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- Simulators for Nuclear Plants
- Mining High Grade Uranium
- Detecting Leaks in Steam Generators
- Blunderland Part II

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Cover Illustration

The photograph on the cover shows a trainee from Korea Electric Power Company (KEPCO) at the Wolsong simulator supplied by CAE Electronics Ltd.

(Photo courtesy of CAE Electronics Ltd.)

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Le Bulletin SNC *est l'organe d'information de la Société Nucléaire Canadienne.*

CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive.
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La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ilf peuvent participer à des discussions de nature technique. Pour tous renseignements concerant les inscriptions, veuillez bein entrer en contact avec le bureau de la SNC, les membres du Counseil ou les responsables locaux. La cotisation annuelle est de 60.00$, 35.00$ pour les retaités, et 20.00$ pour les étudiants.

Editor / Rédacteur
Fred Boyd — Tel./Fax (613) 592-2256
e-mail: fboyd96@aol.com

Associate Editor / Rédacteur associé
Ric Fluke — Tel. (416) 592-4110
Fax (416) 592-4930

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EDITORIAL

Speaking Out

When should an organization such as the Canadian Nuclear Society speak out publicly on an issue? This is a question that members of the governing CNS Council have been debating over the past few months.

Since the CNS is primarily a society of individuals professionals in, or associated with, the Canadian nuclear program, some feel that it is impossible for anyone or any group to represent the views of all members. Other professional or learned societies face the same dilemma.

However, our Society was formed with certain objectives, which are now part of our incorporated status, as the "objects" of "CNS Incorporated". These include:

- to foster the development and beneficial utilization of nuclear science and technology for peaceful purposes;
- to encourage education in, and knowledge about, nuclear science and technology.

Both of these objectives could lead to situations where it would be appropriate, perhaps desirable, for the Society to "speak out" for or against a proposed action or policy.

It is a fine line. The other organization in the Canadian nuclear field, the Canadian Nuclear Association (our former parent), is openly a "lobby" organization, representing the interests of its member firms. The CNS is quite different, which was one of the reasons for finally incorporating as a separate entity.

It is likely that Council will adopt a policy that would permit it to develop and present "briefs" or statements, submissions, or other interventions on topics directly related to the objectives of the Society. Given the debate on the proposed policy, it is evident that any brief will be thoroughly discussed before the Council as a whole would agree with its public presentation.

The members of Council accept that they cannot prevent individual members from speaking out on their own. However, as the "directors" of a corporate body, they will insist that no one purports to represent the Society without their approval.

If the Society is to be effective in making submissions to governments, public hearings, etc., those submissions should reflect the view of the majority of the members. Since it is totally impractical to have close to a thousand persons on a drafting committee there will have to be more debate and discussion among members on topical issues. This can be done through Branches, by special discussion groups, and, probably most practical, by e-mail. It would be possible, for example, to post advanced drafts on our excellent CNS Web site, for all members to access.

We believe that the CNS has a role in speaking out on issues relating to the development, application, and use of nuclear science and technology. Do you?

Fred Boyd

IN THIS ISSUE

If there is any theme to this issue, it is probably "eclectic". There are articles on a range of topics, along with one meeting report.

Starting off is another "Viewpoint" on that perpetual subject "Safety?" by Walter Harrison, a former significant player in the reactor safety research game.

The lead article or "cover" story is on **Simulators for Nuclear Power Plants** – a brief look at the work of CAE Electronics Ltd. in this important field. Then the subject matter switches to uranium mining and the unique problems that come with very high grade ore, in, **McArthur River: high grade ore poses radiation protection challenges.** Reverting to nuclear power plants there is a report on **Steam Generator Leak Detection,** describing some of the new innovative techniques developed at Ontario Hydro technologies, and a look into the future with a report on **Next Generation CANDU.**

The one meeting report is a short note on a **Zirconium Symposium** held in Toronto last June which we were unable to include in the last issue.

There is a short article reprinted (with permission) from another international publication; on the recently formed **International Nuclear Regulators Association.**

Then we have **Part II** of our special feature, **Malice in Blunderland,** Archie Robertson's critique of the environmental panel on the deep geologic disposal concept for nuclear fuel waste, and its report (summarized in the last issue) that concluded the concept was "technically safe" but "socially unacceptable". Part I, which reviewed the Panel's report, was presented in the last issue.

Our standing section on **"General News"** has just a few items which we thought might interest you, since we do not pretend to be a "news" publication. In **"CNS News"** we do attempt to provide members with information on some of the recent happenings in the Society.

Please note the full page advertisement from the Atomic Energy Control Board. Do not be misled by the pretty picture; it is a "positions available" notice. And we welcome back an advertiser from the previous issue, Onsite Engineering Inc. Now that the CNS Council has decided to accept advertising in the Bulletin which is deemed to be of interest to members and other readers we will be endeavouring to have more each issue.

Our thanks to the various authors for their agreement to reprint their papers and their cooperation in providing electronic copies.

Let us know what you think of what we are doing. Our e-mail address is: fboyd96@aol.com

"SAFETY ?"—A Reality Check!

by Walter Harrison

In catching up on my reading two articles in recent issues of the CNS Bulletin caught my attention. The first is the Viewpoint item "Safety and Acceptability: science vs perception" by Jeremy Whitlock in the Jan-March issue and the second is "Malice in Blunderland" by J.A.L. Robertson in the Apr-June issue. To my mind, both of these build intricate semantic arguments at least in part on shaky ground. That shaky ground is referring to and depending on dictionary definitions of "safety" or "safe" as "freedom from harm or danger" or similar phrases. Since nothing is absolutely free of harm or danger—there is risk in everything from finance to romance and all of human endeavour in between—nothing can ever be safe if one goes by the dictionaries. In going by the dictionaries, these articles and the Report of the Environmental Assessment Panel, including the terms of reference they were given, do more to confound the issue than clarify it.

In the early 1980's in the course of public information activities, I wrestled with the meaning (note the meaning, not the definition) of the word "safety" and why the public wasn't buying our story. I came across an explanation and associated definition that clarified things immensely. I subsequently used the approach very effectively in speaking to various groups and in media interviews throughout western Canada. [1]. It worked because it recognised reality. The trick is to recognise and accept that in the public mind, safety has two parts: the objective *and the subjective*, and that this is why we get all the confusion. The definition that works is to define "safety" as a JUDGEMENT of the ACCEPTABILITY of RISK, and "risk", in turn, as a measure of the probability and severity of undesirable consequences [2]. An object or activity is "safe" if its risks are judged to be acceptable. As can be seen, this definition differs significantly from the usual dictionary definitions that have "safe" meaning something like "free from risk" as already mentioned.

To understand what this means, let's look at three key words. The first is judgement. JUDGEMENT implies that safety is a notion in the mind. Safety is not a neatly packaged commodity. It is in the mind, not as a figment of the imagination, because it is very real, but as a notion or feeling. What is safe to your mind might not be safe at all to my mind. That is reality!

The next two words are "acceptability" and "risk". These two words divide an issue cleanly into two distinct and very different parts (as the articles quite accurately pointed out). RISK is an objective although often stochastic entity. You can usually put a number on risk within certain confidence limits and it can be reduced by design within certain practical limits. ACCEPTABILITY, however, is subjective and a matter of personal and social value judgement. This is a very important distinction and failure to appreciate this difference by both scientists and the public is frequently the source of confusion and arguments between "eminent experts" on both sides of a debate.

The current trouble started, unfortunately, with confusion over the meaning of "safety" by those writing the terms of reference for the Panel (and who likely used a dictionary). The reference to the Panel should have been something like:

> *"review the risks, and the acceptability of those risks, of AECL's concept of geological disposal of nuclear fuel wastes in Canada....".*

The confusion between dictionary meanings of "safety" and public reality then dogged the Panel as Archie Robertson so ably points out. Over the meaning of "safety" they were torn among reality to the public, to the technological elite and to the special interest groups. The confusion came through in their report and they then made it much worse on the acceptability component, as Robertson also points out. All that said, the decision now is where it should be—and should stay—in the hands of our elected representatives. We are fortunate to have a representative democracy as distinct from a popular democracy (government by referenda) and it is folly in the extreme to urge otherwise as the Panel seemed to imply. Just look as California!

Back to the word "safety". I urge all of us to chuck the dictionary and recognise reality—that to most people "safety" includes not only risks but how they feel about them. Robertson referred to the two cultures; those more inclined to a rational-scientific approach and those more inclined to an emotional-arts approach. These "cultures" have become more popularly known as left brain and right brain preferences or tendencies according to where these processes are located in the brain. The point is that most people have a whole brain (believe it or not) and although they may tend in one direction or the other, there is some of each side in all of us. Failing or refusing to recognise reality (akin to trying to legislate that π should equal 3.0 because it makes the arithmetic simpler) just adds to the problem rather than the solution.

[1] "Nuclear Electricity in Canada – Its Role and Safety", W.C. Harrison, Presentation to the Science Council of the Alberta Teachers' Association, 22nd Annual Conference, 1982 October.

[2] "Of Acceptable Risk", William W. Lowrance, Wm. Kaufmann Inc., Los Altos, California, 1976.

Ed. Note. *Walter Harrsion is a former long-term staff member of AECL at Whiteshell and Chalk River, who was very involved in the earlier reactor research program. He is now retired and living in Deep River.*

Simulators for Nuclear Power Plants

- CAE Electronics supplies them for CANDU and many other types of plants

Ed. Note: The following article is drawn from a large amount of material provided by Michael Chatlani of CAE Electronics Ltd. on very short notice when, at a late hour, it was necessary to cancel the planned story. We extend sincere thanks to Mr. Chatlani for his cooperation and assistance.

With nuclear power plants being as complex as they are, and with them being used mostly for base load meaning few shutdowns, utilities around the world have turned to the use of simulators for the training of operating staff. Nuclear regulatory agencies have also recognized the value of simulators to test the knowledge and ability of plant staff, especially control room operators.

Full-scope simulators employ control panels identical to those in the particular plant and simulate the behaviour of all systems including the response of monitoring equipment. They are used to train operators in the control and management of the power plant through a "hands-on" experience. Plant staff can experience abnormal as well as normal events to test their ability to respond.

A leading world supplier of simulators for conventional as well as nuclear power plants is the Canadian firm, CAE Electronics Ltd., located in St. Laurent, Quebec (a suburb of Montreal). In its large complex over 3,700 employees, of whom over 2,000 are engineers, design, develop, and build simulators for plants around the world.

This past summer, CAE Electronics was awarded the contract for a full-scope, real-time simulator for the two CANDU 6 units which Atomic Energy of Canada Ltd. and its partners are building at Qinshin, China. The Qinshin simulator will be constructed in two phases. The first phase involves the simulation of the nuclear steam plant, while the second phase will simulate the balance of plant. That approach derives from the availability of design data needed to build the simulator as the plant design progresses. The Qinshin simulator, which will be specific to that plant, is expected to be ready for early training in the beginning of the year 2002, before the reactors go into service.

CAE Electronics supplied the simulator for the Wolsong CANDU units in Korea and has just completed on-site acceptance tests of Phase II of the project . Phase II involved upgrading the Phase I simulator to conform to the Wolsong 2 configuration.

Also this year, CAE Electronics is completing the simulator for the Cernavoda Unit 1 plant in Romania. The Cernavoda simulator Main Control Room panels were updated to match the final Cernavoda Unit 1 configuration and the corresponding software was integrated on the simulator.

This summer the company was awarded a contract to supply a full-scope, replica, simulator for the Kr ko plant in Slovenia, a 632 MWe Westinghouse designed, 2-loop, PWR The simulator is described as a state-of-the-art facility with high-fidelity process and control models, which,.in addition to serving as a training vehicle, will be used for engineering purposes, including development and validation of procedures, optimization of plant operation, and planning of plant modifications. The Kr ko simulator will also have the capability to simulate severe accidents, to allow operators to experience the evolution of such events, and test their ability to mitigate them.

CAE Electronics is also currently working on simulator upgrades for several nuclear plants in the USA. These include adding CAE's latest reactor data processing utility, "CHORUS"1 for the David Besse (PWR) simulator; supplying advanced two-phase thermal-hydraulic, core and containment models for the Callway and Wolf Creek plants.

In addition to the many nuclear plant simulators is has supplied or is working on CAE Electronics has also built a number of simulators for conventional power plants. It is currently upgrading a simulator for the 625 MW natural gas fired Qurayyah plant in Saudi Arabia. Like the other simulators, the Qurayyah unit will employ the "ROSE" simulation environment which is a component-based, visual programming environment for the creation, calibration, testing, integration and management of simulation models.

The Background

CAE Electronics is part of the CAE Inc. group of companies and was, in fact the founding organization. Incorporated in 1947 as Canadian Aviation Electronics Ltd., the company was originally engaged in the repair and overhaul of electronic and electromechanical equipment, primarily for the Royal Canadian Air Force. By the early 1950s it had advanced into designing and supplying flight and radar simulators for the Canadian military. In 1963, after the company began to diversify, it changed its name to CAE Industries Ltd. and in 1993, changed it again to CAE Inc. CAE Electronics Ltd.

remains the largest segment of the CAE Inc. group of companies. CAE Inc. has established its headquarters in Toronto.

An Industrial Technologies Group supplies aqueous-based cleaning equipment, sophisticated separation technologies for various industries, engineered equipment for the forest products industry, and axle re-conditioning services for railways.

The company is probably best recognized for its flight simulators However, as well as these and its power plant simulators, CAE Electronics products include systems for: air traffic control; marine control; magnetic anomaly detection; and engineering and software support for weapons systems. The company exports over 90 % of its products to over 45 countries.

IAEA Connection

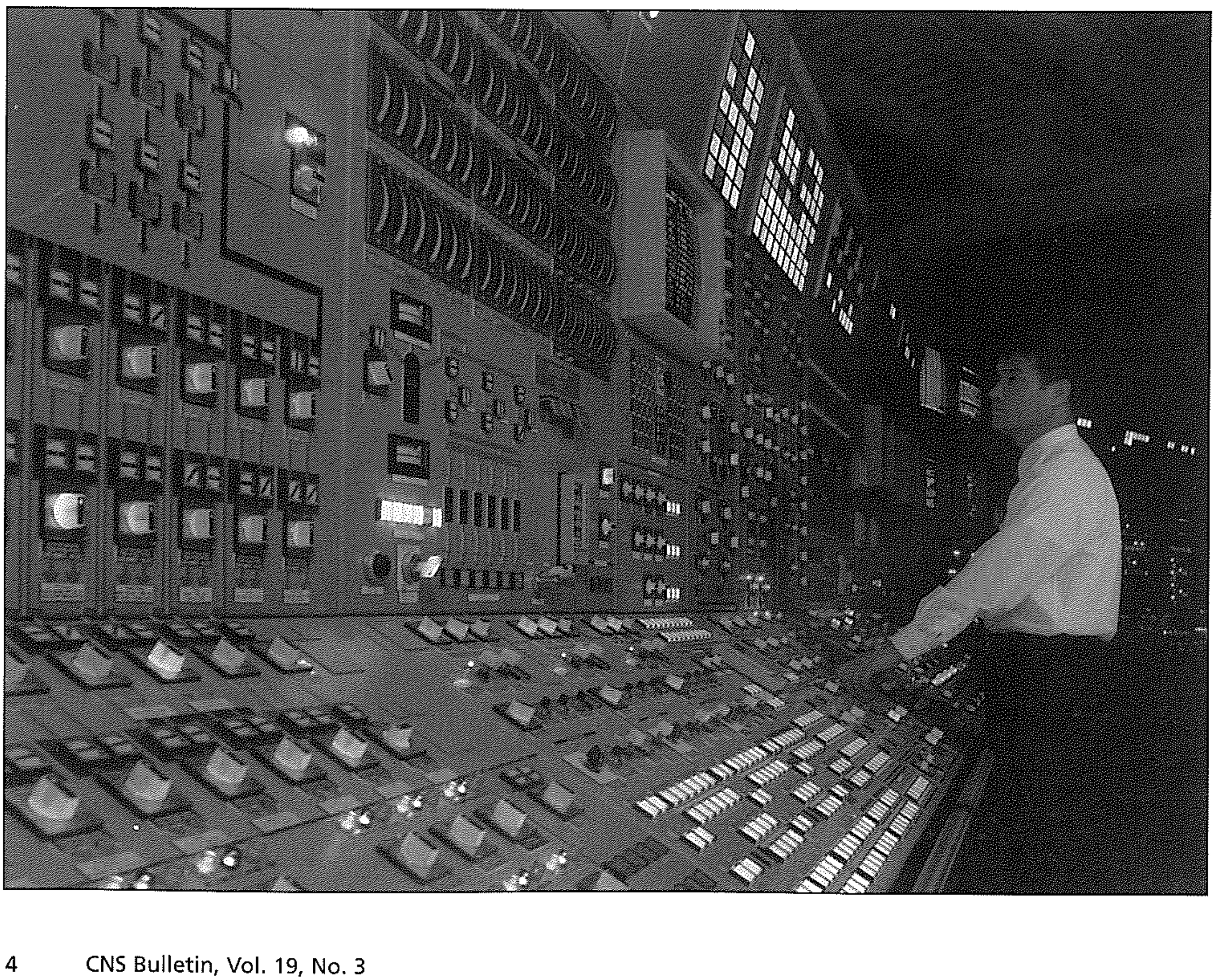
For the International Atomic Energy Agency, CAE Electronics has provided a suite of nuclear plant simulators that models BWR, PWR, and PHWR (CANDU) plants on a typical personal computer, which the Agency uses to assist Member States in education and training. The objective is to provide insight and practice in operational characteristics and response to perturbations and accident situations.

The models used are subsets of CAE's full-scale simulators which can demonstrate the general behaviour of the plants as seen from the nuclear supply system. The special software employs a user-friendly, graphic-based, man-machine interface, to manipulate the inputs, insert malfunctions, and display the behaviour of the systems in a comprehensive manner.

Modular Instructor Station

To assist instructors in controlling the training environment, CAE Electronics has developed a Modular Instructor Station which can be integrated into, or coupled with, an existing simulator environment.

For scenario automation, a plan is first created in edit mode. The instructor then selects the initialization, control, and monitor functions. Once completed the lesson is available without any compilation or linking. System schematics can be created and modified through the CAE special software. The displays operate in real time such that symbols, readouts, and colours represent the current simulation status. Instructor can insert malfunc-



tions to test the reaction of the trainee(s).

The Modular Instructor Station also allows the instructor to do a number of other functions, such as: change the scenario while the simulator is in use; freeze or unfreeze the situation; store and restore plant conditions; replay operator actions; monitor operator performance.

A small hand-held controller for instructors has been developed that can be used with existing CAE simulators. With it an instructor can reprogram the exercise remotely as he roams the simulated control room to observe the trainee's response.

Reactor Kinetics Model

CAE has produced a true three dimensional model for the simulation of reactor neutron kinetics called "COMET"1 (COre Model based on Equivalence Theory) for PWRs and BWRs. A minimum of one radial node per fuel assembly is used for PWRs, and one per four fuel assemblies for BWRs. The neutron diffusion equations are solved at each node, at each time step. The finite difference form of the neutron diffusion equations are solved using an homogenization method (equivalence theory) similar to those used by certain advanced lattice codes.

COMET simulates the flux at the in-core detectors by reconstructing the fine mesh flux, as a function of the fine mesh flux properties in the nodes where detectors are present. This permits local effects, such as the movement of a neighbouring rod, to be fully simulated.

Virtual Panels

Virtual panels, sometimes referred to as mimic or soft panels, are photo-realistic reproductions of plant instrumentation that can be graphically manipulated and dynamically displayed. To generate these, CAE Electronics has developed its "TIGER"1 (The Integrated Graphics Environment for Real-time Systems) editor. Both instructors and trainees can make use of virtual panels. The instructor can override any panel device from his station, which causes a ghost image to appear as a reminder of the override..

Any number of display screens can be put together to form a virtual console. A trainee can then manipulate a panel device using either a touch screen or mouse and the device will behave the same as in the actual control room.

Steam Supply Model

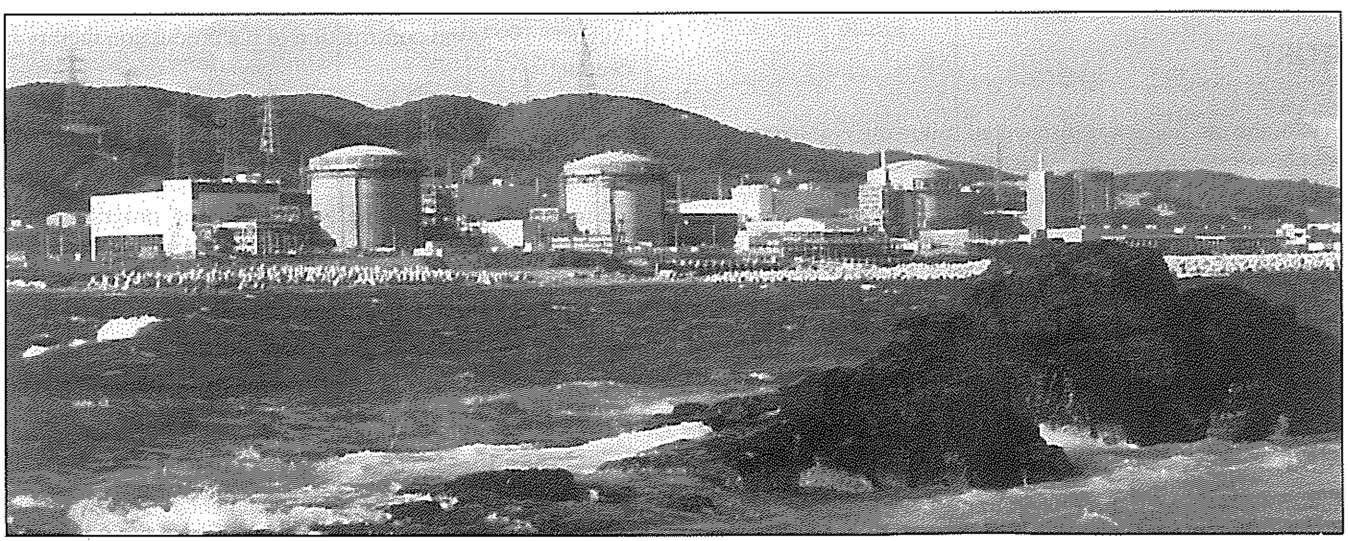
"ANTHEM"1 (Advanced THErmal-hydraulic Model) is CAE's model to provide real-time simulation of both single and two-phase flow under all plant operating conditions. A single model is used for all operations without switching to reduced nodalization or simplified models.

It takes into account feed and bleed cooling, loop seals, natural circulation, flow stagnation, local boiling and the effect of local buildup of voids or non-condensables. ANTHEM is a non-equilibrium, non-homogeneous, drift flux model which is based on a rigorous application of the equations of mass, momentum and energy conservation.

In conclusion

Although the glamour may go with flight simulators, CAE's simulators for nuclear plants have enabled the training of operators and other plant personnel to be much more thorough and thus have contributed to the safety and efficient operation of the plants in Canada and around the world. It is encouraging to see the success of CAE Electronics Ltd., a pioneer Canadian company in this field and now a world leader.

Anyone wishing more information on CAE's nuclear plant simulators should contact Michael Chatlani,, CAE Electronics Ltd. C.P. 1800 Saint-Laurent, QuÇbec H41 4X4; e-mail <michaelc@cae.ca>



A view of the four CANDU units at the Wolsong site, Korea.

McArthur River

A High-Grade Uranium Mine poses Radiation Protection Challenges

by S.E. Frost and J.M. Takala

Ed. Note: The following paper was originally presented at the PBNC 98 Conference held in Banff, in May 1998, under the title, **Radiation Protection Challenges in a High-Grade Uranium Mine.**

INTRODUCTION

The McArthur River project is the world's largest known high-grade uranium deposit, with reserves and resources of 416 million pounds of U_3O_8 (160,000 t U) at an average grade of 13% U. Cameco Corporation is the operator of the project on behalf of the joint venture, which is owned by Cameco (55.844%), Uranerz Exploration and Mining Limited (27.922%), and Cogema Resources Inc. (16.234%). The deposit is between 500 and 600 m underground in the eastern part of the Athabasca Basin in northern Saskatchewan, Canada, 80 km northeast of Key Lake and approximately 620 km north of Saskatoon. It is presently being developed to allow the start of production in late 1999, with full production planned at 18 million pounds of U_3O_8 (6,924 t U) per year. Because the Key Lake high-grade ore will be exhausted by the end of 1999, McArthur River ore will be transported by road to Key Lake mill for processing. Since the uranium grades at McArthur River are roughly ten times those at Key Lake and Rabbit Lake and a hundred times the average grades elsewhere in the world, non-entry mining and remote ore-handling techniques will be used.

HISTORY

In 1988, the ore body was discovered following eight years of systematic exploration in the area. Improved electromagnetic methods allowed the identification of a graphitic conductor in the basement fault structure that controls the location of the ore. Several years of core drilling from surface resulted in the outlining of high-grade mineralization over 1.7 km of strike length.

By 1991, sixty holes were completed, of which thirty-seven holes intersected uranium mineralization at a depth of 500 to 600 metres. Based on this information, a resource of 260 million pounds U_3O_8 (100,000 t U) at an average grade of 4.2% U was estimated. However, the mineralized zone was very narrow and seventy per cent of the estimated resource was based on only seven drill holes, with eighteen per cent based on a single hole, which graded 36% U over 25 metres. Consequently, in 1992 it was decided to undertake an underground exploration programme to provide detailed information about the shape of the individual ore bodies.

The Atomic Energy Control Board (AECB) had been notified of the intention to develop the project in February, 1991. The AECB referred the project to the Federal Environmental Assessment Review Office (FEARO), which initiated the environmental assessment process.

FEARO and the government of Saskatchewan appointed the Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan to look at McArthur River and four other uranium projects.

Although underground exploration did not require a full environmental assessment under any federal or provincial regulations, the Panel felt that allowing the underground exploration to proceed without a detailed examination would harm the credibility of the main hearings. Consequently, the underground exploration was referred to the Panel for review in 1992 and approved in early 1993 (Joint Federal-Provincial Panel, 1993). A shaft was sunk in late 1993 and early 1994, with underground development on one of the two approved levels. The underground drilling over the first 300 m of strike length identified a significant new ore zone, which increased the reserves and resources to the current 416 million pounds U_3O_8 (160,000 t U). During the drilling programme, work proceeded on the environmental studies, and the environmental impact statement (EIS) for the main project was issued in December, 1995 (Wittrup, 1995). Hearings proceeded in 1996, with approval of the project being recommended by the Panel in February, 1997 (Joint Federal-Provincial Panel, 1997). Construction licences were obtained in August , 1997, and construction of the production facility is proceeding.

THE PROBLEMS

From the results of the surface drilling programme, it was apparent that high-grade ore would be encountered and that conventional mining methods would not give adequate control of radiation exposures. Exploration drill core that showed average grades of 20% to 30% U had sections of almost pure U_3O_8. Gamma radiation from such material arises from some of the

1 Stan Frost is Vice-President, Environment and Safety, Cameco Corporation, and John Takela is a member of that department.

2 All costs are given in Canadian dollars.

uranium chain radioisotopes, notably ^{214}Bi with energies over 2 MeV, and radiation fields of $3.5x10^{-5}$ C/kg (equivalent to 1.2 mGy/h) could be expected. Conventional mining has workers within the stope and directly exposed to ore. Such an approach would clearly have led to overexposures in a short time. Hence, mining methods had to be devised that would not involve entry into the stope and that would not involve manual handling of ore or direct exposure to open loads of ore in haulage equipment.

Radon progeny generally represent the most significant airborne radiation hazard in uranium mines, and ventilation is commonly used for control. At McArthur River, the high grade of the ore results in a ^{222}Rn source that is far higher than that encountered in previous mines. In addition, the McArthur River ore occurs at the contact between the Athabasca sandstone and the underlying basement rock of the Canadian Shield. The sandstone is porous and large water flows continue to be experienced during mine development. This water has been in contact with the high-grade ore and contains dissolved radon concentrations up to $1.8x10^{10}$ Bq/m^3.

When this water splashes into a mine opening, it releases the radon in unprecedented concentrations. At these concentrations (up to 70,000 Bq/m^3 predicted in the downwind sections of some drifts with full ventilation), the uptake of radon itself becomes a significant source of radiation exposure. Hence, much higher air volumes would be needed than for similar-sized mines that are not handling radioactive materials. At the present time there is one shaft at McArthur River, with a second one being sunk and a third planned. At full development, Shafts 1 and 2 will supply fresh air and Shaft 3 will be the main ventilation exhaust. In the northern location with its harsh climate, mine ventilation is particularly expensive, because mine air must be heated for much of the year.

Experience from the underground exploration showed that local exhaust ventilation would also be essential to control exposures. Drill holes and water flowing from them could be significant point sources of radon, which if not controlled would cause very high exposures of workers in the vicinity.

Ore dust has not generally been a major source of radiation exposure in lower-grade uranium mines. Usually, other factors have dictated ventilation rates. For example, where diesel equipment is used, the ventilation requirements of the diesel exhaust have been stricter than the requirements due to airborne radioactivity. The assessment of the Eagle Point underground mine, operated by Cameco at Rabbit Lake, showed that the silica content of the ore would limit the dust exposure until the ore grade exceeded 4.8% U_3O_8 (4.1% U) (Cameco, 1992). At McArthur River with its 13% U average ore grade, the high specific activity of the ore clearly changed this situation.

BASIC MINE DESIGN

At the time that the preliminary mine design was being developed, new radiation protection regulations were being drafted in Canada. Although we were not permitted to see the draft before it was formally released, we knew that the new regulations

McARTHUR RIVER PROJECT
RAISE BORE MINING AND BACKFILLING SEQUENCE

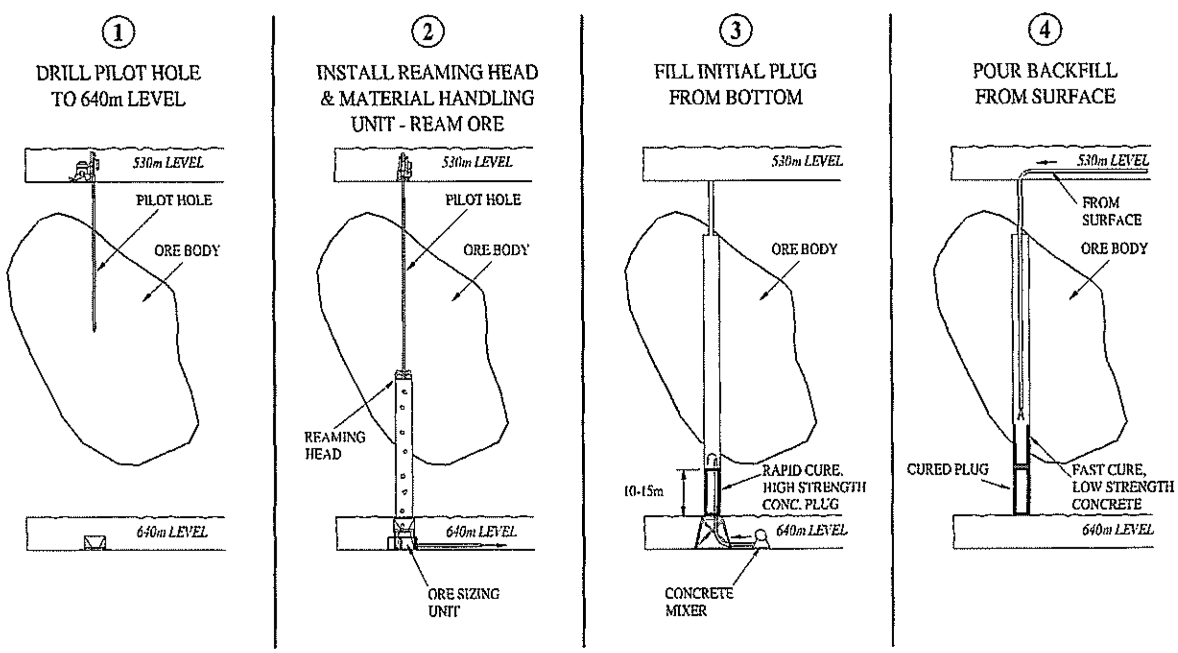


FIGURE: 1

would incorporate the general philosophy of ICRP Publication 60 (ICRP, 1991). This meant that Canada would change from the old critical organ concept, with separate limits for external whole body dose, lung dose and radon progeny, to the effective dose concept, with a 60% lower five-year average dose limit.

From the outset of mine design, it was clear that non-entry mining methods would be required. Strict adherence to the principles of limiting the time of exposure, maximizing the distance between the workers and the ore, and placing shielding between the workers and the ore was necessary in order to limit worker gamma radiation exposures. Mining methods were screened for radiation protection, general safety, flexibility, productivity and maximum use of conventional equipment. Seven potential mining methods were proposed in the EIS submitted for McArthur River, with final selection dependent upon ore grades and ground conditions. These methods were:

1) Raise boring
2) Box-hole boring
3) Remote box-hole stoping
4) Blast-hole stoping, including vertical crater retreat
5) Remote raise-bore stoping
6) Jet boring
7) Remote box-hole stoping with "Viscaria" raise mining

Three of these, raise boring, box-hole boring and remote box-hole stoping, were recommended in the EIS, with raise boring being the choice for the first zone to be mined. The jet-boring method favoured for Cigar Lake was not recommended because of the harder rock at McArthur River; however, it has been retained as a potential secondary method.

Ground and Water Control

Experience from the sinking of Number 1 Shaft and from the underground exploration programme has shown that high water flows and occasional poor ground conditions may be expected. The Athabasca sandstone is very porous and water at full hydrostatic pressure occurs in many places. At 600 m below the surface, the water pressure can be 60 atmospheres. Freezing will be used to stabilise the ground to permit safe extraction of the ore. Both grouting and freezing will be used to control water; however, freezing has the added benefit of stopping the flow of radon-laden water into mine openings, greatly reducing the radon source.

Freezing will be accomplished by circulating chilled brine at -30°C through freeze pipes surrounding the ore zones. Since it must be implemented approximately nine months prior to mining, the 85 holes needed for the freezing of the first two mining areas will be drilled during 1998 to allow the freezing to start in early 1999.

Raise-Bore Mining

Raise-bore mining (See Figure 1) requires the establishment of mine openings in non-radioactive waste rock above and below the ore zone. The raise-bore machine is set up in the production chamber above the ore zone. The machine drills a 300 mm pilot hole from the upper chamber, through the ore zone into the lower extraction chamber. The drill bit is replaced with a 2.4 m diameter reaming head, which then reams upward through the ore. The reamed ore is funnelled downward through a sizing screen to the semi-autogenous mill in underground ore-grinding area. The raise-boring machine is removed and the raise filled with concrete. After the concrete fill has cured, adjacent ore will be extracted by repeating the sequence. By overlapping the raises, a high percentage extraction of the ore zone is achieved.

The raise-boring method will produce, on average, from each raise approximately 190,000 pounds of U_3O_8 (73 t U) from within the initial mining areas of the zone providing most of the production planned during the first years of mining. Due to the high grade of the ore, an average of only 125 t must be mined per day. The total time necessary to mine and fill a raise is currently expected to be about 15 days, of which only three days will likely be spent reaming ore. Four raise-bore machines are planned for full production.

Box-hole Boring

The box-hole boring machine is set up in barren waste rock below the ore body and pushes the reamer upwards through the ore. The ore falls down the raise to a chute above the box-hole machine and is diverted to the sizing screen and grinding area. All further ore processing is as described for the raise-boring method.

Remote Box-hole Stoping

This mining method combines the productivity improvements offered by stoping with the control and containment provided by box-hole boring. The raise is reamed as described in the box-hole boring method. Blast holes are then drilled from drill drifts in waste rock lateral to the raise and above the mining chamber. These blast holes intersect the raise, and are loaded with explosive and blasted, as required, to provide broken ore to the box-hole boring unit. The reamer head is kept within the lower section of the raise. It reduces the size of the broken ore falling from the stope and regulates the ore flow to the sizing screen below.

Ore Transport

At Eagle Point, with an average grade of about 1.3% U and some small zones ranging over 5% U, non-entry mining has been employed. Ore haulage has been by conventional truck, with loading being done by remote-controlled scoop-tram, with the operator remaining within sight of the equipment. However, it became apparent that even at these grades ore spillage from the trucks on the access ramp resulted in unacceptable levels of contamination and created an additional source of radon to contaminate the mine air. The higher grades at McArthur River would only exacerbate these problems. The solution was to develop an ore-transport system that did not involve direct exposure of the miners and would keep the ore generally enclosed. The ore from the underground grinding circuit will be pumped to surface in a slurry pipeline using positive displacement pumps, eliminating the need to hoist the high-grade ore in the shaft used to move men and material and to supply fresh air. On surface, the ore slurry will be blended by grade, thickened to 50% solids and placed in purpose-built containers. The containers will be shipped, four to a truck, to Key Lake, carrying 18 t of ore ($21.2m^3$ of slurry) per trip. Approximately eight trips per day will be required.

Ore Processing

After examining various options for processing the high-grade ore, it was decided to blend it with low-grade mineralized material at Key Lake to produce a feed grade into the mill of 4%. Material of this grade can be handled in the existing equipment without added shielding. This option has the benefit of recovering uranium from the low-grade material, which otherwise would have become a decommissioning liability.

EXPOSURE MODELLING

For the EIS, 60 separate jobs were identified and time and motion studies were assembled for each job. Mine ventilation was modelled with the MINEVENT software developed by SENES Consultants (SENES, 1995a), using the conceptual mine design and placing an upper limit on radon progeny exposure of 1 working level month (WLM) versus the current Canadian standard of 4 WLM. Potential gamma radiation exposures were modelled using the GRADEX software developed by SENES Consultants (SENES, 1995b). Consideration was given to breakdown maintenance requirements and spill clean-ups, as well as normal operations. The highest effective dose (6 mSv) was predicted for the raise-boring operator.

To refine the equipment design, the software MicroShield v5.01 (Grove, 1996) has been used to calculate shielding requirements. Shielding has been designed for tanks, for separate rooms and for piping. To test the theory, field tests were done using ore at 30% U_3O_8 from the test mining of Cigar Lake. Six-metre long pipes of various standard wall thicknesses (defined by pipe Schedule) were filled with the high-grade ore and radiation fields were measured. This information essentially confirmed the calculations done with MicroShield. From this work, the decision was to use Schedule 160 pipes, which are the thickest-walled pipes commercially available without a special production run. In the two primary pipe sizes specified in the design, the Schedule 160 wall thicknesses are 0.531 in. (13.3 mm) for 4-inch and 0.719 in. (18.2 mm) for 6-inch pipe. Design calculations were also confirmed by physical measurements of radiation fields around equipment at the existing Key Lake and Rabbit Lake mills. Tank shielding was based on an average operator distance from equipment of 2 m and an objective of keeping doses below 5 mSv per year with generously estimated occupancy times.

For ventilation design, the minimum air supply was that required for diesel engine operation, 3.8 m^3/min/kW of engine power. For radon progeny control a nominal supply rate of 15 m3/s was developed. Modelling of radon progeny concentrations was done using the software, MINEVENT. Refined operator doses have been calculated as the equipment designs have been specified in greater detail. Currently, the highest exposed worker is predicted to receive an annual effective dose of 7.0 mSv.

ALARA CONSIDERATIONS

The dose calculations have shown that all personnel will meet the ICRP Publication 60 dose limit recommendations. To assess the efficacy of the design, an ALARA analysis has been performed on general underground ventilation, the ventilation of the surface slurry handling facility, concrete shielding specified for various pieces of equipment, and pipe shielding. The analysis used as the base case the doses calculated for the Addendum to the McArthur River EIS (Wittrup, 1996). Dose reductions for various design modifications were calculated conservatively, i.e., overestimating the dose reduction to be achieved. The costs of these modifications were realistically estimated and the costs per unit dose reduction were calculated. These costs of dose reduction were then compared with the upper-end justifiable cost criterion of $100,000[2] per person-sievert (p-Sv) given in AECB Regulatory Guide G-129 (AECB, 1997). In the course of this analysis some low-dose jobs, which had been omitted from the EIS for brevity, were included, so that the collective dose was as complete as possible.

In assessing the effects of ventilation changes, it was assumed that radon gas would contribute the same dose as radon progeny, and ore dust inhalation dose was included. The conversion factor from radon progeny exposure to effective dose was 5 mSv/WLM, as recommended in ICRP Publication 65 (ICRP, 1993). Ventilation costs arise from the capital costs of mine openings and mine fans and the operating costs of electricity to run the fans and fuel to heat the mine supply air in winter. There is some flexibility in fan operation, but as air volume is increased, the limit on any particular size of motor is reached. There is also a limit on the amount of air that can be pushed through a given size of mine opening. When that limit is reached, more power to the fan does not move more air; the fan blades merely start to stall aerodynamically. At this point the only option is to increase the size of the mine opening, which is an enormous capital cost. In this exercise, an estimate was made of the additional air which could be moved by the design fans without additional capital cost. The electricity and heating cost of this additional air was calculated to be $5,900 per year per m^3/s. The effect of the additional air on air changes in the mining and ore-handling drifts was calculated using the tunnel formula for radon progeny calculation, i.e. $WL \propto t^{1.86}$, where t is the residence time of the air (Schroeder and Evans, 1969). The effects on radon gas and dust concentrations were simply the linear reduction in concentration due to additional dilution. The resulting cost per unit dose avoided by the additional ventilation was $4.5 million /p-Sv, far in excess of anything that could be justified by the Regulatory Guide.

A similar calculation for the surface ore-handling facility resulted in a cost per unit dose avoided of $3.0 million/p-Sv, again far exceeding the criterion.

A design thickness of 30 cm of concrete shielding is being used for the various tanks used for handling the ore slurry. The cost of an increment of 5 cm in concrete thickness was estimated. Because of the varying tank geometries, an individual concrete volume and cost had to be calculated for each tank. In addition, the tank location was important, because it costs more to transport and place concrete underground than it does on surface. MicroShield was used to calculate the reduction in gamma radiation field achieved by the additional shielding. The result showed an average reduction in dose rate at 2 m of 1 ÊSv/h, but the average reduction over the entire work area would have been less than this. The collective dose to the entire workforce over a 20-year operating life was calculated. The resultant cost of dose reduction was $365,000/p-Sv, again well above the criterion.

Since Schedule 160 is the thickest-walled pipe commercially available, there are only two options for increasing the shielding on pipes: add external shielding by wrapping with lead sheet or placing the pipes in a concrete utilidor, or buy thicker pipe by special order. The former option was deemed not to be useful, because any maintenance would require greater time in close proximity to the pipe as the shielding is removed and replaced, resulting in higher doses to the maintenance staff who are generally the most exposed anyway. In the pipe sizes being used for the ore slurry, the next thickness of pipe is Schedule XXS. The reduction in gamma fields around the pipes with this wall thickness was calculated and the collective dose to all personnel over 20 years of operation was calculated. The additional cost of this pipe resulted in a cost per unit dose avoided of $1.7 million/p-Sv, again far exceeding the criterion.

Although it would be possible to meet the dose limits using less protection than has been specified in the mine design, it is considered prudent to have some capacity to accommodate upset conditions that may not have been considered in the basic design analysis. This is particularly true of mine ventilation. For concrete shielding, the thickness specified is a standard size for which forming materials are readily available. The cost of fabricating and placing shielding below the standard size could well exceed the savings in concrete cost and result in a net negative benefit in the ALARA analysis. Similarly, the savings in reducing the pipe wall thickness by one Schedule could only be marginally justified in the ALARA analysis.

CONCLUSIONS

McArthur river is the largest, highest-grade uranium deposit yet discovered. In developing the mine design, radiation protection has been paramount. Wherever possible standard sizes of equipment have been used in the mine design to avoid the extra costs of items that are not routinely manufactured. The dose predictions that have been done for all jobs in the operation, including upset conditions, maintenance, and spill clean-up, indicate that all employees will be well below the recommended dose limits of ICRP Publication 60. The ALARA analysis has demonstrated that additional measures to further reduce dose are not justified on a cost -benefit basis, because all results far exceed the $100,000/p-Sv criterion of AECB Regulatory Guide G-129. Nevertheless, when the mine goes into operation, radiation doses associated with the various activities will be carefully monitored to look for additional opportunities to reduce doses to personnel.

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Steam Generator Leak Detection - Developments at Ontario Hydro

Kevin J. Maynard and Vic P. Singh[1]

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ABSTRACT

A method for locating small tube leaks in steam generators has been developed and implemented at Ontario Hydro. The technique utilizes both helium leak detection and moisture leak detection. The combination of these two methods allows tube leaks to be detected in any part of the tube bundle, including those submerged below water near the tubesheet. The estimated detection limits for the helium and moisture leak detection systems are 0.001 kg/hr and 0.05 kg/hr respectively, expressed as leak rates measured at typical boiler operating conditions. This technology is best utilized in situations where the leak rate under operating conditions is smaller than the practical limit for fluorescein dye techniques (~2 kg/hour). Other novel techniques have been utilized to increase the reliability and speed of the boiler leak search process. These include the use of argon carrier gas to stabilize the buoyant helium gas in the boiler secondary.

INTRODUCTION

Leaks in steam generator (SG) tubes are a costly source of capacity loss in nuclear generating facilities. Often, large leaks (>1 kg/hr) are located during an outage with pressurized dye solution. In the so-called 'fluorescein method', a pressurized fluorescein dye solution in the boiler secondary leaks through to the primary side. Tube leaks are then located by a manual visual inspection of the primary side tube sheet with the aid of a black light to illuminate the dye stain. Experience has shown that the practical sensitivity limit for the fluorescein method is approximately 1 kg/hr, measured at typical SG operating conditions. For SG leaks smaller than this limit, other methods are usually applied.

Due to the difficulty in locating small boiler leaks with the fluorescein method, a more sensitive leak detection technique was sought and developed for field use on Ontario Hydro's CANDU Units. This paper describes the particular leak detection system which was recently developed at Ontario Hydro Technologies (OHT). The technique involves helium leak detection, an established method for locating leak paths in a wide variety of industrial and commercial applications, including boilers [1]. Several enhancements have been incorporated to provide a more complete and efficient inspection and the main ones are reported here. The most important of these is a moisture leak detection capability, to allow detection of through-wall tube defects near the SG tube sheet. Such defects, which are often submerged below water in the boiler secondary, remain unobservable by helium leak detection, but observable with moisture leak detection. Other features include a means of stabilizing the helium gas in the boiler shell, using argon as a carrier gas. Due to the propensity of buoyant helium to flow and diffuse away from the boiler tube bundle, this feature proves to be important.

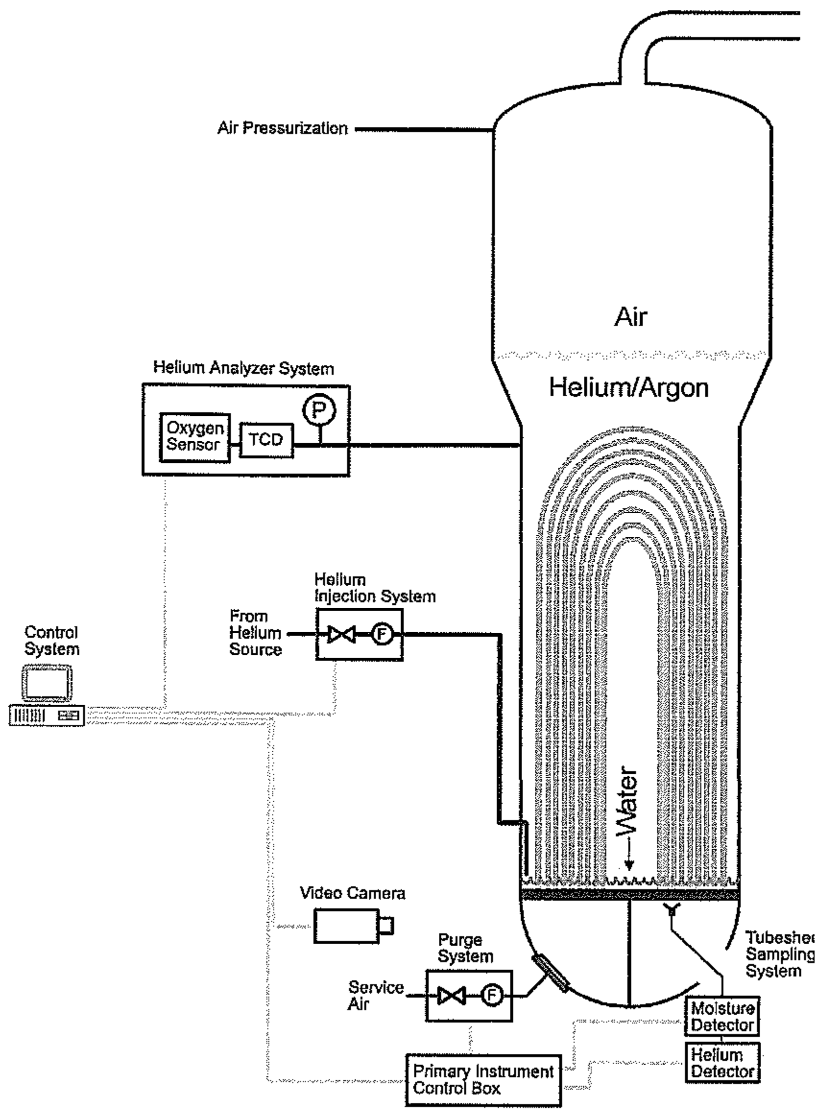
Helium leak detection has an estimated sensitivity of 0.001 kg/hr, expressed in terms of leak rate under typical CANDU operating conditions. These conditions are approximately T_{inlet}= 300°C and DP= 5MPa. The helium tracer gas is completely inert and does not pose any boiler or reactor chemistry consequences. Moisture leak detection has an estimated sensitivity of 0.05 kg/hr under the same conditions expressed above.

LEAK DETECTION METHODS

Overview

Helium leak detection applied to steam generators involves the detection of helium gas leaking across the primary-secondary boundary of the boiler. In the OHT system, a leak search proceeds as follows. The boiler is first drained of water on both the secondary and primary sides. The complete secondary system is then pressurized with air, followed by a 'charging' of helium and carrier gas (usually argon) mixture into the boiler shell. The helium/argon mixture displaces the air and the tube bundle becomes 'submerged' in helium gas. With the

1 Both authors are with Ontario Hydro Technologies.



Detector Characteristics

secondary side pressurized, helium and/or residual water in the boiler secondary flows through the leak path to the primary side. The primary side of the tube bundle is continually purged witn dry air so as to flush any helium gas and/or water vapor toward a detector probe placed in the primary head of the boiler. A "sniffer" probe is positioned within the primary head and is manipulated by a robotic arm around the tube sheet. The sniffer samples the air from each tube in the boiler and both helium and moisture detectors measure the concentrations in this air. A leaking tube is signaled by a helium and/or water concentration statistically above background levels.

The leak detection equipment is composed of several sub-systems installed at various points on the steam generator. These sub-systems are shown in Figure 1. The particular implementation shown reflects a typical SG design (i.e. integral steam drum) but is applicable to other SG/HX designs as well. Adapting the equipment to other facilities involves the construction of several SG-specific fittings. At the boiler primary head are located the purge and tube sheet sampling systems. The robotic arm for probe positioning is installed in either the boiler outlet (cold leg) or inlet (hot leg) side. The systems installed on the boiler secondary include a helium analyzer, a helium injection system and a control system. Each of these systems is discussed more fully in sections below.

Detector Characteristics

In preparation for a leak search, the boiler secondary is drained of water to the best possible extent. However, at the tube sheet, several inches of water may remain which are difficult to completely remove. To detect tube leaks at any point in the tube bundle, including ones below the water line near the tube sheet, the leak detection system is equipped with two different methods of detection. The helium leak detector is a very sensitive instrument which detects any helium gas leaking through from the pressurized secondary side. In cases where the through-wall defect is above water, helium will readily flow through the leak path to the primary side and be detected. For leaks below water however, the helium cannot easily permeate the water layer and such leaks remain undetected by this method. The second detector, a moisture sensor, measures the primary side water concentration in the air from the tube under inspection. For leaks located under water, moisture from the secondary flowing through to the primary side will evaporate, registering as a rise in water concentration (increase in dew point). For leaks above water, the moisture sensor may also register an elevated reading, depending on the humidity and leak rate of the gas in the boiler secondary. Table 1 summarizes these characteristics.

Table 1. Characteristics of helium and moisture detectors.

Detector Type	Detects Leaks Above Water	Detects Leaks Under Water
Helium	Yes	No
Moisture	Maybe	Yes

From these characteristics, it is evident that a leak indication which registers *only* an elevated moisture content must be submerged under water. For cases where a helium indication is measured, the leak *must* be above water, regardless of the moisture reading.

Detection Limits

Detection limits are most useful when conveyed in terms of leak rate under typical SG operating conditions. It is this leak rate which is used as the basis for deciding if or when a boiler is to be removed from service for inspection and repair. For example, if a given leak detection technique has a quoted detection limit of 1 kg/hr under operating conditions, then a leak of this magnitude on an operating boiler should be successfully located once the boiler has been removed from service. Due to the different boiler pressure and temperature conditions present under operation and during a leak search, leak rates are not directly comparable. The leak rate from a given tube under operating conditions will usually be much larger than the same tube under leak search conditions. This is due in part to thermal expansion effects and to the difference in pressure gradient across the leak path. Taking into account factors including the helium detector sensitivity and the correlation between leak rates under various conditions, [2] an operational detection limit of 0.001 kg/hr is obtained for helium leak detection. In other words, boiler leaks of this magnitude or larger under operating conditions have a high probability of being located with helium leak detection. Likewise, the estimated moisture detection limit is approximately 0.05 kg/hr, in operational units. Hence, helium leak detection is roughly 50x more sensitive than moisture leak detection. Both these methods are much more sensitive than the fluorescein method, with an estimated sensitivity of 2 kg/hr. The detection limits are summarized in Figure 2. These detection limits are not intended to be quantitative, but merely estimates which may prove useful in the application of this technology. They have been specifically calculated at typical CANDU operating conditions of T_{inlet}= 300°C and DP= 5MPa.

Helium Buoyancy Control

For a successful leak search, the helium in the boiler secondary must remain there for the duration of the test. Given the fact that the secondary system is not uniformly filled with the same concentration of helium (i.e. the steam drum and steam line contain only air), there are several means by which helium escapes from the boiler. Helium is a light gas which, due to buoyant forces, tends to rise when placed in air. Its small atomic weight also contributes to relatively large diffusion rates in air. There is also the possibility that convection currents and eddies within the boiler can cause bulk flow of helium away from the region surrounding the tube bundle. Therefore, maintaining a uniform helium charge in the boiler secondary poses difficulty. The use of diaphragms or baffles to isolate the boiler from the remainder of the secondary system is undesirable for several reasons, including the need for steam drum entry and possible boiler modifications. However, if helium is pre-mixed with a heavy carrier gas, the mixture can be made negatively buoyant in air which permits it to remain fixed within the boiler secondary. Using a heavy carrier gas also limits the diffusion rate of helium from the boiler. The most suitable heavy carrier gas is argon, because of its chemical inertness and relatively abundant supply. Since no significant amount of the argon added to the boiler can migrate into the primary side, activation of the argon to Ar-41 is not a possibility. Although argon is not chemically toxic, it is an asphyxiant and therefore poses a hazard in confined spaces. In situations where boiler isolation and buoyancy are less problematic, air may be a suitable alternative to argon.

Phased Leak Search

The leak search is divided into two phases- tube sheet survey followed by single tube inspections. The survey covers all of the tube sheet and is intended to localize the leak(s) within a subsection of the tube sheet. The survey is conducted using a multitube funnel fitted to the end of the robotic manipulator arm. If a leaking tube is among the tubes being sampled, a leak signal is registered (flagged) for closer examination in the single tube inspections. The funnel is moved across all of the tube sheet in an organized pattern, with each measurement taking approximately 30 seconds. Using this method, a boiler containing thousands of tubes may be completely surveyed within 24 hours.

Following the leak survey described above, the single tube inspections commence. Their purpose is to find the leaking tube within the subsection(s) already located in the survey. This segment of the leak search is performed with a single tube sniffer probe. Each tube in the flagged subsection is individually checked by moving the sniffer probe in close proximity to the tube sheet plane at the tube exit. The leak detector signal is recorded for each tube before moving to the next tube. Once the leaking tube has been located, its identity is carefully confirmed by noting the readout of the robotic arm position as well as noting the relative position of nearby landmarks on the tube sheet. A marking tool attached to the robotic arm may also be used to apply a paint mark to the identified leaking tube, as an aid to further inspection or repair activities.

LEAK DETECTION EQUIPMENT

Primary Subsystems

<u>Purge System</u>

An air purge system is installed near the primary head of the boiler under test to purge the whole tube bundle with dry air (see

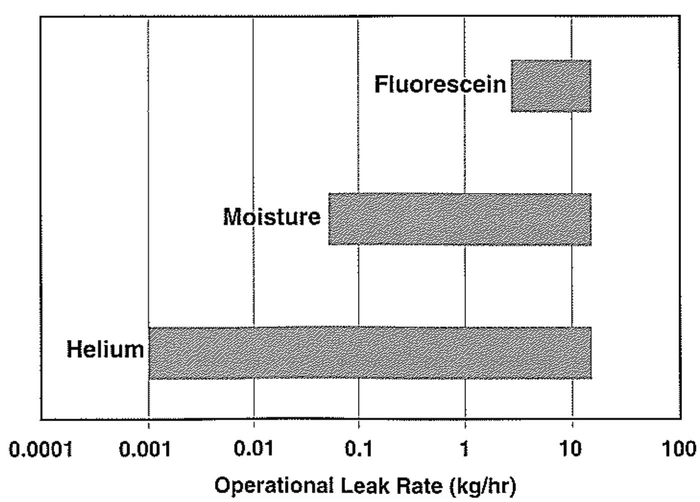


Figure 1). It consists of a gas manifold to regulate and measure air flow into the boiler through the manway. The boiler manway is sealed with a baffle plate to provide a slight pressurization of one side of the boiler bowl which establishes a small air flow through each of the boiler tubes. The air purge direction may be from the primary outlet toward the primary inlet, or vice versa depending on convenience. The purge manifold also contains a 'simulated leak' apparatus, consisting of a small cylinder containing a helium/argon mixture of known concentration. A small stainless steel tube from the cylinder is installed into one of the boiler tubes through a hole in the manway baffle. A small flow of helium gas can be introduced into this tube to act as a diagnostic aid for the helium leak detector installed near the other side of the boiler bowl (to be described below). The purge manifold is connected to an instrument control box, which routes all control and data signals back to a central control system outside the boiler area.

Tube Sheet Sampling System

At the opposite primary manway to the purge system is located the tube sheet sampling system. This consists of a sampling sniffer probe which is manipulated according to a predetermined pattern across the tube sheet in search of helium gas or water vapor leaking through from the secondary side. The gas sample from each boiler tube is routed to the helium and moisture detectors. The helium detector is a commercial mass spectrometer instrument contained within a purged enclosure. The purpose of the enclosure is to isolate the sensitive instrument from ambient helium around the boiler. The moisture detector (dew point meter) is connected in series with the helium detector. As with the purge system, all signals are routed through an instrument control box to the central control system. Facility is made for a video camera to be installed near the boiler primary head to remotely monitor the equipment setup and operation.

Sniffer Probe

The sniffer probe is manipulated remotely across the tube sheet by a robotic arm (such as Zetec SM-23). No primary head boiler entries are required to completely inspect the boiler. The probe is essentially a funnel which is placed very near to the bottom face of the tube sheet. A slight suction draws an air sample from the tubes above the funnel down through a hose into the detectors. Various sizes of funnels have been constructed to inspect groups of tubes simultaneously, thus speeding the inspection process. For boilers with a triangular matrix of tubes, the optimal funnel sizes are fitted for 1, 7 and 19 tubes. The choice of funnel size involves a trade-off between inspection speed and sensitivity. A small funnel samples from a few tubes, thereby providing good sensitivity but with many inspections being required to cover the whole tube sheet. A large funnel provides fast inspection, but with lesser sensitivity because the gas sample from any one "leaker" tube is diluted from many non-leakers under the same funnel.

Secondary Subsystems

Helium Injection System

The pressurization of the secondary side is achieved with a combination of air and helium/argon mixture. This is due to the large volume of gas required to initially pressurize the whole secondary system and to maintain that pressure throughout the leak search. The air is first used to pressurize the complete secondary system (boiler shell, steam drum, steam lines plus ancillary systems), then the helium/carrier mixture is added to the boiler under test (see Figure 1). An air compressor, or some other means of pressurization, is attached to some portion of the boiler secondary system to provide the needed pressure (approximately 500 kPa). The compressor attachment point is preferably on the main steam outlet or near the top of the steam drum. This is to ensure that air leakage through the main steam shutoff valves will not disturb the helium gas charged within the boiler shell. A compressor attachment point near the boiler bottom would result in substantial dilution of the helium gas with air. A helium injection system is attached to the boiler blowdown system to allow helium injection into the *bottom* of the boiler shell. The injection system is essentially a high capacity gas manifold which can regulate and, if necessary, mix the injection gases. Due to the large volume of gas required to fill the secondary shell of the boiler it is most convenient to use premixed helium/carrier gas from a tube trailer. The injection of gas into the boiler is more time consuming and labor intensive if individual gas bottles are used.

Helium Analysis System

It is important to monitor the helium concentration in the boiler secondary during the leak search because of mass transfer processes (e.g. diffusion, convection) which may result in helium dispersal. To confirm the presence of sufficient helium gas in the boiler secondary, a helium analysis system is used. The system functions by drawing a sample of the boiler secondary gas through an automated thermal conductivity detector (TCD) to measure helium content and an oxygen sensor to measure oxygen content in the boiler. The gas sampling line is attached to the boiler secondary through a suitable access point such as a blank flange or boiler level instrumentation. Ideally, the sampling point should be placed at an elevation near the top of the tube bundle to ensure that the whole bundle is completely 'bathed' in helium gas. As with the other subsystems, the helium analysis module is remotely controlled by the central control system.

Control System

Due to the fact that the various leak detection subsystems are installed at different locations on the SG, a central control system is a necessity. Ideally, the control system should be located near to the robotic arm control, due to the need for continual interaction between the leak detection and robotic arm operators during the leak search. All subsystems are connected electronically to the control system with signal cables routed to each of the remote locations. To eliminate the effects of noise and ground loops, the signals between the sub-systems and central control were designed to be completely digital. The heart of the control system is a PC fitted with an RS-485 interface card, permitting high speed, digital communication. The PC software for the control system allows logging of all process parameters on a continuous basis, as well as operator directed control of remote devices such as valves and flow controllers. The helium and dew point signals are graphed on screen so that trends can be discerned by the operators. Other software screens allow the status of all sub-systems to be observed and changed at will.

ALTERNATE LEAK SEARCH STRATEGY

By using only moisture leak detection, a somewhat less sensitive but simplified leak search may be conducted. With the boiler secondary kept filled with water instead of drained and filled with helium gas, leaks in any part of the tube bundle will transmit liquid water to the primary side. This will then be detected with the moisture sensor, as before. The advantage of the 'Moisture Only' mode is the simplified prerequisite process, since some equipment and materials specific to helium leak detection are not required. The disadvantage of this mode is the loss of sensitivity relative to helium leak detection. The choice between 'Moisture Only' mode and 'Helium & Moisture' mode must be based on considerations such as the boiler leak rate, schedule and economic factors. Table 2 below provides a comparison of these two modes of leak detection.

Table 2. Prerequisites and properties of the two leak detection modes.

Prerequisite	Helium & Moisture	Moisture Only
Detection Limit (kg/hr)	0.001	0.05
Primary air supply required	Yes	Yes
Robotic arm required	Yes	Yes
Primary Subsystems installed	All	Partial
Boiler pressurization required	Yes	Yes
Helium supply required	Yes	No
Boiler drained for leak search	Yes	No
Injection system required	Yes	No
Helium analyzer required	Yes	No

CONCLUSIONS

The leak detection technology described herein has been utilized successfully on several occasions at Ontario Hydro CANDU facilities in the past year to locate small boiler leaks. The use of both helium and moisture detection capabilities was found to be essential for a complete leak search on all regions of the tube bundle. The helium concentration in the boiler secondary remained stable throughout the leak search period, confirming the usefulness of the argon carrier gas. An estimated leak rate detection limit of 0.05 kg/hr was deduced for the moisture detection capability, referenced to typical CANDU operating conditions. The corresponding detection limit for helium detection is approximately fifty times better (0.001 kg/hr).

ACKNOWLEDGMENTS

The authors would like to thank the members of the OHT Process Technologies Dept. for their dedicated involvement throughout this project. Thanks also to Ontario Hydro Nuclear personnel for station support and technical assistance. Developmental funding for this project was provided by the Business Units of Ontario Hydro and by the CANDU Owners Group.

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Next Generation CANDU Plants

Kenneth R. Hedges and Stephen K.W. Yu[1]

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Introduction

The evolution of the CANDU® family of Pressurized Heavy Water Reactors (PHWR) featuring horizontal fuel channels and heavy water moderator is based on a continuous product improvement approach. Proven equipment and system concepts from operating stations are standardized and used in new products. Due to the modular nature of the CANDU reactor concept, product features developed for one product size say the CANDU 9 can easily be incorporated in other CANDU products such as CANDU 6. The product evolution is supported by AECL's strong commitment to comprehensive R&D programs. Therefore, CANDU reactor products will incorporate further improvements and advanced features that will utilize results from our CANDU Technology R&D programs in areas such as fuel channels, heavy water and tritium, control and instrumentation, fuel and fuel cycles, systems and equipment, safety technology and constructability.

Future CANDU designs will continue to meet the emerging design and performance requirements expected by the operating utilities. The next generation CANDU products will integrate new technologies into both the product features as well as into the engineering and construction work processes associated with delivering the products The timely incorporation of advanced design features is the approach adopted for the development of the next generation of CANDU.

CANDU development Thrusts

There are three key CANDU development strategic thrusts: improved economics, fuel cycle flexibility, and enhanced safety operation.

Improved Economics

CANDU designs utilize advanced engineering tools, such as 3-Dimensional (3-D) Computer Aided Design and Drafting System (CADDS) tools and advanced construction methods, for better economics and reduced risks to future owners. The 3-D CADDS model is used to establish the layout configuration, optimization of the fabrication sequence and construction, and the choice of composite steel or structural steel modules depending on the layout and complexities of systems.

Modularization allows the manufacturing of modules in parallel with the structural concrete work at site. This not only reduces the construction schedule and costs, but also improves the accessibility for system installation within a module, therefore improving the work quality.

Fuel Cycle Flexibility

The excellent neutron economy gives the PHWR the ability to use different low fissile materials, and provides opportunities in continuing improvements in uranium (or other fissile materials) utilization and reactor/fuel optimization, to decrease in plant capital cost. CANDU fuel cycle flexibility arises naturally from the neutron economy associated with the use of heavy water, and the use of on-power fuelling and simple fuel design. The exploitation of this flexibility results in fuel cycles that optimize the use of uranium resources.

Light Water Reactors (LWR) are designed to burn enriched uranium (about 3.5% U-235) fuel down to a fissile content of 1.5% (0.9% U-235, 0.6% Pu) at the end-of-life of the fuel. CANDU NU fuel starts with 0.7% U-235, which is burned down to concentrations of enrichment plant tailings (about 0.2%). Therefore, CANDU reactors are in a unique position to take advantage of the relatively high fissile content of spent LWR fuel, and the LWR can be viewed as an efficient source of fissile material for future advanced CANDU designs via a number of potential once-through combined fuel cycles. This exploitation of the natural LWR/PHWR synergism will assure long-term fuel supply even if uranium resources become scarce. Also the use of recovered uranium fuel, and the use of mixed oxide fuel with plutonium and depleted uranium, including the recycling of transuranic mix from spent fuel reprocessing, can help to reduce long lived waste. All these fuel cycles are part of the overall strategy for sustainable development of the next generation CANDU products.

Enhanced Safety Operation

AECL has been enhancing the performance of

[1] Both authors are with Atomic Energy of Canada Ltd., Sheridan Park

CANDU reactors under postulated severe accident conditions that go well beyond the normal design basis for nuclear power plants. The presence of the heavy water moderator surrounding the fuel channels effectively mitigates the impact of postulated severe accidents. If primary and emergency coolant is lost from the system, heat is transferred out of the fuel channel and into the moderator water. From the moderator, heat can be transferred to the environment via the moderator water cooling system. This means that CANDU fuel does not melt even if both normal and emergency cooling are unavailable. In addition, the moderator is surrounded by a shield tank containing light water for biological and thermal shielding. In severe core damage accidents, where moderator cooling has also failed, the shield tank can absorb decay heat either from the moderator or from debris inside the calandria vessel, and would prevent the core from melting through to containment for tens of hours, until the water had boiled away. Therefore, in addition to the usual engineered safety systems in plants that meet international safety standards, CANDU reactors contain passive safety features that result from the inherent design of the reactor. Make up to the moderator is included in the current CANDU 6 and for the CANDU 9 design, a large reserve water tank is located high in the reactor building and supplies water by gravity to various systems.

Experience Feedback

AECL has recognized the roles of operational feedback on product. AECL has been active in the CANDU Owners' Group on Information Exchange program where good operating practices are exchanged, events are reported, and data relevant to safe plant operation is collected screened, and distributed to COG members. AECL and Ontario have also held a number of annual Operating Experience Feedback Seminars to allow further exchange between utility operators and the designers. In recent years, there have been a total of four COG/IAEA Technical Committee on Exchange of Operational Safety Experience of PHWRs where all PHWR utilities world wide can share and exchange their operational experience and solutions to safety issues.

To complement these activities, AECL has initiated a systematic feedback process which incorporates regular, formal review of lessons learned from not only operations, but also from construction, commissioning, regulatory activities as well as incorporating R&D results. Recent examples of operational input to designs are:

- ECC performance improvements including strainer design for long term circulation of emergency coolant;
- Improvements to liquid relief valve component and system design for heat transport pressure and inventory control
- Improved safety system signal monitoring with updated digital displays, increased computerized testing for reduced operation burden and increased system reliability
- Steam generator operational improvements such as provision of additional access ports for chemical cleaning and improved divider plates for long term performance

Status of CANDU Products

Progressive CANDU development will continue in AECL to enhance the medium size product - CANDU 6, with an outputs of about 725MWe and to evolve the larger size product - CANDU 9, with a gross output of 945MWe. The development of features for CANDU 6 and CANDU 9 is carried out in parallel. Developments completed for one reactor size can then be applied to the other design with minimum costs and risk.

CANDU 6

The 700 MWe class CANDU 6 nuclear power plant has an outstanding operating performance record since the startup of the first four CANDU 6 units in 1983. Cernavoda-1, the most recent European nuclear plant, started operation in 1996. The most recent project to achieve startup is Wolsong-2, which achieved full power in April 1997; Wolsong 3 and 4 will go into operation in 1998 and 1999 respectively. Most recent of all is the Qinshan project, which started construction in February 1997.

For Qinshan, further improvements from the reference plants at Wolsong have been incorporated, both in plant design and in product delivery. The Qinshan design is tailored to meet stringent local requirements including tornado protection and tight requirements on emissions to allow the Qinshan site to be used for up to 5 projects. The Qinshan plant design incorporates further improvements to such auxiliary systems as fire protection (additional redundancy of water supply system). In addition, the continuing development of fuel channel design had led to the use of improved surface finish of calandria tubes. This has the added advantage of increasing heat transfer margins if the moderator were to be required as an emergency heat sink. Consistent with the 40-year design life target, improvements in feeder material selection, using trace addition of chromium, will enhance resistance to long-term corrosion effects. Similarly, careful attention has been paid to specifications of key components such as the steam generators to allow in-service inspection and cleaning to ensure their capability for a 40-year design life. Specifications are optimized to ensure design fully meets requirements, without placing unnecessary restrictions on manufacturers.

Building on the successful application of CADDS models for CANDU 9 design engineering and for Wolsong 2, 3 and 4 construction support, the Qinshan project will be based on a comprehensive set of 3-D CADDS models. These will be linked to electronic databases covering wiring (INTEC) equipment specifications (TeddyBase) and materials management (CMMS). This will improve the effectiveness of engineering and procurement processes, and in particular will minimize plant design inconsistencies such as physical interferences, material or performance interface errors etc. As a result, the construction and installation stages of the project will be subject to much less schedule or cost risk. Constructability has been further improved by the adoption of open-top techniques for work within the reactor building. This is based on the use of a very-heavy-lift crane to install major equipment before completing the reactor-building dome. Specific equipment items were installed this way for Darlington NGS. Full scale application of this technique has allowed an ambitious project schedule of 72 months from contract effective to first unit in-service to be committed; this despite an extremely restricted site, and the natural additional challenges inherent in the first project in a new environment.

Future CANDU 6 projects builds upon the latest version of the product under construction in Qinshan, China. Design enhancements being considered are in the areas of capital cost reduction, improved licensability, elimination of obsolescence and improved operability.

CANDU 9

The CANDU 9 is a stand-alone version of the successful integrated multi-unit units at Darlington and Bruce Nuclear Generating Stations operating in Ontario, Canada. Added to the advantages of using proven systems and components, CANDU 9 offers a higher output, better site utilization, improved station layout and a control centre with better operability.

Since one of the major risks associated with nuclear power projects is delays due to licensing activities, AECL has submitted the CANDU 9 design to the Canadian nuclear regulator (AECB) for review, and it been confirmed that there are no conceptual barriers to licensing the CANDU 9 in Canada.(2)

Proven Systems, Equipment from Operating Stations

The CANDU 9 employs the standard CANDU lattice design and fuel channel arrangement with the same neutronic characteristics as the other operating CANDU reactors including the CANDU 6. The calandria design, with 480 fuel channels, and the design and arrangement of reactivity control devices are the same as for Bruce B and Darlington. The design of the CANDU 9 calandria and shield tank assembly is based on the Darlington reactor design with improvements incorporated from the CANDU 6 design to meet a 0.2g seismic requirements. The fuel channel of the CANDU 9 reactor is similar to the CANDU 6 design.

There are 12 fuel bundles in each fuel channel as in CANDU 6. CANDU 9 uses standard CANDU fuel consisting of 37 elements of uranium dioxide sheathed in Zircaloy and held together as a bundle by end-plates. CANFLEX fuel, which has many advanced features, can be used in CANDU 9.

The CANDU 9 heat transport system is essentially the same as the single loop Bruce B heat transport system. The major heat transport system equipment including steam generators and pumps, are of the same design as equipment now in operation at Darlington. The design parameters established for the Darlington heat transport system are applicable to the CANDU 9. As a result, heat transport system conditions are the same.

Better Site Utilization

Site area requirements for nuclear power plants is a strong function of the Exclusion Area Boundary (EAB) radius which is a licensing requirement, and the site layout arrangements of the various buildings. CANDU 9 has been designed to require a small EAB radius and to have a narrow 110 metre wide "footprint" that allows several units to be constructed adjacent to each other forming a compact multi-unit station.

The use of a "large dry" containment design (pre-stressed concrete building with a steel liner) gives lower design leakage and therefore greater margin in meeting the requirement of a reduced Exclusion Area Boundary.

Using siting requirements typical of light-water reactors, adapted to CANDU, the CANDU 9 can meet an Exclusion Area Boundary of less than 500m. AECL's calculations have shown that to achieve an EAB of 500m; a containment design leakage rate of 0.6% per day at design pressure is required. Since the design leakage rate of CANDU 9 is 0.2% volume per day about a factor of three less than that used in the analysis, an EAB of 500m is clearly achievable for CANDU 9.

In addition to the Containment Isolation System, provision of a redundant independent, diverse Ventilation Isolation System to isolate the ventilation lines, will provide further defense-in-depth for CANDU 9.

CANDU 9 building arrangement has benefits both from the construction, operational and maintenance viewpoint, as well as from the site utilization viewpoint. The buildings are arranged to allow replication of the initial unit with minimum spacing between units while retaining all the necessary access for the construction of subsequent units. The common services for the units are located in the station service building.

Control Centre With Better Operability

A formal human factors engineering plan defines the process of incorporating human factors into the design of CANDU 9 systems and equipment.(3) All aspects of plant design for which there is an interface with plant personnel will incorporate consistent human factor considerations. Underlying this approach is a refined engineering design process that cost-effectively integrates operational feedback and human factors engineering to define operations staff information and information presentation requirements. Based on this approach, the CANDU 9 control centre will provide utility operations staff with the means to achieve improved operations.

As part of the CANDU 9 design strategy, a physical, full-scale mock-up of the control centre panels and consoles is being used for conceptual evaluation, rapid prototyping, design decision-making, and then for the verification and validation of the design features, displays and operator interactions. The functionality of the simulation supported control centre mock-up provides a dynamic mechanism for the on-going verification and validation design activities by system designers.

The CANDU 9 control centre provides plant staff with improved operability capabilities. A major evolutionary change from previous CANDUs is the separation of the control and display/annunciation features formerly provided by the digital control computers (DCC). This improved function separation provides control in the distributed control system (DCS) and display/annunciation in the plant display system (PDS). This strategy allows powerful computers, without application memory constraints or execution limits, to provide extensive control, display or annunciation enhancements within an open architecture.

Next Generation CANDU development

Use Of Slightly Enriched Core

Future development of the larger size CANDU includes the development of designs with an increase in reactor output. With a modular fuel channel design, a higher reactor output can be achieved without the introduction of new technology while maintaining the same reactor channel licensing and safety limits. The increased output can be achieved by using a new fuel design and/or by using slightly enriched uranium fuels(4) in the same reactor core as the current CANDU 6 and CANDU 9.

By using the new CANFLEX fuel bundle with 43 elements which has improved thermal margin, and by adjusting and optimizing core and heat transport design and overpower detection system design, a modest increase in channel power can be accommodated. The development of the design of this fuel is complete. It has been planned to have in-reactor testing in a CANDU 6 reactor in New Brunswick in order to demonstrate its in-reactor performance, within the same basic plant configuration.

Currently operating CANDU power reactors use a once-through natural uranium fuel cycle, which avoids the need for securing a supply of enriched uranium. Power increases can have a large effect on the unit cost of electricity, especially if they can be accomplished with relatively small changes in plant costs. One approach to increasing the power of PHWRs is to switch from natural uranium to Slightly Enriched Uranium (SEU) fuel containing 0.9 to 1.2% U-235. The SEU can be used to flatten the power distribution over the core to produce about 15% more power, without changing the core design.

In conventional reprocessing, uranium and plutonium are separated from the fission products and other actinides in the spent fuel. The recovered uranium (RU) from conventional reprocessing still contains valuable U-235 (typically around 0.9%, compared to 0.7% in natural uranium fuel). This can be burned as-is in PHWRs, without re-enrichment, to obtain about twice the burnup of natural uranium fuel. Also, approximately twice the energy would be extracted using CANDU reactors, compared to re-enrichment of RU for recycle in a PWR. The U-235 would be burned down to low levels (i.e., 0.2%) in PHWRs compared to PWRs (0.9%) so there may be no economic incentive for further recycle of this material. The CANDU spent fuel would then be ultimately disposed of, after a period of dry storage, in a deep geological repository.

Recovered uranium is currently a liability to many PWR owners, who have no plans to recycle it in their PWRs, because of the complications in fuel fabrication with re-enriched RU, and marginal, if any, economic benefit in PWR-recycle. Therefore, the use of RU in CANDU reactors would appear to be an extremely attractive way of dealing with a waste product while at the same time extracting additional energy.

Larger Size CANDU

Owing to the modular nature of the CANDU core, it is possible to add more fuel channels. For example, the CANDU 9 contains 480 fuel channels. The number of channels could be increased to 640 in the current CANDU 9 reactor shield tank assembly. This larger reactor will be capable of generating about 1200 MW to 1400 MW, depending on the fuel used, with higher power output being produced with slightly enriched fuel such as recovered uranium fuel.

In the longer term, it may be possible to operate the primary heat transport system at much higher temperatures, thereby substantially increasing the thermodynamic efficiency. Such a change would require considerable advances to our understanding of materials at elevated temperatures under reactor core conditions, but the efficiency gains could have a significant impact on unit energy costs.

Future Enhancements

Safety Improvements

For future CANDU products, further systematic review of severe accidents and features to facilitate severe accident management will be made to achieve a balance between preventative and mitigation measures. Due the important role of containment in severe accident scenarios, particular attention is required in meeting the following key requirements for future designs:

- containment structure with larger design margins and low leakage rates
- redundant heat sinks for long term decay heat removal
- good isolation provisions and means of post-accident cleanup
- hydrogen mitigation systems that allow systematic and timely dispersion and reduction of hydrogen concentrations.

Future enhancements are focusing on adapting passive emergency water systems for containment cooling, for decay heat removal and/or emergency depressurization of the steam generators, and for the moderator in its role as a backup to the normal ECC system. A key element of this latter concept is the development of a "controlled heat transfer fuel channel" that is capable of transferring heat to the moderator under accident conditions at lower fuel temperatures and with higher moderator temperatures than is currently the case. The "controlled heat transfer fuel channel" uses an appropriate heat transfer material between the pressure and calandria tubes to ensure rejection of decay heat to the moderator at a low enough fuel temperature to prevent extensive fuel damage.

Future designs need to address requirements for accident management to limit accident consequences and/ or reducing the probability of such accidents, based on systematic evaluation methodologies such as Level 2 PSA. As a result the necessary structures and systems can be hardened with additional margins to ensure sufficient monitoring and control capability and accident management following seismic and other external events, as well as accident conditions.

Health and Environment

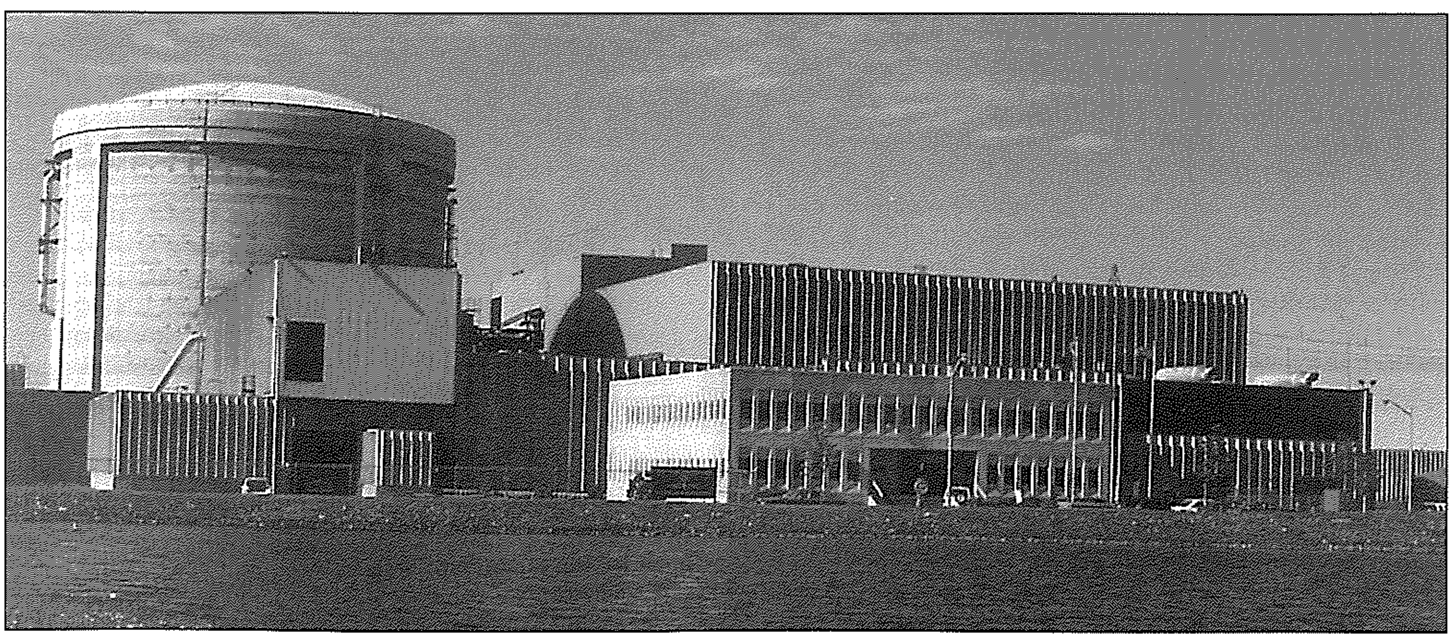
Radiation doses from nuclear power generation are calculated using very conservative assumptions to be a very small fraction of the doses associated with natural radiation sources,. There has been a decreasing trend in the radiation doses associated with all reactor designs during the past decade. AECL is following a methodology for dose reduction that includes measurements at existing stations, examination of operational practices and data, development of improved technologies for measurement and mitigation, and rigorous review of CANDU designs to ensure that full advantage is being taken of the R&D and operating knowledge base. For example, designers and researchers have adopted targets that include reducing the buildup of activation products, tritium and heavy water management processes that reduce tritium emissions, and improved waste management developments to reduce emissions during waste handling. In addition, AECL will continue to examine the more fundamental aspects of radiation and health to ensure a sound basis for any standards that impact on the CANDU product. These more fundamental programs include dosimetry, the elucidation of mechanisms underlying low-level radiation effects, and the characterization of environmental pathways. An important application of this knowledge base is to ensure that the exclusion area boundaries specified for CANDU reactors are based on sound knowledge and modeling.

Control and Instrumentation

CANDU plants have employed computerized control systems since the 1960s, and each new plant has been provided with state-of-the-art systems for optimum performance. AECL's strategy for advanced control center design is to extend the proven features of operating CANDU reactors by combining this experience base with operations enhancements and design improvements. The focus for the advanced features is to improve the operability and maintainability of the station, decrease the likelihood of operator or maintainer errors, to reduce capital and operating costs, and to facilitate higher production capacity factors. The significant features of the advanced control centers include a plant-wide database, extensive cross-checking of similar process parameters, additional operational aids such as automatic procedure call up, configuration management assistance, automated system performance checking, and predictive maintenance.

Conclusion

AECL's current products consist of 700MW Class CANDU 6 and 900 MW Class CANDU 9. Evolutionary improvements are continuing with our CANDU products to enhance their adaptability to meet customers ever increasing need for higher output. Our key product drivers are for improved safety, environmental protection and improved cost effectiveness. Towards these goals we have made excellent progress in Research & Development and our investments are continuing in areas such as fuel channels and passive safety. Our long term focus is utilizing the fuel cycle flexibility of CANDU reactors as part of the long term energy mix.



Point Lepreau NGS – one of the first generation CANDU 6.

The 12th International Symposium on Zirconium in the Nuclear Industry

Ed. Note: The following report is a slightly edited version of one prepared by Dr. Gerry Moan, of AECL, Sheridan Park, who was the Technical Chairman for the Symposium.

The 12th ***International Symposium on Zirconium in the Nuclear Industry***, held in Toronto 1998 June 15 to 18, attracted 250 participants from 16 countries representing zirconium alloy producers, processors, users, researchers, reactor designers, station operators and regulators.

It was the latest in a series sponsored by the ASTM Committee B-10 on Reactive and Refractory Metals and Alloys. The previous three symposia were held in Garmisch-Partenkirchen (1995), Baltimore (1993) and Kobe (1990). The Symposium was last held in Canada in Vancouver in 1982.

The Symposium was a particularly valuable forum for CANDU engineers and researchers because of the importance of the behaviour and properties of the zirconium (Zr) alloys used for pressure tubes, calandria tubes, reactor mechanisms and fuel sheath in CANDU reactors. The Symposium provided the opportunity for the exchange of information about factors that affect the performance of Zr alloys in nuclear power reactors, in the formal sessions and in the many informal discussions.

The 42 papers selected for oral presentation (including 7 from AECL and one from OH) were arranged into 7 sessions that covered the topics: Properties at High Fluences, Hydrogen and Temperature Effects, Deformation and Fracture Studies, Processing and Alloy Development, Effect of Composition and Microstructure on Corrosion, Corrosion Simulation and the Effect of the Environment, and Effect of Oxide Properties on Oxidation and Hydrogen Pickup Rates. The alloys discussed in the papers included Zircaloy-2 (used in CANDU for calandria tubes), Zircaloy-4 (used for fuel sheath), Zr-2.5Nb (used for pressure tubes) plus other alloys being developed and used in Russia, France, USA, Japan and Germany. In addition some 30 authors took part in a Poster Session.

A few of the highlights include:

- the need to decrease the oxidation and hydrogen pick up by Zr alloy fuel cladding as reactor operators increase the fuel burn-up by keeping the fuel in reactor for longer times.

  Among the possible routes being examined is a low tin variant of the Zircaloy-4 alloy that has been in use for many years. The French have studied a variant of the Russian Zr-1%Nb fuel cladding alloy and appear to achieve good performance for it.
- the axial cracking found in some Zircaloy-4 BWR fuel cladding.

  Some of the models make use of Canadian work developed earlier to describe the Delayed Hydride Crack growth in other Zr alloys.
- the possible benefits of increasing the concentration of some elements, such as sulphur, that are usually regarded as impurity or trace elements.
- a US/Japanese paper on the properties of Zircaloy-2 plate following service to ultra-high fluence and two Canadian papers on high fluence irradiations in Zr-2.5Nb indicated there were no surprises.
- a UK paper (based on work carried out in AECL and OH) indicated that the solubility of hydrogen in Zr alloys was increased by irradiation.
- several of the papers described very elegant work studying how the corrosion behaviour is affected by microstructural changes occurring in oxides that are growing during service.

The reviewed papers will be published by ASTM as ASTM STP 1354 in mid 1999.

The contributions by four research workers to the understanding and use of Zr alloys in the nuclear industry were acknowledged with the award of Kroll medals at a special luncheon. The **Kroll Medal,** awarded each year, is named after the original developer of the main step in the refining of Zr and Ti metals.

Ron Adamson from GE, USA, received the 1995 award for his work on the effect of irradiation on Zr alloys, their dimensional stability in service, and for many studies of the microstructures, mechanical properties, deformation mechanisms and corrosion of Zr alloy components.

The award for 1996 went to **Chuck Ells** and **Tony Sawatzky,** both retired from AECL, for their work on characterizing the effect of neutron irradiation and hydrogen on the behaviour of Zr alloys, especially in the areas of hydride orientations, delayed hydride cracking, hydrogen diffusion under different conditions, hydride blisters and mechanical properties.

The 1997 award was presented to Daniel Charquet from CEZUS, France, for developing different processing methods for Zr alloys and for work on understanding the inter-relations between processing parameters, microstructures, properties and behaviour of Zr alloys.

Two other awards were presented. **S.A. Aldridge** from Nu-Tech Precision Metals, Arnprior, received the Russ Ogden Award from the ASTM B-10 Committee for his contributions to the development and use of the alloys of Zr, Ti and other B-10 metals, including superconducting alloys. Nu-Tech is the manufacturer of pressure tubes for CANDU reactors.

The John Schemel Award for the best paper from the previous Symposium was presented to A. M. Garde, G.P. Smith and R.C. Pirek from ABB-CE, USA, for their paper on "The Effects of Hydride Precipitate Localization and Neutron Fluence on the Ductility of Irradiated Zircaloy-4".

The evening receptions, sponsored by Westinghouse, Oremet-Wah Chang, CEZUS and AECL, were much appreciated as they allowed the attendees to meet, to renew friendships and to discuss the fine points in many of the papers and research programs in more detail. Additional sponsorship received from Mississauga Metals and Alloys, Zircatec Precision Industries, and Nu-Tech Precision Metals was also appreciated.

The Symposium Chair was George Sabol, Westinghouse, US and the Editorial (or Technical) Chair was Gerry Moan, AECL SHPK.

International Nuclear Regulators Association:

– enhancing the effectiveness of national nuclear regulatory bodies

by Dr. Shirley Ann Jackson

***Ed Note:** Dr. Jackson is chair of the United States Nuclear Regulatory Commission and the first chair at the International Nuclear Regulators Association. This article is reprinted, with permission, from "NEW", the European Nuclear Society's publication "Nuclear Europe Worldscan", the July/August 1998 issue. For Canadian readers, Dr. Agnes Bishop, who became president of the Atomic Energy Control Board about the same time Dr. Jackson was appointed to the USNRC, was also instrumental in the formation of the INRA.*

Most readers, I suspect, would agree that safety in the generation and use of nuclear energy is a matter that transcends national boundaries.

Perhaps a more subtle point is that the effectiveness of national nuclear regulatory bodies is also an issue with international implications.

In the Fall of 1995, shortly after President Clinton appointed me chair of the US Nuclear Regulatory Commission, I became impressed with the commonality of the challenges facing senior regulators from around the world.

My discussions with those regulators frequently turned toward the need for a permanent forum specifically dedicated to sharing the regulatory policy challenges, viewpoints, and solutions common to national nuclear regulatory organizations.

World dialog

After considerable dialog and several group meetings, the heads of eight such organizations – from Canada, France, Germany, Japan, Spain, Sweden, the UK, and the US – formally constituted the International Nuclear Regulators Association (INRA) in May 1997.

INRA clearly recognizes that nuclear safety must remain the responsibility of the nation states in which the technology is utilized, but also emphasizes the value of sharing regulatory perspectives at the highest levels.

By consensus, the INRA members determined that the aims and objectives of the Association would be:

- to establish a forum for the most senior nuclear regulatory officials to exchange views on broad regulatory policy issues (including technical, legal, economic, and administrative issues);
- to build a global nuclear safety culture;
- to encourage the most efficient use of resources in areas of common interest;
- to work to enhance the stature of nuclear regulatory organizations worldwide;
- to seek consensus on how nuclear regulatory issues can be approached and implemented;

- to facilitate international cooperation in regulation;
- to work to advance nuclear safety through cooperation among its members, cooperation with relevant existing intergovernmental organizations (such as the IAEA, or the OECD/NEA), with other national nuclear regulatory organizations, as appropriate; and
- to identify emerging nuclear regulatory challenges.

The INRA members chose to organize the Association as a forum for periodic (currently biennial) discussions, without an institutional bureaucracy.

Within the organizations represented, the INRA membership is held by the most senior nuclear regulatory official.

The organizational membership is based on a series of criteria related to: (1) the size and scope of the national nuclear program, (2) the existence of a well-established, independent nuclear regulatory authority, and (3) a commitment to the provisions of the Convention on Nuclear Safety.

The initial membership will remain at eight countries for the first two years, while the members deliberate on the most effective methods of achieving their objectives.

From that experience, INRA members will consider when and how to involve other national nuclear regulatory organizations.

This consciously evolutionary approach to expansion is intended to establish sensible foundational guidelines and objectives, while also taking the time to gain experience with their application. In this way, the Association hopes to optimize the process of organizing an international approach to harmonizing national regulatory activities, in a way that will produce a more stable, predictable, transparent regulatory model.

The decision to defer the general issue of a wider INRA membership during this formative period does not preclude the Association from arranging ad hoc activities with other regulatory bodies, where such arrangements are found to be useful in achieving INRA objectives.

For example, China

As an example, for the July 1998 INRA meeting, we invited the director general of the National Nuclear Safety Administration for the People's Republic of China to give a presentation on the emerging Chinese nuclear program, to review bilateral cooperation with various countries, and to discuss China's needs as a recipient country.

In addition, as part of my duties as the first INRA Chairman, I have been asked to ensure that relevant international bodies are informed on a regular basis of INRA activities and focus areas.

As an early area of focus, INRA has sought to identify and agree upon a set of fundamental elements in nuclear safety regulation that are common to the various regulatory systems of nuclear countries, and thereby to define the essential characteristics of a sound national nuclear regulatory infrastructure.

During the January 1998 INRA meeting in Walnut Creek, California, a number of commonalities in regulatory approach were identified, including, for example:

- the existence of a clear statutory and legal framework for nuclear regulation; the establishment of the basic industrial, technological, and human resource infrastructure necessary to ensure nuclear safety;
- an unambiguous recognition that the prime responsibility for the safety of a nuclear installation rests with the holder of the license (i.e., the operator of the installation); and
- a national commitment to safety as the fundamental requirement for a nuclear program.

INRA recognizes that differences exist in the history, development, current structure, and scope of responsibilities of various national nuclear regulatory bodies, as well as in the degree to which nuclear energy plays a role in any given national energy strategy.

However, the similarities identified indicate the value of sharing insights on how best to fulfill fundamental safety objectives, to meet technical and policy challenges, to ensure effectiveness as regulators, and to position these regulatory organizations for change in national and global economies.

Commonality

In addition, the degree of commonality indicates the value of identifying and designating those key elements of nuclear safety that should be incorporated into every national nuclear power program.

In recent years, the experience gained by donors and recipients of nuclear safety assistance has been revealing. In cases where these efforts have not been coordinated well among donors, duplication and confusion too frequently has been the result. The tendency has been to provide short-term assistance, rather than the more practical and worthwhile longer-term cooperation that is needed.

Too often, the regulatory component of nuclear safety assistance has been neglected or over looked entirely. Seldom have these efforts incorporated a coherent overall input from the regulators themselves, related to regulatory safety policy. Given this context, the members of INRA hope that the Association efforts to identify and promulgate the key elements of a national nuclear power program will be of considerable value in advancing international efforts to ensure nuclear safety.

INRA will continue to pursue this and other focus areas, seeking to make substantial contributions to nuclear safety by enhancing the effectiveness of national nuclear regulatory bodies.

Special Feature

Malice in Blunderland - Part II

by J.A.L. Robertson

Ed. Note: Earlier this year the federal Environmental Assessment Panel on Nuclear Fuel Waste Management and Disposal Concept released its report (see Vol. 19, No. 1) which, in essence, concluded that deep geological disposal concept proposed by AECL was technically safe but socially unacceptable.

Mr. J.A.L. (Archie) Robertson, a nuclear pioneer and former senior scientist at the Chalk River Laboratories, followed closely the hearings of the Panel over its eight year existence and made several submissions. He has prepared an extensive and detailed critique of the Panel's report and its operation. Part I of his critique, which was published in the previous of the CNS Bulletin, Vol. 19, No. 2, exposed flaws in the Report. Part II, below, discusses flaws in the Panel's process and suggests how the situation can still be salvaged. An Appendix, with clause by clause comments on the Report is available through the Canadian Nuclear Society's Web site at www.cns-snc.ca

At time of writing, the federal government, i.e., the Ministers of Environment and Natural Resources, has not issued its response to the Panel's report.

Part II

A Flawed Process – and How to Improve It

"'When I use a word,' Humpty-Dumpty said, 'it means just what I choose it to mean - neither more nor less'" - Lewis Carroll

"Never attribute to malice that which is adequately explained by stupidity" - A. Bloch

In assessing the Panel's review process and recommending improvements I have drawn on my familiarity with the composition and findings of more than thirty nuclear inquiries that I reviewed in "Nuclear Energy Inquiries: National and International" (Report AECL-10768, 1993); and my participation in the activities of the Siting (Process) Task Forces (STF) for Low-Level Radioactive Waste Management (LLRWM) from 1986 to the finish in a fiasco at the end of 1996, as well as my participation in the present process from the start. In making recommendations on how the lessons learned from past experience could be applied to future inquiries I use "the commission" as a generic term to distinguish it from the Panel.

Time is Money - and Lives

The most obvious fault in the present process has been its ridiculously long duration, ten years from when AECL submitted its proposal for the disposal of nuclear-fuel wastes to its Minister. All this time just for concept review. Concept review, detailed engineering, approval, construction, siting and implementation were all accomplished in two years for Mulberry, the artificial harbour for the Normandy landings in World War II, a project much more complex and with far more serious consequences than the present one. If it had had to undergo the current review process and the timetable proposed in AECL's Environmental Impact Statement (EIS), D-Day would have been postponed to 1980.

This delay represents an unconscionable misuse of scarce resources. The direct expenditure of about $7 million dollars by the Panel must be more than doubled to allow for consequential costs to other participants in estimating the cost to Canadian taxpayers. The indirect costs are immensely greater. Even if the Panel had endorsed the concept as safe and acceptable the delay will have been responsible for years of avoidable anxiety to all those who have been victims of some critics' scare-mongering. As it is, the Panel's indecision may result in past expenditures of over half a billion of taxpayers' dollars having been wasted on unnecessary research and development. Considering only the money, this amount is now unavailable for more fruitful social objectives. Since many measures for health and safety cost around $1 million per life saved (and many cost much less), the cost in lives of anonymous Canadians as a result of the delay can be easily estimated.

The first two-years delay can be attributed to the federal government. The seven-member Panel was not appointed until October 4, 1989; and its Scientific Review Group (SRG) until August 15, 1990. However, the Panel is responsible for the period of over eight years since it was appointed.

One important reason for the government's part of the

The Environmental Assessment Panel on Nuclear Fuel Waste Management and Disposal Concept at its last day of hearings, March 27, 1997.

delay is the general bureaucratic environment in Ottawa that regards such delays as normal. Royal Commissions go on for years beyond their original mandates and expect to receive repeated extensions, e.g., the Blood and Somalia Inquiries. The government has only now got around to revising the 1946 Atomic Energy Act and its associated Regulations: an earlier attempt was allowed to die in Parliament. Environmental assessments are laudable but modern societies cannot afford a process that takes longer than construction of the project assessed. The need for energy projects is rigorously dependent on economic forecasts which can change drastically during the lifetime of an environmental review. As a result, we may be forced to construct environmentally less attractive installations simply because they can be constructed in a shorter period.

Governments should not institute policies unless they have the resources and the will to implement them expeditiously.

Ideally, an inquiry should be completed within the term of office of the appropriate government, as recommended in the Final Report of the Siting Task Force (STF) for Low-Level Radioactive Waste Management. Since a government is unlikely to initiate an inquiry immediately on being elected, or to make a controversial decision immediately before the next election, this means that a review should be completed within two years.

An inquiry should be completed within the term of office of the appropriate government.

How could this have been achieved for the present inquiry? To begin with, the Scoping Hearings served no useful purpose and should have been eliminated. The Panel's terms of reference were clear and within the Panel, including its Secretariat and possible consultants, there ought to have been someone sufficiently knowledgeable on the subject of the inquiry to have drafted something similar to the 1996 Issues Paper in the Panel's first week. Furthermore, the proponent's original (1988) proposal should have been referred immediately to the SRG and the public for initial review: it should have been obvious that the SRG and many intervenors would never accept any proposal without requiring further information. This in fact happened in the Panel's call for additional information, resulting in AECL's response. Consequently, the Guidelines stage could also have been eliminated. There was much repetition in submissions to the three separate phases of the Public Hearings, so that these hearings could have been greatly abbreviated.

The commission should have available to it someone capable of identifying most of the significant issues immediately on appointment of the commission.

The Panel's report reveals for the first time its definitions for the crucial terms "safety" and "acceptability" against which it was judging the EIS. It also revealed an emphasis on social factors and ethics that were not debated during the life of the Panel. Concurrently with the technical review of the proposal the Panel should have initiated hearings and discussions on those issues within its terms of reference that did not depend on the technical details of the proposal. Of these, priority should have been given to the one on which the technical assessment depended: "examination of the criteria by which the safety and acceptability of (the) concept ... should be evaluated". Others from the terms of reference would have included: "the general criteria for the management of nuclear fuel wastes as compared to those for wastes from other energy and industrial sources"; "the impact of recycling or other processess on the volume of wastes"; "the degree to which we should relieve future generations of the burden of looking after the wastes"; "the methodology required to characterize sites and the potential availability of sites in Canada"; "general criteria for site selection"; advice on "a future site selection process"; as well as any others from the

Panel's Issues Papers, notably the broad issue of ethics. These two parallel sets of activities, technical and non-technical reviews, would have occupied the first year.

Out of these activities, the Panel should have issued an Interim Report, consisting of the SRG's technical report, the Panel's tentative conclusions on the non-technical issues and identification of those areas in which it was seeking further information and discussion. This measure, similar to the Atomic Energy Control Board's (AECB) practice with Consultative Documents, would have exposed the Panel's abuse of the language, allowing it come out later with a defensible final report. It would also have provided a structured basis for hearings, avoiding endless repetitions, irrelevant presentations and a waste of everyone's time. The public hearings and drafting of the final report could have taken place in the second year.

The commission should issue an Interim Report as preparatory material for the public hearings.

Nature and Composition of the Inquiry

As the result of reviewing more than thirty inquiries I concluded that those presided over by a jurist usually resulted in "a clear judgement of the issue based on the evidence presented". Recent Canadian experience, notably with the Blood and Somalia Inquiries, has forced me to reexamine my support for this format. However, the interminable legalistic wranglings that bogged down these two are more attributable to the rules under which they operated, than to the qualifications of the presidents. I further concluded that a useful technique was "at the start (to) translate(d) their general terms of reference into precise questions that were later answered in the conclusions of the final report"; and "the most useful reports, and those of longest lasting value, are those that analyse the arguments, render judgements and provide reasons for the judgements".

The commission's hearings should avoid being over-legalistic.

The Panel satisfied this requirement and framed the two fundamental questions that it had to answer, albeit a quarter of the way through the report.

The desirable qualities in commissioners are:

- An ability to reduce a complex problem to clear questions susceptible to unambiguous answers.
- An ability to ask the right questions to clarify statements, claims and arguments.
- An ability to assess the credibility of those making submissions.
- An ability, and willingness, to control hearings according to agreed procedures.

These are often found in jurists but are not confined to them.

Commissioners should have the qualities to be expected in good jurists.

The Panel framed two fundamental questions clearly, but proceeded to obfuscate them in the report, as already noted. In the few hearings that I attended there was no incisive questioning of those making submissions, and submissions were not restricted to topics within the Panel's mandate. More important, there was no provision of means to establish the truth and validity of what was asserted in the submissions; or of resolving differences between submissions.

Each of these inquiries, non-nuclear as well as nuclear, has had to deal with subjects requiring specialist knowledge. Since members of the commission are selected for their impartiality they presumably do not have the necessary specialist knowledge and experience, raising the question of how these should be made available to them. The Panel was provided with a SRG, consisting of 14 individual experts in various areas of science and engineering relevant to the proposal. Rumour had it that much of the delay in appointing the SRG was due to officals encountering difficulty in enlisting well qualified individuals willing to serve for an open-ended period on the SRG. Had there been an undertaking that the review would not take longer than two years, this stage could have been expedited.

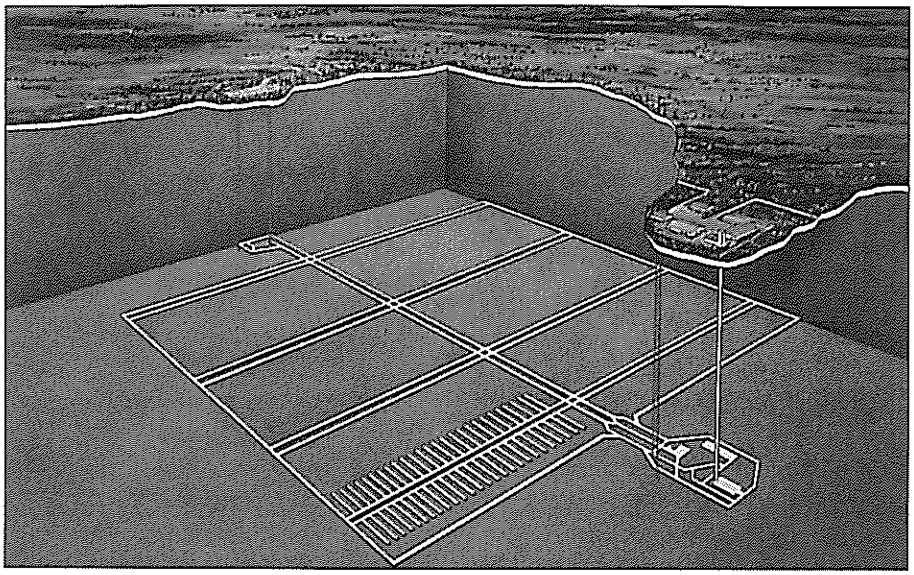
The SRG's Terms of Reference required it to:

1. "critically review and comment on the acceptability and applicability of AECL's high-level nuclear fuel waste disposal concept from a scientific and engineering point of view;
2. review and comment on the choice of predictive techniques, the underlying assumptions and the validity of the results of the predictive techniques used to assess the long-term performance and safety of the disposal concept;
3. provide advice on other issues when requested by the Panel."

The SRG worked largely independently of the Panel, providing its conclusions in the form of written reports.

The most obvious disadvantage of this arrangement was that the Panel did not have the benefit of the SRG's expertise to help it assess the merits of claims made in submissions to non-technical sessions or to help it question those presenting them. Alternative arrangements, avoiding this disadvantage, have been employed elsewhere. In the U.K.'s Windscale and Sizewell Inquiries (see report AECL-10768) an "Inspector" (commissioner) was assisted throughout by two and four "Assessors" (technical experts), respectively. Ontario's five-person Royal Commission on Electric Power Planning was assisted by a Legal Counsel and a Scientific Counsellor, who had the first opportunity after commissioners to question those making presentations: also those making submissions were able to cross-examine each other. The Ontario Nuclear Safety Review employed an Advisory Panel and 37 consultants, five of whom, designated as "senior consultants", worked closely with the Commissioner.

The commission should have available to it appropriate technical expertise to help it assess the technical aspects of all submissions.



An artist's view of a future deep geological disposal vault.

Conduct of the Hearings

Largely due to the absence of technical expertise to assist the Panel at its hearings, but also because of the lack of any provision for cross-examining those making submissions, the Panel failed to identify and resolve debatable statements. The process provided a SRG to advise the Panel on technical aspects of the proponent's EIS, but did not provide the means to resolve differences between the SRG, the proponent and intervenors. Panel members could not be expected to know where submissions were misleading or untrue; or even to know what questions to ask. The Panel was put in the position of a lay jury with none of the assistance of a legal trial; and the proponent (and innocent bystanders) was put in the position of a defendant without any legal protection. To the best of my knowledge I was the only person reviewing and commenting in public on all available submissions: and this was on my own initiative, not on the Panel's. In the paper "A Frequent Flyers Program for Nuclear Mythology" (Canadian Nuclear Society Bulletin, 1997, Spring/Summer) I have listed some of the worst errors and misconceptions about nuclear energy, many gleaned from submissions to the Panel.

The most serious example of unresolved differences was the lack of any agreed definition for "safe and acceptable" in the key sentence of the Panel's Terms of Reference. Another example concerned ethics. Several individuals and groups, including myself, made submissions on this subject. However, as far as I am aware, I was the only one to attempt any dialogue by commenting on the other submissions but without any success. Preaching one's own opinion without regard to what anyone else may say indicates a lack of sincerity in seeking understanding and exhibits contempt for the Panel process.

In any inquiry there is a need to establish the relevant facts, as far as this is possible. After this, it is desirable to try to resolve differences of judgement and opinion; or at least make clear to the commission the essential nature of the disagreement, so that it may make its own judgement. Among the means available are technical counsellors or consultants, cross-examination of and by the proponent and intervenors subject to clear procedures, and round-table discussions on specific topics to which the commission would invite those whom it considered could make useful contributions.

The commission should provide the means for establishing facts and resolving differences.

The Panel's terms of reference clearly defined topics that were "outside the Panel's mandate and should not be addressed during the review". Nevertheless, these topics were repeatedly addressed in many submissions without the Panel apparently taking any action. Indeed, these submissions addressing excluded material were published, in the legal sense, under the Panel's imprimatur, and the report includes a section "Matters Outside the Mandate" that included some comments by the Panel. As a result, opponents of the proposal, and of nuclear energy in general, were able to get public and media exposure without fear of being challenged to substantiate their accusations, while the proponent was constrained by obeying the rules of procedure. A particularly repulsive and despicable example of the Panel failing to provide natural justice in its hearings was the street theatre, slandering past and present AECL employees and permitted by the Panel, in Public Hearings in Ottawa in 1990.

Such abuses could be avoided by proper enforcement of the rules of procedure for the hearings, restricting submissions to topics lying within the commission's mandate. To implement this, written submissions might have to be submitted in advance, so that they could be screened for excluded material. Intervenors could be required to cite references to the proponent's EIS or to the commission's terms of reference for anything in their submissions. Verbal presentations should be interrupted if they strayed into excluded material. Excluded material should not be part of the commision's record. As a compromise, two types of hearings could be envisaged, one for properly argued comments, the other for statements of opinions.

The commission should restrict submissions to conform to the commission's mandate.

Two months from the end of the hearings the Panel announced that any Closing Statements would be limited to three pages and would have to be received by the Panel within 22 days of the end of the hearings. While the time restriction is reasonable, given the general lack of anything new in submissions to the hearings, the limit on length of the statement constitutes a denial of natural justice to the proponent. The proponent has been in the position of defending its proposal against a large amount of erroneous and misleading allegations. It is simply impossible to provide an adequate rebuttal of all these in three pages. The accused and defendant in court cases are not penalized in this manner.

The commission should provide the proponent an adequate opportunity to present its final argument after the end of the hearings.

Information on Panel Activities

One reason that the proponent would have needed much more than three pages to present its final argument was that throughout its life the Panel failed to keep participants adequately informed of its thinking and activities. As a result the participants were unable to judge which topics the Panel considered significant, so that they might prepare appropriate submissions. The failure to inform participants was largely responsible for the unnecessarily large volume of submissions, and the constant repetition within them. The preparation of an Interim Report, already suggested, would go some way to improve the situation but the provision of information should be more frequent.

A specific example of the problem caused by the Panel's failure to clarify issues at an early stage was the lack of agreed acceptance criteria before reviewing the concept: the criteria to be used by the Panel, which were the Panel's responsibility according to its terms of reference, were unknown until the report was issued. The proponent, AECL, and the regulator indicated what they believe should be acceptance criteria, but there appeared to be confusion in participants' minds between criteria for licensing a disposal facility and for concept acceptance. Much of the apparent disagreement on concept acceptability between well qualified scientists could be attributed to this vacuum in the Panel's policy. The Panel failed to make clear to all participants that its mandate was to determine whether the proposed concept is acceptable, not the best possible, and failed to state how it would define "acceptable". The Panel also failed to warn of any intention to include acceptance in its definition of safety.

The commission should keep participants informed on its thinking on the various topics being examined.

Beyond this, the Panel's terms of reference directed it to examine various issues, such as: "The Panel will also examine the general criteria for the management of nuclear fuel wastes as compared to those for wastes from other energy and industrial sources." For most of these issues, the Panel passed the responsibility to the proponent to come up with the analysis and recommendations. As a consequence these issues remained unresolved up to the end of the hearings. In general, participants were left wondering what the Panel was doing on the issues for which it was responsible. The report includes comments on these topics without the public having had any opportunity to review the Panel's proposals, in the way they were able to review the proponent's proposal.

The commission should keep participants informed on its planned activities, and allow for public participation in proposals that it initiates.

Intervenor Funding

Not only did the present process arrange intervenor funding of nearly one millon dollars, the report recommends more intervenor funding if the whole process is repeated to ascertain which concept is acceptable. My politically incorrect position is that intervenor funding often constitutes a wasteful drain on the public purse. The taxpayer was already funding AECL to develop the concept and the regulator, the AECB, to licence and oversee any proposed application which would require public hearings. AECL employed with public funds a Technical Advisory Committee composed of about a dozen independent technical experts to advise it on any weaknesses in its program. Both federal government agencies, staffed by responsible individuals with reputations to defend, are accountable to Parliament and are periodically reviewed by the Auditor General of Canada in value-for-money audits. In addition, the taxpayer is funding the Panel and its SRG to review the concept. My contention is that most taxpayers, if aware of these facts, would object to further public funds being dispensed to special interest groups wishing to promote their interests at the hearings. Having reviewed most submissions, I challenge anyone to show what has been gained from paid interventions that would justify the expenditures of nearly one million dollars.

The government should not devote taxpayers' money to intervenor funding if this duplicates a service that it has already provided by other means.

Salvaging the Situation

The Panel adopted the legalistic attitude of judging only the concept that appeared in AECL's EIS (including its Response to Request for Information). Nothing in its terms of reference prevented it from being more constructive in proposing a modified concept that it could have endorsed with or without qualifications, e.g., requirements for monitoring not in the EIS. This course would have avoided the process being set back to square one with the loss of a massive investment of taxpayers money.

The Panel's report has put the government in a difficult position in deciding its policy on the disposal of nuclear fuel wastes. It might be tempted to accept uncritically and implement the report as an easy way out, but it would be vulnerable to attack by the opposition and an outraged electorate for wasting hundreds of millions of dollars, and for failing to resolve a serious issue. Given the serious flaws in both the process and the report, the government cannot simply take the conclusions and recommendations at face value. Moreover, the government and other readers are unable to reach their own conclusions point by point since the report does not expose the Panel's reasoning in arriving at many of its statements. For this reason alone the government would be unable to defend its decision if it simply endorsed the Panel's findings.

Fortunately, something can be salvaged from the report, providing a way out of the dilemma. With respect to whether the concept is safe, in the normal meaning of the word as used in the Panel's terms of reference, the report finds the concept safe, with certain qualifications. The report's comments on safety "from a social perspective" relate to the acceptability of the concept, and not to safety given its normal meaning. Thus the report finds the concept adequately safe, but with some qualifications to be addressed in subsequent stages. These would be considered, along with all other aspects of the proposal, by the AECB before construction could begin.

With respect to acceptance, the report's conclusion that the concept is not acceptable is based on three factors:

1. claiming, without any justification, that "acceptable" means "broad public support",
2. claiming, again without any justification, that there would not be "broad public support" for the concept, and
3. demanding a wide range of additional "social and ethical" input to the process for determining "broad public support".

The first represents a distortion of the normal meaning of words, so that the Panel did not do what was required of it in its terms of reference. The second is invalid, even with the Panel's misuse of "acceptance", since it undertook no measures to ascertain public opinion, a public opinion that would surely be changed on learning that the concept had been found to be safe. In recommending at 6.2.5 that the Implementing Organization (IO) should find ways to measure broad public support the Panel tacitly admitted that it had not found a way. The third represents a minority view by two or three individuals. Ironically, while criticizing the EIS on this score, these individuals did not expose their own arguments to the same participation, peer review and open discussion to which the EIS was exposed. Thus an honest response from the Panel to the government would be: "We have not determined whether or not the concept would be acceptable".

To test whether there is public acceptance, the government could authorize an IO to seek an acceptable site, using the voluntarism approach (as modified by comments in this report). Recognizing the existence of the concerns identified by the Panel within some unknown fraction of the public, the the government would direct the IO to:

- modify the concept to accommodate criticisms raised in the technical review of its safety,and
- offer as an option in seeking an acceptable host community the centralized underground storage for which "no feasibility problems were identified" (Appendix L. Storage)..

The latter would provide the government and the public with another check-point at which to decide whether to convert from storage to disposal, thus satisfying the Panel's fundamental recommendation of postponing this decision until public acceptance is demonstrated. This course would be preferable to starting the whole process over again as proposed by the Panel. Also, it would be fail-safe in that if no community volunteers an alternative approach would have to be tried , as recommended by the Panel.

19th Annual Conference of the Canadian Nuclear Society Program

Holiday Inn on King, Toronto, Ontario, Canada
1998 October 18-21

Financial support by AECL and Babcock & Wilcox Canada is gratefully acknowledged

Sunday Oct.18 **19:00** **Welcoming Reception**

Monday Oct. 19 **09:00 - 12:00**
Plenary Session (King I) Chair: R. Nixon (AECL)

09:00-09:25 Nuclear Power in the 21st Century: A Reality Check,
G. Kugler (AECL)

09:25-09:50 The Objectives and Activities of the Canadian Radiation Protection Association,
M.J. Haynes (Ontario Hydro)

09:50-10:15 The Future of CANDU: Vision and Realities,
R.B. Duffey (AECL)

10:15-10:45 Break

10:45-11:10 Improving Performance in a Competitive Environment,
R.M. White, J.J. McCarthy, W.S. Pilkington and P.D. Thompson (New Brunswick Power)

11:10-11:35 MAPLE Isotope Reactors: Status Report,
A.G. Lee, D. Taylor, J. Bond and J-P. Labrie (AECL)

11:35-12:00 The Nuclear Option and Climate Change - A Necessary Part of Canada's Kyoto Implementation Strategy,
M.J. Stewart (CNA)

Monday Oct. 19 **12:00** (King II) **Conference Luncheon**
Guest speaker: Dr. A.B. McDonald, Director, SNO, "The Sudbury Neutrino Observatory"

Monday Oct. 19 **14:00 - 17:00**
Session 1A (Regency A) **Waste Management I**
Chairs: F. King (Ontario Hydro) & M.M. Ohta (AECL)

If the federal government response to the Seaborn Panel Report is announced prior to October 19th, the session will be expanded to provide highlights of the announcement.

14:00-14:25 Insights from the Panel Review Process,
B. Seaborn (Former Chair of the Environmental Assessment Panel on Nuclear Waste Management)

14:25-14:50 Lifecycle Management of Used Nuclear Fuel in Ontario Hydro,
K.E. Nash (Ontario Hydro)

14:50-15:15 Siting a Used Fuel Disposal Facility in Sweden,
C. Thegerstrom (SKB)

15:15-15:45 Break

15:45-16:10 Status of High Level Waste Disposal Programme in Japan,
T. Tsuboya, S. Masuda, H. Umeki, H. Hasegawa, M. Yamakawa, H. Ishikawa (Japan Nuclear Cycle Development Institute)

16:10-16:35 Status of Siting a High Level Waste Repository in France,
D. Auverlot (Agence Nationale pour la Gestion des Déchets Radioactifs, ANDRA)

16:35-17:00 Panel Discussion,
D. Auverlot, K. Nash, B. Seaborn, C. Thegerstrom, T. Tsuboya

Monday Oct. 19 **14:00 - 17:00**
Session 1B (Regency C) **Thermalhydraulics I**
Chair: W. Garland (McMaster University)

14:00-14:25 On the Importance of Valve Modelling, Reflected Pressures, and Wall Friction, in CATHENA Water Hammer Simulations,
T.G. Beuthe (AECL)

14:25-14:50 CATHENA Validation in Support of Large Break LOCA Analysis,
T.G. Beuthe and J.P. Mallory (AECL)

14:50-15:15 A Parallel Virtual Machine Interface for CATHENA,
D. Dormuth (AECL)

15:15-15:45 Coffee Break

15:45-16:10 The Unbalanced Distribution of Deuterium in the Two Heat Transport Loops and the Flow through the Pressurizer Inter-Connect Pipe at Point Lepreau Generating Station,
L. Yang (Centre for Nuclear Energy Research), M. Hare and D. Loughead (New Brunswick Power)

Monday Oct. 19 14:00 - 17:00
Session 1C (Regency B) **Advanced Concepts**
Chair: J.M. Hopwood (AECL)

14:00-14:25 Innovative Fuel Elements with Enhanced Decay Heat Removal Capability for Passive, Pressure-Tube LWRs, P. Hejzlar (Czech Technical University of Mechanical Engineering), B.T. Mattingly, N.E. Todreas, and M.J. Driscoll (Massachusetts Institute of Technology)

14:25-14:50 Utilizing the IRF for CANDU Fuel Bundle Irradiations, J.J. Whitlock and R.F. Lidstone (AECL)

14:50-15:15 Concepts of Passive, Light Water Pressure-Tube Reactors, P. Hejzlar (Czech Technical University of Mechanical Engineering), N.E. Todreas, and M.J. Driscoll (Massachusetts Institute of Technology)

15:15-15:45 Coffee Break

15:45-16:10 On the Ignition of the ITER Machine, E. Panarella (Advanced Laser and Fusion Technology, Inc.)

16:10-16:35 CANDU Combined Cycles Featuring Gas-Turbine Engines, J. Vecchiarelli and E. Choy, (AECL), Y. Peryoga and N.A. Aryono (BPPT, Indonesia)

16:35-17:00 A Technical and Economic Evaluation of Reverse Osmosis Nuclear Desalination as Applied at the Muria Site in Indonesia, J.R. Humphries and K. Davies (CANDESAL), T.D. Vu (AECL), N.A. Aryono and Y. Peryoga (BPPT, Indonesia)

17:00-17:25 Advanced Control And Operator Interface Systems For CANDU 9 Fuel Handling System, D. Arapakota, A. Xing, and N. Ichiyen (AECL)

Tuesday Oct. 20 09:00 - 12:00
Session 2A (Regency B) **Waste Management II**
Chair: M.M. Ohta (AECL)

09:00-09:20 Simulating Thermal Behaviour of AECL's Spent Fuel Dry Storage System with CATHENA, G. Sabourin (AECL)

09:20-09:40 Current Status of the Waste Identification Program at AECL's Chalk River Laboratories, G.W. Csullog, N.W. Edwards, and M.A. terHuurne (AECL)

09:40-10:00 Assessing Inventories of Past Radioactive Waste Arisings at Chalk River Laboratories, G.W. Csullog, M.A. terHuurne, M.T. Miller, N.W. Edwards, V.R. Hulley, and D.J. McCann (AECL)

10:00-10:20 Seismic Qualification of Spent Fuel Storage Stacks, L.S.S. Lee, D.K. Panesar and R. Joseph (AECL)

10:20-10:45 Coffee Break

10:45-11:05 The Tunnel Sealing Experiment: *An In Situ Demonstration Of Technologies For Vault Sealing,* N. Chandler, D. Dixon, K. Hara, A. Cournut, and J. Tillerson (AECL)

11:05-11:25 A Method for Solidification of Spent Solvent TBP/OK in Polystyrene, A. Popa and I. Lenghyel (RENEL Nuclear Power Group)

11:25-11:45 Waste Management Strategy for Cernavoda NPP, V. Andrei, F. Glodeanu and V. Simionov (RENEL Nuclear Power Group)

11:45-12:05 Treatment Technology for Radioactive Liquid Waste from Decontamination Process, M. Balasoiu (RENEL Nuclear Power Group)

Tuesday Oct. 20 09:00 - 12:00
Session 2B (Regency A) **Environmental Management I**
Chair: J. Tamm (AECL)

09:00-09:25 Application of the Canadian Environmental Assessment Act to Nuclear Research Projects: Lessons Learned at AECL, D. Grondin (AECL)

09:25-09:50 The Path to "Jiibegmegoong": Lessons Learned in Working with Aboriginal People on Archaeological Assessment of the Bruce Nuclear Power Development Site, K. Johansen, J.H. Peters (Ontario Hydro), W.R. Fitzgerald (Wilfrid Laurier University)

09:50-10:15 Practising Environmental Assessment Overseas: Experience and Lessons Learned, L.F. Cattrysse (ICF Kaiser Company (Canada) Ltd.)

10:15-10:45 Coffee Break

10:45-11:10 Canada's Nuclear Industry, Greenhouse Gas Emissions, and the Kyoto Protocol, D.R. Pendergast, R.B. Duffey and D. Tregunno (AECL)

11:10-11:35 CANDU Reactors and Greenhouse Gas Emissions, S. Andseta, M.J. Thompson (Sheridan College), J.P. Jarrell (Cameco Corporation), and D.R. Pendergast (AECL)

11:35-12:00 Development of a Regulatory Environmental Protection Program at the Atomic Energy Control Board, R. Maloney and L. Chamney (AECB)

Tuesday Oct. 20 **09:00 - 12:00**
Session 2C (Regency D) **Physics I**
Chair: H.W. Bonin (Royal Military College)

09:00-09:25 Homogenization of Linearly Anisotropic Scattering Cross Sections in a Consistent B1 Heterogeneous Leakage Model, G. Marleau and E. Debos (École Polytechnique)

09:25-09:50 Reactor Physics Calculations for Conversion of McMaster Nuclear Reactor from Use of HEU to LEU Fuel,
H.S. Al-Basha (McMaster University)

09:50-10:15 New Geometric Capabilities of DRAGON,
G. Marleau (École Polytechnique)

10:15-10:45 Coffee Break

10:45-11:10 Simulation of Vanadium Detectors in DRAGON,
G. Marleau, M.T. Sissaoui and K. Rousseau (École Polytechnique)

11:10-11:35 Pseudo-Isotopes Generation for the U-235 and U-238 Depletion Chains,
M. Boubcher, G. Marleau and D. Rozon (École Polytechnique)

11:35-12:00 A New Characteristics Algorithm for 3D Transport Calculations,
G.J. Wu and R. Roy (École Polytechnique)

Tuesday Oct. 20 **09:00 - 12:00**
Session 2D (Regency C) **Thermalhydraulics II**
Chair: H.M. Huynh (Hydro-Québec)

09:00-09:25 Studies of Thermalhydraulics in the IRF Chimney using Computational Fluid Dynamics,
T.H. Lan and A.O. Banas (AECL)

09:25-09:50 Prediction of Pressure Pulsation from Pump Operation Under Two-Phase Flow Conditions,
S.I. Osamusali and A.M.C. Chan (Ontario Hydro)

09:50-10:15 Lateral Mixing Between Interconnected Subchannels,
A. Bellil, P. Hernu and A. Teyssedou (École Polytechnique)

10:15-10:45 Coffee Break

10:45-11:10 Analysis of In-Situ TRIH Biases,
J.C. Handbury (ANSL), T. Whynot and C. Bailey (NB Power)

11:10-11:35 Cernavoda NPP's Performance and Its Availability to Supply Steam for District Heating,
M. Metes, M. Casota and Gh. Diaconu (RENEL Nuclear Power Group)

Tuesday Oct. 20 **12:00** **Lunch** (free time)

Tuesday Oct. 20 **14:00 - 17:00**
Session 3A (Regency D) **Detector Systems**
Chair: K.J. Serdula (Serdula Systems)

14:00-14:25 Development of a Portable Micro-Environmental Cell for the Testing of Neutron Bubble Detectors in a Simulated Jet-Aircraft Environment,
P. Tume, L.G.I. Bennett, B.J. Lewis, H.K. Wieland, M.K. Reid (Royal Military College),
T. Cousins (Defence Research Establishment)

14:25-14:50 Reactor Noise Analysis Applications in Ontario Hydro: A Statistical Measurement Technique for Validating Instrumentation Dynamics,
O. Glockler, D.F. Cooke, G. Czuppon and K.K. Kapoor (Ontario Hydro)

14:50-15:15 ROP Optimization Modules in ROVER-F, J. Pitre (AECL)

15:15-15:45 Coffee Break

15:45-16:10 MDRAP - A MATLAB-Based Detector Response Analysis Package,
G. Gomes (AECL)

16:10-16:35 Dynamic Response and Relative Sensitivity of Vanadium In-Core Flux Detectors and Lead Cables in Pt. Lepreau,
B. Sur and G. Gomes (AECL), J. Handbury (ANSL), C.W. Newman and E.G. Young (NB Power)

16:35-17:00 Numerical Accuracy of NOP SDS2 Detector Dynamic Compensation in Darlington Trip Computers,
A.P. Firla (Ontario Hydro)

Tuesday Oct. 20 **14:00 - 17:00**
Session 3B (Regency A) **Environmental Management II**
Chair: J. Torok (AECL)

14:00-14:25 Prevention and Control of Zebra Mussels: Proactive and Reactive Strategies,
R. Claudi (Ontario Hydro)

14:25-14:50 Receiving Environmental Effects Monitoring: Why, What, How and So What?,
D.A. Wismer (Ontario Hydro)

14:50-15:15 Carbon-14 Management: The Implementation of Stack Emissions Monitoring at Ontario Hydro Nuclear ,
J. Holtorp (Ontario Hydro)

15:15-15:45 Coffee Break

15:45-16:10 Carbon-14 at CANDU Stations,
R.J. Cornett, P.J. Allsop, F. Caron, D. Evans, R.R. Rao, J. Torok, S. Vijayan (AECL / Ontario Hydro)

16:10-16:35 The Environmental Assessment of Releases of Radionuclides from Nuclear Facilities (Impacts on Non-Human Species) Under the Second Priority Substance List of the Canadian Environmental Protection Act,
P. Thompson (Environment Canada)

Tuesday Oct. 20 14:00 - 17:00
Session 3C (Regency C) **Physics II**
Chair: J. Koclas (École Polytechnique)

14:00-14:25 Parametric Analysis of Doppler Coefficient of Reactivity in DUPIC Fuel by DRAGON,
W. Shen, D. Rozon, and G. Marleau (École Polytechnique)

14:25-14:50 Simulations of Power Transients in a Loss of Liquid Zone-Control-System Pumps in CANDU 6 Reactors,
H.C. Chow (AECL), G. Delorme and A. Baudouin (Hydro-Québec), J.D. Stebbing (JDS Technologies)

14:50-15:15 Generation of Consistent Nuclear Properties of DUPIC Fuel by DRAGON with ENDF/B-VI Nuclear Data Library,
W. Shen and D. Rozon (École Polytechnique)

15:15-15:45 Coffee Break

15:45-16:10 Optimal Fuel Management of CANDU Reactors at Approach to Refuelling Equilibrium,
C.P. Tingle and H.W. Bonin (RMC)

16:10-16:35 Comparison of Slightly Enriched Uranium Fuel and MOX Fuel in CANDU-6 Reactor,
D. Rozon and Wei Shen (École Polytechnique)

16:35-17:00 Derivation of a Correlation Between Fuel Temperature and Power for CANFLEX Fuel Bundles,
A.C. Mao and Z. Bilanovic (AECL)

Tuesday Oct. 20 14:00 - 17:00
Session 3D (Regency B) **Control Room Operation**
Chair: E. Davey (Crew Systems Solutions)

14:00-14:20 An Approach for Improving Alarm Prioritization Analysis,
R. Basso and E. Davey (AECL)

14:20-14:40 AECL's Plant Information Technologies,
M. DeVerno, L. Lupton, R. Didsbury and R. Judd (AECL)

14:40-15:10 Conduct of Operations: Establishing Operations Focus and Setting Operational Standards,
L. Lane, K. McGuigan (Ontario Hydro - Darlington)

15:10-15:20 Computer-Based Logging - Simplifying Station Log Preparation, Access and Use,
E. Davey, M. Thompson, R. Basso (AECL), K. Herzog, L. Lane and R. Chatterton (Ontario Hydro - Darlington)

15:20-15:45 Coffee Break

15:45-16:10 Operator Stress, B. Patterson (Human Factors Practical), M. Bradley (UNBSJ), W. Artiss (Human Factors Practical)

16:10-16:35 Control Room Annunciation - Problem Assessment and Selection of Improvement Priorities, P. Hartley, D. Yaraskavitch (Ontario Hydro Pickering), E. Davey (AECL)

16:35-17:00 Operational Assessment of Critical Safety Parameter Monitoring - Findings and Lessons Learned,
C. McIntyre, S. Howard, E. Davey, M. Feher (Ontario Hydro Pickering / AECL)

Tuesday Oct. 20 18:30 Conference Banquet
(Regency ABC)

Wednesday Oct. 21
Session 4A (Regency A) **Radiation I - A Tribute to Richard Osborne's Contribution to Radiation Protection in Canada**
Chair: R. Lambert (AECL)

09:00-09:25 From Scientific Evidence to Radiation Protection: A Perspective of Four Decades,
R.V. Osborne (AECL, retired)

09:25:09:50 How Relevant to Radiation Protection is the Adaptive Response Mechanism?,
A. Trivedi and R.E.J. Mitchel (AECL)

09:50-10:15 Effective Doses from Diagnostic X-Ray Procedures,
H.M. Johnson and J. Sandeman (Manitoba Cancer Treatment and Research Foundation)

10:15-10:45 Coffee Break

10:45-11:10 Non-linearity Between Dose and Cancer Risk for Internally Deposited Alpha Emitters in Animals
P. Duport (International Centre for Low-Dose Radiation Research)

11:10-11:35 LNT Theory: A Credible Middle Ground?,
N. Gentner (AECL) and R. Osborne

11:35-12:00 Practical Issues in the Risk Management of Low Dose Radiation,
D.B. Chambers, M.W. Davis, L.M. Lowe, and N.C. Garisto (SENES Consultants Limited)

Wednesday Oct.21 09:00 - 12:00
Session 4B (Regency B) **Ageing Issues & Containment**
Chair: R. Pageau (Hydro-Québec)

09:00-09:25 An On-Line Electrical Resistance Corrosion Monitor for Studying Carbon Steel Corrosion Under Feeder Pipe Conditions,
D. Sun, L. Yang and F. Steward (CNER, University of New Brunswick)

09:25-09:50 SOPHT Modelling of Gentilly-2 Heat Transport Ageing Mechanisms,
S. Chapados, G. Hotte, and K. Joober (Hydro-Québec)

09:25-09:50 Primary Coolant pH for Control of CANDU Plant Ageing,
K.A. Burrill, E.L. Cheluget, D.G. Miller and C.W. Turner (AECL)

09:50-10:15 Identification and Mitigation of Heat Transport Ageing Mechanisms at the Gentilly-2 Generating Station,
G. Hotte, M.A. Petrilli and A. Baudouin (Hydro-Québec)

10:15-10:45 Coffee Break

10:45-11:10 GOTHIC Modelling of Large Scale Gas Mixing Phenomena,
N. Dinadis, K. Yim, R. Wong, and R. Fluke (Ontario Hydro)

11:10-11:35 Optimization Study for Hydrogen Control During Severe Accidents in KSNPP,
S.M. Lee, K.K. Jee, S.H. Yoon and B.C. Lee (KOPEC)

11:35-12:00 Technical Review of Hydrogen Control in KSNPP Under Severe Accident Conditions,
S.H. Yoon (KOPEC)

Wednesday Oct.21 09:00 - 12:00
Session 4C (Regency C) **Physics III**
Chair: E. Young (New Brunswick Power)

09:00-09:25 Three Level Space-Time Kinetics Based on Super Nodal Analysis,
S. Kaveh, J. Koclas and R. Roy (École Polytechnique)

09:25-09:50 Simulation of the In-Core Distribution of Decay Energy from Fuel, Following Shutdown of the CANDU-6 Reactor,
G.T. Pepper and J.W. Thompson (ANSL), R.A. Gibb (NB Power)

09:50-10:15 Methodology Used to Calculate Moderator-System Heat Load at Full Power and During Reactor Transients in CANDU Reactors,
K. Aydogdu (AECL)

10:15-10:45 Coffee Break

10:45-11:10 WIMS-AECL/RFSP Code Validation of Reactivity Calculations Following a Long Shutdown Using the Simple-Cell History-Based Method,
F. Ardeshiri, J.V. Donnelly and B. Arsenault (AECL)

11:10-11:35 Revised Delayed Photoneutron Data for Use in CANDU-Reactor Analysis,
P.J. Laughton (AECL)

11:35-12:00 Xenon Transients Simulation Using the Reactor Code DONJON,
M.T. Sissaoui, G. Marleau and J. Koclas (École Polytechnique)

Wednesday Oct.21 09:00 - 12:00
Session 4D (Regency D) **Fuel**
Chair: B.J. Lewis (Royal Military College)

09:00-09:25 A Standard Approach to Special Fuel Irradiations at Point Lepreau Generating Station,
P.J. Reid (ALARA Research, Inc.), R.G. Steed, R.A. Gibb and R.W. Sancton (NB Power)

09:25-09:50 Validations, Verifications and Applications of the FEAT Code,
Z. Xu, C. Manu, M. Tayal, and J.H. Lau (AECL)

09:50-10:15 Assessment of Fuel Fitness for Service Following Standing Start Process During Gentilly-2 Annual Outage,
Q.M. Lei and P. Gulshani (AECL), H. Huynh (Hydro-Québec)

10:15-10:45 Coffee Break

10:45-11:10 Investigation of Fuel-Bundle Vibration in the Chalk River Single-Channel Test Rig,
V.P. Janzen, T.G. Whan, J.L. Gerardi, I.E. Oldaker, B.A.W. Smith, C.E. Taylor, and J.H. Tromp (AECL)

Wednesday Oct.21 12:00 - 14:00 CNS Awards Luncheon
(King II)

Wednesday Oct.21 14:00 - 17:00
Session 5A (Regency A) **Radiation II**
Chair: N.E. Gentner (AECL)

14:00-14:25 Antioxidants and Biological Radiation Protection, K.J. Lenton and C.L. Greenstock (AECL)

14:25-14:50 Cosmic Radiation Exposure on Canadian-Based Commercial Airline Routes, B.J. Lewis, P. Tume, L.G.I. Bennett, and M. Pierre (Royal Military College), T. Cousins, B.E. Hoffarth, J.R. Brisson, and T.A. Jones (Defence Research Establishment)

14:50-15:15 Neutron Activation Analysis of Ancient Amerindian Ceramics and Clays, M. Ousmoi and G. Kennedy (École Polytechnique), C. Chapdelaine (Université de Montréal)

15:15-15:45 Coffee Break

15:45-16:10 Public Radiation Exposures from a CANDESAL Co-Generation Facility, R. Khaloo (AECL) and A. Simanjuntak (BATAN)

16:10-16:35 Quantification des Flux Litho-Atmosphériques de l'Isotope 222 du Radon dans un Contexte de Prospection Géophysique, M. Daigneault and L. Zikovsky (École Polytechnique)

Wednesday Oct.21 14:00 - 17:00
Session 5B (Regency C) **Pressure Tubes**
Chair: D.E. Teed (GEC)

14:00-14:25 A New CANDU Channel Closure with a Conical Seal, W.T. Diamond (AECL)

14:25-14:50 Limit Analysis of Pressure Components Based on Repeated Elastic Analyses, S.P. Mangalaramanan and N. Idvorian (Babcock & Wilcox Canada)

14:50-15:15 Experimental Investigations into Consequences of Pressure Tube Rupture, P.S. Kundurpi (Ontario Hydro)

15:15-15:45 Coffee Break

15:45-16:10 High Pressure Melt Ejection Relevant to CANDU Reactors, N.N. Wahba and M.H. Bayoumi (Ontario Hydro)

16:10-16:35 Use of Electrical Impedance Spectroscopy to Describe Oxide Films Formed on Zirconium Alloys, M.A. Maguire (AECL)

Wednesday Oct. 21 14:00 - 17:00
Session 5C (Regency B) **Safety**
Chair: D. Wilson (New Brunswick Power)

14:00-14:25 Moderator Circulation Analysis for the Modified CANDU 6 Design using the CFD Code MODTURC_CLAS, P.Y.C. Lee and W.M. Collins (AECL)

14:25-14:50 Preliminary Results of the BTF-105B Experiment: An In-Reactor Test of Fuel Behaviour and Fission-Product Release Under LOCA/LOECC Conditions, J.D. Irish, S.T. Craig, L.R. Bourque, M.G. Jonckheere, G. Kyle, P.J. Valliant, L.W. Dickson and R.T. Peplinskie (AECL)

14:50-15:15 Operational Support of a Safe Operating Envelope for Fuel, T.J. Chapman (ALARA Research Inc.) and R.A. Gibb (NB Power)

15:15-15:45 Coffee Break

15:45-16:10 Safety Analysis to Support a Safe Operating Envelope for Fuel, R.A. Gibb (NB Power) and P.J. Reid (ALARA Research Inc.)

16:10-16:35 Incorporation of Seismically Non-Qualified Systems in the Seismic PSA, B.S. Lee and J.I. Mok (KOPEC)

Proceedings of the 19th Annual Conference of the Canadian Nuclear Society, which will contain full papers, will be available, shortly after the Conference, from the CNS office.

Contact: Sylvie Caron
CNS
144 Front St. W., Suite 475
Toronto, Ontario
M5J 2L7
Tel: 416-977-6152 ext. 18
Fax: 416-979-8356
e-mail: carons@cna.ca

Abstracts, where available, have been posted on the CNS Web site:
www.cns-snc.ca

AECB President Comments on Bill 35

Dr. Agnes Bishop

Ed. Note: Bill 35, the proposed Ontario Energy Competition Act, 1998, is likely to be passed by the Ontario Legislature this fall. It will divide Ontario Hydro into three companies for generation, distribution and service and will lead to the deregulation of electricity markets in the province. In August, Dr. Agnes Bishop, President of the Atomic Energy Control Board, appeared before the Ontario Standing Committee on Natural Resources, which has been reviewing the proposed legislation, to express her concerns as head of Canada's nuclear regulatory agency. Following are extended excerpts from her presentation.

Deregulation and Restructuring

The AECB is interested in the deregulation of Ontario's electricity market and the restructuring of Ontario Hydro for three reasons:

- First, it is important to all Canadians that the proposed changes do not compromise the safe operation of nuclear stations.
- Second, we must be assured that adequate financial guarantees are available to cover the costs of decommissioning Ontario Hydro's nuclear facilities and managing radioactive wastes.
- And third, we must be satisfied that the organization named in an AECB licence is, in fact, competent and in control of the day-to-day operation of the licensed facility.
- Let me expand briefly on each of these points.

The safe operation of nuclear power plants

From a safety perspective, it is important that structural changes in Ontario's electricity sector take into account the specific needs of nuclear power stations. Our two main concerns with the Ontario government's initiative are:

- the control of the power grid, and,
- the financial pressures that are likely to result from the move to a competitive market.

Both factors are important to the safe operation of nuclear reactors, and the impact that restructuring might have on these matters must be properly assessed and understood.

The overall control of the power grid has safety implications for nuclear stations in two ways: First, the safety case for Ontario Hydro's nuclear power stations assumes a certain level of reliability with respect to the grid. From an operational point of view, we would therefore expect power manoeuvres on the grid to be governed by rules that will ensure that the probability of power interruptions to nuclear stations is no greater than at the present time.

Second, I would like to point out that Canada's nuclear plants were designed to supply base-load electricity. They are not well suited to constant changes in requested output. The AECB would, therefore, also expect that nuclear stations not be required to change their power output frequently just because cheaper power can be purchased from elsewhere as market conditions fluctuate. At a minimum, the safety implications of operating in such a manner would have to be properly assessed and found acceptable before changes in operating mode could be authorized.

Let me now explain our interest in the move to a competitive market. Care must be taken to ensure that, when making decisions related to safe operation, nuclear operators are not unduly influenced by the pressure to compete against other energy producers or to make short-term economic gains at the expense of longer term safety objectives. In a market-driven environment, plant maintenance, staff training, and the size and qualifications of the workforce are examples of areas where issues of cost may impact on nuclear safety. The AECB would expect that the move to a competitive market would not jeopardize the implementation of Ontario Hydro's nuclear recovery plan. An important element in judging the success of that plan will be the sustainability of the collective measures put in place.

Financial liability and guarantees

Our second area of concern relates to the financial implications of the proposed restructuring on long-term nuclear safety.

It is the federal government's policy that the producers and owners of radioactive wastes are responsible for the safe management of those wastes. This means that those utilities having nuclear power facilities are responsible for the costs of decommissioning their nuclear stations and management of their spent fuel. The federal policy will be implemented by requiring nuclear utilities to provide financial guarantees as a condition of receiving a licence from the Canadian Nuclear Safety Commission.

I want to make the AECB's position clear: adequate and appropriate financial guarantees must be assured under the new regime. Without an appropriate financial guarantee, the Commission is unlikely to issue an operating licence under our new Act.

Control of nuclear operations

The rationale for the third issue I mentioned — the need to ensure that the named licensee is in control of day-to-day operations of an AECB-licensed facility — is self-evident

If the owner and operator of a nuclear power station are not the same entity, the AECB must be assured that the operator — the licensed party — has adequate managerial control of the facility to ensure its safe operation. In other words, the operator must be making the day-to-day decisions about the facility and must be clearly accountable for all facets of its operation.

It is important for everyone involved in the restructuring to understand that AECB licences cannot be transferred by the licensee, nor can reactors be operated without a licence. New operators will need to go through a formal licence application process, which could place some constraints on the timing of Ontario's plans to deregulate electricity markets and restructure Hydro. I want to emphasize that these issues are real concerns of the AECB, which could have an impact on our ability to permit the operation of nuclear power stations by any new competitive electricity generating companies.

Before the AECB, (or the Canadian Nuclear Safety Commission) could permit such operation, it would have to be satisfied that there is no undue hazard posed by the rules surrounding the operation of the grid, as they would impact on the operations of nuclear plants, or by the relationship between the owners and operator of nuclear plants. [We] would also have to be assured that the new operator is competent and that appropriate financial guarantees are established. It may not be possible to permit operation of nuclear power stations until these issues are clearly addressed.

New operators [of nuclear power plants] will need to go through a formal licence application process.

Other concerns

Those are the broad areas of concern the AECB has with Ontario's electricity restructuring initiative. However, we also have a couple of specific concerns with Bill 35 that I would like to raise with the Committee.

First, I would like to bring your attention to Clause 37 of the Electricity Act, 1998, which deals with emergency planning. We believe the current wording of this section could lead to confusion on an issue where clarity is absolutely essential. Clause 37 proposes to obligate the Ontario Minister of Energy, Science and Technology to require the Independent Electricity Market Operator (IMO) and the operators of nuclear power stations to prepare and file emergency plans with the Minister, and to authorize the Minister to direct implementation of an emergency plan. Regulatory authority over on-site emergency preparedness at nuclear facilities is exercised by the AECB as the federal nuclear regulator. The AECB requires licensees to prepare on-site emergency plans, which the AECB approves as a condition of the licence.

We recognize, of course, that off-site emergency preparedness planning is an area where the provinces exercise authority, and when considering a licence to operate a nuclear plant, the AECB accepts the offsite emergency plan approved by the responsible provincial ministry.

The AECB is also concerned with Clause 105 (a) of the Electricity Act, 1998, which would give the proposed Electrical Safety Authority the power to make regulations for electrical equipment and systems in Ontario. The broad wording of this clause could be construed as implying provincial jurisdiction over the design, construction and operation of nuclear reactors.

Conclusion

Let me close by reiterating that the AECB neither opposes nor endorses the restructuring of the Ontario electricity market and the restructuring of Ontario Hydro that will be implemented through Bill 35. Our objective is solely to ensure that the rules of operation in the new environment, as they relate to nuclear facilities, are well understood from the outset. We believe Bill 35 needs to clearly distinguish between nuclear and non-nuclear activities where appropriate, and to acknowledge the federal role in the nuclear area.

New Regulations to be Gazetted, Oct. 10

to be put on the Web and information meetings scheduled

The Atomic Energy Control Board has announced that the proposed new Regulations to be put into force when it becomes the *Canadian Nuclear Safety Commission* will be published in Part 1 of the *Canada Gazette* on October 10, 1998.

Paper copies of the draft regulations can be obtained from the AECB. They will also be available on the AECB's Web site (www.gc.ca/aecb) along with the *Regulatory Impact Analysis Statement* and the *Dispositioning Document* for comments received last year.

As of the end of September versions of eight of the regulations that are essentially the same as the ones to be Gazetted are already on the AECB Web site.

The *Department of National Defence Exclusion Order*, the *Cost Recovery Regulations*, and the *Rules of Procedure* are not included at this time. The first is still under discussion with DND and the second (Cost Recovery) was sent out separately in the summer of 1998 for comments (See separate article)

Comments on the draft regulations must be received by the AECB by December 1, 1998, to be considered.

The AECB will review the comments as amend the draft regulations as it deems necessary. The regulations must then be approved by the Department of Justice. The final step consists of approval by the new Canadian Nuclear Safety Commission, the Minister of Natural Resources and the Special Committee of Council. That process is expected to be completed in early 1999.

During the comment period the AECB will hold public meetings across the country to assist those wishing to comment and to provide an opportunity for additional information or clarification.

The schedule is as follows. All sessions begin at 9:00 a.m. local time.

Halifax	October 16	Prince George Hotel
Winnipeg	October 26	Delta Winnipeg Hotel
Saskatoon	October 27	Radisson Hotel
Calgary	October 28	Harry Hays Building
Vancouver	October 29	Quality Inn, Marine Drive
Toronto	November 10	Howard Johnson Hotel Scarborough
Montreal	November 12	Radisson Auberge des Gouveneurs
	November 13	AECB 280 Slater Street

The *Nuclear Safety and Control Act* was passed by Parliament in March 1997. However, the Act will not be proclaimed until the associated regulations are finalized. Under the Act, the Atomic Energy Control Board will become the Canadian Nuclear Safety Commission.

AECB Increases Fees

The Atomic Energy Control Board published, in early July, in Part I of the Canada Gazette, a proposed amendment to its Cost Recovery Fees Regulations 1996 that will increase the total by 17%.

The rationale provided is that the AECB expects to have an increase of \$6.5 million in fiscal 1998-99 over the past year, \$5.5 million of which are costs applicable to regulatory activities recoverable through licensing fees. Educational and not-for profit health care institutions, and federal government departments are exempt from AECB licence fees.

The additional costs arise from:

- additional costs associated with the implementation of the Canadian Nuclear Safety and Control Act such as: staff retraining, document production, additional Board (Commission) members
- increased public meetings
- increased salaries
- additional work associated with strengthening safeguards

- year 2000 compliance
- development and implementation of a new job classification system.
- additional efforts to improve regulatory reviews of environmental impacts
- additional effort on general licence assessment and compliance, such as financial assurances, waste disposal; facility ageing and radiation protection

The AECB is reviewing comments received up to the end of August and finalizing the required Regulatory Impact Analysis Statement. After review by ministers the final regulation will be published in Part II of the Canada Gazette and then put into effect.

Following are some examples of the existing and proposed fees.

	Proposed	Existing
Application for construction approval and operating licence,		
- for four reactor unit station	$46,275,000	$39,551,000.
- one reactor unit station	$26,233,000	22,421,000
Issue or renewal of an operating licence		
- four reactor unit station	4,025,000	3,440,000.
- one reactor unit station	2,720,000	2,325,000.
Issue or renewal if an operating licence for a nuclear research and test establishment (CRL)	1,509,000	1,290.000.
Uranium or thorium mining facility application for siting, construction and operating licences mining facility with mill and tailings area	2,597,000	2,220,000.
Group I Waste Management Facility	1,126,000	962,000.

Obituary

Dr. Harold Elford Johns, a Canadian pioneer in radiology and radiation physics, died in Kingston, August 23, 1998, at the age of 83. Johns was born in Chengtu, China, in 1915, where his father was professor of mathematics at the West China Union University

In nuclear circles Harold Johns is most remembered as the developer of one of the first Cancer therapy machines using Cobalt 60, in the late 1940s and early 1950s. That led him into field of medical biophysics which was just beginning at that time.

He began his professional career as a professor in the Physic Department of the University of Alberta in 1939. He moved to Saskatchewan in 1945 to work with both the University of Saskatchewan and the Saskatchewan Cancer Commission. It was there that he designed and built the first Cobalt 60 therapy machine to go into operation. From 1956 to 1980 when he retired Johns was at the University of Toronto associated with the Departments of Medical Biophysics, Radiology, and Physics. During his career he published over 200 peer-reviewed papers and trained over 100 graduate students. His text "The Physics of Radiology" ran to four editions and became the premier textbook in its field.

He was appointed an Officer of the Order of Canada in 1976 and will be inducted into the Canadian Medical Hall of Fame in October 1998.

His family has invited those wishing to remember him to make memorial donations to the Ontario Cancer Institute, 610 University Avenue, Toronto, Ontario, M5G 2M9, for the Harold E. Johns Research Prize in Medical Biophysics.

EECO 98
- Environment and Energy Conference of Ontario

The Ontario Ministries of environment and of Energy, Science and Technology, together with ten other partners, including Ontario Hydro, are a holding a conference and exhibition at the Metro Toronto Convention Centre, November 24 and 25, 1998, on the theme *Environment and Energy in Ontario.* The sub-title is, *Solutions that don't cost the earth.*

Day one will examine challenges and solutions: integrating environmental and business decisions to improve environmental performance; trends in environmental and energy policies; success stories of new products.

Day two will focus on developments in climate change one year after Kyoto.

There will be an accompanying exhibition, and awards for environment and energy excellence will be presented.

For information contact Ana Rosati at: tel. 416-327-7721 Fax: 416-327-1261.

CNS news

Earth Day at the Forks

Morgan Brown

***Ed. Note:** The following account of the travels and travails of one intrepid CNS member was intended for the last issue of the Bulletin but we ran out of space. Morgan Brown is the chairman of the hard-pressed Manitoba Branch.*

Sunday April 26 1998 was a gloriously warm and sunny day at The Forks, the junction of the Red and Assiniboine Rivers in Winnipeg. A year earlier I had been helping people sand bag their homes against the rising flood waters, but this year the rivers were quite low in comparison, thank goodness. So there was no excuse - I was off to run the CNS Manitoba Branch booth at the Earth Day trade show.

I took the CNS-MB banner, literature, a CANDU model, a section of fuel channel with an empty fuel bundle, a model dry storage canister, and a Geiger counter and some radioactive samples. I was nervous - what would my fellow exhibitors say, what would the public think, what would the anti-nuclear protesters say, what might people do? I've given many nuclear energy talks to classes from Grade 7 to university, but never had I done anything so very public, so very vulnerable. Would my life insurance broker consider this a risky activity, like alligator wrestling?

I set up my table in the marquee tent for "corporate" sponsors, in between the Manitoba Heavy Construction Association and the Manitoba Trappers Association. In the same tent were the Manitoba government sustainable development group, Manitoba Hydro, the Model Forest, Archaeology in Manitoba and Natural, peace and disarmament groups, Earth First, and a group encouraging the public to sign the organ donation line on their driver licence. It seemed the whole spectrum of possible "environmental" organizations were represented.

The CNS display looked quite good. if I say so myself. The crowds started to flow through, and the outdoor band kicked it off with some LOUD music (what was the risk to my eardrums for the day?). The CANDU model with the fuel channel section on top was a good drawing card, and people were amazed that the eight (simulated) fuel pellets would be enough to supply the typical Canadian home with electricity for a year.

Around noon a group marched into our tent, led by an accordionist and someone with a megaphone, and followed by a couple of TV cameras. They latched onto my neighbour, the trapper. I'd never seen "environantics" until then, as the lead protester brought out a leg-hold trap and set it off with his placard - for the cameras, of course. There were lots of words from the protesters, who took a while to disperse. The trapper was a pleasant fellow who was trying to eke out a living off the land - without destroying the environment and thus his livelihood. He told me afterwards that the protesters had used a leg-hold trap - they've been banned for 10 years or so. Nothing like dredging up the past!

Some protesters then latched onto me. When it was only one or two at a time we had good discussions, usually ending up with pleasantries and a handshake. One fellow was evidently concerned that "an evidently smart guy like me" (his words!) could support the use of nuclear technology. When I was faced with half-a-dozen protesters, it ended up being a fun game of "us against him". Lots of questions were fired off, without necessarily waiting for my answer before snickering. I don't think they believed that I had pursued a career in the nuclear industry precisely because of my concern for this good and only Earth. One person thought the "corporate tent was really undemocratic because she didn't get to set up a table to counteract mine!

Some protesters attacked food irradiation. One young (almost all of them seemed SO young) lady told me that she had a 9-year old cookie irradiated by AECL, and it still looked the same as the day she got it. Somehow this was awful because, as one person put it, you couldn't tell if food was bad if there was no mold on it (!!?) I told them I wouldn't eat a nine-year old cookie - they go stale after a few months (I have experimentally derived this conclusion from a large sample). Another person thought that irradiating strawberries was bad because they would get stockpiled in warehouses for later consumption (!!?) They were also concerned that the effects of irradiation had not been monitored over two or three generations of human consumers to observe the effects.

I had a chart comparing the waste generation between nuclear and conventional thermal electrical production for 1994, using the numbers from the Environmental Assessment Panel (EAP) on the Nuclear Fuel Waste Management and Disposal Concept. In 1994 the electricity production from each source was very close to one-fifth of Canada's total electrical production. The waste production, by mass, was much less from nuclear than from coal and oil, as we well know. One man told me that I should only compare the 2200 tonnes of used nuclear fuel and the 3780 tonnes of heavy metals in the coal ash. To him, the 4,200,000 tonnes of ash, 95,000,000 tonnes of CO_2, 542,000 tonnes of SO_2 and 168,000 tonnes of NO_x (all dispersed into the environment or put in landfills) from coal and oil-fired generation were irrelevant! As an aside, the EAP comparison includes the tailings and waste rock from the uranium mines, but not from the coal mines (nor the sour gas emissions/flaring from the oil wells).

There were a few other "zingers". One woman looked at the map of Canada's reactors and said "Not only does southern Ontario have all that smog, they have to live with all those reactors too!" My comment that there would be a lot more smog without the reactors fell on deaf ears. The only really rude person was a smug teenage boy who picked up a food irradiation pamphlet and intentionally dropped it. I asked him if he would please pick it up, but he pretended not to understand and ground it up with his heel. Brat!

I had many others drop by the booth, asking lots of questions and taking brochures. The kids loved playing with the Geiger counter, and took lots of the "I'm naturally radioactive - so are you" stickers. They made the day so worthwhile.

On Sunday evening I watched the local news and, sure enough, there was lots of footage of the protesters (disproportionate to their number). Their leader was recorded decrying the rental of tables to corporations like "Pine Falls Paper and AECL". What?! I represented CNS on my own time (I spent all Friday in preparation), CNS paid for the table rental and my mileage. Yes, I work for AECL and borrowed some of their display items, but so what? My AECL brochures were amongst others from CNS, Nordion, AECB, CNA, and the ANS. While I am glad to be employed by AECL, my views on nuclear matters would not change whether I was employed by the nuclear business or not.

All in all, a good day. I believe I made nuclear science and technology a little less remote and a little less frightening for many passers-by. Maybe I even showed some anti-nuclear protesters that I too am human, I too am very concerned over our planet's future. So consider what you might do for next Earth Day, or sooner- it was challenging at times, but worth the effort!

Officers' Seminar

Each year the CNS holds an "Officers' Seminar" to which Branch representatives are invited for discussions with members of the CNS Council. This year the event was held on September 16 at Sheridan Park.

Much of the day was spent, as usual at these seminars, with reviews of the major CNS activities and sharing of information among Branch representatives. Two Branches are struggling because of the changing structure of the industry - Saskatchewan and Manitoba - while the ones centred on Ontario Hydro stations have had to curb their activities because of the pressure of OH Nuclear's restructuring program. On the other hand the branches at Chalk River are very vigorous. The Ottawa Branch, which is just a modest size now, hopes to attract new members from the Atomic Energy Control Board now that staff of that agency are allowed to join the CNS. The recruitment of members at the AECB became, in fact, one of the central themes of the day.

Discussion of how to attract new members was, as always, a topical issue, with suggestions of discounts on membership fees, increased "advertising', providing for resumes on the CNS Web site; involving more women members; and other being raised.

At the associated Council meeting, approval was given to donate $3,500 for a further Workshop on Science Reporting to be held in Moncton, October 16 and 17. This is a follow-up to the one for journalism students last spring to which the Society contributed $2,000. There was wide acceptance of the need to achieve better communication on science and nuclear matters in particular (as emphasized by former president Ed. Price in a talk to two international committees during the PBNC 98 conference last May).

The Honours and Awards Committee will be recommending several awards to be announced and presented at the Awards Luncheon to be held October 21 during the Annual Conference in Toronto.

There was a general consensus that these annual gatherings are beneficial, especially for the Branch people that are able to attend. Unfortunately, pressure of work and other problems meant that not all branches were represented.

New Members

We welcome the following new members of the Canadian Nuclear Society who have joined since the last issue of the *CNS Bulletin*.

Aly Mortada Aly	Kevin James Lenton
Paul Robert Ballantyne	Jay Gordon Merritt
Alexander Guiran Berdnikov	James Nickerson
D. Paul Carson	Hidetoshi Okada
Lucien F. Cattrysse	Robyn Ann Prime
Chien Chung	John Skears
Daniel Paul Fadel	Imre Vencel
Iosif Fekete	Chang Cong Zhao
Nick Fragiadakis	Chunlei Zhao

Peripatetic President

Branches take note ! CNS President Paul Thompson has stated that he wishes to visit all CNS Branches during his term of office - and - he is prepared to "pay for his supper".

Paul is offering to give talks on a number of subjects. His current favorite is CANFLEX fuel, but he is also interested (and able) to talk on "ageing" (reactors that is, not CNS members) and various aspects of reactor safety.

The easiest way to contact him (sometimes the only way) is through e-mail: <pthompson@nbpower.com>

BRANCH ACTIVITIES

Summertime is a slow period for most organization activities in Canada, and that applies to CNS Branches. In addition, the intense focus on recovery at Ontario Hydro stations has precluded much extra-curricula activity, which has impacted on the CNS Branches centred on Bruce, Darlington and Pickering. Nevertheless, there is still some news to report.

BRUCE (Eric Williams)

Because of the context mentioned above, the Branch executive has shrunk but is still planning several meetings this coming season. The opening was scheduled for September 24, when Beth McGillvray, from the Cancer Institute at the Ottawa General Hospital, will give her energetic talk on nuclear medicine.

Branch chairman Eric Williams reports that he hopes to organize another four presentations over the coming season.

CHALK RIVER (Alan Lane)

The Chalk River Branch began the season with an Annual General Meeting on Monday, September 14, with Paul Thompson, CNS President and manager of safety at Point Lepreau, speaking on Irradiation of CANFLEX Bundles at Point Lepreau.

At the meeting outgoing chairman, Jeremy Whitlock reviewed the full and successful season of 1997-98 and the new executive for 1998 -99 was installed;

Chair	Alan Lane
Secretary	May Heinrich
Treasurer	Bryan White
Member-at-Large	Romney Duffey
Past Chair and Program Director	Jeremy Whitlock

Further positions may be filled later.

The Branch intends to hold meetings monthly, similar to the last couple of years.

DARLINGTON (Richard Murphy)

For the same reasons as the other Branches located at Ontario Hydro plants, the Darlington Branch was essentially dormant over the past season. However, the remaining executive hope to revive the Branch and hold a few activities this coming season.

MANITOBA (Morgan Brown)

The Manitoba Branch has been hit by a worse environment than that of the Ontario Hydro stations, namely the closure of AECL's Whiteshell Laboratories. There are, however, a number of former AECL employees in Pinawa and a few members elsewhere. Chairman Morgan Brown, in particular, has been active, especially in the education and information areas, such as speaking at schools and appearing at fairs. (See his account of one of his adventures elsewhere in this issue.)

The CNS Manitoba Branch sponsored a visit by Beth McGillvray (see above) in March when she spoke to several groups. In April, Randy Long of Chalk River Laboratories spoke on advanced calandria tubes manufactured using the shot peening process. In May, Ingo Beckmerhagen of the German Federal Office for Radiation Protection presented a talk on quality management for the design, operation, and surveillance of waste repositories.

NEW BRUNSWICK (Dave Reeves)

(The following news was submitted by Mark McIntyre, secretary of the New Brunswick Branch)

The New Brunswick Branch held a mid-simmer meeting, July 27, with Dave Cox, Manager of the Fuel Development Branch at the Chalk River Laboratories, speaking on Disposition of Excess Weapons Plutonium as MOX Fuel in CANDU Reactors - Swords to Ploughshares. Dave is involved with the PARALLEX program that has the goal of disposing of equal amounts of American and Russian excess plutonium in parallel. However, the two countries have different perceptions - the USA considers the former warheads as a liability while the Russians consider the contained plutonium as a "national treasure". The speaker outlined some of the many technical challenges in the program such as fabrication, test irradiation, safety analysis, transportation. He noted that as well as contributing to world peace by using CANDUs to burn some of the excess military plutonium, there is a potential "disposition" payment by the USA for removing the current safeguarding costs which are estimated to be as high as $1 billion per year.

OTTAWA (Mohamed Lamari)

The Ottawa Branch has not yet begun its 1998-99 season but is planning some special sessions to attract staff members of the AECB who are now able to join the CNS. It is anticipated that the first meeting will be held in early November with Jon Jennekens, former president of the AECB as the guest speaker.

SHERIDAN PARK (Kwok Tsang)

The Sheridan Park Branch hosted the CNS Officers' Seminar on September 16. As of the time of writing the Branch had not yet finalized its plans for the 1998-99 season but expects to present a number of seminars, roughly monthly, as last season.

DEADLINE

The deadline for the next issue, which will be published in early January 1999, will be Tuesday, December 15, 1998.

A Note from Ben Rouben

Ed. Note: The following is the text of a note sent by CNS Past-President Ben Rouben after reading our article on "Incorporation" in the last issue.

I was flattered but more than a little embarrassed by the one-sided credit that you give me as the "driving force" for this achievement [incorporation]. I think the picture this paints is hardly a fair reflection of reality. The "as-hoc" committee which took on the challenge was in fact headed by you [the editor] and included the whole Executive and Duke Segel. Everyone contributed significantly, and the incorporation exercise was very much a team effort.

The fact that we achieved incorporation before our AGM [in June] was the result of good planning and execution by all. It turned out to be very important, not because it was during my "term", but because it avoided all kinds of logistical complications for us.

I want to thank everyone on the Committee, and indeed the entire council, for helping us reach our goal.

Ben Rouben

News of Members

Walter Harrison, a charter member of the CNS and former council member, has retired from AECL after over 30 years in the Canadian nuclear industry. Walter began his nuclear career In 1965 when he joined Canadian General Electric to work on control and safety aspects of the KANUPP reactor. He moved to AECL at Sheridan Park in 1970 to work on the safety analysis and licensing of the Bruce A reactors before going to AECL's Whiteshell Laboratories in 1972 in the Reactor Safety Research program. From 1983 to 1986 he was attached to the National Uranium Tailings Program at CANMET in Ottawa. He returned to Whiteshell in 1986 to become Director of the Technical Services Division, responsible for nuclear operations and design and project engineering. In 1990, he took over the Nuclear Services Division of AECL with responsibility for non-reactor nuclear operations, quality management and training at both WL and CRL. On moving to Chalk River Laboratories in 1994, he became responsible for Radioactive Materials Services across AECL. Walter continues to reside in Deep River and be active as an independent consultant.

An interested passer-by stops at the CNS booth at a Workshop for Journalists.

Canadian Nuclear Society
Société Nucléaire Canadienne

6th International Conference on CANDU Fuel

1999 September 26-29, Niagra-on-the-Lake, Ontario, Canada

CALL FOR PAPERS

On behalf of the Canadian Nuclear Society (CNS), you are cordially invited to submit a paper for the Sixth International Conference on CANDU Fuel to be held in Niagra-on-the-Lake, Ontario, September 26th through 29th, 1999.

This conference will bring together designers, engineers, manufacturers, researchers and modellers to share the wealth of their knowledge and experience. The previous conference in 1997, produced an excellent selection of high quality and well-received papers.

Paper Categories

A. **Fuel Performance:** Station experience, PIE studies/techniques, fuel behaviour (normal operating conditions and extended burn-up);
B. **Fuel Safety:** Licensing issues, accident analysis, fission gas release, fuel behaviour and experimental simulation;
C. **Design and Development of Fuel and Fuel Cycles:** MOX, inert matrices, DUPIC, slightly-enriched uranium, recovered uranium, Thoria cycle, CANFLEX, low-void reactivity, modifications to designs and quality assurance in fuel design and development;
D. **Fuel Model Development:** Predictive capability on thermal, mechanical, irradiation and fission-gas release behaviour under either normal operating, or accident conditions;
E. **Manufacturing & Quality Assurance:** Fuel manufacturing experience, advances in manufacturing & inspection technologies and quality assurance;
F. **Fuel Management:** Fuel management schemes, load following, fuel physics analysis and operational problems;
G. Fuel Bundle Thermalhydraulics: CHF and CCP assessments, reactor ageing, crept pressure tube and fuel simulations; and
H. **Spent Fuel Management:** Handling technology, spent fuel storage and in-storage fuel behaviour.
I. **History of CANDU Fuel:** Developments of CANDU fuel from a design, testing and manufacture viewpoints; implementation of manufacturing quality assurance standards, development of fabrication technologies for CANDU fuel, and development of computer codes demonstrating fuel performance.

Paper Submission

Interested authors should submit a 500-word summary indicating the planned content for the particular session chosen from the above list of categories. Summaries must be received by 1999 January 15. Authors will be notified of the acceptance of their summaries by 1999 March 1. Camera-ready, final manuscripts are required by 1999 June 30. All accepted papers will be printed in the conference proceedings. Submit your summary either in electronic form (WORD 7.0 required) to tayalm@aecl.ca., or in hard-copy to:

Mr. Mukesh Tayal
AECL Fuel Design Branch,
2251 Speakman Drive, Mississauga,
Ontario, Canada L5K LB2
Tel: (905) 823-9060 ext. 4652 Fax: (905) 822-056

The organising committee is looking forward to receiving your summaries.

Nuclear Energy Policy in Canada, 1942 to 1997

by R W. Morrison

This 90 page document is an interesting and informative account of the development of federal government policies related to the Canadian nuclear program and some of the historical context. Anyone wishing to understand the current debates, or just interested in knowing how we got where we are, will enjoy reading this report which was prepared by Bob Morrsion, former director general of nuclear energy at Natural Resources Canada, assisted by Ted Thexton and Dick Williams, two of his former colleagues.

The report is available free of charge from: Brian Moore, Director, Nuclear Energy Division, Natural Resources Canada, 580 Booth Street, Ottawa, Ontario, K1A 0E4; tel. 613-996-3027; fax: 613-995-0087; e-mail: < bmoore@nrcan.gc.ca>

Nuclear Safety Research in OECD Countries
- Capabilities and Facilities

This 100 page report is an update on a report of the same title prepared by the Committee on the Safety of Nuclear Installations (CSNI) of the Nuclear Energy Agency (NEA) which is a unit of the Organization for Economic Co-operation and Development (OECD) in 1995. As the title implies it summarizes the nuclear safety research conducted in member countries of the NEA.

Published by the OECD, 2, rue André-Pascal, 75775 Paris Cedex 16, France (Free)

Nuclear Energy Date, 1997

For those in love with statistics this 50 page document provides a myriad of information on nuclear power plants, uranium production, enrichment facilities and spend fuel storage.

Available (free) from OECD, 2, rue André-Pascal, 75775 Paris Cedex 16, France

AECB Annual Report 1997-98

The Annual Report for the fiscal year 1997-98 of the Atomic Energy Control Board was issue in the summer. It provides an overview of: AECB activities during the period; organization chart with names and photographs of senior officials;, list of facility licences; and financial statements. It is available from the AECB at P.O. Box 1046, Ottawa, Ontario K1P 5S9; fax 613-992-2915; e-mail: info@atomcon.gc.ca >

Nuclear Power: Villain or Victim ?
Our most misunderstood source of electricity

by Max W. Carbon

This is a further book that attempts to explain to the "general " public, and does it very well. Unfortunately, from a Canadian perspective, it is written in the context of the situation of the USA. Nevertheless this book is comprehensive enough to cover the important subjects but short enough to keep the reader's interest. It is up to date, including a discussion of ways to treat plutonium from dismantled weapons. The section on the effects of low-level radiation is particularly well done.

Carbon is professor emeritus of nuclear engineering at the University of Wisconsin, a fellow of the American Nuclear Society and has served on the USNRC's Advisory Committee on Reactor Safeguards..

The book is published by Pebble Beach Publishers fax 608-831-4914; e-mail <pbp@midplains.net>

CALENDAR

1998

October 11 - 14

International Topical Meeting on Safety of Operating Reactors
San Francisco, California, USA
contact: Dr. Garth Cummings
Danville, California
Tel: 510-422-1264
Fax: 510-423-2224
e-mail: cummingsg@ilni.gov

October 18 - 20

CNS Annual Conference
Toronto, Ontario
contact: Sylvie Caron
CNS Office
Toronto, ON
Tel: 416-977-7620 ext. 18
Fax: 416-979-8356
e-mail: carons@cna.ca

October 25 - 28

ENC '98 International Nuclear Congress and World Exhibition
Nice, France
contact: ENC '98 Secretariat
European Nuclear Society
Berne, Switzerland
Tel: 41-31-320-6111
Fax: 41-31-382-4466
e-mail: carons@cna.ca

Nov. 4 - 6

CANDU Lattice Physics Course
Toronto, Ontario
contact: Mr. S. Douglas
AECL Chalk River
Tel: 613-584-8811 ext. 4048
e-mail: douglass@aecl.ca

Nov. 15 - 19

ANS Winter Meeting
Washington, DC
contact: ANS Office
La Grange Park, Illinois
Tel: 708-579-8258

Nov. 15 - 19

Meeting of the Americas: Nuclear Science, Technologies, Applications
Washington, DC (held in conjunction with ANS Winter meeting)
contact: Fred Boyd
Kanata, ON
Tel./Fax: 613-592-2256
e-mail: fboyd96@aol.com

Nov. 30 - Dec. 4

Trends in Design and Development of Evolutionary Water-Cooled Reactors
Seoul, Korea
contact: J. Cleveland
IAEA
Vienna, Austria
Fax: 43-1-2060-20607
e-mail: official.mail@iaea.org

Fall '98

CANDU Reactor Safety Course
Toronto, Ontario
contact: Dr. G. Harvel
AECL Mississauga
Tel: 905-823-9060 ext. 4543
e-mail: harvelg@aecl.ca

1999

January 24 - 27

Health Physics Society Symposium
Albuquerque, New Mexico
contact: J.M. Hylko
Fax: 505-837-6870
e-mail: jhylko@msm.com

February ??

CNA/CNS Winter Seminar
Ottawa, Ontario
contact: Sylvie Caron
CNA/CNS Office
Toronto, ON
Tel: 416-977-6152 ext. 18
Fax: 416-979-8356
e-mail: carons@cna.ca

March 26 - 27

CNS / CNA Student Conference
Trent University
Peterborough, Ontario
contact: Dr. Jim Jury
Trent University

May 10 - 14

International Symposium on Environmental Protection at Facilities
contact: R. Maloney
AECB, Ottawa
Tel: 613-995-5116
e-mail: maloney.r@atomcon.go.ca

May 30 - June 2

CNA/CNS Annual Conference
Montreal, Quebec
contact: Sylvie Caron
CNA/CNS Office
Toronto, ON
Tel: 416-977-6152 ext. 18
Fax: 416-979-8356
e-mail: carons@cna.ca

June 6 - 10

ANS Summer Meeting
Boston, MA
contact: ANS Office
La Grange Park, Illinois
Tel: 708-579-8258
Special Session at ANS
- Industrial Applications of Neutron Scattering

contact: Aslam Lone
AECL Chalk River
Tel: 613-584-8811 ext. 5287
Fax: 613-584-8047
e-mail: lonea@aecl.ca

Sept. 25 - 28

ICENES 2000: 10th International Conference on Emerging Nuclear Energy Systems
Petten, The Netherlands
contact: Dr. Harm Gruppelaar
Petten, The Netherlands
e-mail: gruppelaar@ecn.nl
website: www.ecn.nl

Sept. 26 - 29

6th International CANDU Fuel Conference
TBD
contact: Mukesh Tayal
AECL - SP
Tel: 905-823-9040 ext. 4652
e-mail: tayalm@aecl.ca

October 3 - 8

NURETH-9 - 9th International Meeting on Nuclear Reactor Thermalhydraulics
San Francisco, California, USA
contact: Dr. S. Levy
Levy & Associates
3880 South Beacon Avenue
Suite 112
San Jose, California
USA 95124

Oct. 15 - 19

12th Pacific Basin Nuclear Conference
Seoul, Korea
contact: Mr. Kyo-Sun Lee
KAIF
Seoul, Korea
Fax: +82-2-785-3975
e-mail: kaif@borna.dacoin.cc.kr

Nov. 14 - 18

ANS Winter Meeting
Long Beach, California
contact: ANS Office
La Grange Park, Illinois
Tel: 708-579-8258

Nov. 16 - 18

International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies
(embedded in ANS Winter Meeting)
contact: Dr. R. M. Edwards
University Park, Penn., USA
Tel: 814-865-0037
Fax: 814-865-8499
e-mail: rmenu@engr.psu.edu

CANDU Lattice Physics Course

November 4-6, 1998, Mississauga, Ontario

The Canadian Nuclear Society and the CANDU Owners Group are co-sponsoring a course on the methods used to calculate neutron distributions in the lattice cells of CANDU reactors

The computer codes to be discussed are WIMS-AECL, POWDERPUFS-V, and DRAGON.

Day One: - an overview of how neutron distributions are calculated and used

Days Two and Three: - examination of the underlying methods and approximations in the neutron transport calculations found in these computer codes.

Tuition:
$350 (plus GST) for CNS members
$400 (plus GST) for non-members
$200 (plus GST) for Day One only
$150 (plus GST) for university students

To register, contact: Sylvie Caron
CNS office, Toronto, Ontario
Tel. 416-977-6152 ext 18
Fax: 416-979-8356
email: carons@cna.ca

Program information: Stephen Douglas
email: douglass@aecl.ca

CNS Council • Conseil de la SNC

1998-1999

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President / *Président*	Paul Thompson	(506) 659-6234
	e-mail:	pthompson@nbpower.com
1st Vice-President / *1ier Vice-Président*	Krish Krishnan	(905) 823-9040
	e-mail:	krishnanv@aecl.ca
2nd Vice-President / *2ième Vice-Président*	Ken Smith	(905) 828-8216
	e-mail:	unecan@echo-on.net
Secretary / *Secrétaire*	Ian Wilson	(905) 469-1179
	e-mail:	ian.wilson@ilap.com
Treasurer / *Tréssorier*	Andrew Lee	(416) 592-6843
	e-mail:	sya.lee@hydro.on.ca
Past President / *Président sortant*	Ben Rouben	(905) 823-9040
	e-mail:	roubenb@aecl.ca

Members-at-Large / *Membres sans portefeuille*

Parviz Gulshani	(905) 823-9040
Glenn Harvel	(905) 823-9040
Hong Huynh	(514) 392-5614
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Vince Langman	(905) 823-9040
Raymond Leung	(416) 592-8624
Kris Mohan	(905) 823-9040
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Duke Segel	(416) 322-8363
Harold Smith	(905) 823-9040
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Committees /*Comités*

Branch Affairs / *Affaires des sections locales*
Ken Smith .... (905) 828-8216
e-mail: unecan@echo-on.net

Education & Communication / *Éducation et communication*
Bill Garland .... (905) 525-9140
e-mail: garlandw@mcmaster.ca

Finance / *Finance*
Andrew Lee .... (416) 592-6843
e-mail: sya.lee@hydro.on.ca

Honours and Awards / *Honneurs et prix*
Hong Huynh .... (514) 392-5614
e-mail: hhuynh@cng2.hydro.qc.ca

International Liaison / *Relations internationales*
Fred Boyd .... (613) 592-2256
e-mail: fboyd96@aol.com

Inter-Society / Inter-sociétés
Parviz Gulshani .... (905) 823-9040
e-mail: gulshanip@aecl.ca

Internet
Peter Laughton .... (613) 584-3311
e-mail: laughtonp@aecl.ca

Membership / *Adhésion*
Raymond Leung .... (416) 592-8624

Program / *Programme*
Krish Krishnan .... (905) 823-9040
e-mail: krishnanv@aecl.ca

Universities / *Universités*
Bill Garland .... (905) 525-9140
e-mail: garlandw@mcmaster.ca

Women in CNS / *Femmes dans la SNC*
Jad Popovic .... (905) 823-9040
e-mail: popovicj@aecl.ca

CNS Division Chairs / *Présidents des divisions techniques de la SNC*

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- **Fuel Technologies / *Technologies du combustibles***
  Joseph Lau .... (905) 823-9040
- **Nuclear Operations / *Exploitation nucléaire***
  Martin Reid .... (905) 839-1151
- **Nuclear Science & Engineering / *Science et génie nucléaire***
  Glenn Harvel .... (905) 823-9040
- **Environment & Waste Management / Environnement et *Gestion des déchets radioactifs***
  Mitch Ohta .... (204) 345-8625
  Judy Tamm .... (905) 823-9040

CNA Liaison / *Agent de liaison d'ANC*

Murray Stewart .... (416) 977-6152

CNS Office / *Bureau d'ANC*

Sylvie Caron .... (416) 977-7620
e-mail: carons@cna.ca

CNS Bulletin Editor / *Rédacteur du Bulletin SNC*

Fred Boyd .... (613) 592-2256
e-mail: fboyd96@aol.com
Richard Fluke .... (416) 592-4110

CNS Branch Chairs • Responsables des sections locales de la SNC

1998

Bruce	Eric Williams	(519) 361-2673
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Darlington	Richard Murphy	(905) 623-6670
Golden Horseshoe	David Jackson	(905) 525-9140
Manitoba	Morgan Brown	(204) 753-2311
New Brunswick	Dave Reeves	(506) 659-2220
Ottawa	Mohamed Lamari	(613) 563-7242
Pickering	Marc Paiment	(905) 839-1151
Québec	Willem Joubert	(514) 871-1116
Saskatchewan	Walter Keyes	(306) 586-9536
Sheridan Park	Kwok Tsang	(905) 823-9040
Toronto	Ross Rock	(416) 592-4930

CNS WEB Page

For information on CNS activities and other links

http://www.cns-snc.ca