport System (PHTS) to the Secondary System, and from the point of view of safety, as they are the part of the PHTS and its radioactive inventory pressure barrier. In addition, they are one of the most important cost-related elements for potential life extensions.

Maintenance and inspections are carried out in order to maintain a high availability of the SGs, as they have had a positive impact on the operational availability of the plant, and to reduce the tube failure probabilities, thus minimizing the amount of radioactive effluents and taking care of the condition of the main components in order to enable the plant life management and the planning of the plant life extension. The most relevant maintenance activities performed have been the inspections performed on 100% of the tubes every 3 years, the mechanical cleaning of the inside of the tubes, the sludge removal from the secondary side tubesheet, the divider plate replacement, and the inspection of internals of the secondary side.

Thanks to the latter and to the eddy current inspections, the degradation in the U-bend supports was detected early and every effort is being made to repair them shortly. Besides, a life management program has been started covering the entire plant starting with this important component. The Embalse Nuclear Station's SGs show a low percentage of plugged tubes compared to other stations in similar conditions, but they must be monitored continually and systematically if a life extension is intended.

Introduction

Embalse has four identical steam generators (SGs), two on each side of the reactor. These are important components both from the operative point of view as the heat transport from the Primary Heat Transport System (PHTS) to the Secondary System is performed through them and from the point of view of safety, as they are the PHTS and its radioactive inventory pressure barrier. In addition, they are one of the most important cost-related elements for potential life extensions in case of a replacement thereof.

As the Station reaches the end of its design life, the failures and problems resulting from aging may increase. In order to maintain a reliable, safe and economic operation of the plant, the attention paid to these problems must be increased.

This paper presents a general description of the SGs, highlighting the differences with others manufactured by Babcock & Wilcox Canada (B&W) and significant details regarding their manufacturing. Then the most relevant aspects of maintenance and inspections performed and the results are developed. A summary is presented of the current condition of the SGs and of the most important tasks to be carried out to preserve their safe operation. Finally, the conclusions include recommendations to enable reaching the end of the useful life and potential extension.

General Description

The SGs are heat exchangers with vertical boiler and inverted U tubes that use the heat from the reactor to generate light water steam to move the turbine. The main parts of the SG are: primary head, the tubesheet, the tube bundle, the secondary side housing and the steam drum. In the Figure a general sketch of the SG is shown.

They were designed, pursuant to ASME Code Section III Class I, to produce approximately 1033 kg/sec of dry steam. The ratio of actual circulation, defined as the flow of total upwards mass (in the tube bundle) / the steam flow, is 5.9.

1 Nucleoléctrica Argentina S.A.
2 Atomic Energy of Canada Ltd.

A summary of most relevant SGs dimensional, materials and operational data is presented below.

Table 1: Characeristic Data of the SGs

Dimensional and Material Characteristics:

Total Length	19,31 m
Tubesheet Diameter	2.76 m
Steam Drum Diameter	4 m
Steam Drum Length	6,35 m
Number of Tubes (at initial operation)	3542
Tube Inner and Outer Diameter	15,87 / 13.67 mm
Total Heat Exchange Surface	2.749,9 m^2
Total Weight in Normal Operation	549.600 km
Divder Plate	SA-516-Gr. 70
Tube Sheet	SA-508-C1. 2
Primary Head, Preheater Partition Plates Preheater Deflector Plates, Support Plates, Shell, Cone, Steam Drum Shell and Head, Shroud	
U-Tube Bundle (Incoloy 800)	SB-163 Ni Cr Fe
Drum Internals	Acero al carbono
Primary Inlet and Outlet Nozzles	SA-541-C1. 3 20" Sch. 100
Feedwater Nozzle	SA-541-C1. 3 12" Sch. 80
Steam Outlet Nozzle	SA-541-C1. 3 24.125" D.I.

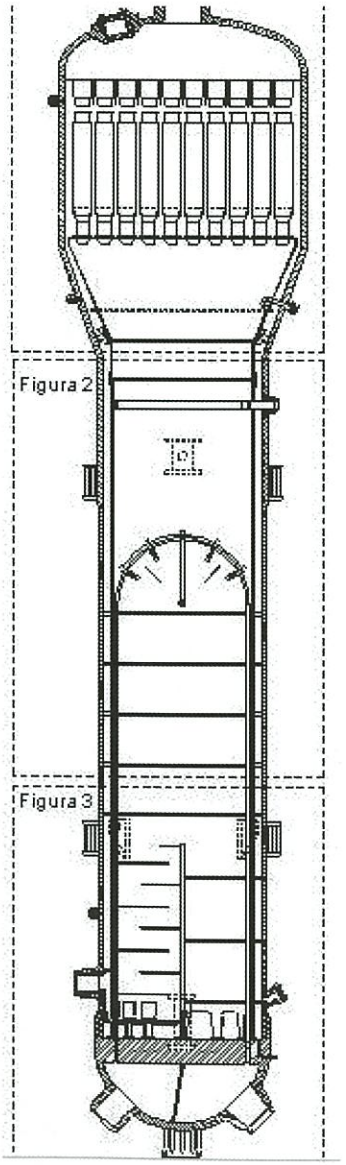
Operational Characteristics

Steam Flow Rate	3,719e^{6}kg/hr
Steam Pressure at Outlet Nozzle	4,69 MPa
Steam Temperature at Outlet Nozzle	260°C
Feedwater Flow Rate	3,719e^{6}kg/hr
Feedwater Inlet Temperature	157°C
Feedwater Pressure	4,826 MPa
D2O Flow Rate	2,73e^{6}kg/hr
D2O Inlet Temperature	309°C
D2O Quality (by wt.) at Inlet	4,4%
D2O Inlet Pressure	9,88 MPa
D2O Outlet Temperature	266,6°C
D2O Outlet Pressure	9,63 MPa
Circulation Ratio	5 (min.)
Continuous Purge Rate	3.374 kg/hr
Steam Quality	0,25% (max.)
Total Heat Transferred (4 SGs)	2061 Mwt
Secondary Side Losses	1 Mwt
D2O Velocity at Tube Outlet	4,3 m/seg

The SGs have been designed in such a way that the normal, abnormal and emergency and failure transient conditions can be tolerated for the specified number of cycles. In the following figure the number of cycles that occurred to date is shown as a percentage of those allowed.

There were two clearly differentiated construction stages of the Embalse SGs: the construction by Babcock & Wilcox Canada (B&W) in its plant in Cambridge, Canada in 1977; and the "in situ" re-tubing of the 4 SGs carried out by B&W in 1980.

The latter was performed as a consequence of deformations found in the tubes (DINGS), after the manufacturing thermal treatment by induced currents. During this "in situ" re-tubing some design changes were introduced which modified some of the original manufacturing processes and which



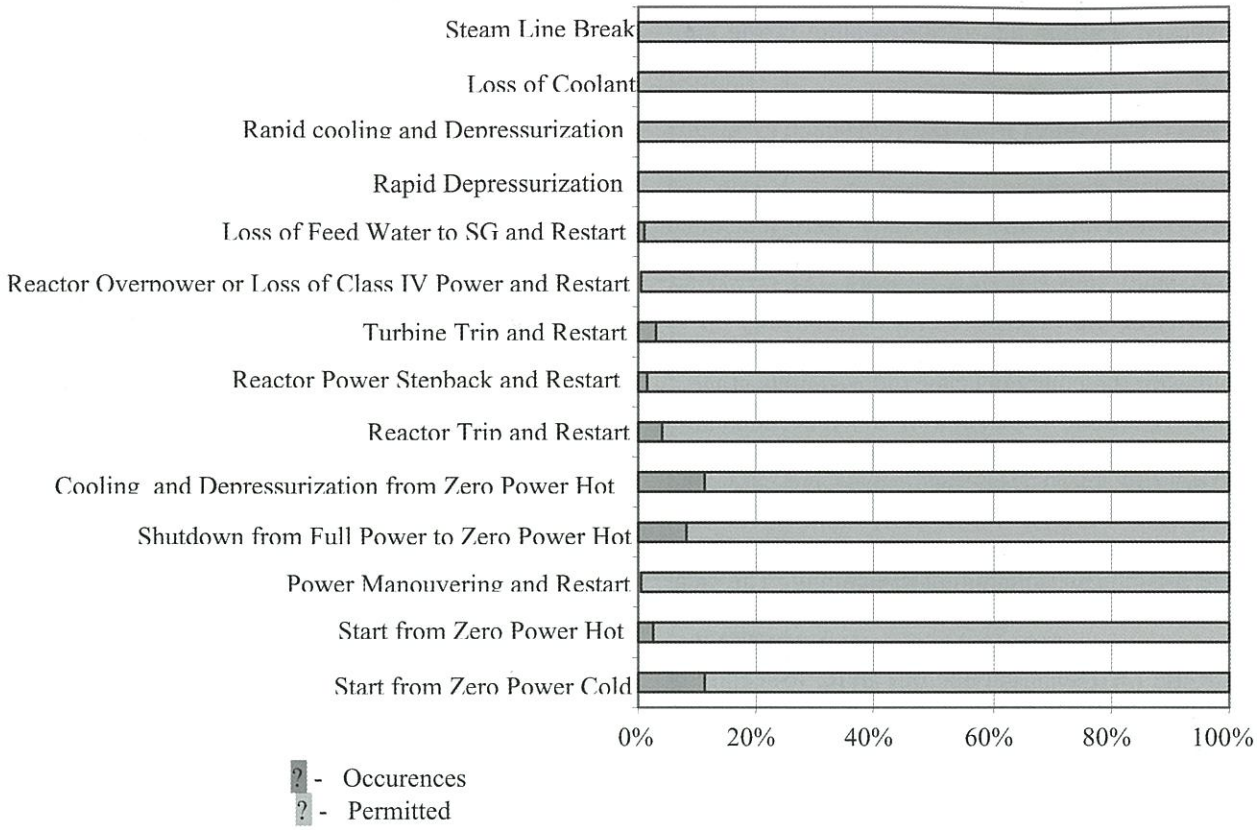


Fig.1. Embalse Steam Generator Transients

could affect or have influence on the aging of the SGs. The most relevant ones were:

- Thermal treatment of the tube bend: The bend was made in cold and the stress relief required to be carried out during the reconstruction equivalent to the original design that included a thermal treatment of the assembly was not performed during the re-tubing.
- Expansion of tubes in the tubesheet: During the manufacturing the tubes were fixed to the sheet by mechanical rolling and subsequent fillet welds for sealing purposes. In the re-tubing they were fixed by hydraulic expansion and the seal welding was "Flush weld". This diminishes the residual stresses in the transition zone of the rolling of tubes.
- Expansion of the tubes in the thermal plate. In the original design the tube rolling was performed and B&W carried out a relief of residual stresses introduced during same, by means of a thermal treatment of the finished component at a temperature of approximately 600ºC for 15 hours. Stress relieving was not performed during the re-tubing and re-assembly.
- The supporting plates, the pre-heater baffle plates and the secondary divider plate were installed in their positions by "shroud welded channels" instead of welding them directly to the shroud as in the original design.
- The material (carbon steel) and thickness (1 ") of the supporting plates remained unchanged. (In Gentilly 2 and Point Lepreau they were changed to stainless steel 410 SS and to 7/8" thick). The "gap/hole clearance" between tubes and supporting plates were increased in order to facilitate the "in situ" assembly, and the holes on both faces of the supporting plates were also given a taper of 3º to enable the rotation of the tubes with the changes in temperature.
- U-bend supporting bars: In the case of Embalse the material remained the same as in the original design, that is, carbon steel, while in other stations stainless steel supporting bars were used.
- Modification of the design of the EWS head to accommodate the large difference in temperature between the head and the shroud and also to avoid the collapse of steam and the subsequent waterhammer loads under certain operation conditions.

The re-tubing was performed in 1980 and the most relevant works were:

1) Disassembly: A cut was made in the steam drum at the EWS nozzle height using a portable milling machine. Then the steam drum assembly and the moisture separators were laterally removed from the generator. Then the U bend supports and the upper bend section of the tube bundle were disassembled by cutting and grinding,

and the straight sections of the previously cut tubes were removed. Cutting and disassembling of the supporting plates, baffle plates, secondary divider plate, shroud sections, thermal plate, etc. and the removal of the tube "ends/tails" from the tubesheet by means of hydraulic devices were also carried out. In parallel the primary side divider plate was removed, the seal welding between tube and tubesheet were machined and removed, the tubesheet holes were conditioned, and inspections and tests were performed to ensure the integrity of the tubesheet and the housing, up to the EWSS nozzle height, and the primary side top head thus releasing the component for the assembly stage.

2) Assembly: Hydraulic expansion of the tube ends was performed fixing the two ends thereof in the tubesheet on the primary face. Then the coarse cut after the mounting and the microcut with special mechanical cutting tools were performed as well as cosmetic tasks such as brushing, trimming and cleaning. The seal welds between tubes and tubesheet were performed by means of automatic TIG machines with INCONEL 600. Later on, the activities carried out were: assembly of the 3rd and 4th stages of the shroud, installation of the sleeve and the EWS header, installation and adjustment of the steam drum, and the preheating, welding and stress relief. To check the integrity of the weld between the tubes and the tubesheet, the secondary side was pressurized with He at 60 psig for 12 hours before the final expansion of the tubes once the installation of the secondary side was completed. The final expansion of the tubes was performed by hydraulic expansion at the height of the face of the secondary side tubesheet, about 3 mm lower. After completing the final expansion of the tubes, the hydrostatic pressure test was performed at 950 psig in the secondary side and at 2000 psig in the primary side.

The INCOLOY 800 tubes were manufactured by cold extrusion with intermediate thermal treatments at 980°C.

Steam Generators Maintenance And Inspections

The probability and consequence of failures in the SGs tubes can be reduced by means of adequate and periodical inspections. Tube inspection requirements vary in different countries because:

- due to different designs and materials, they are susceptible to different types of aging-related degradation. Some types of degradation are easy to detect or lead to consequences that are less severe for safety than other types of degradation.
- an appropriate safety level can only be maintained with an adequate combination of inspections and acceptance requirements.
- the frequency and scope of the inspection frequently increase if problems are observed.

The inspection methods and techniques used at Embalse are those recommended by CAN CSA-N285.4-M1978 standard (and updates CAN/CSA-N285.4-94) and whatever practice and experience may suggest. This requires an inspection of 25% of the tubes in each SG after they are installed and before starting operation. The sample for the initial inspection and the frequency is of 10% of the tubes in a generator of each unit every 5 years. This increases when significant degradation is detected. The Canadian standard requires the use of alternative techniques for "Non-Destructive Tests" to detect defects that are not completely detected by the inspection technique using the standard "bobbin coil eddy current". It also requires that a section of one tube be removed from a SG for a metallurgical examination once every 5 years.

In practice, the operators exceed these requirements and prepare specific inspection and testing programs. At Embalse an inspection program, supplied by the manufacturer 18-PIPD "Periodic Inspection Program Document", which complies with the Canadian standard, is being used and is the basis for the preparation of the PI 1073 "In-Service Inspection Program for Embalse Nuclear Station".

In 1997 a program for the inspection of 100% of the tubes every 3 years was implemented. In the case of Embalse, tube removal has been performed and another tube removal is planned for the March / April, 2004 scheduled outage in order to analyze pitting in the sludge area and fretting in the U-bend.

The inspection techniques for the SG tubes include eddy current methods, ultrasonic techniques and destructive testing. The eddy current method is the most reliable because it performs well in thin wall tubes. At Embalse circumferential probes are used, and in certain cases, the rotating probes (MRPS) are used when defects are detected, mainly in the U-bend area, as a better degradation characterization can be obtained with them.

The following is a chronological synthesis of the inspections performed in the SGs at Embalse.

The plugging criteria are those of ASME Code and the Canadian standard: "the wear estimated before the next scheduled outage greater than 40% " (wall thickness thinning greater than 40% in the next outage). This method requires knowing the degradation increase rate, which makes it somewhat complicated to use. At Embalse the evaluation is carried out taking into account the tube with signals database, and all the antecedents of the inspections performed that have shown defects in the tubes. The data generally available are wear percentage and failure location. Something that is very useful for taking decisions but most times is unknown is the geometry of the defect, the orientation and the dimensions. These data arise from the analysis performed by the induced current evaluation personnel and the component follow-up personnel. Then the

Table 2: SGs Tube Inspections Performed

Month/Year	SG	Objective	% tubes
1982	1-4	Preservice Inspection	100%
04/86	3	Tube X47 Y98 leak	0,42%
10/86	3	- Extraction of tube X45-Y98 with EC signals for destructive testing and for plugging - Inservice Inspection of other tubes	2,54%
08/87	2	Tube X35 Y14 leak	0,76%
08/89	2 y 4	Inservie Inspection (ISI)	8,42%
01/91	3	- Tube X48 Y99 leak - ISI	1,41%
09/91	1	- ISI	3,86%
12/92	1	- Tube X04 Y45 leak	0,56%
10/92	4	- ISI - Tube X55 Y52 Removal	11,01%
11/95	1 y 3	- ISI	23,04%
07/96	2	- Tube X32 Y13 leak	1,98%
09/96	3	- Tube X23 Y52 leak	9,46%
05/97	2 y 4	- ISI	100%
08/98	3	- Tube X23 Y34 leak	10,98%
11/98	1 y 3	- ISI	100%
10/00	2 y 4	- ISI	100%
10/01	3	- Tube X21 Y20 leak	9,89%
05/02	1 y 3	- ISI	100%

wear percentages observed in the same place on the tube in the different inspections are compared.

It should be pointed out with regard to the evolution of signals:

- many of the tubes plugged due to leaks did not show signals before the failure;
- many of the signals found are not found again in subsequent tube inspections.

Checks are performed for increase of wear during the latest inspections. In case of significant wall thickness thinning (of approximately 40%), the signal evaluation is re-checked and the tube is re-inspected. If the result indicates that in the time until the next inspection the evolution of the failure will exceed 40% in tube wall thickness thinning, the tube is preventively plugged.

The first tube plugging in the SGs at Embalse was made with the explosive plugs method (11 tubes). These are no longer used worldwide because of the appearance of cracks. As of 1995 rolled expansive plugs started to be used, which are much simpler and faster to be installed than the explosive ones. To date no problems associated with the use of this type of plug have been recorded in the Embalse SGs. However, some problems have been detected in other stations (Three Mile Island) related to leaks through them that cause damages in the plugged tube and in the neighbouring tubes. For this reason, some suppliers have stopped manufacturing them and are being replaced by welded plugs. The decision has been taken to replace the explosive plugs with welded plugs.

The following table shows a summary of the main maintenance activities and modifications carried out to date in the SGs at Embalse.

Reduction of Pressure in the SGs

Due to the sustained increase in the temperature of the primary coolant at the reactor inlet header because of PTHS aging, along with other factors, the trip margins have been reduced from the initial design conditions.

To recover the initial design trip margins the SGs operating pressure was reduced in order to diminish the coolant's temperature at the outlet so that the station could get to the 2000 scheduled outage without exceeding the temperature limit of 270°C. The pressure was reduced by 1 kg/cm^2, providing a temperature reduction of approximately 1°C.

Internal Cleaning of the SG Tubes

During the 2000 scheduled outage the internal cleaning of the SGs tubes was performed using the system designed by SIEMENS called SIVABLAST. It consisted of blasting the

Table 3: Main Maintenance Activities and Modifications

Year	Activity	Component	Reason
2000	*Pressure Reduction in SGs*	Secondary Side of the SGs – Steam System	Sustained increase in PHTS inlet header temperature
2000	*SIVABLAST – SGs tube inside cleaning to remove magnetite*	SGs Tube internals	Loss of heat transfer efficiency
2002	Divider Plate replacement	SGs Primary head	Loss of efficiency due to passing through the gaps in the segmented divider plates. Potential loss of integrity in case of LOCA
2002	"Water lancing"	Cleaning and removal of sludge at the secondary side of the tube sheet	Eliminate tube pitting in the sludge area above the tube sheet. Improve heat transfer surface area

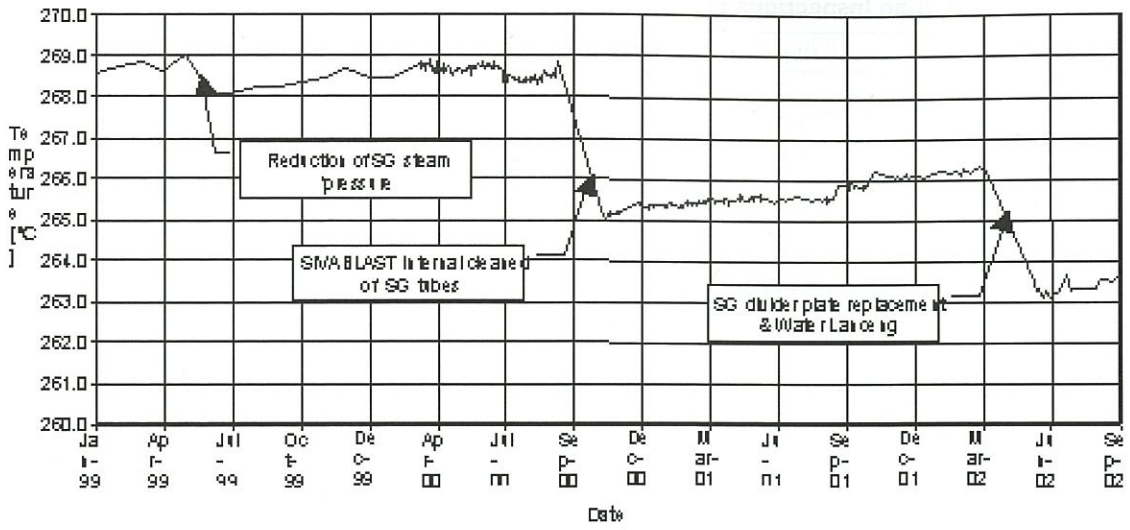


Figure 2: Average Reactor inlet Header Temperature

tube inner surface, with 0.2 mm diameter stainless steel balls with air at a pressure of 6 kg/cm^2 through the injection nozzles. These are coupled to a pair of tubes by means of a computerized manipulator while collecting the balls and the removed oxide (magnetite) at the other end of the tubes. Thereafter, the stainless steel balls and the oxide were separated from each other, and the balls were used again in the injection circuit. The oxide removed (magnetite) was taken to the collecting vessels located in special high exposure shieldings and then to the high radioactivity waste bins. The amount of magnetite removed was 2,602 kg from 10,387 blasted tubes. Considering that the area in each tube is 0.8 m^2, and the density of the magnetite is 5 kg/dm^3, the estimate is that a thickness of 0.05 mm was removed.

After the startup of the station it was observed that the thermal-hydraulic conditions of the Primary Heat Transport system appreciably improved and that the live steam pressure that had been reduced previously could be normalized. The reactor inlet temperature decreased approximately 4.5°C, the PHTS flow increased 4% and the quality at the channels outlet dropped from 3% to 1.3%.

Divider Plate Replacement

During the 2002 scheduled outage the divider plates in the four Embalse SGs were replaced. The original plates formed by 13 bolted segments, bolted and fixed to the head, were dismantled and a new ones made up of 4 segments were installed and welded in situ to the head, forming one single floating piece convex towards the hot side. The task was performed by personnel from Argentine companies with the technical advise of B&W's personnel.

With the performance of this task three main objectives were attained:

i) the undesired passage of water between the cold and hot legs of the SG at the level of the DPs and through the existing tracks between plates and bolts joints produced by erosion was eliminated, thus obtaining a substantial decrease of the primary coolant temperature at the inlet into the reactor, a lower level in the pressurizer and an increase of plant power.

ii) due to this decrease in temperature a better coverage of the trip is attained in the slow loss of regulation events. This is due to the lowering of the inlet temperature and of the quality at the outlet of the channels with which it is more difficult to reach the critical channel power at the moment of shutdown system trip due to high neutron power.

iii) the probability of loose parts due to a detachment of components of the segmented DP caused by erosion corrosion is minimized. Besides in case of a LOCA, the new DP, unlike the old segmented DP, would be removed from its position but would stay, in just one piece in the SG primary head, while the segmented one could get to the PHTS main pumps thereby worsening the situation.

Mechanical Cleaning (Water Lancing) of the Sludge in the SG Secondary Side

The sludge accumulation in the SGs secondary side was detected by the eddy current inspections. The sludge pile reached approximately 38 cm high above the secondary side tube sheet in the center of the hot leg . The presence of this sludge has several negative effects for the plant. Among these, the more important ones are the corrosion mechanisms that occur in this area and the loss of the SGs efficiency.

These were eliminated almost completely by "Water Lancing", a mechanical cleaning with pressurized water jets, during the 2002 scheduled outage. Three hundred twenty kilograms of sludge were removed (wet weight). After the washing visual inspections were carried out to determine the level of remaining sludge. In SG 2 and 4 there remained localized piles of less than 2 inches high and in SG 1 and 3 only flakes were

	Steam Generator				Total of tubes plugged
	SG#1	SG#2	SG#3	SG#4	
During Preservice			1		1
Due to leakage	1	2	5 (*)		8
Preventive	19	16	19	2	56
Due to partial extraction			1	1	2
Total	20	18	26	3	67

Table 4: Current Status of Tube Plugging

(*) 3 out of 5 of these cases were due to fretting in the U-bend zone.

observed in the places where supposedly the pile was located but no other accumulation of sludge in the tubesheet was detected. The tasks were performed and supervised by B&W, the coordination of works was carried out by NASA along with the rest of the activities on the SGs.

The trend graph, attached below, shows the effect of the four maintenance activities described above on the primary coolant's temperature at the reactor inlet header.

Current Condition Of Embalse SGs

Tubes and supports

At the start of operation in April 1982 a certain number of tubes had been already plugged due to design changes during reconstruction (These tubes shall not be taken into account in the statistic analysis of in service degraded tubes). Although during the inaugural eddy current inspection they showed signs of defects caused during the installation of the tubes, none of them was considered relevant enough to be considered for plugging. The following table summarizes the current status of SGs plugging.

In the following figures the plugging history is shown for each SG. SGs 1 and 3 have had a similar plugging history along the 20 years of service. With regard to SGs 2 and 4, the behaviour was independent in each case. While in SG2 there may be relevant degradation mechanisms different from those in SG1 and SG3, SG4 is in an early stage in which it is not possible to determine which is the dominant mechanism.

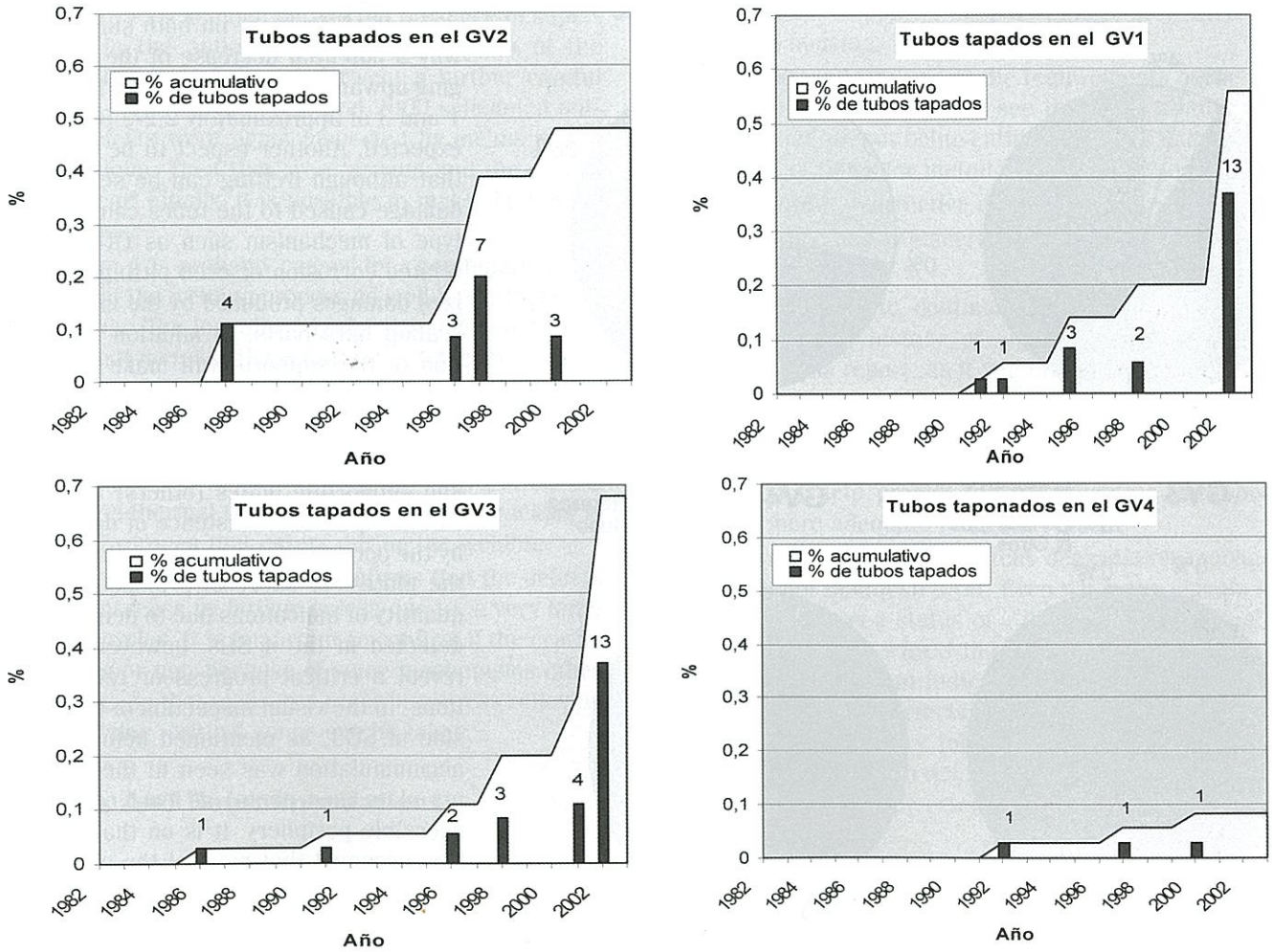


Figure 3. History of Tube Plugging

The following table shows the leaking tubes and leak locations in each SG.

SG	Tube	Year	Leak Location
SG1	X04 - Y45	Dec/92	U-Bend
SG2	X35 - Y14	Aug/87	Thermal Plate
	X32 – Y13	Jul/96	Thermal Plate
SG3	X47 – Y98	Apr/86	Thermal Plate
	X48 – Y99	Jan/91	Thermal Plate
	X23 – Y52	Sept/96	U-Bend
	X23 – Y34	Aug/98	U-Bend
	X21 – Y20	Nov/01	U-Bend

Table 5: Leaking Tubes and Leak Locations

The following figures illustrate for each SG the percentage of eddy current signals that occurred in the critical areas, such as the tubesheet, the U bundle or the thermal plate. From the analyses of these charts it is concluded results that SGs 1and 3 are dominated by the same tube degradation mechanism.

The visual inspections performed on SG3 during the 2002 outage show the existence of fretting in the area of the U bundle supports on the outer surface of the tubes.

The top picture shows one end of the FAC affected scallop bar removed from this SG, while the other two show an increase in the clearance between the scallop bars and the tubes. This is due to Flow Induced Vibrations (FIV) and to the Flow Accelerated Corrosion (FAC) of the supports that generate friction between the Incoloy 800 tubes and the carbon steel supports. These two materials greatly differ in their hardness producing the preferencial wear in the supports. Besides, the process is accelerated by the hard oxide particles layer that form on the carbon steel surface. This degradation mechanism is selflimiting in most cases and it may stop once the surfaces are no longer in contact as a result of the wear on both surfaces. This is why a potential decrease of the current plugging upward trend observed in Figure 3 in SGs 1 and 3 of approximately 2,2-2,8 tubes/year is expected. Another aspect to be considered is that although fretting can be selflimiting, the damage caused to the tubes can trigger other type of mechanism such as ODSSC, fatigue-related corrosion or even pitting due to localized damages produced by the impact of loose scallop bars parts. In addition, the degradation of the supports will make the structure less rigid and more susceptible to vibrations that may initiate fretting in other places.

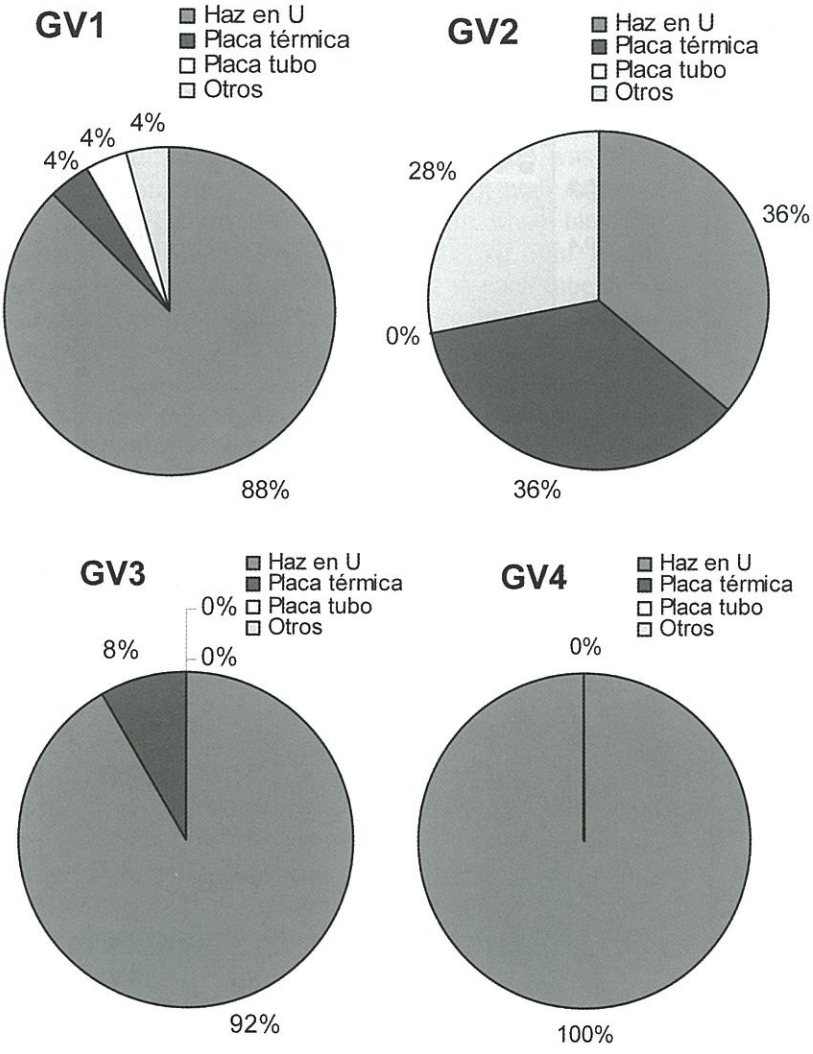


Figure 4: Eddy Current Signals Percentage in The Criticals Sectors

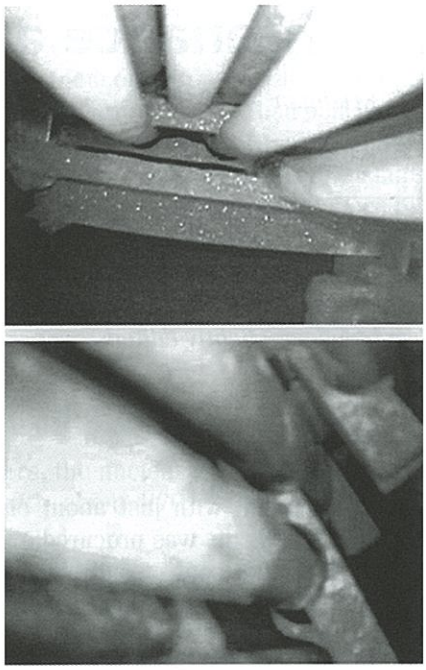
The signals on the tubesheet, thermal plates and supporting plates (others) in SG1 reveal also the potential existence of denting caused by the accummulation of corrosion products in the plates. In successive inspections a large quantity of indications due to denting has been detected in the 4 SGs, however they do not reveal a critical progress or relevant indications. In the visual inspection of the secondary side of SG3, as mentioned before, no sludge accummulation was seen in the top supporting plate (see photo) at least on the visually accesible periphery. It is on that plate where it is assumed that most of the sludge accummulations should be.

During the cleaning of the tubesheet performed in April 2002 outage, a certain degree

of accummulation of up to 400 mm was observed on the hot leg but not on the tubes that show signals. This leads to the assupmtion that there would not be relevant signals due to pitting or cracking (stress corrosion) aggravated by the sludge.

SG2 showed a larger quantity of signals in the thermal plate and in the supporting plates. Apart from the denting that promotes the ODSCC, in this case the signals could be due to external degradation of the tubes intensified by the accummulation of sludge with impurities that foster pitting and cracking (stress corrosion).

A history of the signals observed in the Embalse SGs is being prepared to determine the evolution of the indications observed in the different inspections and to make a more systematic planning of the inspections.



Lateral supports

During the 1995 scheduled outage the presence of superficial cracks in the anti-seismic lateral supports of the SGs was confirmed and they underwent a further careful examination. During the 1998 and 2000 scheduled outages these defects were again inspected by means of the particle technique. Then they were ground and the cracks did not reappear. Finally, it is possible to make the following observations:

- The problem was probably caused by a combination of a deficiency in the welding process as well as in the material selection. The low alloy steels with low contents of elements that increase the resistance, as the one used in the supports (ASTM A-508 GR II), are susceptible to the two phenomena that may have originated the intergranular microcracks. The stress relieve cracking are cracks that are generated in the corse grain ZAC during the post-welding thermal treatment and the cold cracking is caused by hydrogen that enters during the welding.
- The fracture mechanics review confirms that the defects could not increase by fatigue unless due to a very large number of cycles. It is important to confirm if the cracks are growing or not, because of some mechanisms other than fatigue, so that measures regarding stress relieving and minimizing critical zones can be taken.

Conclusions And Recommendations

The Steam Generators at Embalse Nuclear Station have had a very good performance thanks to thorough inspections, checks and preventive and corrective maintenance works carried out with the aim of maintaining the required services and safety margins. The percentage of plugged tubes over the total number is 0.47%, 8 for leaks and 59 preventively.

As the operational requirements for the Embalse SGs are very close to their maximum capacity and to the rapid increase of plugged tubes due to fretting, the repair of the SGs U-bend supports is a critical task.tArrangements are being made to engage the engineering services of B&W together with AECL for the design of the supports and for technical assistance for the supply and installation of these supports in the SGs during the next scheduled outage in 2004.

In addition the intent is to carry out an integrated maintenance plan for the SGs that includes and centralizes all the inspections, maintenance tasks and modifications performed on them, thus enabling their economic and reliable life management. This plan must systematically include:

- the inspections and controls of tubes, feeding nozzles, anti-seismic supports, support plates, preheaters baffles and housing.
- a review and analysis of the requirements of the Code and Standards in order to see the applicability of the points that are not being entirely met. For example, the removal of tubes for metallographic analyses.
- preventive – corrective maintenance program.
- assistance and engineering evaluation.

It is important to continue with the development and updating of the history of signals prepared during the drafting of this report, as it will enable the improvement of the inspection plan. Updating of data for each tube with a relevant signal plus a better knowledge of the factors that cause the degradation mechanisms and of their growth rates would help predict the behaviour of the tubes and produce more adequate plugging criteria.

There could exist other latent degradation mechanisms that have not manifested yet. Even when the signals do not reveal an advanced status of "denting" and "pitting", it is useful to continue with a thorough follow-up and mapping of the most important indications so that they can be correlated with future defects. With the development of these activities, unnecessary tube plugging will be avoided and the SGs will be able to reach the end of their design life and possibly have their life extended with the station generating at its full capacity.

Electrical and C&I Maintenance at Cernavoda NPP

by S. Hada, S. Voiculescu and D. Bigu[1] and V.S. Krishnan[2]

Ed. Note: *The following paper was presented at the 6th CNS International CANDU Mainenance conference in toronto, Ontario, November 2003. It has been slightly edited.*

Abstract

Cernavoda NPP is a relatively new CANDU plant with just about eight years of commercial operation. However much of the plant equipment and components was procured over 17 years ago. Since commissioning in December 1996, a number of electrical, and control and instrumentation (C&I) component failures were encountered. This paper describes the some of these problems and corrective actions.

1. Introduction

Maintenance plays an important role to support the achievement of Cernavoda NPP objectives. For this reason the results of maintenance activities are routinely analyzed to correct equipment deficiencies and to enhance the work methods. Cernavoda NPP is a young plant with only eight years of commercial operation. However much of the plant equipment was procured over 16 years ago.

The biggest challenge has been to properly maintain this operationally young plant with relatively old equipment and to enhance the maintenance methods. Major equipment that required replacement in the past few years were:

- Medium Voltage Transformers (15)
- Chiller Units (all 4); and
- Screens in Raw Water Filtering System (all 6)

Other component problems encountered were:

- High rate of failure of electronic cards;
- Sticking of Rosemount transmitters;
- Lack of the reliability of electrical breakers from the Power Centers;
- Degradation of cooling oil to the Main Output Transformers;
- Short-circuit of Main Output Transformers due to the Fire Detection System;
- Malfunction of locally manufactured transmitters;
- Malfunction of MVs in the Feedwater System;
- Failure of the Sewage System pumps;
- False indications and loss of vacuum to some transmitters; and
- Short-circuit of the breakers of the Liquid Zone Control pumps.

In addition, root cause analysis showed that human error was also a contributor to some of the failures. About 75% of Cernavoda NPP events were generated by equipment failures; the remainder by human errors. To help reduce human errors, Cernavoda NPP has instituted several programs and procedures. Some of these were developed and issued following incidents of human error, and some are based on operational experience at other NPPs.

Some of the programs and procedures to improve the maintenance of the station are listed below:

- Optimization of the Preventive Maintenance Program;
- Enhancement of the Predictive Maintenance Program;
- EQ Program;
- Training Programs for Workers and Supervisors; and
- Work Protection and Field monitoring procedures.

This paper describes how the above maintenance problems were solved, and how the maintenance programs and procedures are being applied to electrical and control and instrument (C&I) systems and components at Cernavoda NPP.

2. Component Failures And Fixes

2.1 High Rate of Failure of Electronic Cards

In the first few years of commercial operation, maintenance technicians reported a number of failures of the safety systems and DCCs caused by electronic cards. Upon investigation, it was found that because of their age, electrolytic capacitors in

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power supplies had failed, producing short-circuits and other damages.

Following an analysis of the impact of this problem on the plant systems, it was decided to replace all the electrolytic capacitors in DCCs, PDCs, Safety Systems and other systems (Public Address System, Main Control Room Annunciation, etc.). The replacement of the electrolytic capacitors was done during one of the early outages. The current plan is to perform a benefit-cost analysis of periodic replacement of the capacitors. If justified, call-up work requests will be issued to replace the capacitors periodically.

2.2 Sticking of Rosemount transmitters

To monitor and transmit process parameters, the nuclear side of the Cernavoda Plant is provided with about 270 Rosemount transmitters.

During plant commissioning difficulties were experienced with safety systems due to the Rosemount transmitters. They frequently stuck to a value within their range. This anomaly was detected only during the OMTs performed on these systems.

Information obtained from the manufacturer revealed that cells with the serial number below a certain value (1662628) had deficiencies related to problems with their manufacturing quality control process. Therefore it was decided to replace all such transmitters in the safety systems. A program was also put in place to monitor other transmitters.

2.3 Lack of Reliability of Electrical breakers in Power Centers

To supply power the multitude of the electrical equipment, the plant is provided for 0.4 kV System with Romanian equipment made in the late 70's and early 80's by "Automatica" Company. These Power Centers contained "OROMAX " type breakers. Because of their frequent failures, known from pre-commissioning and commissioning times, and the lack of the spare parts it was decided to replace them with a new equipment made also by the same company but under ABB licence.

Figure 4 shows the overview and the detail of the old equipment. This equipment contains fine mechanisms, very

sensitive to shocks and vibrations. For this reason, many man-hours were spent trying to repair and regulate them.

Figure 5 shows the new equipment based on new technology. To investigate deficiencies, verify settings or to change them a PLC is required. This new technology makes work easier and shortens maintenance intervention.

CNE-PROD Technical and Engineering Departments have developed design changes and monitored, together with Quality Assurance Department, the manufacturing process. An experienced local contractor was selected to implement this design change. Because of the amount of work involved, the Electrical Maintenance Department supervised the quality and implementation of the work.

The first three Power Centers changed in the 2003 Outage were 5433-BUL, 5433-BUS and 5433-BUU. The work was performed during three weeks, in two shifts around the clock.

Electrical Maintenance Department performed the final verification of the work and settings, and the commissioning.

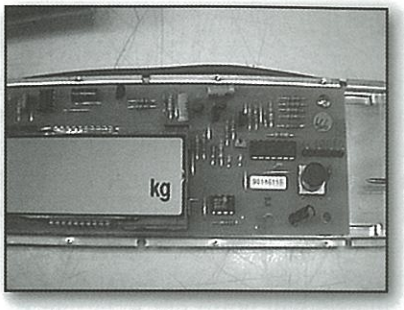

Figure 1: Photograph of a Typical Electronic Card

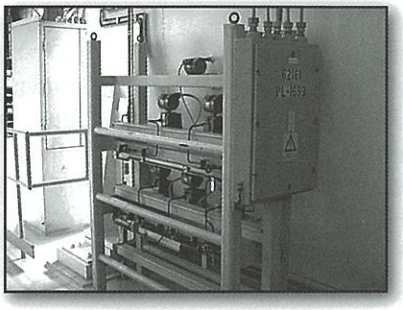

Figure 2: Rosemount transmitter arrangement

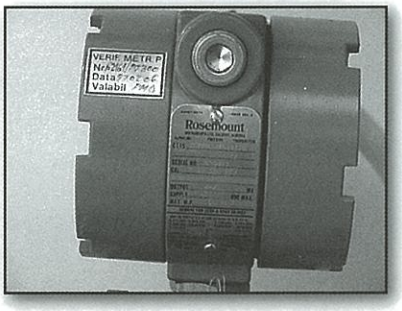

Figure 3: Photograph of a typical Rosemount transmitter

2.4 Degradation of Cooling Oil to the Main Output Transformers

The power produced at Cernavoda NPP is routed through two 24/400 kV Romanian made transformers to the 400 kV Grid Station. Twenty-four (24) cooling fans and eight (8) oil pumps cool the oil in each transformer.

During the early outages, tests and measurements performed showed a degradation of the cooling oil. To keep the oil quality under control, the oil was filtered to remove impurities and moisture. The manufacturer recommended a periodic analysis of the oil. An analysis system was established. Oil samples are now analyzed for density, moisture, impurities and gases. The manufacturer also recommended replacing the oil pumps with uprated ones. The work was performed during two outages. Changes were made to the odd transformer (5114-T01) in one outage and to the even transformer (5114-T02) in the other. The work was done in the 2002 and 2003 outages, with the assistance of the manufacturer and some Romanian Research Institutes.

2.5 Short-circuit of Main Output Transformers due to the Fire Detection System

The Main Output Transformers (T01 & T02) and the Services Transformers (T03 & T04) are provided with a Fire Detection System that consists of temperature detectors set to protect the transformer and to alarm the operators in case of a fire. These fire detectors were initially set to 70 oC. During commissioning trips of the transformers occurred because of the trip logic and the ventilation interlock. It was decided to cancel this logic but that turned out to be an incorrect decision.

The last two summers in East Europe were very hot and on one occasion in 2001 summer the temperature was higher than the set point value. The deluge valves opened and the transformers were flooded. A short circuit was produced between a 400 kV phase (phase C) and ground because of the water quality. Fortunately the transformer protection worked preventing further damage.

Following root-cause analysis, the solution adopted was to return to the initial logic and to change all the fire detectors to avoid the problems from commissioning. The old detectors have now been replaced with new detectors and the set point at 100 oC. These new detectors are expected to prevent further occurrence of the event.

2.6 Malfunction of Locally Manufactured Transmitters

Some of the plant systems were provided with Romanian transmitters. They were in the Water Treatment Plant, Starting Thermal Plant, Pump House, Screen House, etc. These transmitters were made at the end of 70's and beginning of 80's. Because of their age, frequent failures and the lack of spare parts, it was decided to change them with new generation ones.

They have been changed with German Endress-Hauser transmitters. "Smart" Rosemount (Figure 8) have been installed in the place of the old Italian Nuovo Pignone on the Thermal Cycle Drain System.

2.7 Malfunction of MOVs in the Feedwater System

During early operation of the plant, the feedwater systems MVs had to be repaired frequently, because they tripped on thermal relay. The problem persisted. Analysis of the results, using the newly bought Liberty Test Equipment and the command logic, showed the following.

When the operator changed the key (Figure 9) from "Auto" position to "Closed" position and back to "Auto" to perform the changeover, the key passed through "Stop" position and gave an impulse to the valve, which stuck in the seat.

Figure 10 shows the closed control loop for main feed-

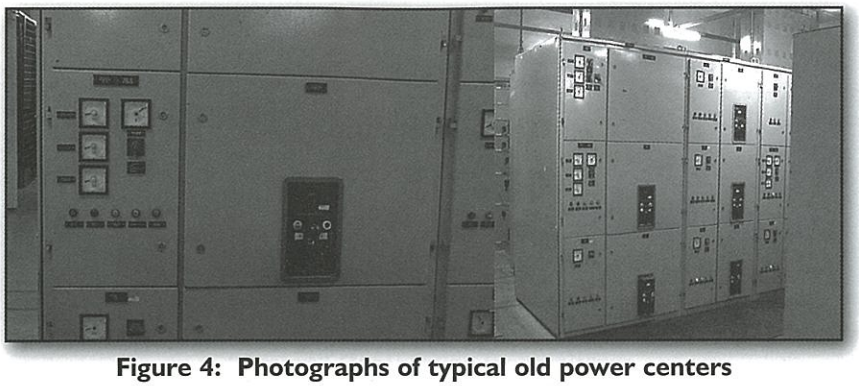

Figure 4: Photographs of typical old power centers

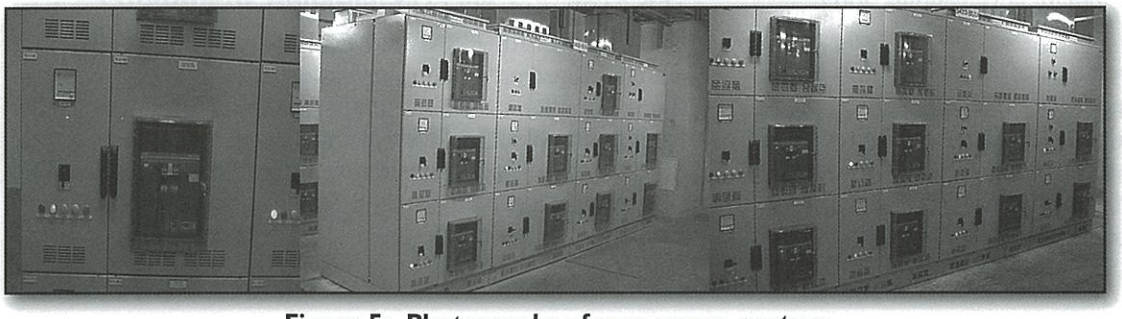

Figure 5: Photographs of new power centers

water motor operated valve. As can be seen from closing control loop when the HS goes to the CLOSE position the relay 3C is energized and the valve goes to the close position until the torque switch closes the torque switch contact TSC. When the torque switch contact closes, the relay 3CX is energized, the contact 3CX 1-2 opens and the contact 3CX 3-4 closes. The relay 3CX remains energized until the HS goes through the STOP position when the relay 3CX loses the power supply and the relay 3C could be again energized. This means that the control room operator can initiate a closing signal to a valve that is already in the seat and the valve will remain closed.

Figure 11 shows the new closed control loop that was implemented and tested temporarily for one motor operated valve. The difference between old control circuit and the new control circuit is that the relay 3CX is energized with permanently 48 Vcc through LSC (limit switch contact) and 3CX 3-4 contact. In this situation the supply of the relay 3CX does not depend on the position of the hand switch. When the valve receives a closing signal the relay 3C is energized and the valve goes to close position. The contact LSC closes before the contact TSC. When the torque switch closes, the relay 3CX is energized (the contact 3CX 1-2 opens and the contact 3CX 3-4 closes). In this situation the relay 3CX will be energized until LSC opens. The limit switch contact opens only when the valve will receive an opening signal and it will go to the open position.

The change was approved by the Engineering Department and implemented after successful testing on one of the valves.

2.8 Failure of the Sewage System pumps

Unit 1 Sewage System is provided with equipment made by a Romanian company. During commercial operation much work had to be done on these pumps. The main problem was the moistening of the motor stator due to water infiltration. There were discussions between Electrical and Mechanical Maintenance Departments about the cause of the problem – either a defective electrical cable seal or a defective mechanical seal (Figure 12). Because of the presence of water and oil in the motor, it was agreed that it was a mechanical problem.

After several unsuccessful attempts to fix the problem, it was decided to send the seals to the manufacturer. However the repaired units continue to show moisture ingress.

2.9 False Indications and Loss of Vacuum to Transmitters

To calibrate the transmitters installed on vacuum lines it is required to follow precise steps to not lose the vacuum. There were instances when vacuum was lost during their calibration. After some routine checks of transmitter calibration, work request received showed that the transmitters did not work and showed false values. It was decided to provide assistance to the operator when he calibrated the transmitter. It was discovered that the operator made an error in operating the isolation valves and vacuum or water was lost from the impulse lines.

To correct the problem an Abnormal Condition Report (ACR) was issued that described the event. The analysis of this ACR established the need for a

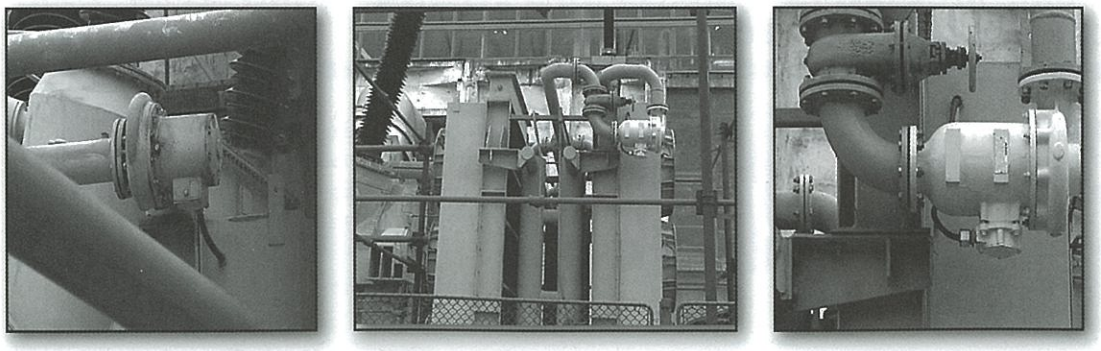

Figure 6: Photographs of old and newly installed oil pumps.

Figure 7: Photographs of old and new temperature detectors

procedure to assist the operator in calibrating transmitter. The completion date for this activity is December 2003.

2.10 Short-Circuit of Breakers of Liquid Zone Control Pumps

A few years ago Cernavoda NPP had a reactor trip due to malfunction of the Liquid Zone Control pumps and some C&I devices in the same system. The motor pumps and the motor compressors are supplied from Main Control Centers (MCC), which are Italian electrical panels of theTozzi type. A short-circuit occurred in the breaker of one pump and the other one could not be started because of the failure of a median selector (Romanian type) and the plant tripped. The short-term actions taken were to repair the breaker and the median selector. After repair of the breaker and the selector and further analysis, it was decided to change the electrical components of all the breakers and all the selectors in the Liquid Zone Control system with another type.

The electrical breakers, which were of the ABB-SACE and TELEMECANIQUE types, have now been changed with KLOCKNER-MOELLER type (Figure 13). The manufacturer provided information about the tight value of the connections and the temperature, which did not influence the breaker. All the selectors have been replaced with AGM type. To avoid recurrence of the event, a call-up work request was issued to verify the drawer components according to the maintenance procedures to every 13 weeks.

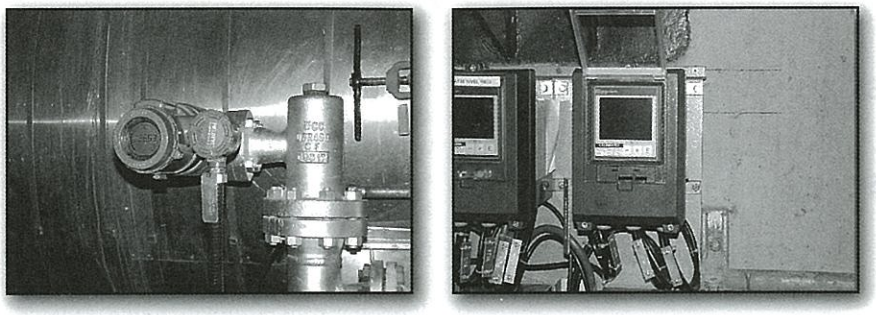

Figure 8: Photographs of Endress-Hauser and "Smart" Rosemount transmitters

3. Equipment Reliability Improvement Programs

To improve equipment reliability, Cernavoda NPP has instituted several programs and procedures. These were developed and issued following incidents of human error, and some are based on operational experience at other NPPs. The following is a brief description of some of these programs.

3.1 Optimization of the Preventive Maintenance Program

As with all the other NPPs, Cernavoda has its own Preventive Maintenance Program. It was started at the beginning of commercial operation using and learning from Canadian experience. Lacking a systematic Preventive Maintenance Program, some system engineers issued a lot of call-up work requests and some others did not. At one point, there were many call-ups for non-critical systems and few for critical systems.

Based on the experience from other NPPs, a Production Internal Procedure was issued that contains criteria for classification of the systems and a list with Critical Systems for Safety and Production. It was found that there was little focus on critical systems and a lot of work on non-critical systems. Based on EPRI recommendations maintenance programs were developed for the critical components from that list. Arrangements were made with Technical Department to reduce the number of call-up work requests for the non-critical components.

At the present time, Preventive Maintenance Programs have been developed for MOVs, Transmitters, High Voltage Motors, Low Voltage Motors, Batteries and Inverters. Further work is in progress.

3.2 Enhancement of the Predictive Maintenance Program

During maintenance work, much time was spent trying to fix non-existent problems or to find out why equipment did not work. To reduce such effort, Cernavoda NPP has bought some testing equipment to support the Maintenance Program. For the MOV and AOV program, test equipment from Crane, Liberty, and Viper kits now allow performance of electrical and mechanical predictive and post-maintenance tests for all the important valves. Personnel were trained at the manufacturer's facility to use this equipment and work was scheduled according to Preventive Maintenance Program. Now about 80% of the work is performed during outages.

Two years ago CNE-PROD bought equipment for infrared thermovision from FLIR Systems. This ThermaCam PM 695 helps monitoring and predicting defects in electrical and mechanical equipment. Plant personnel, trained by the manufacturer on thermography, have started to build an Infrared Equipment Database. The work is scheduled through call-ups and routines as per the Preventive Maintenance Program.

For vibration measurements, test equipment was bought at the beginning of Commercial Operation that allowed building of a database to predict mechanical problems. The work is performed through call-ups and work requests according to the Preventive Maintenance Program.

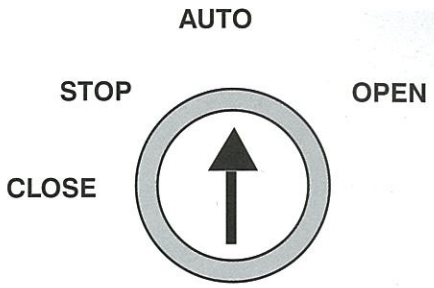

Figure 9: Feedwater motorized valve switch.

Often it was unclear whether a valve was passing or not. To solve this dilemma, ultrasound test equipment was procured. This is now used every time when there are doubts about the status of a valve. This test equipment is used mainly during Operations Mandatory Tests.

To check the type and quality of the oil used in mechanical and electrical equipment, an Oil Analysis System is being procured that will be used as per the Maintenance Preventive Program.

3.3 Environmental Qualification Program

The nuclear side of the plant is provided with equipment that must function and transmit information about the status of the plant in case of an accident. To preserve the EQ of nuclear components a special group has been designated to monitor this equipment and issue requirements for their maintenance. This group is also responsible for verifying the correctness of the Maintenance Procedures. All the maintenance work on qualified equipment is performed following the Maintenance Procedures revised and issued as per the Preventive Maintenance Program.

4. Reduction Of Human Errors

To help reduce human errors, Cernavoda NPP has instituted several programs and procedures. Some of these were developed and issued following incidents of human error, and some are based on operational experience at other NPPs. The following is a brief description of some of these programs and procedures.

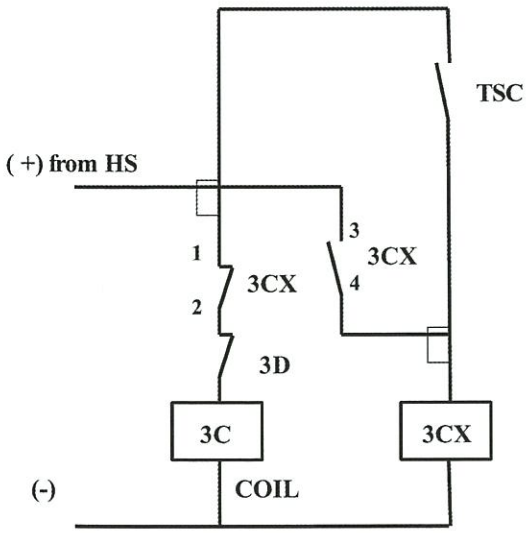

Figure 10: Control loop for feedwater MOV before modification

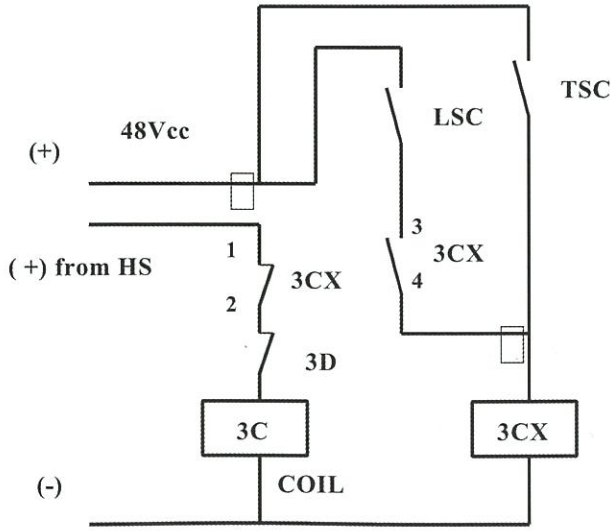

Figure 11: Control loop for feedwater MOV after modification

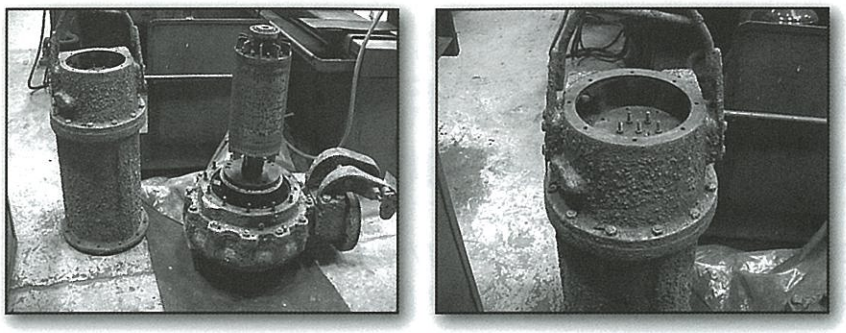

Figure 12: Sewage System Pump cable seal and mechanical seal

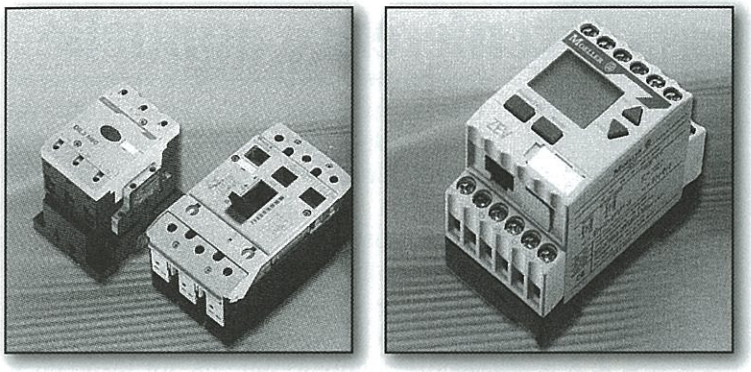

Figure 13: Liquid Zone Controller Pump Motor Electrical breakers

4.1 Training Programs for workers and supervisors

The maintenance work in nuclear power plants must be performed according to approved procedures to avoid mistakes. Based on the other NPPs' experience, plant supervisors were required to spend some of their work time in field to monitor the maintenance work. The monitoring of the work is done following maintenance Internal Departmental Procedure that contains checklist and instructions to fill in the checklist. Training courses were conducted to teach them how to do this job better. The topics included:

- Good Work Practices,
- Team Work,
- Management Staff Development,
- Pre-Job and Post-Job Briefing,
- Independent Verification,
- Coordination and Planning,
- Foreman Conduct, and
- Nuclear Safety Culture.

Training was provided on the following Event Free Tools:

- Pre-Job Briefing,
- Post-Job Briefing,
- 3-Way Communication,
- Procedural Use and Adherence, and
- Questioning Attitude & Conservative Decision-Making, and the STAR Concept:
- Stop,
- Think,
- Act,
- Review,

and how to use them in their work to comply with World Nuclear Standards. The other success component of maintenance is worker skill. Job Related Training Requirements contain a list of skills and refresher courses that help workers perform their jobs. Cernavoda NPP Unit 1 is now involved in training Unit 2 personal according to approved training programs. Canadian experts play an important role in this training.

4.2 Work Protection and Field Monitoring Procedures

"Safety is First" is not only a declaration, but also a way of life in CNE-PROD. To help personnel apply this concept and their knowledge in day-to-day work, CNE-PROD has issued procedures that cover both skills and supervision. The results of work performed in the plant are monitored to improve safety and quality.

Plant personnel use Reference Documents, Station Instructions and Internal Departmental Procedures to comply with the Romanian laws and internal requirements. These documents draw upon EPRI and western NPP experience.

The presence of the Foremen and Shop Supervisors in the field has been shown to minimize the work incidents. This is the main reason why the Plant Management insists on applying this concept and monitors the plant indicators accordingly

3. Summary

This paper has provided a brief description of failures of electrical and C&I equipment in the Cernavoda Unit 1 and the solutions adopted to rectify them. These failures were due in part to the age of the equipment. Some aspects of CNE-PROD's preventive and predictive maintenance programs, EQ and other worker training programs to deal with systematic assessment of plant maintenance, and to reduce human errors have also been described.

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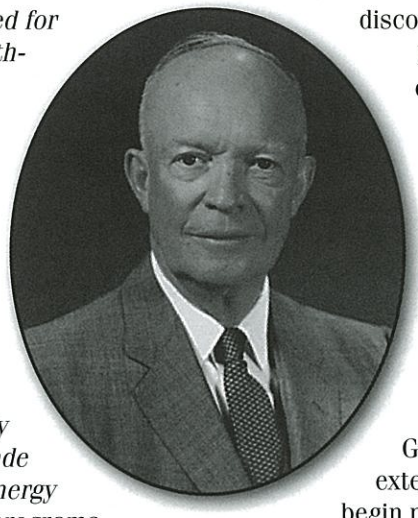
"Atoms for Peace"

- December 8, 2003 was the 50th anniversary of speech that launched the international civilian nuclear program

***(Ed. Note:** The following article was intended for the December 2003 issue but had to be withdrawn because of layout difficulties.)*



In December 1953 the Cold War existed, an "Iron Curtain" divided Europe and the USA and USSR were locked in a race of atomic weapons. It was against that background that US President Dwight Eisenhower gave a speech to the General Assembly of the United Nations on December 8, 1953 that subsequently got titled "Atoms for Peace". In it he made a proposal for an "international Atomic Energy Agency" to which countries with nuclear programs would give uranium and other fissionable materials that could be used for peaceful purposes worldwide.

It took four years and a mandate somewhat different than that envisioned by Eisenhower but the International Atomic Energy Agency was created in 1957. The following year, 1958, the first international "Atoms for Peace" conference was held in Vienna in which a remarkable amount of information that had been classified was presented for all to use.

Following are excerpts from Eisenhower's historic speech.

I decided that this occasion warranted my saying to you some of the things that have been the minds and hearts of my legislative and executive associates and on mine for a great many months.

I feel impelled to speak today in a language that in a sense is new - one which I, who has spent so much of my life in the military profession, would have preferred never to use. That language is the language of atomic warfare.

The atomic age has moved forward at such a pace that every citizen of the world should have some comprehension, at least in comparative terms, of the extent of this development. Clearly, if the people of the world are to conduct an intelligent search for peace, they must be armed with the significant facts of today's existence.

The dread secret and fearful engines of atomic might are not ours alone. In the first place, the secret is shared by our friends and allies, Great Britain and Canada, whose scientific genius made a tremendous contribution to our original discoveries, and the designs of atomic bombs.

My country's purpose is to help us move out of the dark chamber of horrors into the light, to find a way by which the minds of men, the hopes of men, the souls of men everywhere, can move forward toward peace and happiness and well being.

It is not enough to take this weapon out of the hands of the soldiers. It must be put into the hands of those who will know how to strip its military casing and adapt it to the arts of peace.

I make the following proposal: The Governments principally involved, to the extent permitted by elementary prudence, to begin now and continue to make joint contributions from their stockpiles of normal uranium and fissionable materials to an international Atomic Energy Agency. We would expect that such an agency would be set up under the aegis of the United Nations.

The more important responsibility of this Atomic Energy Agency would be to devise methods whereby this fissionable material would be allocated to serve the peaceful pursuits of mankind. Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine, and other peaceful activities. A special purpose would be to provide abundant electrical energy in the power-starved areas of the world.

I would be prepared to submit to the Congress of the United States, with every expectation of approval, any such plan that would:

First - encourage world-wide investigation into the most effective peacetime uses of fissionable material, and with the certainty that they had all the material needed for the conduct of all experiments that were appropriate;

Second - begin to diminish the potential destructive power of the world's atomic stockpiles;

Third - allow all peoples of all nations to see that, in this enlightened age, the great powers of the earth, both of the East and of the West, are interested in human aspirations first, rather than in building up the armaments of war;

Fourth - open up a new channel for peaceful discussion, and initiate at least a new approach to the many difficult problems that must be solved in both private and public conversations, if the world is to shake off the inertia imposed by fear and is to make positive progress towards peace.

A Conversation with Murray Elston, CNA president

The December 2003 issue of the CNS Bulletin noted the appointment of Murray Elston as the new president of the Canadian Nuclear Association. He agreed to meet with the Bulletin editor on Friday, February 13, 2004. Following are excerpts from that conversation.

CNS *Could you provide some personal background?*

Elston I was born and brought up in Wingham, Huron County, Ontario, which is near the Bruce Nuclear Power Development. My father was a farmer and my mother a teacher and farm wife. I had two brothers and two sisters. One [brother] is still farming, the other in the farm industry. My sister's husband is in the nuclear field and has worked at Darlington, Pickering and Bruce.

I went to University of Western Ontario to study history, intending to be a teacher. With the changed curriculum there was no demand for history teachers so I went back to law school. After graduating I practised law in Wingham for four years. In 1981 I ran for MPP and was elected, at the age of 31. Four years later our party [Progressive Conservative] formed the government and I was made Minister of Health. Subsequently I served as Chairman of the Management Board and then Minister of Financial Institutions. This involved dealing with priorities, including electricity and Ontario Hydro, which have been a big part of Ontario politics.

In 1987 the riding boundaries were changed and I ended up representing Bruce County where the Bruce development is located. That continued until 1994 when I got out of politics and accepted a position connected with the Bruce Energy Centre, planning to make use of steam from the Bruce reactors. Unfortunately that failed and I ended up involved with Ontario Hydro on its Green Energy program. In 1998 I became head of the industry association Canada's Research-Based Pharmaceutical Companies until the beginning of this year when I accepted this position.

CNS *What made you decide to join a nuclear association?*

Elston Living in Wingham we were touched by the Bruce nuclear development for many years. It had a major impact on the area. I have had connections with the plant since 1981 when I was first elected as the area's MPP. Even after leaving politics I remained interested.

I remember some years ago looking at international ratings of nuclear plant performance and seeing several Canadian plants in the top ten. I would take those figures to my colleagues at Queen's Park. When I would tell them I had been at the plants and had seen the waste management areas they would ask how many problems there were. I told them "zero" and then ask them how many problems we have with the disposal of domestic waste. The answer would be, "we don't know", and that was my whole point.

In summary I was and am intrigued with Canada's nuclear program.

CNS *What is your perspective of the state of the Canadian nuclear industry ?*

Elston There are similarities and differences with the pharmaceutical industry where I have been for the past few years. Both have stresses and challenges. The major difference I see is that the pharmaceutical industry is seen to be advancing, with new discoveries or products almost daily. Nuclear is not seen as anything new and has a history of not being understood. We [CNA] have an education role to play. Which leads to the question of whom you educate first and how do you do it. These are issues on which my predecessor has been working.

A major question I will be pursuing is how focussed does the industry want the CNA to be on this issue. Our members will have to decide what two or three things it wants the CNA to do. One organization cannot do everything in a short period of time. Each of our members has short term needs and goals that prevent the Association from getting to a [common] focus. Everyone wants us to advance the interest of the industry but that is a very broad mandate. There is, however, a renewed optimism.

While nuclear power is very important it is not the entire nuclear industry. Nuclear also plays a prime role [through radioisotopes] in diagnosing and treating disease.

CNS *Will the CNA be involved in the program of the Nuclear Waste Management Organization ?*

Elston I have met with Elizabeth Dowdeswell [president of NWMO] to better understand their program and to offer help from the CNA. I expressed concern that their website has papers which are factually incorrect. Being published on their site gives them some credibility. I will be encouraging our members to follow the NWMO program and make submissions when appropriate.

CNS *What are your short-term goals for the CNA for the coming year ?*

Elston First, I will be assessing the status of the organization. I will be seeking the members' desires of what they really want the association to be and then implementing some steps to achieve that. Some of the work will be around governance, some about the role of our committees, some about elevating our various connections.

CNS *Have you had a chance to consider the relationship between the CNA and the CNS ?*

Elston It is a bit early for me to say very much but I see it as working separately together. In the technical area I see the CNS as a very valuable resource. I cannot appreciate the technical details but my background in history gives me some perspective. Nuclear science and engineering is one of the few fields in which Canada has excelled and that story must be told. I do plan to attend a CNS Council meeting and definitely will be at your Annual Conference.

CNA 2004 Seminar

Largest attendance ever for annual event

The **2004 Seminar** of the Canadian Nuclear Association, held at the Chateau Laurier Hotel in Ottawa, February 19, drew over 400 attendees, the largest attendance since these events began. Attendees heard overviews of the various aspects of the nuclear scene from leaders of the Canadian nuclear program and invited speakers from abroad. The presentations were informative and generally non-controversial, except for one during the afternoon panel on "Public Acceptance and Political Support".

John Efford

The Seminar was preceded by an enjoyable reception the evening before at which the federal Minister of Natural Resources, **John Efford**, gave a short welcoming address.

He began with a quip directed at Duncan Hawthorne who had introduced him. "Coming from Newfoundland and Labrador I was asked, ' how can you go to Ottawa with your accent?' My answer is "How did Duncan do it?"

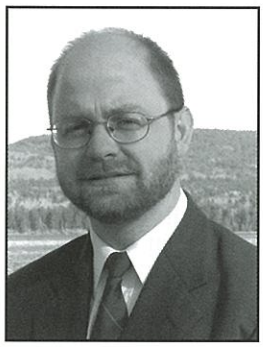
He received applause when he commented, "In the short time I have been here I have learned a great deal. I respect your industry [and] as your Minister in the Government of Canada I am going to champion your industry across the country." "Why would I be supportive of nuclear energy? [It] is environmentally friendly and I want to tell that to the whole country."

"AECL is the greatest company in the world", he commented. Referring to the Qinshan project in China he added, "I have to brag about it as Minister. coming in under budget and under time says great things." "I want you to give them a round of applause for a great job well done."

At the same time, outside the Chateau Laurier Hotel a small group of Greenpeace supporters demonstrated against the use of nuclear energy.

Phillip Prince

A large number of delegates attended a pre-seminar breakfast to hear **Phillip Prince** of the Canadian Energy Research Institute present conclusions from CERI's study of the economic impact of the Canadian nuclear industry. (This was an update of a presentation given in mid-2003.) He included an evaluation of the use of an ACR 700 unit for the extraction of oil from the tar sands with the conclusion that such a plant could be more economical than a gas fired plant and much more environmentally friendly.



Jeremy Whitlock

CNA chairman **Allan Kupcis** officially opened the Seminar and introduced the new president of the CNA. **Murray Elston**, who served as the seminar chairman for the remainder of the day. Elston was followed by **Jeremy Whitlock**, president of the Canadian Nuclear Society. *(See Whitlock's remarks in "CNS News".)*

John Ritch, Director General of the World Nuclear Association, gave the keynote address. Beginning with some impressive photographs, many of them satellite views of the earth, he asserted that "nuclear energy was indispensable" to cope with the challenges of growth of population and energy demand. Nuclear is necessary, he said, for the production of clean energy on a massive scale. He applauded "environmentalists" for creating awareness of the dangers to our environment but, when asked, had no answer for how to convince them that nuclear was needed.

John Ritch

After showing graphs of estimated CO_2 concentrations and global temperatures over the past 400,000 years he noted that CO_2 levels were already higher than ever over that long period. The world must cut CO_2 production by 50 %, he said, adding that the developed countries need to cut their emissions by 75%. He then referenced the "hydricity" cycle promoted by Geoffrey Ballard, using nuclear to produce hydrogen for use in fuel cells.

In closing he referred to the newly created "World Nuclear University" set up by WNA in cooperation with international agencies, the World Association of Nuclear Operators (WANO) and universities around the world. Canada is represented by the UNENE (University Network for Excellence in Nuclear Education). This is a "virtual" university with a small coordinating secretariat in London, which, he commented, is looking for a Canadian member.

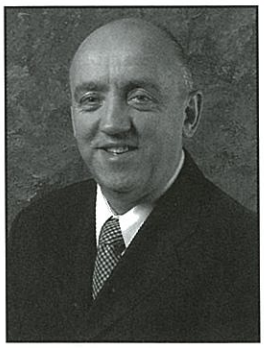
Linda Keen

Linda Keen, president of the Canadian Nuclear Safety Commission, spoke on a "Regulatory Perspective of Nuclear Energy", emphasizing the objective of "smart regulation". A better dialogue is needed between her agency and the industry, she stated. The CNSC will be tabling this spring a report on its plans for 2004 - 2007. She urged the industry to exceed regulatory requirements and invited attendees to make specific recommendations to the CNSC on areas for improvement. In concluding, she invited delegates to attend a free symposium, sponsored by the CNSC, on Safety Culture in Toronto on March 30 and 31.

Following a break, **Rod White,** vice-president New Brunswick Power, chaired a panel on "Nuclear Electricity", with panelists: Pierre Charlebois, acting chief nuclear officer, Ontario Power Generation; Duncan Hawthorne, president Bruce Power; and Robert Van Adel, president Atomic Energy of Canada Limited. White began with references to the blackout last August and the peak demands experienced by all the utilities.

Pierre Charlebois spoke about the improved safety indicators at OPG's nuclear plants and the CNSC approval for Darlington to return to 100% rated power from 98%. He noted that Pickering unit 4 reached 100% rated power on February 11, the first time since April 1996. Referring to Pickering units 1, 2, and 3 he stated that the engineering for the restart of unit 1 was complete but work on units 2 and 3 had been suspended until the report of the OPG Review Committee headed by John Manley. OPG is facing major challenges, he commented, with the proposed phase-out of coal-fired plants and the looming end of life of some of the nuclear plants. Decisions are needed, he stated in closing.

Duncan Hawthorne opened with the statement that the Bruce B plant produced 20% more power in 2003 than the year previous, equivalent to a 600 MWe unit operating at 100% capacity factor. He stated that, contrary to general opinion, nuclear power has: the lowest electricity generation cost; is emission free; is safe by design; its waste is fully managed; and it is our most reliable energy source. Emphasizing the need to develop trust in the public he urged everyone in the industry to inform and explain, commenting that Bruce staff are the best ambassadors for nuclear in their local area. He closed with these recommendations: communicate simply; reassure the public through performance; focus on people; find natural allies; stop apologizing; get more aggressive.



Duncan Hawthorne

Robert (Bob) Van Adel mentioned that decisions on the refurbishment of Point Lepreau and Wolsong 1 are expected this year. After referring to the appointment of Ken Petrunik to oversee projects he emphasized the importance of international partners for overseas projects. He noted that AECL and New Brunswick Power had conducted an extensive planning exercise for the refurbishment of Point Lepreau.

Robert Van Adel

Before closing the session and the morning program Rod White, in replying to questions, noted that on April 1, 2004, New Brunswick Power would be divided into four units, one of which will be NB Nuclear. Robin Jeffries, formerly with British Energy, is conducting a "due diligence" review of the Point Lepreau refurbishment, he said, with the expectation that a decision on that project would be made this summer or early fall.

William D. Magwood IV

After lunch **William D. Magwood IV,** director of the Office of Nuclear energy, Science and Technology of the U.S. Department of Energy presented the 2004 W. B. Lewis Lecture, which he titled "U.S. Energy Policy and Nuclear energy - Now and in the Future". This was the first time that the Lecture had been incorporated into the CNA Seminar.

(The W. B. Lewis lectures were established in 1988 to honour the memory of Dr. W. B. Lewis who headed the scientific program at the Chalk River Laboratories from 1946 to 1972 and is often considered the "father" of the CANDU nuclear power system.)

The text of Mr. Magwood's lecture is reprinted in this issue of the *CNS Bulletin.*

The afternoon program began with a report on the uranium industry by **Tim Gizel,** president of Cogema Resources, who titled his presentation "Optimism and Frustration in Canada's Uranium Industry". The good news was that the spot price of uranium had gone from $10 (US) per pound in 2003 to $16 today. He then gave a concise review of the uranium facilities in Saskatchewan and commented on events around the world affecting the uranium market. *(Excerpts from his paper are reprinted elsewhere in this issue.)*

Tim Gizel

The program then took a different tack, to the subject of "Public Acceptance and Political Support", with a panel moder-

ated by **Graham Green,** editorial page editor of the Ottawa Citizen. Members of the panel were: Scott Peterson, vice-president, Nuclear Energy Institute (USA); Darrell Bricker, president of Ipsos-Reid Corporation (a polling company); and John McKay, M.P. for Scarborough East.

Scott Peterson began by stating that public acceptance was a necessary precursor to political support. The significant improvement in operation of nuclear plants in the USA had led to a gain in public acceptance, which now runs about 60%, down slightly from two years ago because of security concerns. NEI is emphasizing that nuclear is: safe, affordable, creates jobs, makes the country less dependant on foreign energy, and helps maintain clean air.

Darrell Bricker commented that the last 30 years of social and economic upheaval had changed the way we view the world, our country and our lives. There is a marked decline in public trust, he said, that extends to scientists and engineers. He referred to his recent book "Searching for Certainty" for more background. He proposed three rules: trust is everything; the consumer is king; and the attitude "what I want is control, what I need is certainty".

John McKay, M.P. for Scarborough East riding in Ontario, which is adjacent to the Pickering Generating Station, began by stating that he was not speaking for the government. Then he spoke of the "colossal mess" of the refurbishment of Pickering A. Citing a cost 2.7 times the original estimate, a two-year delay, and incompetent management, he denigrated the credibility of the industry. The industry needs to tell the truth, he stated. "What political fool would commit political suicide by supporting nuclear development or the refurbishment of further units at Pickering A", he asked.

A member of the audience gave a spirited and apparently popular rebuttal by referring to political fools who had interfered in Ontario Hydro over the years and, among other problems, caused the large cost overrun of the Darlington plant. Bruce Power's Duncan Hawthorne injected that there is more to the Ontario nuclear program than the Pickering re-start.

After that emotional exchange the last two presentations were, unfortunately, almost anticlimactic.

Elizabeth Dowdeswell, president of the Nuclear Waste Management Organization, outlined the progress NWMO had made since her report last year, referring specifically to their report *"Asking the Right Questions?"*. She stated that they were on schedule to provide a report [to the Minister of Natural Resources] in November 2005. This year NWMO is conducting "citizens' dialogues" in 12 locations across the country, involving over 500 people. A complete dialogue should include the industry, she stated, and asked members of the audience to contribute their knowledge, to help articulate the problem, and to contribute to the understanding of risk and uncertainty.

The final speaker was **David McInnes,** vice-president, MDS Nordion, who presented a quick overview of his company's activities. MDS Nordion supplies over half of all the reactor-produced radioisotopes used for medical diagnosis. It is the largest supplier of Molybdenum 99, which is used, in over 35,000 nuclear medicine diagnostic procedures around the world each day. The MAPLE reactors, still being commissioned at the Chalk River Laboratories of AECL, will be dedicated to producing this and other medical radioisotopes. (This was McInnes' only mention of the troubled MAPLE project.) MDS Nordion is also a major supplier of Cobalt 60, much of it produced in Canadian power reactors, used in machines for sterilization and food irradiation.

The seminar ended with another, smaller reception held in the large corridor outside the main meeting room. Displays had been set up in that area by some of the companies and organizations supporting the seminar, including the Canadian Nuclear Society.

Sponsors of the seminar were: Bruce Power; Ontario Power Generation; Wardrop Engineering; Zircatec Precision Industries; NB Power; GE Canada; Hydro Québec; Cameco Corporation; Cogema Resources; AECL; MDS Nordion; Canadian Nuclear Society.

PowerPoint versions of most of the presentations are available at the CNA website <www.cna.ca>.

Canadian Nuclear Society
Société Nucléaire Canadienne

"Supporting nuclear science and technology for 25 years"
"25 ans de promotion de la science et de la technologie nucléaires"

25th Annual Conference **25ième conférence annuelle**

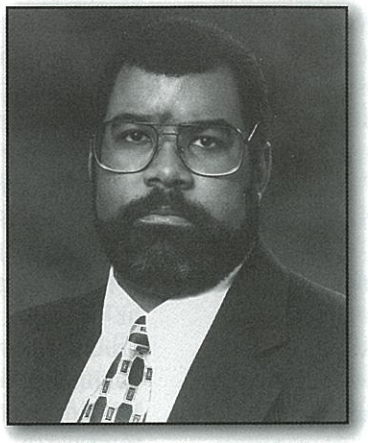
Toronto Marriott Eaton Centre Hotel
June 6 – 9, 2004 **6 – 9 juin 2004**

The 2004 W.B. Lewis Memorial Lecture

Ed. Note: *The W. B. Lewis series of lectures were initiated in 1988 by Atomic Energy of Canada Limited in memory of Dr. W. B. Lewis who headed the science program at the Chalk River Laboratories from 1946 to 1972 and is often called the "father" of the CANDU nuclear power system.*

For the first time the 2004 lecture was given during the 2004 Seminar of the Canadian Nuclear Association, in Ottawa, February 19, 2004.

The lecturer, William D. Magwood IV, is Director of the Office of Nuclear Energy, Science and Technology in the U.S. Department of Energy.



William D. Magwood, IV

Charting a New Course for Nuclear Energy

William D. Magwood, IV

When Sir Isaac Newton wrote to Robert Hooke in 1676, he famously noted: "If I have seen further it is by standing on the shoulders of Giants." In saying this, he also spoke for the generations of scientists and engineers who have come after, particularly those who have strived to look over the horizon and imagine the next steps in the human journey.

With that in mind, it is a true pleasure to be with you here today to provide my thoughts in the name and memory of one of our time's true giants—Wilfred Bennett Lewis. Dr. Lewis's accomplishments serve as testament to the difference that can be made by a single individual who has the drive, imagination, and vision to lead others on a grand quest to improve the state of technology and the state of living on Earth. With that example, we today stand on his shoulders, and those of his contemporaries, to establish a nuclear energy future that is compatible with the economic, security, and safety context of the Twenty-First Century.

In many ways, we here today might envy the times that harbored Dr. Lewis's successes. While the dangers of the Cold War were ever-present, those dangers led to investments in the sciences and technologies that today's physical scientists and engineers can scarcely imagine. The challenge of our time is to do even more than our predecessors with fewer resources and a far more complex political, social, and economic environment. We today must learn to talk more effectively with a public that will never entirely forget Three Mile Island and Chornobyl. We must develop a new generation of nuclear scientists and engineers when the best and brightest often go to medical research and business. We must deal with the realities of a world that is still searching for safety and security in the aftermath of September 11, 2001. We today must find ways of reinventing an industry that was designed for an electric industry very different from that which exists today and which will exist in the future.

Every challenge brings with it new opportunity. But to seize these opportunities, we must avoid the temptation of lamenting about the misdirected Government resources, the blind, self-serving financiers, or the ill-informed public. We must instead stand high on the shoulders of those past giants and look, perhaps, a bit off to the right or a little off to the left rather than straight ahead. The opportunities are there, but they are not where one might have thought in the 1950s or even in the 1980s. We will not be judged on how we held the course set by Dr. Lewis and his ilk, but on how we adapted to the realities of this new, unpredictable century and charted a new path to a new future.

Unfortunately, the past decade or so has not been kind to those who would chart a new future in energy. Complacency and ideology served to block realistic and fully informed debate on the matter of energy and environment. Even as the scientific and anecdotal evidence of the unsustainability of current practices mounted, the world's ability to ignore the major questions facing us and the role nuclear power might play in their resolution seemed without limit. In the 1990s, to be precise, nuclear power was on the brink of becoming irrelevant in the minds of both corporate leaders and government officials.

The 1990s were a tough decade for nuclear power. In the U.S., a quarter century without an order for a new nuclear plant crippled domestic vendors and triggered massive downsizing and restructuring among the traditional leading companies in nuclear power. Policy makers in the U.S. discounted the potential benefits of new nuclear plants because they saw the technology as uneconomical and insurmountably burdened with unresolved issues—generally nuclear waste and safety. Energy planners and market forecasters predicted an ever-increasing supply of cheap natural gas to sate near-term appetites for electricity. As the vision of electricity market deregulation took hold, many

saw nuclear power as a technology too big, too expensive, and too complex to survive.

The nadir, perhaps, came in 1997. That year, Federally sponsored nuclear energy R&D in the United States fell to essentially zero for the first time since President Eisenhower gave his *Atoms for Peace* speech before the United Nations. This was a peak year in the popularity of the "cheap gas forever" theory and also a high point for the electric industry "delamination" advocates who believed that all utilities would give up generating power and simply contract with a roster of independent power producers. All this made nuclear appear anachronistic. I recall one congressional staffer at the time comparing the nuclear industry of the 1990s to the wagon wheel industry of the 1920s. It's time, he told me, has come and gone and we should let it die.

The situation was hardly better in other countries. Around the globe, government policy-makers began to focus on greater use of conservation and renewable energy to satisfy their long-term energy needs—often despite projections that their efforts alone could not meet projected requirements. A few European nations declared the end of their use of nuclear power—even as they took the side of those most strongly committed to the carbon emission limits anticipated by the Kyoto Protocol. In an "up is down" logic that only Lewis Carroll could fully appreciate, some of our European friends with active nuclear programs agreed to ignore the emissions avoided by nuclear energy in calculating their CO2 targets. While Asian countries continued to build new plants, this fact was often seen as an anomaly. Much of the rest of the world had slipped into a complacent dream, one in which gas turbines, windmills, and compact fluorescent light bulbs provided a golden path to energy and environment nirvana. For all but a few countries, this dream was not a vision, but simply a hallucination.

The 1990s were tough for nuclear power

In the United States, events in recent years have served to put the nuclear energy agenda back into prominence. The collapse of Enron in the United States and the not unrelated surge in short and long-term natural gas prices; analyses in the United Kingdom and other countries that point to the need for a wider array of energy options to serve the needs of the future; the success of the nuclear utility industry in operating current plants more efficiently and with great reliability—all these factors have come into play in just a few years.

In my country, the serious reconsideration of our energy future began when a new Administration took over the White House. The newly elected President Bush, a former Texas oilman who knew a thing or two about energy resources, made one of his first priorities to develop a long-term look at how the United States could set on an environmentally responsible path to provide for our future energy needs while reducing our dependence on foreign energy supplies. When the lights went out in California, the very heartland of conservation and renewable energy advocates, it became obvious to many that there was something terribly wrong with the way we were approaching the supply of energy. For the first time since the 1970s, Americans appeared to be facing real energy shortages and whispers began to be heard that perhaps a new "energy crisis" was approaching.

It was with this backdrop that the President issued the National Energy Policy in May 2001. In unveiling this plan, the President said:

> *If we fail to act, this great country could face a darker future, a future that is unfortunately being previewed in rising prices at the gas pump and rolling blackouts in the great state of California. Californians are learning, regrettably, that sometimes when you flick on the light switch, the light does not come on at any price.*

It was one of the early postulates of the Administration's energy review that the idea that the United States could rely on a single source of energy—natural gas--for essentially all its future needs was an idea born of avoiding rather than engaging the complex issue of energy supply. Therefore, the *National Energy Policy* calls for a balanced portfolio of domestic energy generation including renewables and efficiency measures and specifically embraces the expanded use of nuclear power. President Bush and Vice President Cheney have personally engaged this issue and our initiatives at the Department of Energy speak to their vision and understanding of the work that must be done. Secretary Abraham has proven his ability to see the long-term opportunities before us, and has fostered a revival in DOE's nuclear energy research agenda that surpasses anything that we have seen in decades.

Since assuming office, President Bush's Administration has re-energized the national and international discussion about nuclear technology. This Administration has dislodged the process to move forward with a safe and necessary high-level waste repository at Yucca Mountain, providing one of the most vital missing elements needed for the future expansion of nuclear energy. It has also worked closely with leaders in Congress, particularly Chairman Pete Domenici in the Senate and Chairman Billy Tauzin in the House to write new, comprehensive energy legislation to complete the implementation of the policies that were advanced by the *National Energy Policy.* Internationally, the U.S. delegation to the 2003 G-8 summit led the G-8 leaders to agreement on an *Action Plan on Science & Technology* designed to care for our environment while growing our economies. The G-8 Action Plan included initiatives to develop transformational technologies for more affordable and more proliferation-resistant nuclear energy for the near future.

Two years ago, Secretary Abraham unveiled *Nuclear Power 2010,* which has brought nuclear vendors, electric utilities, and government together in a renewed and cooperative dialogue over how to set about building the third

generation of new nuclear power plants in the United States. The challenges facing industry in today's tough energy market as they consider the building of new nuclear plants are daunting. But, from our very intensive high-level discussions, it is clear that it is not technology, nuclear waste, or fears about nuclear safety that are the high hurdles facing new U.S. plants—it is the need for them to be sound financial investments in today's competitive electricity market. We continue to work toward our goal of seeing new nuclear plant projects started in the next few years and we believe this goal is within reach.

Generation IV represents a bright new hope.

The year after his announcement of Nuclear Power 2010, Secretary Abraham unveiled our Advanced Fuel Cycle Initiative, through which we are working with countries with advanced fuel cycle infrastructures such as France and Japan to chart the way to a better, more efficient, and more proliferation-resistant nuclear fuel cycle. If we are successful, we will someday benefit from the full energy value of nuclear fuel, capturing more than 90 percent of its energy value rather than the few percent obtained today. In addition to improving the economics of nuclear energy, this technological achievement would enable nuclear energy to continue serving the world for many hundreds of years into the future—while eliminating the long-term proliferation threat posed by commercial plutonium and vastly reducing the toxicity of nuclear waste.

In January 2000, the United States, Canada, and seven other international partners met for the first time to usher forth a new generation of nuclear energy. In July 2001, a charter was approved to formally establish the Generation IV International Forum. Today, we are ten countries and EURATOM, working toward this goal. Our effort is just getting under way, but we can already clearly see the path ahead. Working with brilliant engineers and scientists from all over the world we have selected six advanced nuclear energy technologies that we will pursue for the future use by nations all over the world.

These Generation IV technologies—which will be more efficient, safer, and more competitive than any nuclear technologies available today—represent a bright new hope for the next era of nuclear energy. With technologies such as the Next Generation Nuclear Plant and the Supercritical Water Reactor, we will produce not just more cost-effective electricity, but other important energy products as well – including heat, clean water, and – perhaps most important – hydrogen.

As you know, in last year's State of the Union address, President Bush issued the challenge of the National Hydrogen Fuel Initiative. This broad initiative calls upon the technical and industrial communities to resolve the issues associated with making clean-burning hydrogen the fuel of the tomorrow's planes, trains, and automobiles in place of imported petroleum. We see this a better, more sustainable path to deal with issues such as climate change over the long term and our new nuclear energy efforts are tailor-made to answer the President's call. It is possible that Gen IV technologies--such as the Next Generation Nuclear Plant--may become commercially available soon enough to realize the President's vision that "a child born today will be driving a car, as his or her first car, which will be powered by hydrogen and pollution-free."

This brings us back to the question of the future. Now that we have emerged from the 1990s with a renewed vision and constructive, supportive leadership, what needs to happen to move our nuclear energy aspirations from concept to reality? In my judgment, there are three ways that nuclear power can regain a healthy share of the future market for new capacity: changes in the market; government intervention; and new technology. While not ignoring the possibility that all three might be necessary, let's consider these paths one at a time.

As good as water-cooled reactor technology is today, it is hard-pressed to compete in the current market. Electricity prices are relatively low and investors and utility executives expect the fastest practical return on the investments they support. The thought of projects that take seven years or longer from concept to the first electrons on the grid give them great pause—especially when you add the potential for unexpected delays in the regulatory process.

That said, there are some positive signs that the market itself may change. Utilities are beginning to order new coal plants. Some of the projects recently announced by utilities will cost nearly $1800 per kilowatt and take nearly as long as a nuclear plant to bring on-line. Despite this, no new plants have yet been ordered. It appears that nuclear faces a higher standard. Similarly, two years ago, we were told by many analysts that the long-term price for natural gas would need to reach $5.00 per million BTU before new plants could be competitive—which no one thought would ever happen. Of course last week, the prices for gas were hovering around $5.30. Did I miss an announcement? The reality is no one can clearly state what economic conditions would be required to guarantee nuclear's return to the market.

Some, who have given up hope that the market alone will ever enable new nuclear plants to be built, have told me that the problem is that nuclear should get proper credit for its environmental benefits—perhaps by giving nuclear operators an emissions credit or by levying a carbon tax on fossil fuels. I find this type of government intervention troubling. It recalls the history of the renewables industry in the United States. In that example, the stock of companies active in producing renewables generally traces the amount of government subsidy the industry receives. If they have good tax credits, sales and stock prices are up; if not, all indicators are down. Nuclear plants take longer to build

than many of us would be willing to bet that government policy will remain unchanged.

A better model for government intervention has been suggested by Senator Domenici as part of the U.S.'s hotly debated energy bill. The bill includes a provision to establish a production tax credit for the first 6,000 megawatts of new nuclear capacity. This idea was designed to make the economics of building the first few plants acceptable to investors and re-establish a track record for building new plants in the United States. The fact that no plants have been built in the U.S. in a generation is, in itself, a barrier that will take some effort to overcome and a proposal like this would address this "First Plant Barrier."

While many of us support such an approach, the reality is that many responsible people question whether the assistance granted to the first few plants would indeed spark a nuclear construction boom in the U.S. Many skeptics suggest that industry would build a handful of subsidized plants and then go back to burning gas. We, and others, are trying to develop better economic analyses, but the debate will remain. To me, the bottom line is that reliance on government policy to sustain a nuclear resurgence is a risky prospect.

That brings us to the final pathway—technology. I believe that the current, state-of-the-art Generation III+ technologies such as AECL's ACR-700, the Westinghouse AP-1000, and the GE ESBWR are outstanding products that could serve the market well. Our Nuclear Power 2010 program is designed to help utilities to decide among these technologies and to get on with the placing of new plant orders. While utilities are positively engaged in this effort, we cannot ignore the fact that ordering a new nuclear plant remains a tough decision for any utility operating in a competitive market.

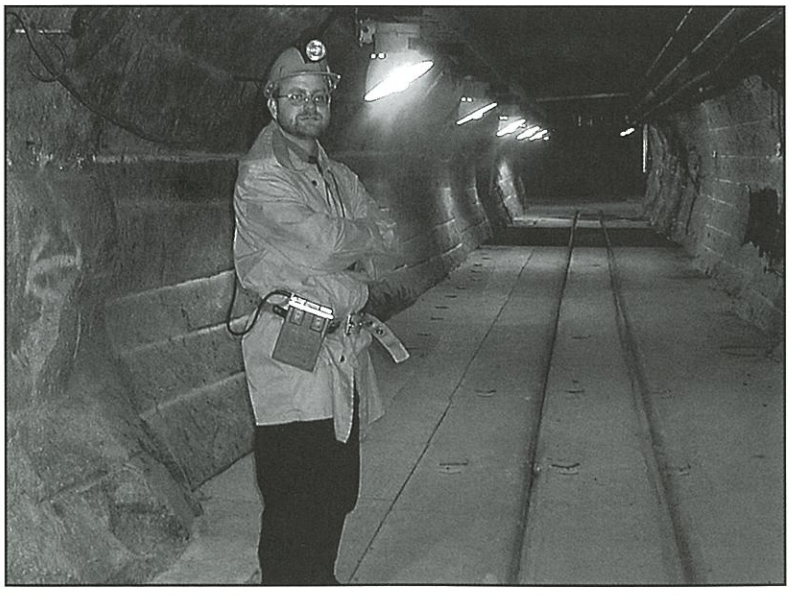
What technology can do – *must do* – to create a vibrant future market for nuclear energy plants is this: make the utility decision to build a nuclear unit a matter of fuel mix rather than an issue of cost and risk. In other words, technology needs to provide a nuclear plant that is a superior business choice to natural gas units in a direct, head-on competition. Such a plant must be capable of coming online in a time frame similar to a gas plant, with no more financial risk. Such a plant must be incapable of impacting life outside the fence under any rational scenario and be licensed and regulated under a regime that recognizes its safety advantages. Such a plant must be highly flexible and able to serve the needs of the market as they evolve.

These characteristics are obviously challenging. But, because of the work we have completed thus far in our work on Generation IV nuclear power systems, we believe these characteristics are achievable. I believe that this type of nuclear plant could be brought to market by the 2020s and be ready to serve the world's long-term needs for many decades thereafter.

All that said, we cannot, as some suggest, "skip Gen III and go right to Gen IV." Without the success of Gen III+, I believe there will be no opportunity to usher Gen IV into reality. Without Gen III+, we will lose the industrial, governmental, and academic infrastructure needed to bring advanced nuclear energy technologies to the market.

I suggest, therefore, that government and industry work together to chart the future course for nuclear energy. One that finds ways to move Generation III+ technologies to the market now while we jointly pursue the development and deployment of Generation IV technologies. I believe we can do this and should do this and, as ever, I stand ready to work with my colleagues in the United States, Canada, and elsewhere to bring this future about.

If we are successful, I believe that Dr. Lewis will have thought well of us.



CNS president Jeremy Whitlock is shown in the Underground Research Laboratory near Pinawa following a talk to the Manitoba Branch.

Canada's Uranium Mining Industry
– Optimism and Frustration

by Tim Gizel[1]

Ed. Note: *The following is excerpted from the text of the presentation by Tim Gitzel to the 2004 Seminar of the Canadian Nuclear Association held in Ottawa, February 19, 2004.*

What A Difference A Year Makes!

Last year we were facing frustratingly low uranium prices. The uranium spot market price was about $10.20 U.S. per pound, showing only a marginal increase from the year before. This price level did not reflect the cost of bringing additional capacity on stream or the cost of keeping some of the world's more marginal uranium production facilities operating. The spot price climbed 45% during 2003 to $14.50 US in December. Today's price of $16.50 is well over 50 per cent higher than a year ago and up over 100 per cent from lows in the year 2000.

However, not all of the news has been great. The uranium mining industry has also had its share of frustrations in the past year. I would like to briefly review the sources of both optimism and frustration in our industry.

Let me start with a quick refresher on the mining operations and projects in Saskatchewan.

Cluff Lake Mine

COGEMA's Cluff Lake mine, the only uranium mine on the west side of the Athabasca Basin, ceased operation at the end of 2002 after 22 years of operation and 62 million pounds of yellowcake production. We have a skeleton crew there and have been able to undertake several site cleanup activities, but we are awaiting regulatory approval to begin decommissioning.

McClean Lake Mine

McClean Lake, operated and 70 per cent owned by COGEMA Resources, is a major part of our future. Beginning production in 1999, the mill has already processed most of the ore from the JEB open pit mine and is now milling stockpiled ore from the Sue open pit. Mining will re-start in 2005 with ore from the McClean and, later, the Midwest projects. The McClean mill is expected to run another 40 years with a combination of these, other local ores, and ore from the Cigar Lake project.

McArthur River Mine / Key Lake Mill

McArthur River, the world's largest and highest-grade uranium mine, is owned 70 per cent by Cameco and 30 per cent by COGEMA Resources. Producing over 18 million pounds in 2002, its 2003 production was about 15 million pounds processed through the Key Lake mill. This was reduced from the anticipated 18 million because of the water inflow situation.

Rabbit Lake Mine

Rabbit Lake, the oldest of Saskatchewan's operating mines and owned 100% by Cameco Corporation, produced almost 6 million pounds in 2003. Rabbit Lake is scheduled to mill ores from the Cigar Lake mine toward the end of the decade.

Cigar Lake Mine

Cigar Lake, the second largest known uranium ore body, is awaiting construction approval to complete the $350 million development work. The ore in slurry form will receive initial processing at McClean Lake with final processing split between the McClean and Rabbit.

Recent Events

The last year or so saw some significant events in our industry. A fire in the solvent extraction plant at the Olympic Dam project in Australia and the flood at the McArthur River mine in northern Saskatchewan both resulted in significant temporary production interruptions and raised the fear of a supply shortage. In addition, we had a surprising court decision regarding our own McClean Lake operation that has put a cloud of uncertainty over the project.

To add fuel to the fire, the supply of Highly Enriched Uranium (HEU), through a program that so far has converted over 8,000 atomic warheads from the former Soviet Union into reactor fuel for consumer electricity, recently became somewhat less predictable. TENEX, Russia's nuclear fuel export agency, terminated its HEU feed contract with the U.S. marketing agency, Global Nuclear Services and Supply, calling into question whether all of the deliveries already agreed to will be made. Russia's expressed need for future HEU for its own blending seems to indicate that a further agreement is unlikely.

Up until very recently, with half of the uranium coming from so-called secondary sources, we were in a buyers market. Marginal mines were closed, industry consolidation

1 Tim Gitzel is President and CEO of COGEMA Resources Inc., Saskatoon, Saskatchewan.

became the norm, and future mine developments as well as large exploration projects were put on hold pending better prices. Now, with shrinking secondary sources and growing uranium demand, nuclear fuel consumers are seeing a reversal in market conditions.

Cheap uranium supplies are finite. Uranium industry concerns of a supply problem were generally ignored. Buyers need to understand the timing and other challenges facing the uranium industry's ability to operate and expand, and work with suppliers to ensure future needs are covered for a longer time period. For the moment, despite significant spot market price increases, our customers are getting a very good deal on their uranium prices.

That was the good news.

Now let me turn to some of the frustrations we continue to face in the uranium mining industry:

Canada's Rising Dollar

Canada's rising dollar, particularly with respect to the US dollar, has eaten up a large portion of the price gains since uranium is generally sold in US dollar prices. As new long-term contracts are signed, we will eventually get ahead, but the strong Canadian dollar has hurt exporters such as ourselves who are selling under long-term contracts for both lower prices and a devalued American dollar.

Continuing Technical Challenges

Our uranium deposits show outstanding grades ranging from 2% U to almost pure pitchblende. The high grade of these ore bodies, however, can pose some unique and challenging constraints.

Our uranium ore bodies are generally found where soft altered sedimentary layers of sandstone overlay rocks of the pre-Cambrian basement, near fractured zones. As a result, they are surrounded by rocks that cannot sustain the weight of the overlying rock once mining starts. In addition, water easily passes through such zones and ultimately into the mine workings. This can provide unpleasant surprises such as the recent McArthur River mine water inflow when a development drift encountered water-bearing fractures.

McArthur River Water Inflow

This summer, McArthur River experienced massive water inflow in a new development area close to the sandstone basin. Production was lost for a period of three months and could have been much worse had it not been for the heroic efforts of the mining crew. This incident has given all involved a "wake-up" call about how precarious mining can be in northern Saskatchewan.

Remote Mining Methods

At McArthur River, raise-bore mining and ore handling by remote methods separate the workers from the radiation sources. Ore is being mined behind a "freeze wall" preventing water from entering the mining area and allowing ore to be mined safely as well as reducing radon emissions in the stope.

Cigar Lake Remote Mining

Technical challenges associated with the Cigar Lake ore body are similar in some respects to those at McArthur River. Poor ground conditions, potential for massive water inflow and high radiation levels are all concerns that have to be managed. One unique technical aspect that will have to be dealt with at Cigar Lake is the fact that the ore body can only be accessed from the competent basement rock below the ore. COGEMA engineers invented a new mining method called **Jet Boring** to deal with this unique situation.

Jet Boring involves massive freezing of the ore body, followed by drilling a pilot hole up into the ore body. A high-pressure jet will then be inserted through the pilot hole into the ore body where it will take a cylindrical cut in the ore three to four metres in diameter. Ore cuttings will then fall down through the pilot hole and into a fully enclosed underground crushing and grinding circuit before being pumped to surface for processing elsewhere.

McClean Lake Mill Design

The McClean Lake operation is a major part of the future of COGEMA Resources. Issues faced in starting up this project included disposal of mine waste rock and tailings as well as the treatment and containment of heavy metals released during the milling process. The McClean mill is expected to run another 40 years with a combination of local ores and high-grade ore from the Cigar Lake project. Designed for safely processing grades ranging from 2 to 29% uranium, this state of the art mill uses shielding, containment, ventilation and innovative work procedures to protect workers.

Complex Regulatory Processes

Regulated by both Federal and Provincial governments, uranium mining is subject to levels of oversight and review not surprising in the nuclear industry, but well beyond what is normally expected in the mining industry. The high levels of environmental protection that are demonstrated by Saskatchewan's operating uranium mines prove their ability to meet and better these intensive requirements.

However, the numerous points of access afforded the public to comment and intervene in the environmental assessment and licensing process has led to long timelines between submission of a project description and the ultimate approval to proceed.

We know that our regulators are cognisant of the pressures faced by industry and are working with industry to seek timely completion of the environmental assessment and licensing process for new and existing projects.

We are also encouraged by the efforts undertaken by the provincial and federal governments and their regulatory agencies to harmonize to the extent possible their regu-

latory programs. Although in the early stages, we believe that these efforts to reduce regulatory overlap will indeed provide the desired efficiency, without sacrificing environmental standards.

Legal Challenges By NGOS

Despite the high standards of our operations, we have been fighting in court with an anti-mining group over a technicality in the wording of our operating licence at McClean Lake.

About 18 months ago, a federal court judge ruled in favour of an application filed by the Inter-Church Uranium Committee Educational Co-operative against the Atomic Energy Control Board, which is now the Canadian Nuclear Safety Commission. The legal issue was whether the Canadian Environmental Assessment Act, which became law in 1995 when the environmental review of the McClean Lake project had been underway for four years under the previous legislation, should apply.

COGEMA followed, to the letter, a rigorous eight-year federal-provincial environmental assessment and licensing process. In fact, this project was granted a revised operating license to allow for increased annual production in 2001 following an environmental screening under CEAA.

The judge decided that the environmental review work that was done under the old legislation was not sufficient and that environmental assessments should be redone under the new CEAA.

The court decision was appealed by both the Canadian Nuclear Safety Commission and COGEMA Resources. A stay has been granted pending the appeal. Now, both the provincial government and Aboriginal-owned northern companies have intervened in this case on our behalf. This is not an environmental or safety issue. Our record at McClean Lake is exemplary. This is simply a technicality in the licensing process. A Federal Court of Appeal hearing is now scheduled for early May.

To ensure production continues whatever the outcome of the legal appeal, we are applying for a new licence for the McClean Lake operation.

High Expectations Of Local Stakeholders

Uranium mining in Saskatchewan is a high profile industry and our sustainability is affected by the opinions of our public stakeholders including, in our case in particular, residents of Saskatchewan and Saskatchewan's North.

In recent years we have seen an increasing demand for jobs, contracting opportunities and other forms of benefit-sharing - demands that we have done our best to accommodate. We have had many successes.

However, the demands are beginning to outstrip our ability to deliver on these rapidly rising expectations, and it will take much effort and communication by the uranium mining industry to manage these expectations.

Conclusion

After many years of claiming that the recovery in uranium prices was "right around the corner", we believe that we have now turned that corner. This is welcome news for beleaguered uranium producers who have learned the value of patience over many trying years.

However, our celebrations are muted by the realization that many obstacles lay in front of us including:

- Technical challenges,
- Fiscal challenges,
- Social expectations.

We believe that with our emphasis on the principles of sustainable development the Canadian uranium mining industry is well equipped to face these challenges and will continue to provide a reliable, low cost supply of uranium fuel for many decades to come.

Cuttler & Associates Inc.

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GENERAL news

WIN reorganizes

Taking advantage of the CNA 20004 Seminar that began that evening, about 70 women and a handful of men gathered the afternoon of February 18, 2004 at the Chateau Laureir Hotel in Ottawa to discuss the revival of a Canadian chapter of **Women in Nuclear** (WIN).

WIN is a worldwide association of women working professionally in the fields of nuclear engineering and radiation application and willing to devote time to public information. Membership is open to women nuclear and radiation professionals and academics, as well as communication specialists. Men who support WIN goals are also welcome.

The meeting was organized and chaired by Susan Brissette of Bruce Power. Following introductory remarks about WIN international, Ms. Brissette introduced a guest speaker, JoAnne Thomas Yaccato, president of the Thomas Yaccato Group, a consulting firm specializing in gender communications.

All of us look through "gender eyes" she stated. Since business is still dominated by men the view of many businesses is distorted. She regaled her audience with stories of her dealings with male-dominated boards of companies, primarily retail. In one she told of taking the board members of a large retail home furnishing firm, giving them a baby (doll) and a 7 year old child, and sending them into the store to shop. They all gave up within minutes.

She acknowledged that while her examples may not fit directly with the objectives of WIN she pointed out that women are much less supportive of nuclear than men. Members of WIN can change that, she said, because they understand the viewpoint of women.

At the close of the session Susan Brissette asked for a show of hands of those who would be willing to try to start WIN groups in their organization. Representatives from several nuclear sites responded.

For more information on this initiative, contact Susan Brissette; e-mail: susan.brissette@brucepower.com

WIN Global is an affiliate of the World Nuclear Association. For background on WIN Global go to the website: www.world-nuclear.org/win-global.

Bruce Power to study restarting units 1 and 2

At the end of January 2004, a few weeks after re-connecting Bruce A unit 3 to the grid, Bruce Power announced that it would conduct a study to examine the feasibility of restarting units 1 and 2 of the Bruce A plant. The study will include a technical inspection of the two plants and an assessment of the cost to upgrade to current standards.

The study will also include a preliminary evaluation of refurbishing the four units of Bruce B, which will reach the end of their useful life over the next 15 years. Further, the potential of building new reactors at the Bruce site will be examined.

Bruce Power CEO Duncan Hawthorne said, "We have a tremendously skilled workforce, a well-established infrastructure and the support of the community. If this study concludes that there is a sound business case to be made for expanding Ontario's rector fleet, I can think of no better place to do it than at Bruce Power".

The reconnection of unit 3 was accomplished just three months after that of unit 4. "This is the first time any company has restarted two CANDU units back-to-back," said Duncan Hawthorne, Bruce Power's President and Chief Executive Officer. "We take great pride in that accomplishment, which required all of our combined skills and efforts. Breathing new life into Bruce A has indeed been a challenge, but we've emerged stronger for the experience and can look to the future with renewed confidence."

Bruce Power announced in 2001 that it would embark on the restart project for the two units. Safety, fire and seismic systems were all reviewed and upgraded to meet or exceed current regulatory standards, including the implementation of an entirely new secondary control area and a back-up emergency power system. Additional work followed the tragic events of Sept. 11, 2001, when the Canadian Nuclear Safety Commission required all Canadian nuclear facilities to improve their security provisions. At the height of the project there were more than 1,100 qualified and experienced employees on the Bruce 3 and 4 project.

Revised guidelines for environmental assessments

Following extensive consultations the Canadian Nuclear Safety Commission has issued a revised and clarified version of: "Guidelines for Environmental Assessments pursuant to the requirements of the Canadian Environmental Assessment Act".

The document is available at the CNSC website: www.nuclersafety.gc.ca

AECL and Hitachi open new office

In December 2003 Atomic Energy of Canada Limited and Hitachi opened a joint New Technology Commercialization (NTC) office in Vancouver, British Columbia. AECL officials stated that the new office is a natural result of the rapidly evolving relationship between AECL and Hitachi, capitalizing on near-term synergistic opportunities.

The goals and objectives of the New Technology Commercialization are to:

- Identify and develop business opportunities based on our synergies
- Focus on short and mid-term business in North America and Asian as well as global markets
- Coordinate overall AECL/Hitachi business
- Secure supply chain management for CANDU refurbishments and CANDU/ACR new builds
- Deliver new strategic opportunities

To secure these objectives the NTC will:

- Maintain fluid lines of communications, creating a seamless environment between all AECL and Hitachi locations
- Work closely with existing business units in delivering technology and services to the markets
- Capitalize on senior executive resources of the NTC

Managing this office are: Mark Pakan, Managing Director - AECL, and Dr. Makoto Kikuchi, General Manager - Hitachi, who report to Akira Maru, Executive Managing Director - Hitachi, and to Dennis Galange, Vice President of Corporate Development - AECL.

CNSC hosts Safety Culture symposium

The Canadian Nuclear Safety Commission (CNSC) is hosting a safety culture symposium on March 30 and 31, 2004 at the Sheraton Gateway Hotel, Toronto International Airport, Terminal 3, Toronto, Ontario.

The objectives of the symposium are to:

- clarify safety culture's meaning, its effect on an organization's daily operations and its role in enhancing safety performance;
- clarify the roles of industry and the regulator with respect to safety culture;
- provide examples of ways to address safety culture including at the working level;
- define the CNSC's vision for the future, our path forward and our expectations of the nuclear industry.

The symposium will be of interest to senior managers within all areas of the regulated nuclear industry together with those staff involved in the area of safety culture program development and implementation. There is no charge.

For information or to register for the symposium, visit the CNSC website <www.nuclearsafety.gc.ca> and follow the links to the Symposium website.

Or contact: Mike Austreng, Canadian Nuclear Safety Commission, 1-800-668-5284 (in Canada) or (613) 995-5894 e-mail: scsymposium@cnsc-ccsn.gc.ca

ITER site selection postponed

Ministers from the partners in the US$5 billion International Thermonuclear Experimental Reactor (ITER) project postponed a meeting scheduled for February 2004 to select a site for the project. The delay has been caused by deadlock over the choice between Cadarache in France and Rokkasho in Japan as the proposed site.

Negotiations over ITER's site have been stalled since a ministerial meeting in Washington, DC, in December, when the USA and South Korea backed the Japanese site, while China and Russia supported the European Union's (EU's) site.

Minister of Natural Resources, John Efford, officially withdrew Canada from the negotiations on December 23, 2003.

Writing to the heads of the negotiating delegations from Euratom, China, Japan, Korea, Russian Federation, and USA he stated:

"I am writing to advise you of the decision by the Government of Canada to withdraw from the ITER negotiations.

As you know, Canada participated in the design phase of the project and has been a party to the subsequent international negotiations. Iter Canada, a private-sector consortium, developed an offer (the Iter Canada Plan to Host ITER) to locate the project at Clarington, Ontario. Based on the excellent attributes of the Clarington site, which include major technical and cost advantages, the offer was presented by Canada to the international Parties at the June 2001 ITER meeting in Moscow. In June 2002, the European Union presented the French site at Cadarache and the Spanish site at Vandellos while Japan tabled its site at Rokkasho-mura. In light of the competitive offers submitted, including significant government financial backing, Canada indicated in December 2002 that it would review the ITER Canada Plan to Host and consider whether to table a revised offer.

Further to discussions conducted with the Government of Ontario and Iter Canada, a decision has been made that Canada will not table a revised offer to host the project, nor participate as non-host. Given present priorities and other demands, Canada is not in a position to table a competitive package that would lead to Canada becoming the host to the ITER project. It has been a difficult decision to reach, and it is with regret that Canada is withdrawing from the ongoing negotiations. Canada is also notifying the International Atomic Energy Agency that Canada will be withdrawing from the ITER Transitional Arrangements."

CNSC invites comments on ALARA

The Canadian Nuclear Safety Commission (CNSC) has issued, for public review and comment, Draft Regulatory Guide, G-129 rev.1, *Keeping Radiation Exposures and Doses "As Low As reasonably Achievable (ALARA)"*

This draft Regulatory Guide, is a revision of Regulatory Guide G-129, Guidelines on How to Meet the Requirement to Keep All Exposures As Low As Reasonably Achievable, issued in September 1997 by the former Atomic Energy Control Board. Specifically, under the current Radiation Protection Regulations, section 4, licensees must now implement a radiation program to keep the dose ALARA. References to action levels in the previous published guide have been removed since they are not within the scope of this document.

The CNSC invites interested persons to assist in the further development of this draft regulatory document by commenting in writing on the document's content and potential usefulness. Please respond by April 19, 2004. Direct your comments to the postal or e-mail address below, referencing file 1-8-8-129.

Draft Regulatory Guide G-129 rev.1, Keeping Radiation Exposures and Doses "As Low As Reasonably Achievable (ALARA)", can be viewed on the CNSC website at www.nuclearsafety.gc.ca.

World Nuclear University created

The World Nuclear Association (WNA), an international trade group with headquarters in London, and the International Atomic Energy Agency (IAEA) have created a new global body, the World Nuclear University (WNU).

Both organizations observed a worldwide shortage of nuclear engineers, workers, scientists, and students. The WNU plans to offer summer courses, strengthen links among academic and research institutions, and eventually establish an international standard for graduate degrees, says John Ritch, the WNA's director general.

The university was officially launched in the fall of 2003 to celebrate the 50th anniversary of President Dwight D. Eisenhower's "Atoms for Peace" initiative. The idea for creating an international university had been around for several years, but was taken up only last year by the WNA and IAEA. Former IAEA director general Hans Blix will be the WNU's first chancellor.

There will be no actual campus. The WNU will operate out of a small office in London, and its staff will initially consist of volunteer experts from research institutes, industry, and government agencies. That office will have links to universities and other educational organizations around the world. Canada is represented by UNENE (University Network for Excellence in Nuclear Engineering).

The WNU is working on what it hopes will be the first in a series of reference books, a manual called English Language Skills for the Global Nuclear Industry. Other planned programs will look at how to preserve the knowledge of the existing generation of nuclear workers before they retire.

Alberta report supports nuclear for tar sands

A recent report by the Alberta Chamber of Resources concluded that nuclear power is an attractive option for steam and hydrogen production for extraction of oil from Alberta tar sands. The report noted that new reactor designs offer significantly cheaper power costs while providing greater safety margins in operation.

The report observed that reliance upon natural gas would not be "unsustainable and uneconomic". It forecast a rise in natural gas demand for tar sands processing from 10 per cent in 2012 of Mackenzie and Western Canada Sedimentary Basin production to 60 per cent by 2030. At that point, the report stated, imported liquid natural gas would be setting North American prices. Therefore, continued tar sands production meant switching to an external fuel source such as coal or nuclear power.

The Chamber report noted that nuclear power was competitive at natural gas prices of $4/gigajoule for an operation producing 150,000 barrels of oil per day.

OPG makes changes at Pickering

Ontario Power Generation acting chief executive Richard Dicerni has stated that all engineering work on two of four units at the Pickering A nuclear generating station has been halted. He was further reported as saying that several senior people and as many as 60 contract engineers will be let go.

Andrew Muller of the Society of Energy Professionals, which represents OPG staff engineers on the project, was quoted as supporting the move.

Dicerni said the decision to continue work on Units 2 and 3 - and even the decision to proceed with restarting Unit 1 - can't be made until a panel headed by former finance minister John Manley completes a report scheduled for March 15.

After that, it will be up to the provincial government to decide on proceeding with the restart of one, or none, of the remaining reactors. The Pickering "A" Review Panel reported in December that restarting all four reactors could cost between $3 and $3 billion and take until 2008.

Ontario Energy Minister Dwight Duncan fired OPG's top executives and installed Dicerni on Dec. 10. He reports to a new board of directors headed by former federal energy minister Jake Epp.

Obituaries

Jim Walker

William James Walker, a pioneer of the Canadian nuclear program, died December 15, 2003 in Toronto, after a brief illness, at the age of 73.

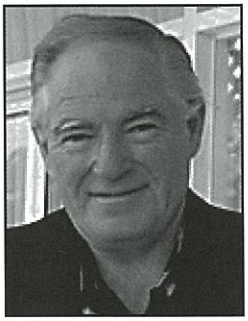
Jim joined Atomic Energy of Canada Limited in the early 1950s and served on the commissioning and operation of the NRU research reactor. He was recruited to become part of the original staff of the NPD demonstration plant as part of the commissioning team that resulted in the first nuclear power plant in Canada starting up in 1962.

He then joined the commissioning group at the Douglas Point prototype unit at what is now called the Bruce site. Then he went to Hydro Québec as senior commissioning engineer on the Gentilly 1 project (a CANDU boiling light water design). After the start-up of Gentilly 1 in 1972 he moved back to Ontario Hydro to work on the Bruce A plant. Rejoining AECL he returned to Gentilly as their representative until the unit was shutdown in 1978. Following that period he was attached to NB Power as part of the commissioning team for the Point Lepreau station.

Jim developed a determination to master both of Canada's official languages and became an ardent student of French, both spoken and written.

He had many interests, including cycling and astronomy, and was a piper with both the 48th Highlanders Pipe Band and the Metro Toronto Police Band. A story is told of one Saturday morning in Trois-Rivieres, when he was working at Gentilly, he came out and played the bagpipes while walking around the yard. As the wail of his pipes swept across the neighbourhood every kid within earshot lined up behind him, Pied Piper style. The parade reportedly lasted several minutes.

A service or remembrance was held December 19, 2003.



Jack W. Richman

Jack Richman, president of Merlin General Corporation and a member of the Board of the Canadian Nuclear Association, died in Point Clark, Ontario on February 15, 2004, just five days shy of his 63rd birthday.

Jack was born in Kent, England and graduated from the University of Wales in 1963. He emigrated to Canada in 1966 and attended the University of Manitoba where he obtained a M.Sc. in 1968 and a Ph.D. in mechanical engineering in1972. During that same time he worked for Bristol Aerospace. Subsequently he worked with Dilworth Secord Meaghan and Associates, Bechtel Engineering and Ontario Hydro. From 1990 to 1995 he was vice-president of the Peterborough consulting firm, Spectrum Engineering.

He was associated with the Canadian nuclear program for many years and was a member of the Board of the Canadian Nuclear Association from 1990 to his death. He served, in an interim capacity, as President of the CNA from 1994 to 1996.

He formed Merlin General Corporation in 1995 and located it at Kincardine, Ontario near the Bruce site. In 1995 his company took on the decommissioning of the Subcritical facility at the University of Toronto. Then in 1999 it decommissioned and dismantled the U of T Slowpoke reactor. Subsequently his company did an upgrade for the Slowpoke reactor at the Royal Military College and is now the primary service organization for the Slowpoke series.

Just last year his company entered into a joint venture with Biomedy AG of Switzerland to offer decontamination services to the Canadian nuclear industry.

A service of celebration and thanksgiving was held in Kincardine, Ontario, on Saturday, February 21, 2004.

CNS news

CNS President's remarks to CNA 2004 Seminar

Following is a slightly edited version of the welcoming (unscripted) remarks by CNS president Jeremy Whitlock at the opening of the CNA 2004 Seminar, February 18, 2004, in Ottawa.

Good Morning. We're living in interesting times in the nuclear industry. That's almost a redundant thing to say in this industry, but for the first time in a long time, the reasons for the times being "interesting" are actually looking more and more positive. For the first time in a long time, nuclear is looking not as a pariah, not as a panacea, but as - lo and behold - exactly what it is: a strategic, baseload energy supply option for the future - that should be kept in the portfolio.

On behalf of the Canadian Nuclear Society, I would like to welcome you all to today's very interesting and exciting events. The Canadian Nuclear Society is 25 years old this year. We started out as the Technical Society of the Canadian Nuclear Association. We've been associated with the CNA through events like this ever since then, and it's our pleasure to co-host this.

The agenda today is full of - as the theme says - "a hard look at the future" of nuclear power and energy in Canada. As you're learning about these hard issues, I would like you also to keep in mind some other hard challenges that remain out there. Things like, getting the youth involved in nuclear science and technology (and science and technology in general), getting young women involved in the industry, communicating issues with the public, and communicating issues amongst ourselves - amongst the people who work in the industry, who work in your companies.

This is where the CNS comes in. We represent the people on the floor, who talk to each other and with the public, and get these ACRs rolling down the conveyer belt. The Annual Conference of the CNS is coming up in June. I invite you all to attend that, and get people in your companies to attend. That is where we will discuss some of the hard issues and those collateral issues on the side that are determining the future of the industry, 20 and 30 years down the road: the people that will be putting out the products that underpin the energy supply [of the future]. Those are the people that will be doing it - the young people that are entering high-school today and deciding whether they want to go into science and technology, or not.

Please enjoy your day today. Learn, speak with each other, and take back to your companies, your people back home - wherever you are in Canada - what you learned today. Spread the word to the public. And please enjoy "Nuclear Day in Canada".

CNS to bid for PBNC 2008

The CNS Council has decided to bid to hold the 2008 Pacific Basin Nuclear Conference (PBNC).

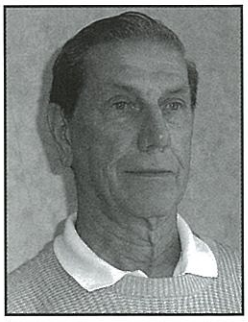
The Pacific Basin Nuclear Conferences are held every two years, under the auspices of the Pacific Nuclear Council (PNC). PNC is an association of nuclear societies and associations from countries around the Pacific Rim. Both the Canadian Nuclear Society and the Canadian Nuclear Association are members.

Canada hosted one of the early PBNC meetings in 1983 in Vancouver. Then it ran one of the most successful PBNC events in Banff in 1998. Members of the CNS Council decided that it would be appropriate for Canada to again host the meeting a decade later.

Ben Rouben is the chair of the PBNC 2008 committee and will be presenting the CNS bid at the next meeting of the Pacific Nuclear Council being held in Hawaii, March 21, immediately prior to the 2004 PBNC meeting which is hosted and organized by the American Nuclear Society. The proposal is to hold PBNC 2008 in Vancouver. The CNA has endorsed the CNS bid. It is understood that Mexico and Russia will also be submitting bids for PBNC 2008. CNS President Jeremy Whitlock and Bulletin editor Fred Boyd will attend the PNC meeting in support of Ben Rouben.

Paul Fehrenbach, of Atomic Energy of Canada Limited, is currently vice-president of PNC and will become president at a ceremony to be held during the PBNC 2004 gathering

EIC Fellowship Award



On March 6th, in Ottawa, Fred Boyd, the long time editor of the Bulletin, will receive a Fellowship Award from the Engineering Institute of Canada. (EIC). The Fellowship is awarded for excellence in engineering, services to the profession and to society. The EIC now comprises nine technical societies, of which the CNS is one, and truly represents the engineering profession in Canada.

Fred Boyd's contributions to the nuclear industry include: participation in the design and installation of the first commercial Cobalt 60 cancer therapy unit; design of the prototype CANDU reactor, NPD; regulatory work as a member of the Atomic Energy Control Board, where he contributed to the development of Canadian policy on nuclear safety; and as nuclear-energy advisor in the Department of Energy, Mines and Resources. He has also served as a consultant to the International Atomic Energy Agency on a number of occasions. He has given considerably of his time and talent as the volunteer editor and co-editor of CNS publications, notably this CNS Bulletin, for almost 15 years. Fred was elected Fellow of the CNS in 1994.

Fred has been the CNS representative on many international organizations, including the Pacific Nuclear Council and the International Nuclear Societies Council, and is a member of the American Nuclear Society's International Committee. The CNS is grateful that he has represented us so effectively in the international arena.

Canadians who have worked in the nuclear industry and who have attended CNS and CNA conferences will recall the many occasions when Fred has asked salient questions during plenary presentations and made his opinions known during panel discussions.

However, his lasting success, for which the industry owes him great gratitude, is building and sustaining the CNS Bulletin over the years as the foremost communication medium of the Canadian Nuclear Society. The members of the CNS would like to wholeheartedly congratulate Fred on this award.

Ed Price
Chair, CNS/CNA Honours & Awards Committee

CNS turns 25

This year (2004) will mark the 25th anniversary of the creation of the Canadian Nuclear Society. It was officially created on June 11, 1979 as the "Technical Society of the Canadian Nuclear Association". The CNA was formed in 1960 and soon thereafter included technical sessions at its annual conferences. However, there was a growing feeling that there was a need for a society that represented the scientists and engineers in the Canadian nuclear program.

The CNA Board of Directors established a task force in 1977 to study the issue, headed by Dr. Langlois, Dean of cole Polytechnique. In March 1979 the CNA Board accepted a proposal to create the technical society.

A pro-tem Council was set up in August 1979 with George Howey as president, John Hewitt, vice-president, and Dan Meneley, secretary-treasurer. (Unfortunately both George Howey and John Hewitt have passed away.) They and the other members of that pro-tem Council developed a Constitution and a set of By Laws and established that the CNS Council would organize the "third day" of the CNA annual conferences.

In June 1980 the first elected council was formed, with George Howey, president, John Hewitt, vice-president, and Bob James, secretary-treasurer. Jim Weller, CNA general manager, provided administrative support.

Although officially a division of the CNA, the CNS soon began to operate separately, both functionally and financially. The CNS Bulletin was begun in 1980 as a copied newsletter, moving to typeset in 1983. A Nuclear Journal of Canada was begun in 1987 but had to be terminated less than two years later because of the financial cost.

In 1998 the CNS, with the blessing of the CNA, took the step of incorporating itself as a separate entity. Now the Society is a vigorous and active technical organization of close to 1,000 members that runs the only full conference on nuclear technology in Canada.

For more information on the early years of the CNS go to the CNS website where webmaster Morgan Brown has placed the entire text of a paper "The Formative Years of the Canadian Nuclear Society, 1976 - 1984" by George Howey, Phil Ross-Ross and John Hewitt, that was originally published in the first issue of the Nuclear Journal of Canada, March 1987. The Bulletin editor has a few reprints of that article if anyone wishes it.

BRANCH ACTIVITIES

Bruce *Eric Williams*

Ron Mottram, VP Bruce A Restart, is scheduled to address the Branch on Tuesday, March 16, 2004.

Several other presentations are in the planning phase.

The Bruce Branch website is up and running, thanks to the efforts of Ms. Michelle Lapointe.

Chalk River *Morgan Brown*

On January 29, 2004, the Chalk River branch had a presentation on «Decommissioning Activities at the CRL Site - Insights into AECL's Past» by Bruce A. Lange, Director,

Decommissioning Planning and Operations, AECL.

Also, the «Beneficial Applications Of Nuclear Science & Technology» essay contest is proceeding. Blair Bromley, who is leading it, has been doing follow-up telephone calls to the county schools to ensure staff are aware of the contest and have received the mail regarding the contest. At the time of writing two students have indicated an interest in participating.

Darlington *Jacques Plourde*

The program to revive the Darlington Branch is running behind schedule because of OPG events beyond our control. A «big push» will begin in the next few weeks.

The Branch joined forces with University of Ontario Institute of Technology (UOIT) to present a late afternoon event on January 26 at UOIT on «Advancing Global Health Through Innovation», by Grant Malkoske, V.P. Engineering & Technology, MDS Nordion. This was organized by Dr. G. Bereznai of UOIT.

New Brunswick *Mark McIntyre*

On Thursday December 12, 2003, the New Brunswick Branch held a Membership Drive in Saint John. Branch executive member, Larisa Duffy, was successful in encouraging new memberships as well as numerous renewals. A similar event was held in Fredericton the following day for the Fredericton based members.

In mid January 2004, the NB Branch was pleased to host Dr. Romney Duffey, Principle Scientist with Atomic Energy of Canada Limited at two presentations. The first was on the campus of the University of New Brunswick, where over 40 hearty Canadians braved the aftermath of a snowstorm to hear the message about the synergies between nuclear power and the hydrogen economy. Dr. Duffey also touched on the economic factors that should be considered when a utility extends the life of a nuclear reactor or expands generating capacity.

The Q&A period was lengthy and very informative. Many questions dealt with the refurbishment of Point Lepreau versus the economics of building a new Generation 3+ reactor. The audience included a wide variety of nuclear industry professionals, UNB students, UNB faculty, consultants and provincial government officials. He gave a shorter version of his talk the following day at Point Lepreau's STOIC theatre.

The Branch is looking forward to hosting CNS President, Jeremy Whitlock, in March.

Ottawa *Bob Dixon*

On February 5, Jeremy Whitlock gave a talk on "Canada's MAPLE research reactors". Unfortunately computer problems prevented him from projecting his slides but members followed the talk with the aid of handouts.

CNS Ottawa will co-sponsor a presentation on TRIUMF by Alan Shotter for the Ottawa Chapter of Sigma Xi on Feb 26.

The Branch widely advertised the W.B. Lewis lecture, which was held on February 19,.during the CNA Annual Seminar.

CNS Ottawa will again be assisting the Ottawa Regional Science Fair, to be held April 3, and offering a prize for projects related to nuclear science or engineering.

Pickering *Marc Paiment*

CNS President, Jeremy Whitlock, is scheduled to give a talk on the MAPLE reactor on March 11. The occasion will be used to begin a membership drive.

Quebec *Michel R. Rheaume*

The Quebec Branch section of the CNS Web Site has been updated by .Jaroslav Franta . Dr Elisabeth Varin, from École Polytechnique de Université de Montreal, has provided the simulation of a CANDU reactor developed by a student supported by the CNS Education Fund (1000$) and Hydro Québec. Now, it is available for anyone to use for information and training.

Sheridan Park *Adriann Buijs*

The new Branch executive has met and planned the following activities. :

1. An attempt will be made to maintain the frequency of one seminar per month.
2. Judges will be sent to two local science fairs. The prize money to be awarded was increased from 300 to 400 CAD for each.
3. When relevant, the branch will manifest itself in AECL family days, etc.
4. The bulletin board in the AECL cafeteria will be brought up to date.

Toronto *Bob Hemmings*

The Toronto Branch has organized programs for the "front-end" of 2004:

- January 26 Grant Malkoske, Vice-President, Engineering & Technology, MDS Nordion, Topic: Advancing Global Health Through Innovation
- February 24 - Speaker: Glen MacDonald (OPG); Topic: Status of the Darlington Tritium Removal Facility; Place: OPG
- April 6t Topic: Natural Background Radiation; Speaker: John LaMarre of OPG; date: April 6; place: U of T
- May 5 Paul Gierszewski "Deep Geological Repositories"; place: OPG.

- June - also our Annual General Meeting - maybe the new CNS president? Or the new CNA President? or the new OPG management? or the new Minister of Energy of Ontario? Place: at U of T (to be confirmed)

The Branch is now busy trying to organize the fall program of presentations and speakers.

The two programs held in the fall of 2003 were well attended: Jeremy Whitlock on CNS and on the Maple Reactors, at UofT; and Ken Petrunik on CANDU 700 in China and the CANDU ACR, at OPG.

New Members

We would like to welcome the following new members, who have joined the CNS recently.

Marcos A. Ara Montrichard, McMaster University
Ahmad Tamiri Osgouee, OPG
Chunzhen Ye, University of Toronto
Frederik G. Beran, Canatom NPM Inc.
Ronald K. Osborne
Myra Elizabeth Burgess, OPG
Darryl J. Wallace, McMaster University
Brent B. Williams, Bruce Power
Thai Sinh Nguyen, McMaster University
Surendra Chawla, Canadian & International Project Services
Leeda Samimi, Atlantic Nuclear Services Ltd.
Paul D. Huntington
Jake Epp, Ontario Power Generation
Jason R. Burke, Durham College
Andrew T. McGregor
Murray J. Elston, Canadian Nuclear Association
David L. Newcombe, Bruce Power
Parva Alavi, AECL
Taesung Ha, McMaster University
Kenneth B. Belfall, Ontario Power Generation

Nous aimerions accueillir chaudement les nouveaux membres suivants, qui ont fait adhésion à la SNC récemment.

James E. Arsenault, President
Dale Greenlaw
Nathan G. Maguire, Neill & Gunter Limited
Neale G. Hunt, Nuclear Safety Solutions Limited
Ryan A. McClure, McMaster University
Ryan P. McCabe, McMaster University
William F. Bohnhardt, Harz Industrial Tool & Equip. Inc.
Ken Petrunik, AECL
Larry Barker, Spectrum Consulting Inc.
Ross L. Obuchi, University of Ontario Institute of Technology
Ken Kirkhope, Canadian Nuclear Safety Commission
Hans Jambrovic, North American Power Partners
José C. Santos, Senior Technical Engineer
Revi K. Kizhatil, Babcock & Wilcox Canada
Michael D. Lees, Babcock & Wilcox Canada Ltd.
Georges J. Comeau, NB Power
Jim I. Czegeny, JIC Engineering Service
Terry Harnadek, AECL
Shahla Alavi

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The Bulletin of the Canadian Nuclear Society is the only publication focussing on the science and technology associated with the Canadian nuclear program.

It is published quarterly and distributed to about 1300 managers, professionals, government officials, and overseas organizations.

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For further information contact
Fred Boyd, editor: e-mail: fboyd@sympatico.ca

Canadian Nuclear Society
25th Annual Conference
"Nuclear Energy - Meeting the Challenges"
Toronto, Ontario, 2004 June 6-9

REGISTRATION FORM

(Please type or write in block letters)

Name: _____
(Dr./Mr./Ms.) First Last

Title: _____

Organization: _____

Business Address: _____
Street # Street Name

_____
City Province/State

_____
Postal Code Country

Business Telephone: _____

Fax: _____

E-mail: _____

If you are a speaker, please check this box: ❑

If a speaker at the Student Conference, pls. check ❑

If you would like vegetarian meals, pls. check this box: ❑

This registration form is also available on the CNS web site, at www.cns-snc.ca

Please mail, fax, or e-mail registration form with payment to Canadian Nuclear Society, 480 University Ave., Suite 200, Toronto, ON, M5G 1V2
Fax: 416-977-8131; e-mail: cns-snc@on.aibn.com
Tel.: 416-977-7620

For further information regarding the Conference, please contact Mrs. Denise Rouben, CNS Office Manager, using the contact information above.

The Conference Hotel will be the Toronto Marriott Eaton Centre, 525 Bay St., Toronto, ON, M5G 2L2. Room reservations must be made directly with the Hotel at 1-800-905-0667. When calling the hotel, you must indicate that the reservation is for the CNS 2004 Annual Conference. A block of rooms is held for the Conference until 2003 May 10; please reserve early. The price of rooms is $199 per night + tax, single or double. Smoking or non-smoking rooms are available upon request.

For Office Use:
CNS Member? Yes ❑ No ❑
ID #:
Entered: 2004/
Processed: 2004/
Receipt sent: 2004/

REGISTRATION OPTIONS Registering:	By May 1	After May 1
CNS Member	$530.00 ❑	$600.00 ❑
Non-CNS Member	$595.00 ❑	$665.00 ❑

(Includes all CNS Sessions, one copy of Proceedings, Reception, Conference meals including Banquet)

CNS Retiree Member	$160.00 ❑	$200.00 ❑
Full-Time Student	$100.00 ❑	$130.00 ❑

(Includes all CNS Sessions, one copy of Proceedings, Reception, Conference meals including Banquet)

One-Day Registration (Includes sessions and Conference meals for the day – Luncheon on Mon. or Wed., Banquet on Tues. Does not include Conference Proceedings.)
Please indicate for which day: ❑ Mon., ❑ Tues., ❑ Wed.

CNS Member	$280.00 ❑	$310.00 ❑
Non-CNS Member	$310.00 ❑	$340.00 ❑

Guest accompanying registrant ❑
(Permits complimentary attendance at Reception)

Guest's Name: _____

Additional Luncheon Tickets: ....@ $45 = _____
For which day? ❑ Mon, ❑ Wed

Additional Tickets for Banquet (+ Pre-Banquet Reception + Entertainment) (Tues): ....@ $75 = _____

Additional CD-ROM Proceedings: ....@ $70 = _____
(Price will be $100 post Conference)

SUMMARY

NOTE: All fees in Canadian dollars. Payments in US$ will be subject to exchange rate of: $1.00 US = $1.30 Canadian

Subtotal of all above fees: $_____

GST (#870488889 RT) _____

- Canadian residents: 7% GST $_____
- Visitors to Canada : 3% GST $_____

Total Due: $_____

METHOD OF PAYMENT

❑ Cheque (to "Canadian Nuclear Society")
or ❑ AMEX ❑ MasterCard or ❑ VISA

Name on credit card: _____
Please type or write in block letters

Card #: _____

Expiry Date (yyyy/mm): 200_/____

Signature (required for card payment):

_____ Date: 200_/__/__

Please note Cancellation Policy: A fee of $100 will be charged for all cancellations received after 2004 May 1.

Société Nucléaire Canadienne
25ième Conférence annuelle
« L'énergie nucléaire – égale aux défis »
Toronto, Ontario, 6-9 juin 2004

FORMULAIRE D' INSCRIPTION

(Veuillez dactylographier ou écrire en caractères gras ou moulés)

Nom: _____
(Dr./Mr./Ms.) prénon nom de famile

Titre: _____

Affiliation: _____

Adresse au bureau: _____
numéro nom de la rue

_____
Ville Province/État

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Code postal Pays

Numéro de téléphone au bureau: _____

Numéro de télécopieur: _____

Adresse électronique: _____

Si vous faites une présentation, veuillez cocher ici : ❑

Si c'est une présentation à la Conférence étudiante : ❑

Si vous désirez des repas végétariens, veuillez cocher ici : ❑

Ce formulaire d'inscription est également disponible au site internet de la SNC : www.cns-snc.ca

Veuillez envoyer le formulaire d'inscription par poste, télécopieur ou courrier électronique, avec paiement, à : Société Nucléaire Canadienne, 480 ave. Université, Suite 200, Toronto, ON, M5G 1V2
Télécopieur: 416-977-8131; tél.: 416-977-7620;
courriel: cns-snc@on.aibn.com

Pour plus d'information sur la conférence, veuillez communiquer avec Mme. Denise Rouben, administratrice du bureau de la SNC, aux numéros ci-haut mentionnés.

La conférence aura lieu à l'hôtel Marriott Eaton Centre, 525 rue Bay, Toronto, ON, M5G 2L2. Les réservations doivent être faites DIRECTEMENT avec l'hôtel Marriott au 1-800-905-0667. Quand vous appelez l'hôtel, vous devez indiquer que la réservation est pour la Conférence annuelle 2004 de la SNC (en anglais, CNS 2004 Annual Conference). Un certain nombre de chambres est réservé pour la conférence jusqu'au 10 mai 2004 ; veuillez faire votre réservation assez tôt. Le prix d'une chambre simple ou double est de 199$ par nuit + taxes. Des chambres fumeur et non-fumeur sont disponibles.

Pour l'usage du bureau:

Membre SNC? Oui ❑ Non ❑

ID #:

Entré: 2004/

Traité: 2004/

Reçu envoyé: 2004/

MODALITÉS D'INSCRIPTION

Inscription:	Jusqu'au 1er mai	Aprés 1er Mai
Membre SNC	530.00$ ❑	600.00$ ❑
Non-membre SNC	95.00$ ❑	665.00$ ❑

(Inclut toutes séances SNC, une copie des comptes-rendus, la réception, les repas de la conférence, incluant le banquet)

Membre retraité SNC	160.00$ ❑	200.00$ ❑
Étudiant à plein temps	100.00$ ❑	130.00$ ❑

(Inclut toutes séances SNC, une copie des comptes-rendus, la réception et repas de la conférence, incluant le banquet)

Inscription d'un jour (Inclut les séances et les repas du jour: lunch lundi ou mercredi, banquet mardi. N'inclut pas les comptes-rendus sur CD-ROM.)
Veuillez indiquer pour quel jour: ❑ Lun., ❑ Mar., ❑ Mer.

Membre SNC	280.00$ ❑	310.00$ ❑
Non-membre SNC	310.00$ ❑	340.00$ ❑

Invité(e) ❑ (Entrée gratuite à la réception du dimanche)

Nom de l'invité(e): _____

Billets additionnels pour un lunch: ....@ 45$ = _____
Pour quel jour? ❑ lundi ❑ mercredi

Billets additionnels pour le banquet (+ réception avant le banquet + divertissement) (mardi): ...@ 75$ = _____

Copies additionnelles des comptes-rendus sur CD-ROM (100$ après la conférence) ...@ 70$ = _____

SOMMAIRE

N.B.: Tous frais d'inscription en $ canadiens. Paiements en $US sujets au taux d'échange 1.00$ US =1.30$ canadien

Sous-total des frais ci-dessus: _____ $

TPS (#870488889 RT) : _____

• Résidents canadiens : 7% _____ $

• Visiteurs au Canada : 3% _____ $

Solde dû : _____ $

Les paiements par carte de crédit peuvent être faits par télécopie de ce formulaire d'inscription au 416-977-8131, ou par courriel au cns-snc@on.aibn.com

MODE DE PAIEMENT

❑ Chèque (au nom de la Société Nucléaire Canadienne).
ou bien ❑ AMEX, ❑ MasterCard ou ❑ VISA

Nom sur la carte de crédit : _____
(dactylographié ou en lettres moulées)

Numéro de carte : _____

Date d'échéance (aaaa/mm) 200_/__/__

Signature (pour paiement par carte):

_____ Date: 200_/__/__

Veuillez noter que toute annulation après le 12 mai 2003 sera sujette à des frais d'administration de 100$.

The Human Factor

by Kim Vicente
Knopf Canada, 2003, ISBN 0-676-97489-9
reviewed by Dan Meneley

The stock of literature dealing with human factors is growing rapidly. This trend should help us to recognize the predominant role of humans in sustaining safety in today's high-technology society. The field is, by its very nature, multidisciplinary with respect to engineering and technology. This work presents a generalist view as observed by a specialist in this field. The book is both informative and entertaining, and holds an important message that can be understood, even by the most technology-averse people among us.

The book offers little new material to experts in this field, but might well expand their knowledge by illustrating the broad range of large-scale technologies in which human behaviour has a marked effect on safety. There is a bias here towards illustration of failures at the human/machine interface, and scant mention of the many situations where humans perform well in spite of poor machine design. Also, there is scant mention of the numerous instances of good human performance assisted by careful attention to human factors in design. This bias is natural in a book concerned with improvement of human performance in large, complex systems.

There are weaknesses -- for example, the lack of reference to, or discussion of, important recent publications in this field, such as References 1 and 2. There is no mention of the largest failure of modern times in the chemical industry at Bhopal, India; likewise, for other major failures determined largely by human factors. Nonetheless, several good examples are included.

The book begins with a brief description of the 1986 accident at Chernobyl, Ukraine. That description misleads more by what it leaves unsaid than by what it says. A major error (human, perhaps) is the statement that "A critical nuclear reaction – the type that occurs by design in an atomic bomb but is never supposed to happen in a nuclear power plant – was inevitable." This sentence has two fatal flaws; first, a critical nuclear reaction occurs continuously and steadily in every operating nuclear power plant. Second, the transient super-critical reaction that occurs by design in an atomic bomb takes place millions of times faster than is physically possible in any nuclear power plant and hence its effects are different, both quantitatively and qualitatively. The uncontrolled burst that destroyed Chernobyl Unit 4 was caused by rapid (a time scale of seconds) production of excess thermal energy followed by a steam explosion and combined, possibly, with a hydrogen explosion. It was 'nothing like' the explosion of an atomic bomb.

The main argument of this book is that engineers should be educated to consider human factors along with the many other factors that influence engineering decision-making. Good advice. In addition, engineers and their managers must be educated to recognize good "human-tech" systems that can be applied productively to the benefit of our society.

References

1. Romney Beecher Duffey and John Walton Saull, "Know The Risk – Learning from Errors and Accidents: Safety and Risk in Today's Technology", Butterworth Heinemann, 2003.
2. Karl E. Weick and Kathleen M. Sutcliffe, "Managing the Unexpected" – Assuring High Performance in the Age of Complexity", Jossey-Bass, 2001.

Deep Waters
The Ottawa River and Canada's Nuclear Adventure

Kin Krenz
McGill-Queens's University Press, 2004, ISBN 0-7735-2691-9
The following is taken from the publisher's notes.

Deep Waters is an intimate account of the principal events and personalities involved in the successful development of the Canadian nuclear power system (CANDU), an achievement that is arguably one of Canada's greatest scientific and technical successes of the twentieth century. Kim Krenz tells the stories of the people involved and the problems they faced and overcame. He also describes the history of the development of the town of Deep River, built exclusively for the scientists and employees of the Chalk River Project, and describes the impact of the Project on the traditional communities of the Ottawa Valley.

The book is scheduled to be released in April 2004. For further information go to the publisher's website: <www.mqup.ca>

Kim Krenz was stationed at the Chalk River Laboratories in the early years and subsequently headed ABRICO Energy Management Services Ltd. He now lives in Lakefield, Ontario.

Split Atoms, Not Infinitives

by Jeremy Whitlock

It was as bold as it was overdue: an ambitious electricity demand/supply plan to launch Ontario into the new millennium. Aggressive demand management, renewables, clean fossil, underpinned by an unprecedented multi-unit CANDU build program.

The year was 1989. For Lorne McConnell, then Ontario Hydro's planning VP, it was a fitting swan song to a career of leadership within the giant utility. Thirty years earlier he had quarterbacked the province, and the entire country, into the Nuclear Power Age as NPD's first station superintendent.

The 1989 plan was of course shelved, but fifteen years later many of its elements have returned to the spotlight in the 10-year outlook of Ontario's grid operator (the IEMO), as well as in the recent report of the Ontario Government's Electricity Conservation and Supply Task Force. People are again discussing a multi-unit CANDU build program, plus refurbishment, and this time the prospect has legs.

What's so different about 2004, compared to 1989, that turns the optics around so dramatically? Besides the use of the word "optics", that is.

Perhaps it's the lack of a hostile NDP government in Toronto. Perhaps it's the lack of a major recession and ten subsequent years of flat demand. Perhaps it's the existence of a private-sector nuclear operator that puts the "Can-do!" back in CANDU. Or an Ontario government with no time for coal. Maybe it's got something to do with a decade of unstable natural gas pricing. Or almost two decades without a major reactor accident anywhere on the planet. How about a sexy new CANDU design ready to take on the world and compete head-to-head with gas, with risk guarantees to boot?

Possibly all of these played a role, but there's no denying the one factor deserving most of the credit for waking politicians and the media to the simple realities of electricity supply: Air Conditioning.

Last August, for several very humbling hours (days in some cases), nobody in Ontario had any.

You see, about five years ago Ontario's summer peak electricity usage surpassed its winter peak for the first time, and hasn't looked back: air conditioning is king in the Land of Plenty. So during the Great Blackout of August 2003, decision makers, news editors, CEOs - society's most elite movers and shakers - all stewed in their own juices just like the most homeless of the homeless, pondering the value of electricity to the social fabric.

People learned what a megawatt can do: their radios told them how many hundreds of these things were coming their way, and then poof - an entire city was alight. Just as quickly, the gift was revoked when too many air conditioners went back on. People learned about supply reliability. They learned how the grid works. They learned that there IS a grid.

Astonishingly, this is exactly what the water-cooler pundits had been advocating for years: "What we need is a good blackout - then people will appreciate what reactors do for them!"

That kind of knee-jerk diplomacy never cut it with the serious PR thinkers, but lo and behold, it happened and it had exactly that effect on people. Go figure.

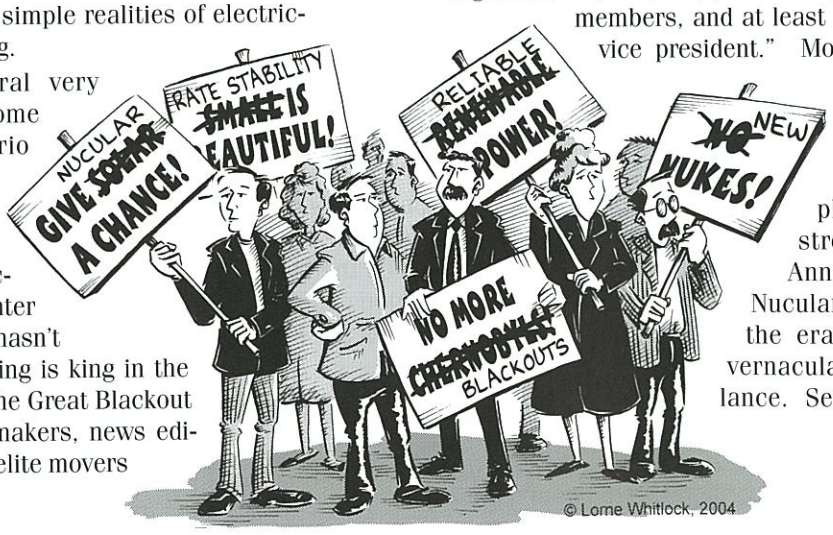
Suddenly nuclear is in the "In" basket again. On the evening news, in the editorial columns, a new rational approach appears - nuclear is neither pariah nor panacea, but a strategic baseload option. Long-time industry defenders are baffled by the new tack of reasonable thought.

There is but one remaining problem on the nuclear social scene: far too many people are still mispronouncing the word as "nucular". If the technology is to play a larger role in people's lives then it's just going to have to be identified correctly.

Unfortunately, this particular verbal negligence is reinforced by many in the industry itself, as well as the high and mighty from George Dubya right back to Eisenhower himself in his "Atoms for Peace" speech to the UN fifty years ago last December.

It's been in the Merriam-Webster dictionary since 1961 ("found in widespread use among educated speakers including scientists, lawyers, professors, congressmen, U.S. cabinet members, and at least one U.S. president and one vice president." Most prestigious, it notes, is the usage by "British and Canadian speakers".)

Thus, social advocacy still has a role to play in a new era of mainstream nuclear tolerance. Announcing the "Campaign for Nucular Phase-out", dedicated to the eradication of this dastardly vernacular from the common parlance. Send your money today.



CALENDAR

2004

Mar. 21 - 25
PBNC 14
14th Pacific Basin Nuclear Conference
Honolulu, Hawaii
website: www.ans.org/meetings/pbnc

Apr. 25 - 29
PHYSOR 2004
Chicago, Illinois
website: www.td.anl.gov/PHYSOR2004

Apr. 25 - 29
ICONE 12 International Conference on Nuclear Engineering
Arlington, Virginia
website: www.asmeconferences.org

May 2 - 6
International Topical Meeting on Advanced Nuclear Installation Safety
San Francisco, California
website: www.ans.org/meetings

May 9 - 14
10th International Conference on Radiation Shielding
Maderia, Portugal
website: www.itn.mces.pt/ICRS

May 9 - 13
IYNC3
3rd International Youth Nuclear Congress
Toronto, Ontario
Contact: Adam McLean
e-mail: adam.mclean@utoronto.ca

June 6 - 9
25th CNS Annual Conference
Toronto, Ontario
Contact: Denise Reuben
Canadian Nuclear Society
Tel: 416-977-7620
e-mail: cns-snc@on.aibn.com

June 13 - 17
ANS Annual Meeting
Pittsburgh, Pennsylvania
Contact: American Nuclear Society
website: www.ans.org

June 13 - 17
International Congress on Advances in Nuclear Power Plants
Pittsburgh, Pennsylvania
website: www.ans.org/goto/icapp04

Aug. 22 - 26
SPECTRUM 2004
Atlanta, George
website: www.ans.org/spectrum

Sept. 22 - 26
4th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human Machine Interface Technology (NPIC & HMIT 2004)
Columbus, Ohio
website: www.ans.org

Oct. 2 - 6
11th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH)
Avignon, France
email: nureth11@cea.fr

Oct. 4 - 8
NUTHOS-6
Nara, Japan
Contact: Hisashi Ninokata
email: hninokat@nt.titech.ac.jp

Oct. 11 - 14
EPRI International Conference on Chemistry of Nuclear Reactor Systems
San Francisco, California
Contact: Christopher Wood, EPRI
email: cwood@epri.com

Oct. 13 - 15
6th International Conference on Simulation Methods in Nuclear Engineering
Montreal, Québec
website: www.cns-snc.ca/simulation2004

Nov. 14 - 18
ANS Winter Meeting
Washington, D.C.
website: www.ans.org

2005

Apr. 17 - 21
Monte Carlo 2005
Chattanooga, Tennessee
Contact: Bernadette Kirk, ORNL
email: kirkbl@ornl.gov

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2004

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CNS WEB Page

For information on CNS activities and other links

http://www.cns-snc.ca

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University Network of Excellence in Nuclear Engineering
Réseau d'Excellence Universitaire en Genie Nucléaire

What The UNENE Universities offer...

- A part-time program designed for students already employed in the industry.
- Courses are offered in flexible formats for part-time students in industry and generally at nuclear sites for the convenience of the students.
- For the degree 10 courses or 8 courses and an industrial research project must be successfully completed over a period of 5 years.
- A student can take just one or a few courses rather than the full program.
- Students must be registered as graduate students in one of the participating universities.

The Courses are planned and some have already been given in:

- ☐ Nuclear Systems and Plant Operations
- ☐ Reactor Physics
- ☐ Reactor Thermalhydraulics
- ☐ Nuclear Reactor Safety Design
- ☐ Nuclear Materials
- ☐ Control, Instrumentation and Electrical Systems in CANDU Power Plants
- ☐ Engineering Risk and Reliability
- ☐ Fuel Management
- ☐ Radiation Health Risks and Benefits
- ☐ Reactor Chemistry and Corrosion

Later in 2004, courses in management areas will also be available.

Who we are...

The University Network of Excellence in Nuclear Engineering (UNENE) is an alliance of universities, nuclear power utilities, research and regulatory agencies for the support & development of nuclear education, research and development capability in Canadian universities.

The purpose of UNENE is to assure a sustainable supply of qualified nuclear engineers and scientists to meet the current and future needs of the Canadian nuclear industry.

UNENE coordinates a Master's of Engineering degree in Nuclear Engineering jointly offered by McMaster University, Queen's University (2005), University of Toronto, University of Waterloo and University of Western Ontario. Other universities in Canada also provide instructional support to the program.*

** subject to regulatory approval*

For more information, please visit our website:

www.unene.ca

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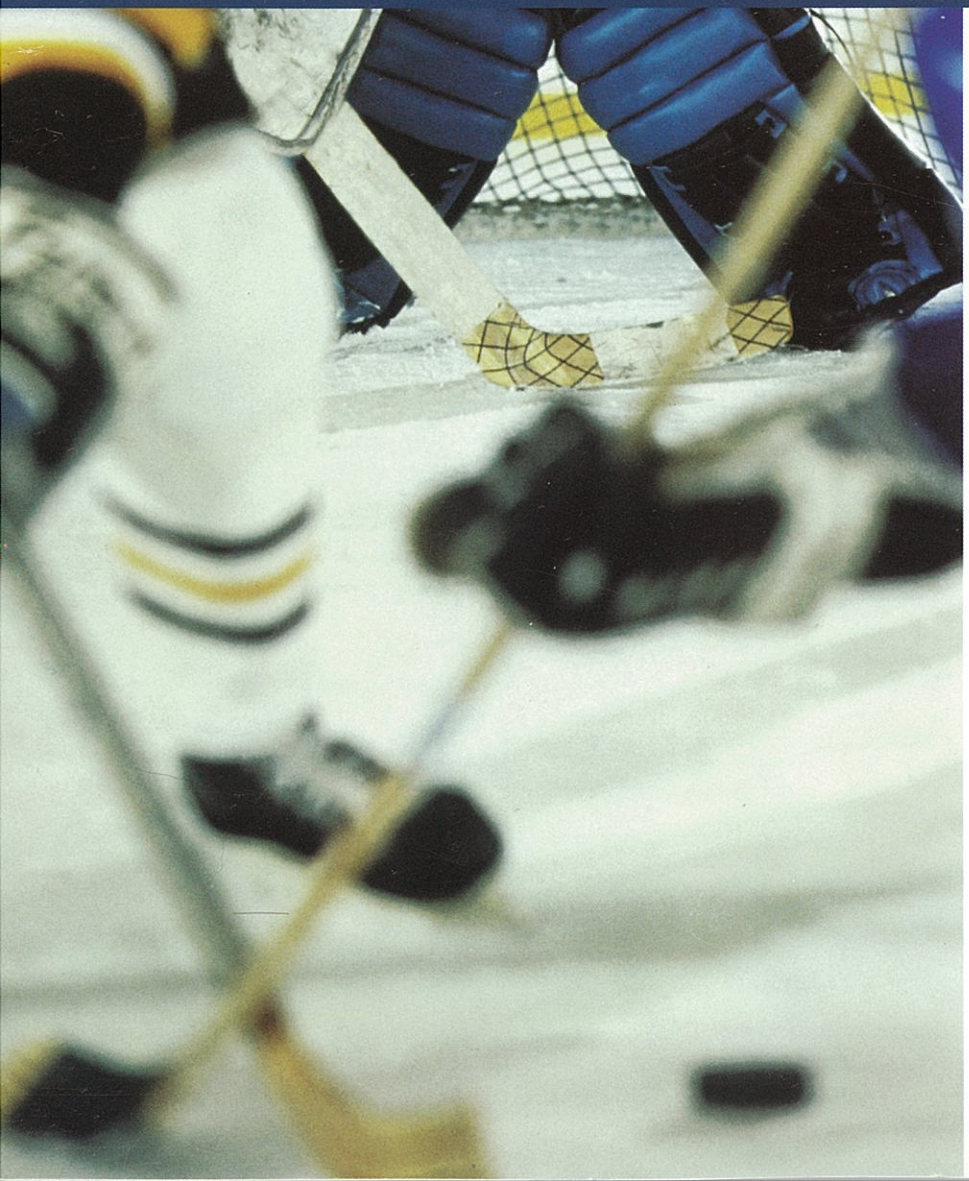
So whether you need to develop life extension strategies, streamline operations and maintenance activities, shorten your outages, or refurbish units to bring them back to best-in-class performance, we will work in partnership with you to ensure your success. After all, it's a goal we all share.

Working as a team
to ensure your success.



Did you know AECL offers:

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- comprehensive Plant Life Management (PLiM) programs, including condition assessment of components
- design and fabrication of specialized equipment and tools
- field services
- engineering services, including licensing support and safety analysis
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- fuel channel inspection services
- environmental qualification
- configuration management
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- turnkey solutions

And more...

For more information, contact your AECL account manager or:

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