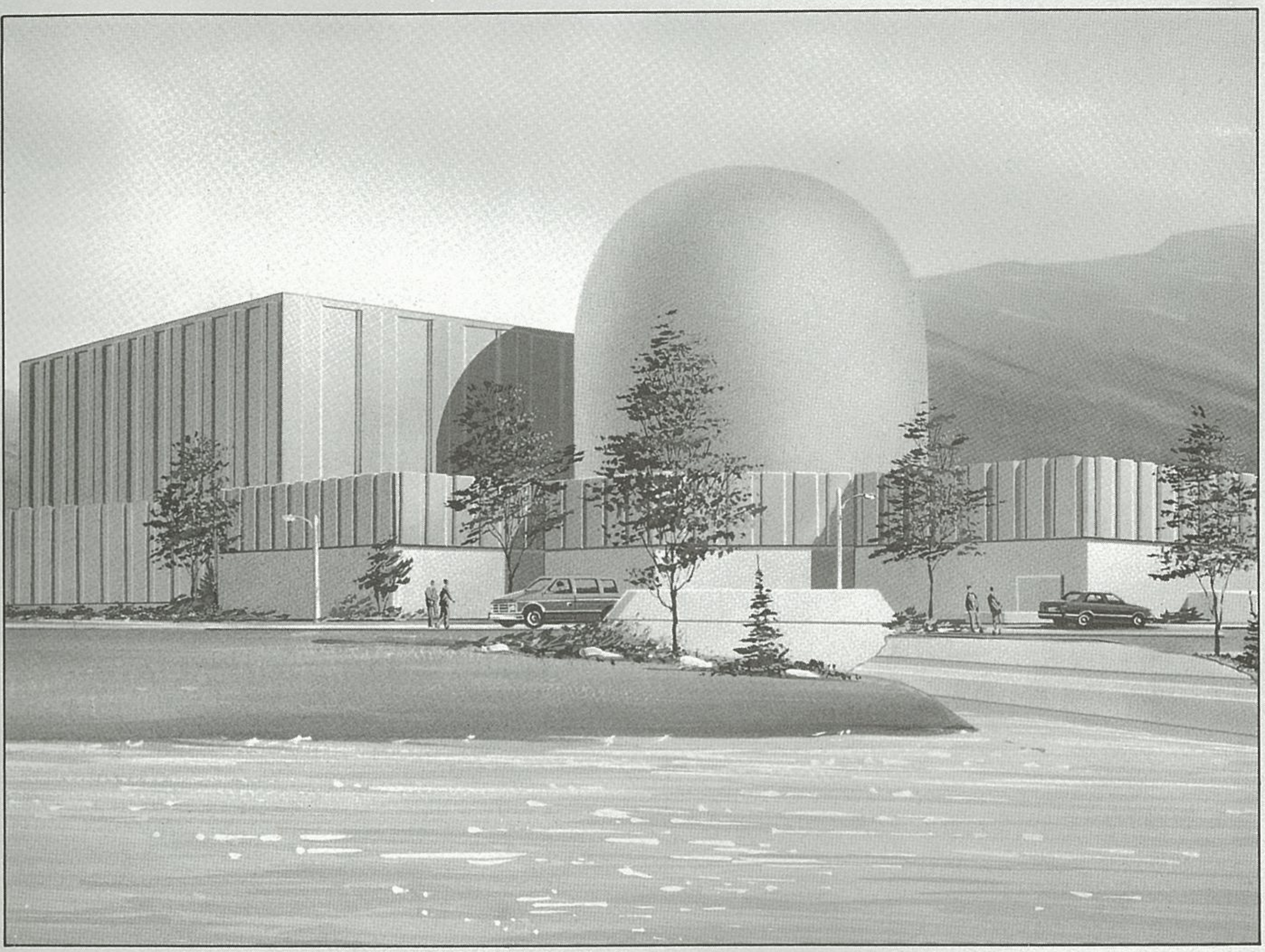
CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

Summer / L'été 1993

Vol. 14, No. 2



IN THIS ISSUE:

- CANDU in the USA
- Ontario Hydro's new nuclear organization
- Employment forum
- Yalow on BEIR V
- Reactor accidents
- Simulation conference
- SLAR

Contents

PRINTED ON RECYCLED PAPER IMPRIME SUR PAPIER RECYCLE

Cover photo

The illustration on the cover is an artist's rendition of a CANDU 3 nuclear power plant. AECL is seeking "design certification" of CANDU 3 by the USNRC.

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.

CANADIAN NUCLEAR SOCIETY
Bulletin
DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

ISSN 0714-7074

The *Bulletin of the Canadian Nuclear Society* is published by the Canadian Nuclear Society; 144 Front Street West, Suite 725; Toronto, Ontario; Canada; M5J 2L7. (Telephone (416) 977-7620; Telex 06-23741; Fax 979-8356).

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 $55.00 annually, $30.00 to retirees, $20.00 to students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. La cotisation annuelle est de 55.00 $, 30.00 $ pour les retraités, et 20.00 $ pour les étudiants.

Editor / *Rédacteur*
Fred Boyd Tel. / Fax (613) 592-2256
Associate Editor / *Rédacteur associé*
Ric Fluke Tel. (416) 592-4110
Fax (416) 978-0193

Printed by Heritage Publications, Peterborough, Ont.

Editorials

The Other Uses

Internationally, as well as here in Canada, supporters of nuclear science and technology are trying to woo the affections of the public and their political representatives. Many of the arguments being presented emphasize the benefits of things nuclear – in particular, the health and social contributions of nuclear medicine, and the economic impacts of the industry (which, in Canada, is largely attributable to uranium mining.)

It is somewhat ironic that the major focus of activity in nuclear industry associations, such as the CNA, or nuclear professional societies, such as the CNS, is on nuclear power NOT on these claimed beneficial endeavours.

The annual conferences of the CNA and CNS, as those of the ANS in the USA and the ENS in Europe, tend to be predominantly centred on nuclear power, e.g., utility programs, new reactor designs, interminable safety analyses, etc., with little or no mention of radioisotopes – the main "nuclear ingredient" in nuclear medicine – or of uranium.

The case of radioisotopes has progressed (or regressed) to the point where the dominant organizations in Canada – Nordion International and Theratronics – are no longer members of the CNA and very few of their professional staff belong to the CNS.

It is not rational to expect those "intelligent laymen" members of the public, to whom most of the promotional material is addressed, to accept the implied benefits of nuclear power based on the real benefits of nuclear medicine when the nuclear community itself does not embrace that activity.

Far more of the people involved in radioisotopes (for medical or industrial applications) belong to the Canadian Radiation Protection Association than to the CNS. It must be inferred that they feel more comfortable and more accepted among the radiation protection fraternity than among the nuclear [power] professionals who constitute the majority of the CNS.

The Future for Nuclear Professionals

Despite the enthusiasm of many of the workshop participants at the Nuclear Industry Forum in June (see separate article) it was frustrating to listen to the academic analyses of future manpower [human resources] needs in Canadian nuclear industry, research, and training, against the context of the current reality.

Ontario Hydro's Don Anderson brought this point strongly into focus when he described the cutting of over 1,000 people from Ontario Hydro's nuclear payroll. Interestingly, many present seemed to think this was a great idea!

The predictions of human resource needs by Irving Silver are undoubtedly sound, but are only as good as the assumptions, and readers can judge for themselves which of the three assumed scenarios for the industry is most likely. From our worm's eye point of view the probability of building one nuclear power unit per year is in the same order as that of the accidents posed by the AECB (even though answering the regulatory questions based on those improbable events is keeping many professionals employed).

Given the more probable scenario of a stagnant industry over the next several years perhaps nuclear professionals should be examining ways they can help themselves. As the organization of those professionals maybe the CNS could examine ways in which it can aid its members, such as:

- urging Ontario Hydro to retain a larger core of experienced people to plan and prepare for the future (for example, there is a great need to document better the experiences from operation for "feed-back" into future designs);
- explore the acceptability of job-sharing to spread the pain of downsizing and to retain as much as possible of the expertise and experience that remains in people's memories.

If the collective wisdom and inventiveness of a large number of members were applied perhaps the current and future threats to nuclear scientists and engineers could be averted.

In This Issue

Part of this issue deals with the efforts of AECL to introduce CANDU into the USA. The first step, that of obtaining a "design certification" from the USNRC, is outlined, together with articles reviewing some of the major design questions that must be addressed.

There is considerable information on recent happenings within the Society – including:

- the Annual General Meeting when the 1993-94 executive were installed;
- the very successful 4th Simulation Conference;
- the equally successful Student Conference;
- the nuclear industry forum;
- and, activities of the branches.

Conferences are the heart – and the financial life-blood – of the Society; so, as you read of these activities think of how you might be involved in the future.

As is often the case, some expected articles never materialized – our major excuse for being late in publishing this issue.

Once again we wish to acknowledge the great contribution of associate editor Ric Fluke.

Forum Explores Employment

"Future human resources challenges" was the basic theme of the Nuclear Industry Forum held in Toronto, June 18.

About 55, mostly senior representatives of the nuclear industry and related government organizations, participated in the event which was co-sponsored by the Canadian Nuclear Association, Canadian Nuclear Society and Employment and Immigration Canada. A feature of the format was group workshops which proved to be very lively exchanges of views leaving the rapporteurs a difficult task in trying to extract some sort of consensus.

Starting the day and providing much background for the discussions was Judith Moses of Employment and Immigration Canada who spoke on "Canadian Industrial Competitiveness and the Labour Market". Much of Ms. Moses' presentation dealt with the changing demographics such as the increasing age of the working force which will increase from an average of 32 in 1971 to 39 in 2000, reflecting the ageing of the population as a whole where the mean age will rise from 30 to 37 in the same time period.

The overall labour force is expected to grow by 15% between 1990 and 2000 but the 35 to 44 age group will increase by 30% and the 45 to 55 group by 55% (!) reflecting the "baby boom" of the 1940s and 1950s. In contrast the 20 to 34 year old group will **shrink** by 7%. This changing make-up of the labour force will have major implications for human resource management over the next decade.

As well as the age shift, the gender composition of the labour force is changing with the participation of women increasing from 27% in 1961 to 47% in 2000, although much of this change has already occurred with women comprising 45% in 1991.

Econometric projections show 1.5 million **NEW** jobs being created during the 1990s, while an additional 2 million will become vacant due to retirement or death. The nature of the new jobs will require an increasingly skilled workforce. In 1986 only 23% of jobs required 16 years or more of education and training. In the 1990s nearly 50% of the new jobs are predicted to require more than 16 years training.

Ms. Moses noted that despite these predictions Canada still has a high school drop-out rate of over 30%.

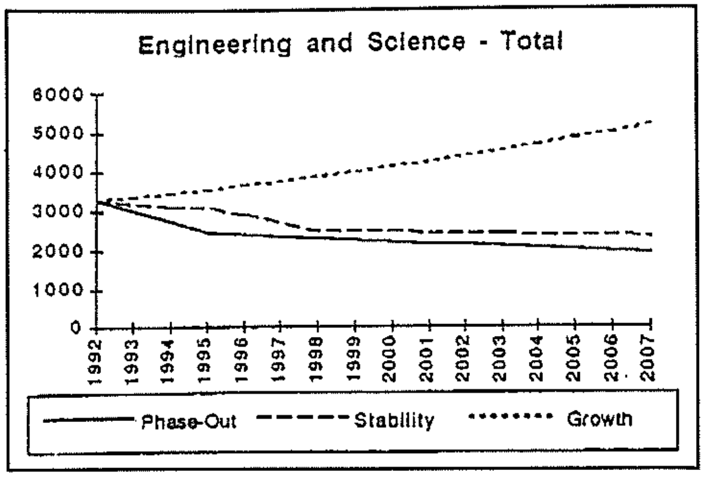
The consensus on the nuclear industry, Ms. Moses said, is for stable or moderately declining employment.

Further insights into the future for the nuclear industry were given later in the day by Irving Silver in his report on his study, "Engineers and Scientists in the Canadian Nuclear Industry, 1992-2007", prepared for the Canadian Council of Professional Engineers. He analyzed the expected requirements for professionals in the nuclear industry for three different, previously defined, scenarios:

- growth – with new orders for about one CANDU unit per year;
- stable – indefinite maintenance of domestic facilities and completion of existing foreign orders:
- phase-out – no new construction or upgrades but maintenance of existing facilities.

His results are summarized in Fig. 1.

Figure 1: Employment, three scenarios: 1992-2007



A different perspective was provided by Tony Going of the firm of Ernst and Young, who conducted an analysis for Atomic Energy of Canada Limited of the investment in nuclear research and development compared to the investment in other energy sectors. The federal government's contribution to AECL over the 40 years from 1952 to 1992 amounted to $5.3 billion while in the 15 years from 1978 to 1992 it appropriated $29.4 billion to other energy projects.

Nuclear is one of just two "high-technology" industries in Canada, Goring noted, with a very high value-added content. The total output of the nuclear industry in 1992 was over $4.3 billion.

His report will be submitted to AECL in July and is expected to be available soon thereafter.

The remaining speaker provided a hard-hitting account of a real "labour force" problem. Don Anderson, Ontario Hydro's new General Manager Nuclear, outlined the restructuring going on in his organization. "When you have 1300 competing for the remaining 500 senior positions you face reality," he said. Ontario Hydro's current nuclear staff of about 11,300 will be trimmed to about 10,000, Anderson commented, with 900 already indicating willingness to take early retirement. (See separate article on Ontario Hydro's nuclear re-organization.)

In between the talks the participants joined in vigorous discussions. Among the many conclusions and recommendations was the observed need for real cooperation among labour, management and government to meet the challenges facing our industry. There was also the indication of the need for Statistics Canada to identify the nuclear industry as a separate sector so that good data would be available and it would not be necessary to commission special studies such as that by Irving Silver.

Deadline

The deadline for the next issue of the CNS *Bulletin*, Vol. 14, No. 3, is September 10 for publication the end of September.

CANDU in the USA?

Three years ago the United States Nuclear Regulatory Commission promulgated regulation 10 CFR Part 52 which enables early site and design approvals. The regulation has three parts: (a) early site permits, (b) standard design certification, (c) combined licences.

The Early Site Permit provisions allow for the early resolution of site safety, environmental protection and emergency preparedness issues independent of a specific design. The Combined Licence provisions permit a utility to reference a Certified Design and Early Site Permit in its application. Issues resolved in those earlier stages are precluded for reconsideration in the specific Construction or Operating Licence process.

The Design Certification process has two major phases. The initial phase involves an extensive staff review of the design leading to a "final design approval". The second phase includes a "rule-making" procedure to "certify" the design and provides for public involvement.

The USNRC is already reviewing four designs under the Part 52 process:

- Advanced Boiling Water Reactor (ABWR) by General Electric;
- AP 600 by Westinghouse;
- System 80+ by ABB-Combustion;
- Simplified Boiling Water Reactor (SBWR) by General Electric.

The first two are well into the process with scheduled "final design approval" in mid-1994 while the last two have recently been re-scheduled to early 1996.

AECL, through its USA subsidiary AECL Technologies, has asked for a "pre-application review" and has very recently (June 1993) been informed that USNRC has agreed to conduct such a review. Formal application for "design certification" is expected in about a year.

AECL Technologies has been supplying NRC with early information over the past several months.

As an indication of the amount of detail involved, representatives of the SBWR project reported at a recent ANS meeting that they had submitted 10 volumes of design documentation earlier this year and had already received several hundreds of questions.

For CANDU 3, AECL faces not only this detailed scrutiny but also a major "philosophical" hurdle because of the fundamental differences in the approach to safety design and licensing in Canada and the USA where the regulatory system has been based on light water reactors.

The following two articles, extracted from papers given at the ANS Annual Meeting held in San Diego, June 20-24, 1993, provide some background to the issue of USNRC licensing of CANDU.

CANDU and U.S. NRC Requirements

S. Azeez[1], M. Bonnchi[1] and L. Rib[2]

1. Introduction

CANDU has several characteristics different from those of light water reactors (LWR). However, a similar philosophy of defence in depth, based on multiple levels of safety and implemented through the provision of several physical and functional barriers against the release of radioactivity to the environment, is applied to both types of reactor. It is not surprising, therefore, that there is a fundamental convergence of safety objectives between the CANDU design and the LWR designs, which in turn translates into an equivalence of CANDU safety with the requirements established by the United States Nuclear Regulatory Commission (NRC) for LWR's.

The demonstration of this safety equivalence has been an important activity for the licensing of CANDU reactors in countries whose regulatory environment has been influenced by the NRC requirements, and has more recently acquired a special emphasis in the context of a preapplication review of an evolutionary CANDU design, the CANDU 3, for its design certification in the U.S.

This paper highlights the design features and fundamental principles of the CANDU safety philosophy and compares them with the equivalent NRC requirements.

2. CANDU Safety Principles and NRC Requirements

A key precept of the defence in depth philosophy is the adoption of high quality standards for the design of safety related systems, with a particular regard to the pressure retaining components. Canadian standards have been developed for design, materials, fabrication and inspection of pressure retaining components (see Table 1). Some of these standards refer to the rules of the ASME Code, Section III, the same way as the NRC regulations do. Other standards have been specifically generated for unique CANDU components such as the pressure tubes.

Another important safety precept concerns the reliability of safety systems. A deterministic single failure criterion is set in the NRC regulations to define the minimum required redundancy of components within each safety system: the plant must be capable of responding to anticipated transients and accidents, assuming the independent failure of a single component in a safety system. Reliability objectives are realized, in CANDU practice, by having diversified sys-

1 AECL CANDU, Mississauga, Ontario
2 AECL Technologies, Washington, D.C.

Table 1 Examples of AECB Regulations

- ▷ Requirements for Containment Systems for CANDU Nuclear Power Plants
- ▷ Requirements for Shutdown Systems for CANDU Nuclear Power Plants
- ▷ Requirements for Emergency Core Cooling Systems for CANDU Nuclear Power Plants
- ▷ The Use of Two Shutdown Systems in Reactors
- ▷ Overpressure Protection Requirements for Primary Heat Transport Systems in CANDU Power Reactors Fitted with Two Shutdown Systems
- ▷ Requirements for the Safety Analysis of CANDU Nuclear Power Plants
- ▷ Quality Assurance Programs for Nuclear Facilities
- ▷ Guidelines for Off-Site Contingency Planning

tems (either safety systems of combinations of process and safety systems) to fulfil each of the required safety functions. These defined systems must be qualified to successfully operate under specified incident-created environments. Each safety system and certain important process systems are provided with redundancy of active components. Additionally, each of the special safety systems for reactor shutdown, emergency core cooling and containment, must be testable in operation to demonstrate an unavailability less than 10^{-3}.

Physical separation of systems is a principal means of protection against common cause events. NRC requirements are based on the separation of redundant trains in safety systems, whereas CANDU reactors fulfil separation requirements by taking full advantage of diverse systems provided for each safety function. Examples are the two diverse, fast-acting shutdown systems and two systems for removing decay heat from the reactor (Shutdown Cooling System and the steam generator). Separation and independence extends all the way through from the front-line systems to their supporting systems, e.g., electrical power supplies and cooling water.

Also, NRC requirements call for functional separation of control and protection systems but allow sharing of equipment between the two categories of systems. The requirement is that the common portion between the protection system and the control system be qualified to the higher standards of the protection system. Isolation devices must be provided at the interface of the two systems to prevent a control malfunction from impairing the protective function. In CANDU reactors, not only are the protection systems totally separate from the control systems, but the protection circuits associated with the different safety systems are also independent of one another. In the CANDU 3 design, the process systems are classified as Group 1 systems and safety systems are classified as Group 2 systems.

Qualification of defined systems is the measure to be taken to ensure that public health and safety is not jeopardized by severe man-made and natural phenomena, most notably an earthquake. CANDU and NRC requirements define a similar concept of earthquake characterized by a very small probability of being exceeded at the site during the lifetime of the plant; it is called Design Basis Earthquake in Canada and Safe Shutdown Earthquake in the NRC regulations. Sufficient systems are to be qualified to shut down the reactor and cool it down to a safe condition, in the event that such safety measures are required following this earthquake. Similarly, the tornado has been considered in the plant design.

3. Approach to Identify Requirement Differences and Acceptance Criteria

For CANDU 3, AECL CANDU and the Atomic Energy Control Board (AECB) have developed a generic approach to licensing issues that may affect the design. In what is called an "upfront licensing approach," AECL CANDU will bring to the attention of the AECB design or analysis aspects of the CANDU 3 which may differ from previous CANDU licensing reviews. This process is designed to flag potential design changes early in the design when the cost of change is minimized. AECL Technologies (AECLT), AECL's subsidiary in the U.S., which is applying for the design certification, has attempted to use this approach for the NRC review.

Since the NRC regulatory guidance was written for LWR's, there are a number of differences that arise when trying to apply this guidance to a different type of reactor system. From this type of review, AECLT developed a list of such differences. Some of the differences were set aside as not being applicable to the CANDU reactor (i.e. reactor pressure vessel cooldown stresses), whereas other differences may affect design margins. These differences were brought to the NRC staff's attention. AECLT selected a group of those differences and produced several reports addressing why the differences, called equivalent safety issues (ESI's), do not reduce safety as a result of the CANDU 3 design approach. The ESI's submitted to the NRC are listed in Table 2.

Table 2 List of Reports on Equivalent Safety Issues Submitted to NRC

- ▷ Emergency Core Cooling System (ECCS)
- ▷ Primary Heat Transport System
- ▷ Containment Design
- ▷ Auxiliary Support Systems and Components
- ▷ Classification of Systems and Components

At a recent NRC Regulatory Information Conference, a paper by Frank P. Gillespie, for the NRC staff's Regulatory Review Group, discussed the potential for a more global review approach. An implication was that a group of design differences could be viewed as a whole in overall safety impact, rather than the current review approach which evaluates one item at a time. AECLT will work with NRC to utilize this global review approach.

Acceptance criteria for equivalent safety findings has to be developed and approved by NRC.

4. Conclusion

The key principles of the CANDU safety philosophy meet the same objectives as the NRC requirements. Although detailed requirements may be different, AECLT is confident that the CANDU approach for high-quality standards, reliability, separation and qualification of safety related systems, has a level of safety equivalent to the NRC regulations.

(Based on a paper presented at the ANS Annual Meeting, June 1993)

CANDU Safety Design - Status and Direction

V.G. Snell and P.J. Allen

Ed. Note: The following article is extracted from a paper presented at the ANS Annual Meeting in San Diego, June 1993. Both Victor Snell and Peter Allen are with AECL CANDU.

1. Introduction

This paper reviews the status and direction of CANDU safety design.

There are two evolutionary CANDUs currently in development at AECL.

The single-unit **CANDU 3** has a net electrical output of 450MWe. The design is about three-quarters complete. In addition to being designed to be licensable in Canada, a pre-application review is underway with the US Nuclear Regulatory Commission (USNRC) as the first stage of Standard Design Certification in the US.

The **CANDU 9**, also a single-unit plant, is being developed for those utilities with a larger electrical grid and/or higher growth rates, and incorporates the economies of scale of units in the 900-1300MWe range. It is currently in the conceptual design stage. The emphasis is on the CANDU 9 480/SEU version, with a net electrical output of about 1050MWe. The core is identical to the Bruce-B/Darlington reactors (hence the designation "480", meaning the number of fuel channels). The increased output (over the Darlington reactors) is achieved by using very slightly enriched Uranium (SEU) fuel - 0.9% U^{235} (natural uranium fuel) used in Bruce and Darlington.

2. CANDU Safety Basis

The accident in the NRX Research Reactor, in 1952, had a profound effect on the subsequent development of CANDU safety philosophy. A unique emphasis was placed on the **special safety systems** - the shutdown systems, emergency core cooling (ECC), and containment. The special safety systems had to be:

- **independent** of each other and of the normal control and process systems;
- **separated** physically from each other, and from the control/process systems, so that common cause events could not affect more than one safety system;
- **redundant**, at both the system and component level, so that isolated failures, either of components or of an entire system, could not disable the safety function;
- **testable** during service, to meet a reliability target of 999 times out of 1000 tries;
- **diverse** in design and operation, so that a generic fault in design, maintenance or operation could not affect more than one redundant system.

Accidents had to be shown to have acceptable consequences - not just for a process system failure - but even if any one safety system was simultaneously unavailable or impaired. This "single/dual" failure approach meant that the three safety functions - shutdown, decay heat removal, and containment of radioactive material - had to be both reliable and redundant at the system level, so that the consequences of the unavailability of any special safety system could be tolerated. This was achieved by a combination of inherent characteristics and safety design.

First, CANDU has two independent safety shutdown systems, each with dedicated instrumentation and mechanisms, equally effective in handling accidents (in addition to the control system). This reduces the chance of an accident with failure to shut down, to negligible values, so that no further design provision is necessary.

Second, the heavy-water moderator provides an independent source of cooling water surrounding the pressure tubes. In the event of an accident, the pressure tube is close enough to the calendria tube that an emergency heat removal pathway is passively achieved. For a loss of coolant accident (LOCA) accompanied by total failure of emergency core cooling (ECC) flow, the pressure tube will overheat, then sag or strain into contact with its surrounding calandria tube. Consequently the fuel decay heat is transferred to the calandria tube through the pressure tube, and then removed by the moderator. The moderator can contain the damaged fuel within the pressure-tubes, without melting of the uranium, so that the core geometry is retained (Fig. 1). This is called "moderator heat sink."

Decay heat removal for non-LOCA accidents is likewise achieved through a number of diverse pathways, including:

- normal feedwater
- auxiliary feedwater
- seismically qualified feedwater and power
- a shutdown cooling system capable of operating at full temperature and pressure conditions.

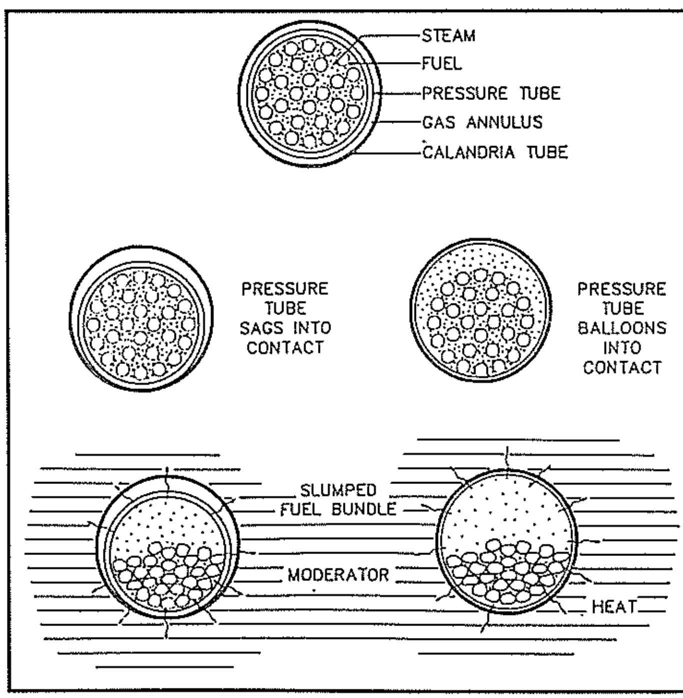


Figure 1: Modes of channel deformation in a large LOCA/LOECI

Third, every postulated accident which releases radioactivity must be shown to have acceptable consequences even if active components in the containment system fail. The plant must meet regulatory dose limits for accidents assuming containment impairments such as open ventilation dampers or loss of air cooler capability.

To prevent or mitigate common-cause events such as earthquakes, fires, and missiles, Canada has developed the **two-group** approach. All important systems in the plant are divided into two spatially separated and independent groups, either of which can, by itself, shut the plant down, remove decay heat, and monitor the plant safety status. Physical protection or environmental qualification is provided so that at least one group will be available when required – e.g., a protected secondary control area is provided in case the main control area becomes uninhabitable due to an earthquake or fire. This approach reduces the chance of severe core damage due to common-cause initiators.

3. Severe Accidents

Because the moderator provides a backup heat sink, a **severe accident** in a CANDU (defined as one in which the fuel heat is **not** removed by the coolant) is different from **severe core damage**, or loss of core structural integrity[1-3]. That is, the consequences of a loss of all primary and emergency coolant can be arrested short of a core melt by the moderator. Should the moderator heat removal system also fail, the shield tank surrounding the calandria vessel provides an additional line of defence. This tank is a large water-filled low-pressure vessel, surrounding the calandria (Fig. 2). Its primary purpose is to provide shielding of the concrete reactor vault from neutrons and gamma rays; its cooling system can remove about 0.3% of reactor thermal power, equivalent to the decay heat several hours after shutdown. The shield tank water can also act as a passive emergency reservoir in case of a severe core damage accident; that is, should the primary coolant, the emergency core cooling system, and the moderator heat removal all fail, the shield tank will either retain the debris inside the calandria, by keeping the outside of the calandria shell cool, or at least delay the progression of the core melt to the concrete floor by 24 hours. This allows time for emergency response while the fission products decay and heat reduces further. These characteristics have been analytically modelled by Prof. J.T. Rogers[4] and were key elements of the first CANDU 6 overall assessment of severe core damage accidents, done with the Dutch utility organization, KEMA[5]. Severe core damage frequencies were calculated to be about 5×10^{-6} per year. The Ontario Hydro Darlington Probabilistic Safety Evaluation, a more detailed assessment of frequencies, gave similar values.

These studies showed the low risk associated with CANDU, but also pointed the way to CANDU product safety enhancements for future plants.

4. CANDU 6 Safety Enhancements

There are four CANDU 6 plants operating since the early 1980's, five under construction in Romania, and three in Korea.

The safety approach for the CANDU 6 plants under construction is to build on a proven, working, highly-successful design to capture the benefits of replication, while making prudent changes to improve safety[6]. Safety enhancements for CANDU 6's now being constructed include:

- Incorporation of operating experience, particularly measures to improve the human factors aspect of parts of the control room, and to further reduce operator dose;
- Incorporation of current licensing requirements, resulting in improvements in safety system performance and reliability;
- Improved separation between the main steam lines and safety-related equipment;
- Improvements in the reliability of special safety systems such as ECC
- More systematic, consistent environmental qualification.

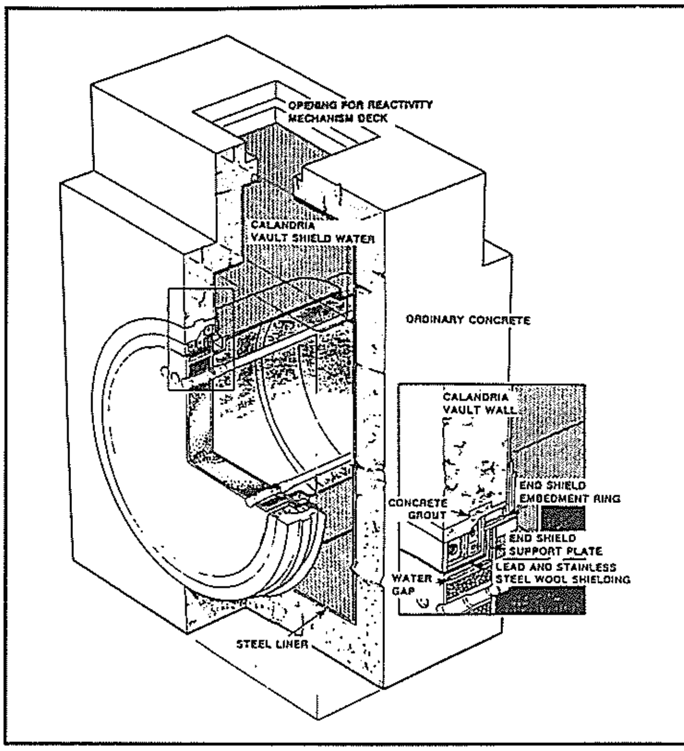


Figure 2: Calandria vault and shield water

5. CANDU 3 Safety Enhancements

The CANDU 3 concept basis is to develop a smaller unit for smaller electrical grids, so as to allow flexibility in capital outlay in the face of demand growth uncertainty. The diseconomies of the smaller size are compensated by designing for rapid construction (35 months)[7].

Safety enhancements include a completely revised plant layout, with clear site-wide separation between redundant safety-related systems, i.e., Group 1 systems and Group 2 systems. The Group 2 systems are located in a separate building, which is heavily protected against external events, and from the consequences of failures of Group 1 systems.

Design simplification was pursued for both operating and safety reasons. Although the primary function of the containment dousing system (which has been a feature of all previous CANDU containment designs) was for pressure suppression, it could also be effective in removing airborne radioactive isotopes, particularly iodine. However, research on the transport of radioactive iodine at the Whiteshell Laboratories, as well as the phenomena observed in the Three Mile Island accident, indicated that a system for iodine removal from containment was not required. Thus the containment dousing system used on previous CANDUs was eliminated and replaced by a more leak-tight containment, with a steel liner.

Predicted operating staff radiation doses per MWe have been cut by at least 50% due to better material selection, ventilation, layout of equipment, and shielding. There is redundant emergency high-pressure decay heat removal, through either a dedicated emergency water supply to the steam generators, or through the shutdown cooling system. Human factors engineering in the control centre provides the operators with improved information management and plant status knowledge. Further automation of safety functions, such as the ECC recovery mode, has extended the time before operator action is required to hours in most cases.

Substantial licensing acceptance is being sought from the regulatory agencies in advance of project commitment. Progress so far with the Canadian AECB is satisfactory, with major conceptual issues identified and largely resolved.

The development of further confidence in the prediction of the CANDU 3 behaviour in severe accidents is part of the project plan. The severe accident philosophy is to:

1. Define frequency and consequence targets for severe accidents.
2. Meet these targets in a way which takes advantage of CANDU characteristics, namely the moderator and the shield tank.
3. Develop accident management procedures to control the consequences of severe core damage if it occurs.

The concept PSA[8] is complete; weaknesses in the design were identified and addressed, giving confidence that the final PSA will show substantial safety improvements.

6. CANDU 9 Safety Enhancements

The CANDU 9 concept basis is to capture the economies of scale for large electrical grids, while using proven components to reduce risk to the utility[9]. The design process and safety enhancements use most of the improvements developed in CANDU 3. The enhancements include:

- CANDU 9 has a strong Group 1 / Group 2 separation, with a separate Group 2 building. The arrangement of buildings on the site is optimized for a smaller station footprint.
- The containment building has been improved over CANDU 6 by the use of a steel liner, and elimination of the dousing system. However an elevated reserve water tank performs the other safety functions of the CANDU 6 dousing tank – water supply for medium-pressure ECC, and for the steam generators in an earthquake. It also provides passive cooling of the end-shields in case normal cooling is lost, as well as makeup water to both the heat transport system and the moderator.
- The shield tank has been changed from octagonal (Bruce / Darlington) to cylindrical in shape, to enhance the seismic capability; the overall reactor vault also has better seismic capability and the geometry is more favourable for arresting the progression of severe core damage.
- The moderator nozzles have been relocated to improve the moderator temperature distribution; the lower peak temperature is helpful in severe accidents as it gives more margin to calandria tube dryout.
- The increase in enrichment of the fuel from 0.7% to 0.9% is too small to have any significant safety effect. Criticality in light water is still precluded, as with natural uranium. There are changes to the channel power distribution, of course, which requires an adjustment of the Regional Overpower Protection system. Changes to reactivity coefficients are minor. Finally, the fuel performance is within the envelopes of the current operating plants, in terms of maximum burnup, maximum bundle power, and maximum channel power.
- Design improvements are underway to increase the reliability of the shield tank as an "ultimate" heat sink for the core.
- The ECC has been greatly simplified. All components (except for the gas tanks) are located inside the containment building. The valves formerly used to separate Heat Transport System coolant from the ECC water have been replaced by one-way rupture disks to increase reliability and simplicity.

These safety enhancements continue the evolutionary improvement of CANDU safety.

7. References

1. V.G. Snell, S. Alikhan, G.M. Frescura, J.Q. Howieson, F. King, J.T. Rogers, and H. Tamm, "CANDU Safety Under Severe Accidents", invited paper for the IAEA/OECD International Symposium on Severe Accidents in Nuclear Power Plants, Sorrento, Italy, March 1988; also *Nuclear Safety*, Vol. 31, No. 1, p. 20.
2. G.L. Brooks, V.G. Snell, P.J. Allen, J.M. Hopwood, J.Q. Howieson and R.A. Olmstead, "The Approach to Enhancing CANDU Safety", invited paper for the 8th Pacific Basin Nuclear Conference, Taipei, April 1992.
3. D.A. Meneley and V.G. Snell, "Safety Considerations in International Growth of Nuclear Energy", invited paper for the ANS/ENS 1992 International Conference, Chicago, November 15-20, 1992.
4. J.T. Rogers, "A Study of the Failure of the Moderator Cooling System in a Severe Accident Sequence in a CANDU Reactor", Proc. 5th International Meeting on Nuclear Reactor Safety, Karlsruhe, Germany, September 1984; Vol. I, p. 397, KfK 3880/1 December 1984.
5. P.J. Allen, J.Q. Howieson, H.S. Shapiro, J.T. Rogers, P. Mostert, and R.W. Van Otterloo, "Summary of CANDU 6 Probabilistic Safety Assessment Results", *Nuclear Safety*, Vol. 31, No. 2, Apr.-June 1990, p. 202.
6. Chung Bo Hun and K.J. Petrunik, "Korea's Team CANDU", paper presented to the CNA/CNS conference, Saint John, New Brunswick, 1992.
7. K.R. Hedges and E.M. Hinchley, "CANDU 3 aims to provide a smaller, cheaper, more reliable alternative", *Nuclear Engineering International*, May 1990, p. 22.
8. P.J. Allen, "The Use of PSA in the Design, Safety Assessment, and Licensing of the Advanced CANDU Design", PSA '89 – International Topical Meeting on Probability, Reliability, and Safety Assessment, Pittsburgh, April 1989.
9. R.S. Hart, A. Dastur, R.A. Olmstead, E.G. Price, V.G. Snell, and S.K.W. Yu, "CANDU 9 – Overview", IAEA Technical Committee Meeting on 'Advances in Heavy Water Reactors', Toronto, Canada, June 1993.

Severe Accidents and CANDU – A Challenge for Regulators and Designers

P.H. Wigfull

Ed. Note: *The following is a summary of a presentation by Peter Wigfull at the ANS annual meeting in San Diego, CA, June 23, 1993. He is director of the Safety Evaluation Division of the Atomic Energy Control Board.*

At the present time there are no Canadian regulatory requirements for what are generally known as severe (or beyond-design-basis) accidents. The reason for this is partly historical, partly because of the unique CANDU design and partly because of the overall approach to safety taken in Canada. Recently the Atomic Energy Control Board has been considering if a severe accident policy similar to that used for light water reactors should be adopted. It has been suggested that such a policy would assist in the development of a more coherent and effective accident management strategy.

Following is an outline of the current Canadian approach and the difficulties associated with adopting a core melt as the starting point for a severe accident analysis.

Although a large-scale core melt cannot be discounted, it is suggested that this is less likely in a CANDU reactor than in current light water designs. On the other hand there are accident sequences which, although these do not necessarily lead to a core melt, could be considered as being equivalents to light water reactor severe accidents. These also appear to have a very low probability of occurrence. Studies carried out by the industry indicate that the cumulative frequency of such events could be as low as 4 X 10^{-6}/year. It has even been suggested by some members of the industry that these studies show that current CANDU reactors have already approached the target for a core melt frequency of 10^{-6}/year proposed for some advanced light water reactor designs.

Further, many of the accident sequences which can lead to extensive core damage in CANDU reactors are already within the design basis (for example large loss-of-coolant accident and loss of emergency core cooling) and, because of this, engineered safeguards have been provided to mitigate their consequences.

A severe accident policy could be devised in which it is necessary to assume failure of these engineered safeguards. This would be truly beyond-design-basis, but would it be reasonable? The most serious of the hypothetical sequences encompassed by such a policy would lead to a core disruptive condition, a situation which is very difficult to analyze and is almost inevitably speculative. Further the frequency of occurrence of these sequences would be so low that it could not be quantified with confidence. (The studies which have been done suggest frequencies of somewhat less than 10^{-7}/year).

Another approach would be to arbitrarily assume that a large-scale core melt has occurred, in much the same way as is done for light water reactors. This approach would have the advantage of covering-off any potential shortcomings in defining the initiating event sequence. On the other hand, it is quite difficult to rationalize how a CANDU core could get into such a state. Since it would by necessity imply that a series of undefined failures had already occurred, the effectiveness of potential mitigating systems would not be clear. As a result, any consequential analysis would be likely to be very unrealistic.

The Atomic Energy Control Board has long argued that speculative analyses are of doubtful value and that they should be avoided by design changes (e.g., the installation of engineered safeguards) whenever possible. A severe accident policy seems almost inconsistent with this philosophy. On the other hand, accident management strategies are required and these should be based on some form of reasonable "worst case." It will be a challenge for designers and regulators to develop such a "worst case" for CANDU reactors on the basis of current knowledge.

Probabilistic safety analysis is one technique which has been used in the past to address problems of this type, but this can only be relied on to a limited extent. The inherent problems of its quality and completeness have never been satisfactorily addressed. Several of the studies for CANDU reactors indicate that major off-site releases have such a low probability of occurrence (i.e. less than 10^{-7}) that their consequences can be ignored. It would clearly be imprudent to take these results at face value, despite the fact that the analysis appears to have been carried out to a similar standard to that used elsewhere.

AVAILABLE

Annual Report

The Annual Report for 1992-93 of the Atomic Energy Control Board is now available.

Video

The Atomic Energy Control Board has produced a 21-minute video entitled "Radiation and Our Environment" which is available without charge. It comes accompanied with a brochure (available in bulk) and is very suitable for showing to general audiences.

For copies (free) or information contact:

Office of Public Information
Atomic Energy Control Board
P.O. Box 1046
Ottawa, Ontario
K1P 5S9
Tel. 613-995-5894 FAX 613-992-2915

SLAR

A successful operation ...
but will the patient survive?

Ric Fluke

On April 30, 1993, Ontario Hydro hosted a seminar on the SLAR project where engineers from AECL, General Electric Canada Inc. and Ontario Hydro spoke to an attentive audience in the packed auditorium, with a "spill-over" crowd in the foyer. The speakers reviewed the history of SLAR and the evolution of the "Mark III" version of the tool, and described many of the innovative design features which led to its successful application at the New Brunswick Electric Power Commission's Point Lepreau GS.

The SLAR tool was developed to locate and reposition the spacers ("garter springs") which separate the pressure tube from the calandria tube in the fuel channel assembly of a CANDU reactor. An acronym for Spacer Locating And Repositioning, the SLAR tool has sensitive instrumentation to locate the spacers and any tube defects or "blisters". It also incorporates mechanical, hydraulic and electromagnetic devices to reposition the spacers into their proper position. Each tool costs about $250 thousand to manufacture although it cost almost $100 million to develop, and the operation costs from $3 to $10 million per reactor for replacement power, depending on the number of channels to be "slarred".

Recently at Pt. Lepreau, fourteen channels were slarred with a total spacer movement of nearly 30 m. It is expected that this will prolong channel life to 2008. The operation took 11 days from reactor shut down to removal of all SLAR equipment from the containment building.

At the time of writing, reactor unit 4 at Bruce NGS A was well into a successful refurbishment using the SLAR Mark III tool. This is expected to defer the need for re-tube of that reactor for ten more years.

We have now seen that the tool works; we must now wait to see if the operation, which was a success, will have been effective in keeping the reactor alive for ten more years.

The history of the SLAR project began on August 1, 1983, when pressure tube G16 ruptured in reactor unit 2 at Pickering NGS. What followed was an engineering challenge of unfathomable proportion.

When a pressure tube ruptures, it is an economic crisis because it takes several months to replace the tube and resume operation. Most of the cost, which can exceed $20 million, is for replacement power from the fossil stations. It also raises concerns within the public about safety.

When G16 ruptured, an industry wide investigation was launched to determine the cause. A few years later at Bruce NGS A, pressure tube "N06" ruptured. Although N06 failed under different circumstances than G16, a common observation was made from inspections and some tube removals. Evidently, some pressure tubes in older reactors were sagging and making contact with the calandria tube. This was outside the design intent; spacers called "garter springs" were designed and positioned to keep the pressure tubes away from the calandria tubes. Somehow, the spacers had moved from their intended positions. The main purpose of the spacers is to minimise heat loss from the coolant to the moderator by maintaining a gap filled with an insulating gas (annulus gas system).

We now know another reason to avoid contact: to prevent hydride "blisters" which are sometimes observed at contact locations. These blisters form by enhanced uptake of hydrogen at the colder point of contact. Hydride weakens and embrittles the pressure tube making it more susceptible to rupture. This problem is further exascerbated by irradiation induced creep. This elongation process allows the tube to sag with the weight of the fuel bundles. Hence, proper spacer location becomes even more important as the reactor ages.

Unfortunately, the spacers were positioned between the pressure tube and calandria tube at the time of assembly and they were never intended to be moved or accessed afterwards. Since the need to reposition the spacers was not anticipated, no provision for this was designed. Hence the challenge: without a major dose of ingenuity and innovation, it would be necessary to re-tube the reactor prematurely, which is a very expensive proposition. To avoid the expense of pressure tube replacement, an important constraint for SLAR is that it move the spacers *from inside* the pressure tube!

Working from inside the pressure tube precludes all possibility for physical contact, and so an electromagnetic solution was sought to provide the physical force needed to move the spacer. The main problem with this approach is that the spacer material is similar to the tube, non-magnetic, and indeed has very little electrical conductance. Another problem is the electromagnetic shielding of the tube through which a coupling must be established. In order to induce any practical force on the spacer a very high current would be required which may damage the tube.

A group of engineers at Ontario Hydro Research Division came up with a novel approach, based on the principle of a linear induction motor (LIM). It induces a travelling magnetic field driven by steady-state AC current with appropriate spatial and time phase shifts. Affectionately called the Zapper, it was first demonstrated in a field trial at Pickering reactor unit 4 in 1986, moving its first *in-situ* garter spring a distance of 50 cm. [More information on the LIM is reported in the *Nuclear Journal of Canada*, Vol. 1, No. 4, Dec. 1987.]

Some pressure tubes had sagged to the extent that the spacers were squeezed between the pressure tube and calandria tube, so that they could not be moved by the LIM. A jacking device was needed to lift the pressure tube inside the calandria tube. All operations have to be performed from *inside* the pressure tube. A mechanical jack in the Mark II tool was only partially successful in the first full scale SLAR outage at Gentilly 2 in 1991. In fact, the SLAR team was very disappointed with the tool performance because 33 out of 46 contacted channels were left in contact, and 13 additional channels were predicted to exhibit contact prior to the scheduled re-tube date.

The SLAR Mechanical Test Team quickly responded and a few months later, a "proof-of-principle" tool was built and tested at AECL's Sheridan Park Engineering Laboratory. Although several improvements were made to make it more robust and resistant to fatigue, this articulated, hydraulically actuated tool became the Mark III version which was recently used at Pt. Lepreau.

In addition to the basic function of spacer locating and repositioning, it contains a complete complement of special instruments such as eddy current systems to locate the spacers and measure the "before and after" gap, ultrasonic transducers to measure tube wall thickness and detect "blisters", a delivery system as innovative as the tool itself, and computer and software systems for control and data acquisition. Jammed into the four inch tube space is a host of cables, or umbilical system, delivering six power cables each at 600 V and 450 A, heavy water hydraulic hose, and instrumentation wire bundles. The entire project from concept to production spanned ten years and involved more than 120 team members.

If SLAR tools are used on every reactor in Canada, the net unit cost of adding ten years to the life of a reactor is about $12 million. Ten years of reactor operation would displace the burning of fossil fuels for a net savings of almost $1 billion. Does 100:1 return on investment sound too good to be true? Call back in ten years to find out!

At the Centre of Things International

A Canadian is at the centre of international developments in nuclear safety.

Zyg Domaratzki, currently Director General, Reactor Regulation at the Atomic Energy Control Board, holds two influential positions at the International Atomic Energy Agency; that of chairman of the International Nuclear Safety Advisory Group (INSAG) and chairman of the conference on an International Nuclear Safety Convention.

INSAG was created by the IAEA after the Chernobyl accident in 1986 to provide a senior level, objective overview of nuclear safety. Canada's first representative was Dan Meneley, then professor of nuclear engineering at the University of New Brunswick. Domaratzki was named to replace Meneley in 1989 and re-appointed for a second three-year term in 1992. Shortly after that re-appointment he was chosen to be chairman of the group.

INSAG's first task, which led to its first report, INSAG-1, was to review the Chernobyl accident. It then proceeded to examine nuclear reactor safety more generally and in 1988 produced INSAG-3, "Basic Safety Principles for Nuclear Power Plants", which has become the standard reference internationally. This was followed by a study of the organizational factors in safety and their report INSAG-4, "Safety Culture".

More recently INSAG re-reviewed the Chernobyl accident and produced a further report, INSAG-7, "The Chernobyl Accident: Updating of INSAG-1". In their summary assessment INSAG wrote:

> *There is a need to shift the balance of perception so as to emphasize more the deficiencies in the safety features of the design which were touched on in INSAG-1, and to recognize the problems conferred by the framework within which plant operation was carried out.*

The concept of an international convention was seriously discussed at a major international meeting in the fall of 1991. The IAEA's Board of Governors picked up the proposal and convened a conference in 1992 to develop such a convention. Domaratzki was elected to chair that group which consists of about 90 representatives from 40 of the IAEA member countries.

A caricature of Zyg Domaratzki by an attendee at the IAEA Safety Convention meeting.

The group met most recently in May 1993 and was unable to reach a consensus on the scope of the convention or on who would prepare the next draft. The argument over the scope is between those who wish it limited to nuclear power reactors and those who wish it to apply to all nuclear activities, especially radioactive waste.

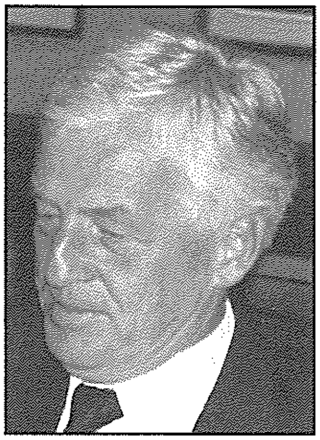
Domaratzki says there is broad agreement that a convention should be limited to obligations to meet broad principles. Those who favour limiting the convention to nuclear power point to documents like INSAG-3, which do not exist for other nuclear activities. One possibility is to proceed with nuclear power now with a clear commitment to extend the convention as soon as practicable.

In June the IAEA Board of Governors asked the chairman of the convention (Domaratzki) to prepare a further draft for consideration this fall.

With these tasks before him it is unlikely that Zyg Domaratzki will enjoy many holidays this summer!

Ontario Hydro Nuclear Organization

***Ed. note:** The following is extracted from a presentation by Don Anderson, General Manager of Ontario Hydro Nuclear to a meeting of the Atomic Energy Control Board, 11 June 1993.*



Don Anderson

An organizational transformation was initiated by our Chair, Maurice Strong, earlier this year, which will make Ontario Hydro more responsive to customer needs. I will focus on the impact of these changes in the nuclear part of the business.

The driving force for the changes has been the need to stabilize the electricity rates. These rates are greatly influenced by the cost and performance of the nuclear generators.

It is vital that we make our business more cost conscious, and that we do so in a way which does not compromise safety. I firmly believe that good safety performance and good cost performance are not mutually exclusive.

I will first explain the organization. Then I will discuss how it is intended to work, and how we will make the transition.

Ontario Hydro has now been set up in three major business groups, and three much smaller support organizations. The core of the business is the Electricity Group which is made up of the Nuclear, Fossil and Hydraulic suppliers, and the Grid System which is their customer. The Nuclear business, like the other two suppliers will establish formal contracts with the Grid System to supply energy and capacity at a negotiated price.

Ontario Hydro Nuclear has been set up with all resources needed under the control of the General Manager. This is a major improvement over the previous situation in which many functions were funded as corporate overheads, and accountability was difficult to establish.

We also brought primary control of all needed resources as close as practical to the four generating stations: Pickering, Bruce-A, Bruce-B, and Darlington. You will see how we have moved engineering, supply, and other functions out to the plant site, and have them report to the new Station Directors. We also increased the number of managers who are accountable for safe station operation.

For services which could not practically be de-centralized, the vast majority will be provided on a fee-for-service basis; this ensures that the resources are controlled by the stations, and makes accountability much clearer than it has been. I will briefly describe the four fee-for-service businesses.

The Heavy Water Business is responsible for production, inventory management, marketing, and delivery of heavy water.

The Training and Simulator Services Business is responsible for all training. This includes operator authorization programs, refresher training, radiological protection training and management skills development.

Nuclear Technology Services brings together all of the highly specialized engineering, inspection, maintenance, and analysis capabilities. One of the units within Nuclear Technology Services will provide analysis capability in the areas of Fuel and Physics, Thermal Hydraulics, and Risk Assessment.

The fourth fee-for-service business is Environment and Waste Management Services. It will manage the Bruce waste management facilities, radioactive waste transportation, environmental policy, and environmental services.

There are also three management service divisions which provide staff support to the General Manager. These are Employee Services, Finance and Business Services, and the Nuclear Safety Directorate.

Employee Services includes many of the functions which we used to refer to as Human Resources, however it is noteworthy that we have also included dosimetry services in this division. The intent is to treat personal dosimetry as an employee service so that the employee can have confidence that dose is being assigned without any perceived line organization production bias.

Finance and Business Services will provide the services implied in its name, but will also be the support organization for our Continuous Quality Improvement process. We already have a team developing the foundation for the Continuous Quality Improvement Process for the new business. The new process will build upon the existing processes in Operations, Engineering and Construction Services, and Supply.

In recognition of the need to maintain and improve the focus on safety, we have created a Nuclear Safety Directorate. I must emphasize that safety is a line responsibility, starting with me, and extending to the shop floor workers. We have been careful to set up the Directorate as providing policy and assessment support to me, while in no way removing responsibility from the line. The Directorate will establish where our safety management program is working effectively, and where more attention is needed. It will incorporate the Peer Evaluation function which will continue to be a cornerstone in providing me with an overview of safety performance. The Directorate will be the point of contact with the AECB on generic issues. It will also be our primary means of monitoring external operating experience, and feeding that back into our safety management process.

Moving the current business toward the organization I have just outlined will be a major challenge. We are fortunate to have just undergone a very similar organization change in Engineering and Construction Services, and we will apply lessons learned there to this similar but much larger change.

We are aware of the need to pay particular attention to the basics of the business while people are being moved around. We have backfilled the key positions vacated by the new directors. We have put in place a registry of the official licence holders, and of personnel who are responsible for day-to-day station operation. We have made it clear to management staff that safe operation takes precedence over the transition process. We have also initiated a review of our Emergency Response capability to ensure that it is maintained during the transition.

We are moving toward an August 1 turnover to the new organization.

Reactor Accidents Revisited
A lecture by David Mosey

reviewed by Ric Fluke

Pravda, 20 May, 1988: *"As we approached the station we were taken aback by the appearance of the sky. At a distance of some 8-10 km from the station we could see a crimson glow. It is well known that a nuclear power station with all its installations and pipes from which there is no visible emanations represents a very clean and meticulous structure. And suddenly it looked like a metallurgical plant or a major chemical enterprise over which there hung a huge crimson glow covering half the sky."*

Academician Valery Legasov dictated these observations to tape as part of his memoirs, published in *Pravda* after his death by suicide on 27 April, 1988, the second anniversary of the accident at Chernobyl. He was head of the Soviet delegation to the IAEA in August, 1986, where the USSR report laid the blame for the accident squarely on the shoulders of the operators. His memoirs, two years later, tell a different version. Other factors were causative to the accident at Chernobyl; such factors were also causative, more or less, to all past reactor accidents.

According to David Mosey, "understanding past accidents, and learning new lessons from the new perspectives we can bring to bear upon them, is an essential component in the safety management of any technology." David made these remarks in his lecture to the Ontario Hydro Nuclear Safety Analysis Department as part of its continuing education and training programme. The educational rôle can not be overemphasised, since only by reviewing past accidents, examining the What, How and Why, can the challenges to nuclear safety and its management be recognised.

What

David provided a detailed account of past accidents at NRX, Windscale, SL-1, Fermi-1, Lucens, TMI-2 and Chernobyl. Rather than dwell on such details here, readers can refer to David's book[1] for factual descriptions of what happened. In summary, NRX was a reactivity induced accident (RIA) which was preceded by operator error. Windscale was caused by Wigner energy release brought about by a hastily executed procedure. SL-1 was another RIA, preceded by an unexplained operator action during control rod maintenance. Fermi-1 was a loss of coolant accident (LOCA) caused by an unfastened plate which relocated and blocked off cooling flow. Lucens was a LOCA caused by cladding corrosion which flaked off and restricted cooling flow, causing fuel overheating, melting the cladding which relocated and blocked all cooling flow with subsequent fuel melting. TMI-2 was a LOCA caused by loss of boiler feed-water which initiated the failure of the pressuriser relief valve to close and the operator action to turn off the emergency core cooling injection. Chernobyl was an RIA preceded by a series of operator errors. Of these reactors, NRX, Lucens and Chernobyl were engaged in a test of some component or system, and were therefore not operating normally before the accident. Windscale and SL-1 were in a shut down condition prior to the accident. Both Fermi-1 and SL-1 were prototype demonstration reactors. Only TMI-2 was in normal routine operation before the accident.

Although examination of the detailed event sequences is necessary to understand what happened, David pointed out that the events in the last few moments before the "bang" are rarely very important. The scene is usually set long before anything appears to go awry. At NRX, for example, the operator pushed the wrong button. Although this was an operator error, such events themselves do not shed light as to how and why the accident occurred. More analysis and scrutiny of the accident is needed, argued David.

How

To understand how an accident occurred requires a significant effort of analysis. David noted that at the time of the NRX accident, conventional wisdom held that the safest reactor condition is with all neutron absorbers fully inserted in the core. He cited the conclusions of Lewis and Ward[2] who examined safety shut-down in detail:

> "... *in any operation it is possible that the reactivity will be changed. In many cases it is knowingly changed, for example by the removal of a shut-off rod for maintenance, by altering the pile load or fuel or moderator. Also, however, equipment failures or errors can change the pile reactivity. In the normal shut-down state if all the shut-off rods are in, then the monitoring instruments have no control and cannot guard against the unintended reactivity changes.*"

Furthermore, David noted their conclusion regarding the conditions for fast shut-down to be invoked. A reactor trip on over-power is not sufficient protection because a reactivity insertion at low power can cause a power transient that is rising too fast (exponential "runaway") for any mechanical shut-off system to catch, if it is not actuated until the over-power trip condition is reached. Hence they conclude that it is also necessary to trip at low power if the rate of flux is increasing rapidly. These conclusions published in 1953 did not prevent the accident at SL-1 on 3 January, 1961. Although it was initiated by an unexplained operator action, David pointed out that the operating staff did not understand why having all rods inserted was an unsafe condition. The same might be said of Chernobyl, except that there were rules about having a sufficient reactivity margin, rules which were said to have been violated.

Following the TMI-2 accident, extensive R&D programmes were initiated around the world to gain a better understanding of the phenomenology of that accident. This has led to passive safety features on new reactor designs to make them more "intrinsically safe". But as David suggested, this may not be enough. Not only must we review what has happened, and understand how it happened, it is also necessary to determine why.

Why

Why accidents happen is probably the least understood area and yet probably the most important, according to David. It is for this reason that David spent a considerable portion of the lecture in identifying causative factors. He cautions, however, that understanding why past accidents occurred does *not* mean that we have everything sorted out now; his key point is that achieving safe design and operation is a continuing challenge that requires on-going scrutiny of operating experience in order to meet that challenge successfully.

In all of the accidents examined, there was a high priority on production. Military programmes, which were of national urgency in the 1950's, placed high demands on production at NRX, Windscale and SL-1. Fermi-1 was an important prototype of a commercial LMFBR, and both TMI-2 and Chernobyl were commercial power reactors supplying electricity to the grid.

According to David, production pressures influenced the decision to proceed with a low power experiment at NRX which would require some abnormal configurations to be made, even though some safety interlocks that would prevent unintentional withdrawal of control rods were defective and taken out of service. Configuration changes included jumpers and cooling hose connections for some fuel channels, supplying lower than normal cooling flow. The safety implications of this configuration were not realised by the operating staff.

When the test began and the reactor had not achieved criticality as planned, the operator decided to withdraw another rod rather than stop the experiment. But several rods were withdrawn by mistakenly opening the wrong bypass valves. When the supervisor saw the "rods out" indicator lights come on, he immediately went to the basement to close the by-pass valves. He thought the rods dropped back into the core because the indicator lights went out, but in fact the rods only moved partially, to just below the top-of-travel limit switch, which was problematic for that design. It was then that the supervisor made the fateful telephone call to his assistant at the control desk, and gave the wrong button number to be pressed. When power increased rapidly, the operator tried to trip the reactor but the rods did not fall. At 30 s, power reached 17 MW causing the "test" channels with hose connections to boil dry. This sudden void caused a 2.5 mk reactivity increase. As power continued to climb a moderator dump was initiated at 45 s. Power was now at 90 MW, three times full power! Twenty seconds later, the moderator dump was complete and the reactor was shut down. After a three minute pause, when all of the staff thought it was safe to sigh with relief, there came a loud "rumble" accompanied by ejection of water through the top of the reactor, most probably due to a hydrogen burn from within the calandria.

David summarised his analysis of causative factors of the NRX accident: there was a production prerogative to complete the experiment; the reactor was operated in a known degraded condition (safety interlocks out of service); there was inadequate understanding by staff of the safety implications of the test configuration (there was less reactivity margin available); there was a lack of documented procedures for control rod by-pass valve operation; there was a design problem (rod position indicator lights); and, the operator did the wrong thing. After the NRX accident, the Reactor Safeguards Branch was formed to provide an operational review facility. This accident is significant because it led to the current Canadian safety philosophy of separating the function of reactor shut-down from reactor control.

David's analysis of the accident at Windscale showed that the causative factors were similar to those at NRX: production prerogative, poor documentation, design flaws and a lack of fundamental understanding (of the phenomenon of the Wigner energy release). Perhaps more important,

"The Chernobyl accident is a sobering example of the destructive and lethal consequences of reactivity accidents"

David cited the Penney Report on Windscale[3] which identified "deficiencies and inadequacies of organisation". Unclear division of responsibilities between the Industrial Group and the technical advisors at UKAEA Harwell led to failures in communication, with "undue reliance on technical direction by committee". The report also noted that the Windscale operations staff were not well supported by technical advice. After the start of Windscale operations, "other demands on the UKAEA have been so heavy that insufficient technical attention has been available to ensure their safe operation."

When David described the accident at SL-1 it sounded like an old refrain, only sung a lot louder. The reactor was designed and commissioned by ANL, after which responsibility was assumed by Combustion Engineering who also provided training for the US Army, the operator. Several groups including the Idaho Operations Office, its Military Reactors Division and the Army Reactors Office in Washington all participated in decisions, but as David noted, there was no single group with continuous safety responsibility, awareness of the growing problems, and authority to take decisive action. There was also a serious design flaw because with all rods inserted, a "runaway" could be initiated by raising the one central rod about 17 inches. Furthermore, the control rods were deteriorating because of materials problems, and would sometimes stick and not drop into the core. The control rod "sluggishness", documented 33 times in the operating log, was not reported to the project manager because "it was not thought to be a malfunction". After their review, CE concluded that SL-1 was in a seriously degraded condition and recommended some rehabilitation; the US Army agreed but work was deferred due to budget constraints.

The accident happened during a control rod maintenance procedure on the night shift. David described the poorly documented procedure, which read like a GM Shop Manual ("reassembly is the reverse of the above"). The maintainer was required to raise the rod by four inches and to secure it with a C-clamp. Raising it by 16 inches would result in criticality. There was no mechanical stop to prevent this and the four inches had to be estimated. On the fateful shift, there were three people on the crew: a Chief Operator, an Operator-mechanic, and a trainee. The CE proposal for 24-hour staffing by a physicist was rejected by the USAEC on budgetary grounds. With a flawed unsafe design, operated in a degraded condition by staff who lacked understanding of reactor physics and relied on poorly documented procedures, and with organisational deficiencies with no clear assignment of safety responsibility in an economically constrained production prerogative, it would not be fair nor true to place the blame on operator error. The maintainer was killed in the accident and so nobody knows exactly what happened – the control rod deterioration may have resulted in enough loss of neutron absorbing material that criticality was reached with only a four inch rod removal, or the rod may have stuck (history of sticking rods) and the maintainer pulled too hard and it suddenly came free, or as some speculated, the maintainer may have committed suicide – but whatever the maintainer did, it was not the most significant cause of the accident.

On the accident at Fermi-1, David noted the organisational deficiencies (run by a committee of consortium members), some design deficiencies and lack of documented procedures including criteria for when the reactor should be shut down. But more interesting, as David noted, was the failed component that started the accident. Zirconium plates had come loose and one of them blocked flow to some fuel channels. These "plates" were recommended by the Advisory Committee on Reactor Safeguards to help divert molten fuel in the event of a meltdown. Significant analytical efforts by the operator were required to justify to the ACRS *not* installing these plates. To avoid licensing delays, the path of least resistance was taken. However, the "as built" drawings were not updated to show this design modification, there was no design review and there was no analysis. After the accident, the analysis was done; it showed that the plates were unnecessary.

"Achieving [safety] is a continuing challenge that requires on-going scrutiny"

The accident at Lucens, a CO_2 cooled reactor, was initiated by faulty shaft seals in the water cooled blower. Seal leakage and moisture ingress into the primary circuit was a chronic problem. But no new reactors of that design were planned and the designer of the blower shaft seal left the company. Several design modifications were made by the operating company without success, and each time, the blower had to be tested on-reactor because the test rig was dismantled due to the phase-out of that design. Leakage continued, corroding the fuel's magnesium cladding. The build-up of oxide restricted the coolant flow until the fuel overheated. The remaining cladding melted and relocated until all cooling flow was blocked, causing the fuel to melt. Two causative factors are readily seen: continuing to operate in a degraded condition; and, lack of technical support (the design was abandoned).

The accident at TMI-2 has been well studied. A key event was the operator shutting off the emergency core cooling injection because the pressuriser was filling up (or going "solid"). Although this action has been termed "operator error", David explained that the operator training emphasised that the pressuriser should not go solid. There was no safety reason for this operating instruction; apparently, the computer simulator would "crash" when the pressuriser went "solid" and so that condition was not allowed to occur. Another important factor identified in David's analysis was failure to communicate and respond to an "accident" two years earlier at David Besse, a similar design, in which the same TMI accident sequence and operator response occurred, except that the reactor was at low power. It was a "non-event" because no damage occurred. Both the NRC and Babcock and Wilcox (designer of both reactors) investigated the David Besse incident and concluded that significant damage could have occurred if the reactor had been at full power. The consequence of erroneous operator action was also noted and communicated to the Advisory Committee on Reactor Safeguards, one year before the TMI accident. As noted by David, no information about the likelihood of a stuck open pressuriser relief valve and the expected inappropriate operator response was communicated to utilities before the accident at TMI.

"A careful and comprehensive exchange of knowledge among all involved [is needed]"

The Chernobyl accident had global implications and is a sobering example of the subtle, fast, destructive and lethal consequences of reactivity induced accidents. Most western countries responded by pointing out their design differences from the RBMK that would preclude such a scenario. (See, for example, the clear and informative descriptions of the CANDU and RBMK reactors by Dr. Victor Snell of AECL[4].) The Soviets knew that the RBMK design had inadequacies and were phasing it out. But many of the causative factors of other accidents that David spoke of applied to Chernobyl – lack of understanding by operating staff, production imperative (reactor power dictated by the needs of the grid authority, need to conduct test before maintenance outage), organisational deficiencies with no clear line of responsibility for safety, and violation of operating policies such as the operating reactivity margin (ORM) and other safety system "jumpers". David also noted a failure to act on operating experience. During commissioning a phenomenon known as the "positive scram" effect was discovered (three years before the accident) and counter-measures to prevent this were recommended. These counter-measures were never implemented, nor were there any warnings given to the operators about this hazard. It is also important to note that the "violation" of ORM is an unfair description; the ORM was never communicated in the operating manuals as a safety limit, but rather as an operational limit to control the power density. It was therefore unfair and untrue for the Soviets, in their report to the IAEA in 1986, to lay the blame on operators disregarding operating policies and principles, since no such operating policies and principles had been communicated. It was not until the senior station staff members were released from prison and their analysis of the situation published (Bagdasarov *et al.*), that the truth became known. Clearly, there was a general absence of an effective safety culture.

Conclusions

David identified three common features in the six accidents that were revisited: (a) a design flaw existed which created an unexpected "trap" into which the operator fell; (b) the operator did the wrong thing; and, (c) there was a chronic problem, either with instrumentation and control or equipment performance.

Three needs were suggested as essential for nuclear safety: (a) a common understanding by all specialists of the whole picture, without a responsibility "vacuum"; (b) decisive response to operating experience by observing, analyzing, communicating and taking actions; and (c) separation of safety responsibility from production and economic imperatives. The last need is not limited to control room activities and is an on-going conflict in design, training and operation.

According to David, the significance of the NRX accident was that it focused attention on shut-down systems and led to the development of current Canadian design philosophy. But he adds that other events leading up to the accident suggest that factors other than design and direct operator action can influence nuclear safety: operating the reactor in a degraded condition, lack of clear documented procedures, and a general lack of understanding in all areas. As pointed out by Lewis:

> *"To reduce the risk of human error and mechanical failure, no doubt a better system of review and inspection should be established. This should relate the design considerations to experience."*

The Windscale Report revealed a set of "deficiencies and inadequacies of organisation". No clear responsibility for technical decisions existed; instead, there was "undue reliance on technical direction by committee". Of particular significance, as noted by David, the Windscale operations staff were not well supported by technical advice from Harwell, which became burdened by other priorities once Windscale was operational.

On the SL-1 accident, David quotes from the Thompson Report[5] which gives some basic organisational principles of reactor safety: responsibility for safety and all facets of reactor operation should be unequivocally defined ("a line organisation should be used, not a committee"); and, safety reviews should be carried out by a *single* competent group external to the operating organisation – reviews conducted by competing safety groups can "unduly harass the operating group and thereby reduce safety".

David's review of Fermi-1 illustrates the importance of proper design review and safety analysis to support a design change instead of following the most expeditious pathway to licensing. The accident at Lucens reinforces the need for technical support and commitment to a design. The TMI accident illustrates the need to respond to operating experience with review, analysis, understanding and action. The Chernobyl accident drives home the message that an effective safety culture must be in place, which goes well beyond the reactor control room.

David quoted Academician Valery Legasov's notes, published posthumously in *Pravda* in 1988, about this absence of safety culture:

> *"[there existed] situation of collective responsibility for the quality of work performed ... All this confusion and a system lacking an apparatus personally responsible [assignment of individual responsibility] for quality has led to a great deal of irresponsibility, as shown by the Chernobyl experience"*

David goes on to say that there is an absolute requirement that all involved, whether in design, analysis or operation, should be sensitive to the operational totality of the system and how their own work impacts on it. Everyone should not just understand WHAT has to be done and HOW it has to be done, but WHY it has to be done. This implies a careful and comprehensive exchange of knowledge among all those involved. Watertight compartments must be avoided.

He quoted from the 1991 report of the Commission to the USSR State Committee for the Supervision of Safety in Industry and Nuclear Power, which criticised the current situation in their country:

> *"All those involved in the development and operation of nuclear power plants are responsible only for those parts of the job which they perform themselves ... decision making is separated from the responsibility for the decisions. Moreover, following the repeated reorganisation of government authorities, those bodies which made crucial decisions earlier no longer even exist. As a result, there are dangerous facilities for which no-one is responsible."*

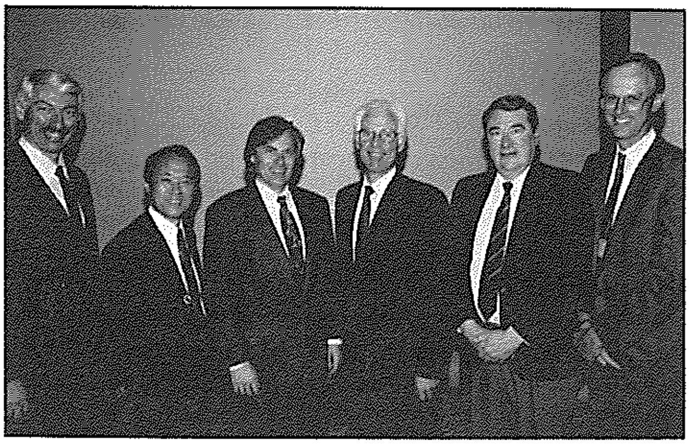
The "crimson glow" described in Legasov's memoirs was an awesome manifestation of the destructive consequences of the Chernobyl accident. Understanding why past accidents occurred does *not* mean that we have everything sorted out now. Achieving safe design and operation is a continuing challenge that requires on-going scrutiny of operating experience in order to meet that challenge successfully. David's bottom line: – review of past accidents is a part of on-going experience.

References

1. Mosey, D., *Reactor Accidents: Nuclear Safety and the Role of Institutional Failure*, Nuclear Engineering International Special Publications, Quadrant House, Sutton, Surrey, UK, 1990. (ISBN 0-408-06198-7)
2. Lewis, W.B., and Ward, A.G., "An Appreciation of the Problems of Reactor Shut-off Rods with Special Reference to the NRX Reactor", *AECL-490*, Atomic Energy of Canada, Limited, May 1953.
3. Penney, W., *et al., Report on the Accident at Windscale No. 1 Pile on 10 October 1957*, Report to the Chairman of the United Kingdom Atomic Energy Authority, October, 1957.
4. Marples, D.R., *The Social Impact of the Chernobyl Disaster* (Introduction by Snell, V.G.), The University of Alberta Press, Edmonton, Alberta, 1988.
5. Thompson, T.J., and Beckerley, J.G., *The Technology of Nuclear Reactor Safety*, MIT Press, 1964, Chapt. 11.

Fusion Energy Seminar

Shayne Smith



Speakers at the CNA/CNS Fusion Energy Seminar held in Toronto 21 April 1993 pose for the Bulletin. *L-R: Don Dautovich, Dave Jackson, Richard Bolton, Eric Storm, Genn Saji, Dale Meade*

A one day seminar on fusion energy entitled "Technological Challenges and Opportunities for Industry" was held in Toronto on April 21, 1993. Approximately 70 participants gathered to discuss the current Canadian program and the status of international fusion programs. A reception for seminar participants was held on the evening before the meeting, giving the participants a chance to get an early look at the industry exhibits. Twelve exhibits featured the activities of Canadian industry/organizations in fusion energy R&D activities. The seminar was organized by the CNS/CNA Fusion Committee.

The morning session featured a number of key speakers from the Canadian Fusion Program, and from a number of key international projects. Dr. Dave Jackson, head of the National Fusion Program, noted that the program continues to receive federal government support despite the difficult budget situation that exists. Dr. Jackson discussed Canada's participation in the International Thermonuclear Experimental Reactor (ITER) Project, as a contributor to the European Community program. Dr. Don Dautovich, Program Manager for the Canadian Fusion Fuels Technology Project (CFFTP) located in Mississauga, Ontario and Dr. Richard Bolton, Program Manager for the Centre canadien de fusion magnetique (CCFM) near Montreal, Quebec each outlined the current status of their programs, which comprise the major elements of the Canadian fusion R&D effort.

The current status of the ITER project, and the challenges to industry resulting from the design effort for the $6 Billion (US) device, was presented by Dr. Genn Saji, from the ITER Joint Central Team Co-Centre in San Diego, California. Dr. Dale Meade, from Princeton University's Tokamak Fusion Test Reactor (TFTR), gave a spirited talk on the status of fusion programs in the United States. He noted TFTR's plans to conduct tritium experiments, and thanked Canada for their ongoing support in this regard. Canadian industries are currently involved in the supply of a $3 Million isotope separation system for TFTR. Dr. Meade also discussed the Clinton Administration's plan to fund the successor to TFTR, known as TPX.

The morning session was completed with a presentation by Dr. Eric Storm, from the Lawrence Livermore National Laboratory (LLNL), on the progress of inertial confinement research. This was an excellent overview on recent innovations in using laser or particle beams, which are focused on tiny tritium/deuterium fuel pellets to achieve fusion energy production. Although many of the technological details remain classified under military projects, inertial confinement systems may prove to be a feasible alternative to the conventional tokamak approach, producing more compact, lower power designs.

Following a buffet lunch, Dr. Paul Gierszewski from CFFTP presented three Canadian graduate students with CFFTP Fusion Technology Fellowships. The Fellowships, which are normally awarded for three years and consist of a stipend of up to $10,000 per year, plus tuition fees in some cases, were officially presented to Wojtiech Fundamenski, David Kingdon, and David Leblanc.

The afternoon program focused on Canadian industrial involvement in fusion, and featured presentations from six Canadian industries on their experiences and involvement with the Canadian fusion R&D effort. From these presentations, it was apparent that fusion R&D encompasses a wide variety of cutting edge technologies which are of interest to Canadian companies. Since involvement in these programs tends to be of an international nature, fusion represents a unique forum to meet with companies in other countries and to explore other business opportunities. Companies presenting were Spar Aerospace Ltd., Qualprotech Inc., Wardrop Engineering Inc., Spectrum Engineering Corporation Ltd., MPB Technologies Inc., and Advanced Laser Fusion Technology Inc..

This seminar was the second CNS/CNA fusion energy seminar, the last of which was held in Ottawa in October 1991. They serve to focus attention on the opportunities presented to Canadian industry through fusion R&D programs and provide a forum in which to exchange updated information on Canadian and international progress in this area.

BEIR V or FEAR V?

Dr. Yalow Debates the Societal Benefits and Risks of Radiation

Ric Fluke

Those who attended the CNS Public Presentation Series at the University of Toronto on March 23, 1993 were given a very special treat. Dr. Rosalyn S. Yalow gave a fiery account of her efforts to address the public's fear of radiation.

Misconceptions about radiation, its benefits and its risks, lead to fear which threatens its use for beneficial purposes, from medical diagnosis to meeting our electricity needs. Fear is escalated by biased and incomplete disclosure of all the facts, and according to Dr. Yalow, the committee that put forth the BEIR V Report is a flagrant example of, as she put it, dishonest non-reporting of all the facts.

Dr. Yalow is Senior Medical Investigator, Emeritus, at the VA Medical Center, New York, where she has worked since 1947. She won the 1977 Nobel Prize in medicine for her work in developing Radioimmunoassay (RIA), a breakthrough in providing a highly sensitive technique for measuring minute traces of substances in biological samples. RIA is now an accepted method in nuclear medicine and is used around the world in physiological health.

Dr. Yalow feels, however, that those who foster public fear of radiation are threatening the use of RIA, and nuclear medicine in general. The public are unable to grasp all of the facts, especially when the significance of the facts is disputed by scientists and experts. But when facts are withheld, how can the experts ever reach any consensus? She is particularly critical of the BEIR V Committee, which did not allow reports by BEIR III Committee members whose views were less biased about the harmful effects of radiation. Several examples were cited.

TABLE 1 Cancer Rates in U.S. White Population in Rocky Mountain States Compared with the U.S. Average, 1950 - 1967[a]

	Highest States	U.S. Average
Background (mrem/yr)	210.	130.
All malignancies[b]	126.	150.
Leukemia	7.0	7.1
Breast Cancer	21.5	25.3
Lung cancer	14.5	20.4
Thyroid cancer	0.055	0.057
Malignancies, age 0-9	9.1	8.5

a M.A. Frigerio and R.S. Stowe. In: Biological and Environmental Effects of Low-Level Radiation. Vienna. International Atomic Energy Agency, pp. 385-393, 1976.

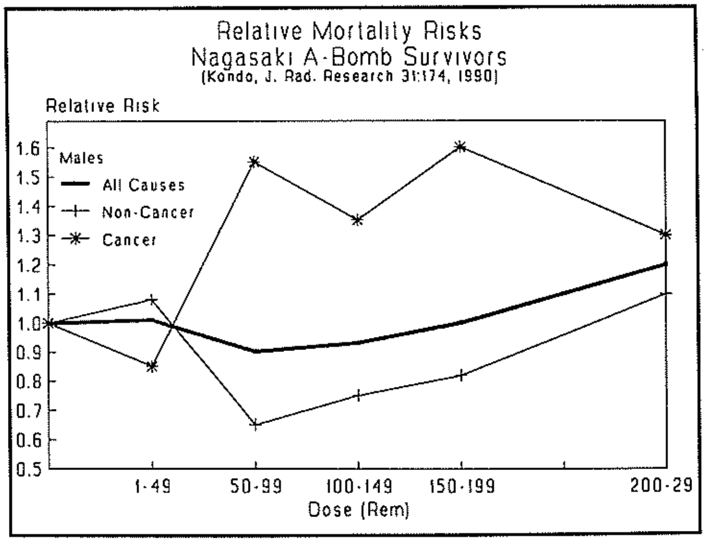
b Rates per 100,000 population per year.

Table 1 shows the cancer rates for the seven U.S. states having the highest background radiation. Compared to the U.S average, the rate for all malignancies was more than 10% lower in the higher radiation states. In fact, lung cancer rates in the high background states, where radon levels are also higher, were only about ⅔ the national average. One might conclude from this that a little radiation is good for you. However, Dr. Yalow has no doubt that if the rate of malignancies were higher in the high background states, that everyone would blame the radiation. Another problem with such comparisons, she noted, is that people move from place to place, and hence one may not have received all of the radiation dose that one might have otherwise obtained. Furthermore, the higher background states are also at a higher elevations where oxygen levels are low. There may also be a lower rate of smoking in those states. Before making a judgement on the effects of radiation, Dr. Yalow warns that other factors must also be taken into account.

Another example cited was a high background region in China where 90% of the Han peasants have lived in the same region for six generations or more, and were also not smokers of American cigarettes. Compared to a low background region of China, radon concentrations were three times higher but there was no difference in the lung cancer mortality, or in the frequency of hereditary diseases, congenital deformities or any other cancer mortalities in these non-smoking populations.

The BEIR V report states that the average annual dose to inhabitants of the high background Gurapari region in Brazil is 640 mrem, six times the global average. Although the report concedes that studies on health effects in this region are "limited", a cytogenetic study of 200 individuals from the region was compared to a control group living in a similar village and it showed an increase in chromosome aberrations. The total number of breaks in the high dose region was reported as 0.85±1.20, compared to 0.57±0.93 for the control group. Although the "data" shows a 50% increase in total breaks for the high dose region, Dr. Yalow wonders how any sensible person could draw a conclusion or even make sense out of numbers which have standard errors that are considerably larger than the reported values. Dr. Yalow wonders if the BEIR V committee even bothered to read the original paper!

In Karala, India, people live on radioactive sand where they receive a 4-fold higher level of background radiation. The BEIR V reports shows an increase in Down's syndrome for these people. Dr. Yalow notes that although the BEIR V report cites the correct paper in *Nature* (262-60, 1976), it attributes the work to Maruyama, *et al.* instead of Kochupillai, *et al.*, the true authors. In the *Nature* paper, it reports twelve cases of Down's syndrome among 12,900 births in the high background region, while there were no cases reported in a neighbouring control population of 5,900. For

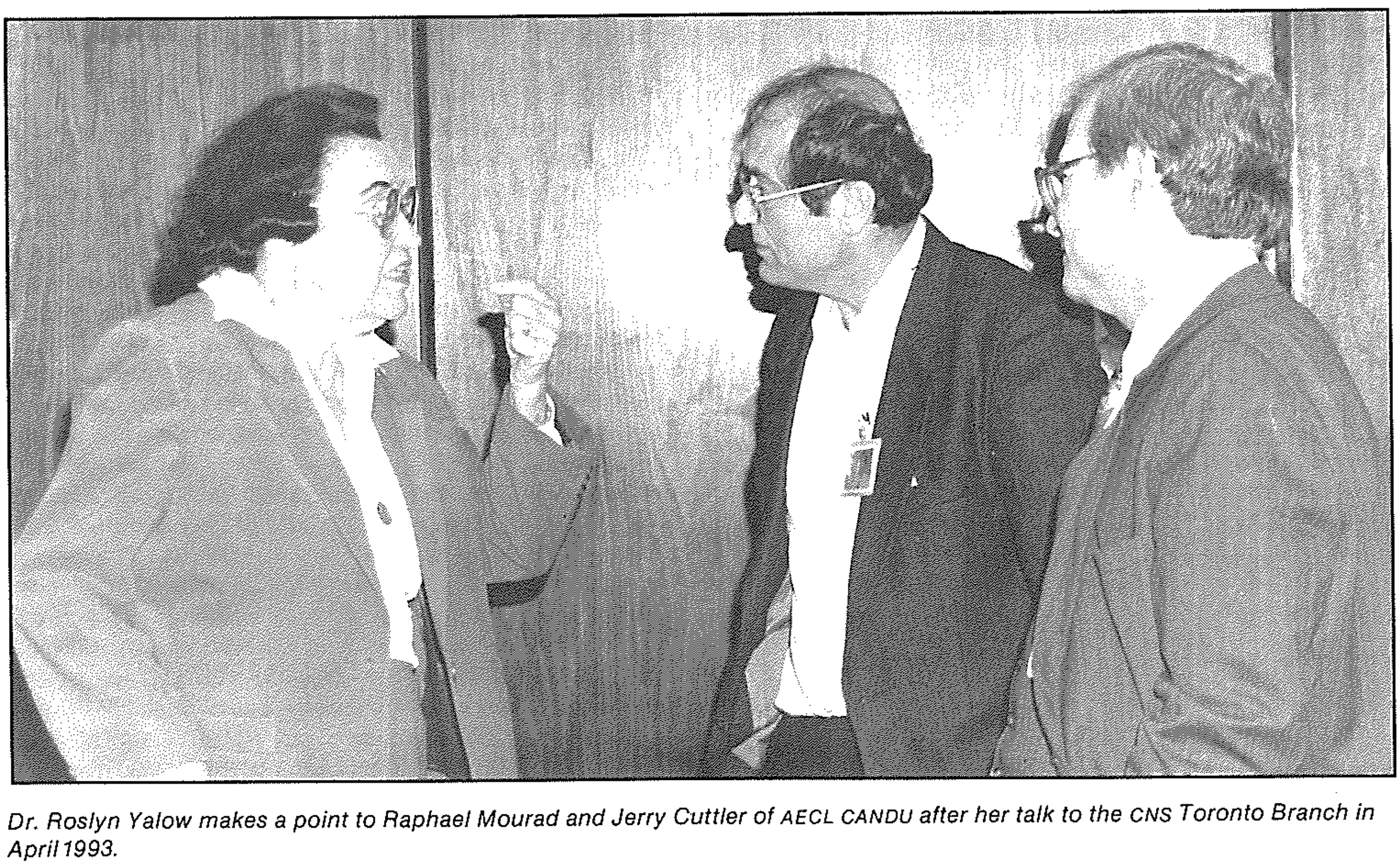


some reason, the BEIR V committee neglected a previous paper (Verma, I.C., et al., *The Lancet*, May 24, 1975, p. 1200) which reported that the incidence of Down's syndrome among 58,000 newborns in India was one in 1215, about the same as in the high background Karala region! According to Dr. Yalow, a more complete review of the facts would have shown that the BEIR V committee's conclusion was incorrect.

Now that Dr. Yalow was beginning to warm up, she abandoned her "nice-guy" approach and presented some of her negative views about the BEIR V report. For example, the BEIR V report does not reference a 29 year follow-up study of army radiology technicians who receive 50 to 100 rem during their three year training (by taking x-rays of each other every day!) during WW II (Jablon, S. and Miller, R.W., Radiology 126:677, 1978). Jablon, who had served on the BEIR V committee, reported no difference in cancer mortality among these radiology technicians compared to a control group of medical technicians; somehow, his findings did not make their way into the BEIR V report.

The survivors of the Hiroshima and Nagasaki bombings have been studied extensively. Without the excess radiation, 4,500 cancer deaths would have been expected by 1978. There were 90 excess leukaemia deaths and 160 other cancer deaths presumably attributable to radiation, which was a 6% increase overall. However, these excess cancers are the combined totals from Hiroshima and Nagasaki despite the fact that two different bombs were dropped; Hiroshima had a high neutron exposure whereas at Nagasaki, it was primarily gamma radiation. As Dr. Yalow noted in the figure above, doses in the 50-99 rem range seem to have been highly protective for the Nagasaki survivors! Maybe this was the result of better medical care for this group during the follow-up study period, but the fact remains that there were no increases in deaths due to all causes at doses less than 150 rem. Dr. Yalow explained that the Nagasaki data is unique because it is not "contaminated" with uncertainties in the neutron dose, yet it receives very little attention in the BEIR V report. More incredible, she stated, is the omission from the report that the Hiroshima/Nagasaki survivors received an additional dose of up to 40 rem through various medical examinations after the bombings.

Another flagrant omission from the BEIR V report, in Dr. Yalow's view, has to do with incidence of leukaemia among participants in nuclear weapons tests. There were 3,224 participants at the Smoky test, which was a high yield



Dr. Roslyn Yalow makes a point to Raphael Mourad and Jerry Cuttler of AECL CANDU after her talk to the CNS Toronto Branch in April 1993.

tower detonation with 10 to 20 times more fallout than other tests. By 1977, there were 9 cases of leukaemia compared to 3.5 expected. According to Dr. Yalow, this is clearly too small a sample to draw a meaningful conclusion; but not too small to be well cited in the BEIR V report. In another weapons test, Operation Greenhouse, there were more than 12,000 participants who received double the average dose than Smoky participants. There must have been a protective effect of this higher dose because 4.4 excess cases of leukaemia were expected but only one occurred. Dr. Yalow wonders whether the BEIR V committee deliberately concealed this apparent protective effect; to be honest, BEIR V should have reported the decrease at Greenhouse and said that it was simply a consequence of small number statistics. The dishonesty of the BEIR V committee, said Dr. Yalow, is that they suggest the increase in leukaemia at Smoky is real and significant without noting the decrease at Greenhouse.

Entertainers say it is best to stop when the audience clearly wants more, and Dr. Yalow's approach was no exception as she laid BEIR V to rest with the kind of dignity usually afforded to a fallen mosquito. But despite her weakened voice (a consequence of Toronto's miserable climate come lately), she did not stop firing but simply changed her aim. Beginning with a review of cancer statistics from 1930 to 1987, she attacked the media reports that suggest a cancer epidemic caused by man-made environmental contamination. Death rates due to stomach and liver cancer have declined remarkably. These are the type of cancers usually associated with diet. Is the decline of such cancers the result of a parallel increase in the use of pesticides and fungicides? More alarming is the rapid rise in the rate of death due to lung cancer. Male lung cancer deaths paralleled cigarette production with about a 20 year delay. Among women, lung cancer deaths did not start increasing until the 1960's, 20 years after the war when women started smoking for its genre (e.g. You've come a long way, baby!). Now it is the leading cause of female cancer mortality and is continuing to rise.

Can this be blamed on radon gas? The U.S. Environmental Protection Agency (another of Dr. Yalow's antagonists) might lead one to just that conclusion in the statistics it releases, blaming radon for 5,000 to 20,000 lung cancer deaths annually. What is not included in EPA statistics is that it is based on studies of smoking uranium miners. If the data are examined more closely, she argued, it is clear that lung cancer deaths are in proportion to smoking habits and not to radon levels.

Dr. Yalow explained several pathological studies which show that lung cancer in nonsmokers occurs in the deeper portions of the lung. Most lesions that are associated with smoking or radon and its daughters originate in the tracheobronchial tree and not in the deeper portions of the lung (Kabat and Wynder, Cancer 53:1214, 1984). Therefore, if lesions in nonsmokers occur in the deeper portions of the lungs, they cannot be the result of radon and its daughters. Dr. Yalow pointed out that of 148,000 lung cancer deaths expected in 1991, no more than 7,500 would occur in nonsmokers. Most of these would originate in the deeper portions of the lung. For the few nonsmoker lesions that might originate in the tracheobronchial tree, there is no statistical evidence to support the EPA view that it is due to radon; more likely, it is the result of "second hand" smoke or industrial air pollution.

Another tactic cited by Dr. Yalow is the publicising of reports as "showing" evidence of increasing lung cancer with increased exposure to radon. One such report studied residential radon and lung cancer among females in New Jersey, and the data showed that lung cancer increased with increasing radon levels for one-pack-a-day female smokers. However, there was no increasing trend with radon levels among nonsmokers. More interestingly, there was a significant decrease with increasing radon among heavy (two-pack-a-day) smokers. Because of the few cases there is no statistical significance; but Dr. Yalow showed how to "play the EPA game" in reverse, by publicising the report as "showing" that radon prevents cancer in heavy smokers!

TABLE 2 Lung Cancer in New Jersey Females (Relative Rates)

Radon (pCi/L)	Lifetime Nonsmokers	Smokers (cigarettes/day)		
		< 15	15 - 25	> 25
< 1.0	1.0	1.0	1.0	1.0
1.0 - 1.9	0.9	1.7	1.1	0.8
2.0 - 11.3	1.2		2.4	0.4

Dr. Yalow concluded her session with a call for honesty and fair perspective. Honesty includes releasing all the facts. Some examples cited were: separate the smokers from nonsmokers when studying the effects of radon; show the Nagasaki data beside that of Hiroshima; and show the Greenhouse data beside the Smoky data. When attempting to correlate cancer with radiation exposure, look for other factors as well including smoking habits, diet, lifestyle, etc. When reviewing the Japanese bombing survivor data, include the extra dose received in establishing their medical history, and do not exclude data because it shows less of a harmful radiation effect than other data.

Following the Chernobyl accident, Cs^{137} concentrations measured in human tissue appeared alarming, even to scientists, when they were compared to "control" samples that had much less Cs^{137}; the data is not as impressive when it is compared to the natural K^{40} concentration *in the same tissue sample*! Her plea is to take the other measurements in the same sample in order to establish a fair perspective.

[Follow-up note: Dr. Yalow, after returning to New York from her Toronto series of talks, suffered a stroke. She is recovering well and is expected to return to work this summer at the Veterans Administration Medical Center. We wish her well.]

Conférence étudiante

Solange Laberge

L'Institut de génie énergétique (I.G.E.) de l'École Polytechnique de Montréal a été l'hôte les 2 et 3 avril de la 18e conférence étudiante annuelle ANC/SNC. Grâce au grand nombre de participants ainsi qu'à la qualité des communications cette conférence a été un succès. Un total de 78 personnes y ont été reçues venant des universités du Nouveau Brunswick (4), de Carleton (2), d'Ottawa (1), de Toronto (23), de Waterloo (2), du Manitoba (1), de Montréal (1), de Laval (2), de McMaster (11) ainsi que du CRESELA de l'Institut Armand-Frappier (2), du Collège Royal Militaire du Canada (9), du Massachusetts Institute of Technology (2) et de l'École Polytechnique de Montréal (14). De plus, parmi nos invités étaient présents des représentants d'Hydro-Québec (3) et d'E.A.C.L. Montréal (1).

Parmi les participants, 35 étudiants ont présenté un total de 36 communications dont 15 au niveau du doctorat, 16 au niveau de la maîtrise et 5 au niveau de baccalauréat. Le bon déroulement de la conférence a été assuré par une équipe de 11 étudiants de l'I.G.E. qui ont apporté un support technique aux membres du comité organisateur. La conférence a permis de mettre en valeur la qualité des travaux des étudiants dont les présentations ont d'ailleurs été qualifiées d'excellentes par tous les participants.

Pour souligner les efforts des participants s'étant le plus démarqués et dans le but de les encourager à poursuivre leurs efforts, un jury composé de représentants de l'industrie a sélectionné les meilleures communications et de nombreux prix ont été décernés. Le choix des jurés n'a pas été facile vu la qualité de toutes les communications. Néanmoins, 6 lauréats se sont vus attribuer des prix (voir liste ci-jointe). Ces prix ont d'ailleurs été décernés essentiellement grâce à des subventions supplémentaires reçues de compagnies, organismes et ministères.

De plus, nous avons eu l'honneur de recevoir 3 personnes qui ont contribué directement ou indirectement à promouvoir le nucléaire au Québec. En premier, Dr André Bazergui, Directeur de l'École Polytechnique, la plus grande école d'ingénierie de langue française au Canada, a ouvert la conférence. Il a accueilli les participants avec enthousiasme en soulignant la fierté de l'École Polytechnique d'être l'hôte d'une conférence principalement tenue en anglais mais faisant aussi une place importante à la langue française. Par la suite, Dr Wladimir Paskievici, l'une des personnes clés ayant contribué à la fondation de l'I.G.E., a introduit de façon élogieuse lors du banquet l'orateur invité, Dr Daniel Rozon, Directeur actuel de l'I.G.E.. Dr Rozon nous a décrit de façon réaliste, dans son discours intitulé «l'avenir du nucléaire au Québec et au Canada pour les 20 prochaines années», les options énergétiques québécoises et canadiennes. Dr Rozon a particulièrement insisté sur la nécessité d'une ouverture sur la scène internationale de l'enterprise nucléaire canadienne.

Finalement, Dr Hugues Bonin du Collège Royal Militaire du Canada a clôturé la conférence en remerciant les participants et les organisateurs. Tout en encourageant les participants dans leurs efforts, Dr Bonin nous a tous invités à nous joindre à la prochaine conférence étudiante annuelle de l'Association Nucléaire Canadienne et de la Société Nucléaire Canadienne qui aura lieu l'année prochaine à Toronto.

Liste des récipiendaires des 5 prix décernés pour les meilleures communications de la 18e conférence annuelle étudiante ANC/SNC, les 2 et 3 avril à l'École Polytechnique.

PREMIER CYCLE:
MEILLEURE COMMUNICATION (350$) :
M. Tinku Dhoum, University of Toronto

DEUXIÈME CYCLE :
PREMIER PRIX,
MEILLEURE COMMUNICATION (350$) :
M. Raymond C. Quan, University of Toronto

DEUXIÈME PRIX EX AEQUO,
MEILLEURE COMMUNICATION (125$) :
Mlle Mirielle Gourde, Université Laval

DEUXIÈME PRIX EX AEQUO,
MEILLEURE COMMUNICATION (125$) :
M. Mustapha Samri, Université Laval

TROISIÈME CYCLE :
PREMIER PRIX,
MEILLEURE COMMUNICATION (350$) :
M. Peter Tye, École Polytechnique

DEUXIÈME PRIX,
MEILLEURE COMMUNICATION (250$) :
M. Greg N. Naterer, University of Waterloo

R.E. Jervis Award

The Canadian Nuclear Society is sponsoring an award to recognize the contribution of Prof. Robert E. Jervis who retired from the University of Toronto last year. Dr. Jervis' research career centred on radiochemical and radioactivation techiques and their applications to interdisciplinary fields.

The award has a value of $500 and will be given annually.

Candidates must be a full-time graduate student at a Canadian university, pursuing research involving the development of radiochemistry or its application and be a Canadian citizen or landed immigrant.

For further information contact Prof. G.J. Evans, U. of T. Tel. (416) 978-1821; FAX (416) 978-8605.

The Representations of the Various Inter-subchannel Transfer Mechanisms and their Effects on the Predictions of the ASSERT-4 Subchannel Code

P. Tye
Institut de Génie Énergétique
École Polytechnique de Montréal

Ed. Note: *Following is the abstract of the paper that won Peter Tye first prize in the Third Cycle (doctoral level) at the CNA / CNS Student Conference held at École Polytechnique, April 2 and 3, 1993.*

In this paper, effects that the constitutive relations used to represent some of the inter-subchannel transfer mechanisms have on the predictions of the ASSERT-4 subchannel code for horizontal flows are examined. In particular the choices made in the representation of the gravity driven phase separation phenomena, which is unique to the horizontal fuel channel arrangement seen in CANDU reactors, are analyzed. This is done by comparing the predictions of the ASSERT-4 subchannel code with experimental data on void fraction, mass flow rate, and pressure drop obtained for two horizontal interconnected subchannels. ASSERT-4, the subchannel code used by the Canadian nuclear industry, uses an advanced drift flux model which permits departure from both thermal and mechanical equilibrium between the phases to be accurately modeled. In particular ASSERT-4 contains models for the buoyancy effects which cause phase separation between adjacent subchannels in horizontal flows. This feature, which is of great importance in the subchannel analysis of CANDU reactors, is implemented in the constitutive relationship for the relative velocity required by the conservation equations.

In order to, as much as is physically possible, isolate different inter-subchannel transfer mechanisms, three different subchannel orientations are analyzed. These are: the two subchannels at the same elevation, the high void subchannel below the low void subchannel, and the high void subchannel above the low void subchannel. It is observed that for all three subchannel orientations ASSERT-4 does a reasonably good job of predicting the experimental trends. However, certain modifications to the representation of the gravitational phase separation effects which seem to improve the overall predictions are suggested.

The Radiolysis of Aqueous Organic Systems and Their Influence on Iodine Volatility

Raymond C. Quan
Department of Chemical Engineering and Applied Chemistry
University of Toronto

Ed. Note: *The following is a summary of the paper presented by Raymond Quan at the CNA / CNS Student Conference in Montreal, April 2 and 3, 1993, which gained him first prize in the Second Cycle (masters' level).*

Radioiodine (I-131) is one of the most important of the fission products which may be released from a nuclear reactor following an accident. This is because it has a high radiotoxicity and can assume many volatile (i.e. airborne) forms, giving it the potential to be released from containment structures, resulting in significant environmental damage.

It is believed that certain organic compounds may enhance the formation of volatile iodine species. These compounds may exist in nuclear reactor containment structures in the form of paints, wiring, lubricants, and water chemistry control chemicals, for example.

This study was done in two parts. The first of these was a scoping study, aimed at identifying specific organic compounds which may enhance or suppress iodine volatility. The second part consisted of detailed studies which looked at the effect of related factors such as solvent concentration, iodine concentration, and pH.

A group of some organic compounds was chosen for the scoping study. The choice of candidates was based on the need to cover a wide range of classes of organic compounds. It was also important to pick compounds representative of those actually expected in reactor containment.

The experiments involved the Co-60 irradiation (dose rate: 0.3 kGy/hr) of aqueous 10^{-5}M CsI solutions containing a small amount (10^{-3} to 10^{-1}M) of organic compound. These conditions were selected so as to approximate the post-accident environment expected in a CANDU reactor containment structure. The solutions were irradiated in flasks which allowed for a liquid volume of 10mL, with a gas phase of 50mL.

Many of the compounds were found to contribute to the formation of volatile iodine. The iodine partition coefficient (H = iodine concentration in the liquid phase/iodine concentration in the gas phase) varied, from as low as 300 for aqueous chloroform solutions, to as high as 1 X 10^5 for aqueous phenol solutions. As a reference, a partition coefficient of 10^4 is often used in safety analysis.

The increase in iodine volatility appeared, in most cases, to be related to the reduction in aqueous pH, believed to be due to the radiolytic conversion of the organic compounds to carboxyllic acids. Most of the compounds tested followed this trend, with one group producing low H values and low pH, and the other high H and pH. A third group deviated from this general trend, showing a reduction in pH, but maintaining toluene.

Compounds in the first group (low H, low pH) included chloroform, 1,2-dichloroethane, methanol, ethylene glycol, diethyl ether, butyl acetate, acetone, and methyl ethyl ketone. Examples from the second group (high H, high pH) were toluene, xylene, hexane, n-heptane, pentene, chlorophenol, polyethylene, polypropylene, teflon, and poly vinyl chloride. Deviations (high H, low pH) from this general relationship of increasing H with pH were seen in phenol, formaldehyde, chlorobenzene, cyclohexylamine, and diethylamine.

Detailed studies were performed on five of the compounds tested in the scoping studies: chloroform, MEK, paraldehyde, phenol, and toluene. These compounds were chosen based either on their ability to contribute to iodine volatility (the first three), or on their ability to suppress volatility (in the last two). These experiments were performed at a dose rate of 12.5kGy/hr, with smaller flasks, with a liquid volume of 5mL, and a gas volume of 10 mL.

The first of these tests concerned the effect of organic solute concentration. Experiments were performed at the following concentrations: 10^{-6}M, 10^{-4}M, 10^{-2}M, and 1M. As the solute concentration was increased, the partition coefficient decreased in the case of chloroform, MEK and paraldehyde. There was no significant change in H for phenol and toluene.

In experiments conducted over a range of CsI concentrations (10^{-8}M, 10^{-5}M, and 10^{-4}M), different compounds showed different behaviour. In the case of chloroform, the partition coefficient dropped as the concentration was increased. In the case of phenol and toluene, little change was seen in the partition coefficient over the range of CsI concentrations.

Studies concerning pH were performed using buffered solutions at pH3, 5, 7, 9, and 11. Results from these tests showed a similar trend to those observed in the scoping studies, in that the partition coefficient increased with an increase in pH. At every pH level, phenol and toluene produced a higher partition coefficient than that seen in chloroform, MEK, and paraldehyde.

A final group of studies was performed in which a group of bromine-containing organic compounds was irradiated (bromoform, bromobutane, bromobenzene, and bromophenol). It was found that in most of the bromine compounds, the partition coefficients produced were similar to those seen in their chlorine counterparts, except in the case of bromoform, which produced a partition coefficient roughly two orders of magnitude higher than that seen in chloroform.

Calls for Papers

Reactor Physics Faces the 21st Century

Knoxville, Tennessee

11-15 April 1994

The meeting will provide a forum for presentation and discussion of advances in the understanding of the physics of reactors and developments in the methods for reactor analysis.

Deadline for abstracts of about 1,000 words is 1 September 1993.

Submit to: Brian Worley
Oak Ridge National Laboratory
Oak Ridge, Tennessee
FAX: 615-574-9619

3rd International Conference on Containment Design and Operation

Toronto, Ontario

19-21 October 1994

This conference is a forum for all aspects of containment from design and analysis through commissioning, operation and ageing.

Deadline for abstracts of 300 to 500 words is 15 November 1993.

Submit to: Canadian Nuclear Society
144 Front Street West, Suite 725
Toronto, Ontario
M5G 2L7
For information: Tel. 416-977-7620; FAX 416-979-8356

SPECTRUM '94 – Nuclear and Hazardous Waste Management International Topical Meeting

Atlanta, Georgia

14-18 August 1994

Technical papers are solicited in every aspect of nuclear and hazardous waste management and environmental restoration.

Deadline for summaries of 1,000 to 1,500 words is 15 February 1994.

Submit to: Laura Jordan
Westinghouse Savannah River Company
Aiken, South Carolina USA
29808
For information: John Plodinec
Tel. 803-725-2170

International Conference on Expanded and Rolled Joint Technology

September 13-14, 1993
Toronto, Canada
contact: CNS office 416-977-7620 or Gary Kharshafdjian 416-823-9040

Annual General Meeting

The 1993 Annual General Meeting of the Canadian Nuclear Society took place in Montreal on June 2.

Since there was no annual conference this year (in deference to INC '93) the timing and venue were chosen to coincide with the 4th International Conference on Simulation Methods in Nuclear Engineering which was held in Montreal June 2nd to 4th. The CNS was the major sponsor of that conference.

Despite the somewhat unusual arrangement about 30 members attended.

The format followed the usual one for an AGM, with reports from the chairmen of major committees and divisions, presentation of the financial report, formal acclamation of the new Council, and short speeches by the out-going and in-coming presidents.

The speeches by Bill Midvidy, president during the 1992-93 year and by Paul Fehrenbach, president for 1993-94 are reprinted below as is the report on branch activities. The auditor's report is presented elsewhere in this issue.

A Successful Year

Ed. Note: *The following is the report from outgoing president Bill Midvidy to the Annual General Meeting held in Montreal, 2 June 1993.*

This has been a successful year for the CNS despite the generally troubled times that our nuclear industry is experiencing. Other council members will be giving detailed reports on specific areas, so this will be a brief overview.

At last year's Annual General Meeting I set three specific objectives for my term as president. First was the establishment of a detailed task list for the officers of the CNS. This was done. This "live" document serves as a useful reference particularly for new members of Council. Second was the establishment of an up to date and well organized filing system in our CNS office. We were partially successful in this endeavour. The filing system has been updated but its usefulness is contingent on all of us sending important documents to the correct file. A third objective was to hold meetings of the CNS executive. The aims were to increase attendance at Council Meetings, the efficiency of Council and to permit the executive to meet with the branches. This is discussed below. I am also pleased to report that the Society remains on strong financial ground.

We currently have ten branches and members of the executive met with most of the branches this year. We had hoped to meet with members of all the branches but this did not prove possible. The meetings that we did have were very well received and well worth the effort. This has been an active year in most of the ten branches of CNS. These are now spread across Canada from Saskatchewan and Manitoba to Quebec and New Brunswick, with six branches in Ontario. The general CNS thrust to reach out and interact with the public is being led by a number of these Branches, with greater involvement in educational activities and public policy forums. One important activity in several of these Branches was to organize and sponsor activities with local schools which are funded by the CNA/CNS Educational Fund.

This year the Honours and Awards Committee recommended, and the Council approved, four new admissions to the honorary membership category known as Fellow of the Canadian Nuclear Society. Also the Innovative Achievement Award will be presented tomorrow.

Membership continues to grow at a steady pace. The Society is on sound financial ground due in part to numerous successful conferences. The Society publishes a quarterly bulletin which includes news items, announcements, reports, editorials, and technical papers. We are very proud of the CNS Bulletin which continues to be an attractive, interesting and effective journal and are grateful to its editors for doing such a great job. We are also very active in the International Nuclear Societies Council.

This year, in addition to the Annual CNS Conference, three major conferences and three smaller conferences/seminars were held. The Student Conference held in Montreal and the Fusion Seminar, sponsored in conjunction with the CNA, were very successful. The Safety Course, co-ordinated by the Nuclear Science and Engineering Division, was well received and will be run again in the near future.

The Annual Conference in Saint John was a technical success with about 106 papers in 16 sessions offered to attendees. The CNS Simulation Symposium was held at the Royal Military College, Kingston, in August. Sixty participants were attracted to this annual event.

The latter part of the year saw two very successful conferences. In October, the Third International Conference in CANDU fuel was held in Pembroke. The event attracted 91 delegates from 6 countries with over 50 papers presented. The success of this conference was reflected in the expressed desire of the attendees to hold a fourth conference in two years time.

The best attended conference of the year was the Second International Conference on CANDU Maintenance, held in Toronto. It attracted over 300 delegates for the 2 day event in late November. The conference content and format elicited favourable comment from the attendees and it was obvious the conference needs to be held every 2 to 3 years. It was 5 years since the first conference.

I am confident that the Fourth International Conference on Simulation Methods in Nuclear Engineering, which is currently underway, will also be a great success. Preparations for the INC 93 Conference are proceeding well. The CNS is heavily involved in arranging the technical and educational programs.

I have found my year as President to be very rewarding despite the amount of work involved. I have had a superb Council to work with and am very grateful for their cooperation and diligence.

Canadian Nuclear Society Financial Statements • December 31, 1992

Auditors' Report

To the Members of the Canadian Nuclear Society

We have audited the balance sheet of the Canadian Nuclear Society as at December 31, 1992 and the statements of operations and surplus and education fund for the eleven months then ended. These financial statements are the responsibility of the Society's management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with generally accepted auditing standards. Those standards require that we plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In our opinion, these financial statements present fairly, in all material respects, the financial position of the Society as at December 31, 1992 and the results of its operations for the eleven months then ended in accordance with generally accepted accounting principles.

Toronto, Ontario
May 21, 1993

Doane Raymond
Chartered Accountants

Balance Sheet

	Dec. 31, 1992	Jan. 31, 1992
ASSETS		
CURRENT		
Cash	$148,443	$ 88,998
Receivables	52,424	20,922
Prepaids	691	—
Short term deposits (market value $92,782; 1991 - $133,384)	93,403	133,384
Conference advance	6,000	—
	300,961	243,304
CNS share of education fund assets (Note 2)	12,000	12,000
	$312,961	$255,304
LIABILITIES		
CURRENT		
Payables and accruals	$ 48,728	$ 2,475
Payable to CNA	56,553	62,369
Membership fees and contributions received in advance	11,892	19,782
	117,173	84,626
EQUITY		
Accumulated surplus	183,7881	158,678
Education fund (Note 2)	12,000	12,000
	195,788	170,678
	$312,961	$255,304

See accompanying notes to the financial statements.

Statement of Operations & Surplus

	11 months ended Dec. 31 1992	12 months ended Jan. 31 1992
INCOME		
Membership fees	$ 33,914	$ 33,995
Publications	4,269	5,638
Interest	7,038	14,985
Other	6,870	—
Loss on sale of investment	(7,038)	—
	41,379	54,618
SOCIETY PROJECTS		
Excess of income over expenditures		
Annual conference	15,188	31,649
Nuclear simulation symposium	4,863	10,306
CANDU maintenance conference	61,414	—
CANDU fuel conference	7,021	—
Regional overpower trips course	4,225	—
CANDU chemistry seminar	—	2,143
Containment design & operation conference	—	258
Steam generator & heat exchanger conference	—	568
Neutron radiography conference	—	5,908
Fusion seminar	—	1,211
	92,711	52,043
	134,090	106,661
EXPENSES		
Office overhead charge from CNA	27,500	30,000
Office services	20,957	27,895
Canadian Nuclear Society *Bulletin*	26,344	18,291
Branch activities	6,720	(501)
Membership committee	14,780	8,820
Program committee and technical divisions	1,058	1,697
Stationery and printing	4,990	4,181
Council activities and promotion	3,276	3,161
Students' conference	1,500	3,799
Innovative Achievement Awards	1,168	5,711
International Nuclear Societies	687	—
	108,980	103,054
Excess of income over expenses	25,110	3,607
Surplus, beginning of period	158,678	155,071
Surplus, end of period	$183,788	$158,678

Statement of Education Fund

	11 months ended Dec. 31 1992	12 months ended Jan. 31 1992
Surplus, beginning of period	$ 12,000	$ 12,000
Surplus, end of period	$ 12,000	$ 12,000

See accompanying notes to the financial statements.

Notes to the Financial Statements • December 31, 1992

1. SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES
   (a) **Revenue Recognition**
   Membership fees are included in income in the fiscal year to which they relate. Interest and other income is recorded on the accrual basis.
   (b) **Short Term Deposits**
   These investments are carried at cost adjusted for amortization of premiums or discounts.
   (c) **Change in year end**
   The Society changed its year end to December 31 from January 31 effective December 31, 1992. Accordingly, the current year financial statements cover an eleven-month period.

2. EDUCATION FUND
   From 1988 to 1991, annual contributions amounting to $3,000 from the Society and $7,000 from the CNA were allocated from the income from the annual conference. The interest on these funds is available for educational purposes to the local branches of the Society. The principal remains the property of the CNA and the Society.

The total fund is composed as follows:

		Dec. 31 1992	Jan. 31 1992
Principal contributions:	CNA	$ 28,000	$ 28,000
	CNS	12,000	12,000
		40,000	40,000
Accum. interest available to CNS local branches		15,199	11,725
		$ 55,199	$ 51,725

The Coming Year

Address by incoming CNS President P.J. Fehrenbach, AGM in Montreal, June 2, 1993.

First let me say that I consider it an honour to have the opportunity to serve as President of CNS. I believe that the CNS, as a society of the men and women who provide the technical expertise in the Canadian nuclear industry, has an important role to play in explaining the benefits of nuclear technology to all Canadians. The need to provide a calm and reasoned voice in support of such technology has never seemed so clear, particularly in the energy sector.

I would like to acknowledge and pay tribute to the excellent stewardship provided this past year by Bill Midvidy. He has set an inspiring example as a very dynamic leader who succeeded in getting many of us on Council more effectively involved in supporting and promoting CNS. Bill has spoken out on numerous occasions on the value of our society to the nuclear industry in Canada, and encouraged our employers to support CNS activities. He has been active in encouraging CNS Branch activities, and made the effort to personally attend a number of Branch functions across the country. Bill has also remained keenly interested in the success of the technical divisions, and continued to stimulate the divisions to maintain active programs for the technical benefit of CNS members.

All of this effort on behalf of CNS came at a time when Bill was managing a very important experimental program, and required a significant personal sacrifice on his part. I am equally sure that it also represented a sacrifice by his family, who would have liked to see a lot more of him this past year.

On behalf of Council, and all members of the Society, I extend to Bill our sincere appreciation and thanks for his leadership and hard work in serving as President this past year.

And now – what about the coming year? Bill has set the CNS on a steady course, and I foresee no major course corrections. However, there are several areas in which we need to continue our efforts to improve. My priorities for the year will be to work with the relevant committees of Council to address these areas.

One of the areas in which we can improve is to generate a higher public profile for the Canadian Nuclear Society. I believe that this is primarily a role for the Branches, since that is the forum in which the major strength of our society, that is the individual members, can interact most effectively with a large cross section of the public. It will be one of the goals of the Branch Affairs Committee to encourage the Branches to be more pro-active, and to reach out to a greater degree to the public by sponsoring more seminars and events of general public interest, and by getting more involved in educational activities. We will also encourage more Branches to become active in responding to opportunities to prepare briefs in support of nuclear energy at various panel hearings. I believe that this will have the added benefit of involving more of our members, and potential members, in an active role within the Canadian Nuclear Society.

This latter point is important, because membership is another area in which we must continue to focus attention this year. The Membership Committee deserves credit for

Outgoing president Bill Midvidy (L) happily turns over the gavel to Paul Fehrenbach at the CNS Annual General Meeting, 2 June 1993.

continued success in attracting new members, an additional 15% in 1992/93, but an equivalent number of our members are not renewing their membership. We need to reverse this, and make CNS membership one of the first things people decide to renew each year. A greater degree of activity at the Branch level will help by both raising the profile of CNS and by providing an active and meaningful role on behalf of the industry for more of our members. But we also need to understand all of the reasons people do not renew their membership, and then address these issues. Our goal for the coming year will be to achieve a real increase of 15% in membership. To achieve this, the Council and Membership Committee will need the help of all CNS members. There are many potential CNS members among our colleagues and co-workers. Each of us needs to follow Bill Midvidy's example and talk to them, persuade them of the value of the CNS and the benefits of membership, and convince them to join us.

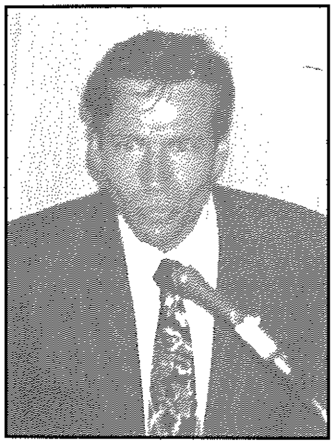
Consistent with the desire to encourage Branches to undertake more activities involving the educational system in their communities, we will ask the Education and Public Affairs Committee to assist by helping to identify potential activities of interest.

The technical activities of CNS are carried out through the technical divisions. Several of these are active and very successful in organizing seminars and topical meetings on a variety of topics. A goal for the coming year will be to achieve the same level of success in all of the technical divisions of CNS.

A major activity in 1993 will be the International Nuclear Congress (INC 93) to take place in October. Most of the organizational activities for this event are in place, and the plenary and technical programs for this meeting will be outstanding. One of the remaining tasks will be to achieve a good attendance; a goal toward which we will devote our efforts.

I look forward to working with the newly elected Council in establishing goals for all of the committees of Council, and getting each member of Council involved in the work of these committees. However, as I noted above, the strength of the society is the expertise and enthusiasm of its individual members, and I urge all of you to get involved in local Branch and technical division activities. If we all get involved, we can have a major impact on both the perception and the contribution of nuclear technology to Canada and the world.

Simulation Conference



Paul Lefrenière

Over 150 specialists from eight countries converged on Montreal in early June for the **14th International Conference on Simulation Methods in Nuclear Engineering**.

In the elegant atmosphere of Le Chateau Champlain, 76 papers were presented over the three days of the conference, June 2 to 4, 1993.

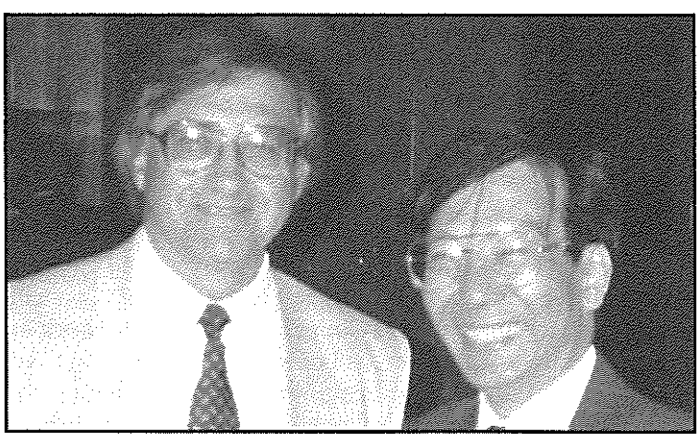
After the plenary session, first morning attendees had the choice–or difficult decision–among three parallel sessions where the major topics were: thermal hydraulics, fuel behaviour, safety analyses, reactor physics and reactor control.

On the evening of June 3 activities moved to the Queen Elizabeth Hotel for the conference banquet. Those who were perplexed by the change of venue acknowledged the wisdom of the organizers after enjoying what many commented was the best conference banquet they had ever attended.

The conference banquet served as the setting for the presentation of the CNS Innovative Achievement Award to Dr. Dé. Groenveld of the Chalk River Laboratories. (See separate article.)

After-dinner speaker Paul Lefrenière, chef de service at Hydro Quebec's Gentilly 2 nuclear generating station, captivated his audience with his clear, concise comments on the challenges of operating a single unit nuclear power plant in a predominantly hydraulic electric utility. He evoked enthusiastic audience response and empathy with his perceptive but pithy comments on the Canadian nuclear regulatory climate.

"We are seeing a disturbing movement away from the original importance of performance criteria towards unpredictable *ad hoc* decisions," he affirmed. "There is no acceptance by the regulator [AECB] of the cost/benefit relevance," he added.



Conference co-chairman Hong Huynh confers with CNS Treasurer Ben Rouben at the 4th International Conference on Simulation Methods in Nuclear Engineering in Montreal, June 1993.

With many of the papers in the conference dealing with complex analyses to answer regulatory questions, Lefrenière touched on a topical issue with his comment, "Regulatory pressure in a vacuum will siphon utility resources from serious [real] operational safety issues towards improbable postulated accident scenarios."

(Perhaps reflecting the attitude of the regulator, the Atomic Energy Control Board was notably absent from the conference.)

The conference was primarily sponsored by the CNS with co-sponsorship of the American Nuclear Society. The co-chairmen, Hong Huynh and Nina Oliva, and the program committee of Daniel Rozon, Mike Carver and Bill Midvidy, and others involved, can be proud and satisfied with what many attendees commented was the best such conference yet. It will serve as a major challenge for the organizers of the 5th International Simulation conference scheduled for 1996.

Ontario Hydro Appointments

A feature of the re-organization of Ontario Hydro has been the devolution of business and operational responsibility to the functional units. The heads of the operating stations and of the major service units have been designated as "directors" in recognition of this expanded role.

In late May, Don Anderson, General Manager Nuclear in the new Ontario Hydro organization, announced the following appointments:

Directors

Bruce 'A'	Ken Talbot
Bruce 'B'	Brian Churchill
Pickering	Pierre Charlebois
Darlington	Bob Stickert
Heavy Water Business	Paul Burroughs
Nuclear Environment Services	Ken Nash
Nuclear Technology Services	Bryan Murdoch
Training and Simulator Services	Bob Schuelke
Finance and Business Services	Ron Field
Employee Services	Linda McCrae
Nuclear Safety	Ron Lewis

A condition of the Operating Licences for the nuclear generating stations is the naming (and approval by the Atomic Energy Control Board) of the person with the direct operating responsibility. Formerly this was the Station Manager. With the re-organization this responsibility is shared by the Director and the Operations Manager. To meet AECB requirements Don Anderson announced the following appointments in early June:

Operations Managers

Bruce 'A'	Jim Bagshaw
Bruce 'B'	Mike Raven
Pickering	Mike Williams
Darlington	Allan Holt

CNS Branch Activities: Annual Report for 1992/93

Paul Fehrenbach

1992/93 has been an active year in all ten of the local Branches of the CNS. Our objective for this year of helping Manitoba and Quebec to "get rolling again" has therefore been achieved. The general objective of the CNS and CNA to reach out and interact to a greater extent with the public is also being achieved as the Branches are becoming more active in educational activities and public forums. Following are some of the Branch highlights from 1992/93.

Bruce

During the past year, the Bruce Branch activities have understandably centered around the evolving situation within Ontario Hydro, specifically with respect to the status of Bruce A. The Branch has become active in letter writing to government representatives in defence of Bruce A, and is urging non-members to do the same. They have also launched an initiative to increase the flow of information to the public by identifying and answering misinformation articles in the papers, and offering speakers to various community groups.

Central Lake Ontario

With all four Darlington units on the grid, members of the Central Lake Ontario Branch had a little more time toward the end of this year to resume Branch activities. The Branch returned to active status with a presentation on "Nuclear Power Plant Simulators" and a tour of the Ontario Hydro Eastern Nuclear Training Centre. A full year program is anticipated for 1993/94.

Chalk River

Chalk River has had another exceptionally active year, hosting 13 seminars on science and technology topics, one of which was held in Pembroke in conjunction with Algonquin College. Both the speakers and the topics were quite high profile, and many of the seminars were reported in the local media. Members of the Branch writers club also helped to prepare the CNS submission of Evidence to the Environmental Assessment Board on Ontario Hydro's Demand/-Supply Plan. The Branch added to their educational activity program of providing mathematics prizes, support for the Deep River Science Academy, and support for the Science for Educators program by assisting local science teachers with resources for implementation of new mandatory physics experiments in the Ontario secondary school curriculum.

Golden Horseshoe

The rejuvenated Golden Horseshoe Branch had a half-dozen interesting activities this year, beginning with a tour to Darlington and ending with a presentation by MPP Sean Conway on "Current Issues Concerning Ontario Hydro." One of the highlights in between was the establishment of relations with the Rensselaer Polytechnical Institute American Nuclear Society Student Chapter.

Manitoba

Good news from Manitoba! The Manitoba Branch is active again with a rejuvenated executive and growing membership. Things started slowly with a noon-hour video of Dr. Rummery's presentation to the Chalk River CNS Branch, but picked up speed considerably in April and May. Ken Talbot participated in a "double-header" in April with a presentation at the University of Manitoba Faculty Club, co-sponsored by the Engineering and Applied Science Industrial Affiliation Program of U of M, and then to a standing room only crowd at Whiteshell Laboratories. Several more presentations are planned for this year, and the Branch is looking forward to a full program of activities for 1993/94.

New Brunswick

The highlight of the New Brunswick Branch program was the annual dinner meeting attended by about 70% of the Branch members, and several members of CNS Council. The featured speaker was J. Nathwani, of the University of Waterloo Institute for Risk Research, who gave a very interesting presentation on the perception and evaluation of risks associated with energy production. This is a topic of general public interest which other Branches may wish to consider. At this meeting, the Branch also continued their tradition of selecting a "Member of the Year," and announced the 1992/93 recipient of this award as Sardar Alikhan of New Brunswick Power.

Ottawa

The Ottawa Branch also increased the level of Branch activity this year under their new executive with a program of visits and seminars. The most recent activity was the annual dinner meeting, at which the new slate of Officers for 1993/94 was presented. The featured speaker was Dr. D. Jackson who spoke on the world-wide status of advances in fusion, with a focus on the role of Canadian industry and research in that effort. The Branch has set as objectives for 1993/94 to expand the membership base, to establish closer contacts with local industry, research, and educational institutions, and to broaden the Branch program to appeal to a wider audience.

Quebec

The Quebec Branch returned to active status this spring with a joint meeting at Gentilly-2 at which the featured speaker was Dr. J. Cuttler who described some of the activities and successes of the AECL Operating Stations Support (OSS) program. An Executive meeting of CNS Council was held in conjunction with this meeting. For the coming year, the Quebec Branch will organize itself into two sections, one at Gentilly, and one centered in Montreal, so that it can plan and undertake activities of interest and accessible to a greater number of its members. Marc St. Laurent has agreed to be the Gentilly representative on the Quebec Branch Executive.

Saskatchewan

In addition to a very successful seminar series with high profile speakers such as Dr. Margaret Maxey, Dr. Dixie Lee Ray, and Dr. Tore Straume, the Saskatchewan Branch has also been very active in participating in public forums and arranging briefings with municipal and provincial decision makers. The Branch made submissions to the Rabbit Lake Review Panel on the "Review of the EIS for Collins Bay A-Zone, D-Zone, and Eagle Point Development," and to the Public Hearings of the Federal/Provincial Panel on Uranium Mining in Northern Saskatchewan on "Comments on McArthur River Underground Exploration Project." The efforts of Saskatchewan Branch members helped to create the environment which allowed the Saskatchewan Government to re-establish the agreement with the Federal government and AECL to complete the design of the CANDU-3. The Branch also provides prizes to winning science fair participants in the eleven regions of Saskatchewan.

Toronto

The very active Toronto Branch organized another excellent program of activities for 1992/93 consisting of six lectures and several student events in conjunction with the University of Toronto. The student events consisted of a Student/Industry Social following the Branch meeting at which Ken Talbot spoke, and a visit to Cameco Corp. and Zircatec Precision Industries in Port Hope. Other speakers in the seminar series included Dr. Rosalyn Yalow on "The Societal Benefits and Risks of Radiation," Dr. Brien Stewart on the Darlington Fuel Damage Problem, Dr. Norm Gentner on Health Effects of Chernobyl: Fact or Fiction, Dr. Dan Meneley on Improving RBMK Safety, and Ms. Marion Fraser, Ontario Hydro on "The Case for Demand Management." A number of these activities were covered by the Toronto media.

Summary

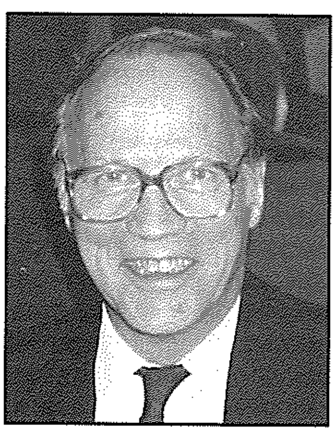
In summary, 1992/93 was even better than last year for Branch activities, with an impressive array of high profile speakers and large audiences, and an increased level of public interaction and educational activities. President Midvidy and members of Council were successful in attending at least one function at most Branches. In the coming year, we will continue to encourage Branches to increase their level of public involvement and the degree of interaction with educational institutions in their communities. Ideas for local Branch activities of interest to CNS members and the local communities are particularly welcomed by the Branch executives. Please give them your support.

Rogers Awarded W.B. Lewis Medal

A long-term and active member of the Canadian Nuclear Society, Terry Rogers, a professor at Carleton University in Ottawa and a recognized expert in thermal-hydrodynamics and reactor safety has been awarded the W.B. Lewis Medal by the Canadian Nuclear Association.

The Medal was awarded at a special awards dinner held in Toronto on June 17.

Following is the citation for Dr. Rogers' award.



Terry Rogers

"Nuclear power reactor safety is no less important in the 1990's than it was 25-30 years ago in Dr. W.B. Lewis' prime time. In reality, reactor safety probably has an even higher profile now in the wake of major reactor accidents in the US and at Chernobyl. CANDU owners, designers and operators press for ever higher safety standards, notwithstanding experience and confidence gained through a total of many hundreds of reactor operating years of demonstrated reliable and safe operation. It becomes increasingly important to convince the public and the regulator that a high level of safety is there. As an aid to establishing what actual degree of safety CANDU designs and construction achieve, there has been a move to rely more, especially during the past decade or so, on probabilistic, risk-based approaches to reactor safety assessment. Convincing the regulator, intervenor groups and the public that acceptable safety standards are met is a daunting task.

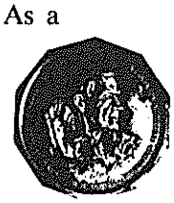
The career work of Professor J.T. Rogers, Carleton University, has contributed very significantly to the present status of reactor heat transport, thermohydraulics and safety analysis in Canada and abroad. Almost doggedly at times, he has pressed for risk-based approaches to reactor safety assessment as the preferred methodology for both designer and regulator to use. Dr. Rogers (or 'Terry' as he is well known in Canadian nuclear circles) started his nuclear engineering career in 1955 with Canadair, Montreal as Project Engineer for the PTR test reactor, Chalk River. When that division was dissolved he transferred to General Atomics, San Diego at a time of very vigorous new reactor design and development and was a design engineer on their gas-cooled reactor project. However, he soon returned to Canada to head up the heat transfer and fluid dynamics unit of CGE's Atomic Power Dept. While in industry he made a number of significant contributions to the thermo-hydraulic, heat transfer and safety analysis and design aspects of CANDU and other reactors. Increasingly through the years since as nuclear consultant and professor of nuclear and energy engineering, Carleton University, he has concentrated on reactor safety. Research results and analytical methods developed by him, his colleagues and his students have been and are being used in safety design and analysis of power reactors and other new reactor concepts. Moreover, in developing and advocating his approaches to nuclear safety he has kept well informed on work elsewhere in safety analysis and code development and has dialogued with AECL and utility engineers and his counterparts in US and Europe.

His expertise in reactor safety has been drawn on very much by the Canadian nuclear industry and abroad to such an extent that for most of the past 15 years he has been on 50% academic appointment and the remainder as consultant to AECL, Ontario Hydro, Hydro Quebec, AECB and to nuclear institutions in the UK, Mexico, Pakistan and US. He was a consultant to the Ontario Nuclear Safety Review, described by Dr. Kenneth Hare, the commissioner, as "Canada's leading academic student of (nuclear) accident analysis." He is expert on the major reactor analysis codes and their applicability to CANDU, and to the safety analysis and heat transfer aspects of SLOWPOKE heating reactors. He was instrumental in conceiving, organizing and publishing the proceedings of the 1989 International Conference on Fission Product Transport Processes in Reactor Accidents held in Dubrovnik.

In recognition of his extensive and unique expertise in reactor safety, he was appointed a member of the AECB's Reactor Safety Advisory Committees which were predecessors of ACNS (Advisory Committee on Nuclear Safety) which he joined when it was first formed in 1980. As a member and chair of expert working groups, he has played a leading role in the development of recommendations for probabilistic safety requirements for power reactors, for comparative risk analysis, implementation of ALARA and reactor commissioning. Within the ACNS, he is known for his quietly confident-but-persuasive urging for high safety standards based on in-depth analysis with the best available analytical tools.

Apart from his active research and consulting, Terry Rogers has done much to spur the development of both the CNA and CNS in Canada and their awards and student programs. He is an active family man and enjoys travel – mostly done for professional purposes. He has been honoured by a number of fellowships including those of the EIC (1980), the Canadian Society for Mechanical Engineering (1985), and especially, by the award of the 1991 Stachiewicz Medal of the Canadian Society for Chemical Engineering and Canadian Society for Mechanical Engineering for "outstanding contributions to heat transfer in Canada, especially in nuclear energy."

Prof. J.T. (Terry) Rogers well exemplifies the type of lifetime dedication to safety aspects of reactor design that Dr. W.B. Lewis epitomized in Canada and, as such, is a most worthy recipient of the 1993 W.B. Lewis Medal award.



Following are excerpts from Dr. Rogers' response.

I was quite overwhelmed when I was informed that I was to be awarded the W.B. Lewis Medal for 1993. When I think of the accomplishments of previous recipients of the Lewis Medal, I am truly honoured to be included in their company.

When I played football for McGill University, a sports writer characterized my play as "dogged but not flashy." Now, Gord Brooks has described me as "almost doggedly (pressing) for risk-based approaches to reactor safety assessment." At least he didn't say that I wasn't flashy.

A very important factor in any contribution that I have made to this field is the influence of the fifteen years that I spent in the nuclear industry before joining the academic world. This experience, in Canadair's Nuclear Division in Montreal, at General Atomics in San Diego and especially at the Atomic Power Department at Canadian General Electric in Peterborough, instilled in me the importance of, and the scope for, the application of sound engineering science in analysis and design in a high technology field such as nuclear energy. This experience also led me to focus my university research on applied problems in the nuclear field; my goal has been to produce research results that can be used by nuclear engineers and analysts, not simply results that can be published.

As was indicated, I have been increasingly involved in reactor safety in recent years, particularly as a member of the Advisory Committee on Nuclear Safety of the Atomic Energy Control Board (AECB). In this role, I have continued to advocate a more rational approach to reactor safety issues through the increasing use of probabilistic methods, the consistent application of the ALARA principle and the use of value-impact analysis in safety evaluations and decisions. One of the strengths of the Canadian approach to reactor licensing in the past has been its non-prescriptive nature, in which the AECB set targets, leaving the designers free to choose the best means to achieve the targets. I am concerned that the AECB has become more prescriptive in recent times and that it is not utilizing consistently the above approaches that I, and others, advocate. I think that I can safely say that the ACNS will continue to press the AECB in this direction.

I am extremely proud to have been associated with such a magnificent accomplishment as the CANDU reactor and with the Canadian nuclear program in general and am greatly honoured to have my name associated with that of Dr. Lewis, the "father of the CANDU reactor."

Of course, I would not have been able to make any useful contribution in the nuclear field without the significant help and cooperation of my colleagues in industry and my students in university.

Finally, and most importantly, I acknowledge the tremendous support and encouragement that I have always received from my wife, Sharon. I thank her for the patience and understanding she, and our four children, have shown over the years about the many evenings, weekends and vacations disrupted by the work that has contributed to the award of the W.B. Lewis medal.

Dé Groeneveld Receives Innovative Achievement Award

Dr. Dionysius C. (Dé) Groeneveld was presented with the CNS Innovative Achievement Award for 1993 at the banquet of the Fourth International conference on Simulation Methods in Nuclear Engineering in Montreal, 3 June 1993.

The Innovative Achievement Award was established by the Canadian Nuclear Society in 1981 to recognize significant innovative achievement in the implementation of new concepts in the nuclear field in Canada.

The award trophy, on which all recipients' names are inscribed, is in the form of an original sculpture showing three figures supporting the CNS logo. Each recipient retains a miniature figure from the sculpture as well as a commemorative certificate.

Retiring president Bill Midvidy made the presentation to Dr. Groeneveld after John Hewitt, chairman of the Honours and Awards Committee, read out the following citation.

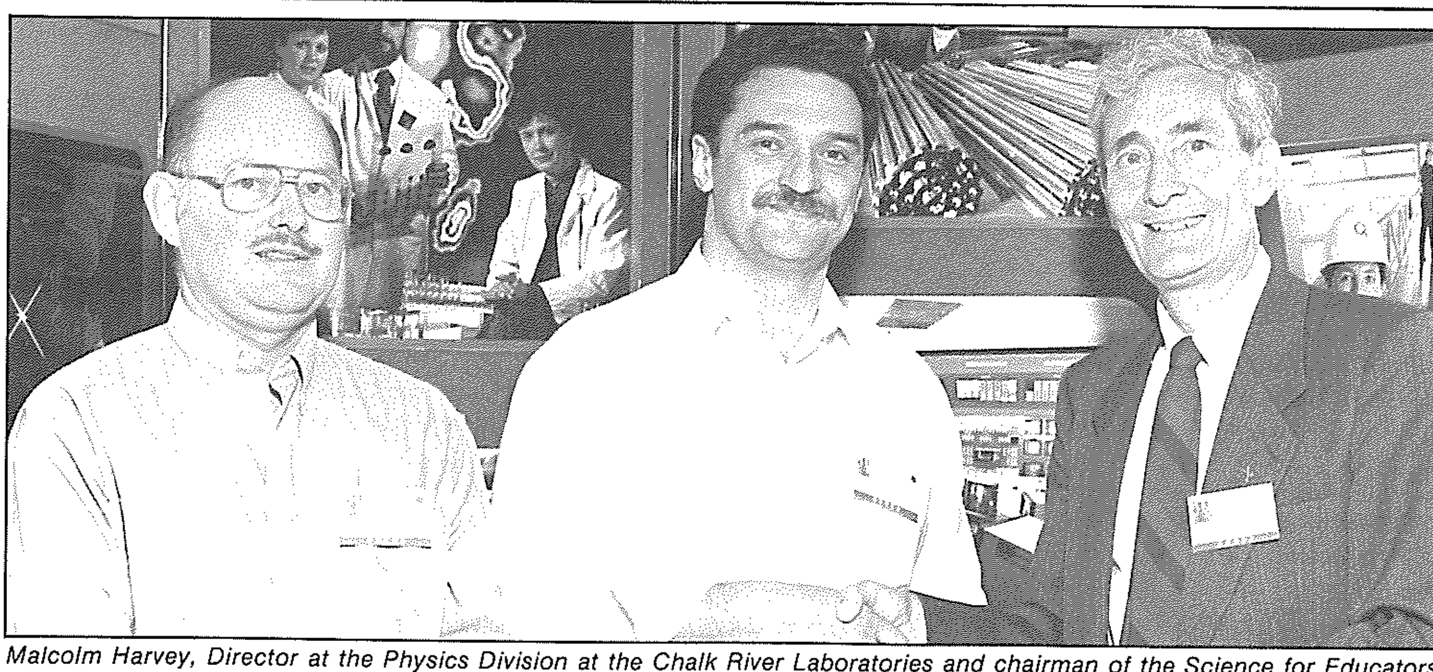
Citation

A very large amount of experimental work has been undertaken around the world to measure critical heat flux (CHF) in a wide variety of geometries, but for most power generating purposes, the CHF within heated tubes, or within bundles of heated rods is of key interest. These CHF data are represented by over 400 different correlations – most covering only a small range of operating conditions. However, for nuclear reactor applications it is necessary to be able to predict the occurrence of CHF over a wide range of coolant conditions, in order to cover the wide range of postulated accidents that must be investigated.

Although the table-look-up approach has been used for many years to predict coolant properties, a Russian by the name of Doroschuk first proposed it as an appropriate replacement for the plethora of limited range CHF correlations within heated tubes. Dr. Groeneveld recognized the value of this concept, but also identified the need for it to be based on a larger and more carefully selected data base, if the CHF predictions were to be of sufficient accuracy for use in the nuclear industry. He published such tables in 1982 and 1986. To broaden the usefulness of these tables, he developed a series of correlation factors to extend the applications of his CHF table from vertical tubes to rod bundles, to horizontal bundles, and non-uniform heating. The value of his look-up table has become widely recognized, so that the Groeneveld 1986 CHF table is used in a number of international thermal-hydraulic prediction codes.

In 1993, Dr. Groeneveld was able to reach an agreement with the Russians to include their large CHF data base in the international look-up table that he had developed. This increased the size of the table from 15,000 to over 28,000 data points, and has increased the accuracy, breadth, and confidence of the look-up table. This table now represents the new world standard for the prediction of CHF over a wide range of conditions for use either manually, or with various codes, and is the basis for this award.

Dionysius C. Groeneveld was born in Holland and received his B.Sc. degree from the Dordrecht Technical College in that country in 1962. He then came to Canada to further his studies at the University of Western Ontario, where he received his M.Sc. degree in 1965. He joined AECL at Chalk River in September 1966 and received his Ph.D. from the University of Western Ontario in October, 1972, with his thesis based on experimental work on "post-critical-heat-flux transfer," which he did at AECL. Dr. Groeneveld is a former head of the Thermalhydraulics Development Branch at AECL, Chalk River, and is currently a section head and project Manager in that Branch. Dr. Groeneveld is a widely published, world authority on critical heat flux (CHF) and post-dryout heat transfer.



Malcolm Harvey, Director at the Physics Division at the Chalk River Laboratories and chairman of the Science for Educators Seminar program, is shown (R) with two of the 88 attendees at the 1993 seminar, Thane Lelacheur of Montague, PEI, and Paul Notty of Goose Bay, Nfld.

Science for Educators Seminar - Another Successful Year

Millie Humphries

Eighty-eight teachers from all of the provinces except Nova Scotia, Alberta and British Columbia attended the 18th annual Science for Educators seminar held at Chalk River Laboratories from Thursday, April 15, to Saturday, April 17.

"Such gatherings are essential if we are to raise Canadian awareness of the crucial role that science and technology play in our society," said seminar program chairman Malcolm Harvey, "not to mention the contributions AECL makes."

The seminar provides educators with opportunities to learn about current scientific and environmental issues from scientists directly involved in research. Participants may choose from a wide variety of seminars and lab tours, meet one-on-one with scientists in their fields of interest, and participate in several social events. The primary aim of the seminar is to encourage free and open discussion of innumerable aspects of science and technology.

One-third of the teachers were past participants with one or two returning for the fourth or fifth time. The large number of returnees suggests that they feel Science for Educators is a valuable professional development opportunity. One of them remarked that "nuclear energy and topics on nuclear radiation should become a core curriculum in our science courses." Another remarked that the seminar is "One of the highlights of my professional development [is] seeing this facility, its organization, teamwork and spirit of discovery evident in all of the staff."

Full Agenda

On Thursday, the educators participated in a number of pre-seminar options, including general site tours and the popular "Share an Afternoon with a Scientist" feature, in which the teachers spend time with researchers in the workplace. For this year's seminar, CRL staff from TASCC Accelerators and Development, Nuclear Physics, Neutron and Condensed Matter Science, Environmental Research, Radiation Biology, Health Physics, System Chemistry and Corrosion, Physical Chemistry, Instrumentation and Control, and Information Technology Development branches opened their doors. Gwen Greenstock and Leni Ohta of Education Partnerships conducted a session on "Careers at AECL Research," while Dr. J.L. Hilborn, Research Emeritus gave a stimulating "Introduction to Nuclear Technology."

The City of Pembroke once again hosted the official welcoming reception on Thursday evening at the Best Western Pembroke Inn; Deputy Mayor Les Scott made formal introductions on behalf of mayor Terry McCann. Displays were presented in Chalk River's cafeteria by the Petawawa National Forestry Institute, the Deep River Science Academy, the Canadian Nuclear Association, the Chalk River Career-Women's Association, and the Sudbury Neutrino Observatory sent their model for the entire week so that CRL staff might also view it.

Malcolm Harvey, Director, Physics Division, gave an overview of AECL on Thursday evening ("Who we are and what we do"). Dr. D.F. Torgerson officially welcomed teachers to the CRL site on Friday morning. The opening plenary session featured Dave Thompson, Director, Reactors Division, who spoke on "Nuclear Research Reactors: Their Uses and Operation."

The balance of Friday's program enabled teachers to choose from parallel sessions on the wide variety of activities at CRL. This year's offerings included presentations on AECL's environmental science programs, microwave plasma chemical processing, mapping the DNA molecule, major science projects in subatomic physics, medical radioisotope production and applications, and current physics research topics such as the Sudbury Neutrino Observatory.

Activities of the day also included tours of the Nuclear Fuel Fabrication Facility, of the Tandem Accelerator Superconducting Cyclotron (TASCC), of the neutron radiography facilities, and of laser spectroscopy labs; demonstrations of electron microscopy equipment; an environmental research field trip; and a visit to the glassblowing shop.

Regretfully the planned after-dinner address by Dr. Jasper McKee (Manitoba) had to be cancelled because of illness in his family. The participants welcomed extra time for discussions and some impromptu jokes by Dave Thompson.

Saturday's parallel sessions featured presentations on particle accelerator research and applications, neutron scattering at the National Research Universal (NRU) reactor, NRU's operation, and Unit 2000, a CRL think tank. Ms. Beth MacGillivray of the Ottawa General Hospital, spoke on "Radioisotopes and Medicine" at the closing plenary session. A crucial role was played by the CRL tour guides who steered the participants to the many sessions across the site.

Many Contributors

Financial support for participants' travel was provided by the Ontario and Manitoba teachers' associations, the New Brunswick Electric Power Commission, the Association of Professional Engineers of New Brunswick, the Canadian Nuclear Association, the Canadian Nuclear Society, AECL CANDU, AECL's Education Partnerships and the many school boards in the provinces. The Science Teachers Association of Ontario were co-sponsors for the Seminar as they have been for many years.

The organizing committee plans to continue the seminar series next year, with a new selection of topics that reflect changing activities within AECL Research.

Millie Humphries is Executive Assistant to the Vice-President, Physical Sciences, AECL Research, and coordinated activities for the Science for Educators seminar with Joan Vaudry.

Members of the 1993-94 CNS Council pose after the Annual General Meeting in Montreal, 2 June 1993. Back row (L-R): John Hewitt, Ben Rouben, Bill Midvidy, Paul Fehrenbach, Gil Phillips, Stefan Kupca. Front row (L-R): Joel Almon, Ed. Price, Jerry Cuttler, Hong Huynh, Surinder Singh

CNS Council for 1993-94

Executive

President
Paul Fehrenbach .... AECL Research, CRL

1st Vice-president
Ed Price .... AECL CANDU

2nd Vice-president
Jerry Cuttler .... AECL CANDU

Secretary
Stefan Kupca .... DND

Treasurer
Ben Rouben .... AECL CANDU

Members at Large
Oguz Akalin .... Ontario Hydro
Hong Huynh .... Hydro Quebec
Ed Jelinski .... Ontario Hydro
Troy Lassau .... ORTECH
Fran Lipsett .... AECL Research, CRL
Aslam Lone .... AECL Research, CRL
Daniel Rozon .... Ecole Polytechnique
Surinder Singh .... AECL CANDU
Ken Smith .... UNECO Consultants

Ex-Officio

Committee Chairmen
Shayne Smith .... Education and Public Affairs
Ken Talbot .... International Liaison
Joe Sobolowski .... Intersociety Affairs
John Hewitt .... Honours and Awards
Phil Ross-Ross .... Past Presidents
Ian Hastings/
Hong Huynh .... 1994 Annual Conference

Division Chairmen
Colin Allan .... Waste Management & Environmental
Joel Almon .... Nuclear Science & Engineering
Gary Kharshafdjian .... Design and Materials
Al Lane .... Mining, Manufacturing & Operations

Branch Chairmen
Jeff Lafortune .... Ottawa
Lisa Hammann .... Toronto
David Malcolm .... Saskatchewan
Dan Meraw .... Central Lake Ontario
Karel Mika .... Bruce
Paul Thompson .... New Brunswick
Chuck Vandergraaf ..... Manitoba
Jeremy Whitlock .... Golden Horseshoe
Pierre Wolfshagen ...... Quebec

CNS *Bulletin*
Fred Boyd

CNA Liaison
Kathy Murphy
John Reid

Science and Law – It's a Match

Carmen Kirschling

Positive identification of criminals is made possible when tissue samples are subjected to a relatively new type of forensic testing called DNA-typing. Sometimes called genetic fingerprinting, this fascinating procedure and its use in criminal courts was explained to an attentive audience at the April meeting of the Chalk River Branch of the Canadian Nuclear Society (CNS) in Deep River. CNS-Chalk River held the event in collaboration with Algonquin College.

The speaker was Mackenzie High School graduate Hilary McCormack, now L.L.B., Department of Justice, Canada. McCormack anticipated the importance of DNA-typing in criminal prosecutions (it had already been successfully used in Britain) and seized the opportunity to introduce it for the first time in Canada in a 1989 assault case. Confronted with dramatic forensic evidence, J. McNally confessed to the brutal sexual assault on a 68-year-old widow. In 1991, McCormack went on to prosecute the first murder case in which DNA evidence was admitted.

What is DNA-typing? In order to explain its complexities to jurors, overcoming their resistance and bafflement, McCormack says she has "to take the science out of science." She does this by explaining DNA and the matching procedure with general terms and descriptive phrases such as "molecular scissors," "jello-like," and an analogy to horse racing.

DNA-typing's secret is based on the DNA molecule (deoxyribonucleic acid) as the genetic blueprint that determines each individual's inherited traits. No two people – except for identical twins – have precisely the same pattern. Every cell in a person's body contains the same DNA. Even a minute sample of blood, semen, hair or skin can be examined by isolating and comparing microscopic strands of DNA. The final test results are shown in enlarged photographs as a series of black and white bands. Matching, evenly aligned bands provide positive identification. Conversely, DNA-typing can accurately exclude a suspect.

What makes the technique so compelling is probability. How many times can you expect to see this match between two different individuals? Depending on circumstances, it can be one in 20 million or even 100 million. McCormack likes these odds; experts agree that the exact numbers do not matter when the range is so impressively high.

The procedure is thus a ground-breaking tool in criminal investigations. "Eye witness testimony is notoriously poor evidence," says McCormack. "During closing remarks, a judge will often tell a jury to act with caution as eye witness is frail and uncertain. DNA-typing is entirely reliable." Science has produced results far beyond a reasonable doubt.

Energy, Ethics and Atoms

Dr. Stan Hatcher, past President and CEO of AECL, gave three presentations on "Energy, Ethics and Atoms" to the Maitoba Branch of the CNS during a recent visit to Manitoba.

His first presentation was given in Winnipeg on May 18 at a breakfast meeting of CNS members and guests at the Museum of Man and Nature. The second meeting was billed as "An evening with Stan." It was held in Pinawa, the same day. Stan spoke to an appreciateive audience of approximately 50 members and visitors, including two candidates for Parliament for the Provencher riding, persently held by the Hon. Jake Epp. The third presentation was a noon hour talk at AECL's Whiteshell Laboratory. This time, the attendance was in excess of 100. This presentation was videotaped and has since been shown at AECL's Underground Research Laboratory.

In all three talks, Dr. Hatcher presented the premise that, to provide a reasonable supply of energy to a growing world population, the shortfall can only be supplied by nuclear energy. He stated that, barring a major catastrophe such as major wars of an epidemic on the scale of the black plague during the Middle Ages, the world's population is expected to increase during the next twenty years. He showed a direct correlation between energy use and life expectancy and / or quality of life. Although this relationship may not be one of cause and effect, i.e., a high energy consumption may not lead directly to higher quality of life or longevity, evidence shows that underdeveloped societies tend to use much less energy than societies with a high standard of living. One cannot deny, on ethical grounds, any society or group its rightful share of available energy, he argued. Even if the developed world were to cut its energy demands drastically, the world would require a large increase in energy production. This increase in energy appetite cannot be met by fossil fuels, hydro or solar, but only by nuclear energy.

All three presentations generated a lively discussion. Some of the comments made ranged from a skepticism that the developed world would not voluntarily reduce its energy demands to a warning that a more even distribution of energy use might well come as a result of some economies running out of steam.

In his three presentations, Dr. Hatcher raised our awareness that many of the world's problems transcend the spheres of science, ethics, and economics.

Four CNS Fellows Named

Four members were named as Fellows of the Canadian Nuclear Society at the Annual General Meeting held in Montreal, 2 June 1993.

They are: John S. Foster; Terrance E. Rummery; Kenneth H. Talbot; and, Alan Wyatt.

Presentation of the Fellowships will be made at some future CNS event still to be determined.

The "Fellow" category of membership was established in 1982 to denote outstanding merit; the criteria for admission include "major sustained contributions to the sciences and / or professions that relate to the advancement of nuclear technology in Canada." Demonstrated maturity of judgment and breadth of experience, as well as outstanding technical capability and service to the Society, are also among the requirements for admission.

The International Nuclear Societies Council

The Canadian Nuclear Society not only serves nuclear professionals in Canada but also represents them internationally. As part of this external focus the CNS is a member organization of the International Nuclear Societies Council (INSC).

The INSC was formed in 1990 as a successor of the less-structured International Nuclear Societies Group, an informal gathering of representatives of nuclear societies that had met from time to time over several years. INSC is composed of most of the nuclear societies of the world grouped into four geographical regions:

- North America
- Central and South America
- Europe
- East Asia

plus an "at-large" category.

The basic objective of the INSC is global cooperation in the peaceful uses of nuclear science and technology for the benefit of mankind keeping public health and safety and environmental protection paramount.

Currently the member societies of INSC have a total membership of over 40,000.

As well as the practical work of encouraging and facilitating communication between member societies to achieve some coordination in activities the INSC has been active in other ways. It developed a "Global Creed" for nuclear professionals; produced a statement on "nuclear energy in the 21st century"; and prepared and submitted comments on the proposed international nuclear safety convention being developed under the aegis of the IAEA (see separate article). The last was prepared by an International Nuclear Safety Committee set up by the INSC chaired by Pierre Tanguy of France and including CNS past-president Bill Midvidy.

A current activity is the preparation of a "vision" of nuclear energy over the next 50 years. This was initiated by former INSC chairman Jean van Dievoet of Belgium and will be developed by a special working group on which Stan Hatcher has agreed to represent Canada.

Since its formation the INSC has met twice a year, usually in conjunction with a major international meeting, such as the Pacific Basin Nuclear Conference in Taiwan in the spring of 1992 and the ANS/ENS conference celebrating 50 years of fission held in Chicago last November. The most recent meeting was held June 20 in San Diego just before the Annual Meeting of the American Nuclear Society where the CNS was represented by president Paul Fehrenbach and *Bulletin* editor Fred Boyd. (Ken Talbot, the CNS official representative to INSC was unable to attend.) The next meeting will be held in Toronto in October in conjunction with INC '93.

The current INSC chairman is Manning Muntzing, former ANS president. Other members of the executive are: 1st vice-chairman, Dr. Mishima Yoshitsugu of Japan; 2nd vice-chairman, Manuel Acero of Spain; secretary-treasurer, Jorge Spitalnik of Brazil. Secretariat services are being provided by the ANS for the time being.

The INSC proposed "Global Creed" and the statement on nuclear energy in the 21st century are reprinted below.

Nuclear Energy in the 21st Century

A Sustainable Energy Resource

There is a growing global consensus on the need for sustainable development. Adequate energy supply is critical for emerging economies to develop and for industrialized economies to support the legitimate needs of their societies. Energy in the form of electric power is essential to improve efficiency, develop conservation techniques, recover, recycle and properly dispose of wastes, and minimize environmental pollution. Nuclear energy can play a vitally needed role in meeting future electricity needs.

Safety and Environmental Assessment

Electricity generated from nuclear fission energy has been evaluated in more depth than any other energy source. Licensed nuclear power plants, designed to established standards and operated by qualified personnel, have amassed a safety record unmatched by any alternative energy source. The accident at Chernobyl was indeed serious. Important safety features required by Western safety standards, including a pressure-resistant containment building, are not present in the Chernobyl-type plants. All new designs must meet stringent safety standards, and international efforts are proving successful in instilling a safety culture and management controls to all operating plants.

With the exception of those regions where more hydroelectric power is available, nuclear energy is the only large-scale source of base-load power that produces no sulfur oxides, no acid rain and no carbon dioxide emissions. It does produce radioactive wastes. These are sufficiently concentrated that it is worth the effort and cost to confine them and dispose of them in permanent repositories, and thereby keep them out of the environment forever.

Wastes already exist from more than thirty years of commercial nuclear electricity production. The technology for safe disposal is well understood and is being pursued in a number of nations. High-level wastes are concentrated, carefully handled, and are being stored safely. The major nuclear nations have plans for permanent disposal facilities. It is the obligation of the current generation to dispose of them safely and permanently. The proper test for any repository is safety, and not its location relative to state or national borders.

A Part of the Mix for Base-Load Electricity Production

No claims are made that nuclear power is the only answer to electricity needs. Nuclear plants provide base-load power, day and night, while peak loads can be met by natural gas and even oil. Alternative energy sources: solar, wind, geothermal and hydro, should be used whenever they are available. Choices for future plants need to be based not only on the cost of production, but also on environmental impacts. In some nations, attempts are being made to estimate and internalize environmental costs into the calculated costs of production.

Energy conservation programs can lower demand growth rates, and delay for a few years perhaps, but not eliminate, the need for new power plants.

The record around the world shows that nuclear plants can compete effectively with coal and other alternative sources. They provide diversity of supply, and in some nations are of critical importance in reducing the need for imported oil and liquified natural gas. Reliability records are improving each year. New plants are currently under construction in France, Japan, China, Korea, Brazil and Romania.

Uranium resources are abundant and fuel supplies are economical at this time. Recycling of plutonium will help to keep nuclear fuel prices down and extend the natural uranium resource well into the 21st century. Ultimately, breeder reactors will be able to produce enough new plutonium to assure sufficient nuclear fuel supply for future centuries.

The Civilian Nuclear Power Fuel Cycle and Safeguards

The commercial nuclear electric power fuel cycle is not a logical or effective pathway to nuclear weapons. Systems of safeguards under International Atomic Energy Agency (IAEA) agreements have proven successful in assuring that diversion of plutonium has not taken place. Experience has shown that accurate inventories of critical materials can be maintained.

The major weapons states are IAEA signatories and have put their commercial fuel cycles under IAEA safeguards. Most non-weapons states have accepted full-scope safeguards, committing themselves to having no national program to develop nuclear weapons. It is of critical importance to bring the remaining nations into IAEA agreements.

The sad experience with Iraq proves that if a nation is determined to acquire nuclear weapons, it will not depend on the nuclear power fuel cycle. Iraq's weapons facilities were totally clandestine. It had no nuclear power plants.

Summary

Nuclear energy is a safe and environmentally acceptable source for base-load electricity generation. Because radioactive wastes already exist, facilities must be built for their ultimate disposal. Commercial nuclear power under IAEA safeguards is not a realistic pathway to nuclear weapons. Therefore, decisions affecting the extent of nuclear power's future role will likely depend on economics, diversity of fuel supply and environmental considerations.

Electricity will help build a clean energy base upon which sustainable future development will be based. As other energy sources become practical, they can join fossil fuels and nuclear energy to sustain a diverse base of energy supply for the future.

Global Creed

Nuclear professionals should uphold and advance the integrity, honor, and dignity of their profession by:

- Promoting the involvement of Societies and professionals worldwide in the quest for excellence and quality in the application of nuclear science and technology for the service of humanity.
- Promoting the use of their knowledge and skills for the enhancement of human welfare by furthering public health and safety and environmental protection in the implementation of nuclear projects and programs.
- Enhancing the peaceful uses and application of nuclear science and technology.
- Ensuring the public is informed of the facts surrounding nuclear science and technology in an objective and truthful manner.

Toronto Student Branch Activities

March and April were a busy time for members of the CNS Toronto Student Branch.

On March 11, 1993, a group of students from the University of Toronto's Nuclear and Thermal Power group participated in an excursion to the uranium refining facilities located in Port Hope, Ont. The purpose of the visit was to observe the manufacturing processes involved in the creation of nuclear grade fuels and products, and involved tours of the Cameco uranium refinery and the Zircatec fuel manufacturing plant. Zircatec specializes in the manufacture of uranium fuel pellets and the assembly of fuel bundles. One of the most interesting aspects of the tour was the fact that the fuel bundles required such precision that the pellets had to be loaded into the pencils by hand.

Thanks to to the CNS and the Department of Chemical Engineering at the University of Toronto for the opportunity to view this nuclear technology firsthand.

On March 26-28, 1993, a group of graduate students under the supervision of professor Greg Evans of the University of Toronto attended the 1993 Northeast/Midwest Regional Student Conference of the American Nuclear Society (ANS). The conference was held at Rensselaer Polytechnic Institute (RPI) in Troy, NY. This marked the second year in which U of T students attended this conference. Christopher Deir and Raymond Quan both presented papers, with fellow students Fariborz Taghipour and Masoud Shams providing moral support. Raymond Quan won the award for best session paper in the area of environmental assessment and public policy, for his paper entitled "The Radiolysis of Aqueous Organic Systems and Their Effect on Radioiodine Volatility".

The major American schools represented included the Massachusetts Institute of Technology (MIT), Pennsylvania State University, Purdue University, and the University of Cincinnati. We found that our colleagues in the US shared our interest in many common issues, including the current political climate surrounding nuclear power, programmes in deep waste disposal (i.e. Yucca Mountain), and the stagnant job market for new engineering graduates. The research programme at U of T on the environmental impact of nuclear facilities drew a good deal of interest from many of our American counterparts. The trip proved to be a great experience, and plans are being made to attend next year's affair, which is tentatively scheduled to be held at MIT in Boston.

The following week, on April 2-3, 1993, a large delegation of students and staff from the University of Toronto attended the 18th annual student conference of the CNS/CNA, held at L'école Polytechnique in Montréal. In all, our team numbered 23, consisting of professors Brian Cox and Greg Evans, along with 12 graduate students and 9 undergraduates.

Papers were presented by graduate students Christopher Deir, Khalid Hammad, Sunling Gong, Mehdi Mesbah-Oskui, Mike Fila, and Raymond Quan, and by undergraduates Tinku Dhoum and Paul Bekeris. Tinku Dhoum won the award for best paper in the undergraduate category for his paper entitled "Radiolytic Abatement of NOx from Flue Gas", while Paul Bekeris warranted an honourable mention in the same category for his paper entitled "Iodine Behaviour in the Slowpoke Reactor". Likewise, Raymond Quan won the award for the best paper in the master's degree category for his paper entitled "The Radiolysis of Aqueous Organic Systems and Their Influence on Radioiodine Volatility". All three of these students were under the supervision of professor Greg Evans.

It was one of the best CNS student conferences in recent years. As expected, Montréal was a tremendous venue for the conference, and several of the group took time out to get a taste of the city life. The Centre for Nuclear Engineering at U of T looks forward to hosting the 1994 CNS/CNA student conference in Toronto, and this year's conference is a very tough act to follow.

Book Review

The Trinity Paradox, Kevin Anderson and Doug Beason, Bantam, New York, 1989.

Reviewed by Keith Weaver

"I am become death, the shatterer of worlds."

Julius Robert Oppenheimer, that elusive and (to some) sinister kingpin in the Los Alamos portion of the Manhattan Project, was the man who recited these words as the first nuclear explosion was set off in the New Mexican desert.

John von Neumann, Richard Feynmann, Enrico Fermi, Leo Szilard, Edward Teller, Stanslau Ulam, these and other intellectual heavyweights were all associated with the Manhattan Project. They are not people to be dismissed easily or lightly, certainly not in their own fields, and certainly not because they didn't have the wherewithal for reflection and scrutiny of the moral issues involved.

The work these people carried out was set against a cultural, technical, and social backdrop that no longer exists. So, although an individual can readily arrive at his or her own personal appreciation of the significance, in today's setting, of early work on nuclear weapons, any such view is heavily influenced by a vast panoply of subsequent political developments, of revolutions in personal and social mores and of enormous technological advance. An adequate and balanced view of the actual events back then, why these people did what they did and the whole feel of the times in which those events took place, these partially intangible things are all but lost. The historical problem widens as the rate of technological and social change accelerates.

The Trinity Paradox is a novel, not a factual reconstruction. Such a reconstruction, if it were to be even a minimally defensible historical work, would be so recondite and vast as to be easily beyond the scope of all but a few experts. Too many factors that are no longer of today's everyday world would be involved, too much analysis would be needed. In a novel such as The Trinity Paradox, one can relax these constraints and bring subtle but powerful literary forces to bear so that whole areas of a way of life, of a feel of the times can be summed up with relatively little descriptive effort.

Elizabeth Devane, modern day nuclear activist, and protagonist in the story, is (the authors assure us) the only truly fictional character in the work. All others are represented as themselves or are based on real people who were involved. Without giving away any important bits of the plot, she is placed in a situation where her modern outlook and the intellectual and moral realities of wartime Los Alamos are brought into direct confrontation. There is a mildly science fiction aspect to the story (heavy on science – Anderson is a technical writer at Lawrence Livermore, Beason directs an Air Force plasma research lab – with most of the fiction being historical) that lumbers off harmlessly over the horizon under its own steam. There is also a personal and intellectual aspect of the book that is worth considering.

It should be said straight away that the book, while not really a failure, is disappointing. The action and the storyline are linear and fairly uninspired; the characters and dialogue are wooden. At another level, however, the authors juxtapose the rather "hardened" protest and demonstration mentality of the 1970s and 1980s with the "simpler," "more innocent" and "less sophisticated" view of the 1940s. The artistic license that is applied to twist physical reality a bit and thereby enable these two world views to collide, is crude but effective. As a result, history doesn't evolve "the way it should," and this is the science fiction aspect of the story. Of rather greater interest, in my opinion, is the implied comparison and evaluation of two very different social scenes.

How did it feel to be involved in a kind of intellectual war with Germany, when the people concerned generally did not have much information on what the Germans were up to or how far advanced they were? What was one to think then of a scientific and technical venture whose sole immediate objective was to create a new and qualitatively different weapon, but a weapon with social, political and moral dimensions that could only be guessed at? Just how out of place would today's mentality be in those times? How could a 1980s person become reconciled to a new and similar social and intellectual niche, but which was cast back forty years?

For me it is only on this level that the book has real interest. Whether the actual mentality of a one of today's young American female protesters has been captured, I can't say, and in any event this is not very important. There is material here to make one ponder. As a study on this level, the book is not bad, but as a novel this otherwise rather interesting volume comes with a few buts.

Canadian Nuclear Society

Membership Application / Renewal Form

SURNAME ______ GIVEN NAMES ______ ☐ MR. ☐ MS. ☐ DR.

HOME ADDRESS ______

COMPANY/INSTITUTE/SCHOOL ______ STUDENT ☐

BUSINESS ADDRESS ______

CITY ______ PROVINCE ______ POSTAL CODE ______

PHONE (HOME) ______ PHONE (BUSINESS) ______ FAX ______

BUSINESS TITLE (IF APPLICABLE) ______ RETIRED ☐

IS CORRESPONDENCE TO BUSINESS ACCEPTABLE? ☐ YES ☐ NO REFERRED BY ______

CNS BRANCH TO WHICH YOU WOULD LIKE TO BELONG

- ☐ BRUCE
- ☐ CHALK RIVER
- ☐ GOLDEN HORSESHOE (Hamilton)
- ☐ MANITOBA
- ☐ NEW BRUNSWICK
- ☐ OTTAWA
- ☐ QUEBEC
- ☐ SASKATCHEWAN
- ☐ TORONTO
- ☐ CENTRAL LAKE ONTARIO (Pickering, Darlington, Port Hope, Peterborough)
- ☐ USA AND INTERNATIONAL

CNS DIVISION TO WHICH YOU WOULD LIKE TO BELONG

- ☐ NUCLEAR SCIENCE AND ENGINEERING
- ☐ DESIGN AND MATERIALS
- ☐ MINING, MANUFACTURING AND OPERATION
- ☐ WASTE MANAGEMENT AND ENVIRONMENTAL AFFAIRS

MEMBERSHIP TYPE AND FEE SCHEDULE FOR 1993†

☐ REGULAR	$55.00
☐ CHARTER	55.00
☐ STUDENT	20.00
☐ RETIRED	30.00
☐ INSTITUTIONAL	55.00

If you are a non-member and attend an event on the CNS Events Calendar, you are entitled to a $15.00 introductory discount on your first-year fees. Simply deduct $15.00 from your fees amount. ______
Please indicate name of CNS event.

METHOD OF PAYMENT

☐ CHEQUE ☐ VISA ☐ MASTERCARD ☐ AMEX

CARD NUMBER ______

EXPIRY DATE ______ SIGNATURE ______ DATE ______

Please send payment with this invoice now. Credit card payment may be faxed to (416) 979-8356. An official receipt will be sent in return.

Please complete and return to

The Canadian Nuclear Society, 144 Front St. W., Ste. 725, Toronto, Ontario M5J 2L7

Telephone 416-977-7620

Société
Nucléaire
Canadienne

Renseignements sur l'abonnement
Formulaire de renouvellement

NOM DE FAMILLE ______________________ PRÉNOM ______________________ ☐ M. ☐ Mme ☐ Dr

ADRESSE (DOMICILE) ______________________

COMPAGNIE/ÉCOLE/INSTITUT ______________________ ÉTUDIANT(E) ☐

ADRESSE DU BUREAU ______________________

VILLE ______________ PROVINCE ______________ CODE POSTAL ______________

N° DE TÉLÉPHONE (DOMICILE) ______________ (BUREAU) ______________ TÉLÉCOPIEUR ______________

TITRE (SI UTILISÉ) ______________________ RETRAITÉ(E) ☐

CORRESPONDANCE SERA ENVOYÉE AU BUREAU: ☐ OUI ☐ NON RÉFÉRÉ PAR ______________

SECTION LOCALE À LAQUELLE VOUS DÉSIREZ APPARTENIR

- ☐ BRUCE
- ☐ CHALK RIVER
- ☐ CROISSANT D'OR (Hamilton)
- ☐ MANITOBA
- ☐ NOUVEAU-BRUNSWICK
- ☐ OTTAWA
- ☐ QUÉBEC
- ☐ SASKATCHEWAN
- ☐ TORONTO
- ☐ LAC ONTARIO CENTRAL (Pickering, Darlington, Port Hope, Peterborough)
- ☐ ÉTATS-UNIS ET INTERNATIONAL

DIVISION TECHNIQUE À LAQUELLE OU AUXQUELLES VOUS DÉSIREZ APPARTENIR

- ☐ SCIENCE NUCLÉAIRE ET GÉNIE CIVIL
- ☐ CONCEPTION ET MATÉRIAUX
- ☐ EXPLOITATION MINIÈRE, FABRICATION ET EXPLOITATION DES CENTRALES
- ☐ GESTION DES DÉCHETS RADIOACTIFS ET ENVIRONNEMENTALES

TYPE D'ADHÉSION ET COTISATION POUR 1993†

☐ RÉGULIER	55.00 $
☐ FONDATEUR	55.00
☐ ÉTUDIANT(E)	20.00
☐ RETRAITÉ(E)	30.00
☐ INSTITUTIONNELLE	55.00

Si vous ne faites pas parti des membres de la SNC et que vous vous êtes inscrit à l'un des événements au calendrier des activités de la SNC, vous avez alors droit à un rabais de 15.00 $ sur le montant de votre première cotisation. Veuillez simplement déduire 15.00 $ sur le montant. ______________________
Indiquer le nom de l'activité

MÉTHODE DE PAIEMENT

☐ CHÈQUE ☐ VISA ☐ MASTERCARD ☐ AMEX

NUMÉRO DE CARTE ______________________

DATE D'EXPIRATION ________ SIGNATURE ______________ DATE ______________

Veuillez faire parvenir votre paiement, incluant le numéro de facture, le plus tôt possible. Les paiements par carte de crédit peuvent être envoyés par télécopieur au (416) 979-8356. Un reçu officiel sera expédié dans les plus brefs délais.

Veuillez compléter et retourner à
Société Nucléaire Canadienne, 144, rue Front ouest, Ste 725, Toronto, Ontario M5J 2L7
Téléphone (416) 977-7620

Calendar

1993

August 14-18 — **16th Reactor Operations International Meeting**
Long Island, New York
contact: Terry Maugeri
Brookhaven National Laboratory
Upton, NY, USA 191973

September 5-11 — **International Conference on Nuclear Waste Management & Environmental Remediation**
Prague, Czechoslovakia
contact: Radovan Kahout
Ontario Hydro
Tel.: 416-592-5384

September 8-10 — **8th Annual Symposium of the Uranium Institute**
London, England
contact: Uranium Institute, London
Fax: 071-225-0308

September 13-14 — **International Conference on Expanded and Rolled Joint Technology**
Toronto, Ontario
contact: G. Kharshafdjian
AECL-CANDU
Tel.: 416-823-9040, Ext. 2102
Fax: 416-823-8006

September 12-16 — **Future Nuclear Systems: Emerging Fuel Cycles and Waste Disposal Options**
Seattle, Washington
contact: Alan Walter
Richland, Washington
Tel.: 509-376-5514
Fax: 509-376-6282

September 20-24 — **7th International Conference on Emerging Nuclear Energy Systems**
Makuhari, Japan
contact: Dr. T. Hiraoka
Japan Atomic Energy Research Institute
Tokai-mura, Japan
Tel.: 81-292-82-5517
Fax: 81-292-82-6122

September 27-30 — **Topical Meeting on the Technical Basis for Measuring, Modelling and Mitigating Toxic Aerosols**
Albuquerque, New Mexico
contact: Mark Hoover
Inhalation Toxicology Research Institute
P.O. Box 5890
Albuquerque, NM, USA 87185-5890

October 3-8 — **International Nuclear Congress – INC '93**
Toronto, Ontario
contact: Dr. Ben Rouben
AECL-CANDU
Tel.: 416-823-9040
Fax: 416-823-8006

October ? — **Nuclear Technology**
Ankara, Turkey
contact: Murat Onder
Chamber of Mechanical Engineers
Sumer Sokak No. 36/1-A
06440 Ankara, Turkey
Fax: 90-4-231-31-65

November 14-19 — **ANS Winter Meeting**
San Francisco, California
contact: Dr. W.I. Midvidy
Ontario Hydro
Tel.: 416-592-5543
Fax: 416-978-0193

1994

March ? — **CNA/CNS Student Conference**
Toronto, Ontario
contact: Dr. Brian Cox
Centre for Nuclear Engineering
University of Toronto
Toronto, Ontario
Tel.: 416-978-2127

April 3-6 — **4th International Topical Meeting on Nuclear Thermal Hydraulics**
Taipei, Taiwan
contact: Justice Liu
PG & E, San Francisco, CA, USA
Tel.: 415-972-4592

April 17-30 — **International Meeting on Advanced Reactor Safety**
Pittsburgh, Pennsylvania
contact: D. Squarer
Westinghouse Electric Corp.
Tel.: 412-256-2063

April 24-27 — **8th International Conference on Radiation Shielding**
Arlington, Texas
contact: Richard Rubin
Dallas, TX, USA
Tel.: 214-812-8247

April 24-28 — **4th International Conference on Nuclear Fuel Reprocessing & Waste Management**
London, England
contact: British Nuclear Forum
22 Buckingham Gate
London, SW1 E 6LB, UK

April 24-27 — **International Symposium on Decontamination and Decommissioning**
Knoxville, Tennessee
contact: Analyses Corp. Conference Management
Oak Ridge, TN, USA
Fax: 615-576-0709

April 27-29 — **Chemistry in Water Reactors**
Nice, France
contact: French Nuclear Society
Bureaux 48, rue de la Procession
F 75724 Paris Cedex 15, France

1994 cont.

May 1-6	**9th Pacific Basin Nuclear Conference** Sydney, Australia contact: 9PBNC Conference Secretariat Fax: INT 61-6-273-2918
May 17-19	**Annual Meeting on Nuclear Technology** Stuttgart, Germany contact: Dr. K.G. Bauer INFORUM GMBH Bonn, Germany Fax: 49-228-5072-19
May 30 - June 2	**International Conference on Nuclear System Thermalhydraulics** Pisa, Italy contact: N. Spinks AECL Research, CRL Tel.: 613-584-3311
June 5-8	**CNA/CNS Annual Conference** Montreal, Quebec contact: Kathy Murphy CNA/CNS Fax: 416-979-8356
June 13-15	**Steam Generator Conference** Toronto, Ontario contact: D. Lister UNB Tel.: 506-453-5138
June 19-24	**ANS Annual Meeting** New Orleans, Louisiana contact: Dennis Tolleison Martin Marietta Energy Systems P.O. Box 2009-8221 Oak Ridge, TN, USA 37831-8821 Tel.: 615-574-9877
August 14-18	**SPECTRUM 94 International Nuclear and Hazardous Waste Management Conference** Atlanta, Georgia contact: John Steele Westinghouse Savannah River Aiken, South Carolina, USA 29802 Tel.: 803-725-1830
October 2-6	**ENC '94** Lyon, France contact: Dr. Peter Feuz European Nuclear Society Monbijoustrasse 5, P.O. Box 5032 CH 3001, Berne, Switzerland Fax: 41-31-22-9203
October 19-21	**3rd International Containment Conference** Toronto, Ontario contact: D. Pendergast AECL-CANDU Tel: 416-823-9040 Fax: 416-823-8006

Miscellany

Regulations Delayed

The "General Amendments to the Atomic Energy Control Regulations" and the revised radiation protection regulations based on the recommendations in ICRP-60 are not likely to be issued until the latter part of 1994.

This was part of the message of John McManus, Secretary General of the Atomic Energy Control Board in a paper at the annual conference of the Canadian Radiation Protection Association in Toronto in June.

There were so many comments on the General Amendments after they were issued for comment two years ago that "substantial changes" were required, McManus said.

On other regulatory initiatives McManus said the Physical Security Regulations are being reviewed for possible amendments to be issued later this year; the Transport Packaging of Radioactive Materials Regulations are being revised to reflect 1990 international agreements; and, some proposed amendments to the Uranium and Thorium Mining Regulations will be issued this summer.

The AECB's Cost Recovery Fees Regulations were amended in April to increase the fees by about 25%.

Work has been underway for some time on a possible new act to replace the Atomic Energy Control Act which was passed in 1948 with only one significant amendment in 1954.

AECB Moves

By the end of August the Atomic Energy Control Board will be in new offices.

Over three weekends the AECB is moving from its present location at 270 Albert Street in Ottawa, where it has been since 1975, one block north to 280 Slater Street.

There will be no change in the AECB's telephone or FAX numbers nor its mailing address, which will remain:

P.O. Box 1046
Ottawa, Ontario
K1P 5S9

As pointed out by the AECB, the move was not initiated by the agency but is a consequence of lease negotiations by Public Works Canada (now part of Services Canada) which is the federal government's property manager.

A casualty of the move will be the AECB's "store-front" public information office which will be sharing the fourth floor of the new quarters with the library.

The total space is about 200 square metres (2,150 square feet to those of you still on the old units) smaller than the AECB's existing quarters where many changes and improvements – including a new board room to accommodate the public – have been made over the past few years.

CNS Council • Conseil de la SNC

1993-1994

Executive / *Exécutif*

President / Président
Paul Fehrenbach (613) 584-3311

1st Vice-President / *1ier Vice-Président*
Ed. Price (416) 823-9040

2nd Vice-President / *2ième Vice-Président*
Jerry Cuttler (416) 823-9040

Secretary / *Secrétaire*
Stefan Kupca (613) 992-7446

Treasurer / *Trésorier*
Ben Rouben (416) 823-9040

Past President / *Président sortant*
Bill Midvidy (416) 592-5543

Members-at-large / *Membres sans portefeuille*

Oguz Akalin	(416) 592-5997
Hong Huynh	(514) 344-0561
Ed Jelinski	(416) 623-6606
Troy Lassau	(416) 822-4111
Fran Lipsett	(613) 584-3311
Aslam Lone	(613) 584-3311
Daniel Rozon	(514) 340-4803
Surinder Singh	(416) 823-9040
Ken Smith	(416) 828-8216

Standing Committees / *Comités fixes*

Finance / Finance
Ben Rouben (416) 823-9040

Program / *Programmes*
Ed. Price (416) 823-9040

Membership / *L'adhésion*
Hong Huynh (514) 344-0561

Branch Affairs / *Affaires des filiales*
Jerry Cuttler (416) 823-9040

Education & Public Affairs / *Éducation et relations publiques*
Shayne Smith (416) 673-3788

Special Committees / *Comités spéciaux*

Honours and Awards / Honneurs et prix
John Hewitt (613)

International Liaison / *Relations internationales*
Ken Talbot (519) 368-7031

Intersociety Relations / *Relations intersociétés*
Joe Sobolewski (416) 569-0928

Past Presidents / *Ex-présidents*
Phil Ross-Ross (613) 584-2535

1994 Annual Conference / *Congrès annuel 1994*
Ian Hastings (613) 584-3311
Hong Huynh (514) 344-0561

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

- **Nuclear Science & Engineering / *Science et génie nucléaires***
  Joel Almon (416) 506-8669
- **Mining, Manufacturing & Operations / *Exploitation minière, fabrication, et exploitation des centrales***
  Al Lane (613) 584-3311
- **Design & Materials / *Conception et matériaux***
  –Gary Kharshafdjian (416) 823-9040
- **Waste Management & Environmental Affairs / *Gestion des déchets radioactifs et environnement***
  Colin Allen (204) 753-2311

CNA Liaison / *Agent de liaison de l'ANC*
Kathy Murphy (416) 977-6152
John Reid (416) 977-6152

CNS Bulletin Editor / *Rédacteur du Bulletin SNC*
Fred Boyd (613) 592-2256

CNS Branch Chairs • Responsables des sections locales de la SNC

1992-1993

Bruce	Karel Mika	(519) 368-7031
Central Lake Ontario	Dan Meraw	(416) 697-7218
Chalk River	Bob Andrews	(613) 584-3311
Golden Horseshoe	Jeremy Whitlock	(416) 525-9140
Manitoba	Chuck Vandergraaf	(204) 753-2311
New Brunswick	Paul Thompson	(506) 659-2220
Ottawa	Jeff Lafortune	(613) 563-2122
Québec	Pierre Wolfshagen	(514) 871-1116
Saskatchewan	David Malcolm	(306) 665-6874
Toronto	Liza Hammann	(416) 592-4533