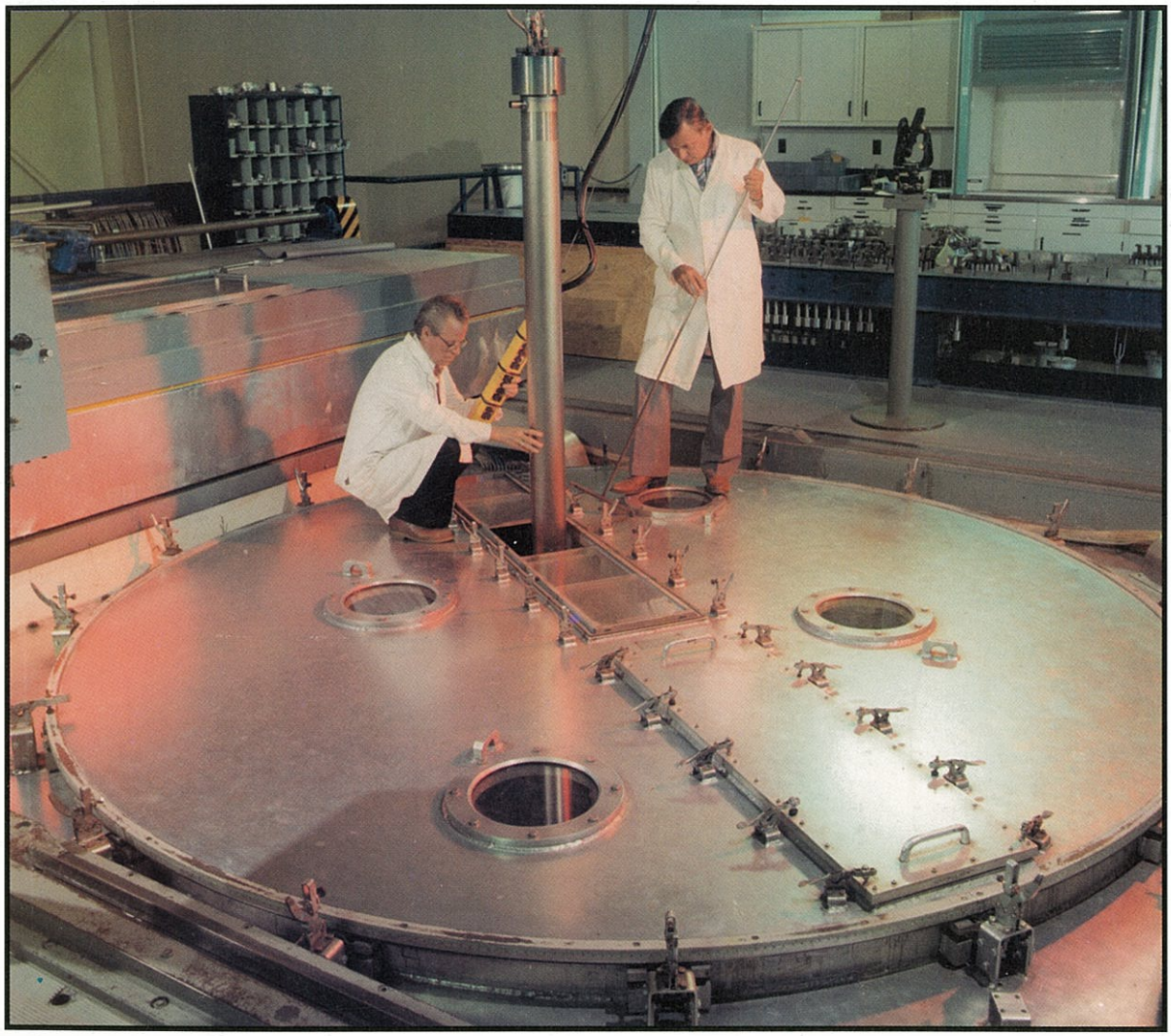
CANADIAN NUCLEAR SOCIETY

bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

May 2000 Mai

Vol. 21, No. 1



- ZED-2, 40th anniversary
- Nuclear Industry Winter Seminar
- Reports from industry leaders
- More on low doses
- CNS Annual Conference – Preliminary Program

Contents

Editorial 1

ZED-2, the first 40 years. 2

Evaluation of Supercell Codes Using ZED-2 Measurements 6

Meet Bill Clarke, the new CNA president 13

Nuclear Industry Winter Seminar 15

A Report on OPG. 17

A view from the uranium industry 21

Low doses of ionising radiation incurred at low dose rates 25

Improvements to the Operator Workspace of the Point Lepreau Control Room 28

The Three Stages of Nuclear Power: From Panacea to Pandora's Box to Pragmatism. 33

General News

- *New Regulations Approved* 36
- *ITER Canada issues an "Expression of interest"* 37
- *Obituaries* 38

CNS News

- *From the President's Desk* 40
- *Branch Activities* 41
- *25th CNS/CNA Student Conference* 43
- *News of Members* 53
- *Preliminary Program CNS 2000 Annual Conference.* 48

Publications Available 52
Book Review 52
Calendar. 53
Endpoint. 55

Cover Illustration

The illustration on the cover shows two researchers inserting a test assembly into the ZED-2 reactor.
This photograph and those with the article "ZED-2, the first 40 years", are courtesy of Atomic Energy of Canada Limited.

CANADIAN NUCLEAR SOCIETY

bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

ISSN 0714-7074

The *Bulletin of the Canadian Nuclear Society* is published four times a year by:

The Canadian Nuclear Society
380 University Avenue, Suite 200
Toronto, Ontario, Canada, M5G 1V2
Telephone (416) 977-7620
Fax (416) 977-8131
e-mail: cns-snc@on.aibn.com

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. Membership fee is $60.00 annually, $35.00 to retirees, $20.00 to students.

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

The comments and opinions in the CNS Bulletin are those of the authors or of the editor and not necessarily those of the Canadian Nuclear Society. Unsigned articles can be attributed to the editor.

Printed by The Vincent Press Ltd., Peterborough, ON

Canada Post Publication Agreement #1722751

EDITORIAL

Challenging times

It was the best of times, it was the worst of times.

Perhaps it presumptuous to quote Dickens but that phrase kept coming back as we observed the news surrounding the Canadian nuclear scene over the past few months.

There was a renewed positive attitude at the annual *Nuclear Industry Winter Seminar* in Ottawa in February, the rehabilitation of the Ontario nuclear power plants is proceeding, the first of two MAPLE isotope production reactors at Chalk River started up, and the Qinshan project in China continues to go well (thanks to the dedicated work of many hundreds in Canada and abroad). In addition, TRIUMF received ongoing funding and construction has begun on the Canadian Light Source accelerator in Saskatchewan.

However, countering this good news, funding for the Canadian Neutron Facility has not been approved. Coupled with no budget increase for the National Research Council, the future of this, in our view desperately needed, facility looks very uncertain. If there was ever a time for lobbying by members of the Canadian nuclear community now is the time.

The market for nuclear power plants remains very limited and extremely competitive. Despite the great potential contribution nuclear power can make to the climate change issue there is only partial recognition of this fact. There is even the possibility that nuclear will be excluded in the final policy proposals for meeting the Kyoto targets for greenhouse gas emissions.

The misperceptions about things nuclear, in particular nuclear power plants, remains widespread, especially among certain parts of the media. Our national broadcaster is one of the worse offenders, displaying almost a religious antipathy to anything nuclear. The extreme, and repeated, reaction of CBC radio to the shipment of a minuscule amount of MOX earlier in the year was typical. That was repeated a couple of months later when they heard that as much as 600 grams !!! of MOX might be coming from Russia instead of the 240 supposedly approved. The TV network joined in this diatribe in programs such as Counterspin.

Interestingly, recent opinion polls in the USA indicate that the public there is becoming supportive, or at least accepting, of nuclear power. However, the polls also showed that supportive individuals believed they were in the minority because of the media reports.

Just as we were "going to press" there was an encouraging report of a meeting of AECL's Allen Kilpatrick and senior executives from the Chalk River Laboratories with the local media which resulted in positive accounts. In our view this type of activity is highly desirable, not just by senior officials, but by all who believe in the benefits of nuclear science and technology. We have a positive story to tell, let's do it.

Fred Boyd

IN THIS ISSUE

First, to mark the beginning of our third decade of publication we have made some modest changes to the layout, including a new typeface. We hope you like it.

Also, for a number of technical and other reasons the printing of this issue has been delayed. We offer our apologies and ask that you do not blame, excessively, the post office.

Our lead article celebrates another anniversary, the 40th birthday of the ZED-2 reactor at the Chalk River Laboratories. That story, **ZED-2, the first 40 years**, is followed by a technical paper which illustrates the use of ZED-2 in developing and validating reactor physics computer codes, **Evaluation of Supercell Codes Using the ZED-2 Reactor.**

The other articles and papers are an eclectic mixture. Recognizing the close relationship of the *Canadian Nuclear Society* and the *Canadian Nuclear Association* we are pleased to offer an interview with the CNA's new president in **Meet Bill Clarke, new CNA president.** That is followed by an account of this year's CNA/CNS jointly sponsored **Nuclear Industry Winter Seminar** back in February, along with two of the important addresses: **A Report on OPG** by Ron Osborne, president and CEO of Ontario Power Generation Inc., and **A View from the Uranium Industry**, by Bernard Michel, president, CEO and chair of Cameco Corporation.

In the context of the imminent new radiation dose limits we offer a further contribution to the ongoing debate over the validity of the linear no threshold (LNT) hypothesis in **Low doses of ionising radiation incurred at low dose rates** by Don Higson of Australia who chaired a special task group of the International Nuclear Societies Council. An interesting paper describes, **Improvements to the Operator Workspace of the Point Lepreau Control Room**, and, Allen Kilpatrick, CEO of AECL, provides some intriguing observations in **The Three Stages of Nuclear Power: From Panacea to Pandora's Box to Pragmatism.**

There is our usual modest section on **General News** with a number of items we thought you might not have seen elsewhere. That is followed by an extensive **CNS News** section which includes, as well as the normal report on activities of the Society, an account of the **25th CNS/CNA Student Conference** and the **Preliminary Program** for the **CNS Annual Conference** coming up in June.

The issue closes with notes on publications available, an updated Calendar, and the imitable commentary by Jeremy Whitlock in **Endpoint.**

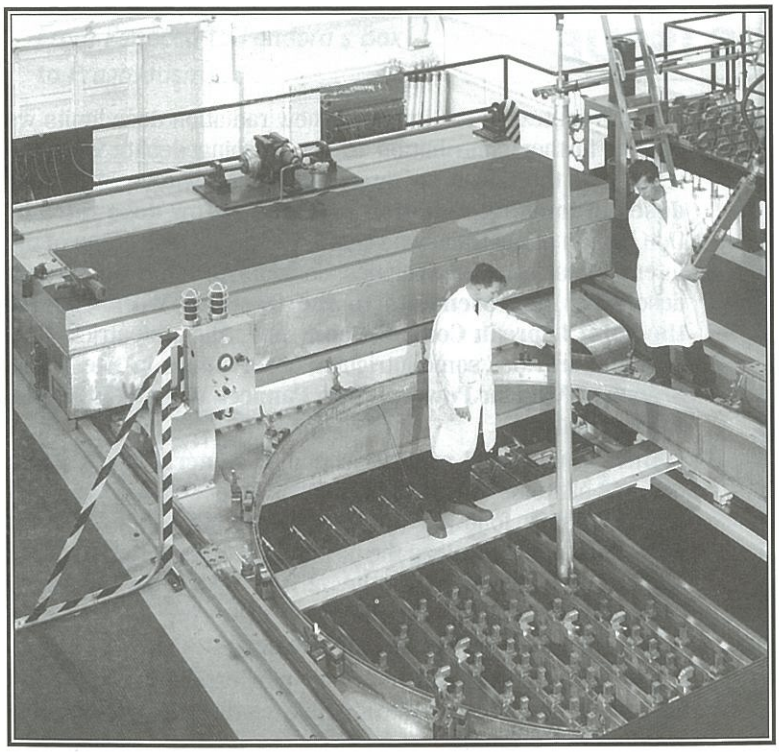
We thank all of our contributors and hope that you find something of interest in this mixture.

ZED-2, the first 40 years

by Fred Boyd

Preamble: Another birthday is coming up. September 7, 2000, will mark the fortieth anniversary of the initial criticality of ZED -2, a low power research reactor at the Chalk River Laboratories which is still in use to confirm analyses of CANDU reactor physics.

In anticipation of this event we met in early April with Rick Jones, Manager of Reactor and Radiation Physics at the Chalk River Laboratories of Atomic Energy of Canada Limited, who is currently responsible for ZED-2, and retirees Chas. Millar, former Director of Advanced Projects and Reactor Physics at AECL-CRL and Al Okazaki, formerly senior ZED-2 physicist, to reminisce about the beginnings and early days of the facility as well as its ongoing use. The following article is derived from that meeting. Additional input was provided by Ben Rouben, Manager of Reactor Core Physics at the Sheridan Park site of AECL and Ralph Green, former AECL vice-president and one-time senior physicist for ZED-2. Our thanks to all of them but note that any inadequacies or errors in this account are the responsibility of the writer.



This photograph from the 1960s shows Paul Ferrigan and Ed Pleau loading an experimental assembly into ZED-2.

The Beginning

Most readers are undoubtedly aware of ZEEP - the small zero energy assembly which, when it started in 1945 at what was then called the Chalk River Project, was the first reactor in Canada and the first in the world outside the USA. ZEEP was used to confirm the physics design of NRX and, subsequently, NRU, and, over the next two decades and more, for basic reactor physics studies. *(See Vol. 16, No. 3, Autumn 1995 issue of the* CNS Bulletin *for an account of ZEEP on the occasion of its 50th anniversary.)*

When the power reactor program was launched in the mid 1950s it was realized that ZEEP was too small to test adequately the fuel lattice arrangements proposed for NPD, Douglas Point and the following CANDU reactors.

In 1958 Dave Hone, a senior researcher, wrote:

An additional low power lattice testing reactor is required... to obtain rapidly more accurate experimental measurements on which to choose an optimum design of power reactors.

Such a reactor would be used for the same type of measurements as are done in ZEEP, viz:

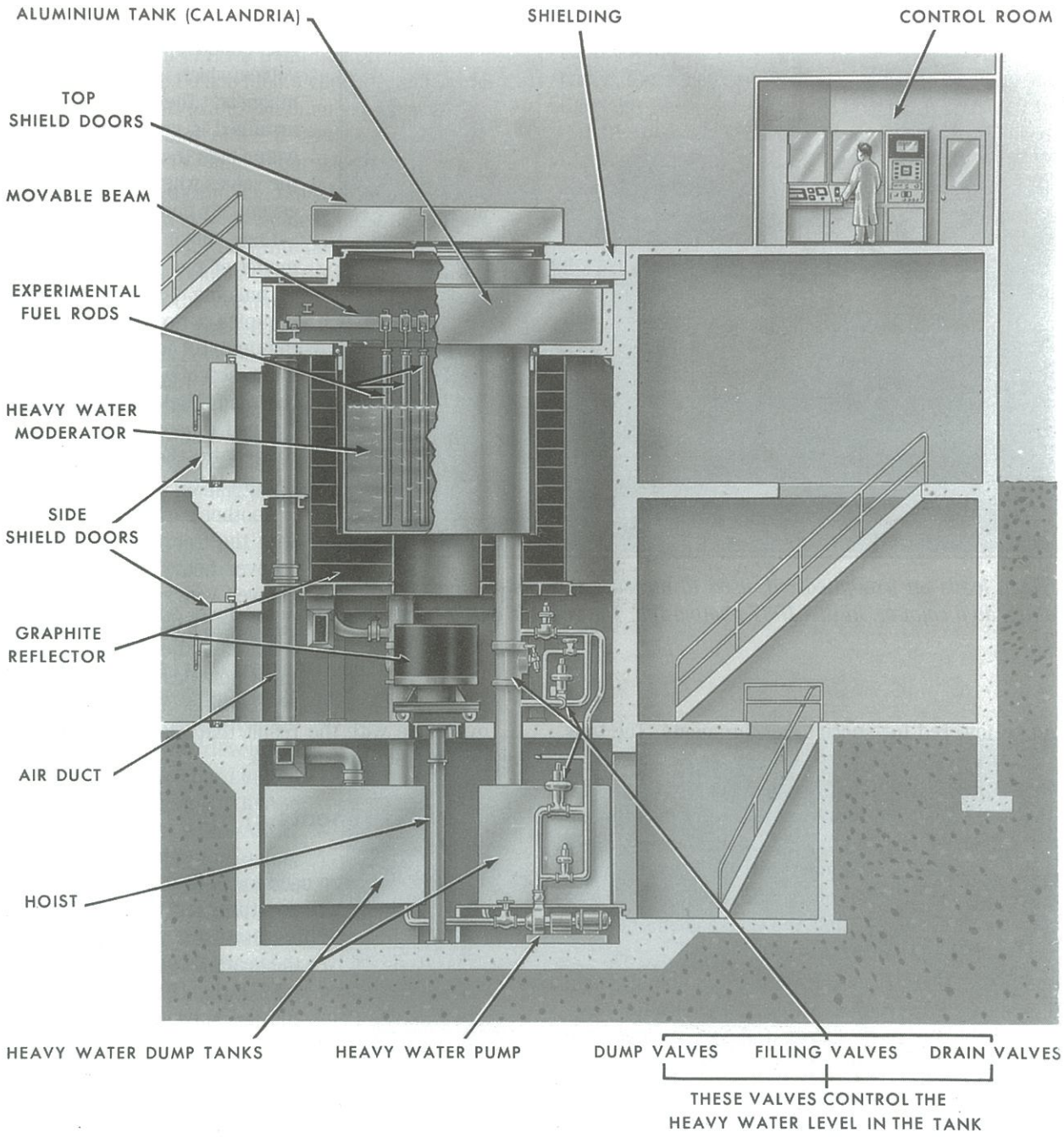
- *buckling vs lattice pitch*
- *critical size measurements*
- *fine structure through cells*
- *temperature coefficients*
- *void coefficients*

[and] in addition

- *flux distribution in rods in assemblies not necessarily uniform*
- *rapid measurements of the effect of various reflectors.*

The decision was made that year (1958) to proceed with the desired reactor, which was named "ZED-2".

It was chosen to locate ZED-2 in a structure attached to building 145 on the Chalk River campus which already housed the swimming pool type PTR reactor used for swing experiments. The design was done in house with Stu Russell serving as project manager. The firm of Foster Wheeler was chosen to



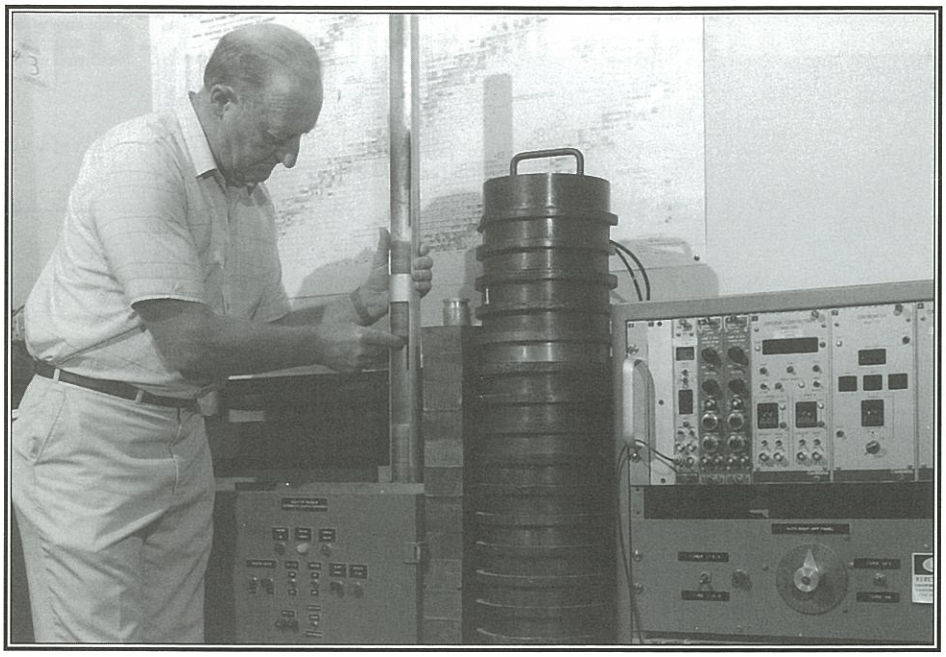
ZED-2 REACTOR

A schematic drawing showing the key components of the ZED-2 reactor.

construct the facility. Construction began in 1959 and was completed in mid 1960. The first "core" was installed using rods from ZEEP and initial criticality was achieved on September 7, 1960. Since then ZED-2 has been in use continuously over the four decades of its existence except for several months 27 years ago when its heavy water was "borrowed' for the Pickering A reactors.

The Design

The chosen design was a tank 3.36 metres diameter and 3.35 m. high which could hold 30,000 kilograms of heavy water. Surrounding the tank is a 0.6 m. thick assembly of high purity graphite blocks to serve as a reflector. There is also a bottom reflector of 0.9 m thickness, the central portion of



Paul Ferrigan loads an irradiated foil, used to measure flux distribution, into the custom automated counter, in this 1987 photograph. The counter is still being used at ZED-2.

which can be lowered for special measurements. The tank and reflector are in a square room with 46 cm. thick walls of heavy concrete to provide radiation shielding. (See Fig. 1)

Over the tank is an adjustable structure of beams and hangers on which can be hung fuel assemblies, flux measuring foils, and absorbers, as required for the various experiments. Above this is a rotatable lid (to isolate the heavy water from the atmosphere and the consequential downgrading) and a movable concrete shield.

Despite the fact that ZED-2 was designed to be operated at very low powers (maximum 200 watts) safety was very much in the minds of the designers (the NRX accident had occurred only a few years previously). As the primary shutdown mechanism it was decided to have fast acting dump valves to lower the moderator level rapidly in the event of any reactivity excursion, as well as providing for 12 shut-off rods containing cadmium. AECL's internal safety committee, which had been constituted a few years previously, scrutinized the design closely. Even after initial criticality a critical review was conducted by John Hilborn which led to further questioning by the committee.

Although a relativity simple design, the desired objectives for ZED-2 still presented a number of engineering challenges. Reportedly, Dave Hone told the designers that the pumps and valves in the heavy water circuit should have "zero" leakage. Understandingly, the design engineers said that was not possible. Nevertheless, they came very close and even after four decades the leakage is minuscule.

An example of how that was achieved is the design of the three 46 cm. diameter moderator dump valves which are the primary shutdown mechanism. Simple but effective, these are basically flap valves which are held closed by electromagnets. They have a flexible gasket arranged in such a way that the head of water aids the sealing. The leakage past the valves when in their closed position is essentially undetectable.

Chas Millar recalls that a full scale model of the reactor tank, built outside of building 145 to test the moderator dumping action, drew much attention at the time. He added that the first time the dump action was tested with a full lattice the many fuel rods hanging in the tank clanged together due to the turbulence caused by the sudden opening of the dump valves.

Another early problem was associated with the freezer / drier system used to recover heavy water. The initial design allowed water to accumulate in traps in the piping which then became frozen and resulted in the bursting of pipes. As with most new designs there were a number of "teething" problems, all of which were overcome with the result that ZED-2 has operated without incident for four decades.

The Experiments

ZED-2 has been used to confirm the reactor physics design of all of the power reactors. Experiments involve designing fuel assemblies representative of those in the reactor lattice to be studied. Over the years these have included the early 7 element fuel used in NPD, the 19 element fuel of both NPD and Douglas Point and the subsequent larger diameter fuel elements used in the commercial CANDU power reactors.

In the early years tests were made on uniform critical lattices. With that arrangement measurements were made of the overall reactivity, the relative conversion ratio (U238 capture to U235 fission relative to the same ratio in a pure thermal neutron spectrum), and, the fast fission ratio (fission of U238 to that of U235).

In more recent times the cost and size of fuel assemblies required the development of techniques to enable measurement of lattice properties using just a few test fuel assemblies. This is accomplished by substituting a small array of the test fuel into a host lattice of know properties.

Much of the work over the past decade has been focused on determining accurately the reactivity effect of voids in the coolant of the power reactors, which has been an ongoing safety question. This has required techniques to create and measure voids, to heat the fuel assemblies and, to simulate the characteristics of fuel with various burn-ups, in particular

fuel at equilibrium core burnup.

For this last challenge the ZED-2 team has produced their own version of MOX (mixed oxide fuel). Pellets are made of a mixture of natural uranium oxide, plutonium oxide and dysprosium, a neutron absorbing element used to simulate the effect of the fission products found in burned-up fuel.

Measurements have been conducted for the 28 and 37 element standard fuel and the new 43 element CANFLEX design The objective is to obtain highly accurate measurement of the reactivity effect of coolant voiding to verify (or serve as the basis of modifications to) the computer programs used for safety analyses and for fuel management in the power reactors. The primary focus has been on the lattice (or cell) codes which are the fundamental level of computer programs for reactor physics analysis. Other computer codes are used to compute the reactivity effects of absorbers such as the adjuster and control rods, and top level codes used to determine flux shape and direct fuelling patterns.

The computer codes

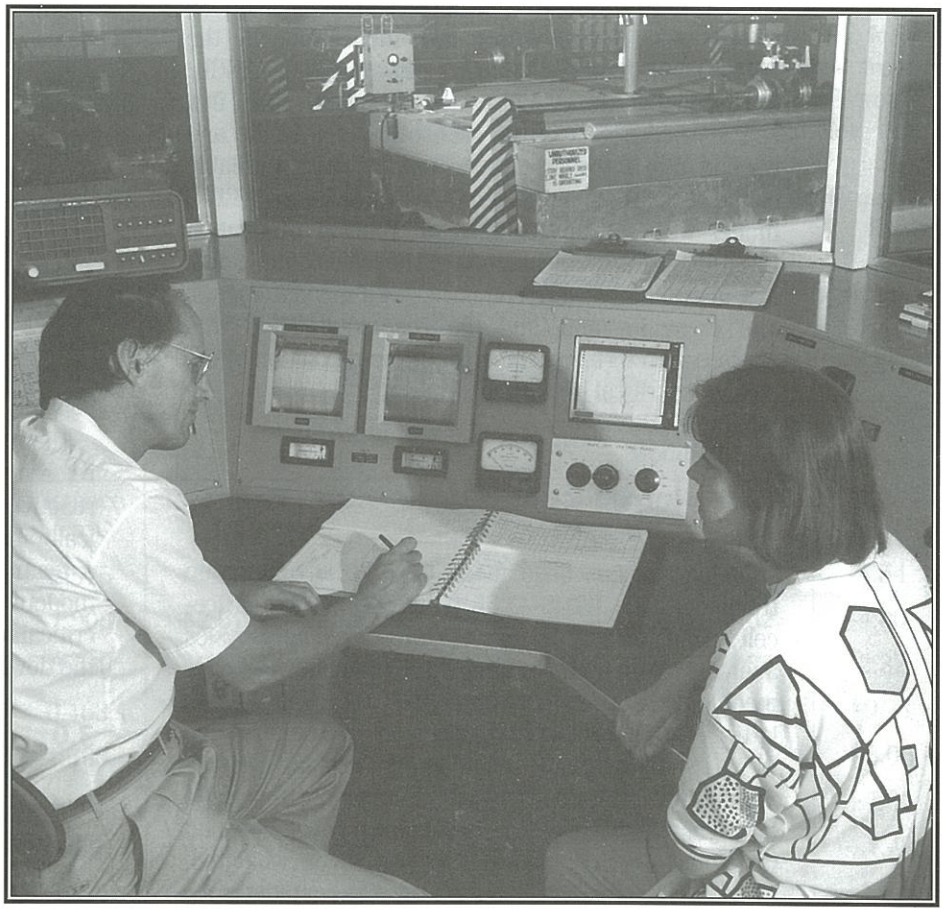
For many years the code used for modelling lattice cells was a semi-empirical one, POWDERPUFF. This code has been modified over the years and the current version, called POWDERPUFF V, is still used at some Canadian nuclear power plants. A more fundamental lattice code was developed by Atomic Energy of Canada Limited based on one originally created in the United Kingdom. This code, WIMS-AECL, is being increasingly used for safety analysis and has been adopted as the Industry Standard Tool (IST) for future lattice calculations in all applications. The highly precise measurements made in ZED-2 are being used to validate WIMS-AECL which has been found to have a very high level of accuracy.

ZED-2 measurements of the reactivity worth and flux perturbations caused by CANDU reactivity control devices have also been used to validate code predictions of these effects. The output of the cell codes referenced above serves as input to codes for calculating the reactivity effect of various absorbers in a CANDU core. For years the MULTICELL code was used for this purpose. This is now being replaced by a more accurate code firmly founded on neutron transport theory called DRAGON which was developed at Ecole Polytechnique de Montréal.

Finally there are "finite reactor" codes for determining core reactivity and flux shape which are used for core design and to govern fuel loading and refuelling patterns. (The flexibility of CANDU's on-power fuelling capability presents the challenge of being able to determine, on a daily basis, the reactivity effects of every refuelling operation.) Currently there are three "finite reactor" codes in use for CANDU reactors: RFSP, developed by AECL and used by Point Lepreau and the off shore CANDU operators; SORO, developed and used by Ontario Power Generation; and, HQSIMEX, developed and used by Hydro Québec at Gentilly 2.

The future

Although the work done by the many people associated with ZED-2 has now provided confidence in the codes used for CANDU safety analyse and fuel management, the complexity of the problems and the continued development of new fuel designs means that the need for ZED-2 and its expert team will exist for many years to come.



Rick Jones and Debbie Goldberg are seen in this 1987 photograph of the ZED-2 control room.

Evaluation of Supercell Codes Using ZED-2 Measurements

B. Arsenault and H.C. Chow[1]

Ed. Note: *The following paper was originally presented at the 1999 CNS Annual Conference in Montreal. Although quite technical it illustrates the value of the work done at the ZED-2 reactor.*

Abstract

As part of an effort to assess the supercell methods used to calculate the incremental cross sections representing reactivity devices, a benchmark study was performed by comparison with ZED-2 measurements. ZED-2 is a research reactor used to measure criticality, fine-flux and core-flux distributions for a given lattice arrangement. The measurements selected for the study included various absorbers similar to the light-water liquid-zone controllers and adjuster rods used in CANDU reactors. Two types of supercell calculations were tested by comparison with measurements: the DRAGON code and the WIMS-AECL/SPH/Modified-MULTICELL suite of codes. The flux shape calculated with the supercell codes inside and outside the absorbers was compared with available copper-activation measurements. A full-core ZED-2 model was set up for Reactor Fuelling Simulation Program (RFSP) calculations. The calculated global flux distributions were compared with measurements. The error in modelling the reactivity effect was expressed in terms of the error in the prediction of the change in critical height.

1. Introduction

A decision has been made to use the multigroup transport code WIMS-AECL (Reference 1) for lattice-cell calculations in all future CANDU reactor-physics analyses. Within this framework, 2-group device incremental cross sections, compatible with WIMS-AECL lattice cross sections are required for core simulations. A full-2-energy-group option in the Reactor Fuelling Simulation Program (RFSP) (Reference 2), for static and dynamic core simulations has been developed, and functionally tested, and is currently being validated. Two supercell methods have emerged as candidates for generating 2-group incremental cross sections: the WIMS-AECL/SPH/Modified-MULTICELL suite of codes (Reference 3) and the DRAGON transport code (Reference 4).

An AECL R&D program was initiated to evaluate the supercell methodologies for calculating 2-group device incremental cross sections. In one component of this program, the supercell methods were tested using available ZED-2 measurements performed with various absorbers similar to the light-water liquid controllers and adjusters used in CANDU reactors.

2. Experimental Set-up in ZED-2

ZED-2 is an experimental reactor used to measure criticality, fine-flux and core-flux distributions for various lattice arrangements. It has an open aluminum vessel, surrounded by a graphite reflector. The circular side wall of the calandria vessel has an inside diameter of 336 cm, a thickness of 0.635 cm, and a height of 334 cm. The bottom plate of the calandria vessel is 2.97 cm thick. The graphite reflector surrounding the calandria has a mean thickness of 60 cm. There is a 2.86-cm gap between the calandria vessel and the radial graphite reflector. Below the calandria vessel, there is a bottom graphite reflector, 90 cm thick.

In many experiments, the fuel consisted of 28-element bundles. The fuel stacks were hung vertically down into the core from support rails positioned above the moderator. Each bundle stack was contained in an aluminum pressure tube containing heavy-water coolant, identical to moderator heavy water.

The moderator critical height was measured for the reference lattice without the reactivity device. The reactivity device was then introduced into the core, typically, interstitially at the core centre. If the device was a neutron absorber, it would require an increase in moderator height to maintain criticality. The change in critical height was a measure of the reactivity effect of the device.

3.0 Analysis Methodology

The validation of the supercell methodologies involves two levels of comparison of the flux distribution for each absorbing device. The first level is the

1 Atomic Energy of Canada Limited, Sheridan Park

comparison of the microscopic flux distribution calculated by the supercell codes with the measurement data. The second level is the comparison of the macroscopic flux distribution obtained by solving the diffusion equation in core simulations using RFSP. It also involves the comparison of the predicted reactivity effect of the device with measured values in terms of the change in critical moderator height.

3.1 Basic Lattice-Cell Properties

The ZED-2 reactor was modelled using the RFSP code. The lattice properties provided to the RFSP core model for the reference 28-element fuel lattice were generated using WIMS-AECL version 2-5a. The 89-energy-group ENDF/B-V library was used for this analysis.

3.2 Supercell Methods

Incremental cross sections were calculated for the absorbing devices using both the DRAGON code and the WIMS-AECL/SPH/Modified-MULTICELL suite. The calculations performed with each of these methods were completely independent, and are described in the following subsections.

3.2.1 The DRAGON Code

The DRAGON code was developed by École Polytechnique of Montréal and allows 2-dimensional (2D) and 3-dimensional (3D) lattice-cell and supercell calculations (References 5 and 6). The code solves the transport equation (References 7 and 8). The main characteristics of the code are:

- access to multi-energy-group libraries (the 2D and 3D transport calculation can be performed with the same number of energy groups)
- self-shielding calculation capability
- neutron flux calculation in multi-energy groups from the fundamental mode (using the Bn equation)
- calculation and editing of nuclear properties
- burnup calculation capability, and
- collision-probability solution.

The DRAGON supercell model allows a 3D, mixed cylindrical and Cartesian representation: cylindrical geometry for the absorber and for the fuel channel and Cartesian geometry for the moderator. The latest version used in this study, DRAGON971124.zed2 (References 9 and 10), also allows the rectangular meshes to intersect with the cylindrical mesh. The 89-energy-group ENDF/B-V library was used for all the calculations.

Using a DRAGON supercell model with a fine-mesh structure (especially where a 3D representation is necessary) and a full 89-energy-group calculation is very demanding on computation-hardware resources and computation time. This demand is primarily due to the large size of the collision-probability matrices (region-to-region and region-to-surface) and the large number of energy groups. A standard procedure for the device-incremental-cross-section calculations has therefore been developed and tested. The procedure is sufficiently general to be suitable for all reactivity devices in most configurations. The 3-step process is described as follows:

A 2D basic lattice cell with cluster geometry is treated, and the maximum number of energy groups from the microscopic library is used to calculate the fine-flux distribution. The cross sections are condensed to the number of energy groups specified by the user (typically 33) to be used in Step 3, and are also homogenized over 3 regions: the moderator, the pressure-tube-and-calandria-tube annulus region, and the fuel-coolant-cladding region.

1. With a coarse-mesh supercell model, a full 89-energy-group flux solution is sought. The flux distribution is used to condense the absorber properties to the number of energy groups specified by the user (typically 33 groups). The 89-energy-group properties used in the coarse-mesh supercell model for the fuel, annulus, and moderator regions are obtained from the 2D cluster calculation of Step 1. The 33-group macroscopic cross sections calculated for the absorber device are used in Step 3.
2. A calculation is then performed with a fine-mesh

Table 1: Comparison of the Fine-flux Distributions with the Measurements for the Liquid Absorbers (Surface of the Absorber at 0.0 cm).

	(Measured-Simulated) / Measured (%)					
	DRAGON			WIMS-AECL/SPH/ Modified-MULTICELL		
Distance (cm)	B0	B1	B2	B0	B1	B2
-2.575	+2.78	+0.00	-9.09	-4.03	+1.92	-4.54
-1.908	+2.07	-3.64	-12.00	-4.77	-1.82	-4.00
-0.956	+0.82	-7.24	-11.63	-5.82	-4.35	-2.32
0.163	+1.76	-1.90	-1.94	+0.00	+2.83	+9.71
1.565	+0.85	-1.72	-6.45	-1.98	+1.72	+8.06
1.985	+0.57	-1.69	-6.25	-2.46	+1.69	+7.81
3.695	-0.09	-2.48	-10.45	-3.89	-1.65	+1.49
5.035	-0.10	-4.17	-11.76	-4.80	-4.17	-1.47
6.225	-0.63	-5.13	-13.33	-6.56	-6.84	-4.44

Table 2: B0, B1 and B2 Absorbers / RFSP Simulation Results

	Measured Critical Height H_c (cm)	Measured Critical Height Change ΔH_c (cm)	RFSP Computed K_{eff}	Reactivity Error - $\Delta\rho$ (mk)	Moderator or Level Coef. (mk/cm)	Calculation Error in ΔH_c (cm)	Calculation Error in ΔH_c (%)
	Incremental Cross Sections from DRAGON						
Reference Core	309.264	—	1.00252	—	—	—	—
With B0	321.232	11.968	1.00285	+0.338	0.416	+0.813	+6.8
With B1	340.584	31.320	1.00270	+0.189	0.348	+0.540	+1.7
With B2	351.049	41.785	1.00244	-0.080	0.309	-0.258	-0.6
	Incremental Cross Sections From WIMS-AECL/SPH/Modified-MULTICELL						
Reference Core	309.264	—	1.00252	—	—	—	—
With B0	321.232	11.968	1.00263	+0.109	0.416	+0.263	+2.2
With B1	340.584	31.320	1.00124	-1.275	0.348	-3.664	-11.7
With B2	351.049	41.785	1.00025	-2.264	0.309	-7.326	-17.5

model using the few-energy-group structure (typically 33 groups) to generate the detailed spatial flux distribution and the incremental cross sections homogenized in 2 energy groups.

3.2.2 WIMS-AECL/SPH/Modified-MULTICELL

In this method, the calculation of the supercell properties is based on the solution of the diffusion equation throughout the supercell, but with the absorber material properties formed in such a manner that the reaction rates calculated in the supercell are matched to those predicted by using a simplified WIMS-AECL model through SuPer Homogenization (SPH) techniques (Reference 11).

In the first step, a WIMS-AECL 1-dimensional (1D) model is set up with the absorber surrounded by a fuel annulus at an appropriate distance, typically representing the average distance of the neighbouring fuel channels. With this 1D model, the reaction rates in the absorber are calculated by a detailed transport calculation, using typically 33 energy groups. In the second step, an equivalent model with the same geometry is treated in a diffusion calculation in 2 energy groups to determine the SPH factors to be applied to the absorber cross sections so that the various reaction rates in the absorber match those calculated in the transport-based WIMS-AECL calculations.

A 3D supercell model is then set up for flux calculation in 2 energy groups using the modified MULTICELL. The cylindrical absorber and fuel channels are rectangularized since only Cartesian geometry is allowed. A full 2-group flux solution is sought for all regions delineated by the meshes including the absorber and the fuel channels.

The basic premise of this method is that the correct reaction rates in the absorber are being reproduced in the supercell calculation and that the reactivity rates determined from the 1D WIMS-AECL model are correct.

3.3. RFSP ZED-2 Core Model

A full-core ZED-2 model was set up for 2-group RFSP calculations. The radial and bottom graphite reflectors, the aluminum tank, the D_2O reflector, and the lattice properties were all included in the calculation model. The top of the core was cut off at the moderator free surface, and an appropriate extrapolation distance imposed. The air gap separating the graphite and the tank was smeared with the aluminum tank wall in the model. The axial extrapolation distance was specified to cater to the moderator surface, but was also applied at the bottom end of the ZED-2 model, because RFSP does not distinguish between top and bottom extrapolation distances. This did not introduce any error, since, in any case, the flux drops quickly at the boundary between the core and the 90-cm-thick reflector. The extrapolation distance at the top of each core configuration was established by a cosine fit to the measured axial flux shape.

The 2-group cross sections for 28-element-fuel, the D_2O reflector, the aluminum tank (bottom), the homogenized air gap and aluminum tank wall, and the graphite reflector were calculated using the WIMS-AECL code. The RFSP code version 2-15HP was used throughout this study.

3.4 Benchmarking of the Supercell Methods

The accuracy of the supercell method can be gauged from the fine-flux-shape and global-flux-shape comparisons with measurements and from the comparison of the reactivity effect in terms of change in critical height in the measurements. These criteria are described below.

a. Fine-Flux-Shape Comparisons

The thermal fluxes calculated with the supercell model inside the absorber, along the absorber tube or around its circumference, and in the neighbouring moderator can be compared to

available copper-wire-activation measurements. These comparisons validate the local flux perturbation that is due to neutron absorption and scattering by the absorber materials, and the escape of neutrons from inside the absorber back to the moderator region. The measurements of flux shape were in terms of ^{64}Cu activity. Thus a proper comparison is with the total absorption rate in ^{63}Cu, computed by the supercell code.

For comparison purposes, the calculated ^{63}Cu absorption rates and measured ^{64}Cu activity were normalized to the same value at the surface of the absorber. With DRAGON, in addition to fluxes for each mesh region in the supercell model, a computation of reaction rates can be performed. Thus the ^{63}Cu neutron-absorption rates were computed and compared directly with measured data. With WIMS-AECL/SPH/Modified-MULTICELL, the comparisons were more involved. Inside the absorber, ^{63}Cu absorption rates obtained from the WIMS-AECL 1D model were compared with the measured ^{64}Cu activity. Outside the absorber, the calculated flux shape obtained from the Modified-MULTICELL supercell code was used in the comparisons. The two sets of reaction rates were normalized to the same value (measurement value) at the surface of the absorber.

Table 3: Comparison of the Global Flux Distributions with the Measurements for the Liquid Absorbers. (Measured-Simulated) / Measured (%)

	DRAGON			WIMS-AECL/SPH/Modified-MULTICELL		
Distance from Core Centre (cm)	B0	B1	B2	B0	B1	B2
13.97	-1.77	-7.69	-10.18	-2.18	-6.24	-6.51
41.91	+1.39	-0.34	+1.42	+1.45	+0.21	+3.20
69.85	+1.61	+2.04	+2.87	+1.70	+1.89	+3.54
97.79	+0.74	-0.69	+0.66	+0.74	-1.19	+0.76

a. Reactivity-Effect Comparisons

The reactivity effect of the absorber was measured in terms of change in critical height in the experiment. The error in modelling of the reactivity effect, expressed in terms of error in prediction of critical-height change, was inferred in the following manner. The reference core (without the absorber) was simulated using an RFSP model with an axial core height that corresponded to the measured critical height, and an upper extrapolation distance deduced from global flux-shape measurements. The perturbed core with the absorber inserted was also simulated with an axial core length that corresponded to the measured critical height, and an upper extrapolation distance deduced from global flux-shape measurements. The difference between the two calculated k_{eff} values indicated the error in modelling the reactivity effect of the absorber. It was, however, necessary to translate this k_{eff} error into an error in critical-height change. A moderator-level reactivity coefficient was determined using the perturbed-core configuration but with an arbitrary (1 cm) change in moderator level. Using this coefficient, the error in k_{eff} was converted to an error in critical-height change, which was then expressed as a percent error in the total measured critical-height change.

a) Global Flux-Shape Perturbation

Insertion of an absorber into the core causes a change in the global flux shape. In the experiments, the global flux perturbations were measured with copper wires placed at strategic interstitial locations, both for the reference core and for the perturbed core. These measurements allowed comparisons to the RFSP-computed flux shape, indicating whether

- the core model was properly set up to account for symmetry, and whether the relative neutron production and absorption in the fuel region, the heavy-water reflector and the graphite regions were reasonably predicted, hence adequately reproducing the flux shapes.
- the perturbation caused by the absorber was adequately captured via the set of incremental cross sections.

4.0. Results

This section compares results obtained with a set of light-water-absorber and stainless-steel adjuster measurements.

4.1 Comparison with Light-Water Absorber Measurements

A set of light-water-absorber measurements in ZED-2 is described in References 12 and 13. The absorbers used in these experiments were aluminum tubes containing pure or borated light water, inserted vertically at the centre of the core. Measurements were made with two different square lattice arrangements, with lattice pitches of 22.86 cm and 27.94 cm. Three sizes of liquid-absorber tubes were used, the largest being of outer diameter 6.35 cm, and wall thickness 0.147 cm. Measurements with this tube size were selected for this study because it is the most similar to the dimensions of the liquid-zone controllers in CANDU reactors. The light water in the absorber had 3 different boron concentrations:

1. B0 - Pure H_2O
2. B1 - H_2O + boron (2.5 mg/mL)
3. B2 - H_2O + boron (8.0 mg/mL)

The fine-flux distributions obtained from the supercell simulations were compared with measurements in the radial direction, from the centre of the absorber toward the centre of a fuel channel. The global flux distributions calculated with RFSP

were compared against the measurements in the axial direction, on a line intersecting the centre of the absorber and the mid-point between two fuel channels.

4.1.1 DRAGON Results

The supercell model was 2D, and consisted of four channels with or without the absorber at the centre. The ^{63}Cu absorption rate inside the absorber and in the moderator region was calculated and compared with measured ^{64}Cu activity. Table 1 gives the comparison of the calculated fine-flux distributions with the measurements.

Comparisons of the fine-flux distribution can be considered separately for the region inside the absorber and for the neighbouring moderator region. Inside the absorber, with pure light water, the scattering process competes with absorption. The flux peaking or depression inside the absorber is sensitive to the relative reaction rates, and it is a fairly stringent test of the code to accurately represent the two competing reactions and reproduce the flux shape. On the other hand, when the light water is borated, the absorption reaction becomes dominant.

In the moderator region, the trend of the flux shapes is generally well reproduced by the calculations. The agreement for the B0 absorber case is within 1.76%. With the B1 absorber, the agreement deteriorates but is still within a reasonable range of 5.13%. With the strong B2 absorber, the predicted flux shape in the moderator generally agrees with the measured data, but the absolute magnitude differs substantially.

Table 2 shows, however, that the reactivity effect is very well reproduced for the B2 absorber, to within 1%, which is comparable to measurement uncertainty. For the B1 absorber, the agreement is within 2%. For the B0 absorber, the percent error in critical-height change prediction is equal to +6.8%. A positive sign for the calculation error means the reactivity effect is underestimated.

The measured global flux shape for the reference core in the axial direction at a location near the core radial centre at an elevation near the axial-flux peak is compared with the thermal flux shape computed by RFSP in Table 3. The results show that the calculation scheme over estimates the absorption rate with increasing boron concentration.

4.1.2 WIMS-AECL/SPH/Modified-MULTICELL Results

The fine-flux distributions calculated by the WIMS-AECL/SPH/Modified-MULTICELL method are compared with measurements in Table 1. The flux shape inside the absorber is from the WIMS-AECL model, whereas the flux shape outside the absorber in the moderator region is from the Modified-MULTICELL model. The flux shape inside the B0 unborated light-water absorber is most difficult to predict. WIMS-AECL overestimates the flux increase substantially. This discrepancy is not too surprising, given that the balance between scattering and absorption is sensitive to the spectrum, which in turn is dependent on neutron sources. These are modelled rather crudely in the 1D WIMS-AECL calculation.

Table 2 shows that the reactivity effect is predicted quite well for the B0 absorber. However, the agreement deteriorates as the absorption strength increases, and the reactivity effect of the B2 absorber is overestimated by 17.5%

The calculated global flux shape with the absorber inserted is compared with the measurements in Table 3. The results show that the calculation scheme over estimates the absorption rate with increasing boron concentration.

Table 4: Comparison of the Fine-flux Distributions with the Measurements for the Vertical Adjusters (Surface of the Adjuster at 0.0 cm).

	(Measured-Simulated) / Measured (%)					
	DRAGON			WIMS-AECL/SPH/Modified-MULTICELL		
Distance (cm)	V1	V2	V3	V1	V2	V3
-2.583	—	-2.91	-0.87	—	-0.61	-2.83
-1.970	—	-1.02	+0.42	—	+1.87	-0.68
-0.786	—	-1.32	+0.57	—	+1.27	-0.78
0.440	-0.10	-3.09	+3.08	+0.10	+0.00	+1.48
1.700	+1.70	+1.93	+2.77	+2.59	+4.44	+3.76
2.410	+1.96	+2.37	+3.20	+2.61	+4.12	+3.71
3.830	+2.20	+2.58	+3.57	+1.68	+4.31	+3.03
5.350	+1.73	+2.32	+4.04	-2.10	+3.59	+1.95
6.510	+1.53	+2.29	+4.79	-1.54	+2.83	+1.47

4.2 Comparison with Stainless-Steel Adjuster Measurements

The adjuster rods in CANDU reactors consist of stainless-steel tubes, either with or without a concentric stainless-steel shim rod. In Reference 14, ZED-2 experiments with stainless-steel adjusters of similar design to those of power reactors are described. Measurements of the reactivity effect and flux perturbations were performed with a variety of tube thicknesses and shim-rod sizes, with the adjusters placed vertically (parallel to the fuel) at the core centre.

The reference core contained 52 fuel rods arranged in a square lattice of 28.575-cm pitch. The fuel rods consisted of 28-element natural-uranium fuel. Three adjuster types, with different tube-and-rod combinations, were analyzed. All three

types have a stainless-steel tube of outside diameter 7.62 cm and a wall thickness of 1.713 mm, which are representative of the dimensions of adjusters in the power reactors:

1. Vertical Adjuster Type V1: No Shim Rod
2. Vertical Adjuster Type V2: Shim Rod O.D. 19.08 mm
3. Vertical Adjuster Type V3: Shim Rod O.D. 12.73 mm

The fine-flux distributions obtained from the supercell simulations were compared with the measurements in the radial direction, from the centre of the absorber toward the centre of a fuel channel. The global flux distribution calculated with RFSP was compared with measurements in the axial direction, on a line intersecting the centre of the absorber and the mid-point between two fuel channels.

Table 5: V1, V2 and V3 Adjusters / RFSP Simulation Results

	Measured Critical Height H_c (cm)	Measured Critical Height Change ΔH_c (cm)	RFSP Computed K_{eff}	Reactivity Error - Δp (mk)	Moderator Level Coef. (mk/cm)	Calculation Error in ΔH_c (cm)	Calculation Error in ΔH_c (%)
	Incremental Cross Sections from DRAGON						
Reference Core	308.611	—	1.00462	—	—	—	—
With V1	323.665	15.054	1.00491	+0.287	0.366	+0.784	+5.2
With V2	329.181	20.570	1.00458	-0.040	0.357	-0.111	-0.5
With V3	326.581	17.970	1.00441	-0.208	0.386	-0.539	-3.0
	Incremental Cross Sections From WIMS-AECL/SPH/Modified-MULTICELL						
Reference Core	308.611	—	1.00462	—	—	—	—
With V1	323.665	15.054	1.00497	+0.347	0.366	+0.947	+6.3
With V2	329.181	20.570	1.00447	-0.149	0.357	-0.417	-2.0
With V3	326.581	17.970	1.00463	+0.010	0.386	+0.026	+0.1

4.2.1 DRAGON Results

Table 4 shows the comparison of the fine-flux distribution calculation with measurements. The results of the calculation were normalized to be the same as the measurements at the surface of the adjuster tubes. In the cases of the V2 and V3 adjusters, which have a central shim rod, the fine-flux distribution inside the adjuster was also compared and showed very reasonable agreement. The flux shapes in the nearby moderator region are also in general good agreement, with a maximum difference of about 5%.

The RFSP simulation results for all cases are summarized in Table 5. The agreement between the measured and calculated reactivity effect is very close in all cases, with or without the shim rod, and for different sizes of the shim rod.

The comparison of the RFSP-calculated global-flux-shape distribution with the measurements is given in Table 6. In general, the agreement is very satisfactory with a maximum error of -4.33%.

4.2.2 WIMS-AECL/SPH/Modified-MULTICELL

The fine flux-shape comparisons are presented in Table 4. The results of the calculations were normalized to the measurement values at the surface of the adjuster tube. The flux shape in the nearby moderator region is in good agreement, with a maximum difference of 4.4%.

The reactivity effect comparison is given in Table 5. The agreement with the measured reactivity effect is very good, the worst case being the 6.3% overestimate for the V1 (tube-only) adjuster. The degree of agreement is quite comparable to that obtained using DRAGON increments.

Comparisons of the global flux-shape distribution are presented in Table 6. The same degree of agreement with measurement data as obtained using DRAGON incremental cross sections is observed.

5.0 Conclusion

Based on the results presented in the tables, DRAGON supercell calculations gave very good overall agreement in the case of liquid absorbers with a range of absorption strengths and in the case of various adjuster rod-and-tube designs. Good agreement is shown in fine- and global-flux-shape comparisons, as well as in reactivity-effect comparisons. The WIMS-AECL/SPH/Modified-MULTICELL calculations gave good overall agreement in the case of the unborated liquid absorber and in the case of various rod-and-tube adjuster designs. However, with borated light-water absorbers, the reactivity-effect comparison shows a maximum calculation error of about 20%.

References

1. J.V. Donnelly, "WIMS-AECL: A User's Manual for the Chalk River Version of WIMS", AECL Report, AECL-8955, 1996.
2. B. Rouben, "Overview of Current RFSP-Code Capabilities for CANDU Core Analysis", AECL Report, AECL-11407, 1996

Table 6: Comparison of the Global Flux Distributions with the Measurements for the Vertical Adjusters. (Measured - Simulated) / Measured (%)

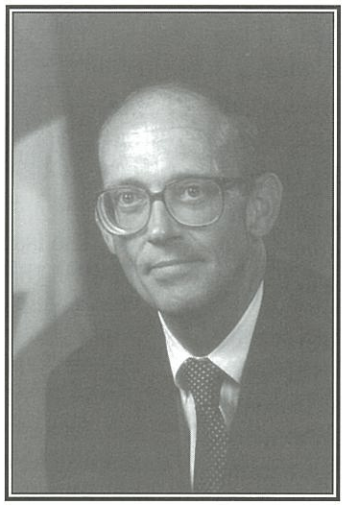
	DRAGON			WIMS-AECL/SPH/Modified-MULTICELL		
Distance from Core Centre (cm)	V1	V2	V3	V1	V2	V3
14.29	-0.18	-2.34	-4.33	-2.22	-2.51	-4.50
42.86	+1.73	+2.55	+0.56	+1.69	+2.55	+0.56
71.44	+1.91	+2.42	+0.42	+1.91	+2.38	+0.46
100.01	-0.78	-0.59	-1.96	-0.78	-0.30	-1.90

January.

3. B.J. Min and J.V. Donnelly, "WIMS-AECL/MULTICELL Calculations with SPH for Wolsong-1 Reactivity Devices", Proceedings of the Korean Nuclear Society Spring Meeting, 1996 May.
4. G. Marleau, A. Hébert and R. Roy, "A User's Guide for DRAGON", Report IGE-174, Revision 1, École Polytechnique of Montréal, 1996 March.
5. G. Marleau, A. Hébert and R. Roy, "New Computation Methods Used in the Lattice Code DRAGON", Topical Meeting on Advances in Reactor Physics, Charleston, SC, March 8-11, 1992.
6. G. Marleau, R. Roy and A. Hébert, "DRAGON: A Collision Probability Transport Code for Cell and Supercell Calculations", Report IGE-157, École Polytechnique of Montréal, 1993.
7. R. Sanchez and N.J. McCormick, "A Review of Neutron Transport Approximations", Nuclear Science and Engineering, 80, p. 481-535, 1982.
8. R.J.J. Stamm'ler and M.J. Abbate, "Methods of Steady State Reactor Physics in Nuclear Design", Academic Press, New York, United States, 1983.
9. A. Hébert, G. Marleau and R. Roy, "A Description of the DRAGON Data Structures", Report IGE-232, École Polytechnique of Montréal, December 1997.
10. G. Marleau, "The Excell Geometries Numbering Scheme in DRAGON", Report IGE-233, École Polytechnique of Montréal, December 1997.
11. A. Hébert and G. Mathionnière, "Development of a Third-Generation Superhomogenization Method for the Homogenization of a Pressurized Water Assembly", Nuclear Science and Engineering, 115, 124-141, 1993.
12. R.E. Kay, "Zone Control Absorber Experiments in ZED-2", AECL Report, AECL-2694, 1967 May.
13. F.N. McDonnell, "Liquid Absorber Experiments in ZED-2", AECL Report, AECL-5025, 1975 July.
14. R.T. Jones, "Adjuster Rod Experiments in ZED-2", AECL Report, AECL-5833, 1977 August.

Meet Bill Clarke, the new CNA president

Preamble: Along with moving its offices to Ottawa in March, the Canadian Nuclear Association acquired a new president, William L. Clarke, who comes to the CNA after 34 years with the federal government in international affairs with the former Department of Industry, Trade and Commerce and the Department of Foreign Affairs and International Trade. He has served as Ambassador to Sweden and to the Baltic Republics and, most recently, as Assistant Deputy Minister, International Business and Chief Trade Commissioner.



Given the historical relationship of the Canadian Nuclear Society with the CNA and the expected interest of readers of the CNS Bulletin, we asked Bill Clarke for an interview. Despite being on the job for less than three weeks he quickly agreed. Following are excerpts from a very interesting 1½ hour conversation with this former diplomat, now spokesperson for the Canadian nuclear industry.

Q. Given your long and successful career in international affairs why did you decide to take on the task of president of the Canadian Nuclear Association?

A. After 34 years with the government I felt like a change and having reached the age and service for retirement I chose to do so. Having spent so much time abroad I wished to settle down in Ottawa. When I learned of the opening with the CNA, and having some involvement with nuclear sales abroad, I decided to apply and, fortunately, was chosen for the position of CEO and president of the Association. Now, I am looking forward to the task. The nuclear industry has many good messages which we need to get out and there are real opportunities. Also, I have spent considerable time in the past helping with nuclear sales abroad.

Q. What do you see as the primary objectives of the CNA over the next year or two?

A. I have had some good comments from the CNA Board and have spent the first 2½ weeks calling on members of the Association. The first priority identified is to communicate clearly the importance of the Canadian nuclear industry in the Canadian economy to government policy makers. This will include the key role that nuclear power can make in the climate change issue by avoiding emissions of "greenhouse" gases. I believe that message will be well received by government politicians and officials, and by the general public.

Of course, many (NGO) groups will oppose any role for nuclear but I am convinced that most government officials accept the need for nuclear to meet our targets for reduction of "greenhouse" gases. I was aware of the symposium sponsored by the Canadian Nuclear Society on climate change last fall and the positive results from it. That symposium and a proposed follow-up one was brought up at the recent "Globe 2000" conference in Vancouver. In this context, I liked the speech by [former CNA president] Murray Stewart (on nuclear and the Kyoto protocol) and he has agreed that we may use it

Q. How do you propose that the CNA pursue these objectives?

A. One method that we propose to get the message across to key people is to prepare a brief "fact sheet" that would be sent by fax to key people perhaps every two weeks. In addition, I propose to meet personally with as many politicians and government officials as possible, both to present information about the nuclear industry and to learn their concerns and questions. As a former public servant I believe that most officials will welcome representatives of the private sector if they come to help with key issues rather than to present a confrontational message.

Q. What advantages and disadvantages do you see in the move of the CNA to Ottawa?

A. On a personal level I was pleased since I wished to remain in Ottawa. I believe there are a number of advantages and feel that the CNA Board made the right decision. It is much more effective to carry the nuclear message to key people in the federal government when you are located here and can meet them easily, not only in their offices but also socially. Through direct contact you also learn more easily of "scuttlebutt" and rumours to which you might wish to respond.

The disadvantage is that we are somewhat separate from many of the key players in the nuclear industry who are locat-

ed broadly in the Toronto area. To ensure that is not a serious disadvantage I am embarking on a travel program to visit all or most of the member companies of the Association. Personally, half the fun of the job is getting out, seeing the facilities, meeting people and seeing what they do.

Q. Will the CNA register as a "lobby" organization?

A. The Association is already registered with the federal and Ontario governments as a lobby organization. At the federal level this was required by new legislation in the early 1990s.

Q. Does it concern you that the federal departments, Natural Resources Canada and the Department of Foreign Affairs and International Trade, have decided to cancel their membership in the CNA, presumably because of CNA lobbying?

A. Lobbying has a pejorative tone, we prefer "advocacy". Virtually every national organization has registered because of the wording of the legislation. Nevertheless a number of government departments have become members of some of those organizations by differentiating between the "lobby" activities and other activities of the group in question. That was the case for NRCan and DFAIT. Given that the CNA has decided to be much more active in its advocacy role, the two departments decided they should withdraw. In my view, as CEO of the CNA, I think that it may be a good decision for the Association because it will clarify relations and we will not be taking advocacy actions towards our own members.

Q. It is recognized that public opinion is a critical factor in the future of nuclear power. Does the CNA have any plans in this area?

A. I agree that public acceptance is absolutely essential. There are some encouraging numbers from polls taken in the USA where it appears that public support for nuclear energy is stronger than most people (and politicians) think it is. In a recent poll in the USA, 62% said that nuclear power should be an important part of the country's energy mix. There are similar positive figures coming from Sweden and Germany even though there are official policies to phase out nuclear power. For our part, the CNA has decided to commission, this year, some polling of attitudes of the Canadian public towards nuclear energy by a leading organization, to identify the issues people perceive as important about the use of nuclear energy. With that information we will then decide what, if any, further steps the Association should take in this regard.

Q. What plans does the CNA have to try to achieve more balanced reporting of nuclear news by the media?

A. The first step is to learn about public attitudes, as discussed in the context of the last question. With that information we can contact the media and provide the factual background. I believe that we will find that the Canadian public accepts nuclear as part of the energy mix, especially in the light of concerns about climate change. In the meantime we can reach out through good speeches such as that by Allen Kilpatrick [CEO of Atomic Energy of Canada Limited] to the Canadian Club in Ottawa, April 18, which received fairly positive coverage. We will continue to respond to all media inquiries but feel we must be careful about getting into media interviews which can be distorted. One thing that we can do, and intend to do, is to go to columnists and editorial boards and provide the facts.

Q. The issue of Russian MOX has arisen again in the media. Will the CNA be taking any steps to clarify the distorted media messages?

A. We feel that we must be discrete. This is primarily a federal government issue arising from international disarmament concerns. It is the government that decided the tests would be done at the Chalk River Laboratories of AECL. Personally, I support the [MOX testing] program as one step to help Russia disarm and believe most officials do also.

Q. Will the CNA be supporting initiatives to encourage expansion of nuclear programs in Canadian universities?

A. I would like to see how we can help. However, we are a relatively small group with limited resources and have already chosen our focus. I believe this is an area more in the realm of the Canadian Nuclear Society. I suggest that the best approach is to get out a positive message that the Canadian nuclear industry is active, efficient, and forward thinking, with a definite future. If universities and students receive such a message further programs and attendance should follow.

Q. How do you see the ongoing relationship of the CNA with the CNS?

A. We touched on one aspect in the previous question. I want to meet with the CNS executive as soon as possible and hope to attend the CNS Council meetings. The CNS can help in getting the message across to government people. Some messages are better coming from technical or scientific people rather than from industry. Although the CNA has dropped their annual conferences we will be supporting the CNS ones and, in fact, I will be speaking at the upcoming CNS Annual conference in June. Despite the physical separation we should be able to share and cooperate in many ways.

Nuclear Industry Winter Seminar

- increased government representation at annual event

This year's *Nuclear Industry Winter Seminar,* the annual review of the Canadian nuclear program aimed at federal parliamentarians and officials, was held February 14, 15, 2000, in Ottawa as usual. There was a significantly larger number of government representatives than in past years among the more than 125 delegates at the event which was sponsored by the Canadian Nuclear Association and the Canadian Nuclear Society.

At the opening dinner the guest speaker was **Brian George** who, among other roles, is vice-president of the Royal Academy of Engineering of the UK. In that position he was very much involved in the 1999 report jointly prepared by the Academy and the Royal Society on "Nuclear Energy - the future climate". (See Vol. 20, No. 2 of the *CNS Bulletin* for a summary of that report and Vol. 20, No. 4 for a review.) He reviewed the main points of that report and its broad message that, despite the current negative attitudes, "it is vital to keep the nuclear option".

Brian George

Allen Kilpatrick

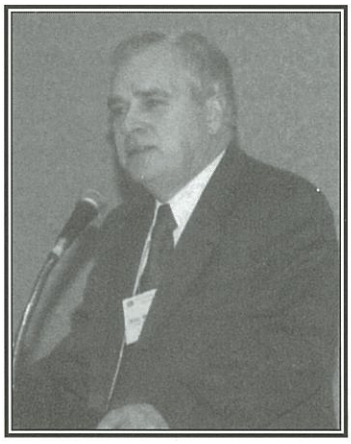
Opening the full day seminar CNA chairman **Tom Gorman** reported on the changes underway at the Association and the move of its offices to Ottawa (which took place in mid March). He acknowledged the work of Murray Stewart as president over the past five years and informed that an announcement would be made shortly about the new president. CNS president **Krish Krishnan** gave a quick overview of the Society's activities and noted the move of the CNS office in Toronto. He closed with an appeal for support of university nuclear programs and urged delegates to join the CNS.

Ron Osborne, president and CEO of Ontario Power Generation Inc. set the scene for the day with an update on his company's progress over the first ten months of its existence. (See elsewhere in this issue of the *CNS Bulletin* for a reprint of much of Osborne's talk.) He noted that a fundamental difference between the previous monopoly situation of Ontario Hydro and the coming competitive one is that a monopoly fears too little capacity (and therefore tends to overbuild) while a competitive company fears too much capacity. In the latter regime cost is the determining factor.

President and CEO of Atomic Energy of Canada Limited, **Allen Kilpatrick,** reviewed the potential markets for CANDU. The decision on the bid to Turkey was due the end of February. *(Ed. Note: The decision was deferred further and had not been announced at the time of writing.)* Korea plans two more units at Wolsong but has not decided on the technology. China has indicated that it will not discuss further units until the two at Qinshan III are completed. AECL has bid on a new research reactor in Australia. "There is a limited market", he commented, "but AECL will get its share".

Kilpatrick commented that AECL is holding ongoing discussions with its shareholder (federal government) to obtain the flexibility needed in the competitive marketplace. Only if the capital cost of plants is reduced is there is a role for nuclear, he emphasized. The nuclear industry cannot rely on environmental concerns, he added. In closing he emphasized, "our long term success will depend to a large degree on the extent to which we are successful in persuading the public that we have a safe, economic, emission free source of energy generation".

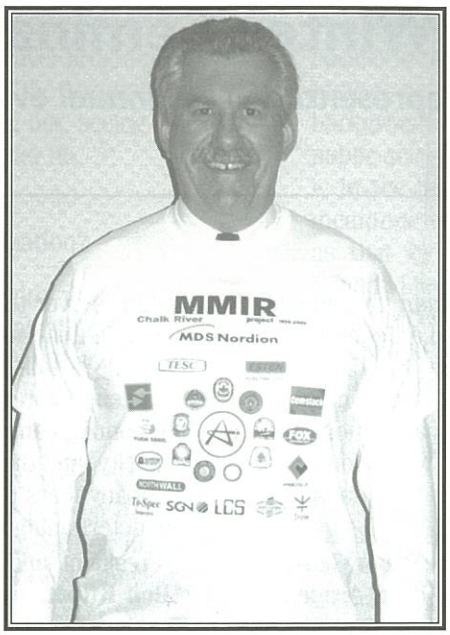
Another perspective on the nuclear power program, from the uranium industry, was provided by **Bernard Michel,** chair, president and CEO of Cameco Corporation.



Brian McTavish

Davinder Valeri

(See excerpts from his talk elsewhere in this issue of the *CNS Bulletin.*) The key factors affecting the electricity generating sector are, he said; deregulation, consolidation, privatization, and climate change. Noting that the uranium industry has already gone through privatization he commented that a major change is that shareholders of private companies have a very short time horizon compared to that of government. Uranium demand is relatively predictable, he observed, but supply is not. Uncertainties come from the existing inventories, potential exports from Russia and FSU states, and fissile material from dismantled nuclear weapons. In conclusion he commented that the signs are positive but the industry must rise to the many challenges facing it. "Nobody will do it for us, we must do it ourselves."



Grant Malkoske of MDS Nordion shows off the special shirt displaying logos of all organizations involved in the Maple Medical Isotope Reactors, at the Nuclear Industry Winter Seminar in Ottawa, February 25, 2000.

Grant Malkoske, vice-president MDS Nordion, gave another of his impassioned talks on the radioisotope business. "Fuel was loaded in Maple I yesterday", he announced, referring to the first of the two isotope reactors built by Nordion at AECL's Chalk River Laboratories. (Maple I achieved first criticality a few days later, February 19.)

AECL vice-president, **Bill Hancock,** reviewed the innovative studies underway towards reducing capital cost and improving safety and performance of future CANDU plants. (See the paper by David Torgerson in Vol. 20, No. 4 of the *CNS Bulletin.*)

John Roots, of the National Research Council, spoke on the need for the proposed Canadian Neutron Facility (CNF) for neutron based materials research. (At the end of his presentation Hec Clothier, M.P. for Renfrew, Nipissing, Pembroke, rose from the audience to give his enthusiastic support for the project.)

After lunch, **Dr. Agnes Bishop**, president of the Atomic Energy Control Board, provided an update on the *Nuclear Safety and Control Act.* She reported that the final proposed Regulations for the new Act would be presented to the Board on March 23. Following Board approval-in-principle the Regulations will be submitted to Cabinet through the Minister. Once approved formally at that level a date will be set for the new Act to come into force. On that date the Board will become the Canadian Nuclear Safety Commission

It is recognized, she said, that certain members of the industry will not be able to comply immediately with some of the new regulatory requirements. "For this reason, at its first meeting the Commission will consider temporary exemptions that could be up to two years for certain requirements", she added.

Dr. Bishop made specific reference to the requirement for financial guarantees in the new Regulations. "It should be noted", she said, "that financial guarantees are already required under the present Uranium and Thorium Mining Regulations."

Referring to her involvement in the International Nuclear Regulators Association she mentioned some common concerns, such as organizational management and succession. On the latter point Dr. Bishop reiterated her concern about the lack of young people entering the nuclear field.

Robert Connelly, vice-president, Canadian Environmental Assessment Agency, noted that the mandatory five-year review of the Environmental Assessment Act is underway and invited input. A background report is available.

Brian McTavish, senior vice-president, OPG, provided an update on the plans to restart the four units of the Pickering "A" station. Among other changes being made, the shutdown systems are being improved to meet regulatory requirements and fire protection is being upgraded.

The last speaker was **Davender Valeri**, a young engineer from AECL-SP, who spoke about her involvement with the Young Generation Network in support of nuclear at the COP 5 (post Kyoto) meeting in Bonn last fall. (For a report on the YGN at COP 5 see Vol. 20, No. 4, of the *CNS Bulletin.*)

The increased number of government representatives attending the sessions made this year's Winter Seminar one of the most successful of recent time.

CNA past-chairman Lloyd Jones (R), presents a gift to outgoing CNA president Murray Stewart in recognition of his service to the Association, at the Nuclear Industry Winter Seminar in Ottawa, February 15, 2000.

Nuclear Industry Winter Seminar

A Report on OPG

- *Ontario Power Generation president Ron Osborne reviews the first ten months of the new company*

Ed. Note: The following is a slightly edited (for publication) version of the speaking notes used by Ron Osborne, president and CEO of Ontario Power Generation, for his address to the CNA / CNS Nuclear Industry Winter Seminar held in Ottawa, February 15, 2000.

Introduction

Ontario Power Generation is a new company. It was created just 10 months ago, as part of the provincial government's decision to deregulate Ontario's electricity industry and allow open competition into the marketplace. The new market is scheduled to open this November.

The electricity sector is undergoing major changes. This talk is about these changes, Ontario Power Generation's role in the new market, and why we believe we are in a good position to succeed.

Electricity restructuring

Electricity industry restructuring follows that of other major industrial sectors – such as telecommunications, natural gas and financial services. Other countries – the U.K., Australia and New Zealand come to mind – are well advanced in deregulating their electricity industries. In the U.S., the pace of deregulation is increasing. Five years ago, fewer than 10 states were restructuring their electricity sectors. Today, there are at least 40.

We're also seeing electricity industry consolidation on a massive scale. The proposed merger of Unicom and PECO in the U.S. represents combined assets of $31.8 billion (U.S.), and brings together two companies with major nuclear programs. The planned $30 billion (U.S.) merger of American Electric Power with Central and South West Corp. will create one of the largest generators in North America at 38,000 megawatts. These would be major energy powers stretching across large parts of the continent.

As in financial services, as in telecommunications, as in media and entertainment....size matters in the electricity business and will increasingly be a key success factor. New competitors have already declared their interest in the Ontario retail electricity market. Duke Energy – one of the largest electricity companies in the U.S. – has acquired an energy services company here in Toronto. Enron, the largest U.S. energy marketer, is here as well. All this new competition promises to bring higher levels of innovation ... more choice ... and more customized products and services. Competition will be good for customers – wholesale and retail.

Ron Osborne

Ontario Power Generation's focus is on the wholesale side of the electricity business, as a result of how our industry has been restructured. The retail side of the industry has historically been the responsibility of the municipalities, while the transmission business and a rural retail business lies with Ontario Hydro Services Company.

The Ontario wholesale market for electricity promises to be very competitive. Over the past year or so, in response to the government's announcement that the electricity market would be deregulated, a number of companies have announced new electricity generation projects here in Ontario. The most recent was Sithe Inc., which is planning to build two 800 megawatt plants in Mississauga and Brampton. They will join TransAlta's 525 megawatt generating station planned for Sarnia, and a number of other announced projects totalling an additional 600 megawatts. We look forward to competing with these companies on a level playing field where all participants are subject to the same market rules.

Decontrol

New players will also emerge as Ontario Power Generation reduces its presence in the Ontario market. Currently we have an 85 per cent share of the market for electricity generation. To ensure competition in generation, we must reduce our control over electricity generation in two phases over the next 10 years. The first phase involves the decontrol of 4000 megawatts of mostly fossil-fuelled generation by 2004. The second

phase, to be completed by 2010, involves the additional decontrol of our assets so that we will represent no more than 35 per cent of the supply options available to the province.

We have many decontrol options. We could swap generation, lease our facilities, or sell assets. The result will be more players and more choice for electricity customers.

In response to the request of the Minister of Energy, Science and Technology that we accelerate the schedule for decontrol, we will provide within the next month to the Minister and to the province's SuperBuild Corporation our plan for meeting the first phase objective. We are targeting roughly 4,000 megawatts of hydroelectric and fossil generation including our 2,100 megawatt Lennox station near Kingston, and our 1,100 megawatt Lakeview station in Mississauga. Our goal is to meet our Phase 1 objective of decontrolling 4,000 megawatts prior to the market's scheduled opening in November. This would be more than three years earlier than required.

Our goal is to decontrol 4,000 megawatts by November

Any deals we make will protect the value of these investments and our shareholder's interests. There will be no fire sale of assets.

We are also moving quickly on another front. Last fall we began seeking public-private partnerships for our Bruce Nuclear facility near Kincardine. This includes 3000 megawatts at the temporarily laid up Bruce A station, and a similar amount of operating capacity at our Bruce B station. We have already met with several potential partners and expect to report soon to our shareholder on these discussions.

When added to the 2700 megawatts of planned independent generation in Ontario, the 1700 megawatts that independent generators supply today, and the 4000 megawatts that can be brought into the province through interconnections with other jurisdictions, by this time next year we could see up to 15,000 megawatts provided by other companies. Another way of looking at these numbers is that non-Ontario Power Generation sources could control more than 40 per cent of the electricity generation available to the province.

Competition in electricity generation will be a reality. We intend to be very competitive, and we look forward to proving it.

Operating performance

In terms of overall performance, we had a satisfactory first year.

Our nuclear stations generated eight per cent more electricity than planned. Last year, nuclear power satisfied almost half of the province's need for electricity – that's all the power needed by the large industrial users in Ontario plus all the residential, commercial and industrial customers in the cities of Toronto, Ottawa, Hamilton and Mississauga.

Our hydroelectric production almost hit plan, in spite of dry conditions last year. We carefully husbanded the water available to us while respecting the needs of other users.

Our fossil-fuelled stations consistently rose to the occasion, doing what they do best – ensuring that customers are reliably served during high daily and seasonal demand periods. And we are very careful to minimize any negative environmental impacts produced by those plants – a point I will return to later on.

We were especially successful in meeting customer demand last summer, when many U.S. jurisdictions experienced power shortages and very high prices. Despite high temperatures and seven new summer customer demand records, OPG was able to meet the needs of the province without any disruption in service.

During 1999, we made progress towards our goal of world class nuclear performance. Our nuclear plants used to be mired in the bottom quartile of the nuclear power industry. Over the past two years they have moved up slowly, making headway against a North American nuclear industry that is also registering performance improvements. There is still a gap to bridge. Our nuclear improvement progress has been slower that we hoped. This reflects the enormity of the task. We remain committed to reaching our overall nuclear performance objective of top quartile performance by 2003.

We plan to return to service the four units of our Pickering A nuclear plant. This project is subject to all regulatory approvals, including the approval of an environmental assessment. Our cost estimates are being analysed independently, to confirm the soundness of our approach. The Pickering re-start would add 2000 megawatts of what promises to be, without exception, the lowest cost energy in the province on an incremental basis.

Environmental performance

Over 99 per cent of our installed generation has received ISO 14001 certification – the international standard of excellence in environmental management. Our environmental management systems are subject to regular external audits. We are one of the first generating companies in North America to have all its major facilities registered under this standard.

Collectively, our electricity production facilities produce some of the cleanest power in our airshed – which stretches from Tennessee to Michigan and into Ontario.

Our nuclear stations produce virtually no acid gases or greenhouse gases of any kind. Thanks to nuclear energy, our air is considerably cleaner than it otherwise would have been. Between 1971 and 1999, use of nuclear power in this province has avoided:

- 11 million tonnes of sulphur dioxide, which causes acid rain
- 2.5 million tons of nitrogen oxide, which contributes to acid rain and smog; and

- 1.2 billion tonnes carbon dioxide, which is a greenhouse gas that contributes to global warming.

Nuclear energy is making a major contribution to our environment.

Nuclear energy is making a major contribution to our environment. If we as a nation are really serious about meeting Canada's greenhouse gas emission targets as set by the Kyoto Conference on Global Warming, then one of the best ways to do that lies right here in this province – with the 9,000 megawatts of nuclear power OPG currently operates and the 2000 megawatts of additional clean, competitively priced power from our proposed restart of Pickering "A". If our laid up Bruce A station can be brought back into service either by us or a new investor, this would also contribute another 3,000 megawatts of clean electricity.

In addition we have 7,000 megawatts of hydroelectric power, which also has no emissions.

The environmental record of our fossil-fuelled stations and of our ongoing efforts to reduce air emissions is noteworthy. Through continuing investments in technology, such as sulphur dioxide emission scrubbers, improved low nitrogen oxide burners, and our use of low sulphur coal, our coal-fired plants produce the same amount of energy they did 15 years ago, but with 60 per cent fewer emissions of acid gas.

Our generation mix is cleaner than that of any power company in our future market area. Electricity generated to serve Ontario produces significantly less air pollution than electricity that powers states such as Michigan, Illinois, Indiana, and others to the south, which rely mostly on coal-fired generation. In fact, these states contribute much more to southern Ontario smog than do our facilities. Various studies show that our fossil stations add between 2 per cent and 8 per cent of the nitrogen oxide that leads to smog. Even under the worst case scenario it is clear that most of the pollutants originate from U.S. sources upwind of us, as well as from vehicles and industries here in the province. I know that there is a higher level of expectation attached to us, and we will strive to live up to these expectations. But the reality is that we are only a small part of the smog problem.

We will obviously respond to the recent emission regulations introduced by the province and will do whatever is necessary to comply with them. In terms of comparisons with the U.S., we will meet the new U.S. Clean Air Act emission rate standards for sulphur dioxide and nitrogen oxide this year. With planned technology improvements, we will better the standard for nitrogen oxide emissions by 10 per cent in 2001. Our emissions performance, and our adoption of the ISO 14001 standard, will help set us apart from the competition in the eyes of electricity customers.

Nuclear waste

In the area of nuclear waste, our commitment is absolute. Our nuclear plants produce small amounts of waste. In fact, all 12 of our operating nuclear power units generate only 600 cubic meters of waste annually – you could fit it all in three suburban garages. Every ounce of that waste is captured, accounted for and stored safely.

We accept that the nuclear industry must be responsible for long term management of reactor waste. To this end, last year we allocated more than $400 million to segregated funds for long-term nuclear waste disposal and decommissioning of nuclear reactors. This year, and in future years, we will set aside similar amounts. When the time comes to decommission our nuclear units, and to permanently deal with their wastes, we will have the funds available. We continue to work closely with the federal Department of Natural Resources to develop an industry-wide approach to managing nuclear waste over the long term.

Labour relations

One of the most important initiatives in preparing to compete and win in the new marketplace. is labour relations. It's no secret that relations with unions were poor under Ontario Hydro.

With the co-operation of our union leaders, we have struck a partnership agreement with both of our large unions to foster a more collaborative relationship. This partnership approach will be important to our decontrol process as we seek to ensure that we maximize value to the province and protect the interests of our employees. And we are exploring the possibility of introducing gainsharing to all employees, so that a portion of their compensation is tied to performance. Last year, 6,000 of our employees were eligible.

Real cultural change will only occur when everyone has a stake in the performance of the company. While there is obviously room for further improvements in this area, much progress has been made.

Business relations

We are forming new partnerships in key business areas, again with the active support of our unions.

In information technology, we plan to set up a joint venture with a major IT company to create a new stand-alone company that will provide information technology services to Ontario Power Generation and to other energy companies.

On the R&D front, Ontario Power Technologies – our technical-innovation and development arm – is forming a partnership with AEA Technology of the U.K., Scientech of the U.S., and CANATOM in Canada. Upon closing the deal, the three new partners will have a 10 per cent stake in Ontario Power Technologies and options on a further 40 per cent. They bring considerable marketing and technology development capabili-

ties to the venture. In the area of strategic procurement, we have achieved nearly $40 million in annualized savings so far and expect to eventually save at least $100 million per

Long term strategy

Our longer term strategy is to become a major North American competitor. Our immediate priorities are to improve our financial position, enhance our nuclear performance, accomplish our decontrol objectives, and return Pickering A to service. Once these objectives are secure, our plan is to move more aggressively into the U.S.

Our long term strategy is to become a major North American competitor.

Ontario will always be our home market and a major focus for our business endeavours. But, as competition accelerates, we also need to look at growth opportunities beyond our borders – specifically in the U.S. According to the U.S. Department of Energy, over the next two decades there will be a need for about 400,000 megawatts of new electrical generation in the U.S. In addition to opening new opportunities to us, expansion into the U.S. will offer benefits to our shareholder, and the people of Ontario.

The contribution we make to the province now is already considerable. We employ 15,000 highly skilled employees, and we pay out over $1 billion in annual salaries – which go towards personal taxes, major purchases like houses and cars, consumer goods of all kinds, and investments in companies here and across Canada. We purchase $1 billion a year from suppliers, 80 per cent of whom are based in Ontario. Our head office in Toronto attracts and supports a wide range of professionals adding significantly to the city's critical mass of knowledge workers.

The revenues we earn in Ontario, will stay in Ontario…and much of the money we earn abroad will be repatriated to the province – in the form of R&D, salaries, capital investment, pension contributions, environmental and community initiatives and corporate taxes. Not to mention helping to pay down the historical debt of Ontario Hydro.

In addition… as an Ontario based, North American competitor, our head office presence will remain strong. There will be plenty of room for investment from all parts of the world. But we want to ensure that there will be at least one strong Ontario-based generator whose focus is on benefitting the province. We intend to be that company.

Conclusions

Our prospects for success in a larger North American market are excellent.

We have one of the most flexible, reliable, and clean generation mixes on the Continent.

We have one of the lowest marginal cost structures in our market area, which will allow us to deliver very competitive prices.

We will leverage all of these strengths to the advantage of our shareholder, the people of Ontario.

We have the performance, the people, the expertise, and the plan to succeed.

We will succeed…for the benefit of our employees, our customers, and Ontario.

Nuclear Industry Winter Seminar

A view from the uranium industry

by Bernard M. Michel

Ed. Note: The following is a slightly edited version of the speaking notes used by Bernard Michel, Chair, President and CEO of Cameco Corporation, for his address to the CNA/CNS Nuclear Industry Winter Seminar *held in Ottawa, February 15, 2000.*

The following is my view of the forces which are shaping the future of the nuclear power industry, which I will call the "industry", along with some comments on my own sector, the uranium mining business.

It is clear to everyone that the industry is undergoing a profound and durable transformation. In the future, it will be:

- dominated by few large players
- owned through multinational structures
- selling electricity beyond regions and borders
- seeking customers who are free to choose their supplier of electricity
- part of a balanced electricity generation mix and, most importantly, cost competitive.

While the industry faces public acceptance and economic challenges, particularly as far as new projects are concerned, I am of the view that it is advancing in the right direction.

I see encouraging sign posts which read:

- deregulation
- consolidation
- privatization
- climate change.

Let us look at each of them.

Deregulation:

This is a term which now belongs to the language of electricity producers. It means, in general, the withdrawal of governments from the business of providing electricity to captive markets and, in most cases, the end of regional market monopolies.

It results in a fierce competition for the consumer dollar. It takes many different forms, depending upon a variety of national and local policies, yet the consequences are generally the same everywhere: The industry must meet, and beat, competition and will do that through improving operating performances.

Bernard Michel

Consolidation:

Faced with the challenge of deregulation and the open competition which comes with it, nuclear utilities world wide are restructuring through merger and acquisitions, thus achieving economies of scale and optimum use of critical human resource expertise. These new super nuclear utilities present new challenges to those who participate on the supplier side in the nuclear industry. They have enormous buying power and are committed to cutting costs.

Examples of consolidation abound.

In the US, one expects to see the number of nuclear operators decrease from 40 today to only 10 or 15 some ten years from now. In Germany, four utilities have announced plans to consolidate. As a result, two large companies will emerge to operate 12 nuclear reactors representing 68% of Germany's nuclear generating capacity.

Deregulation and consolidation go hand in hand. The first demands competitiveness — the second delivers it and the results already are spectacular.

Let us look at US nuclear capacity utilization. It was, on average::63% in the '70s; 74% in the '90s, and last year was above 80%. Increasing capacity utilization through flawless operation and shortened refuelling periods results in cheaper, more competitive electricity.

As an example of how significant improved performances are.

If the 25% least performing US reactors would improve to achieve a capacity utilization factor

equal to that of the average of all US reactors, the impact on nuclear generation in the country would be similar to adding eight new average size reactors to the grid!

And, I would be failing in my duty to Cameco's shareholders if I did not note the direct relation between capacity factors and uranium consumption. If utilities around the world were able to sustain an average capacity factor of 85%, compared to the current rate of 78%, annual uranium consumption would increase by some 11 million lbs U3O8 per year, a considerable amount given the current supply constraints.

Privatization

It is unavoidable that deregulation, which finds its philosophical roots in the belief that free markets work better, cause government-owned electricity businesses to become privatized.

Pioneered in the United Kingdom, the privatization of the electric business has happened, and will continue to happen in industrialized and developing countries. Governments anxious to balance their books tend to welcome private capital when it is willing and able to provide electricity. The consolidation of the business to which I made reference earlier makes privatization easier. Giant international utilities can reach beyond borders and deploy not only their considerable expertise but also their ability to raise capital.

Since Cameco was privatized in 1991 we are watching, with interest and empathy, how the reactor industry manages this change to privatization. We learned that a shareholder is, as an owner, quite different from a government. To meet his or her expectations, a privatized organization must undergo a profound cultural change. Unlike long term planners in governments, shareholders have a short term investment horizon, hardly consistent with what comes with the utility business. Shareholders look at the next quarter, not the next decade. As a result, we at Cameco have learned to slice our ten year plan into quarterly instalments.

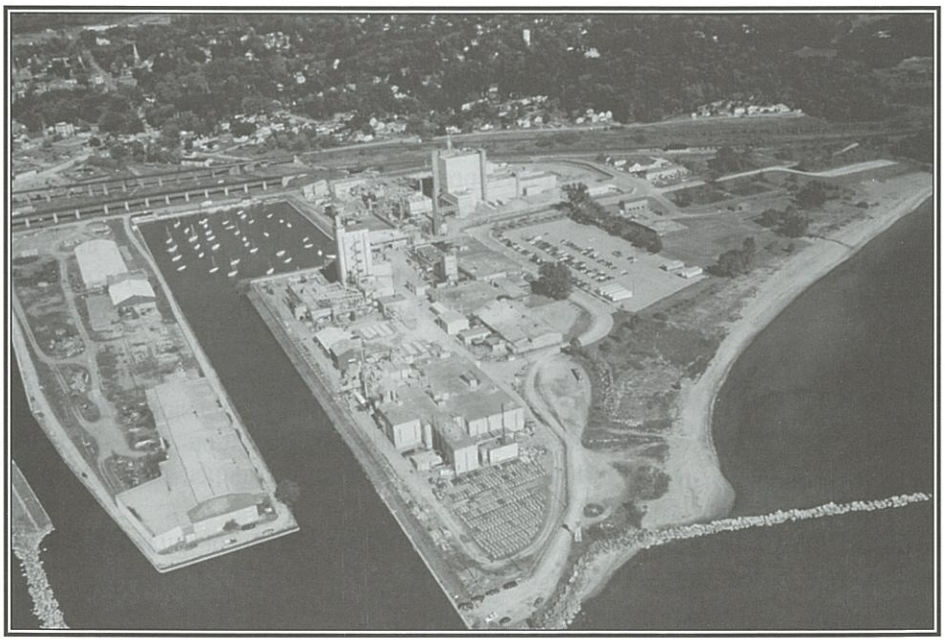
In the electricity business, privatization demands a special type of investor, one who should be oriented towards yield - rather than growth.

Climate Change

At the same time as fundamental restructuring is underway in our industry, the growing public concern over climate change offers an opportunity to position nuclear technology not as a problem, but as an essential component of the solution. Some, from outside our industry, are now prepared to acknowledge the ongoing role and merits of nuclear technology:

- the US Gas Research Institute reported recently that they are restating their gas estimates based on changes in the nuclear industry — changes which they say will result in increased demand for nuclear because it is clean and competitive.
- The US Department of Energy also points to the fact that the United States increasingly relies upon nuclear electricity production to reduce greenhouse gas emissions.

While these signs are positive much remains to be done to ensure that these messages reach those who influence the shaping of public policies. Invaluable work is being done by industry groups such as the Canadian Nuclear Association here in Canada, the Nuclear Energy Institute in Washington and the London-based Uranium Institute. Today, these organizations find receptive audiences where formerly nuclear was not a welcome subject to raise. This is a significant and encouraging sign post.



An aerial view of Cameco's Port Hope refinery and conversion plant, looking north from Lake Ontario

However, they face powerful, well financed, opposition: from the oil, gas and coal lobbying efforts which see nuclear as serious competition; and, from influential environmentalist organizations fanatically opposed to anything nuclear. They need our financial support if they are to remain effective advocates of the nuclear cause and to build on the success already achieved.

The uranium industry

Let us turn to the uranium industry, a key sector at the front of the global nuclear business.

The uranium industry has undergone

much of the restructuring which the electricity business faces today. Consolidation, as a result of market forces and privatization, has been with the uranium industry for quite a while. Today, the industry is dominated by only a few players.

Some consolidation came, not as a result of government policies, but as a result of the changing nature of its physical assets, the uranium deposits. Consolidation happened courtesy of mother nature in northern Saskatchewan. Forty years ago, uranium deposits with a grade between .1% and .5%, for a total of 20 million pounds of uranium reserves, were seen as economically attractive. Then, about 20 years ago, uranium deposits ten times greater in grade and in size were found in Saskatchewan, the most remarkable of them being the recently depleted Key Lake deposits. Today, McArthur River and Cigar Lake are hallmarks of a new generation of mines, with grades ten times greater again and 300 million to 500 million pounds in size.

The Delmar open pit at Key Lake, no longer being mined.

Developing underground mines to extract extremely high grades of uranium ore in a difficult geological and hydrogeological environment necessitates the introduction of innovative and costly mining methods and procedures.

In other parts of the world with deposits at the other end of the grade spectrum, mining techniques have progressed to the point where extremely low grade mines have been able to survive and will continue to compete with our rather extraordinary Saskatchewan deposits.

Consolidation of the uranium industry has therefore already happened. There are only five significant producers and four uranium converters in the western world. Canada now accounts for 30% of the world production whereas ten years ago it was only 18%. The growth in Canada has been achieved at the expense of Europe, the US and Africa.

Like that of the electricity industry, ownership of the uranium industry has become very much an international affair. For example, the McArthur River and Cigar Lake deposits include Canadian, French and Japanese interests. Like the market for electricity, the uranium market crosses borders. Our customers are relatively free to purchase their uranium from a variety of countries.

Nuclear power - uranium interaction

It is in this highly competitive arena of the uranium market place that the nuclear electricity producers meet the uranium suppliers. That interaction is played out in the familiar supply-demand scenario.

The total demand for uranium over the next 10 to 15 years is relatively easy to predict. It is, however, less easy to figure out the manner in which it will express itself. The emergence of fewer, larger nuclear utilities will bring about a new type of relationship with the suppliers of uranium, uranium conversion and enrichment and fuel fabrication.

While demand for uranium is predictable, supply is characterized by a number of uncertain factors.

Western production is the best known of them all and will come mostly from the McArthur River and Cigar Lake mines in Saskatchewan and from the Australian operations of Western Mining and Energy Resources. It should meet between 50% and 60% of the total ten year demand. Given that it takes a long time to discover, develop and start new mines, nothing is likely to materialize which can threaten these operations in the next ten years.

Beyond western production, other sources of supply exist which are far less certain. Unfortunately, from a uranium producer perspective, these sources of supply have a habit of becoming price setters because no clear cost can be attached to them. They include:

- excess western inventories which may represent some 10% of the ten year forward demand.
- exports from Russia, Kazakhstan and Uzbekistan, countries where weak currencies and a pressing need for hard currencies lead to rather erratic market behaviours.
- the recycled material and for what was, until last year, a real wild card: the commercialization of the uranium displaced by the dismantlement of the Russian nuclear weapons.

The signing of a historical agreement with Russia in March 1999, a Cameco-led initiative, has provided an orderly mechanism for the entry of this material into the western uranium market.

The Canadian industry, having the lowest cost world wide as a result of its large and high grade reserves, is meeting the

The mill facilities at Key Lake.

challenges presented by these foreign price setters. However, the Canadian uranium industry also faces serious, homemade self-inflicted challenges in the forms of taxation and regulatory burden.

Taxation

- Through the combination of the uranium royalty regime in Saskatchewan with the Canadian corporate income tax system, Canada has become, to my knowledge, the jurisdiction which, on a world wide basis, subjects its uranium producers to the most burdensome tax payments.
- The uranium industry is expected to pay federal tax on money it will never see since not all of the provincial royalties payable are considered deductible expenses in the calculation of the federal tax.
- It is unfortunate to give up, through excessive taxation, much of the rewards that uranium industry participants should receive out of the risks they take in the exploration, development and operation of their extraordinary deposits.

Regulatory burden:

- All uranium industry participants strive to be exemplary corporate citizens, committed to the operation of facilities which offer protection for the health and safety of employees and of the public and which also protect the environment.
- One should always balance, in a broad sense, the benefits of new regulatory demands with the incremental costs which they create. Unfortunately, this does not seem to take place.
- Canada should not squander its extraordinary uranium wealth through unnecessarily expensive and overlapping provincial and federal regulatory institutions.

Conclusion

We should all be encouraged by what is emerging in terms of deregulation, consolidation, and privatization of the nuclear industry and in terms of an increasing public realization that nuclear technology is safe and environmentally clean.

The greater transparency which flows out of the restructuring of our industry encourages accountability and promotes excellence in every way.

There are early signs of a changing public attitude toward nuclear technology. Opponents find it more difficult to refute facts and, for some, impossible to come up with credible alternatives.

- in Sweden, 52% of people wish to have the "nuclear phase out" policy subjected to a new referendum
- in Germany, 70% of people support the continuing operation of nuclear reactors.
- In Saskatchewan, public support for uranium mining remains strong at 70%.

This, I believe, is an indication that the public may now be getting ahead of politicians.

On the strength of its exceptional discoveries and of a constructive political climate, the uranium industry has invested $1.7 billion in the past five years and positioned itself strongly for the future.

- The sign posts are in many ways positive for the nuclear and for the uranium industries.
- We must learn from them and develop a growth strategy which capitalizes upon them — for the greater benefit of our industry and for that of society at large.
- We must ensure that policies are in place for the successful deployment of that growth strategy.
- We must therefore be committed to share our message of confidence and record of success with those who today are sceptical because they are ill informed.
- Nobody will do it for us and we must, therefore, do it ourselves — and do it now!
- We must, as an industry, rise to the challenges of deregulation, consolidation, privatization and ensure that our voice is heard loud and clear when policies are made in response to the world wide growing concern over our global environment.
- Our success tomorrow can only result from our actions today.

Low doses of ionising radiation incurred at low dose rates

- *further thoughts on LNT*

by Donald J. Higson[1]

Ed. Note: As noted elsewhere, it is likely that our new governing nuclear legislation, the Nuclear Safety and Control Act, will be put into force by this summer. One of the contentious aspects of the coming regulatory regime is the new radiation protection limits that will be imposed. The dramatic lowering of the limits is based on the recommendations of the International Commission on Radiological Protection (ICRP) which, in turn, are derived on the assumption of the "linear, no threshold, theory" (LNT) which presumes that any amount of radiation has deleterious health effects. That theory has been questioned in more and more fora over the past few years, including the Airlie conference which was reported in the last issue (Vol. 20, No. 4 of the CNS Bulletin*). It is understood that LNT and dose limits will be a topic at the upcoming conference of the International Radiation Protection Assocaiton (IRPA-10) to be held in Japan in May 2000. It is in that context we offer this paper.*

The following paper was presented by Dr. Higson at the International Symposium of the British, French, Dutch and Swiss / German Societies for Radiological Protection held in the UK in June 1999. As he notes, it is basically a summary of a much longer paper with the same title prepared under the auspices of the International Nuclear Societies Council (INSC) by a task group which he headed. The original version of that paper was included in a booklet issued by the INSC in late 1998 under the title of "Worldwide Integrated View on Main Nuclear Issues" which was reviewed in Vol. 19, No. 4 issue of the CNS Bulletin. *We thank Dr. Higson for his permission to reprint his paper.*

Abstract

In this paper, it is concluded that there is no scientific evidence to support the assumption that radiation causes increases in the incidences of cancers or hereditary effects in humans, for acute doses less than 10 mSv or chronic dose rates less than 20 mSv per year. Except for the purpose of scientific research, it should therefore be assumed that there is no significant biological effect from such low levels of radiation.

Introduction

Many scientists have become concerned that the practices of radiation protection and regulation are not consistent with scientific evidence on the biological effects of low doses (defined for the purpose of this paper as total doses less than 10 mSv, received at high rates in single events, and dose rates less than 20 mSv per year received continuously). There are several different ways of looking at the available information, as follows:

1. The scientific approach is not always comprehensible and acceptable to the lay-public and can be frustrating for politicians and journalists. Our scientific understanding of cancer induction and incidence is improving but it tends not to provide the quick, definitive answers which are often sought by the news media and the public.
2. In the practice of radiation protection and regulation, it has proved necessary to adopt the "linear no-threshold (LNT) hypothesis" as a simplifying assumption to facilitate decisions about complex situations. It is not widely understood outside the radiation protection profession that the LNT hypothesis overestimates risks, sometimes greatly, and that it may indicate a risk where none exists.
3. With the practice of radiation protection being predicated upon the LNT hypothesis, it is understandable that members of the public believe there is no safe dose of radiation. Many people do not appreciate that this fear is based on a pragmatic assumption, not on scientific evidence. Such anxieties are unwarranted and harmful.
4. Few politicians are scientists and even scientists sometimes have difficulty perceiving the distinction between 1 and 2 above. Political perceptions of the issue tend to line up with radiation protection practices which are pragmatic and public perceptions which are often misinformed.
5. The news media are primarily interested in selling their products and therefore prefer to feature a sensational piece of controversy ahead of a boring fact. That's life! There is no point in scientists getting upset about it.

1 Dr. Higson is an Australian scientist and editor of the Newsletter of the Australasian Radiation Protection Society.

Each of these approaches is considered to be legitimate by most of those who adopt it, but there are factions which deliberately exploit the misconceptions that unfortunately have developed about low doses of radiation. The purpose of this paper is to challenge these misconceptions, and perhaps break into the closed "loop" formed by public and political perceptions and media presentation. The paper itself is a condensed version of a report prepared by a Task Group of the International Nuclear Societies Council (INSC). The full report, which is regarded as a "living document", was published in 1998 by the European Nuclear Society on behalf of the INSC, and a revised version has been published in the Journal of the Australasian Radiation Protection Society[1]. Sources of information are discussed in the full report but not in this paper.

Biological Effects at the Molecular and Cellular Level

Damage caused by ionising radiation to DNA in living cells can lead to risks of cancer in exposed persons and of hereditary effects in their descendants. Cells are adept at repairing their DNA molecules. However, the National Radiological Protection Board argues that even the lowest possible dose and dose rate (a single radiation track traversing a cell) might result in incorrectly repaired DNA damage and hence lead to cancer. DNA repair systems exist primarily for damage other than radiation damage but there is considerable evidence that low doses and low dose rates of radiation may induce or activate additional cellular DNA repair capacity. This is called the "adaptive response" to radiation, and it may reduce the effects of damage from subsequent doses of radiation or from other causes.

Most human cancers arise from DNA damage due to agents other than radiation. If low doses of radiation enhance repair of any such damage, the net effect could be a reduction in overall risk, in spite of any risk increment due to the radiation itself. Such an effect, sometimes called "radiation hormesis", has been observed beyond reasonable doubt in cells from virtually all types of organisms, in whole plants and animal species other than humans, and in human cells. Alternatively, the net effect may be so close to zero that it should be regarded as insignificant ? whether it is bio-positive or bio-negative. This is not simply a matter of thresholds to carcinogenesis or mutagenesis, although thresholds may exist.

Human Observations of Carcinogenesis - Epidemiology

Epidemiological studies provide the only clinical evidence of radiation-induced risks of cancer, i.e. when a statistically significant increase in the incidence of cases in a population correlates with radiation exposure, allowing for the appropriate period of latency. Even among atomic bomb survivors in Hiroshima and Nagasaki, however, the increase in the incidence of cancer has been only a small fraction of the total incidence. At low levels of exposure, the effects are generally too small to be discerned with any certainty, because of statistical difficulties of measuring them against variations not caused by radiation (i.e. the uncertainties may be too large for any meaningful conclusion to be drawn).

It has been reported that radiation doses greater than about 50-100 mSv cause a risk of cancer, when the dose is incurred at a very high rate for a short period, as in an atomic bomb explosion or during some medical procedures. However, there is no discernible increase in the incidence of cancer due to doses up to at least 1,000 mSv spread uniformly over a lifetime. The distinction between dose rate and total dose is important but seems to have become blurred in the transition from observed effects to regulatory standards.

Natural background radiation is the main source of exposure to radiation for most people, and should therefore be a major potential source of information on the effects of exposure. The dose rate from background radiation ranges around the world from less than 1 mSv per year to more than 100 mSv per year locally. It has not been possible to demonstrate a positive correlation between rates of cancer in humans and background radiation. In fact, the reverse has often been reported, *viz:* comparatively low rates of cancer have been observed where levels of radiation are comparatively high. This is consistent with the laboratory observations of an adaptive response.

Hence, it is reasonable to postulate that radiation hormesis occurs in humans, although reasons for it and its overall significance are not well understood. Unfortunately, this issue tends to be emotionally charged, with opinions polarised even among scientists. However, some evidence certainly exists for biologically positive effects of low doses, although it does not convince everyone, but there is not consistent evidence for negative effects.

Genetic effects of radiation, if they occur at low doses, would have been a continuing factor in the evolutionary process. The human race (as it now exists) represents only the small, successful part of all the trials and errors of evolution, which has taken place in the presence of natural background radiation. It is a fundamental tenet of evolutionary biology that organisms adapt to their environment so that levels of survival and fitness which are optimum, with respect to radiation, might be expected within the range of natural background radiation. This effect has been well documented in lower organisms.

The Linear No-Threshold Assumption

For radiation protection purposes, the ICRP recommends the assumption that the risk of radiation induced cancer is proportional to dose without a threshold. This assumption, the "linear no-threshold (LNT) hypothesis", appears to depend on assuming that dose is the only variable involved. Because of the known dose-dependence of biological processes, including the adaptive responses to radiation, it is not

likely that the probability of cancer would be a simple function of dose or even that it would necessarily increase with the dose. There are also many epidemiological indications that thresholds exist, that the relationship is not linear and that the probability of cancer decreases with increasing dose at low levels.

Nevertheless, the LNT hypothesis has been endorsed by most national health authorities and is central to the practice of radiation protection, so that many practitioners are required to apply it. It is often used for estimating risks to specific individuals from low doses, although it was not intended for this purpose. On the basis of the LNT hypothesis and risk coefficients recommended by the ICRP, about 5% of all cancers in Australia would be attributable to background radiation, which seems unlikely, and more than 100% in some parts of the world. It therefore needs to be recognised that the LNT hypothesis is intentionally conservative, i.e. the real risk is between zero and the estimated value (or less than zero if there is a beneficial effect). Estimates based on the LNT hypothesis should correctly be regarded as setting the upper boundary to the range of uncertainty in radiological risk estimation, and not as defining the actual risk.

In a recent OECD/NEA report[2], the "precautionary principle" is cited as endorsement of the current system of radiation protection based on the LNT hypothesis, *viz:* due to a lack of total certainty that no adverse effects result from exposure to low levels of radiation. This argument not only "flies in the face of nature" (see the previous section of this paper) but it belies the lack of certainty that there are no benefits from exposure. For low levels of radiation, on the basis of currently available information, it is at least as likely that the effects of exposure are bio-positive as bio-negative. Unless the reduction of radiation exposure can be guaranteed not to increase risk, it is not a precaution. Essentially, there is no useful application of the precautionary principle to these matters.

Discussion, Conclusions and Recommendations

There is currently a widely held view that any dose of radiation, no matter how small, causes increased risks of cancer. There is no scientific evidence to support this view and, even with observations of hormesis excluded, the balance of evidence is consistent with the assumption that there is no risk from low doses. Unjustified concerns about exposure to low levels of radiation may lead, not only to misguided policies on the protection of health and safety, but also to the misallocation of resources in the pursuit of them. This is just not good enough, either for the protection of workers or for the safety and benefit of the public.

Application of the ALARA principle using the LNT hypothesis may result in significant costs for radiation protection measures which do not achieve demonstrable health benefits. The radiation protection profession should be cautious of expending real resources to reduce hypothetical risks in this way – risks that may be non-existent. It should also recognise that ALARA may be counterproductive if exposure to low doses actually reduces the risk of incurring cancer, which is a scientific possibility. Spending money to increase risk would be the ultimate irony. The long-term occupational dose limit of 20 mSv per year is so low that clear compliance with it should be regarded as synonymous with ALARA.

The most significant challenge for the future is therefore to demonstrate, to the satisfaction of public and political opinion, that the LNT hypothesis is not applicable to low doses and low dose rates. Obviously, this will create problems for radiation protection practice, in which the LNT hypothesis has become virtually an essential tool. The real problem is that others misuse it. However, a policy, which has no scientific validity, should not be considered defensible. The effect of low doses on health (if there is one) is too small to be of regulatory concern. A pragmatic decision should be made that low levels of radiation dose do not need to be regulated.

Further fundamental studies at the molecular and cellular level, backed by experimentation on animals, are needed to investigate the uncertainties that do exist about the effects of low levels of radiation exposure. Epidemiology is unlikely to resolve those uncertainties where the effects are small. The existence of radiation hormesis must be recognised and its significance should be properly considered without prejudice.

References

1. Graham, J., Higson, D. J., Jae-Shik Jun, Kobayashi, S. and Mitchel, R. E. J., "Low Doses Of Ionising Radiation Incurred At Low Dose Rates".
   Radiation Protection in Australasia, J. of the Aust. Rad. Prot. Soc. **16(1)**, 32-47 (March 1999).

2. NEA Committee on Radiation Protection and Public Health, "Developments in Radiation Health Science and their Impact on Radiation Protection" (1998).

Inserted Brochure

Enclosed with this issue of the *CNS Bulletin* is a brochure on "Jobs" in the nuclear industry. This is one of a series produced by Keewatin Publications with support from Ontario Power Generation Inc., Natural Resources Canada, and the Canadian Nuclear Society. The purpose of the pamphlet is to inform students of the employment opportunities in the nuclear industry. If you would like further copies of this brochure for distribution to schools or youth groups contact Keewatin Publications.

Improvements to the Operator Workspace of the Point Lepreau Control Room

by T. Hitcock, H. Storey[1], E. Davey[2], B. Patterson[3]

Ed. Note: The following paper was originally presented at the 20th Annual Conference of the Canadian Nuclear Society in Montreal, June 1999.

Abstract

The Point Lepreau control room operator workspace was designed in the mid-seventies.

Through the eighties and nineties, station staff have introduced new operational practices, added new control room resources, and modified or replaced some existing control room equipment to improve the overall effectiveness of control room operations. By 1994, it was recognized that the existing operator console and workspace equipment was limited in supporting certain operating functions and would restrict further incremental expansion and workspace improvements. Subsequently, station Operations staff undertook a design study to systematically characterize operator control room workspace needs and design a workspace that would integrate new and old facilities to better support efficient operation into the next century.

This paper describes the findings and lessons learned from the initial workspace reassessment study, console redesign and implementation, and early operational experience with the new workspace implementation.

Background

CANDU plant control centres are designed to support Operations staff in supervision and control of plant operation. However, the support requirements are never static. For example, the workspace support needs of Operations staff change as new operational practices and control room systems are introduced to improve plant safety and production performance.

This need to accommodate ongoing operational changes and improvements places demands for change on the control room workspace layout. Ideally, a workspace that offers flexibility in configuration, versatility of function, and expandability may best support ongoing operational refinements.

Through the eighties and nineties, station staff at Point Lepreau introduced many changes to refine and improve the overall effectiveness of control room operations. By 1994, it was recognized that the existing operator console and supporting workspace equipment (see Figure 1 and 2) was limited in supporting workspace improvements (e.g., addition of Generic Monitoring System display terminals) and future incremental expansion. Subsequently, station Operations staff undertook a design study to systematically characterize operator control room workspace needs and design a workspace that would integrate new and old facilities to better support efficient operation into the next century (Feher and Davey, 1995). The primary emphasis of this study was to design an improved operator console.

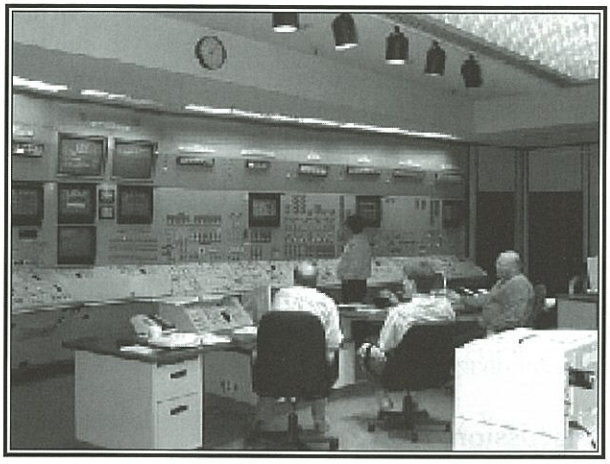


Figure 1: Console Desk at Time of Assessment (1994).

The objectives of the design study included:

- Document current control room workspace usage and the critical factors important in supporting plant operation,
- Develop inventories of control room tasks and supporting resources,
- Characterize control room resources by frequency of use and required accessibility,

and

- Report assessment findings and recommendations for workspace improvement.

1 Point Lepreau GS, NB Power
2 Crew Systems Solutions
3 Human Factors Practical

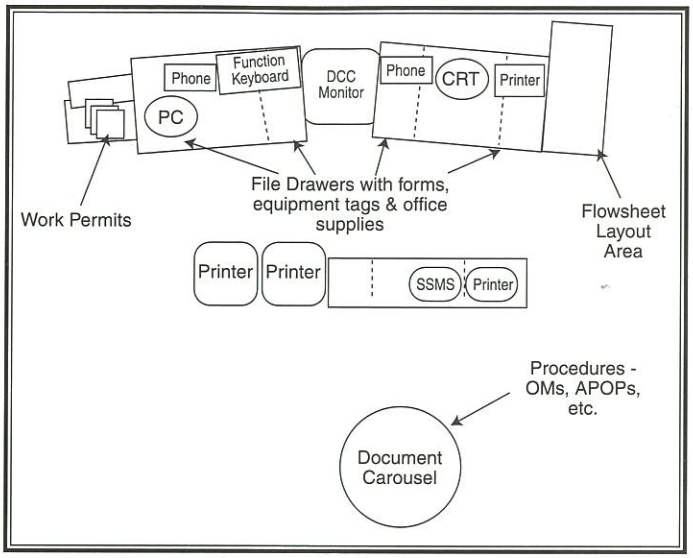


Figure 2: Control Room Operator Workspace at Time of Assessment (1994)

Characterizing User Needs and Improvement Priorities

The assessment team comprised a senior operator from Point Lepreau and two control centre designers from the Control Centre Technology Branch of AECL at Chalk River. The following activities and information sources were used by the assessment team in determining workspace needs:

- Review of crew roles and responsibilities for all operational situation
- Observations of crew work practices and use of resources in the existin
- Interviews with selected Operations staff to determine suggestions for workspace improvements and improvement priorities, and
- Discussion of future workspace needs with Operations staff, Trainers, Technical Unit staff and Point Lepreau management.

Key findings from the assessment phase included:

- Additional free surface areas are required for temporary layout of procedures, flowsheets, and documentation in support of multiple tasks,
- Operating procedures and reference documentation need to be located closer to the seated operator work-positions to simplify access,
- Computer-based support for frequently performed monitoring, control, analysis and administrative tasks should be made accessible at the console desktop, for example
  - VAX and network applications should be accessible to both the Senior Power Plant Operator (SPPO) and Power Plant Operator (PPO) seated work-po
  - Current standalone monitoring and analysis applications should be made accessible from desktop networked personal computers, and
  - The PPO should be provided with a dedicated Digital Control Computer (DCC) display and keyboard.
- Computer keyboards should be relocated to adjustable drawers beneath the desktop to improve positioning for keyboard tasks and free-up console workspace.

Proposed Improvements

The development of console and workspace improvement proposals involved consideration of the PLGS organization, technical capabilities and constraints, and operator needs. The assessment team established the following design principles to guide selection and development of workspace improvements:

- Design the layout to support the current operational philosophy, staff structure and work relationships,
- Locate the control room resources in support of each user according to:
  - The frequency of access or use,
  - The importance of accessibility, and
  - The major operational tasks to be supported.
- Provide support for the preferred and backup mode of use in performing each task.

Point Lepreau station management and the assessment team also established the following project constraints to limit design options and the cost of prospective changes:

- Retain the console pedestal location to access existing floor penetrations for control desk power and interface wiring,
- Re-use as much of the existing control room resources as possible to minimize change costs,
- Introduce only inexpensive changes that can be easily implemented during plant shutdown, outage, or at power with minimal disruption to normal operations,
- Maintain important lines of sight,
- Maintain important communication paths,
- Maintain current traffic patterns to the control panels and the control room entrances and exits.

The proposed new console and workspace layout based on the principles, constraints and assessment study findings are shown in Figure 3 and Figure 4. Key improvement aspects addressed by the proposed console and workspace features include:

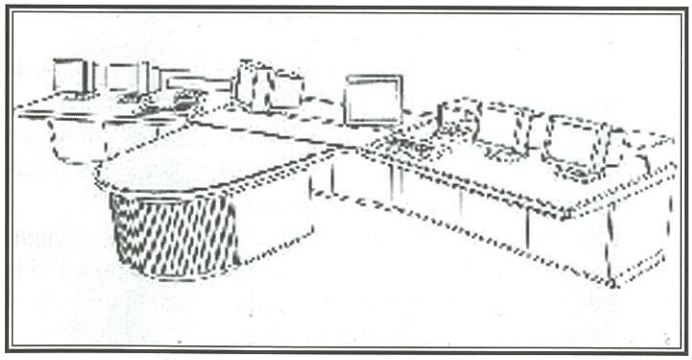


Figure 3: Proposed New Console Design (1995).

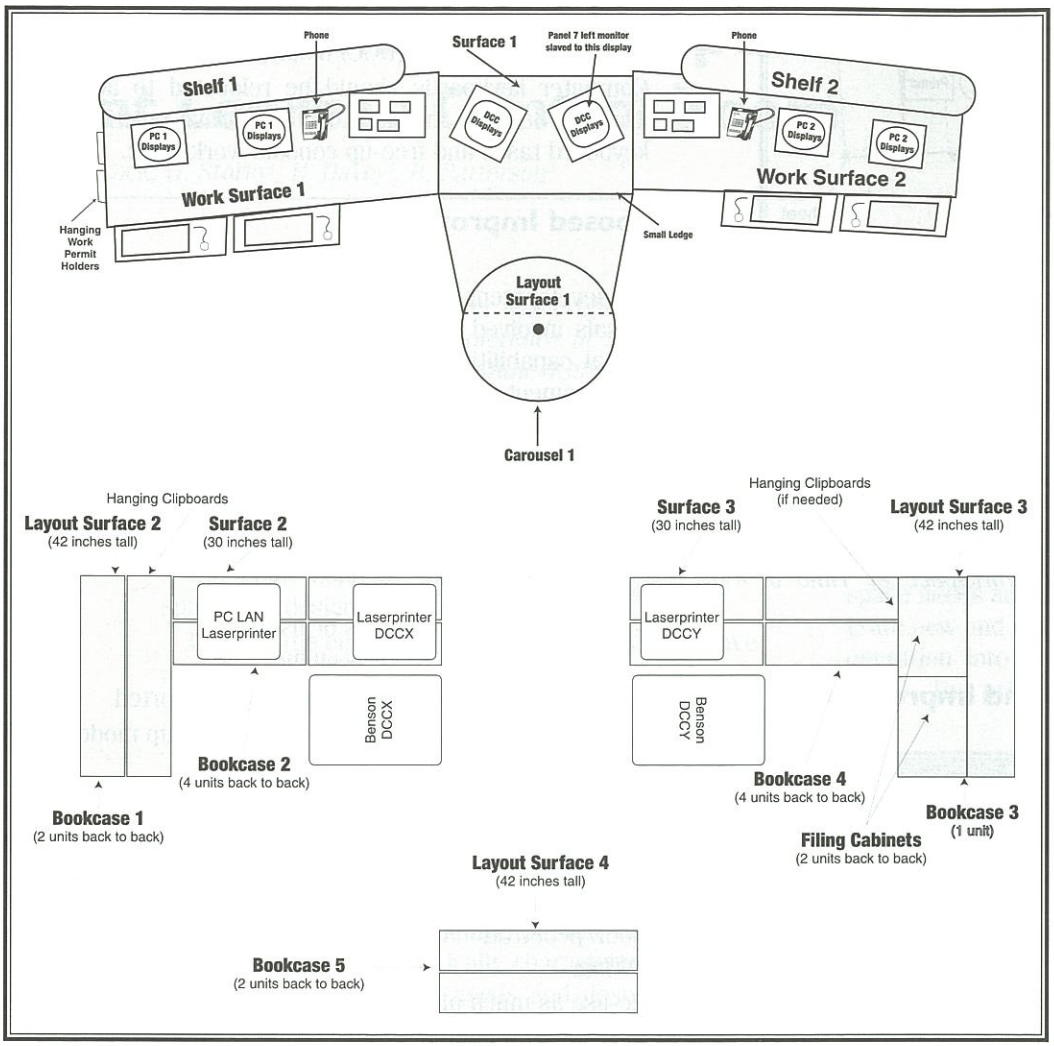


Figure 4: Proposed Control Room Operator Workspace (1995).

- Increased Console Desk Surfaces - Increased work surfaces for organization of SPPO and PPO work,
- Layout Space for Operating Manuals - Addition of a shelf to the front of the console for layout of Operating Manuals when working at the panels,
- Operating Procedure Accessibility - Addition of a central console document carousel for improved accessibility and storage of Operating procedures for the SSPO and PPO,
- DCC Display and Function Keyboard for PPO - Addition of a DCC display and function keyboard for the PPO console work position,
- Reduced Desk Clutter - Relocation of computer keyboards to trays beneath the console top, and
- Document Storage - Addition of bookcases and filing cabinets immediately behind the console for storage of reference documentation and supplies.

This workspace design provides a substantial improvement in documentation layout areas and accessible storage, and is implemented with commercially available equipment and components.

Implementation

The Point Lepreau Control Computer Group undertook implementation of the console upgrade. This group developed additional requirements for the upgrade pertaining to accessibility, serviceability and expandability (e.g., provision of spare rack mounted equipment locations to accommodate future needs) to ensure maintenance and support needs would be met.

Each wing of the console is divided into three sections. Each section contains a 19 inch rack mount chassis for mounting industrial PCs for the control room operators use. The outer sections of the console house rack mounted computers for monitoring signals gathered by the station s distributed data acquisition system. The middle sections house Management Information System computers. The 19 inch rack space in the inner sections have been left empty for future expansion. The console surface of the inner sections is used to mount the DCC keyboard. Currently, a DCC keyboard is provided only on the SPPO wing of the console. Installation of a second DCC keyboard on the PPO console wing is planned as a future improvement.

The centre section of the console provides two swivel bases for mounting DCC monitors in a recessed area. The swivel bases allow the monitors to be used from both sides of the console and recessing the monitors into the desk ensures that the monitors do not block operator sight-lines to key panel indications.

This project provided an excellent opportunity for the station s Electrical Maintenance staff to clean up the central console wiring, confirm or correct documentation, and create new under console space for future expansion needs. The layout of the central console wiring before and after the console upgrade is

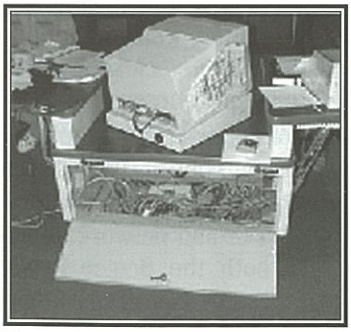


Figure 5: Central Console Termination Rack Pre Change-out.

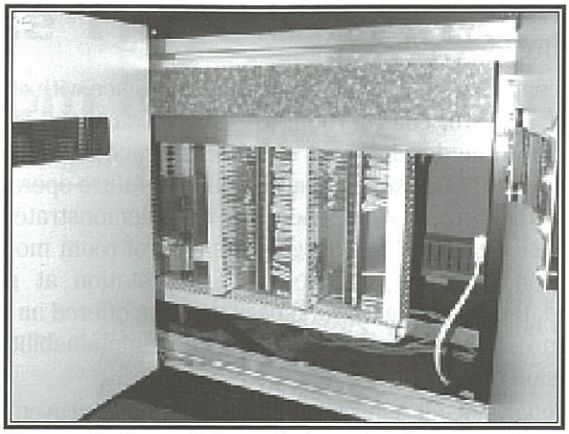


Figure 6: Central Console Termination Rack Post Change-out.

shown in Figures 5 and 6 respectively. The new wiring implementation consists of channelized cable termination racks Figure 6). The opportunity to clean up the console wiring and improve wiring channelization was an additional benefit of the console upgrade.

The equipment for the new workspace design was acquired in 1996. A modular approach to console implementation was selected to simplify construction and installation. Installation and commissioning of the new console in the Point Lepreau control centre was completed in 1998.

The console was replaced with the station at power during a low traffic period in the control room (i.e., 4 PM Friday to 8 AM Monday). Prior to the installation, the SPPO work location, PC, and phone were relocated to a temporary desk close to Panel 7 to facilitate plant monitoring and DCC keyboard access. Next the DCC keyboard on the operator's desk was disabled by disconnecting the process interrupt input to the DCCs and all the discrete inputs for each of the function keys. With this isolation complete, removal of the old console and installation of the new console could begin.

The center section of the new console had been pre-wired as much as possible in order to shorten the installation time. In addition, measurements and floor markings had been made for the new console ahead of time to further shorten the installation period required. The new console was put in place, secured, leveled and the equipment re-installed in the weekend time frame allotted. Two views of the finished console are shown Figures 7 and 8.

To date the workspace equipment and storage areas behind the console have not been altered to the extent originally proposed. For example, Operations staff decided to retain the large circular document carousel since it provides an excellent area for document layout and discussions.

Operational Experience

Early operational experience indicates that the new console workspace design provides substantial improvement in supporting operator tasks. Specific improvements cited by Operations staff over the past design include:

- Console Layout Space - The larger desk surface better supports layout and organization of work documents and permits two computer workstations and a DCC keyboard/monitor interface to be located at each work position without cluttering the console surface,
- Layout Space for Operating Manuals - The shelf along the front of the console is very useful for layout of Operating Manuals and test procedures when performing panel actions, and
- Central Console Peninsula - The central console peninsula has proven useful as a work surface to support discussions between the SPPO and PPO, and as a layout surface for shift group discussions. Although it may appear as a physical barrier, experience has shown that the console peninsula has proven to promote and better support control room communication.

However, the success of any design is dependent on the relevancy of past design assumptions to current operational needs. Operations staff have identified two design aspects that have not proven out as intended:

- Carousel for Operating Documentation - The purpose of the addition of the console carousel was to improve the accessibility of the Operating documentation to Operations staff. Formerly, Operating documentation was stored in a large carousel with other reference information at the rear of the control room. The new console carousel has not worked for a number of reasons:
  - The carousel does not have the capacity to house all the current Operating documentation,
  - Operations staff find it distracting when other staff come into their work area to use or update the Operating documentation, and
  - The carousel restricts comfortable use of the peninsula desk surface as a meeting table.
- Console Drawer Storage - The former console drawers for storage of pencils, tape tags and forms were removed in the new design and relocated to cabinets behind the console to improve console legroom. The items commonly stored in these drawers are not items of frequently used or

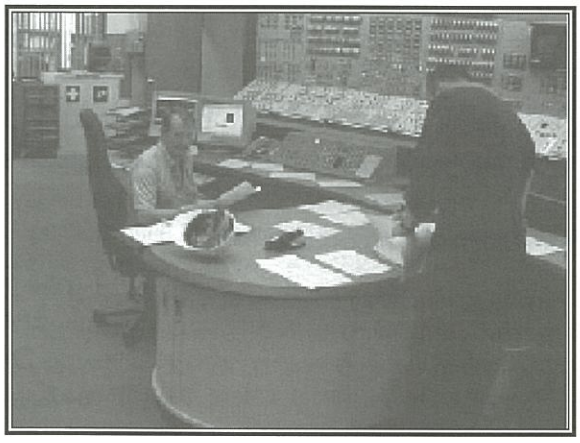


Figure 7: Installed Console - Side View (1998).

Figure 8: Installed Console - Front View (1998).

requiring quick accessibility. However, Operations staff have found the lack of drawer storage at their work location inconvenient, and a drawer unit has been retrofit to the new console to meet this need.

Future Work

We expect that the new console will easily accommodate future Operational needs to support control room change for some time. As more experience is gained with the new console and workspace layout, we expect further refinements to be initiated. The same console and workspace upgrade will be implemented in the PLGS simulator in the near future.

Conclusions

This paper has described the PLGS experience with characterizing operator control room workspace usage and support needs, and the development of successful and cost-effective solutions for better supporting current and future operational needs. The project experience has also demonstrated two additional benefits. First, large scale control room modifications can be safely installed with the station at power. Second, the console and workspace upgrade offered an excellent opportunity to improve equipment maintainability and expansion capabilities.

Although not all aspects of the design have proven to be useful as intended, the design and research efforts up-front proved to be invaluable in the successful restructuring of the control room area. Several aspects of the new console design have also been adopted by AECL for use in the new CANDU control centre currently under development.

References

Feher, M. and Davey, E. (1995). Recommendations for Control Room Operator Workspace at Point Lepreau. AECL Research Control Centre Technology Branch report HMSD-19-TCN-1 Revision 0, Atomic Energy of Canada, Chalk River, Ontario.

The Three Stages of Nuclear Power: From Panacea to Pandora's Box to Pragmatism

by Allen Kilpatrick

Ed. Note: Following is a condensed version of a talk given by Allen Kilpatrick, president and CEO, Atomic Energy of Canada Limited, to the Canadian Club in Ottawa, April 18, 2000.

There are clear signs that we are now entering a third stage in the public debate over nuclear energy...from panacea, to Pandora's box and now to pragmatism — a common sense understanding that nuclear has an important role to play in the world's energy future.

Today, I'd like to talk to you about those three stages in the nuclear energy debate, and in particular:

- the factors that have driven the pendulum swings
- the role of the news media in accentuating the swings
- and the myths about nuclear energy that still must be dispelled before the pendulum will finally come to rest.

Panacea

Let's begin with the tremendous optimism that characterized the pioneering "panacea" days of nuclear energy in Canada and elsewhere in the world.

In those optimistic days, cost wasn't even going to be an issue. Lewis Strauss, the Chairman of the U.S. Atomic Energy Commission, went so far as to predict that electricity from the atom would be "too cheap to meter."

For Canada, nuclear energy provided an opportunity to stand tall on the world stage. And the vast majority of Canadians took pride in the accomplishments of their nuclear program.

That pride continued to grow with the production of more than 60 per cent of the world's medical isotopes, over 80 per cent of cobalt for the treatment of cancer and, eventually a Nobel Prize for Canada. But most of the focus was on the commercialization of the made-in-Canada CANDU reactor and the construction of CANDU power stations in Ontario, Quebec and later New Brunswick. The initial world-leading performance of the CANDU nuclear units caused Canadian chests to expand even more.

Pandora's Box

Then, a little over 21 years ago, the pendulum made a very sudden and dramatic swing — thanks to an accident at a power plant outside of Harrisburg, Pennsylvania, known as Three Mile Island. Suddenly, everyone remembered that nuclear power was spawned by the terrifying nuclear weapons industry.

The tone of the media coverage was set by legendary CBS broadcaster Walter Cronkite. "The danger faced by man for tampering with natural forces, a theme familiar from the myths of Prometheus to the story of Frankenstein," he told his national audience, "moved closer to fact from fancy through the day." Pregnant women and preschool children living near the plant were advised to evacuate and the media and activists descended on the area.

It all made for great drama, but lousy science.

Three Mile Island was a serious and very expensive industrial accident, but it was hardly the nuclear disaster portrayed by the anti-nuclear activists and the media.

Since the accident, researchers have searched continually for serious health effects in the local communities, only to come up empty handed. No one died at Three Mile Island. No one got seriously ill. Researchers could find no more cancer deaths, developmental abnormalities or genetic ill health than they would have expected to find without the accident.

I don't want to underplay the importance of the accident. It did have two very serious repercussions.

First, it pointed out the complacency and the sloppiness that had crept into the industry. In many ways, the industry was a victim of its own success.

Three Mile Island was a wake up call for the whole industry. The accident was key in driving improvements in nuclear design, operations, and management in the United States, here in Canada, and elsewhere around the world. The high degree of safety and performance in the industry today is a direct result of that wake up call.

The second major repercussion from Three Mile Island was the loss of public confidence — the triumph of drama over science. Nuclear scientists and engineers proved a poor match for the anti-nuclear activists. That's because the deck was stacked against them.

Nuclear power is complex, and therefore easy to distort by pseudo-experts. The origins of nuclear power — coincident in the minds of many with the atom bomb and the cold War — make it easy to create a sense of guilt by association. And the news media — seldom schooled in science and perpetually in search of a provocative story — too often repeat unchallenged the assertions of the anti-nuclear activists, whose credentials are seldom held up to scrutiny.

The anti-groups can make all sorts of wild accusations, and there are no consequences when they are proven wrong. They are not held accountable or responsible. Their business is influence not education, attack not debate.

However, until the Chernobyl accident, the nuclear industry was beginning to make some headway against the anti-nuclear movement. Then came the terrible tragedy, and the anti-nuclear activists renewed their attacks with a vengeance. There was no recognition that our reactors are much safer, or that a Chernobyl-style reactor would never have been licensed to operate in Canada or the US.

Somewhat surprisingly, though, given the seriousness of the accident, Chernobyl has had much less of a lasting impact on public attitudes than Three Mile Island. In fact, in most countries, support for nuclear power has jumped back to pre-accident levels.

Pragmatism

This brings me to the third stage in nuclear energy — pragmatism. The common sense acceptance that nuclear has an important role in our future energy mix.

We're not fully in the third stage. However, there are indications that public attitudes in the US are beginning to shift. In a recent CNN poll 60 per cent of respondents said they believed nuclear energy was safe, and 71 per cent believed that new plants should be licensed. A Nuclear Energy Institute poll also found about a 60 per cent support for nuclear power. Tellingly, when those people who supported nuclear power were asked if they believed they were in a majority — 90 per cent said no.

Support is growing even in countries such as Sweden and Germany, which are planning to phase out nuclear power. In Sweden, for example, only 20 per cent in a recent poll backed the government's decision to close the Barseback plant. In looking at the energy alternatives, many Swedes and Germans now believe their governments were too hasty in turning away from the nuclear option.

Why is nuclear support growing again? The big answer, of course, is climate change and global warming. Nuclear power produces no greenhouse gases or other harmful emissions such as nitrogen oxide, and sulphur dioxide. If Canada did not have nuclear generation our greenhouse gas emissions from electricity production would double. It seems abundantly clear that there is no solution to global warming without a significant nuclear component.

Global warming is important, critical even, but it's not the only factor behind the growing support for nuclear power. Improved safety and reliability is also having an impact. Just look at the turnaround in the U.S. In 1980, the average capacity factor for large U.S. reactors was 58 per cent. By 1990 it had increased to 66 per cent. It's now over 80 per cent and still rising. Operating nuclear power stations is becoming "normal" business.

Myths

Despite the turnaround in support, our transition from Pandora's box to pragmatism is far from complete. There are a number of myths about nuclear energy that must still be dispelled before the pendulum will finally come to rest.

Myth #1 - Nuclear power is the most unsafe, untested and risky way to generate electricity.

Here are the facts: Nuclear plants have been generating electricity for half a century, with almost 8,000 reactor years of experience. France relies on nuclear power for more than 70 per cent of its electricity; Sweden, 45 per cent; Belgium, 55 per cent; Switzerland, 40 per cent; Japan, 34 per cent; and Ontario, 55 per cent. In not one of these jurisdictions has there been one death or injury related to commercial nuclear power.

Myth #2 - The radiation from nuclear plants constitutes a clear and present danger to health.

Here are the facts: The radiation released from nuclear power stations each year is minuscule. Less than one tenth of one per cent of the radiation an average Canadian is exposed to comes from nuclear power.

A coal-fired power station releases far more radioactive material into the atmosphere than does a nuclear power station. Moreover, Grand Central Station in New York, which is made of granite, gives off more radiation than the Pickering nuclear station.

Myth #3 - Nuclear power is uneconomic compared to other energy sources.

Here are the facts: Average production costs for nuclear energy are 1.9 cents CDN per kWh compared to 3.4 cents CDN per kWh for natural-gas fired combined cycle gas turbine plants, the next best alternative. Because of the much lower production costs for nuclear compared to natural-gas, it is more economical to invest in extending the life of nuclear plants rather than build new natural-gas fired plants.

Natural-gas fired plants have a competitive edge over nuclear because their capital cost is about one-half that of a nuclear plant of the same output. As result natural-gas fired plants offer short pay-back periods and higher financial returns for investors.

The competitive challenge is to reduce nuclear plant capital costs by about 40%. We are confident that this target can be reached for advanced CANDU plants and development work is underway.

There's one final point about electricity economics that needs to be mentioned - the environmental costs. Today, nuclear power is the only electricity source that includes the financial cost of managing waste by-products and of disman-

tling of the plant at the end life. Natural-gas fired plants discharge, free-of-charge, millions of tons of nitrous oxides and carbon dioxide annually into the atmosphere. The addition of appropriate costs to mitigate the effects of atmospheric pollutants would substantially improve the economics of nuclear plants compared to natural-gas fired plants - and, also, the quality of the air we breath.

Myth #4 - The foreign sale of nuclear reactors encourages the proliferation of nuclear weapons.

The fact is, it is extremely difficult to separate the type of plutonium needed for weapons from the fuel contained in a nuclear power reactor. The physics are very different. That is why no nuclear weapons state has used material made in power reactors to make bombs.

In addition, Canada, as you know, refuses to sell nuclear technology to any country that is not a signatory of the Non Proliferation Treaty, which opens their programs to mandatory international inspection. Furthermore, we insist on a separate bilateral Nuclear Co-operation Agreement, which is even more stringent than the NPT.

Myth #5 - Alternative energy sources could replace nuclear power.

What do the facts say? While alternative energy sources will and should continue to play a role in meeting our energy needs, there are very severe limits imposed by the laws of nature and by financial and environmental costs. It would take 40,000 wind generators spread over a land mass four times the size of Prince Edward Island just to meet the energy needs of the city of Toronto.

To quote the World Energy Conference: "It must be recognized from a realistic point of view that alternative and renewable energy sources are not likely to provide a major part of the world's future energy requirements in the foreseeable future.... It must be recognized that not all alternative and renewable energy sources are environmentally benign, either in the short or long-term."

Myth #6 - Nuclear waste is a danger to present and future generations.

Here are the facts: More than 90% of the nuclear waste produced by a nuclear plant is the used fuel, which is a highly stable ceramic material. The used fuel is stored initially in water-filled pools incorporated into the nuclear plant. As the pools fill up, used fuel assemblies are transferred to steel-lined concrete canisters where they can remain indefinitely. After about 300 years, the radioactivity of typical used CANDU fuel has reduced to the level of the original natural uranium.

Eventually, the used fuel will be transferred to a central permanent disposal facility. AECL has completed extensive research to develop the technology for disposal deep in the rock of the Canadian Shield. This disposal concept has been reviewed by [an environmental] Panel which concluded that the technology was sound, but that broad social acceptance was required before proceeding further. The federal government is developing policy for the next steps.

Conclusion

Those are some of the pervading myths we must dispel in order to regain public acceptance and support for nuclear energy. I think in each case we've got a very strong argument. Our challenge is to convince people that nuclear energy isn't Pandora's Box — but part of a pragmatic and environmentally smart solution to the growing energy needs of an expanding global population.

There is no panacea when it comes to energy. The answer for Canada and other parts of the world isn't gas, or solar, or windmills, or nuclear - it's the appropriate combination of various energy sources, each of which has its own costs and benefits.

All we're asking for from the public and the news media is a balanced and common sense evaluation of the facts. I firmly believe that any informed and responsible debate would conclude that nuclear energy – in conjunction with other approaches including renewable resources and conservation – has an important role to play in the World's energy future.

It may not make for very good drama - but it is good science.

GENERAL news

New Regulations Approved

- new Act soon to be put in force

On March 23, 2000, the Atomic Energy Control Board approved in principle the Regulations and By-Laws prepared for the Nuclear Safety and Control Act. Although the latter was passed in 1997 it could not be put into force until all of the necessary regulations were ready.

With that step the Board has forwarded new Regulations to the Minister of Natural Resources (through whom the AECB reports) for submission to Cabinet. When that formal process is completed the Act will be put into force and the Regulations will become law. At that time the Atomic Energy Control Board will cease to exist and the members will form the new Canadian Nuclear Safety Commission

Although AECB president, Dr. Agnes Bishop, stated to the Nuclear Winter Seminar in February, that "we have endeavoured to minimize substantive change to the regulations and requirements", there are several significant changes.

Probably the most contentious are the new, much reduced, radiation dose limits. These were announced years ago following the publication of the 1990 recommendations of the International Commission on Radiological Protection in its report ICRP 60. Nevertheless, many in the industry have been and still are critical. In summary the changes in the Regulations are:

- for Nuclear Energy Workers - from 50 millisievert (nSv) per year to 100 mSv over 5 years (an average of 20 mSv/yr)
- for pregnant NEWs - from 10 mSv/yr to 4 mSv/yr
- for members of the public - from 5 mSv/yr to 1 mSv/yr.

The reduced dose limits have been criticized as being too stringent and unnecessary. Female NEWs expressed particular concern that the ICRP recommendation of 2 mSv/yr for pregnant workers would lead to discrimination. In that case the AECB modified its Regulation to 4 mSv/yr.

However, there is a growing argument that there is no basis for the "linear, no-threshold" hypothesis (LNT) that is the basis for the ICRP recommendations. (See the paper by Higson on Low Doses of Ionising Radiation Incurred at Low Dose Rates in this issue.)

Another significant change is the requirement for financial guarantees for decommissioning and waste management. Such guarantees are already required for uranium mines but they will now be required of all major nuclear facilities. Associated with the financial guarantees, facility licensees will also have to submit their plans for decommissioning and waste management at the end of life of the facility.

The new Regulations define two categories of nuclear facilities. Class I includes reactors, high-energy accelerators and uranium processing facilities. Class II include low-energy accelerators, irradiators and radiation therapy installations.

In her talk to the Nuclear Winter Seminar in February , AECB president Dr. Agnes Bishop, stated that the Board (or new Commission) would consider exemptions in some cases for a period of up to two years.

The new Regulations can be accessed at the AECB's web site: www.aecb-ccea.gc.ca.

Senate Committee holds hearings on nuclear safety

The standing committee on Energy, the Environment and Natural Resources of the Senate of Canada has been holding hearings on nuclear reactor safety. It began its review early in February of this year and, at the time of writing, is continuing into May.

The Committee has been inviting or receiving a wide range of "witnesses". The first persons appearing before the Committee were David Torgerson and Victor Snell from Atomic Energy of Canada Limited. They were followed by Jim Harvie and associates from the Atomic Energy Control Board and, shortly thereafter, by Norman Rubin of Energy Probe. In early April, Carl Andognini from Ontario Power Generation provided an extensive submission. Other organizations scheduled to appear include: Nuclear Awareness Project; Power Workers Union; Canadian Institute for Environmental Law and Policy; the Nuclear Insurance Association of Canada

Anyone interested in obtaining further information on the work of this or other Senate committees should contact the Senate Committees Directorate at 613-990-0088. Schedules for Senate committee meetings are posted on their Web site: www.parl.gc.ca/english/senate/com-e

ITER Canada issues an "Expression of interest"

ITER Canada has formally submitted an "Expression of Interest to Host ITER" to its European Union partner in the proposed International Thermonuclear Experimental Reactor (ITER) project.

ITER is large fusion device that was initially proposed some years ago as an international project involving Europe, Russia, Japan and the USA. Canada has been participating as a partner with the European Union. ITER Canada is a is a non-profit Canadian corporation supported by the Canadian, Ontario and two local governments, the Canadian labour movement and a large number of major Canadian corporations, universities and institutions.)

The "Expression of Interest" is not a formal proposal to host the large project but is intended to identify Canada's interest in doing so and to outline the many advantages of locating the project here. ITER Canada has indicated that a formal proposal will be submitted in 2001.

The submission argues that ITER must be built promptly to preserve existing R&D capabilities needed to make fusion a world energy option for the future. It notes that the timing of the construction decision is governed by the Parties' budgetary planning cycles that could provide construction funds beginning in 2003. Equally important, it states, is the international agreement that must be negotiated including agreement on the location of the ITER site. Excessive delays in making these decisions could severely hurt the project's momentum by eroding the international will and the engineering and design capabilities that have brought the project to the readiness stage.

Two potential sites are identified: at the Bruce nuclear complex, and, adjacent to the Darlington NGS. They are both owned by Ontario Power Generation Inc. The submission notes, "Both proposed sites are in the province of Ontario, the heartland of Canada's industrial and construction infrastructure, with a large labour force experienced in the construction of major projects. Both sites have governments and communities that have known about ITER for many years and are fully supportive of the project being located in their areas."

The submission puts forth the following points in favour of locating ITER in Canada.

"Conditions in Canada lead to the lowest project risk because of increased confidence about key aspects of the project:

- the infrastructure already exists and requires only modest upgrades
- the existing regulatory system in Canada is sufficiently flexible to cover fusion technology without extensive changes to legislation and regulations. The proposed sites have been judged acceptable for fission nuclear power plants
- risks of public intervention with respect to the transport of radioactive substances are minimized. ITER Canada would provide for the storage of radioactive substances in Canada at the chosen ITER site, thereby eliminating the need to transport activated materials
- political risks in obtaining a construction approval are minimized."

"Canada is a truly international and neutral location. ITER Canada supports the ITER goals of full access to the project and its research and is committed to open and international oversight. Canada is an equally attractive location for Europe and Japan, is convenient for Russian and American fusion experts, and would be a location that would favour entry by new participants. Canada enjoys excellent diplomatic relations with all the ITER Parties. The proximity of the Toronto International Airport to the sites means that ITER would be readily accessible. Canada will seek to benefit from the advance of scientific and technological know-how in the fusion field resulting from developing ITER in conjunction with the Parties but without seeking a dominant role."

Further US approval for food irradiation

On February 22 the US Department of Agriculture gave approval for the irradiation of refrigerated or frozen uncooked meat, meat byproducts and certain other meat products. The stated reason is to reduce levels of food borne pathogens and to extend shelf life. Over the past few years the USA has approved the irradiation of an incresing number of food products. In Canada, however, there has been litle progress on applications dating back eight years.

MAPLE I starts up

Following a tradition of reactors starting up in the early hours of the day, the first of the two MAPLE reactors at the Chalk River Laboratories of Atomic Energy of Canada Limited, achieved criticality at 2:53 a.m. on February 19, 2000.

MMIR 1 (for Maple Medical Isotope Reactor No. 1) is one of two 10 MW(th) reactors being built at CRL for MDS Nordion. They will be used for the production of medical isotopes. Once both are in operation isotope production in the large NRU reactor will cease on a routine basis.

The reactor and the associated radioisotope processing facility were granted Operating Licences by the Atomic Energy Control Board late last year and the operating team obtained AECB authorization in March.

TRIUMF receives federal funding

On April 18, 2000, John Manley, Minister of Industry and Minister responsible for the National Research Council of Canada (NRC) announced that the federal government is committing funding in the amount of $200 million over five years for the TRIUMF (TRI-University Meson Facility) particle accelerator laboratory in Vancouver.

TRIUMF, which is located on the campus of the University of British Columbia (UBC), is part of a global network of particle physics laboratories used by scientists from across Canada and around the world. It is a primary link for Canadian participation in research conducted at foreign accelerator laboratories.

In addition to fundamental research, TRIUMF also has important applied research programs in materials and life sciences. TRIUMF's Positron Emission Tomography (PET) group works with the Neurodegenerative Disorders Centre at UBC which is considered a world leader in studies of movement disorders, especially Parkinson's disease. TRIUMF also treats 15-20 patients each year for eye cancer at its proton therapy unit, the only facility of its kind in Canada. In addition commercial companies routinely employ TRIUMF's Proton Irradiation Facility to test electronic components for sensitivity to solar cosmic rays, which can disrupt circuitry in high-altitude aircraft and spacecraft.

Obituaries

Three prominent members of the international nuclear community died in recent months.

Walter H. Zinn, one of the pioneers of the US nuclear program, died February 14, in Florida, at the age of 93.

Zinn was born in Canada, in Kitchener, Ontario in 1906, but did his postgraduate studies in the USA at Columbia University and remained in the USA thereafter. Following the discovery of neutron induced fission in early 1939 he collaborated with Leo Szilard in a crucial experiment - measuring the number of prompt neutrons emitted per uranium fission. Their number of 2.5 still stands. He joined the Manhattan Project, working with Enrico Fermi at the University of Chicago on the CP-1 reactor. Later he was in charge of the design and construction of the CP-3 reactor, the first heavy water moderated rector which started up in 1944.

In 1946 he was named the first director of the Argonne National Laboratory, a post he held for ten years. In 1956 he resigned from ANL and formed the General Nuclear Engineering Corporation and then, in 1964 became vice-president of Combustion Engineering when that company took over GNEC. He retired from that position in 1970 but remained on the board of CE until 1986.

Zinn was involved in many national and international groups and was the founding president of the American Nuclear society in 1955-1956.

Sigvard A. Eklund, the second director general of the International Atomic Energy Agency, died January 30, in Vienna.

Eklund served as DG of the IAEA for 20 years from 1961 to 1981. On his retirement he was granted the unusual title of "Director General Emeritus". The IAEA's Board of Governors credited Eklund with having done more than anyone "to further the development of the Agency".

Eklund was born in Sweden in 1911. After obtaining a M.Sc. In 1936 he worked at the Nobel Institute of Physics until 1945, simultaneously pursing a Ph.D. which he was awarded in 1946. From 1946 to 1950 he was a senior scientist at the Research Institute for National Defence and also assistant professor at the royal Institute of Technology in Stockholm. From 1950 to 1956 he was director research at the Swedish Atomic Energy Company and from 1957 to 1961 director of reactor development at AB Atomenergi.

Dr. George Michael Volkoff, an internationally renown nuclear physicist and a member of the team at the Montreal Laboratory, died April 24, 2000, at the age of 86.

George Volkoff was born in Moscow in 1914 and came to Canada with his family in 1924. In 1930 he entered the University of British Columbia and then went to the University of California where he obtained a Ph.D. in 1940. During those post graduate years he worked with Robert Oppenheimer (of atomic bomb fame) on a seminal paper on neutron stars.

He returned to UBC in 1940 as an Assistant Professor but a few years later joined the small team at the Montreal Laboratories that was designing a heavy water moderated nuclear reactor as head of the theoretical physics group. In 1946 he returned to UBC and subsequently became head of the Department of Physics from 1961 to 1971 and then Dean of the Faulty of Sciences until his retirement in 1979.

For his work at the Montreal Laboratory he was awarded an M.B.E. in 1946 and many years later, for his overall contribution to science in Canada, in 1994 was named an Officer of the Order of Canada.

NPT review underway

The sixth 5-year review of the International Treaty on the Non-Proliferation of Nuclear Weapons (commonly referred to as NPT) began in New York on April 24, 2000 and is scheduled to continue until May 19. As of February of this year there were 187 states party to the Treaty.

The NPT was developed in the mid 1960s, signed in 1968 and put into force in 1970. Its objectives are:

- to halt the spread of nuclear weapons;
- to provide security for non-nuclear-weapon states;
- to create a climate for fostering the peaceful uses of nuclear energy; and,
- to encourage good faith arms-control negotiations leading to the eventual elimination of nuclear weapons.

At the fifth review meeting in 1995 the parties to the Treaty agreed to extend it indefinitely.

Canadians were very involved in the development of the NPT and of the international safeguards system of the International Atomic Energy Agency (IAEA) which preceded it and is a key component of the implementation of the Treaty. Canadian policy restricts nuclear exports to countries that have signed and ratified the NPT and Canada was the first advanced nuclear nation to open all of its nuclear activities to IAEA safeguards inspection. The IAEA maintains a team in Toronto.

Science for Educators Seminar

The annual Science for Educators Seminar, sponsored by Atomic Energy of Canada Limited, was scheduled to take place at AECL's Chalk River Laboratories, April 27 to 29, 2000. There are 75 teachers registered for this year's seminar. Over two and a half days they will participate in a choice of 31 sessions on topics in may areas, including: biology, chemistry, physics, engineering, environmental science, waste management. It is planned that Allen Kilpatrick will join the group for a commemorative tree planting ceremony in recognition of AECL staff involved with science education Dr. Paul Unrau, a former AECL researcher and now with the Human Genome Project, is slated to talk at the seminar dinner on "Genetics and Uniqueness".

Pickering "A" Environmental Assessment

Officials of Ontario Power Generation informed that the draft Environmental Assessment Screening Report (EASR), required for the restart of the four-unit Pickering "A" station, had been submitted to the Atomic Energy Control Board in mid April. It is understood that AECB staff have judged it as adequate and will be recommending that it be forwarded to the Canadian Environment Assessment Agency for formal review.

The AECB issued a draft of the required scope of the EASR for public comment in November 1999. After considering the comments received the AECB issued the final Scoping Document in January 2000, enabling OPG to complete the report

Early approval of the EASR is considered very important in the decision whether or not to proceed with the re-starting of Pickering "A".

Notice

Canadian Nuclear Association

Annual General Meeting

The **Annual General Meeting** of the **Canadian Nuclear Association** will take place

Tuesday, June 13, 2000, beginning at 10:30 a.m.

in the

Baker Room, Delta Chelsea Hotel, Gerrard Street West, Toronto, Ontario

CNS news

From the President's desk...

This is the last time I'll be writing to you in this column. My term as your President is almost over. As I sit back and reflect on the year past, I cannot help but wonder how quickly it has sped by. However, as usual, the constant has continued to change. I refer to the growing challenge facing the Canadian nuclear industry. There has been no new reactor sale, the nuclear R&D budget has continued to shrink, the federal budget did not include funding for the proposed neutron research facility, the number of University students interested in pursuing nuclear related career continues to decrease, staff recruitment by the nuclear industry has not increased, staff attrition has continued, and so on. What is going on? Two things come to my mind, although to many these may come across as restating the obvious.

Fundamental to any industrial advancement is a good R&D infrastructure. This is especially true of nuclear. To maintain competitiveness with other energy options, newer designs with lower costs need to be explored. We need to be able to attract our young scientists and engineers to work on advancing the technology. Only an adequate R&D and engineering base will help accomplish this objective. It is up to the nuclear industry (designer, operators, regulator and suppliers), government and Universities to work together to maintain a strong infrastructure to sustain nuclear science and technology, and hence a strong nuclear industry, in Canada.

Second, a well-informed public and public support for nuclear are key components in the overall nuclear equation. The industry needs to communicate the nuclear advantage better with the public. At the end of the day, it is the public that will decide the fate of nuclear.

What can we as CNS members do to help? The answer is - a lot. Get involved locally and think nationally. Very few Canadians appreciate the benefits of nuclear science and technology. Fewer still are aware of the positive effects of nuclear energy on the environment. There are ways to correct this situation. Contact your local CNS Branch, get in touch with the some of the local high school principals and arrange talks to students on nuclear science and technology. Organize information seminars in your place of work. Talk to family, friends and government representatives about the benefits of nuclear science. Write letters and articles to newspapers and magazines on nuclear science and technology. One thing leads to another. It is important to speak out to influence policy that will ultimately benefit Canadians. I commend many of our members who are already doing all of the above. We need the active involvement of everyone and more new members.

I have enjoyed serving as your President and pledge to continue to work for the promotion of nuclear science and technology in the years to come.

V.S. (Krish) Krishnan
President

New Members

Welcome to the following new members of the Canadian Nuclear Society.

David Jackman Wallace	Marc Leger
Wendy Ann Walker	Gerry Waterhouse
Yury Verzilov	Dale F.Weeks
Michael Taylor	Krishna Pada Chakraborty
Shyam Ramachandran	Patrick M. Tighe
Victoria Briant	Larisa May Duffy
Robert Jr. Pasuta	Stephen Hall
Ken Robert Chaplin	Roger Barakat
Ravikumar Aladi	Gus Joseph Edmond
Lars Henriksson	Antonino F. Oliva

CANTEACH

- CNS University Committee and AECL team up in an innovative project.

The CNS University Committee, chaired by Prof. Bill Garland of McMaster University, has joined with Atomic Energy of Canada Limited in a new program named CANTEACH, to develop instructional materials for CANDU. Dan Meneley of AECL is the project director. Industry partners are being sought.

The objective is to develop integrated, university level, instruction materials on CANDU for a diverse audience which could include university students, power plant trainees, management, and government officials. Recognizing the range of interest of the potential clientele, the teaching modules will be varied. Much material has already been prepared and compiled by George Bereznai who has been in Thailand for the past five years on a program, initially co-sponsored by CIDA and AECL, developing university level courses on nuclear power with emphasis on CANDU.

The initial objective is to improve availability of these materials in China. Chinese professors are now writing several Putonghua (Mandarin Chinese) monographs on CANDU 6. Raymond Sollychin of AECL, who has a knowledge of Putonghua, is assisting with the project.

BRANCH ACTIVITIES

Ed. Note: Following is news from the CNS branches as has been supplied from them.

Golden Horseshoe

David Jackson

The CNS Golden Horseshoe Branch provided financial support to the successful CNS Student Nuclear Conference which was held at McMaster University on March 10-11. Some Branch members were also involved in its organization.

Manitoba

Morgan Brown

The Manitoba Branch hosted two talks in March.

On March 9th, Alistair Miller, Manager of AECL's Heavy Water Technologies Branch, gave an address at Whiteshell Laboratories on *Heavy Water: Manufacturers Guide for the Hydrogen Century.* Dr. Miller discussed the old and new technologies for D_2O production, including the new pilot production plant in Hamilton. Amongst other things, we learned that D_2O is chemically

identical to heavy water, except for the reaction kinetics. Apparently there is no noticeable difference if one had a few percent heavy water in your body, but it would become noticeable above 10%. A level of 20% heavy water in our systems would be enough to kill us, because of the different reaction rates in the many chemical processes in our bodies. Which leads to thoughts of a murder mystery where the poison goes undetected (by the usual chemical forensic work, anyhow). "Death by Deuterium"? "Murder from Deuterient Excess"?

On March 31, we welcomed Ingo Beckmerhagen, of the German Federal Office for Radiation Protection, back to Manitoba. He last spoke to us in May 1998, en route to a conference. He spoke to us on *Safety Management to Improve the Operational Safety of Nuclear Installations Performance,* describing some case studies from the implementation of a safety quality management system. He also described the present political situation in Germany, and its effect on the nuclear industry.

New Brunswick

Mark McIntyre

The New Brunswick Branch has had 2 very interesting sessions over the last couple of months. On February 15, 2000, we had a repeat performance of Dr. Ed Waller's talk about his visit to the Chornobyl site in the summer of 1999. The location for the talk "A Walk in the Exclusion Zone: Thirteen Years after the Chornobyl-4 Accident" was the Point Lepreau Generating Station Theatre. (Note the spelling of Chornobyl, as explained by Dr. Waller, it more accurately represents the Ukrainian language and is preferred by the residents of the area.) A detailed review was included in the January 2000 edition of the Bulletin.

On March 16, 2000, the NB Branch went on a field trip to the Saint John Regional Hospital, where Stephen Hall, Director of the Saint John School of Radiation Therapy, hosted an evening detailing the medical uses of ionizing radiation. Stephen started the session with a presentation on cancer and risk factors. A tour of the lab followed with an explanation of diagnostic tools, shielding methods and the capabilities of each piece of therapeutic equipment. As a token of appreciation from the branch, Stephen was made a member of the CNS. It was noted by many CNS members they appreciated the format of moving the talk into the community. The Branch Chairman responded: "Every attempt will be made to

increase the number of lecturers from the non-power generation community in our Guest Speaker Program."

Ottawa Branch
Bob Dixon

David Cole of Science Applications International Corporation gave a presentation entitled *"Post-Accident Radiation Monitoring at Chernobyl"* on March 23, 2000. Attendance was good and interest high.

CNS Ottawa members participated in the Ottawa Regional Science Fair as judges on April 1, 2000. Unfortunately, for the second consecutive year, no project met the CNS Ottawa Branch criteria. However, members also judged entries on behalf of AECL for the AECL prize, which was awarded.

Sheridan Park
Parviz Gulshani

The Branch's Education Committee (Sadok Guellouz, Scott Guay, Olga Jevremovich) attended and presented award to students at the Peel Region Science Fair and at the Hamilton District Science Fair.

The Branch has had a number of interesting seminars and further ones are planned.

- March 7 Dr. S.H.H. Pang (Deputy Qinshan Project Director, AECL), on *Qinshan CANDU Project Update*
- March 14 Dr. H.H. Rogner (Section Head, Planning and Economic Studies Section, DOE, IAEA), on *Nuclear Industry Forum*
- April 7 Mr. P. Charlebois (Senior Vice President, Nuclear Operations Support and Services, OPG Inc.), on *OPG's Improvement Programs and How They Relate to Plant Performance Improvement*

The Branch is arranging for Dr. Y. Li (former Chairman of the Chinese Atomic Energy Authority and now Senior Advisor, China National Nuclear Corporation) to make a presentation to the Branch on June 8 on "The Future of the Nuclear Industry in China" prior to his speaking at the CNS Annual.

Canadian Nuclear Society

Annual General Meeting

The **3rd Annual General Meeting** of the incorporated *Canadian Nuclear Society will take place*

Monday, June 12, 2000 beginning at 5:00 p.m.
in the
Scott Room, Delta Chelsea Hotel, Gerrard Street West, Toronto, Ontario

All members of the Canadian Nuclear Society are invited to attend.

While the AGM will be held in conjunction with the 2000 Annual Conference it is not necessary to be registered at the conference to attend the meeting.

Refreshments will be served.

CNS members please note that the formal notice of the AGM, with agenda and nominations for Council, is enclosed with this issue of the CNS Bulletin. If you do not receive the package contact the CNS office.

For further details go to the CNS Web site < www.cns-snc.ca >
or call the CNS office at 416-977-7620

25th CNS / CNA Student Conference

- again, quality rather than quantity

Members of the organizing committee for the 25th CNS/CNA Student Conference, held at McMaster University in Hamilton, March 10, 11, 2000, pose for the CNS Bulletin.
L to R: Jeff McDonald, Sonia Lala, Evelyn Jackson, Nima Safaian (chair), Bill Garland (staff adviser), Rob Pasuta, Imre Vencel. (Missing: Joe Dallaire, Simon Day.)

The year 2000 CNS / CNS Student Conference was held at McMaster University on Saturday, March 11, with a pre-conference dinner the evening before at a nearby inn. It was a social, professional and financial success, thanks to the student organizers.

As has been the situation for the past few years, the number of participants in this year's CNS / CNS Student Conference was not large, probably reflecting the decline in university programs related to nuclear science and technology. However, again representative of recent years, the quality of the papers presented was very high.

This was the 25th Student Conference, making the event older than the Canadian Nuclear Society itself. The series of conferences was begun under the auspices of the Canadian Nuclear Association in 1976 but following the creation of the CNS in 1980 the Society has taken the lead in ensuring the continuation of the annual forum.

In actual fact the organization and running of the conferences has been by students - this year from McMaster University in Hamilton (with some advice and cajoling by Professor Bill Garland).

The pattern was similar to that of recent years with a dinner and guest speaker on the Friday evening, paper presentations most of Saturday, and a tour, this time of the McMaster Nuclear Reactor. (For a story on the MNR see the previous issue of the CNS Bulletin, Vol. 20, No. 4.) The Friday evening dinner was attended by more than a dozen representatives of the nuclear industry, giving the students an opportunity to meet with them in a relaxed atmosphere.

At the dinner Jeremy Whitlock, a relatively recent graduate of McMaster, gave an interesting and entertaining talk which he entitled: "The Impotence of Being Earnest - Adventures in Communicating the Nuclear Vision". He reflected on his attempts, through letters to the editor, his own Web page, and his involvement in a number of Web chat groups, to get the nuclear message out, often with frustration. (Jeremy currently authors the *Endpoint* commentary located on the last page of the *CNS Bulletin.*)

Thirty students attended but just a total of eleven papers were presented in three categories; undergraduate, masters, and, doctorate. Many made use of computer generated projections giving a very professional impression. They covered a range of topics and were of a uniformly high quality, presenting the judges with some difficult choices, especially in the Masters category. (The full list of papers is given below.)

As noted, the conference was put together by a team of students from McMaster University, with Prof. Bill Garland (who is chair of the CNS Universities Committee) as adviser. Not only did they organize all details of the event they also found a number of sponsors such that, financially, the conference more than broke even.

The organizing committee consisted of: Nina Safaian, chair, Joe Dallaire, Simon Day, Evelyn Jackson, Sonia Lala, Jeff McDonald, Robert Pasuta, Imre Vencel.

List of Papers *(in order of presentation)*

J. A. Kennedy and S. E. Day (M) McMaster University
Comparison of McMaster Nuclear reactor Irradiation experiments with Simulation

M. J. McCall and M. Pierre (M) Royal Military college
A Feasibility Study of the SLOWPOKE-2 Reactor as a Neutron Source for BNCT

A. McLean (U) University of Toronto
Modelling the Creation of Methane and its Derivatives in the Tokamak Edge-Effect Simulation Code DIVIMP

Shown are the winners of the 25th CNS/CNA Student Conference, held March 10, 11, 2000.
L to R: Adam McLean (undergraduate), Ibrahim Attieh (doctorate), Mike McCall, Tom Chalovich (masters, tie).

T. Chalovich (M) Royal Military College
Neutron Radioscopy at the SLOWPOKE-2 Facility at RMC for the Inspection of CF-18 Flight control Surfaces

G. Harrington (M) University of New Brunswick
Hideout of Sodium Phosphates in Steam Generator Crevices

L. McCrea (M) University of New Brunswick
Deposition of Corrosion Product Particles onto Heat Exchange Surfaces

I. K. Attieh (P) University of Tennessee
Regularization of Feedwater Flow Rate Evaluation for Venturi Meter Fouling Problem in Nuclear Power Plants

I. Miedema and M. Walker (M) Royal Military College
High Polymer-Based Composite containers for the Disposal / Storage of High, Intermediate and Low Level Radioactive Waste

I. Vencell (M) McMaster University
An Investigation of the Performance of System That is Guarded by a Responsive System of Protection

M. McCall (M) Royal Military College
Development and Validation of a Predictive Code for AirCrew Radiation Exposure (PC- AIRE)

I. K. Attieh (P) University of Tennessee
Pattern Recognition Techniques for Transient Detection to Enhance Nuclear reactors' Operational Safety.

Summaries of winning papers

Undergraduate

Modeling Creation of Methane and its Derivatives in the Tokamak Edge-Effect Simulation Code (DIVIMP)
Adam Mclean University of Toronto

Abstract

Cross section and reaction rate coefficients for the creation of Methane (CH4) and it's derivatives are processed for use in the Monte Carlo simulation code DIVIMP (DIVertorIMPurity). Due to a lack of verifiable experimental data for individual methane fragment reaction cross sections, consideration of hydrocarbons in the plasma solution has been left out of DIVIMP until now. A new module has been developed with utmost flexibility and expandability in mind for integration into DIVIMP. This module follows the state of a hydrocarbon molecule and in a Monte Carlo way, tracks the interactions it undergoes as electrons and protons collide with the fragment. Program structure and development as well as examples of single-step and full-fragment evolution are presented.

Masters

(1)
Neutron Radioscopy at the SLOWPOKE-2 Facility at RMC for the Inspection of CF-18 Flight Control Surfaces
T. R. Chalovich Royal Military College

Abstract

Recent developments in Charged Coupled Device (CCD) cameras have made real and semi-real time neutron radioscopy an affordable and reasonable alternative to neutron radiography utilizing film techniques. Developing and analysing the capability of a Neutron Radioscopy System (NRS) at the SLOWPOKE-2 Facility at Royal Military College (RMC) was carried out with the result that neutron radioscopy was determined to be feasible for use in the detection of water ingress in CF-18 flight control surfaces.

(2)
Development and Validation of a Predictive Code for AIrCrew Radiation Exposure (PC-AIRE)
Michael J. McCall Royal Military College

Introduction

Recently, it has been determined that jet aircrew are routinely exposed to levels of natural background radiation (i.e., cosmic radiation) which are significantly higher than those present at ground level. In 1990, the International Commission on Radiological Protection (ICRP) recommended that aircrew be classified as occupationally exposed. They also recommended a reduction in the occupational exposure (from 50-20 mSv/yr) as well as a reduction in the general population exposure (from 5 to 1 mSv/yr).

Prior to the ICRP recommendations, there was little

detailed consideration of the radiation safety aspects of Galactic Cosmic Rays (GCR) exposure at passenger aircraft flight altitudes. In the past, radiation protection regulators did not see the possibility of overexposure to natural radiation. Recent studies of major Canadian airlines by Lewis et al. at the Royal Military College of Canada (RMC) determined that the exposure to most aircrew is comparable to the average exposures of nuclear workers.

International airline regulators now realize that some type of radiation monitoring for aircrew worldwide is most likely to be mandated. This monitoring could take several forms, such as the wearing of dosimeters (as in the nuclear industry) or the use of a computer prediction program, based perhaps on an experimental database. If a program proved successful, the cost and infrastructure of utilizing such a tool would be considerably less than the option of badging aircrew.

This paper describes the method of collecting and analyzing radiation data from numerous worldwide flights, and encapsulating the results in a program which calculates the radiation dose for any flight in the world in the past, present or near future. The use of such a program rests with airline and radiation safety regulators.

Doctorate

Pattern Recognition Techniques for Transient Detection to Enhance Nuclear Reactors' Operational Safety

I.K. Attieh, A.V. Gribok, J.W. Hines, and R.E. Uhrig
University of Tennessee

Introduction

Nuclear power plants are highly complex systems that are operated and monitored by humans. When faced with an unplanned transient, such as a plant accident scenario, equipment failure or an external disturbance to the system, the operator has to carry out diagnostic and corrective actions. The anomalous operating conditions must be diagnosed and identified through the process instrument readings. The sheer number of instruments can make the diagnosis process fairly difficult. The difficulty in the diagnosis process is compounded by the fact that these anomalies develop over time. Hence, depending on the severity of accident, instruments' readings might not give clear indication of an anomaly at its incipient stage. The operator's response may be too late to mitigate or minimize the negative consequences of such anomalies. The objective of this research is to develop a module based on artificial intelligence technologies that will assist the operator to identify the transients at the earliest stages of their developments. Early detection will help in minimizing or even mitigating the negative consequences of such transients. It is equally important to identify the type of transient correctly. Misidentification of transients might result in incorrect action by the operator.

Transient detection can be classified as a pattern recognition problem. When a transient occurs starting from steady state operation, instruments' readings develop a time dependent pattern. These patterns are unique with respect to the type of accident, severity of accident, and initial conditions. For example, the system's response to a Main Steam Line

Prof. Bill Garland explains the fuel handling tools at the McMaster Nuclear Reactor to participants of the 25th CNS/CNA Student Conference, March 11, 2000.

CNS/CNA 2000 Student Conference Winning Papers

Undergraduate:

Adam McLean, University of Toronto
Modelling the Creation of Methane and its Derivatives in the Tokamak Edge-Effect Simulation Code DIVIMP

Masters (a tie)

Tom Chalovich, Royal Military College
Neutron Radioscopy at the SLOWPOKE-2 Facility at RMC for the Inspection of CF-18 Flight control Surfaces

Michael McCall, Royal Military College
Development and Validation of a Predictive Code for AirCrew Radiation Exposure (PC-AIRE)

Doctorate

Ibrahim Attieh, University of Tennessee
Pattern Recognition Techniques for Transient Detection to Enhance Nuclear reactors' Operational Safety.

break will differ from its response to a loss of coolant accident. Therefore, by properly selecting the variables used by the pattern recognition system, the relevant features will be extracted from the measurements.

To tackle this problem, a number of linear and nonlinear pattern recognition techniques can be utilized. For this work, artificial neural networks will be utilized for transient identification. Their advantages are the following: adaptive learning, nonlinear generalization, faults tolerance, resistance to noisy data, and parallel processing. However, the standard pattern recognition techniques will classify any pattern to fit the closest matching pattern. However, since the neural network cannot be trained on all possible transients, it is important that it does not classify transients on which it has not been trained. Otherwise, the system will wrongly classify patterns that it does not know.

This will hinder the proper diagnosis of the problem by the operator. To overcome this problem, it was proposed by Bartal, Lin and Uhrig (1995) to use probabilistic neural networks. These networks have a parameter that will classify a pattern depending on its probability to matching a specific pattern. Hence, when a pattern has low probability of being any of the "learned" patterns, it will be classified as "Don't Know". For this work, to minimize the pitfall of false identification of transients on which the network has not been trained, a network is trained to identify each individual transient, each network has only one transient associated with it. Each network is not only trained to identify each transient, but it is also trained to reject the other transients as being that specific transient. In other words, the neural network that is trained to identify loss of coolant accidents is also trained to classify the other transients as "normal" operating condition to minimize transients' misidentification.

21st ANNUAL CNS CONFERENCE
Delta Chelsea Hotel, Toronto, Ontario
2000 June 11 - 14

REGISTRATION FORM
(Please type or write in block letters)

Name: _____
First Last

Title: _____

Organization:

_____

Business Address: _____
Street # Street Name

_____
City Province/State

_____
Postal Code Country

Bus. Telephone:

_____

Fax: _____

Email: _____

Are you a Speaker? Yes_____ No _____

A. Regular Delegate Registration

Includes all CNS Sessions, Reception, Conference meals, one copy of Proceedings and Fun Night (Banquet)

Before 2000 May 5		**On or after 2000 May 5**
$530	.CNS Member, including Speaker.	.$590
$595	.Non-CNS Member, including Speaker	.$695

B. Retiree/Student Registration

Includes all CNS Sessions, Reception, Conference meals, one copy of Proceedings and Fun Night (Banquet)

Before 2000 May 5		**On or after 2000 May 5**
$160	.Retiree CNS Member	.$200
$160	.Student (Full Time only)	.$200

C. One-Day Registration

Includes sessions and Conference meals for day selected
Please circle the day you wish to attend: Mon. Tues. Wed.

$280 for Mon. or Wed. (Includes Luncheon of the day)
$310 for Tuesday (No Luncheon, Includes the Banquet)

D. Additional Conference Proceedings

Note: Proceedings will be on CD ROM only

$70 per copy .....Quantity:_____

E. Extra Tickets (if applicable)

Please indicate the quantity

Extra Luncheon Ticket .....**$35 x** _____

Please circle the day you wish to attend the luncheon: .....**Mon. or Wed.**

Extra Fun Night (Banquet) ticket for Tuesday .....**$65 x** _____

F. Guest Registration (Complimentary)

(Spouse/Guest accompanying delegate):

Full Name: _____
Complimentary (Reception only)

Summary

NOTE: All fees are in Canadian dollars. If paying in US $, please note: Exchange rate applied: $1.50 Canadian = $1.00 US

Please show total of sections A to E: .....$_____

Please add 7% GST (#870488889 RT) .....$_____

.....Total Due ...$_____

If you are using a credit card, you are welcome to reply by FAX: 416-977-8131 – Attn: Sylvie Caron or Denise Rouben

Method of Payment

Cheque Mastercard Visa AMEX

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

Card #: _____ Exp. Date (yy/mm) _____

Signature:

_____ Date: _____
Required

For further information, please contact Denise Rouben or Sylvie Caron: Tel 416-977-7620 - Fax 416-977-8131 or Email <cns-snc@on.aibn.com>.

Registration form also available at www.cns-snc.ca

Cancellation Policy: A fee of $100 will be charged for all cancellations received after 2000 May 5.

Hotel booking must be made directly with the Delta Chelsea. The phone numbers are 416-243-5732 and 1-800-243-5732.
Please indicate that the reservation is for the CNS Annual Conference (Code Name is GENUC). A block of rooms is held for the Conference until 2000 May 11. The price of the rooms is $199 per night (+ tax), single or double. Smoking or non-smoking rooms are available upon request.

Preliminary Program

CNS 2000 Annual Conference

21st Annual Conference of the Canadian Nuclear Society

Theme: *A Better Nuclear Tomorrow*

Delta Chelsea Hotel, Toronto, Ontario, Canada
2000 June 11 - 14

Monday June 12, a.m.

07:30-12:00 **Registration - Windsor Room**

Session 1: **Plenary I: Nuclear Industry Updates - Churchill Ballroom (08:30-11:45)**

Chair: **P. Charlebois (Ontario Power Generation)**

08:30 **Welcome**, *V.S. Krishnan (CNS) and P. Charlebois (Ontario Power Generation)*

08:45 **AECL Update**, *A. Kilpatrick (AECL)*

09:10 **Pickering A Restart**, *R. Strickert (OPG)*

09:35 **The MAPLE Medical Isotope Reactor**, *G. Malkoske (Nordion International)*

10:00 **Break**

10:30 **Next Generation CANDU**, *D.F. Torgerson (AECL)*

10:55 **Improving Performance at Point Lepreau**, *R.M. White, W.S. Pilkington, R.M.Crawford, K. Miller, B.M. Ewing, J.J. McCarthy, P.D. Thompson (New Brunswick Power)*

11:20 **Recent Developments re Disposal of High- and Low-Level Radioactive Wastes**, *P. Brown (NRCan)*

12:00 **CNS Luncheon - Mountbatten Ballroom**
Guest speaker: G. Preston, Executive Vice-President and Chief Nuclear Officer, Ontario Power Generation

Monday June 12, p.m.

14:00-17:00 **Registration - Windsor Room**

Session 2A: **Physics I - Scott Room (14:00-17:00)**

Chair:

14:00 **Update on RFSP-IST**, *D.A. Jenkins and B. Arsenault (AECL), A.U. Rehman and W.M. Kelly (Ontario Power Generation)*

14:25 **Validation of WIMS-AECL/RFSP Analysis of Moderator and Heat-Transport Temperature Reactivity Effects in Darlington Unit 2 During Commissioning**, *F. Ardeshiri (AECL)*

14:50 **Efficient Compliance with Licence Limits Using Hypothesis Testing with Operational Reactor Data**, *P. Sermer and C. Olive (Ontario Power Generation), F.M. Hoppe (McMaster University)*

15:15 **Break**

15:45 **The Analytic Nodal Method for CANDU Reactor Diffusion Calculations**, *J. Mao and J. Koclas, École Polytechnique de Montréal*

16:10 **Power-Peaking Factors in the McMaster Nuclear Reactor**, *S.E. Day (McMaster University)*

16:35 **Coupling of Reactor Physics and Thermalhydraulics Codes for CANDU Analysis**, *B. Dionne, J. Koclas, P. Tye and A. Teyssedou (Institut de Génie Nucléaire)*

17:00 **CNS Annual General Meeting - Scott Room**
All CNS members welcome; host bar

Monday June 12, p.m.

14:00-17:00 **Registration - Windsor Room**

Session 2B: **Environmental Assessment - Rossetti Room (14:00-17:00)**

Chair: **K. Dormuth (AECL)**

14:00 **Radiological Environmental Monitoring Programs at Canadian Nuclear Facilities - A Practical Model for Follow-Up Activities Under the Canadian Environmental Assessment Act**, *J.A Tamm and R. Zach (AECL)*

14:25 **Role of Project Description in an Environmental Assessment Report for a Nuclear Power Plant Project**, *K.M. Aydogdu, C.R. Boss, and P. Hnatiuk (AECL)*

14:50 **Using Environmental Assessment to Kick-Start Organisational Environmental Management Systems**, *L.F. Cattrysse (ICF Consulting Canada Inc.)*

15:15 **Break**

15:45 **Greenhouse Gas Reduction and Canada's Nuclear Industry**, *D. Pendergast (Computare), J. Bowman (Babcock & Wilcox Canada), T. Gorman (Canadian Nuclear Association), M.J. Stewart (Stewart Advantage Consulting)*

16:10 **Environmental Protection at the New Generation of Uranium Mines in Northern Saskatchewan**, *R. Pollock (COGEMA Resources Inc.) and J. Jarrell (Cameco Corporation)*

16:35 **"Status of the Canadian Environmental Assessment Agency's 5-Year Review of the CEA Act"**, *J. Clarke (Canadian Environmental Assessment Agency)*

17:00 **CNS Annual General Meeting - Scott Room**
All CNS members welcome; host bar

Monday June 12, p.m.

14:00-17:00 **Registration - Windsor Room**

Session 2C: **Thermalhydraulics I - Wren Room (14:00-17:00)**

Chair:

14:00 **Heat Transfer in CANDU-Type Fuel Bundle During a LOCA Experiment**, *D.J. Wallace (AECL)*

14:25 **A Multiple-Node Real-Time Pressurizer Model**, *H. Tang (New Brunswick Power)*

14:50 **Numerical Simulation of the RD-14M Test T9308,** *M. An and W. Thompson (Atlantic Nuclear Services Ltd.), M. Wright (Consultant)*

15:15 **Break**

15:45 **Centrifugal Filtering for CANDU Secondary-Side Water Cleaning,** *A. Eyvindson (AECL)*

16:10 **Verification of a CATHENA Integrated Point Lepreau Plant Model For Safety Analysis,** *A.V. Galia and R. Girard (New Brunswick Power), M.A. Wright (Consultant)*

16:35 **Analyzing and Modelling Natural Circulation Phenomena in a CANDU 6,** *P. Gulshani (AECL), C.H. Nguyen (Hydro-Québec), and M.A. Wright (Consultant)*

17:00 **CNS Annual General Meeting - Scott Room All CNS members welcome; host bar**

Monday June 12, p.m.

14:00-17:00 Registration - Windsor Room

Session 2D Safety and Licensing I - Carlyle Room (14:00-17:00)

Chair:

14:00 **Application of Flux-Tilt Parameters to Support Regional Overpower Protection Trip Coverage for a CANDU-6 Reactor,** *J.A. Walsworth and D.F. Basque (Brunswick Nuclear Inc.), E.G. Young and B. Willemsen (New Brunswick Power)*

14:25 **Bruce B Risk Assessment Results and Applications,** *R. Parmar and W.A. Webb (OPG Nuclear)*

14:50 **Canadian-Based Aircrew Exposure From Cosmic Radiation on Commercial Airline Routes,** *A.R. Green, M.J. McCall, B.J. Lewis, LG.I. Bennett, M. Pierre, and H.W. Bonin (Royal Military College of Canada)*

15:15 **Break**

15:45 **Risk Assessment and Risk Management for Conventional Hazards at Nuclear Plants,** *M. Oliverio (Ontario Power Generation)*

16:10 **Regulatory Positions on Safety-Related Setpoints and Instrumentation Uncertainty of Wolsong NGS,** *O.-.P Zhu, S.-H. Lee, B.-R. Kim and S.-H. Oh (Korea Institute of Nuclear Safety)*

16:35 **Application of Operating Experience in Environmental Qualification,** *S. Y. Lee and R. Wise (Ontario Power Generation)*

17:00 **CNS Annual General Meeting - Scott Room All CNS members welcome; host bar**

Tuesday June 13, a.m.

07:30-12:00 Registration - Windsor Room

10:30 **CNA Annual General Meeting - Baker Room**

Tuesday June 13, a.m.

07:30-12:00 Registration - Windsor Room

Session 3A: Safety and Licensing II - Carlyle Room (08:45-11:45)

Chair:

08:45 **IAEA Safeguards – Developing to Keep Up with a Changing World,** *Alec C.F. Hadfield (New Brunswick Power) and J. K. Cameron (Atomic Energy Control Board)*

09:10 **CANDU Core Health Monitoring Systems,** *B. Sur, P. Tonner and S. Craig (AECL)*

09:35 **The DCYPWR Code: Fuel Decay Power Calculations for CANDU Fuel and Reactor Cores,** *D.F. Basque, J.A. Walsworth and R.A. Prime (Brunswick Nuclear Inc.), R.W. Sancton and E.G. Young (New Brunswick Power)*

10:00 **Break**

10:30 **Safety Upgrades to the NRU Research Reactor,** *E. Mutterback (AECL)*

10:55 **HAZOP Powerful Risk-Analysis Tool,** *J. Krasnodebski (Consultant)*

Tuesday June 13, a.m.

07:30-12:00 Registration - Windsor Room

Session 3B: Environmental Risk Assessment - Rossetti Room (08:45-11:45)

Chair: J. Tamm (AECL)

08:45 **Integrated Risk Assessment Using A Screening-Level Computer Model,** *D.R. Hart, D.L Lush and N.P. Morris (Beak International Incorporated)*

09:10 **Environmental Risk Assessment - A Practitioner's Perspective,** *D.B. Chambers and M. W. Davis (SENES Consultants Limited)*

09:35 **A Framework for Selecting Assessment and Measurement Endpoints for Ecological Risk Assessment of Canadian Nuclear Power Stations,** *A. Trivedi (AECL), D. Wismer (OPG) and N.E. Gentner (AECL)*

10:00 **Break**

10:30 **Ecodosimetry Weighting Factor for Non-Human Biota,** *N.E. Gentner and A. Trivedi (AECL)*

10:55 **The Importance of Environmental Monitoring Data in Environmental Risk Assessment: An Ecosystem Approach,** *T.L. Yankovich, R.W.D. Killey, M.H. Klukas, R.J.J. Cornett, R. Zach, C. Lafontaine, B. O'Donnell, T. Eve, T. Chaput, M.L. Benz, and M. Haas (AECL)*

11:20 **Status of the Assessment of "Releases of Radionuclides from Nuclear Facilities (Impacts on Non-Human Biota)" on the Second-Priority-Substances List of the Canadian Environmental Protection Act,** *P. Thompson and G. Bird (AECB)*

Tuesday June 13, a.m.

07:30-12:00 Registration - Windsor Room

Session 3C: Physics II - Scott Room (08:45-11:45)

Chair:

08:45 **Photoneutron Experiment Performed in ZED-2,** *M.B. Zeller, A. Celli, R.T. Jones and G.P. McPhee (AECL)*

09:10 **The Coolant Void Reactivity Program in ZED-2,** *A. Celli, R.S. Davis, S.R. Douglas, R.T. Jones, G.P. McPhee, and M.B. Zeller (AECL)*

09:35 **Validation of the DRAGON/DONJON Code Package for MNR Using the IAEA 10 MW Benchmark Problem**, *S.E. Day and Wm. J. Garland (McMaster University)*

10:00 **Break**

10:30 **Validation of the Substitution Method for Measurement of Void Reactivity**, *R.S. Davis, A. Celli, S.R. Douglas, R.T. Jones, D.C. McElroy and M.B. Zeller (AECL)*

10:55 **Derivation of Non-Linear Iterative Nodal Expansion Method for CANDU Analysis**, *W. Shen (AECL) and H. Choi (KAERI)*

11:20 **"Extension to the Three-Dimensional Characteristics Solver MCI in DRAGON"**, *G.J. Wu and R. Roy (École Polytechnique)*

Tuesday June 13, a.m.

07:30-12:00 Registration - Windsor Room

Session 3D: Reactor and Components - Wren Room (08:45-11:45)

Chair:

08:45 **Estimating the Response Times of Pressure and Flow Transmitters and RTDs via In-Situ Noise Measurements**, *O. Glöckler, D.F. Cooke, G.J. Czuppon and K.K. Kapoor (Ontario Power Generation)*

09:10 **On Relating Inelastic and Redistributed Elastic Analyses Stress Distributions**, *P. Mangalaramanan and W. Reinhardt (Babcock & Wilcox Canada)*

09:35 **Monitoring the Mechanical Vibration of In-Core Detector Tubes and Fuel Channels via ICFD Noise Analysis**, *O. Glöckler, D.F. Cooke, G.J. Czuppon and K.K. Kapoor (Ontario Power Generation Nuclear)*

10:00 **Break**

10:30 **The Origin of Anisotropy DHC Behavior in Zr-2.5%Nb Pressure-Tube Materials**, *S.-S. Kim, S.C. Kwon, K.N. Choo and Y.M. Cheong (Korea Atomic Energy Research Institute)*

10:55 **Creep Strength of Zr-Nb Alloys with a Variable of Manufacturing Process**, *Y.S. Kim, S.S. Kim, K.N. Choo, S.C. Kwon and Y.C. Suh (Korea Atomic Energy Research Institute)*

11:20 **New Packaging and Transport Regulations for IP-2/IP-3 ISO Freight Containers Are in Force in Canada Since April 1, 2000**, *A.G. Frick, L. Henriksson, J. Migenda and F.H. Timpert (STM Safety Technology Management)*

Tuesday June 13, p.m.

14:00-17:00 Registration - Windsor Room

Session 4: Plenary II: Nuclear Industry - Current Trends - Churchill Ballroom (13:30- 17:00)

Chair:

13:30 **Integrated Improvement Program at Ontario Power Generation, Nuclear**, *A. Schwabe (OPGN)*

13:55 **Comparative Costs of Electricity Generation**, *S. Guindon (Natural Resources Canada)*

14:20 **Regulatory Aspects Related to the Pickering A Restart**, *J. Harvie (AECB)*

14:45 **Break**

15:15 **Fuel Processing, International and Domestic**, *R. Steene (Cameco)*

15:40 **Gentilly-2 Full-Power Operation: History and Future Challenges**, *R. Pageau (Hydro-Québec)*

16:05 **Worker Perspective on Safety**, *J. Murphy (Power Workers' Union)*

16:30 **Climate Change and Emission Reduction Opportunities**, *B. Rozendaal, (AECL)*

18:30 **Pre-Banquet Cocktails - Mountbatten Lane Followed by Conference Banquet - Mountbatten Ballroom**
A mystery evening

Wednesday June 14, a.m.

07:30-12:00 Registration - Windsor Room

Session 5A: Plenary III: Looking to the Future - Churchill Ballroom (08:45-11:45)

Chair:

08:45 **Going Up or Going Down? The History and Future for CO2 and Nuclear Power**, *R.B. Duffey (AECL)*

09:10 **The Future of the Nuclear Industry in China**, *Li Yulun (China National Nuclear Corporation)*

09:35 **The Canadian Neutron Facility**, *P. Fehrenbach (AECL)*

10:00 **Break**

10:30 **"Canada's Approach to Meeting its Kyoto Commitment"**, *D. Oulton (Climate Change Secretariat)*

10:55 **CANDU-X: Conceptual Designs for High-Temperature CANDU Reactors**, *S.J. Bushby, G.R. Dimmick, R.B. Duffey, and N.J. Spinks (AECL)*

11:20 **COG - The New Initiatives**, *C. Guiry (CANDU Owners' Group)*

12:00 **CNS and CNA Awards Luncheon - Mountbatten Ballroom**

Wednesday June 14, p.m.

14:00-17:00 Registration - Windsor Room

Session 6A: Thermalhydraulics II - Wren Room (14:00-17:00)

Chair:

14:00 **Study of the Lateral Mixing Between Horizontal Interconnected Subchannels Under Low Inlet Mass Flux Conditions**, *J. Gaspo, A. Teyssedou, P. Tye (Institut de Génie Nucléaire, École Polytechnique de Montréal)*

14:25 **Refinement of the Mass Conservation Algorithm Used in CATHENA**, *T.G. Beuthe (AECL)*

14:50 **Simulation of Darlington Loss-of-Flow Event**, *W.S. Liu, S. Ho, W.K. Liauw, T. Toong, R.Y. Chu and R.K. Leung (Ontario Power Generation)*

15:15 **Break**

15:45 **Evaluation of Temperature Measurement Systematic Errors in PHTS of EMBALSE NGS**, *M.E. Pomerantz, E.E. Coutsiers, C.A. Moreno (Nucleoeléctrica Argentina S.A.)*

16:10 **The New Emergency Core Cooling (NECC) System for the National Research Universal (NRU) Reactor,** *T. Jackson (AECL)*

16:35 **Moderator-Flow Measurements at Darlington and Bruce-B Nuclear Generating Stations,** *D. Zobin, V. Ton and J.R. Sherin (Ontario Power Generation)*

Wednesday June 14, p.m.

14:00-17:00 Registration - Windsor Room

Session 6B: Environmental Models and Monitoring - Rossetti Room (14:00-17:00)

Chair:

14:00 **Tritium in the Great Lakes: Concentration-Time Model,** *M.H. Klukas (AECL)*

14:25 **Development of a Pipe Contamination Monitor for the Waste Segregation Program at the AECL Chalk River Laboratories,** *M.E. Stephens, G.A.W. Walker, A. Eyvindson, P. Primeau and H. Jessup (AECL), L. Champagne and P. Singh-Khera (Lou Champagne Systems Inc.)*

14:50 **Toxicity Limitation on Radioactive Liquid Waste Discharge at OPG Nuclear Stations,** *T. Dobson, Z. Lovasic and G. Nicolaides (OPG)*

15:15 **Break**

15:45 **Special-Case Comparison of Gaussian and Non-Gaussian Atmospheric Transport of Radionuclides,** *P.M. Lord, T.J. Jamieson and K.P. Marshall (SAIC)*

16:10 **Modelling Emissions of Carbon-14 and Argon-41 Released from a CANDU 6 Reactor,** *G. Gomes and C. R. Boss (AECL)*

16:35 **Carbon-14 Chemistry in CANDU Moderator System,** *J. Torok (Consultant) and F. Caron (AECL)*

Wednesday June 14, p.m.

14:00-17:00 Registration - Windsor Room

Session 6C: Control Room - Carlyle Room (14:00-17:00)

Chair: **E. Davey (Crew Systems Solutions)**

14:00 **Operator Error and Emotions,** *B.K Patterson, M. Bradley and W.G. Artiss (Human Factors Practical Incorporated)*

14:25 **Plant Status Control – with an Operational Focus,** *L.A. Lane (Ontario Power Generation)*

14:50 **The Importance of Function Analysis for the Nuclear Industry,** *S. Chen-Wing and U. Sengupta (AECL)*

15:15 **Break**

15:45 **CANDU Control and Shutdown System Computer Obsolescence,** *G.A. Hepburn and N. Ichiyen (AECL)*

16:10 **Practical Control Centre Retrofit for Refurbishment,** *M.P. Feher (AECL)*

16:35 **Criteria for Operator Review of Workplace Changes,** *E. Davey (Crew Systems Solutions)*

Wednesday June 14, p.m.

14:00-17:00 Registration - Windsor Room

Session 6D: Fuel & Fuel Cycles - Scott Room (14:00-17:00)

Chair: **P.G. Boczar (AECL)**

14:00 **Main Aspects of the SEU Fuel Program at the Atucha I PHWR After Five Years of Operating Experience,** *J.M. Fink, R. Pérez, M.Higa, J. Piñeyro, J. Sidelnik, J.A. Casario, L. Alvarez (Nucleoeléctrica Argentina S.A.)*

14:25 **Optimization of CANDU Reactor Performance Using SEU Fuel,** *P.S.W. Chan and D.B. Buss (AECL)*

14:50 **Possibility of Plutonium Burning Out and Minor-Actinide Transmutation in CANDU-Type Reactor,** *A.S.Gerasimov, G.V.Kiselev and L.A.Myrtsymova, State Scientific Center of the Russian Federation, Institute of Theoretical and Experimental Physics*

15:15 **Break**

15:45 **Calculations Supporting the Shipment of Irradiated CANFLEX Demonstration Fuel Bundles,** *M.-J. Basque and J.A. Walsworth (Brunswick Nuclear Inc.), R.W. Sancton (New Brunswick Power)*

16:10 **The Dryout-Power Improvement of CANFLEX SEU Bundles in CANDU Reactors,** *L.K.H. Leung and K.F. Rudzinski (AECL)*

16:35 **Nuclear Safety of Low-Flux and High-Flux Thorium Mode of CANDU-Type Reactor,** *A.S. Gerasimov, G.V.Kiselev, L.A.Myrtsymova and T.S.Zaritskaya, State Scientific Center of the Russian Federation, Institute of Theoretical and Experimental Physics*

Wednesday June 14, p.m.

14:00-17:00 Registration - Windsor Room

Session 6E: Software and SciCodes - Rossetti A Room (14:00-17:00)

Chair:

14:00 **CSA N286.7, A Canadian Standard Specifying Software Quality Management System Requirements for Analytical, Scientific, and Design Computer Programs and its Implementation at AECL,** *R. Abel (Consultant)*

14:25 **Electronic Information Management on the QINSHAN CANDU Project,** *R. Didsbury, L. Vrancea and M. Matta (AECL)*

14:50 **A Method to Implement CSA N286.7-99,** *J.A. Walsworth, R.A. Prime, D.F. Basque and M.-J. Basque (Brunswick Nuclear Inc.)*

15:15 **Break**

15:45 **Validation of the Atmospheric Dispersion Model ADDAM for the CANDU Reactor Site at Wolsong, Korea,** *M. H. Klukas and P.A. Davis (AECL)*

16:10 **A SciCode Web Site: Building Bridges Between Owners and Users,** *C. Gaver (AECL)*

16:35 **3D CAD on Qinshan CANDU Project,** *D. Goland (AECL)*

Publications available

Canadian Environmental Quality Guidelines are now available in a 1,000 page book published by the Canadian Council of Ministers of the Environment. For information contact: CCME Documents, 200 Vaughan Street, Winnipeg, Manitoba, R3C 1T5, Tel. 204-945-4664; Fax 204-945-7172; e-mail: < spccme@chc.gov.mb.ca > or visit their Web site < www.ccme.ca > .

Progress towards geological disposal of radioactive waste: where do we stand? and **Confidence in the long-term safety of deep geological repositories.** These two publications, 27 and 80 pages respectively, are available, free, from the Nuclear energy Agency . Contact: NEA Publications Office, France, Fax 33 (0)1 4524 1110; e-mail: < neapub@nea.fr >.

Energy, Electricity and Nuclear Power Estimates, for the period up to 2020. This is the 19th edition of this reference book containing the most recent estimates of energy, electricity and nuclear power trends up to the year 2020. 130 Austrian Shillings. Available from the International Atomic Energy Agency, Vienna, Fax 43 1 2060 29104

Environmental Activities in Uranium Mining and Milling This report, prepared jointly by the Nuclear Energy Agency of the OECD and the International Atomic Energy Agency, provides an overview of uranium-related environmental activities in 29 countries. It discusses environmental and safety activities related to the closure and remediation of formerly utilised sites; the operation, monitoring and control of producing sites; and the planning, licensing and authorisation of new facilities. Available form the OECD Paris Centre, 2 rue André-Pascal, 75775 Paris Ced.16, France or online at < www.oecd.org/publications > $47.00 US

BOOK REVIEW

The Chornobyl Accident: A comprehensive risk assessment

edited by George J. Vargo
Batelle Press 236 pages hard cover 1999
ISBN 1-57477-082-9 $34.95 US plus $4.50 shipping

Batelle Press, 505 King Avenue, Columbus, Ohio 43201-2693 USA
e-mail: press@batelle.org Web < www.batelle.org/bookstore >

(Publisher's note.)

The authors, all of whom are Ukranian and Russian scientists involved with the Chornobyl nuclear power plant since the April 1986 accident, presents a comprehensive review of the accident. In addition, they present a risk assessment of the remains of the destroyed reactor and its surrounding shelter, Chornobyl radioactive waste and disposal sites, and environmental contamination in the region. The authors explore such questions as the risks posed by a collapse of the shelter, radionuclide migration from storage and disposal facilities in the exclusion zone, and transfer from soil to vegetation and its potential regional impact. The answers to these questions provide a scientific basis for the development of countermeasures against the Chornobyl accident in particular and the mitigation of environmental radioactive contamination in general. They also provide an important basis for understanding the human health and ecological risks posed by the accident.

The editor is with the Northwest National Laboratory (Hanford) which is operated by Batelle.

New CNA address

As reported in the last isue of the *CNS Bulletin* the Canadian Nuclear Association has moved its office to Ottawa. Their new office adminstrator is Lyse Marshall.

Their new address is:

Canadian Nuclear Association
130 Albert Street, suite 1610
Ottawa, Ontario
K1P 5G4

Tel. 613-237-4262 Fax 613-237-0989

CALENDAR

2000

May 7 - 11

PHSOR 2000 ANS International Topical Meeting on Advance in Reactor Physics, Mathematics and Computation into the Next Millennium
Pittsburgh, Pennsylvania, USA
contact: I.K. Abu-Shumays
Bettis Atomic Power Laboratory
e-mail: abushuma@bettis.gov

May 14 - 19

10th International congress of the International Radiation Protection Association
Hiroshima, Japan
For info. Website:
www.convention.co.jp/irpa10
e-mail: irpa10@convention.jp

May 29 - 31

Canadian Radiation Protection Assocation Annual Conference
Montreal, Quebec
contact: CRPA office
Tel: 613-258-9020
Fax: 613-258-1336

June 4 - 8

ANS 2000 Annual Meeting
San Diego, California
contact: ANS Office
LaGrange Park, Illinois
Tel: 708-579-8257
Fax: 708-579-8234

June 11 - 14

21st CNS Annual Conference
Toronto, Ontario
contact: Ms. Jad Popovic
AECL Sheridan Park
Tel: 905-823-9060 ext. 4709
e-mail: popovicj@aecl.ca

July 10 - 13

Plutonium Futures - The Science
Sante Fe, New Mexico, USA
For info.
Website: www.lanl.gov/Pu2000
e-mail puconf2000@lanl,gov

Aug. 6 - 11

10th International Symposium on Thermaldynamics of Nuclear Materials
Halifax, Nova Scotia
contact: Richard Verrall
AECL - CRL
Tel. 613-584-3311
e-mail: verrallr@aecl.ca

Sept. 24 - 26

21st CNS Nuclear Simulation Symposium
Ottawa, Ontario
contact: Ms. Anca McGee
AECL-SP
Tel. 905-823-9060 ext. 6540
e-mail: mcgeea@aecl.ca

Sept. 24 - 28

Spectrum 2000 International Conference on Nuclear and Hazardous Waste Management
Chattanooga, Tennessee
contact: Spectrum 2000 secretariat
Tel: 865-974-5048
e-mail: spectrum2000@engr.utk.edu

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

Oct. 9 - 11

Plutonium 2000 – an international conference on the future of plutomium
Brussels, Belgium
contact: Werner Couwenbergh
Belgian Nuclear Society, Brussels
tel: +32-2-774-05-38
fax: +32-2-774-05-02
e-mail: Pu2000@belgonucleairc.be

Reminder

to: CNS members:
If you have not yet renewed your membership for the year 2000, please do so now. Please note that unpaid memberships will soon be deactivated, so to keep receiving the CNS Bulletin and other CNS mailings, renew now.

If you have already renewed, thank you. Please encourage your colleagues to join the CNS too!

Aide-mémoire

Aux membres de la SNC:
Si vous n'avez pas encore renouvelé votre adhésion pour l'an 2000, veuillez le faire au plus tôt. Les adhésions non en règle seront désactivées bientôt. Pour continuer à recevoir le Bulletin et les autres envois de la SNC, veuillez donc renouveler aujourd'hui-même.

Si vous avez déjà renouvelé, nous vous en remercions. Voudriez-vous encourager vos collègues à joindre aussi la SNC?

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

Oct. 29 - Nov. 1

Symposium on Hard Facing Alloys in Water Reactor Environments
Quebec, Quebec
contact: Dr. E.V. Murphy
AECL-SP
tel: 905-823-9040
e-mail: murphyv@aecl.ca

Nov. 5 - 10

Heat Transfer Enhancement in Multiphase Flow at 2000 ASME International Congress & Exposition (IMECE 2000)
Orlando, Florida
contact: Jovica Riznic
AECB Ottawa
Tel: 613-943-0132
e-mail: riznic.j@atomcon.gc.ca

Nov. 12 - 17

ANS/ENS 2000 International Meeting
Washington, D.C.
contact: ANS Office
La Grange Park, Illinois
Tel: 708-579-8257
Fax: 708-579-8234

Nov. 13 - 17

ANS International Topical Meeting – Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies
Washington, DC
contact: Richard Wood
Oak Ridge National Laboratory
Tel: 865-574-5578
e-mail: woodrt@ornl.gov

Nov. 19 - 21

CNS 5th International Conference on CANDU Maintenance
Toronto, Ontario
contact: Martin Reid
OPG Pickering
Tel: 905-839-1151 Ext. 3645
e-mail:
martin.reid@ontariopowergeneration.com

Dec. 14 - 19

Radioisotope Production and Applications in the New Century at 2000 International Chemical Congress
Honolulu, Hawaii
contact: Dennis Phillips
Los Alamos National Laboratory
Tel: 505-667-5425
Fax: 505-665-3403

21st CNS Nuclear Simulation Symposium

Sheraton Ottawa Hotel, Ottawa, Ontario

September 24-26, 2000

The 21st Nuclear Simulation Symposium organized by the Canadian Nuclear Society will be held September 24 to 26, 2000 at the Sheraton Ottawa Hotel in Ottawa, Ontario.

The scope of the Symposium covers all aspects of nuclear modelling and simulation, and generally includes sessions in thermalhydraulics, reactor physics, and safety analysis. The main objective of the Symposium is to provide a forum for discussion and exchange of views amongst scientists and engineers working in the nuclear industry.

For information contact: Ms. Anca McGee
Atomic Energy of Canada Limited
2251 Speakman Drive
Mississauga, Ontario
Canada, L5K 1B2

phone: (905)823-9060 ext. 6540 fax: (905)403-7364
e-mail: mcgeea@aecl.ca

Zeep Doesn't Live Here Anymore

by Jeremy Whitlock

"The Italian navigator has landed in the New World."
- Arthur Compton, 1942, reporting the first criticality of CP-1

"Operational condition reached."
- Lew Kowarski, 1945, reporting the first criticality of ZEEP

"The Project has achieved a major milestone for which we are all very proud."
- Jean-Pierre Labrie, 2000, reporting the first criticality of MMIR-1

The births of babies and reactors are anticipated with similar emotion. A collective sigh of joy and relief greeted the word of Chalk River's MAPLE isotope reactor going critical at 2:13 AM on Saturday, February 19. Once more the dragon's tail had been tickled in the deep bush of the Canadian Shield.

For AECL the milestone was both extraordinary and routine. On the one hand, the days are gone when creating a self-sustaining fission chain-reaction brought us one step closer to God – today it's not "if" it can be done, but whether the paperwork will weigh more than the reactor itself when it is done. On the other hand, the event marks the operation of the first MAPLE reactor in Canada (but not the world; the Koreans took that honour in 1995), and probably the first reactor in the world of the new millennium.

© Lorne Whitlock, 2000

The gestation period was long and trying for all involved. Almost aborted in the mid-90s, the embryo was ultimately split to create identical twins. At the same time a paternity suit and a fresh infusion of cash (the life's blood of science) ensured both the viability of the foetuses, and one notable aspect of their future life: they would not be civil servants. Owned by global radioisotope supplier MDS Nordion of Kanata, Ontario, the two reactors are also the first in Canada built exclusively for, and funded by, the private sector.

Ironically, and unbeknownst to many observers, the MAPLE project at Chalk River sits on the hallowed site of the ZEEP reactor. As every red-blooded Canadian youngster should know, ZEEP was this country's first nuclear reactor, and the first in the world outside the United States. (It wasn't the world's first heavy-water reactor, although by coincidence a Canadian, the late Walter Zinn of Kitchener, Ontario, claimed that honour in Chicago a year earlier.)

Canada's first "pile" achieved initial criticality three weeks after the end of the WWII, on September 5, 1945, with heads still spinning over Hiroshima and Nagasaki.

Until very recently ZEEP, as an item of national heritage, held an important distinction over its world-famous cousin in the squash court at Stagg Field: it was still around. Historically-minded Americans, their government having decades ago removed all traces of Fermi's first pile and the building that housed it at the University of Chicago, had to settle for etchings, chunks of graphite, and a monument that looks oddly like the marriage of a skull and a mushroom cloud.

The simple structure housing Canada's first reactor languished for years following ZEEP's shutdown in 1970, but eventually served as a humble and appropriate museum to the early days at Chalk River. In 1995 the "Little Reactor That Could" was royally feted on its 50th birthday: a vivid symbol of Canada's technological Coming of Age and the beginning of post-war prosperity.

Then, over the summer of 1997, ZEEP was summarily erased to make room for the second of the two MAPLE isotope reactors, thus adding a final distinction to its record: first Canadian reactor to be completely decommissioned,

right to the dirt. Being a symbol of achievement means diddly when you're standing in the way of progress.

Although the characteristic building and dusty lab within are gone, the reactor components have been painstakingly catalogued and stored. Hopefully AECL will follow through with its intentions of a worthy ZEEP memorial, although many share the opinion that the national treasure was destroyed along with the building. That may be unforgivable.

In ZEEP's place (literally) a commercial isotope production reactor awaits completion. Itself a shining testament to Canada's maturity in the research-reactor business, the young MAPLE need not concern itself with Ghosts of Reactors Past. How apt, though, to compare the old and the new; the symbolism is too striking to ignore:

ZEEP was built as a top-secret government research tool, eventually declassified but forever dedicated to the pursuit of knowledge. Its descendent fifty years later is being built on a commercial basis, solely as a producer of medical radioisotopes. What was once a subsidized curiosity now brings home the bacon.

ZEEP was part of the war against Germany and Japan; MAPLE is part of the war against sickness and disease.

ZEEP's primary purpose was to test the fuel lattices for the behemoth NRX reactor next door. Half a century later the test lattice for the MAPLE reactor exists only in electronic form, refined at the touch of a button on a desktop computer.

In ZEEP's day transatlantic travel generally took a week. Today the isotopes created in the two new MAPLE reactors can be extracted, processed, and placed in the hands of doctors anywhere in the world within that same time frame.

The public still says "who cares?" to any of this; that much hasn't changed.

So happy birthday MMIR-1, a worthy harbinger of the next fifty years of nuclear technology in Canada. May your twin sister's schedule slip just a tiny bit so she can become the world's first reactor of the mathematically correct millennium.

CNS Office

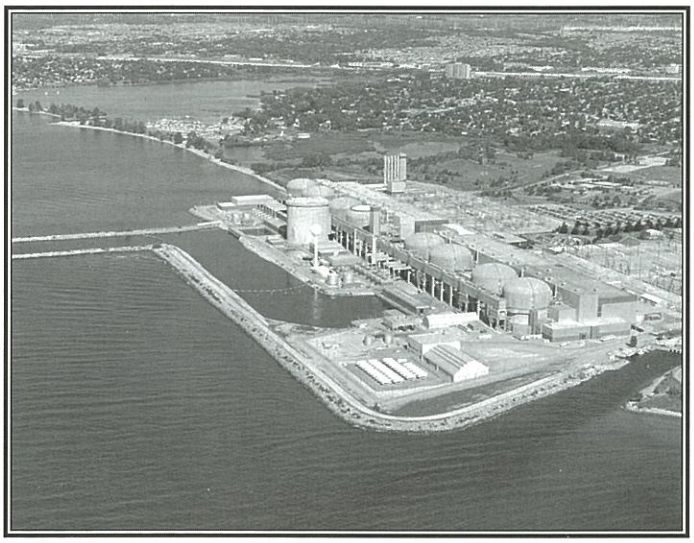
As announced in the previous issue of the *CNS Bulletin* the Canadian Nuclear Society has moved to new offices in Toronto. The new address is:

Canadian Nuclear Society
480 University Avenue, Suite 200
Toronto, Ontario
M5G 1V2

Telephone: 416-977-7620
Fax: 416-977-8131

e-mail: < cns-snc@on.aibn.com

Office administrator: Denise Rouben



Pickering NGS

Call for papers

Symposium on Hard Facing Alloys in Water Reactor Environments

Québec City, Québec

October 29 - November 1, 2000

Papers are invited. This specialized symposiumis co-sponsored by the Canadian Nuclear Society and the Société Francaise de l'Energie Nucléaire. The deadline for submissions is June 1, 2000.

For further information contact: Dr. E. V. Murphy
Atomic Energy of Canada Limited
2251 Speakman Drive
Mississauga, Ontario L5K 1B2
Tel. 905-823-9040 E-mail: murphyv@aecl.ca

1999 - 2000 CNS Council • Conseil de la SNC

Executive / *Exécutif*

President / *Président*	Krish Krishnan	905-823-9040
	e-mail	Krishnanv@aecl.ca
1st Vice-President / *1ier Vice-Président*	Ken Smith	905-828-8216
	e-mail	Unecan@echo-on.net
2nd Vice-President / *2ième Vice-Président*	Dave Jackson	905-525-9140
	e-mail	Jacksond@mcmaster.ca
Secretary / *Secrétaire*	Ian Wilson	905-469-1179
	e-mail	Ian.wilson@ilap.com
Treasurer / *Tréssorier*	Andrew Lee	416-592-6843
	sya.lee@ontariopowergeneration.com	
Past President / *Président sortant*	Paul Thompson	506-659-6234
	e-mail	pthompson@nbpower.com

Members-at-Large / *Membres sans portefeuille*

Parviz. Gulshani	905-823-9040
Glenn Harvel	905-823-9040
Dave Jenkins	905-823-9040
Kris Mohan	905-823-9040
Aniket. Pant	905-885-4537
Jad Popovic	905-823-9040
Ed. Price	905-823-9040
Michel Rhéaume	819-298-2943
Ben Rouben	905-823-9040
Duke Segel	416-322-8363
Victor Snell	905-823-9040
Judy Tamm	905-823-8040

Committees /*Comités*

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

Education & Communication / *Éducation et communication*
Jeremy Whitlock . . . . . 613-583-3311 whitlockj@aecl.ca
Dave. Jackson . . . . . 905-525-9140 Jacksond@mcmaster.ca

Finance / *Finance*
Andrew Lee . . . . . 416-592-6843 sya.lee@hydro.on.ca

Fusion / *Fusion*
Ed Price . . . . . 905-823-9040 pricee@aecl.ca
Dave Jackson . . . . . 905-525-9140 Jacksond@mcmaster.ca

Honours and Awards / *Honneurs et prix*
Hugues Bonin . . . . . 613-541-6000 bonin-h@rmc.ca

International Liaison / *Relations internationales*
Fred Boyd. . . . . 613-592-2256 fboyd96@aol.com
Kris Mohan . . . . . 905-823-9040 mohank@aecl.ca

Internet /
Dave Jenkins . . . . . 905-823-9040 jenkinsd@aecl.ca

Inter-Society / *Inter-sociétés*
Parviz Gulshani . . . . . 905-823-9040 gulshanip@aecl.ca

Membership / *Adhésion*
Ben Rouben . . . . . 905-823-9040 roubenb@aecl.ca

Past Presidents / *Présidents sortant*
Paul Thompson. . . . . 506-659-6234 pthompson@nbpower.com

Program / *Programme*
Glenn Harvel . . . . . 905-823-9040 harvelg@aecl.ca

Universities / *Universités*
Bill Garland. . . . . 905-525-9140 garlandw@mcmaster.ca

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

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

- Design & Materials / Conception et matériaux
  Bill Schneider 519-621-2130 schneidw@pgg.mcdermott.com
- Fuel Technologies / Technologies du combustibles
  Joseph Lau (905) 823-9040 layj@aecl.ca
  Erk Kohn (416) 592-4603 erl.kohn@ontariopowergeneration.com
- Nuclear Operations / Exploitation nucléaire
  Martin Reid (905) 839-1151 reidmartin@hptmail.com
- Nuclear Science & Engineering / Science et génie nucléaire
  Anca McGee (905) 823-9040 mcgeea@aecl.ca
- Environment & Waste Management / Environnement et Gestion des déchets radioactifs
  Duane Pendergast (905) 823-9040 pendergastd@aecl.ca
  Judy Tamm (905) 823-9040 tammj@aecl.ca

CNA Liaison / *Agent de liaison d'ANC*

Bill Clarke . . . . . (613) 237-4262

CNS Office / *Bureau d'ANC*

Denise Rouben. . . . . (416) 977-7620
e-mail: cns-snc@on.aibn.com

CNS Bulletin Editor / *Rédacteur du Bulletin SNC*

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

CNS Branch Chairs • Responsables des sections locales de la SNC

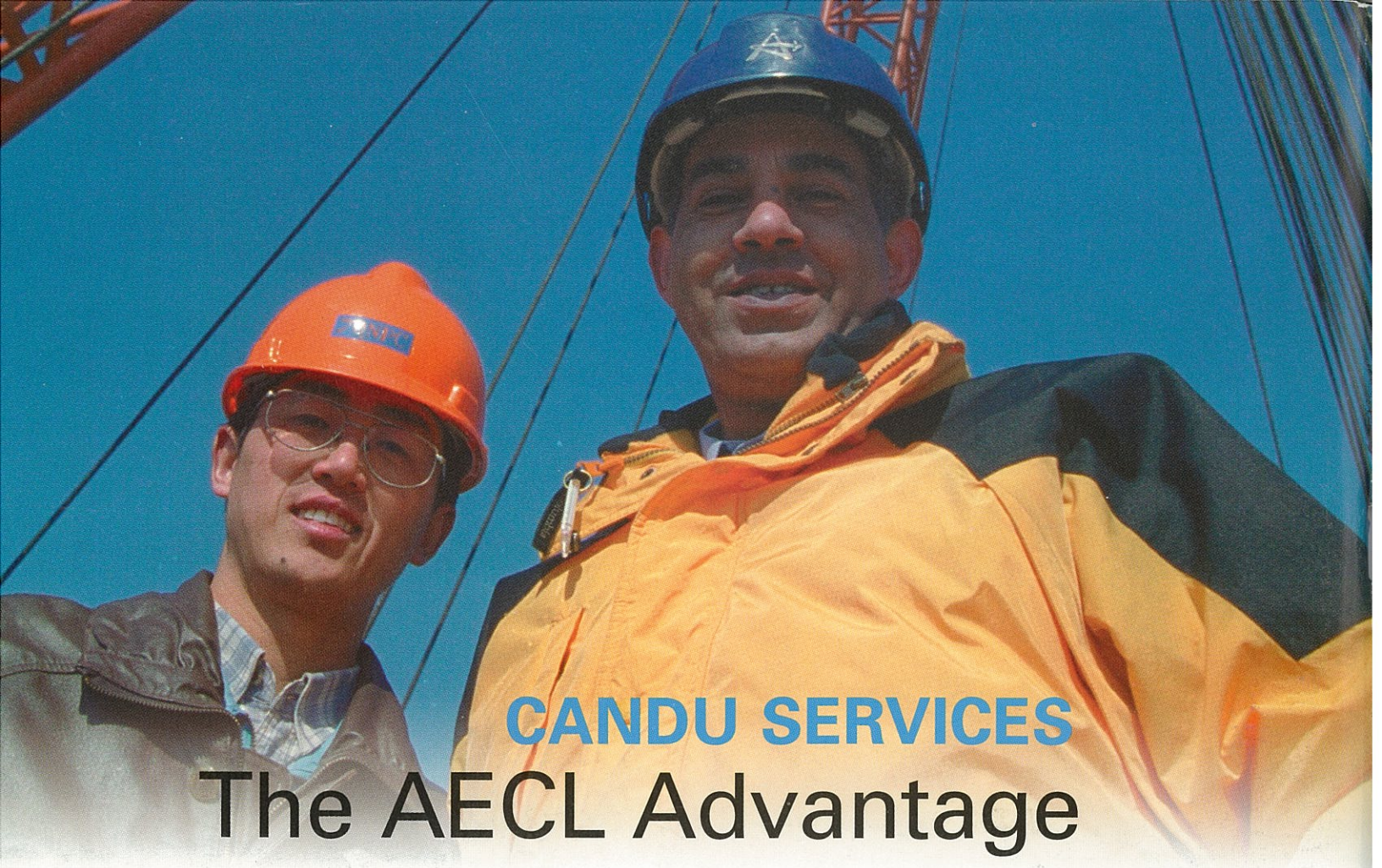
1999

Bruce	Eric Williams	(519) 361-2673	**Ottawa**	Bob Dixon	(613) 834-1149
Chalk River	Michael Stephens	(613) 584-3311	**Pickering**	Marc Paiment	(905) 839-1151
Darlington	Vacant		**Québec**	Guy Marleau	(514) 340-4202
Golden Horseshoe	David Jackson	(905) 525-9140	**Saskatchewan**	Ralph Cheesman	(306) 586-6485
Manitoba	Morgan Brown	(204) 753-2311	**Sheridan Park**	Parviz Gulshani	(905) 823-9040
New Brunswick	Mark McIntyre	(506) 659-2220	**Toronto**	Adam McLean	(416) 534-0616

CNS WEB Page

For information on CNS activities and other links

http://www.cns-snc.ca



CANDU SERVICES
The AECL Advantage

AECL—Proven industry experts in:

- fuel channel services
  - inspections
  - fitness-for-service assessments
  - fuel channel replacements
- custom systems for control, display and reactor protection
- design and manufacturing
- equipment supply
- field services
- plant life management
- pump seals and elastomers
- safety and licensing support
- spare parts provisioning
- steam generator and BOP services
- testing and analysis
  - EQ and QA
  - post-irradiation examination
  - surface analysis
- turnkey engineering

AECL, the developer of the CANDU nuclear power reactor, has an unequalled knowledge of the CANDU system. Our experienced CANDU Services team—backed by our comprehensive laboratory and manufacturing facilities, and industry-renowned advanced technologies—provides stations with cost-effective, integrated maintenance services designed to optimize CANDU performance.

At AECL our business is CANDU®. Our commitment is to our customers.

AECL Sheridan Park (Head Office)
2251 Speakman Drive,
Mississauga, Ontario, Canada L5K 1B2
Telephone: (905) 823-9040 Fax: (905) 855-1383
Web Site: http://www.aecl.ca

Canada

AECL Atomic Energy of Canada Limited

EACL Énergie atomique du Canada limitée