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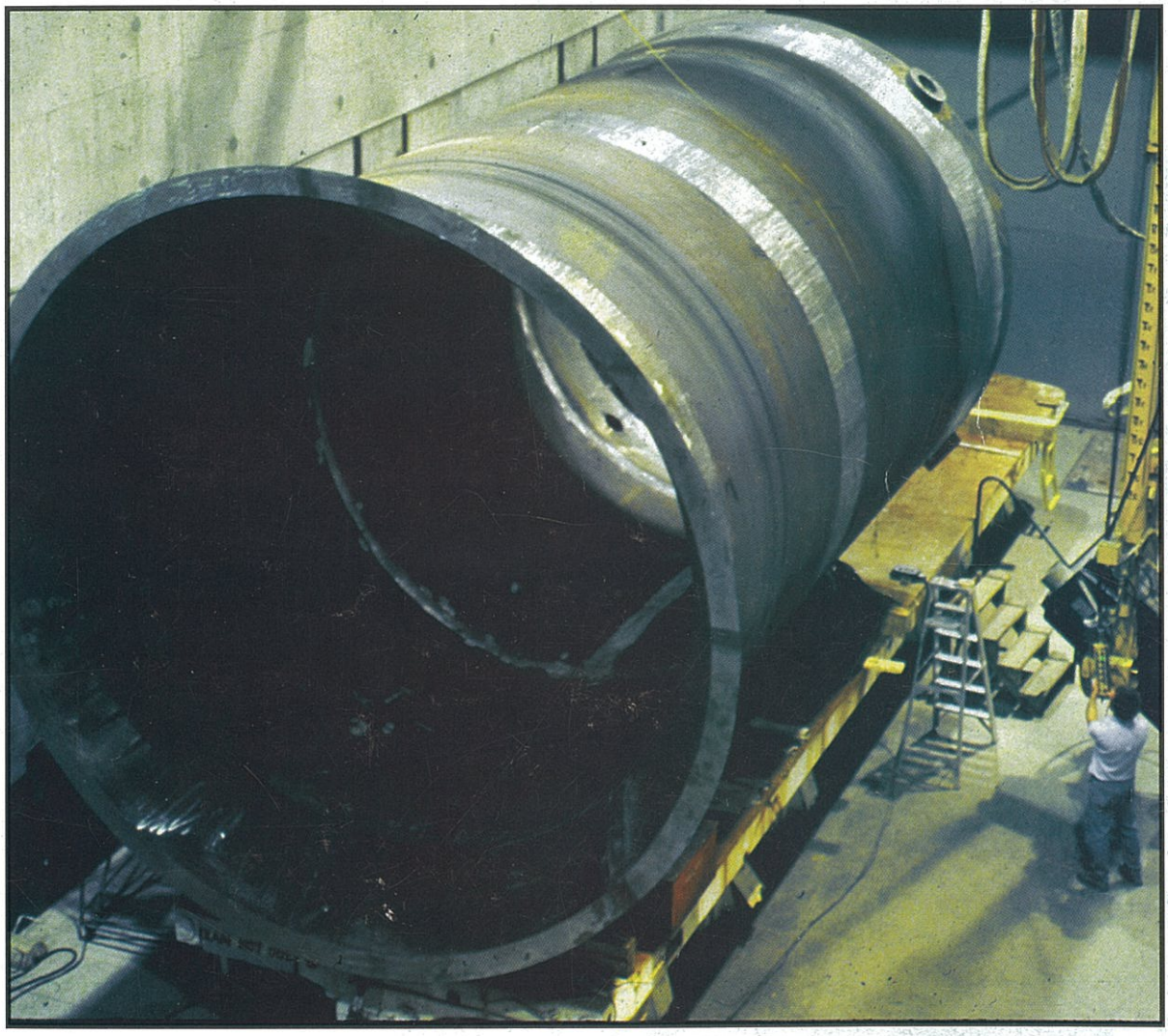

- Conference, Symposia
  - PBNC '98
  - Steam Generator
  - Low Dose
- Incorporation
- B&W Canada
- Annual General Meeting

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The photograph on the cover shows a shell of a CANDU 6 steam generator during manufacture at Babcock & Wilcox Canada, Cambridge, Ontario.

(Photo courtesy of Babcock & Wilcox Canada)

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La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ilf peuvent participer à des discussions de nature technique. Pour tous renseignements concerant les inscriptions, veuillez bein entrer en contact avec le bureau de la SNC, les membres du Counseil ou les responsables locaux. La cotisation annuelle est de 60.00$, 35.00$ pour les retaités, et 20.00$ pour les étudiants.

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

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

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EDITORIAL

Kyoto vs. Public Acceptance

A theme often voiced at the recent large PBNC'98 gathering was that the Kyoto Protocol (on "green-house" gases) should usher in a new era for nuclear power. This view was advanced by many of the speakers even though, as only one or two acknowledged, the Kyoto Protocol makes no mention of "nuclear", implying that the agreed reductions in emissions of CO_2 and other gases contributing to global warming would be achieved through conservation or the use of "renewable" sources of energy. This despite studies by the World Energy Council and others that show conservation can only slow the grow of demand for energy and that "renewables" are unlikely to be able to provide more than a small percentage of the needs.

The only countries which recognize the important role nuclear power can play are those of "Asia Pacific". In "western" countries we have "market" forces, associated with the de-regulation and privatization of electricity generation, pushing the use of natural gas for electricity generation..In the "global" economy, nuclear cannot compete with natural gas. With its short-term viewpoint the "market" ignores, as "external" factors: the cost of "global warming"; the fact that natural gas is valuable for many other uses than just burning it to make electricity; and that it is a limited and irreplaceable resource. When these market forces combine with the negative public attitudes prevalent in North America and western Europe the prospects for nuclear power in these areas are dismal.

Which raises the other major topic at PBNC'98, "public acceptance". Speaker after speaker acknowledged that, without a change in public attitudes towards things nuclear, what little political support exists in "western" countries for nuclear energy will evaporate. And without political (government) support (through policies, R and D, etc) nuclear power programs will likely disappear.

If western countries are truly concerned about meeting their Kyoto commitments a logical step would be to internalize the costs of the detrimental environmental effects of greenhouse gases by imposing an emission tax. That would make a more level playing field for nuclear, but is unlikely with current attitudes

Leading up to Kyoto there was very little "lobbying" by the nuclear industry, except at the last moment by a hastily conceived coalition of some nuclear energy organizations (not including any from Canada). The CNA is now trying to have some input into the discussions on how Canada will respond to its Kyoto commitments. Perhaps better late than never. But, the negative public perception of nuclear energy remains and will, undoubtedly, influence political decisions.

IN THIS ISSUE

There has been almost a plethora of conferences, meetings, symposia, etc, of interest, over the past few months, and, we have reports on, and papers from, several of them in this issue.

But, first, there is the great (to us) news that the Canadian Nuclear Society is **Incorporated,** an event to which we dedicate page 2.

The cover story continues our series on companies and organizations that are part of the Canadian nuclear program. In this case, instead of our own review we are reprinting a paper, **Babcock & Wilcox Canada Steam Generators; Past, Present and Future.**

The first of the meeting reports is, **PBNC'98,** a review of the large *11th Pacific Basin Nuclear Conference* which was held in Banff in early May. Our overview article is augmented by excerpts from some of the key presentations in **Messages from PBNC'98,** and a Canadian paper on the **Economics of Nuclear Power,** one of the key issues discussed at the conference.

Next is an account of the **3rd International Steam Generator and Heat Exchanger Conference** held in Toronto in late June. To accompany our overview we are reprinting the paper on the **Regulation of Ageing Steam Generators.**

Following, is a further short report on the CNA/CNS **Student Conference** that was held back in late March and briefly noted in the previous issue of the *CNS Bulletin* along with abstracts or summaries of the winning papers.

There is a summary of an interesting one-day **Symposium on Low Dose** convened by the recently established *International Centre for Low Dose Radiation Research* at the University of Ottawa. The dissatisfaction with the linear, no-threshold, hypothesis for the biological effect of ionizing radiation, was very evident at that gathering.

Reflecting the growing relationship between the CNS and the Canadian Radiation Protection Association, there is a short account of **CRPA 98 ACRP,** that organization's annual meeting in June

As a *special feature,* we have the first of a two-part critique of the controversial report from the Environmental Assessment Panel on Nuclear Fuel Waste, by former AECL senior scientist, Archie Robertson, in **Malice in Blunderland.**

There are a number of items grouped under **General News,** and an expanded section on **CNS News,** reflecting the Annual General Meeting held June 21, 1998, in Toronto.

You may note, also, that there are two "positions available" advertisements. This is a trial. Traditionally, we have not run advertisements in the *CNS Bulletin,* but the CNS executive decided that ads of benefit or of interest to members and readers might be included. We welcome your reaction, on that topic and any other aspect of your journal.

CNS Incorporated !

The Canadian Nuclear Society is now incorporated as a legally separate organization - thanks largely to Ben Rouben

At the 1998 Annual General Meeting of the Canadian Nuclear Society, out-going president Ben Rouben announced proudly that he had just received the Letters Patent, recording officially the incorporation of the Society as a legally separate organization. "This is a mark of the maturity of the Society", he said in making the announcement and inviting those present to the first Annual Meeting of the incorporated Society which followed immediately after the adjournment of the final AGM of the Society as it has existed since its formation in 1979.

As most members know, when the Society was created in 1979 it was as the *"technical society of the Canadian Nuclear Association"*. Although the CNS has operated as a separate organization and, in recent years, has achieved financial independence with significant assets, the legal situation remained - the CNS was, in law, a division of the CNA.

There was a move about ten years ago to incorporation when Eva Rosinger was president. However, following presidents were either against the move or indifferent. There was no progress until about two years ago when, under the presidency of Hong Huynh, the topic was raised again. This time the president and Council supported studying the move. Following a report from a task group, coordinated by Fred Boyd, Council endorsed the concept in principle.

When Ben Rouben became president (June 1997) he became a strong supporter of the move and, with Council's approval, directed the task group to develop specific plans. This was done. By Laws (as required under the federal law) were drafted and in early 1998 a letter vote was taken of all members - with 97 % of those voting (about 2/3) approving the move to incorporation.

In parallel, discussions were held with officials of the CNA regarding items such as: use of the name *Canadian Nuclear Society,* official release of assets and other details. All in the CNA were very supportive of the move and encouraged the CNS to proceed with its application for incorporation. The final formal step by the CNA was taken at its AGM, in Banff, May 4, during PBNC'98, when the requisite formal motions were passed. In allowing the "new" CNS to use the name, the CNA reserved the right to take it back if the incorporated CNS ever folds.

Throughout all of this, Ben Rouben was the driving force. On top of his many responsibilities as CNS president, he personally became very involved in developing the By Laws and in all of the many steps necessary to actually achieve incorporation. In this endeavour, he was greatly assisted by Ken Smith, then CNS treasurer. As a measure of the care taken, the By Laws drafted were approved by Industry Canada with no changes.

Members are unlikely to see any significant change in the operation of the Society.. Formal arrangements have been made to continue to use the office services of the CNA, so the address will remain the same and Sylvie Caron will continue to be the day to day contact person. It is also intended to continue to work together with the CNA when appropriate. There will be a change this year, however. When the CNA cancelled its Annual Conference to support PBNC'98, the CNS decided to hold its own Annual Conference in October.

A special aspect that will be pursued is the question of membership by staff of the AECB. Several years ago that organization forbad its staff from joining the CNS because of its legal connection with the CNA, which the AECB considers as a "lobby" organization.

All members of the former CNS are members of CNS "incorporated". Hopefully, all will take pride in the new legal status of our Society and will help it become an even more effective voice and agent for those working in or with the Canadian nuclear program.

Fred Boyd

CNS president Ben Rouben (2nd from left) and CNA chairman Ernie Card shake hands after the CNA Annual General Meeting, May 4, 1998, at which the CNA passed the necessary motions to open the way for the incorporation of the CNS. With them are Murray Stewart, CNA president (L) and Paul Thompson, CNS president-elect.

Cover Story
Babcock & Wilcox Canada

Providers of Steam Generators Past, Present and Future

by J.C. Smith[1]

Ed. Note: *This article is presented as part of our intended series of prifiles of some of the organizations within the Canadian nuclear program. In this case we are taking the easy route of re-printing a paper prepared by a member of the target company, Babcock & Wilcox Canada*

Babcock & Wicox Canada is part of the large Babcock & Wilcox Power Generation Group with headquarters in the USA and plants around the world. The Canadian company, whihc operates quite independantly, has its major plant in Cambridge, Ontario, whihc has over 1600 employees. The plant builds fossi-fuelled boilers as well as nuclear steam generators.

Introduction

Nuclear steam generators in both CANDU reactors and Pressurized Water reactors (PWR's) perform the same function, and are geometrically similar. (See Figure 1). Babcock & Wilcox Canada has supplied more than 200 steam generators to CANDU reactors in Canada, and worldwide, and is also using the same technology which evolved from 40 years of design, manufacturing and operational experience with the CANDU steam generators for supply of replacement steam generators to PWR's, to date entirely in the USA. Including steam generators fabricated in co-operation with local partners such as Hanjung in Korea, B&W Canada has contracted for 223 CANDU steam generators, and 34 PWR replacement steam generators to date.

The steam generators designed in the early part of this 40 year history have had a reasonably good operating history, compared to worldwide standards. However, B&W Canada has constantly worked on improvements to the product. The product which has evolved from the 40 years of experience is currently being supplied to the US PWR replacement steam generator market and current CANDU projects. Further evolution is anticipated in the future, and this paper will also address what is seen as future steam generator trends.

Historical Steam Generator Performance

Some of the earliest steam generator experience by Babcock & Wilcox Canada was at the NPD reactor in Rolphton (shut down in 1987) and at the KANUPP plant in Pakistan (still in operation). However, the most detailed feedback from operation is at the Pickering, Bruce, Darlington, and earlier 600 MWe CANDU plants. The following is a summary of the steam generators and their performance by plant:

Pickering:

Reactor rating: 515 MWe
SG's per reactor: 12
Approx Wt. Per SG: 80 tons
No. of tubes/SG: 2600
Tube size: 13 mm
Tube Material: Monel 400
Tube supports:

Pickering A: CS Lattice grids	Startup 1971-1973
Pickering B: CS Broached Plates	Startup 1984-1986

Plugging through end of 1996: (plugged tubes per reactor, out of 31,200 tubes/reactor) (Ref 1)

Unit 1	115	Pitting under sludge: (Phosphate treatment 1st 3 years operation)
Unit 2	3	
Unit 3	1	
Unit 4	0	
Unit 5	1913	Pitting under sludge in tube supports. Stopped by chemical cleaning performed in 1992.
Unit 6	4	
Unit 7	0	
Unit 8	21	

The performance of Pickering has generally been good. The serious chloride pitting problem in Unit 5 demonstrated two things:

1. Sludge will accumulate relatively quickly in broached plates compared to lattice grids
2. Monel 400 is susceptible to chloride pitting. Monel 400 had stood up very well in Pickering A, and the view that it was impervious to corrosive attack was suddenly changed. When pitting was

1) Director, Nuclear Steam Generator and Component Marketing, Babcock & Wilcox Canada

searched out under tubesheet sludge in Pickering 1 in 1994, the resultant plugging (shown above) was essentially the first serious plugging in the 25 year + history of Pickering A.

The Pickering units have integral preheaters. There has been no fretting whatsoever in the preheaters. There has been no U-bend support fretting. It is believed, however that this is partially due to the circulation (Units are designed for a circulation ratio of about 5.5) possibly being lower than predicted due to separator carryunder. Separator carryover is judged as acceptable, although not exceptional. The separators used at Pickering (IMP model) are adapted from fossil fuel boilers.

Bruce:

Reactor rating: 769 MWe (Bruce A) 860 MWe (Bruce B)
SG's per reactor: 8
Approx. Wt. Per SG: 150 tons (Bruce B)
No. of tubes/SG: 4200
Tube size: 13 mm
Tube Material: Alloy 600, HTMA + Stress Relieved
Tube Supports: CS Broached Plates:
Startup: Bruce A: 1977-1979
Bruce B: 1984-1987

Plugging through end of 1996:

Unit 1:	59	
Unit 2:	1861	Lead induced cracking from secondary side at tube supports
Unit 3:	56	
Unit 4:	54	
Unit 5:	107	Fretting at AVB's
Unit 6:	32	
Unit 7:	110	Fretting at AVB's
Unit 8:	61	Fretting at AVB's

In early years of operation, the Bruce SG's have been good, but after some aging, problems have shown up. The broached tube supports are accumulating sludge, and extensive lancing has been required in tube supports, U-bend supports, etc. Although the amount of actual plugging to date appears quite low (except for Unit 2 which experienced a unique lead ingress problem), there is extensive circumferential cracking at the tube roll transitions, from the secondary side in virtually all of the SG's. This leads us to conclude that Alloy 600 will fail eventually, even in a HTMA condition with stress relief, and with relatively low T-hot (T-hot at Bruce is 579 F). The fretting in Bruce B which is not seen in Bruce A is likely contributed to by the use of a newer generation of GXP primary separators in Bruce B, which work better in the carryunder area and hence deliver more flow to the U-bend region. The separators in Bruce B are showing signs of flow-assisted corrosion in several areas. The cracking of the alloy 600 is cause for consideration of replacement of the steam generators at Bruce.

Darlington:

Reactor rating: 881 MWe
SG's per reactor: 4
Approx Wt. Per SG: 380 tons
No. Of tubes per SG: 4664
Tube size: 15.9 mm
Tube Material: Alloy 800
Tube supports: SS Lattice Grids
Startup: 1990-1993

Tube Plugging through end of 1996:

Unit 1:	0
Unit 2:	0
Unit 3:	0
Unit 4:	10

The performance of these units has been quite good. Although it is not yet reflected in the plugging statistics, there is now evidence of some U-bend fretting at Darlington. The Darlington separators, labelled "CAP-1" design, have performed very well (carryover measured at 0.06%) and were the model that later separators ("CAP-2" and "CAP-3") used in the PWR replacement SG's were modelled from. The PWR replacement SG's also use lattice grids and U-Bend supports derived from the Darlington design. The Bruce experience caused B&W Canada to move back to lattice grid tube supports, and non-restrictive flat-bar U-bend supports.

CANDU 6 Units

B&W Canada has supplied (or is in the process of supplying) steam generators for: Pt. Lepreau, Gentilly II, Cordoba (Argentina), Wolsong 2,3, and 4 (Korea), Cernavoda 1&2 (Romania), and Qinshan 1&2 (China). In the case of the Wolsong and Qinshan units, the design is by B&W Canada, and fabrication is split between B&W Canada and Hanjung (Korea).

Reactor rating: 680 MWe
SG's per reactor: 4
Approx wt. Per SG: 240 tons
No. of tubes/SG: 3530
Tube size: 15.9 mm
Tube material: Alloy 800
Tube Supports:

Cordoba: CS broached	Startup 1984
Lepreau, Gentilly II: SS broached plates	Startup 1983
Cernavoda, Wolsong, Qinshan: SS Lattice Grids.	Startup 1996-2002

Tube Plugging through end of 1996:

Pt. Lepreau	48	Primarily pitting
Gentilly II	3	

Cordoba 10
Cernavoda 1 0
Others: Not yet in operation

Generally, the performance of these steam generators has been good. In the newer units, from Cernavoda onwards, the SS lattice grid design has been adopted, as well as newer generations of CAP separators (CAP-2 and CAP-3). The MWe output of Cernavoda, from startup, has been higher than expected, contributed to by the efficiency increase from the very low carryover from the CAP separators. Similar MWe output increases have been detected at every PWR into which B&W Canada replacement steam generators have been installed. Although the steam separator type used in Pt. Lepreau, Gentilly II, and Cordoba is the same type as used in Bruce B, the flow assisted corrosion detected at Bruce B has not as yet been seen in the CANDU 6 units. There is a level of concern about Pt. Lepreau due to its history of phosphate water treatment, and seawater cooling. There is sludge in the steam generators (tubesheet, first 2 tube support plates) and there has been pitting under the sludge. The problem has mainly been that the pitting has resulted in an unusually high number of leak-related forced outages. Otherwise the CANDU 6 SG's have performed well.

Design Synthesis for PWR Applications:

The design decisions in the PWR RSG's evolved as follows:

Tubing: All of the SG's being replaced by B&W Canada had either LTMA or HTMA Alloy 600 tubing. The objective in B&W Canada's RSG designs is to provide a RSG with the BWC features but without changing the overall shell geometry. Therefore, drastic changes to thermal performance of tubing (from that of alloy 600) are undesirable. Alloy 690 has a lower thermal conductivity than alloy 600, but equal or higher strength, depending on the exact specification. Alloy 800 has considerably lower conductivity than alloy 600, lower strength, and has shown signs in the laboratory of susceptibility to chloride cracking and pitting, and caustic cracking (cracking in alloy 800 has not been observed in the field). Properly specified, alloy 690 is immune to virtually every imaginable steam generator water chemistry, except some of the most aggressive lead-caustic combinations. B&W Canada therefore elected to use alloy 690 in all PWR replacement steam generators.

Tube Supports: Due to the relatively good performance of B&W's lattice grid SG's compared to the broached plate units, B&W Canada is using exclusively SS lattice grids and flat-bar U-bend supports in its PWR Replacement Steam Generators.

Separators: The latest generation of CAP separators developed by B&W Canada, the CAP-3, have been laboratory tested full scale, full flow in steam and water, to steam flows of 7.5 kg/sec/separator, whereas the most heavily loaded separators in operation see only 5.3 kg/sec/separator steam flow. Therefore, there is a margin of over 40% between actual and tested conditions. The B&W Canada separators in RSG's have performed very well, in some cases showing carryover as low as 0.01-0.015%. All of the PWR's where B&W Canada RSG's have been installed have reported increased electrical output (typically 7-10 MWe) at constant 100% reactor power due to the increased plant thermal efficience from the very dry steam.

Maintainability: On thing learned from past experience with steam generators is that steam generators will always need maintenance, and the best plan is to accommodate maintenance right from initial design. All of B&W Canada's replacement steam generators incorporate:

- numerous large handholes above the tubesheet face.
- numerous inspection ports in the shell from which the tube bundle can be viewed and accessed. In some steam generators there are 2 inspection ports at every tube support elevation, plus U-bend inspection ports.
- manway, handhole and inspection port designs which allow use of automatic stud tensioning equipment.
- permanent access tunnels through the separator modules to allow access to the tube bundle and feedwater header without removing any separators
- permanent row/column markings on the tubesheet for remote video placing of eddy current probes.
- no free-lane obstructions to water lancing at the tubesheet elevation..recessed blowdown headers are used exclusively.
- in some of the more recent RSG's, extensive use is being made of forged shell sections (vs. plate) in order to reduce periodic in-service inspection requirements.

Steam Generators replaced to date by Babcock & Wilcox Canada

Plant	# of SG's	Startup Date (with B&W RSG's)
Millstone 2	2	1992
Catawba 1	4	1996
Ginna	2	1996
McGuire 1	4	1996
McGuire 2	4	1997
St. Lucie 1	2	1998
Byron 1	4	1998
Braidwood 1	4	1999
D.C.Cook 1	4	2000
Calvert Cliffs 1	2	2002
Calvert Cliffs 2	2	2003

Future Trends in Replacement Steam Generators

To date all SG's replaced by B&W Canada have been those with mill annealed alloy 600 tubing. However, there is evidence that steam generators with mill annealed plus heat treated alloy 600 tubing may yet require replacement. This category of steam generators includes:

- Bruce A and B steam generators (HTMA + Stress relief at 1125°F)

A B&W Canada replacement steam generator is shown on a special railway car for shipment to a nuclear plant in the USA

- B&W Once Through Steam Generators (OTSG's) at seven operating PWR's in the US.
- Steam generators in 16 other US PWR's where the present SG's have alloy 600 tubing with thermal treatment (7 of which have already replaced SG's once).
- This is in addition to 17 US reactors presently running with alloy 600 MA where no commitment to SG replacement has been made.

In many cases, a commitment to SG replacement in the US will be tied integrally to licence renewal. The US NRC has recently begun receiving licence renewal applications, and has taken steps to make the process of license renewal both faster and more predictable. As the US Utilities work through deregulation, and stranded cost issues, license renewal will be an more popular way to get the maximum benefit out of the relatively new nuclear plants with thermally treated alloy 600. However, this will result in some additional SG replacements as it becomes apparent that thermally treated alloy 600 has limitations.

Conclusions

Based on over 40 years of designing, fabricating, and maintaining nuclear steam generators, B&W Canada has evolved a high reliability design for either new or replacement steam generators. It appears that there is going to be a future demand for such products, in new plants, plants with alloy 600 MA tubing (replacements), and also plants with alloy 600 with either Stress Relief (B&W plants) or Thermally treated tubing. All replacements are anticipated to have Alloy 690 tubing.

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1. Dow, B.L. Jr., "Steam Generator Progress Report Revision 13", Research Project WO3580-06, EPRI, October, 1997
2. Klarner, R. et al, "Design and Performance of BWC Replacement Steam Generators for PWR Systems", Proceedings of 1998 CNS 3rd International Steam Generator and Heat Exchanger Conference, Toronto, June 1998.

PBNC'98

With almost 700 delegates from countries around the Pacific rim, excellent organization and exceptional weather, the 11th Pacific Basin Nuclear Conference was an unqualified success

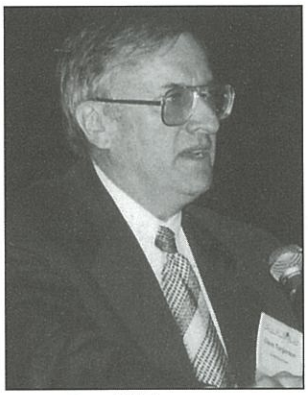
Close to 700 delegates from 29 countries descended on Banff, Alberta, May 3 to 8, 1998, for the **11th Pacific Basin Nuclear Conference (PBNC'98).** This was only the second time this large, international, bi-annual event, which brings together representatives of the nuclear industry in countries around the Pacific rim, has been held in Canada. Unseasonably warm weather and the attractive mountain setting enhanced the enjoyment of this very well-organized and run meeting.

Hans Blix

The official theme of the conference was: *International Cooperation in the Pacific rim for the 21st Century.* However, two topics were predominant, in the plenary sessions and throughout the conference

- the opportunity for nuclear power in the context of the Kyoto protocol on green-house gases,
- the on-going problem of public acceptance (or lack thereof).

In addition to these pervasive topics, the several plenary sessions also dealt with: financing, regulation, international cooperation, nuclear power plant performance, and non-power applications. The almost 200 technical papers presented covered a wide range of subjects, such as: nuclear power plant operation and maintenance; fuel and fuel cycles; decommissioning; waste management; training; and radioisotopes.



David Torgerson

An exhibition which ran concurrently with the conference had 25 organizations displaying their wares or services.

In the conference keynote address **Reid Morden,** president of Atomic Energy of Canada Limited, spoke of the opportunity presented by the greenhouse gas problem. What is new, he said, is the emerging scientific and political consensus that global warming is not simply a theory but reality. "Not only is nuclear power relevant to sustainable development", he said, "but sustainable development simply will not triumph without nuclear power". On the question of public acceptance, Morden acknowledged that the nuclear industry had done an "abysmal job" in getting its message out. *(Ed. Note: With no mention of the CNA public information program that had been killed a year or so ago.)* "Let's de-mystify the myths", he urged, "let's make nuclear power familiar, not foreign", He identified three ongoing challenges for nuclear power: financing; waste disposal; public education

Hans Blix, former director-general of the International Atomic Energy Agency, commenting on the growing need for energy, especially electricity, also emphasized the potential of nuclear power in reducing greenhouse gas emissions. He pointed out, however, that the Kyoto protocol makes no mention of nuclear. "Efforts must be made to inform and educate", he said in closing, referring to governments, political parties as well as the public. He, and others, observed that the only countries with continuing nuclear power programs were on the Pacific rim - China, Japan, Korea, Taiwan.

Two speakers from the USA, **James Levine,** sr.v.p. of Arizona Public Service Co., and **Marvin Fertel,** v.p. NEI, were somewhat optimistic, saying that there was a changing attitude in the USA, partly associated with the "greenhouse gas" problem, and that, in there opinion, nuclear power was on the verge of a new future..

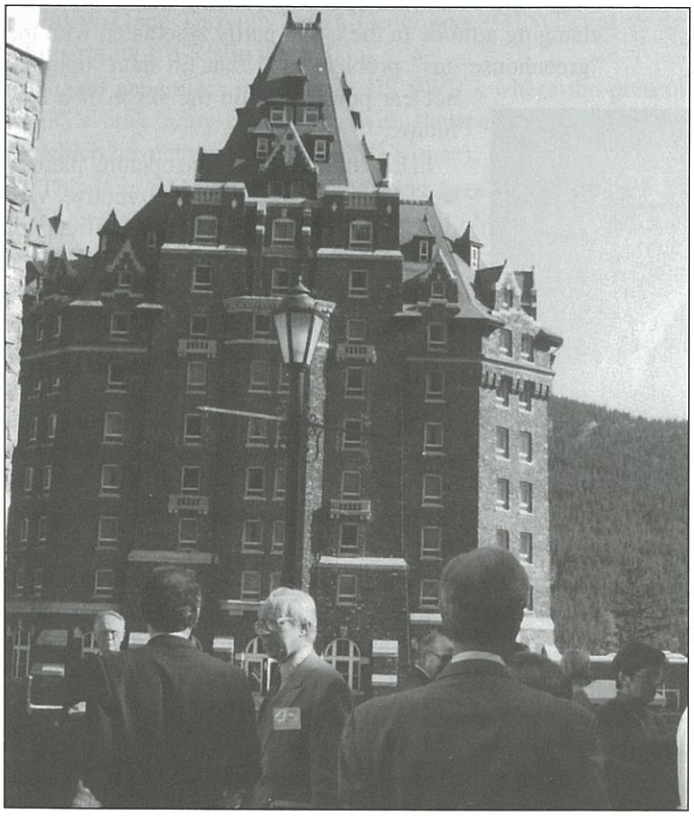
In his address during the opening plenary session, **Carl Andognini,** executive vice president and chief nuclear officer of Ontario Hydro, gave an overview of the nuclear recovery plan to restore the utility's nuclear power plants to operational excellence. He said his timetable is to have all engineering and maintenance backlog completed by the summer of 1999. The decision on re-starting the four Pickering A units would be made at that time also. Later, he and **Warren Peabody**, another member of the team brought in to turn around Ontario Hydro Nuclear, gave an extended presentation on the Independent Integrated Performance Assessment (IIPA) and the Nuclear Asset Optimization Plan (NAOP). Their emphasis on the former, highlighting all of the problems identified at OHN, visibly disturbed many delegates

Bernard Michel, president and CEO of Cameco Corporation, the world's largest uranium company, said the next decade was reasonably predictable for his indus-

try but beyond that there are many uncertainties. Existing uranium inventories are limited, he said, but the low price of uranium precludes much exploration.

Dr. Agnes Bishop, president of the Atomic Energy Control Board, cautioned that public education or information programs would not lead to greater public acceptance. Quality management of nuclear power plants must be demonstrated, she stated, and it must occur in all countries with nuclear power plants. What happens in one country, she warned, will influence public opinion in all other countries.

Among the many technical sessions, one that had broad interest was on the **Health Effects of Low-Level Radiation.** Three of the four papers advocated abandonment of the "linear no-threshold" (LNT) hypothesis for the effect of low doses of ionizing radiation. (That hypothesis assumes that any amount of radiation will have a deleterious health effect proportional to that observed for high doses.) **Dr. Theodore Rockwell** asserted that application of LNT leads to absurd and grossly over-conservative predictions of harm and that it has prevented many beneficial uses such as food irradiation. **Dr. Myron Pollycove** said that recent research showed that the human biosystem adapts to low doses of radiation with increased activity, resulting in lower cancer mortality. **Dr. Sadao Hattori** discussed a ten-year research program in Japan on hormesis, i.e., stimulative and beneficial effects of low doses. In contrast, the paper by **Drs. Norm Gentner** and **Richard Osborne** of AECL Chalk River, expressed caution. While acknowledging that the basis for LNT is not solid they argued that statistical limitations prevent a definitive answer and suggested that further radiobiological and epidemiological studies are needed before the conservative LNT model should be discarded.



Delegates to PBNC '98, May 3-7, 1998, enjoy a break against the backdrop of the Banff Springs Hotel.

An interesting panel session on waste management included **Blair Seaborn,** chairman of the environmental assessment panel that issued, this past spring, a controversial report on the proposed concept for deep geological disposal of nuclear fuel waste. (See Vol. 18, No. 1 issue of the *CNS Bulletin.*) Other panelists included **Chang Sun Kang** of Korea; **Atsuyuki Suzuki** of Japan; **Lake Barnett** of the USA; and **Udi Imardjoco** of Indonesia. While most of the panelists agreed that high level radioactive wastes could be managed and disposed safely with today's technology, Seaborn re-iterated the message of his Panel's report that public acceptance was an over-riding criterion.

In his closing remarks, conference chairman, **David Torgerson,** re-stated the view that there is a growing recognition that burning of fossil fuels to generate electricity is a leading contributor to global warming. With that recognition, nuclear power is emerging as the electricity choice in Asia-Pacific. However, he and others acknowledged that the industry can not rest on its technological advantages but must do more to educate and convince the public of the environmental benefits of nuclear power. **Stan Hatcher,** president of the American Nuclear Society and honourary chairman of the conference, emphasized the need for nuclear to become economically competitive. Others repeated the message of Dr. Bishop that nuclear plants must be operated very safely and economially to win public support.

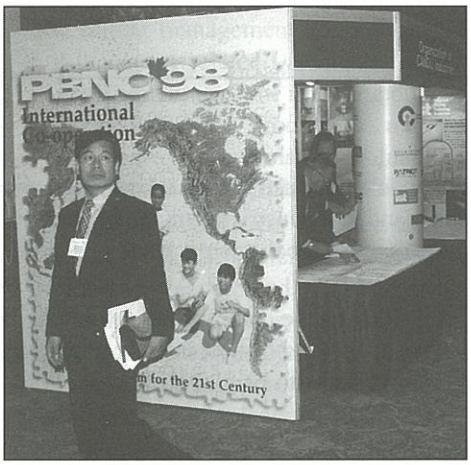
As a relief from all of the serious technical sessions there were a number of social events at which delegates could just enjoy themselves. An excellent reception was held at the Banff Springs Hotel, the venue for the conference, on the Sunday evening, prior to the official opening, that provided an enjoyable setting for renewing acquaintances. A beer and pretzel gathering was sponsored by the exhibitors at the end of the Tuesday sessions. Then, on the Wednesday evening, in place of a traditional banquet, delegates and guests were bussed to a nearby ranch for a "Western Night" that included a mock "shoot out", a hearty barbecue, and dancing to country music. Throughout the conference refreshment breaks were held in the exhibition area, providing delegates an opportunity and incentive to examine the exhibits.

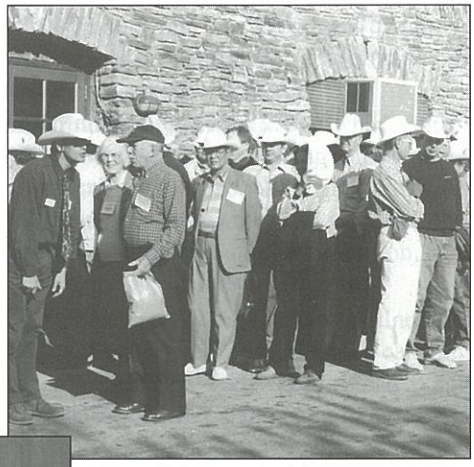
Taking advantage of the presence of many international delegates, the Pacific Nuclear Council and the International Nuclear Societies Council held meetings on the Sunday prior to the opening of the conference

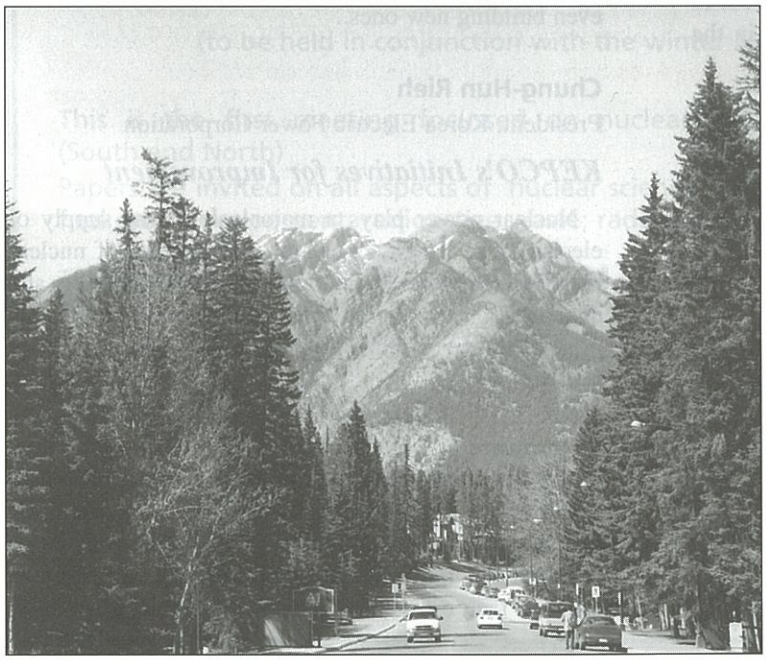
The Pacific Basin Nuclear conferences are presented under the auspices of the Pacific Nuclear Council. PBNC '98 was sponsored by the Canadian Nuclear Association and the Canadian Nuclear Society, with significant contributions from AECL and Cameco and support from 24 other organizations. **David Torgerson,** of AECL, was the overall chairman for this very well planned and executed conference, and **Paul Fehrenbach,** also of AECL Chalk River, was chairman of the Technical Program Committee.

At the close of PBNC'98, **Dr. Chang Kun Lee,** of the Korean Atomic Energy Commission and chairman of the next conference in the series, invited everyone to the 12th PBNC in Seoul, Korea, in October of the year 2000.

Views of PBNC '98







Messages from PBNC'98

Ed. Note: *There were many thoughtful presentations at the 11th Pacific Basin Nuclear Conference (PBNC'98) held in Banff, Alberta, in early May 1998. To provide readers with some insight into the nature and diversity of the views expressed, following are a few excerpts from talks by a few people in senior positions in various countries.*

Neville Chamberlain

Deputy Chairman, BNFL plc

Nuclear's Contribution to Sustainability

Undoubtedly, the biggest potential environmental threat to the world today is from the effects of global warming. The long-term impact of society's discharges of greenhouse gases into the atmosphere is still uncertain. What is increasingly certain is that the impact is real, is beginning to have discernible effects and the great majority of scientists agree that the consequence could be catastrophic. The agreement made at Kyoto last December to cut emissions by 5% from the 1990 level by 2012 was a small but very important step in that it was the first legally binding agreement on governments. *(Ed. Note: The Canadian agreement was for a 6% cut.)*

That target will have little impact if, as feared, the greenhouse effect is real. We need a global 60% cut in emissions simply to stabilize the levels of CO2 in the atmosphere

What I find absolutely staggering is that none of the official statements from Kyoto mentioned "nuclear". That is what we have to change. Many governments recognize that nuclear energy must have a role to play but are frightened. The nuclear industry has to prepare them better, to give them confidence, and to arm them with the necessary arguments so that at future conferences on climate change a balanced argument will be put.

In Kyoto, for the first time, nuclear industry presented itself, admittedly in the fringes. A new organization emerged, the International Nuclear Forum, embracing the NEI, the Uranium Institute, European Atomic Forum and the Japan Atomic Industry Forum. A unified voice from the nuclear industry was presented, and, although most of the participants at Kyoto tried to ignore that voice it was heard. I believe progress was made. At COP-4 in Buenos Aires in November it is essential that the nuclear industry talks coherently, non-confrontationally, and in a constrictive manner, presenting itself as part of the global energy strategy for the future.

The issue of CO2 in the atmosphere is clearly a global one. Our campaign to promote nuclear energy as part of the solution has also to be global.

James Levine

Senior vice-president, Arizona Public Service Co.

The Need for Operational Excellence

Safe, efficient and predictable operation is the silver bullet to the demons of our business. When we operate as we should - and as we know we can - the rest will take care of itself. Experience has shown that the benefits our industry brings to society are easily overshadowed when we don't uphold our end of the bargain.

There is no inherent reason why every [nuclear] plant shouldn't turn in capacity factors of 95 percent in non-outage years.

With the kind of operational proficiency that I know we can achieve I see a time when plant life extension is a common occurrence. There is a broad recognition in my country [USA] that, with the growing concerns over global climate change, we must have the option of keeping as many nuclear plants operating as possible, and even building new ones..

Chung-Hun Rieh

President, Korea Electric Power Corporation

KEPCO's Initiatives for Improvement

Nuclear power plays a major role in the supply of electricity in Korea. Excellent performance of nuclear plants yields more efficient production of electricity and enhances public confidence in the safety, economic competitiveness, and environmental advantages of nuclear energy.

One basic indicator of the technical and economic performance of a nuclear plant is capacity factor. Great efforts have been made to improve the availability and safety of nuclear power plants in Korea. As a result, the Korean nuclear power plants have shown remarkable performance improvement. For instance, the average capacity factor in 1996 was 87.5%, sustaining over 80%

level for the last six consecutive years.

KEPCO has implemented a comprehensive program for improving plant performance, which can be listed as follows:

- **Management by Objectives (MBO) system:** This is done by setting management goals for capacity factor, reliability of the safety related systems, eliminating unscheduled outages, shortening of the refueling outage periods, reduction of radioactive waste production, and quality control. These goals serve as the basis for evaluation of plant performance and contributions of plant personnel.
- **Systematic feedback of operating experiences:** Events, operation and maintenance experiences, good practices, findings or recommendations and results from the evaluation of in-house, regulatory and outside organizations are systematically incorporated into plant procedures, goals, and plans. Also this information is quickly disseminated to the all other nuclear plants.
- **Enhancement of nuclear safety culture:** This is a basic element for high-level safety and good performance. We incorporated this concept in training courses as a process for learning from experience and for feeding back such lessons into improvement of operations, with no culture of blame. Safety culture is taught in every training class as a compulsory subject. Special training courses for safety managers and personnel of nuclear power plants and assessment system were developed and implemented.
- **Quality management:** Quality policy, strategy and objectives are established and implemented. Also a training course for this was set up to upgrade quality management. We encourage our people to achieve quality goals by applying the quality objectives in evaluating the performance of our nuclear power stations.
- **Utilization of benchmarking techniques:** We have introduced benchmarking techniques for making our nuclear plant management a world class level. Benchmarking was applied to the administrative organization performance, plant operation, radiation control, refueling duration, and other areas.
- Improvement and Replacement of Aged or Vulnerable Equipment: KEPCO's research institute , KEPRI, is carrying out a plant lifetime management study for the lead plant, Kori Unit 1, to develop lifetime management strategies and technologies for life extension.

Comparative Costs of Electricity Generation: A Canadian Perspective

by Brian Moore and Sylvana Guindon[1]

Ed. Note: *Following is a slightly edited version of a paper which was originally presented at the 11th Pacific Basin Nuclear Conference, in Banff, Alberta, May 1998*

Electricity Production in Canada

Total electricity generation in Canada in 1996 was 547.8 TW.h, with over 60% supplied from hydro, 16 percent from nuclear and 20 percent from fossil fuels, primarily coal. Domestic electricity demand is projected to grow at an average annual rate of 1.0 percent for the next twenty five years, a much lower ratethan the 2.6 percent annual growth rate witnessed during the last fifteen years. Significant excessgenerating capacity currently exists in all regions of the country, leading to a situation where no additional baseload generating capacity is likely to be required until about the year 2010.

Canada's electric power industry is entering a period offundamental change toward a more competitive, deregulated market. The restructuring of electricity markets is expected to lead to a lowering of retail electricity prices over time, thereby increasing competitive pressures on generators to produce electricity at the lowest possible cost. Thus, when new capacity is required, average production costs per unit will be a significant investment criteria.

The Levelized Unit Energy Cost (LUEC) Methodology

The Levelized Unit Energy Cost (LUEC) approach to the comparative economics of various generating options focusses on the discounted life-cycle average cost per unit of electricity produced taking into account all capital and operating costs. This all-in unit cost of producing electricity can then be used as one measure of the relative attractiveness of each option.

Capital, operating and maintenance (O&M) and fuel costs vary widely for different generating options and technologies. Costs can also vary from station to station, from design to design and from year to year for a given option for different types of plants. LUEC adopts common assumptions for the main technical and economic parameters (eg. plant life, capacity utilization factors) in order to provide a consistent framework for comparing the cost of electricity from different energy sources and different technologies.

LUEC is defined as the discounted average cost of producing electricity from a power plant over its anticipated operating life, and is expressed in terms of cents or mills per kWh. costs. LUEC is also helpful in analysing major capital investments in existing plants to determine whether the plants are financially amenable to refurbishment and life extension.

While the LUEC approach is extremely useful for comparing various investment options, utilities do not make planning decisions solely on the basis of average unit production costs. The utility must do a complete study of its options and the markets in which it operates including, supply-demand balances, price outlooks for fuels, potential timing and impacts of technology improvements, rates of return, payout periods and other factors. Most recently, greenhouse gas emission reduction obligations under the Kyoto Protocol may constrain future electricity generation choices.

International studies provide an indication of the relative economics of the various generating options within and between countries. However, caution is advised in the application of LUEC in assessing different technologies and in comparing costs between regions and countries because of fluctuating exchange rates and of variations in design and site requirements, capital, fuel and O&M costs. As well, there are differences in regulatory and legislative frameworks, infrastructure and site specific conditions, economic assumptions such as material and labour costs, and policies, such as those relating to fuel management, etc. The most meaningful comparison is one in which specific plant types meeting the requirements of a country or region are costed in that particular country or region on a common basis.

LUEC and Different Generating Sources

The LUEC methodology enables one to vary capacity factors, operating lives, interest (or discount) rates and other key factors to assess the impact of different assumptions on costs. Changes in fuel, capital and O&M costs also have varying effects on unit costs for different generating options.

Hydro and nuclear electricity costs are dominated by capital costs and are very sensitive to the time taken for plant construction, interest rates on borrowed funds,

1 Natural Resources Canada

explicit or implicit return on equity, changes to the regulatory regime, and price changes for equipment, material and labour during the construction period. The high up-front capital costs result in greater investment risk if there are construction delays or cost overruns. The high up-front capital cost of hydro and nuclear plants is counter-balanced by the low fuel and water rental costs.

To be economic, nuclear plants must have increasingly larger capacities, which increase capital requirements, and therefore financial exposure. During periods of low or uncertain load growth, the financial risk may be too substantial to order a large, high cost plant that will only come into service in six to ten years.

Once built, nuclear plants are in principle relatively immune to inflationary pressures, but their cost efficiency over a 30 or 40 year lifetime will depend on their capacity utilization factor. A high level of power output is needed to provide adequate returns on investment. It is for this reason that the nuclear option is particularly suited to meeting base load demand. Although the performance record of nuclear power plants has been generally improving, any lengthy shutdown, with attendant high-cost repairs, exposes reactor owners to financial exposure not faced by owners of low capital cost stations.

Coal and gas-fired plants, which are less expensive to build, carry a higher risk on variable operating costs, such as fuel prices and availability of fuel. The LUEC data supplied by Canada for the 1997 Nuclear Energy Agency/International Energy Agency (NEA/IEA) *Generation Cost Study* shows that fuel costs represent over 68% of the total LUEC for the combined cycle gas station while capital cost represents only 25% of the LUEC. On the other hand, for nuclear stations, fuel cost represents about 9% of the total LUEC while capital costs represent about 66% of the total.

All types of plants are facing increasingly stringent regulatory and environmental controls. Efforts are underway in various for a to find ways of internalizing the costs of many impacts that were previously considered external. The nuclear industry believes that it has largely internalized its safety, environmental and waste management costs and that this internalization is reflected primarily in the relatively high capital costs for the stations.

On the other hand, emissions of greenhouse and sulphurous gases have not been internalized even though they are significant. Studies by Natural Resources Canada (NRCan) show that in 1996, nuclear energy reduced electric utility emissions in Canada by about 50%. In other words, emissions were about 50% lower than they would have been if fossil fuels had been used instead of nuclear generation in 1996. Table 1 summarizes the impact of nuclear generation on Canadian emissions from the electric power sector in1996.

Emission Type	Acutal Electricity Sector Emissions (tonnes)	Emissions Avoided by Nuclear Plants	Emissions Reduction in the Electricity Sector (%)
CO2	91552000	81900000	47%
NOX	5000	222200	52%
VOC	1774	1497	52%
CH4	CH4	526	41%
41%	497000	491200	49%

Table 1 Emissions Avoided from the Use of Nuclear Energy in 1996

Over the period 1971-96, electricity generated by Canada's nuclear plants have avoided 1,222 million tonnes of carbon dioxide emissions alone. The impact on comparative costs of these emissions merits further study and the LUEC approach could be a useful tool for this type of analysis. The impact of these costs on LUEC are not discussed in this paper, nor are external costs associated with the construction of hydro plants. Limitations and levies on air emissions could render coal and gas-fired generation considerably more expensive.

Studies using LUEC

Canadian utilities, the National Energy Board (NEB) and NRCan make use of LUEC, as do international energy organizations such as the Nuclear Energy Agency (NEA) of the OECD and the International Energy Agency (IEA). Recent LUEC studies by NRCan and the NEA/IEA differ in their assumptions, their scope, their purpose, the time at which they were done and the timing of the projects they consider. Consequently, they give somewhat different results. Nonetheless, some fundamental common trends emerge from these studies.

NRCan's specific interest in using the methodology is to better understand the factors impacting on costs of baseload generation options available in Canada in the medium term. NRCan's most recent study, undertaken in the mid-1990's, used as the reference case an in-service date of 2000, a 75% capacity factor (except for hydro plants), a 30 year life (except for hydro plants) and a 5% real discount rate. NRCan uses its model to:

(1) run Canadian utility data submitted to the NEA/IEA;
(2) run reference cases using NRCan fuel price projections (for gas, coal, nuclear and hydro plants as well as renewable sources of energy).
(3) run sensitivities to determine the impact on all plants of changes to discount rates, capital costs, capacity factor, fuel price and operating life.
(4) assess the comparative costs of refurbishment.

The 1997 NEA/IEA study, is the fifth of a series completed roughly every three years beginning in 1983. In the 1997 study (not as yet published), the NEA/IEA used data provided in 1997 by 16 OECD and 5 non-OECD countries. It focuses on baseload nuclear, fossil, renewable plants and new technologies pertaining to all fuel types. Hydro is not considered in this study as its costs tend to be site-specific.

There are cost differences between regions and countries with respect to capital, O&M and fuel cost inputs. The studies require participants to use some common economic and technical variables for all types of stations; the 1997 study required participants to provide cost data for a 75% capacity factor, 5 and 10% real discount rates and a 40 year operating life.

Results of the Studies

Natural Resources Canada:

The NRCan study results at the 5% and 10% real discount rates for gas, coal, nuclear and hydro show that:

- There are strong regional differences in Canada. Fossil-fired generation in western Canada, for instance, have the lowest LUECs.
- At the 5% real discount rate, LUEC was lower for nuclear than for coal and natural gas in Central Canada; the ratio of nuclear to coal is about 0.80. Nuclear power loses its advantage over coal at the 10% real discount rate.
- In Central Canada, the LUEC for a gas-fired plant was significantly higher than coal and nuclear at both the 5% and 10% real discount rates.
- Nuclear energy is a competitive baseload source of electricity in regions of Canada without immediate access to low-cost fossil fuels and large base-load hydro resources.

It is anticipated that the results of current studies, to be completed by the spring of 1998, will show a significant reduction in the LUEC for natural gas in Central Canada.

Table 2 presents LUEC data for three different technologies: nuclear (CANDU 6 and 9), natural gas (combined cycle gas turbine or CCGT) and coal. It is assumed that both fossil stations would be located in Central Canada.

Sensitivities were run to determine the impact of: capital cost, capacity factors, fuel cost, and economic life. Nuclear and hydro were more sensitive to capital cost increases, discount rates, capacity factor and plant life than coal or gas, which are more sensitive to the cost of fuel. Lifetime extension impacts more heavily on the capital intensive nuclear plants. Capital cost decreases have a greater impact on LUEC than a lifetime extension for nuclear for a new plant. However, a life extension for an existing plant is generally more economic.

Unit	O&M	Fuel	Investment	LUEC
CANDU 9 (2x881 MWe)	8.1	3.1 23 34.2	23	34.2
CANDU 6 (2x665 MWe)	11.4	3.3	25.1	39.8
CC Gas Turbine (2x750 MWe)	2.7	30.5	11.2	44.4
Coal (4x750 MWe)	5.4	23.9	13.8	43.1

Table 2 LUEC at the 5% Real Discount Rate (CDN mils/kWh)

An economic evaluation using the LUEC approach for re-investing in the power plants at Pickering A and Bruce A was undertaken by Ernst and Young for Ontario Hydro. In the study, natural gas combined cycle plant was assumed to be the long-run price setter for base-load generation. The study shows that while refurbishment costs are high, (783$ M CDN for Pickering A, 2741$ M CDN for 4 units at Bruce A, and 878$ M CDN for units 3 and 4 at Bruce A), electricity costs from rehabilitated Pickering A and Bruce A units are competitive. However, poor performance of the units, lower than anticipated price for gas and/or higher than anticipated efficiencies for gas units could affect the LUEC for Bruce A which requires higher up-front infusion of capital.

NEA/IEA Study:

Although the NEA/IEA's update to the 1992 Generation Cost Study had not been published at the time of preparing this paper, the key findings are consistent with Canadian results.

The price of fuel is the key determining factor for coal-fired and gas-fired LUEC. Coal prices are expected to be in the $1.00 - $3.20 (U.S.) per GJ range in the year 2005 in OECD and non-OECD countries; the average real price escalation rate is estimated to be 0.3 per cent per annum. Delivered gas costs in the year 2005 are expected to be in the $1.60 US to $5.35 $US/Gjoule range and average real gas prices are expected to increase at about 1% annually over the plant life. [NOTE: these price estimates were produced before the Kyoto Protocol which could impact on estimates.] In the 1992 study gas cost was $3.50 to $4.50 per GJ range for Central Canada and in other industrial countries; prices in western Canada are much lower.

In OECD countries, the construction cost of nuclear plants is in the $ 1,500 to $2,500 US per kilowatt (kWe) while that for coal is in the$ 1,000 to$ 1350 US per kWe range. Natural gas capital costs are much lower (below $ 800$ US per kWe in most OECD and non-OECD countries). Nuclear costs are much more sensitive to the discount rate, capacity utilisation factor and economic life than coal or gas-fired plants. The NEA/IEA study results show that the estimated real nuclear LUECs for plants to be in service in about ten years remain fairly steady for most countries. Coal-fired electricity continues to be competitive because of low coal prices. Gas-fired LUECs have declined since the last study due to decreases in the estimated cost of natural gas, making gas-fired generation increasingly competitive. The ratios between cost estimates show the increasing competitiveness of gas-fired power plants versus coal and nuclear plants. Natural gas LUECs are more competitive in regions or countries with access to large, low-cost natural gas supplies. Natural gas is an attractive near-term option because of low cost, simple construction, maintenance, low fuel cost projections and low environmental emissions relative to coal.

At the 5 and 10% real discount rates, three countries, France, Japan and Korea, and Central Canada project generating costs lower for nuclear than for gas-fired plants.

CANDU LUEC (see Table 2) show that a CANDU 6 and a CANDU 9 are more economic than coal and gas in Central Canada at the 5% discount rate but not at the 10% real discount rate The nuclear/coal ratio is 0.89 for a CANDU 6 and .75 for a CANDU 9.

While the data must be used with caution, the LUEC for the CANDU 6 and the 9 are among the lowest in the OECD countries. This is due primarily to the lower fuel costs (no enrichment needed and on-line fuelling). Electricity costs in Canada, particularly gas-fired generation in western Canada, are among the lowest in the OECD countries.)

To summarize, while results are different when different assumptions are used, there is consistency in the overall relative costs of the various options. In Canada, as in other parts of the world, no one fuel will be able to satisfy demands in all regions and under all circumstances. Nuclear power remains competitive with coal and gas-fired generation in certain regions of Canada and of the world but this competitiveness has been eroded in recent years by the low cost of fossil fuels.

Outlook, Uncertainty and Externalities

What do these studies of LUEC tell about future prospects for the nuclear industry in Canada and around the world?

Economic studies show that nuclear energy is holding its own in terms of absolute costs.Increases in some cost components, such as O&M and refurbishment costs, are offset by decreases in other areas such as fuel costs. Nuclear is still competitive in some regions at low discount rates. Anything that can be done to lower the impact of interest rates, such as fast construction times and low real interest rates themselves, increase the relative attractiveness of the nuclear option.

However, coal and especially natural gas fired generation are becoming much more competitive. In the case of coal this is largely due to the reduced cost of the fuel itself. In the case of natural gas, it is due to a combination of reduction in the cost and the lower escalation rate of natural gas and also to the lower cost and improved efficiency of the technology for generating electricity from gas, along with heat in some cases.

Comparing historical LUEC estimates with experience in the real world, one notes some disparities. For instance, the assumed uninterrupted operating life has not materialized for all reactors in many countries, including Canada. When capacity factors for the Ontario Hydro stations were high in the late 1970's and early-to-mid-80's, nuclear costs were significantly less than fossil stations. This advantage faded in the late 1980's when plants had to be repaired, capacity factors fell, and fossil fuel prices dropped. The Ontario Hydro decision of August, 1997 has shown that:

(1) nuclear assets need to be maintained in order to ensure good performance and good return on the investment;

(2) the cost of maintaining nuclear assets is high when one looks at the immediate impact on balance sheet although on an LUEC basis nuclear is still competitive;

(3) one needs to balance this high cost against emissions from fossil plants.

In Ontario, there were also significant capital cost overruns which impacted on the average cost of Darlington electricity and rates charged to consumers. At the same time, the CANDU 6 units in Quebec, New Brunswick, Korea, Argentina and Romania, some of which have been operating for close to 15 years, have had very good capacity factors, and, consequently, low energy unit production costs.

There are other limitations to the LUEC methodology in its inability to take into account the full costs and benefits of the options, many of which are difficult to quantify and estimate on a per kilowatt hour basis. The following costs are not included:

- infrastructure costs (e.g., R&D),
- broader macroeconomic factors such as indirect impact on employment, and, as previously noted,
- environmental externalities, such the contribution to climate change from the burning of fossil fuels.

Many utilities in North America and in countries of the OECD and international bodies, have begun integrating these costs to arrive at the least cost mix of resources within a sustainable development framework.

Conclusions

The cost of generation will be a critical factor in the decision-making process for electric power utilities in the years ahead as plans for new capacity are made under the pressures of a more competitive, deregulated market. Technologies with low capital, fuel and operating costs, short construction schedules, capacity closely matched to load growth and minimal regulatory/public acceptance problems are generally more attractive.

As the LUEC studies show, natural gas plants require ready access to low-cost supply of natural gas in order to compete. In areas with access to large supplies of low cost natural gas, it is therefore quite likely that natural gas turbines will be chosen, perhaps in combined cycles, for the next round of capacity increases in order to minimize financial risks. Gas turbine plants are relatively quick to build, have a low capital cost and high thermal efficiency and can be written off over shorter periods of time. There is now a general expectation that natural gas's contribution to electricity supplies will increase in Canada and other OECD countries.

While natural gas plants are attractive, access to the fuel, the potential escalation of natural gas market prices due to geopolitical and other events, the release of methane into the atmosphere during extraction and transmission are additional factors to consider. Even though it is too early to evaluate the impact of the Kyoto Protocol, it is possible that it will drive up natural gas as well as coal LUECs.

From a cost perspective, the challenge for the nuclear industry in Canada is to ensure, in the short to medium term, that the existing plants reach their full operating life and that they operate consistently at high capacity factors. In the longer term, improvements which lower the capital costs of nuclear plants, decrease construction times and increase capacity utilisation factors will enhance the competitiveness of the nuclear option.

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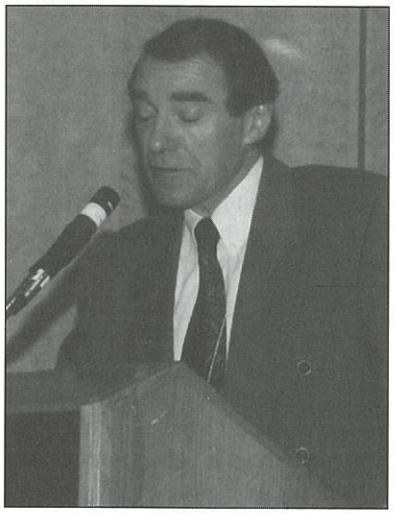
3rd International Steam Generator and Heat Exchanger Conference



Bob Tapping

Although the theme for the **3rd International Steam Generator and Heat Exchanged Conference** had been billed as: *The success of technological improvements - today and in the future,* most of the papers that were presented focussed on the many problems that continue to be experienced with steam generators in nuclear plants.

About 170 specialists from Canada and around the world registered for the Conference, which was held in Toronto, June 21 to 24, 1998. Attesting to the "international" aspect of the conference, about 40 per cent of the delegates were from outside Canada.

The attendees participated actively in the three days of paper presentations. Most of the papers dealt with the performance of steam generators in nuclear power plants and with the studies and research conducted to attempt to explain the spectrum of problems that have been experienced.. A poster session with 20 contributions, augmented the oral presentations.

On the Tuesday evening a busload of delegates were hosted by Babcock & Wilcox Canada to a tour of their large plant in Cambridge, Ontario (about a 1 hour bus ride from Toronto) followed by an excellent dinner. *(See the cover story on Babcock & Wilcox Canada experience.)*

Six sessions were run consecutively, sparing delegates the need to decide between various topics. Perhaps surprising, given the diversity of the topics, there was a very good attendance at all sessions, including the last afternoon.

The six sessons covered the following topics:

- operations and life cycle management
- operations and fitness for service
- thermal and thermalhydraulic performance
- mechanical performance
- corrosion
- secondary side chemistry

The posters were divided into three groups:

- operations, maintenance and assessment
- corrosion and chemistry
- thermal and mechanical performance

To enhance interest in the posters, coffe breaks were held in the poster room on the Tuesday and a prize was awarded for theone judged best. The prize was presented to Marc Basset from the University of New Brunswick for the poster co-authored by N. Arbreau, J. McInerney and D. H. Lister, on *Deposition of Magnetic Particles onto Alloy 800 Steam Generator Tubes.*

An underlying message throughout the conference was the importance of steam generator behaviour to the performance, i.e., capacity factor, of nuclear power plants. The complexity of the problems encountered, particularly those of corrosion, tube cracking and fouling, and deposition, was highlighted.

In the opening address, Paul Spekkens, of Ontario Hydro, noted that despite the efforts made since the first such conference, steam generators were still the source of many problems at nuclear plants. He commented that at the first conference (in 1990) the steam generators at Ontario Hydro's nuclear plants were still operating well, some after 20 years, while those in PWRs (especially in the USA) were experiencing many problems. By the time of the second conference Ontario Hydro also had similar problems with its steam generators. "The boilers are talking to us", he said, "and we must listen". He referred to the IIPA (Independent Integrated Performance Assessment) undertaken by Ontario Hydro Nuclear in 1997 and to the competitive environment now developing for the electricity market. "We must be able to operate without surprises", he stated, "operation must be predictable".

Papers from France and Germany reported on the relatively good performance of their steam generators. Particular mention was made of the proposed new European PWR, being designed jointly by the two countries, which will use a steam generator based on the ones used in the newest French N4 plants. Speakers from Babcock & Wilcox Canada proudly referred to the success the company was enjoying in providing replacement steam generators for nuclear plants in the USA.. Other Canadian speakers labelled the success of steam generator management, especially at Ontario Hydro, as "mixed".

Bob Tapping of AECL Chalk River, who chaired the organizing committee of this well run conference, summed it up as follows.

> This Conference brought together people with a wide range of disciplines who have an interest in steam generator design and operation. The intent of this conference, as in the previous conferences in this series, and indicated by the program, was to show how all these disciplines must interact effec-

tively to acheive problem-free operation. We are learning more and more about how to successfully manage ageing.

This management requires proactive life management strategies. These must involve a good understanding of the degradation mechanisms that are plausible, of the projected evolution of these in a given SG, and of how best to manage repair and remediation efficiently so that sream generators no longer contribute significantly to outage time.

Much of the knowledge gained through monitoring is being applied to new designs. For those with relatively little steam generator generator repair and remediation needs, this same knowledge can be applied to putting in place effective maintenance strategies.

The conference revealed again that chemistry control is still a major imperative, and that if Inconel 600 is used for tubing it is going to be very difficult to achieve design life. Nevertheless, there are a few steam generators with Inconel 600 tubes with many years of good service. There is still no clear understanding of the variability of Inconel 600 performance, nor whether we should expect the same from Incoloy 800 or Inconel 690 tubing.

Given this, and the operational experience presented at the Conference from around the world, it is prudent to continue to operate nuclear steam generators as if the tubing is potentially highly susceptible to corrosion. This implies the need for good chemistry control, adequate chemistry monitoring, routine inspection and frequent cleaning.

The conference was sponsored by the Canadian Nuclear Society with support from the CANDU Owners Group.

Proceedings of the full conference, including the many questions and answers which were recorded, will be available this fall from the CNS office in Toronto.

The poster session at the 3rd International Steam Generator and Heat Exchanger Conference in Toronto, June 1998, drew considerable attention.

Call for Papers

2nd International Symposium on Ionizing Radiation

Ottawa, Canada

May 10 - 14, 1999

The objective of this symposium is to bring together experts from various areas to discuss, and provide guidance on, the development and implementation of environmental protection programs in the nuclear industry.

Papers are invited on the following three main topics:

1. **Environmental; Protection Regulations, environmental Risk Assessment and Management Methods and Approaches**
2. **Public Participation in a Multistakeholder Process**
3. **Effects of Multiple Stressors**

Abstracts of no more than 500 words should be sent no later than **September 1, 1998,** to:

Symposium '99
c/o The Willow Group
582 Somerset Street West
Ottawa, Ontario, Canada K1R 5K2
e-mail: kjones@thewillowgroup.com

Symposium organized by: *Atomic Energy Control Board*
Environment Australia
Swedish Radiation Protection Institute

Regulation of Ageing Steam Generators

by B.L. Jarman, I.M. Grant & R. Garg

Ed Note: *The following is the text of a paper presented at the CNS sponsored 3rd International Steam Generator and Heat Exchanger Conference held in Toronto, Ontario, June 21-24, 1998. All of the authors are with the Atomic Energy Control Board.*

ABSTRACT

Recent years have seen leaks and shutdowns of Canadian CANDU plants due to steam generator tube degradation by mechanisms including stress corrosion cracking, fretting and pitting.

Failure of a single steam generator tube, or even a few tubes, would not be a serious safety-related event in a CANDU reactor. The leakage from a ruptured tube is within the makeup capacity of the primary heat transport system, so that as long as the operator takes the correct actions, the off-site consequences will be negligible.

However, assurance that no tubes deteriorate to the point where their integrity could be seriously breached as result of potential accidents, and that any leakage caused by such an accident will be small enough to be inconsequential, can only be obtained through detailed monitoring and management of steam generator condition.

This paper presents the AECB's current approach and future regulatory directions regarding ageing steam generators.

1.0 INTRODUCTION

1.1 Regulatory Mission

In Canada, the Atomic Energy Control Board (AECB) is the agency of the federal government entrusted with ensuring that the use of nuclear energy poses no undue risk to health, safety, security or the environment. The AECB is responsible, under the current Atomic Energy Control Act, for regulating nuclear power plants. Since the provincial governments regulate pressure retaining equipment in general, jurisdiction in such matters was shared with the provinces.

Underlying the AECB's regulation are the following general objectives:[1]

- Nuclear activities should not pose unacceptable risks to workers, the public or the environment;
- Events that lead to the escape of radioactive material or the exposure of people to ionizing radiation should occur with low frequency, decreasing as the consequence increases, so that the likelihood of catastrophes is virtually zero.

Nuclear power plants in Canada were originally licensed based on analyses, documented in the Safety Reports, of postulated accidents initiated by failures in the plant and external events.[2] The analyses were required to show that the public radiation dose resulting from each event is within limits derived from the recommendations of the International Commission on Radiation Protection (ICRP).

1.2 Significance of Steam Generator Ageing

Several Canadian plants have experienced steam generator tube degradation in recent years.[3] This physical ageing changes the licensing assumptions by increasing the potential for tube failures during operation, upsets or accidents. The tubes form part of the reactor pressure boundary, so their failure causes a small Loss of Coolant Accident (LOCA). They form part of the containment boundary also. Thus any radionuclides that escape by leakage to the secondary side are released eventually to the environment. The Safety Reports recognized the possibility of tube ruptures during operation. In the analyses of other events, however, it was assumed that the tubes would not leak more than nominal amounts.

Therefore the need exists to show that the practices followed in ageing steam generators give an acceptable overall level of safety. The AEC Act gave broad discretionary powers to the regulators. In the past, the AECB and its licensees have negotiated resolution of such issues case by case based on their impact on nuclear safety.[4]

The AECB's position has been that regulation of steam generators should ensure the following:

- A low probability of spontaneous tube rupture, in terms of occurrence per plant year, under normal operating conditions.
- A very low probability of tube rupture under accident conditions, in terms of the probability of occurrence of a design basis accident and consequential SG tube rupture.
- Primary to secondary leakage during normal opera-

tion and during postulated accidents within siting guide dose limits.

2.0 EXPERIENCE IN REGULATING STEAM GENERATORS

2.1 Bruce B Fretting

Fretting at U-bend supports in Bruce B steam generators was discovered in 1989 during a periodic inspection. The maximum depth reported was about 50% through wall. A theory was advanced that fretting was "self limiting." Consequently, action was initially limited to periodic monitoring of steam generator condition. Prototype anti-vibration bars were also installed in Unit 5. However, fret depth continued to show an increasing trend until, in 1995, a tube leak occurred in Unit 7. On inspection, several other flaws were found in that Unit to have approached the maximum tolerable flaw size.

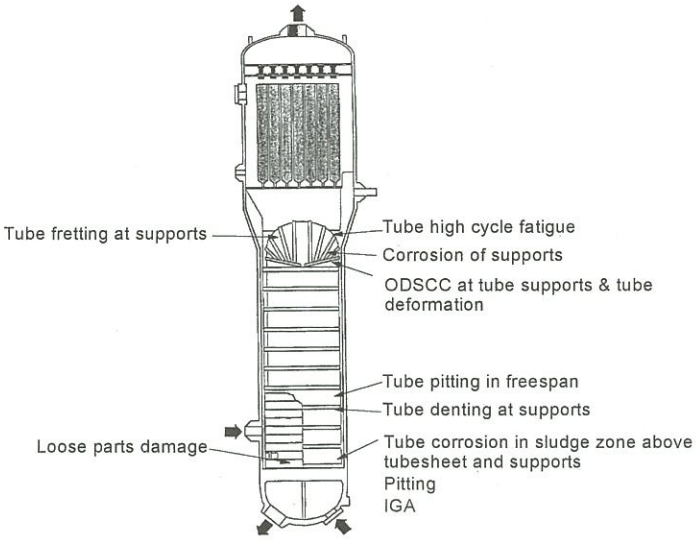


Figure 1: Tube Degradation Mechanisms in CANDU Steam Generators

At this point, AECB staff asked Ontario Hydro to change its strategy for dealing with steam generator tube fretting to one that manages the risks more rigorously. Ontario Hydro has responded by setting up a schedule of inspection and tube plugging designed to ensure that few tubes will be at risk of failure during the current inspection interval. The latter criterion was supported by a safety assessment of consequential tube failures. The AECB has also asked Ontario Hydro to use inspection results regularly to confirm the models for predicting future steam generator flaw populations.

2.2 Bruce A U-Bend Stress Corrosion Cracking

A series of tube leaks in 1991 caused by circumferential cracks at the U-bends was the first sign of trouble in Bruce Units 1 and 2. Initially, the response was limited to finding and plugging the leaks. The absence of other indications from inspection was assumed to justify continued operation, despite information[5] that the technique did not readily detect circumferential cracking.

After a seventh forced outage, Units 1 and 2 were shut down for investigation. Tube removal revealed that tubes in the U-bend region contained outside diameter stress corrosion cracking (ODSCC). The cracking was especially severe in steam generators 2 and 3 of Unit 2. There, several tubes contained through-wall cracks. The inspection had not detected these defects.

A case for fitness for service of Unit 2 was eventually based on inspection with the specially-developed Cecco-3 eddy current probe.[6] The probe performance was demonstrated on removed tubes. This exercise credited the probe with an 80% probability of detection (POD) for cracks deeper than 60% through-wall. The possibility that some defects may have remained after inspection was addressed by showing that consequential failures in the event of an accident would not cause leakage beyond tolerable limits.

However, reinspection of Unit 2 after a year of operation revealed many new crack indications. Statistical models suggested that faster-than-expected crack growth rates were responsible. These findings implied that tube plugging could soon reach unacceptable levels (Figure 2).

To justify continued operation of Unit 2, AECB staff asked for the following information:

- Acceptance criteria for the maximum numbers of plugged tubes in Unit 2 steam generators;
- An assessment of the remaining life and a planned date for shutdown;
- An inspection strategy;
- Predictions of end-of-interval crack populations and justification of their acceptability.

Inspection during a planned outage in 1994 confirmed the trend of crack growth. Unit 2 was laid up in October 1995.

2.3 Pickering B Pitting

Unit 5 at Pickering B experienced tube leaks in the early 1990s due to pitting in the lower regions of the steam generators. Recurring leaks and growth of inspection indications gave evidence of rapid corrosion. More than 1000 tubes were plugged in a short period. Ontario Hydro submitted plans for plugging up to 500 tubes per steam generator. To avoid tube plugging, Ontario Hydro also proposed a novel repair process known as electro-sleeving. The AECB, however, held that laboratory evidence was needed to support field trials, and that long-term field trials were required before large-scale use could be considered. Therefore it is unclear that the problem could have been managed by plugging or electro sleeving. Ontario Hydro acted aggressively to clean the steam generators and to improve the feedwater chemistry and materials. This action appears to have solved the problem.

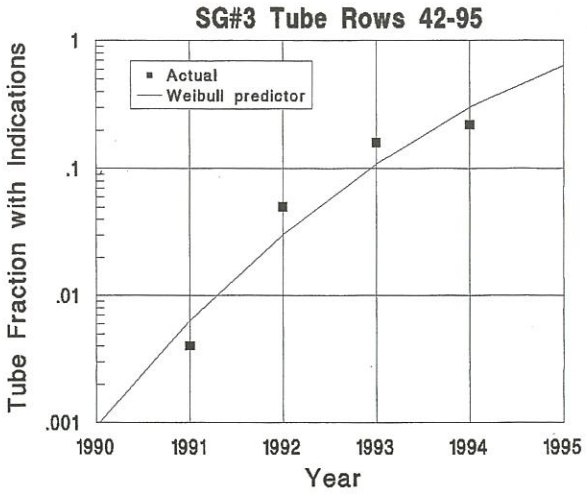


Figure 2: Bruce Unit 2 ODSCC Development

2.4 Bruce B Preheater Fretting

In June 1997, a tube leak was detected in a Unit 6 preheater. Ontario Hydro subsequently inspected approximately 30% of the tubes in each of the four preheaters in this unit and found tube fretting at the supports. This lead to identification of a generic problem similar to—and, from a safety standpoint, additional to—the steam generators. Until then the preheaters had not been inspected and were assumed to be in good condition. The AECB has requested that Ontario Hydro apply a strategy for managing the preheater tube degradation similar to that for the steam generators.

2.5 Bruce A Top of Tubesheet SCC

In April 1997, Ontario Hydro found that SCC at the tubesheet roll transition was the cause of a tube leak in Unit 1. Tube removals and 100% inspection of the lower 30 inches of the hot leg tubes revealed many other OD and ID flaws in Units 1, 3 and 4.

These findings posed new concerns. The absence of indications from previous inspections implied two equally disturbing alternatives. Either the inspection failed to pick up the problem, or the cracks developed rapidly since the last inspection.

The situation was perceived also to be less tolerant to uncertainties in management than previous cases involving fretting, pitting, or SCC, where the flaws were limited in circumferential extent. "Leak before break" was less assured. Since leak rate increases sharply with increasing circumferential crack extent, the risk of consequential tube failures following a plant upset or accident seemed greater than previously.

Since concerns about inspection accuracy and crack growth rates limited our confidence in continued fitness for service, other assurances were sought. By taking credit for the actual concentration of radioactivity in the reactor coolant, Ontario Hydro demonstrated tolerance for at least one steam generator tube rupture during a plant upset. On this basis, and with a reduction in the limit for primary-to-secondary leakage, AECB staff accepted the return to service of Units 3 and 4 until the planned shutdown in April 1998.

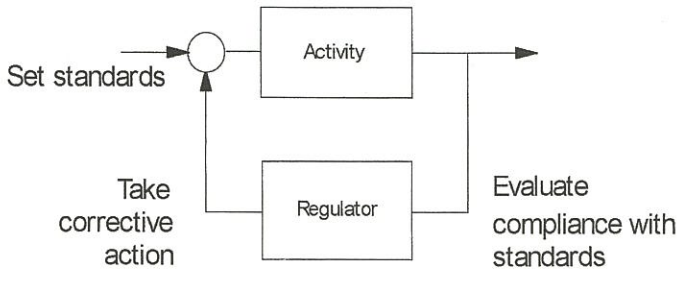


Figure 3: Regulatory Processes

2.6 Darlington U-Bend Fretting

Ontario Hydro recently reported U-bend support fretting in Darlington Unit 2. Indications were detected in 28 tubes with a maximum depth of approximately 35%.

Despite its apparently benign state, experience suggests that fretting will worsen over time. We expect Ontario Hydro to produce plans to define the extent and severity of U-bend fretting and rates of change in all DNGS units. In the longer term we expect measures to manage and mitigate the problem.

3.0 LESSONS LEARNED

3.1 Regulatory Process

A regulatory strategy consists of the processes of setting standards for an activity, evaluating its compliance with the standards, and promoting compliance. In systems engineering terms, the processes overall can be likened to a feedback controller (Figure 3).

For steam generators in operating plants, the main regulatory controls consist of the inspection requirements and acceptance criteria in the CSA standards, called up in conditions attached to the operating licenses, the limits on steam generator tube leakage in licensee Operating Policies and Principles, and requirements for reporting of pressure boundary degradation.

In theory, the regulator evaluates compliance with the criteria stated above, and takes action in response to a detected non-compliance. While this generally has worked in practice, experience has revealed some weak points. These are discussed below.

3.2 Problem Recognition

Awareness of problems in reactors develops gradually. In the early stages, information is often ambiguous. Denial—"it can't happen here"—is a not-uncommon reaction to signs of trouble. Given imperfect information, two decision errors are possible: acting when no problem exists (false call), or failing to act when a problem exists (non-response). While recognizing the possibility of overreaction, AECB staff attempts to act as a catalyst by asking "what if."

A serious weakness is that the CSA standards for periodic inspection specify samples that are too small and too infrequent to detect deterioration of steam generator tubes promptly. In several cases, problems have developed without detection by the periodic inspection program, e.g., Bruce A SCC, Bruce B pre-

heater fretting. Statistics show that at least 20% of the population of tubes must be inspected to give confidence that a given condition affects less than a small fraction. A recent AECB research report on fitness for service guidelines recommended larger inspection samples.[7]

On the other hand, 100% inspection does not eliminate uncertainty. It eliminates sampling error. Several sources of uncertainty remain. Inspection techniques, scope and frequency are inevitably shaped by planning assumptions about the defects of concern, the areas at risk, and rates of development. "100% inspection" is vulnerable to lack of knowledge and inaccuracies in these assumptions.

Even when inspection is accurately targeted, the performance of present day eddy current techniques leaves room for doubt about the flaw population that remains after inspection. Performance demonstration gives valuable evidence of what the technique does and does not detect. However, such exercises may be biased or incomplete. Bias creeps in, for instance, from focussing only on tubes in which defects are called. This procedure controls the "Producer's Risk" in Figure 4 below. However, the regulator is primarily interested in what is left in service, i.e., the "Consumer's Risk." Correcting this bias requires random investigation of tubes with acceptable indications. However, limits exist. Proving the nonexistence of non-detectable defects is logically impossible. Thus, probability of detection exercises should avoid attempting to quantify the unquantifiable.

	Defect Characteristics	
Inspection Call	**"Good"**	**"Bad"**
Reject	Producer's Risk	OK
Accept	OK	Consumer's Risk

Figure 4: Inspection Outcomes

Leak monitoring supplements inspection to give warning of tube degradation. It also acts as a real check on the consumers risk. Leak monitoring does not by itself guarantee safety, however. In some circumstances, leaks have occurred only after the defects have grown beyond the maximum tolerable flaw sizes, e.g., Bruce A SCC. This experience shows that "leak before risk of break" is not assured in all circumstances.

Other informal sources of information are reports of experience elsewhere, and research. Such information helps to anticipate problems. In systems terms, adding a predictive capability improves the feedback controller's response and reduces time lags and oscillation. This information has not always been effectively used.

3.3 Ageing Management

In the short term, the AECB has responded to reports of steam generator problems by doing or requesting the following:

- Investigation of the noncompliance;
- Assessment of the safety of continued operation, and the tolerance to probable failures;
- Judgement of the time available to gather more information;
- Adjustments to controls: e.g. expansion of inspection to define the scope and severity of the problem, inspection of similar components or other reactor units, and repeated inspections to define its kinetics.

Over the medium term, steam generator tube degradation has

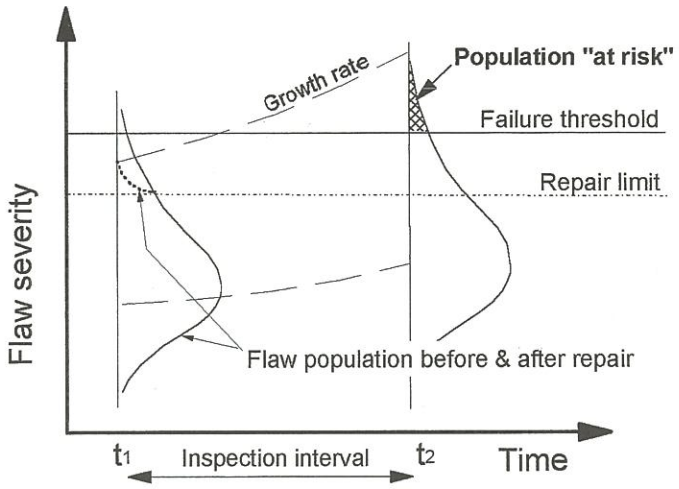


Figure 5: Management of Physical Ageing by Periodic Inspection

been managed by a strategy of periodic inspection and reassessment. The process is depicted in Figure 5. As this figure suggests, statistics usefully describe steam generator ageing, in view of the large tube population, individual variation and inspection uncertainties. The AECB has sponsored research that resulted in a software package named CANTIA for modelling flaw populations and assessing failure probability.[8]

Elements of the strategy are listed in Figure 6. The objective is to ensure that the population of degraded tubes remains fit for service, while individual flaws meet the CSA standard or alternate repair criteria consistent with the ASME Code. Extreme as opposed to average behaviour is a key issue. Figure 5 shows that the "upper tail" of the population is of concern. Limits on the population "at risk" are based on the need to ensure that radioactive releases caused by tube failures during plant accidents or upsets will not exceed regulatory limits. Because different tube defects and stresses can produce a wide range of primary to secondary leak rates, and because the condition of individual tubes is not well defined, the AECB has generally requested large margins between the consequential leak assessments and the legal limits.

This strategy has worked satisfactorily, but it has the weakness that the regulator and the licensees get comfortable with it. However, if many steam generator tubes are subject to degradation, it is merely playing out the end game. As experience at Bruce A and elsewhere has shown, the situation can deteriorate quickly unless a solution is found.

3.4 Problem Mitigation/ Prevention/Solution

The AECB attempts to focus attention on the long term endpoint, on rejection criteria (i.e., conditions beyond which operation will not continue), problem mitigation and solution. Examples of such outcomes include the request in the case of Bruce 2 for a planned shutdown to avoid the risks of indefinite operation, chemical cleaning of Pickering steam generators, which appears to have eliminated leaks due to pitting, and installation of antivibration bars at Bruce B which have been shown to reduce fretting wear.

4.0 REGULATORY DIRECTIONS

Although in the past jurisdiction was shared with the provinces, a 1993 decision by the Supreme Court of Canada made it clear that regulation of nuclear facilities is a federal responsibility. Furthermore, in early 1996, the Minister of Natural Resources tabled Bill C-23, *The Nuclear Safety and Control Act* in the House of Commons. This Act is expected to come into force this year. Besides changing the name of the AECB to the Canadian Nuclear Safety Commission, the new Act provides for more explicit and effective regulation by giving the Commission clear and specific powers.

Consequently, the AECB has started to restructure its regulation of pressure boundaries. As a first step it has changed the license conditions for power reactors to state explicitly the requirements for pressure vessels and piping. These require compliance with the technical content of CSA standards N285.0 and B51. The AECB has arranged with provincial agencies to carry out authorized inspection to administer these conditions.

In future the AECB intends to publish federal pressure vessel regulations and guides to compliance under the Act. The AECB wants to refer to CSA standards for construction and in service requirements. However, the present nuclear standards lack adequate rules for inspection and guidelines for dispositioning flaws. AECB staff would like to correct this deficiency by asking its licensees to develop fitness for service guidelines for steam generator tubes that can be incorporated into the CSA standards. The standards should cover inspection, acceptance criteria, and either prescribe levels of inspection consistent with practices in the nuclear industry or contain the logic that leads to current requirements. To meet targets for publishing new standards and regulations, this needs to be done within about eighteen months.

In absence of such standards, the AECB will continue to mandate actions it considers necessary for public safety.

i	Confirmation of the ability of the examination method to detect and size flaws
ii	Description of the population of degraded components and rates of change
iii	Failure criteria for normal and accident conditions
iv	Repair criteria with appropriate margins against failure
v	Procedures for repair of unacceptable defects
vi	Acceptance criteria for population at risk
vii	An in-service inspection plan that ensures the population meets the acceptance criteria
viii	Definition of a long-term end point

Figure 6: Elements of Strategy for Managing Ageing Degradation

5.0 CONCLUSIONS

Past practice under a flexible regulatory regime allowed the AECB to make judgements on specific cases of steam generator degradation. This practice was successful up to a point but involved considerable effort in motivating licensees to deal with emerging problems rather than treating the regulators as the problem.

Changes in the regulatory climate in Canada driven in part by the poor performance of the industry, privatisation, ineffective legislation and government reorganization have resulted in stronger emphasis on compliance and enforcement.

The rules on operation with degrading equipment do not exist in a legally enforceable form. In most case the types steam generator degradation encountered to date are manageable and tolerable for limited periods of operation. Degradation can be covered in rules for operation, fitness for service criteria and inspection strategies.

The AECB expects to have in place rules for steam generator degradation within the next 18 months.

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CNA / CNS Student Conference

The 21st annual Student Conference, sponsored by the Canadian Nuclear Society and the Canadian Nuclear Association was held this year at the royal Military College in Kingston, Ontario, March 27 and 28.

There were 24 papers presented, representing 29 authors. They were judged in three categories: Undergraduate; Masters level; and Doctorate level.

Cadet LCdr. Christopher Tingle was the student chairman while Professor Hugues Bonin was the chairman of the technical committee.

The winning papers were:

Undergraduate: *Armements Nucléaires*
M. Pérusse et M. D. F. Boivin
RMC / CMR

Masters: (Tie) *Thermoluminescence Dosimetry*
M. DiMarco
Université de Montréal

A model for Corrosion and Mass Transport in CANDU
L. LangUniversity of New Brunswick

Doctorate: *The Impact of Organics on Radioiodine Behaviour under Reactor Accident Conditions*
F. Taghipour, University of Toronto

An honourable mention was also named:
Subcooled Flow Boiling Hysteresis Charecteristics of Freon 134a in a Tubular Channel
D. Novog, McMaster University

Abstracts of, or excerpts from, the winning papers are printed below:

Undergraduate
Masters
Doctorate
Honourable Mention

Undergraduate

La Bombe Atomique et Ses Effets

Dany Boivin et Marc Pérusse
Collège militaire royal du Canada

Introduction

«Le premier effet d'une explosion nucléaire dans les airs est un éclat de lumière aussi rapide que l'éclair mais mille fois plus lumineux. Cet éclat est accompagné par une puissante vague de radiation thermique capable de brûler les combustibles légers sur un rayon de 14km». Ceci pourrait ressembler à un témoignage d'une personne qui a assisté aux bombardements d'Hiroshima ou de Nagasaki survenus au mois d'août 1945.

Depuis cet événement, plusieurs tremblent à la seule mention du mot nucléaire. Pourtant, la plupart de ces gens ne comprennent même pas le fonctionnement du fruit de leurs craintes. L'article suivant résume le fonctionnement des bombes atomiques en général.

Masters

Thermoluminescence Dosimetry

Marie Di Marco, University of Montreal

Introduction

This work presents the results of a thermoluminescence (TL) analysis of LiF:Cu^{2+} dosimeters, doped with various Cu^{2+} concentrations, and exposed over a wide range of γ and β radiation doses. Measurements were performed at the Radio protection Laboratory of the University of Montreal. Particular attention has been given to the study of the influence of Cu dopant concentration on the TL response, and its linearity over the range of exposure doses. Among the results obtained, the TL response is found to be linear over a wide range of radiation doses, and generally linear with dopant concentration.

Masters

A Model for Corrosion and Mass Transport in CANDU Reactor Coolants

by Lisa Lang

Abstract

Like all technological endeavours, a nuclear power plant relies on the integrity of its equipment for its safe lifetime oper-

ation. Since corrosion is a phenomenon that can jeopardize the integrity of components, it is important to understand corrosion and its ramifications in order to optimize performance and maximize lifetimes in the primary coolant circuit. Modelling the mechanisms of corrosion is an important aspect of understanding the phenomena, so a research project at UNB is developing a model of the corrosion of the carbon steel piping in CANDU primary coolant circuits. As well as contribute to our understanding of feeder thinning and other issues, the model will eventually be incorporated into a code for estimating out-of-core radiation fields.

The corrosion of carbon steel in CANDU primary coolant is controlled by the behaviour of the magnetite layer that develops on its surface. The dissolution or precipitation of the oxide layer involves the interplay of many variables: mass transfer as diffusion, magnetite solubility, and spalling. The model postulates that a portion of the iron ions immediately precipitate to form the inner oxide layer. The remaining ions diffuse across the inner layer and enter the coolant in the fluid boundary layers. As the coolant becomes saturated in iron, precipitation occurs and the outer oxide layer is formed.

The coolant reactor core inlet temperature is 266°C and the outlet is 310°C. At pH25C of approximately 10 or greater, magnetite solubility increases with temperature. Therefore, under normal operating conditions, the coolant is undersaturated in iron as it exits the core, leading to dissolution of the oxide layer in the outlet feeder region. Particles of oxide are loosened as the layer dissolves and becomes less compact and at a certain instant, the shear stress from the moving fluid becomes greater than the forces holding the particles in place and portions of the oxide spall off. The size of particles released is assumed to be inversely proportional to the velocity in the feeder. Measurements of particle size from operating reactors can be used to obtain the proportionality relationship, and in fact a particle size distribution obtained from the Gentilly-2 primary circuit is used to account for the spalling events.

Sixty-four outlet feeder thickness measurements were taken during Point Lepreau Nuclear Generating Station's 1996 plant outage. A feeder thinning correlation was developed, in which wear rate was found to be proportional to velocity raised to the power of 1.52. The model, which includes the spalling phenomenon, generated values of thinning rate for 95 outlet feeders and found it to be proportional also to velocity raised to the power of 1.52, giving some support to the model assumptions.

Doctorate

The Impact of Organics on Radioiodine Behaviour under Reactor Accident Conditions

Fairborz Taghipour and Greg J. Evans, University of Toronto

Introduction

An accident in a nuclear reactor may result in fuel damage and a subsequent release of radioactivity into the surrounding containment structure. Some of this radioactivity may become airborne in the containment atmosphere and a portion of this activity could be released to the environment. All fission products released from a station would contribute to the radiological dose. However, the most potentially significant relases are the radioisotopes of iodine due to their biosensitivity and volatility.

Among various parameters that affect iodine volatility, the most significant one is the presence of organic compounds. Organic impurities will arise in the containment aqueous phase from various sources such as paints, oils, and insulations. These organic compounds significantly affect iodine volatility, reacting with molecular iodine, to form a variety of organic iodides. Organic iodides dominated the gaseous iodine speciation following the reactor accidents.

The impact of radioiodine release can be controlled and minimized by understanding its behaviour under reactor accident conditions. From the perspective of reactor safety, it is therefore important that the rate and extent of iodine volatilization, particularly in the presence of organics, be understood and predicted. This work addresses a set of bench-scale experiments performed to evaluate the impact of organic compounds on iodine behaviour in an irradiated system for a range of possible post-accident conditions in a containment structure. The results of these experiments were used to develop and validate an iodine behaviour model under reactor accident conditions.

Honourable Mention

Subcooled Flow Boiling Hysteresis Characteristics for Freon 134a in a Tubular Chanel

David R. Novog, McMaster University

Abstract

In many heat transfer applications Freon 134a (F134a) is replacing environmentally damaging refrigerants such as R-12 and R-11. Furthermore in thermalhydraulic experiments F134a is used as a modelling fluid because its liquid to vapour density ratio approximates that of water at a much higher system pressure. This permits the study of thermalhydraulic phenomena important in nuclear safety modelling of fuel channels such as the onset of nucleate boiling (ONB), subcooled nucleate boiling (SNB) and the critical heat flux (CHF) with greater safety reduced cost. This paper experimentally studies the thermodynamic behaviour of F134a flow boiling in a tubular channel using direct electrical heating. The experiments cover mass fluxes from 100 to 625 kg/m2s, inlet subcooling from 25 to 6°C at a system pressure of 575 kPa. The single- and two-phase heat transfer and pressure drop results are analysed and discussed. The results show a significant hysteresis phenomena at the onset of boiling which has not been sufficiently studied in the past. This hysteresis phenomena requires much larger liquid superheats than is predicted using existing methods. A physical mechanism for this hysteresis behaviour is proposed based on surface tension effects.

CRPA Annual Meeting

Indications of closer ties between CNS and CRPA

Michael Haynes

The 1998 Annual Meeting of the Canadian Radiation Protection Association, held in Ottawa, May 25 to 27, contained, for the first time, papers sponsored by the Canadian Nuclear Society. This was a result of the proactive efforts of Parviz Gulshani, chair of the CNS Intersociety Committee and CNS president Ben Rouben to develop closer relations with this sister organization. As a reciprocal action, the CRPA is organizing a session for the CNS Annual Conference in October.

Two of the CNS sponsored papers were technical:

Prediction of reactor-face dose rates for full-system decontamination of a heat transport system, by D. Taylor, et.al.

Radiation dose-reduction measures in CANDU reactors, by K. Aydogdu, et.al.

While the third was a description of the CNS and exploration of possible joint activities:

The Canadian Nuclear Society - a brief review of its aims and objectives and its potential relationship with the CRPA, by F. Boyd.

which had been invited by the meeting organizers.

THE CRPA 1998 Annual Meeting had several somewhat unusual aspects for a meeting of a technical society. Most of the first day involved presentations on, or related to, communication - with the public and with other professionals. Mark Hart, of the Lawrence Livermore National Laboratory gave a fascinating talk on *What is Radiation.* Aimed at a general audience the talk was received enthusiastically by the CRPA delegates. In the afternoon, Bob Pike, president of Creative Training Techniques Institute, gave a two part presentation on *Communications - breaking down preconceptions* in which he provided tips on how to overcome the attitudes of persons or audiences.

The technical papers were given in sessions running in parallel, two at a time. Topics ran from broad ones such as *Health effects and radiation protection,* to very specific ones such as *Measurement of $^{14}CO_2$ in the environment using passive sampling.*

The first half of the Tuesday afternoon was devoted to a workshop of all delegates on the subject *Where are we going?* - an exercise to discuss the causes of the stagnant membership and explore what to do. The last half of the afternoon was the Annual General Meeting. Awards were presented:

- Founders Award
  to John Tai Pow formerly of Ontario Hydro
- Distinguished Achievement Award
  to Karen Gordon of the Health Sciences Centre, Winnipeg
- Certificate of Appreciation
  to former president Michael Rheaume and outgoing treasurer Daniel Buksak

Michael Haynes, of Ontario Hydro, was installed as president for 1998-99.

On the Thursday afternoon, following the close of the CRPA meeting, the Atomic Energy Control Board held a workshop to explain some of the new regulations to be issued later this year.

Cait Maloney, conference coordinator, greets special lecturer Bob Pike at the 1998 CRPA Conference in Ottawa, 24 May 1998.

Special Feature

Malice in Blunderland?

Part I, A Flawed Report

by J.A.L. Robertson

Ed Note: *The Executive Summary of the report of the Environmental Assessment Panel on Nuclear Fuel Waste Disposal Concept was published in the last issue of the CNS Bulletin (Vol. 19, No. 1). The report stated that AECL's concept for the deep geological disposal of nuclear-fuel wastes was technically safe but not publicly acceptable.*

Archie Robertson, a retired senior scientist from AECL Chalk River, followed the Panel over its eight year existence, attended many of the hearings and submitted several briefs. He has prepared a detailed review of the Panel's report and recommendations for the future. The length of his paper has dictated that we present it in two parts. Part I, presented below, exposes the many flaws in the Panel's Report, Part II ,which will be printed in the next issue of the CNS Bulletin, will discuss flaws in the Panel's process, and suggest how the situation can still be salvaged.

Preamble

> *"'When I use a word,' Humpty-Dumpty said, 'it means just what I choose it to mean - neither more nor less'"* - Lewis Carroll
>
> *"Never attribute to malice that which is adequately explained by stupidity"*
> - A. Bloch

Introduction

In March of 1988, ten years after Atomic Energy of Canada Limited (AECL) submitted its proposal for the disposal of nuclear fuel wastes for review by a Panel appointed by the Minister of the Environment, the Panel has issued its report. This finds that the proposed concept is adequately safe from a technical perspective: but recommends against implementation because the Panel believes that the concept "has not been demonstrated to have broad public support".

If this report had been produced by first year students in logic, they would have deserved a failing grade. As the product of nine years study by a panel of eight individuals selected for their supposed wisdom it is an indictment of both the panel members and the process. The report is shot through with illogicalities, unjustified claims, inconsistencies, simple errors and debatable statements that were not debated. But what destroys it completely is the fact that its two central arguments, and hence its conclusions and recommendations, are constructed on flawed foundations. The Panel was advised of virtually all the points made in this report in written submissions during the hearings. It has not rejected them with cause in this report, but has simply ignored them. It is for present readers to judge whether they should have been considered.

The Panel's recommendations, if implemented, would set back the question of disposal of these wastes to the late 1970s when the Federal and Ontario governments endorsed a study by independent consultants recommending deep underground geological disposal. The waste of roughly seven millions of taxpayers' dollars in direct costs for the Panel, plus at least as much again by participants responding to the Panel, is trivial compared with over half a billion dollars spent on developing the concept as directed by both governments. The technical expertise assembled in developing this world-leading enterprise would be dissipated and the momentum towards solving a serious social problem would be lost. Even more serious would be the precedent created: that at every stage of a major project one must go back to square one and reexamine previous decisions. And nobody would be accountable.

This paper analyzes the flaws in the Panel's report; examines how many of these stem from weaknesses in the process that the Panel instituted and proposes an improved process that would avoid making the same mistakes the next time; and suggests how the situation can still be salvaged despite the Panel's blunders. An Appendix* provides detailed comments not covered in the main text, to further substantiate this paper's conclusions.

By the Panel's terms of reference it was required to:

> "review the safety and acceptability of AECL's concept of geological disposal of nuclear fuel wastes in Canada ...."

However, it arbitrarily assigned its own special meaning to both "safety" and "acceptability", completely different from their conventional meanings as found in dictionaries, and proceeded to confuse the two.

Safety

One of the Panel's Key Conclusions is:

> "Safety must be viewed from two complementary perspectives: technical and social."

While this is true in assessing the acceptability, the Panel illogically deduced from this that safety included social acceptance. If the two are "complementary" one does not include the other. The Panel's terms of reference clearly distinguished between safety and acceptance by requiring the Panel to "review the safety and acceptability of AECL's concept ...."

The repeated use of the term "safety from a social perspective" indicates that this concept is different from what is generally understood by "safety". The report does not define the term but from the context and the way it is contrasted to "technical safety" it is presumably "perceived safety", i.e., the inverse of the well documented perceived risk. While technical and perceived safety are not independent, they are not parallel: an assessment by professional analysts that an activity is safe can affect the public's perception of its safety, the perceived safety, but the reverse is not true. According to the Panel's logic, since there is water in milk there is also milk in water. In the Panel's terms of reference "safety" should be interpreted as technical safety, while the perceived safety should be a factor in considering the acceptability.

Talking of "safety from a social perspective" simply obfuscates internal dissent within the Panel. Apparently one faction was satisfied with the conventional use of "safety", while recognizing that professional analysts and the general public differ in their assessments of safety, while another would not accept this view. Rather than paper over the dissent by changing the meaning of words, it would have been more honest to have issued majority and minority reports. Apparently the stress on ill defined social aspects at the expense of clear and unequivocal findings is due to two or three individuals. This dissent reflects a split in society, recognized by the author C.P. Snow forty years ago in "The Two Cultures", between those more inclined to a rational-scientific approach and those more inclined to an emotional-arts approach. If the Panel could not bridge this divide it seems naive to expect the public to do so.

Acceptance

The Panel's 1989 terms of reference required it to review the acceptability of AECL's concept as one of two major activities, and the members willingly undertook this commitment. Its 1998 report admits, at 5.1, that "an appropriate process for determining the acceptability of the AECL concept has not yet been developed". Its inability to discharge its responsibility is attributable to a misuse of language.

The Panel equates acceptance in its terms of reference to the far stronger broad public support. Acceptance is essentially passive, implying the absence of opposition, whereas support is active. Acceptance characterizes the great majority who are satisfied or apathetic on most public issues.

For instance, most Canadians accept the government elected into office even if most electors voted for other parties and only the small minority of card-carrying party members actively supported its election. If the government had wanted to know the Panel's finding on broad public support it would surely have said so in the terms of reference, and not asked about acceptance.

It is abundantly clear that governments have to make hard decisions on controversial issues even when these are opposed, sometimes violently, by vociferous special interest groups. Policies on abortion, capital punishment and gun control have not been required to pass the test of broad public support. Moreover, public opinion is fickle: it can change overnight and "the public" cannot be held accountable for the consequences of its opinion. If policies are to be determined by public opinion at some arbitrary moment in time, Parliament might as well be replaced by a polling firm.

In judging acceptance, the Panel makes the false assumption that it knows public opinion. Throughout its long existence it did nothing that would have let it determine public opinion; yet it recommends that establishing a means of determining public opinion should be one of the responsibilities of an implementing organization. The report uses "the public" and "participants" interchangeably as if the Panel believed that participants represented the public. The Panel received roughly one thousand submissions. This leaves 30 million Canadians who were not sufficiently concerned by the proposed concept to make a submission, even a single-sheet hand-written note. A stronger gauge of acceptance is hard to imagine.

The nature of the submissions also has to be considered. Less than half of them showed any evidence of the author having read AECL's Environmental Impact Statement (EIS) that was the subject of the Panel's review, even in summary form. Many based their opposition to the concept on false beliefs of what was being proposed, e.g., that the wastes would be irretrievable, or on objections that were already addressed in the EIS. Many also repeated as facts claims by dedicated anti-nuclear organizations, claims that were refuted or challenged in other submissions. However, there is no evidence in the report of the Panel having tried to resolve these differences.

Just as serious is the fact that all these submissions opposing the concept were made before it became known from the report that the concept was considered adequately safe from a technical point of view. Also, an appendix to the report refutes the belief, expressed by many participants opposing the concept, that low levels of radiation are much more harmful than currently estimated: indeed, the reverse may be true. Nobody knows how participants' opinions might have been changed by this information. While there is validity in recognizing people's perceptions regarding the safety of the concept, as opposed to technical assessments, decision makers must surely consider what weight to place on opinions that are either uninformed or misinformed.

The Panel asserts at 2.2.3:

"One key element of acceptability is that the public and deci-

sion-makers be in a position to make informed comparisons and a considered choice among reasonable alternatives."

It proposes that this be a major component of a reiteration of the whole 20-year process. The report does not point out that the EIS provided informed comparisons of reasonable alternatives, so that the criticism is that the information was not sufficient in the Panel's opinion. It should therefore have taken measures to obtain the information during the more than eight years of its existence, especially since its terms of reference put the onus for examining alternative approaches on the Panel, not on AECL. Also, for long-lasting projects such as this one there must be a limit on how each generation can second-guess the previous one. Repeated reexamination of previous decisions represents paralysis by analysis.

It seems probable from the submissions that those who oppose the disposal concept would, given the opportunity, oppose nuclear energy in general. However, as stated at 7.1 in the report, the federal government's policy is to continue to support nuclear energy. Thus it apparently does not consider this opposition sufficient to render the option unacceptable to Canadians. The report is rejecting the government's meaning of "acceptable".

The Aboriginal Viewpoint

One of the Panel's criteria for acceptance is that the concept must be acceptable to Aboriginals. This example of reverse discrimination is undemocratic. Aboriginals should have the same rights in this matter as all other Canadians. Aboriginal values should certainly be considered, along with those of all other groups in Canadian society. However, no single group can be given a veto on the concept's acceptability.

The report does not describe the Aboriginal viewpoint in sufficient detail to distinguish it from that of many other Canadians who wish to protect human health, future generations and the environment. Nor does it identify anything in the EIS that is inimical to that viewpoint.

At the stage of concept approval there is no knowing whether or not implementation would be on territory claimed by Aboriginals. The pre-closure hazard and the land use of only 25 square kilometres are not significantly different from any other large industrial project on the Canadian Shield, e.g., a mine or a hydro-electric dam. Any post-closure hazard would be so far in the future that nobody can predict who, Aboriginal or non-Aboriginal, might be affected. The critical group defined in the EIS adequately represents anyone, Aboriginal or non-Aboriginal, who might be affected.

If the voluntarism approach to siting were to be adopted all Aboriginal communities, just like non-Aboriginal ones, would have the opportunity to state under what, if any, conditions compatible with their cultural values they would be willing to accept a disposal facility. No community should be denied this opportunity, if it decides it wants this form of development, by the Panel's interpretation of what all Aboriginals think based on a selective review of submissions. Some Aboriginal submissions indicated an interest in learning more about the possible implementation.

The Panel's Conclusions

The report provided four Key Panel Conclusions:

1. "Broad public support is necessary in Canada to ensure the acceptability of a concept for managing nuclear fuel wastes."
2. "Safety is a key part, but only one part, of acceptability. Safety must be viewed from two complementary perspectives; technical and social."
3. "From a technical perspective, safety of the AECL disposal concept has been on balance adequately demonstrated for a conceptual stage of development, but from a social perspective, it has not."
4. "As it stands, the AECL concept for deep geological disposal has not been demonstrated to have broad public support. The concept in its current form does not have the required level of acceptability to be adopted as Canada's approach for managing nuclear fuel wastes."

For reasons already discussed, the first is not valid; the first sentence of the second is valid, but not the second; the third should read "The safety of the AECL disposal concept has been on balance adequately demonstrated for a conceptual stage of development", since a social perspective is not relevant to safety as normally defined; and the fourth is invalid because "acceptability" cannot be equated to "broad public support", and because the Panel never determined the level of public support.

Other objections to the Panel's criteria and reasoning are detailed in the Appendix.

The Panel's Recommendations

The report provided four Key Panel Recommendations, occupying in total nearly a page. In summary they are:

1. "A number of additional steps are required to develop an approach for managing nuclear fuel wastes in a way that could achieve broad public support." followed by seven specific recommendations.
2. A Nuclear Fuel Waste Management Agency should be established, as described in six following points.
3. "Until the foregoing steps have been completed and broad public acceptance of a nuclear fuel waste management approach has been achieved, the search for a specific site should not proceed."
4. If, as a result, AECL's concept is chosen certain government agencies should review and address various alleged shortcomings noted in the Panel's report.

Essentially, these amount to starting the whole process over again, not just the part spent by the Panel, but back to the concept selection of the 1970s. This fundamental recommendation is invalidated by the fact that the Panel's conclusions are flawed. The Panel failed to find the concept acceptable but, since it also failed to show that it would be unacceptable, there is no reasonable justification for such costly retrogression.

For this reason it is worthless criticizing the four recommen-

dations one by one here. However, some points are worth special attention, while others are detailed in the Appendix.

The Panel makes public participation a central issue, both in reviewing the EIS and in proposing future actions. However the report is unrealistic and unreasonable in its assessment and expectation of participation. Participation cannot be legislated and cannot be forced. The requirement should never be participation but the opportunity for participation.

The EIS tells of AECL's attempts to involve the public throughout its program for concept development, but these were largely unsuccessful in attracting public participation. Submissions to the Panel told of other attempts, also unsuccessful, to engage the public in discussion of nuclear issues. The Panel's hearings further demonstrated that the public at large had no interest in participation; and the Panel offered no analysis of its own failure and no suggestions for how to increase participation in future activities. The report is unreasonable in rejecting the EIS for not having succeeded in doing something that the Panel failed to do; and in recommending future actions based on a participation that nobody knows how to achieve. "Do what I say, not what I do".

The Panel's recommendations on transportation should be totally unacceptable to governments. Applying its criteria for the selection of transportation routes for one particular commodity could lead to anarchy. The only requirement is, and should be, that any vehicle that satisfies the relevant laws and regulations should be allowed free passage. Giving individual communities on transportation routes a veto on what may be transported through their communities could result, for instance, in a few hundred people with political agendas being able to bar trains exporting grain to China or trucks carrying goods made by non-union labour on the Trans-Canada Highway. It would be culpably irresponsible to require that advance notice of proposed shipments should be published. This would simply invite illegal, and often violent, opposition by activist groups that want their consciences to be our guide.

The Panel's proposed process for siting is based on the implicit assumption at 6.3.1.8 that the implementing organization would be dealing with "The potential host community", i.e., one only. The essence of the modified voluntarism siting process, as recommended in submissions to the Panel, is that potential host communities, i.e., plural, would submit bids stating under what conditions they would be willing to receive the wastes, allowing the implementing organization to make a selection based on all relevant factors.

The Panel's recommendations would result in the wastes continuing in surface storage indefinitely. No decision is in fact a decision to do nothing. By the Panel's own logic it should have demonstrated broad public support for this course of inaction. The present lack of public opposition to the current situation, except by the usual vociferous minority of dedicated opponents to all nuclear energy, shows that there is public acceptance of continuing storage. Indeed, the report states at 2.1.6: "This implies that the level of risk associated with storage facilities is currently acceptable to society."

However, this falls far short of the broad public support that the Panel demands of the alternative, geological disposal, and should therefore be unacceptable to the Panel.

Nuclear Fuel Waste

The chairman comments on the report from his Environmental Assessment Panel

Ed. Note: *The following is extracted from remarks by Blair Seaborn, chairman of the Environmental Assessment Panel on Nuclear Fuel Waste Disposal Concept, during a session at PBNC '98 in Banff, May 6, 1998.*

Over the last several years, Canada has gone through a lengthy environmental assessment process dealing with the long-term management of nuclear fuel wastes and a concept for their deep rock disposal put forward by Atomic Energy of Canada Limited (AECL). The Panel established for the purpose, which I chaired, and recently submitted its report to the federal government. We are awaiting the government's response to our conclusions and recommendations.

In very brief form, our findings can be summarized as follows:

- Broad public support is necessary in Canada to ensure the acceptability of any concept for managing nuclear fuel wastes. Safety is a key part, but only one part, of acceptability.
- From a **technical** perspective, safety of the AECL concept has been on balance adequately demonstrated for a conceptual stage of development, but from a social perspective it has not.
- The AECL concept in its present form does not at this time have the required level of acceptability to be adopted as Canada's approach for managing its nuclear fuel wastes.
- A number of additional steps, which I shall refer to later, are required to achieve broad public support.
- Until these steps have been completed and broad public acceptance of a nuclear fuel waste management approach has been achieved, the search for a specific site for disposal should not proceed.

What are the public concerns which lead us to conclude that there is not the necessary level of broad support to proceed to siting and the implementation of deep rock disposal of our nuclear fuel wastes?

The first is what is referred to as the "dread factor", a deeply entrenched fear and mistrust of nuclear technology. It stems from the mysteriousness (for most people) of nuclear fission; from the imperceptibility, mobility and longevity of the radiation hazard; from the association with nuclear weapons and past disasters; and from anxiety over worst-case scenarios, regardless of their low likelihood. Experts may challenge the correctness or the relevance of these fears, but they remain in the public mind nonetheless.

A source of public frustration in our hearings, and therefore another general concern, was the fact that our mandate limited us to nuclear fuel waste and specifically excluded energy policy and the role of nuclear therein. Many participants found it very difficult to express their views on nuclear fuel waste management in isolation from their views on nuclear energy itself.

A second set of concerns relates specifically to the safety of the proposals put forward in the AECL concept for deep rock disposal, proposals which are similar to those envisaged in many other countries. These concerns include:

- Lack of confidence in the state of scientific knowledge about the concept, and particularly in modelling to predict very long term events and effects.
- Uneasiness about a system which does not envisage indefinite monitoring of what is happening in the disposal vault and the geosphere, and is moreover not designed for easy retrieval of the wastes should anything go wrong.
- The failure to look at a sufficiently wide range of "worst-case scenarios" and their consequences.
- The lack of precedent anywhere in the world to demonstrate that this is indeed a safe and acceptable method for the long-term management of the wastes.

I should perhaps add that in the case of our Panel some confusion, frustration and concern derived from the fact that we were looking at a **concept** for nuclear waste disposal, not a specific site, and not a site-specific design. There was a suspicion in some quarters that a site had in fact been secretly chosen and not revealed.

A third set of public concerns relates to important elements of the acceptability of the proposal in addition to the key factor of safety, whether safety is viewed from a technical or a social perspective. These concerns include:

- The need for public confidence in the implementing organization and in the regulator of the industry.
- The absence of information about **options** for dealing with the long-term management of the wastes, and therefore the absence of effective choice.
- The means for the public to be adequately and impartially informed about the facts and the issues.
- The means by which the public, both nationally and locally, can participate in decision-making.

Our Panel considered that these elements of acceptability, over and above the key factor of safety, are critical to obtaining broad public support and therefore require much greater attention than has so for been the case in Canada.

It is the view of the Panel that certain steps have to be taken if there is to be any hope of gaining broad public acceptance of any long-term management proposal. These include the following:

- There must be a participation process designed with and for our Aboriginal population, many of whom inhabit the areas most frequently suggested as suitable physically for a disposal facility.
- An agency at arms length from the utilities and from AECL should be established to manage and co-ordinate the full range of activities, technical and social, related to long-term management.
- The risks, costs and benefits of a few viable options for managing the wastes in the long term must be developed and compared so that the public and the decision-makers can make an informed choice as to the preferable option. These options include: a version of the AECL disposal proposal, indefinite storage at the reactor sites, and a central storage facility, above or below ground, with provision for indefinite monitoring and planned retrievability.
- There must be provision for engaging the public in an educational process around the facts and the issues involved, making explicit the social and ethical assessment framework within which decisions will be made. There must also be an agreed plan which sets forth the means by which and the points at which the public will be involved in decision-making.

Shown are members of the panel on Nuclear Fuel Waste at PBNC '98. Blair Seaborn, chairman of the Canadian Environmental Assessment Panel is seated in the centre of the panel.

GENERAL news

AECB Holds Workshop on New Regulations

Taking advantage of the gathering of about 150 radiation protection people in Ottawa for the Annual Meeting of the Canadian Radiation Protection Association, the Atomic Energy Control Board held a workshop on the afternoon of May 28, 1998, to present and explain its revised proposed Regulations. The Nuclear Safety and Control Act, which was passed last fall, cannot be proclaimed until the associated regulations are prepared.

Ross Brown, director of the regulations group at the AECB, and three associates outlined the status of the General Regulations, and three of the specific ones; those for Radiation Protection, Transportation, and Nuclear Substances and Devices. They stated that there were no "substantive changes" from the existing regulations or common licence conditions except: incorporation of ICRP 60 recommendations (for radiation protection); power reactor operator re-certification; licences for service equipment; update of transportation regulations to conform to IAEA Safety Series 6; and new security requirements.

Brown stated that the proposed Regulations would be published in the Canada Gazette, probably in August (1998), except for the rules of Procedure, and the Cost Recovery Regulations which will be published later in the fall. There is a period of 60 days for public comment after publication in the Gazette. To questions about the more than 1500 comments on the initial proposed regulations issued last year, Brown stated that a "disposition document" was being prepared. The Canada Gazette can now be accessed through the Internet at the federal government site.

It is likely the new Act will be proclaimed early in 1999, Brown said, and the accompanying Regulations put into force at that time. The AECB then will become the Canadian Nuclear Safety Commission (CNSC).

MDS Nordion acquires Theratronics and expands

On May 20, 1998. MDS Inc. announced the acquisition of Theratronics International Limited from the Canadian Development Investment Corporation for $15,450,000.

Theratronics is an industry leader in isotope-based radiation therapy and computerized treatment planning for cancer patients. It was formerly part of AECL's Commercial Products division which later became the AECL Radiochemical Company. In 1988, as part of the federal government's privatization moves, the organization was split in two, forming Nordion International and Theratronics.

Theratronics will become an operating division of MDS Nordion. Located next to MDS Nordion in Kanata, Theratronics employs 240 people, many specializing in mechanical systems, electronics, computer technology and software design. Theratronics designs, manufactures, sells and services cobalt-60 radiotherapy equipment and sources used in the treatment of cancer around the world.

The cobalt 60 for the machines is supplied by MDS Nordion.

Then, on June 25, 1998 MDS Nordion announced a $12.3 million expansion plan for its facilities in Kanata, The company will build a new radiopharmaceutical building and expand its cobalt-60 operations.

The plan is to build a $7.3 million, two storey, 48,000 square foot building for the specialized production of radiopharmaceuticals, laboratories for microbiology and quality control and space for packaging, shipping and warehousing. The project will be complete by August 1999.

In addition, MDS Nordion intends to expand its cobalt-60 operations in order to maintain and grow its current business of providing cobalt-60 sources for gamma sterilization systems. The 19 month, $5 million expansion will also accommodate production of cobalt-60 for a new medical device used to treat tumours and vascular disorders of the brain.

Sudbury Neutrino Observatory Officially Opened

Official opening ceremonies were held April 28, 1998, for the Sudbury Neutrino Observatory

SNO is a large assembly, located deep in the former Creighton Mine at Sudbury, designed to detect neutrinos emanating from the sun. The assembly consists of a large sphere made of acrylic, in which 1,110 tonnes of heavy water are placed, surrounded by another sphere filled with ultra-pure (light) water. Outside these spheres are banks of photomultiplier tubes to detect the Cerenkov light given off as neutrinos collide with the deuterium atoms of the heavy water.

A major objective of the observatory is to determine the number of neutrinos emitted from the sun, for comparison with astrophysical theory. Two other, smaller experiments found that the number observed was only about one third of that predicted.

Atomic Energy of Canada Limited loaned the heavy water required for the observatory As well, SNO Director, Dr. Arthur McDonald is an alumnus of AECL's Chalk river Laboratories, as was his predecessor, Dr. George Ewan.

Dr. Stephen Hawking, the renowned physicist from Cambridge University was the guest speaker at the official opening ceremonies. Despite the effects of Lou Gehrig's disease which confines him to a wheelchair and requires him to speak via a computer-controlled voice synthesizer, Prof. Hawking captivated te audience with his eloquent and forceful comments on the importance of fundamental research.

CNA Awards

Prestigious W. B. Lewis Medal goes to Dr. John Davies

Each year the Canadian Nuclear Association presents awards to acknowledge the contributions of individuals and groups to Canadian nuclear science, technology and industry. This year the awards were presented at a special luncheon held during the PBNC'98 conference in Banff, Alberta, on May 5, 1998

The two historic awards are the **W. B. Lewis Medal,** for scientific or technical contributions and the **Ian McRae Award** for contributions towards the advancement of nuclear energy in Canada, other than scientific or technical., both established in 1973. A further category, **Outstanding Contribution Awards,** were established in 1980 and are open to groups as well as individuals.

W. B. Lewis Medal

The W. B. Lewis Medal was created in 1973 in honour of Dr. W. B. Lewis, who was senior vice-president of Atomic Energy of Canada Limited from 1946 until his retirement in 1973 and often referred to as the "father" of CANDU..The Medal recognizes Canadian scientists or engineers who have demonstrated a level of technical competence and accomplishment in the field of nuclear science and engineering, as exemplified by Dr. Lewis during his involvement in the Canadian nuclear energy program.

The 1998 W. B. Lewis Medal was awarded to **Dr. John Davies,** recently retired from AECL Chalk River.

CNA chairmen Ernie Card (R) presents the W.B. Lewis Medal to Dr. John Davies at the special ceremony, May 5, 1998, during PBNC '98 in Banff, Alberta.

The citation read as follows:

It is very fitting to award the W.B. Lewis Medal this year to an individual who was for many years a senior researcher on Lewis's staff at Chalk River and who, in many ways, mirrors the kind of intensity, scientific intuition and perseverance that "W.B." exhibited. Lewis was a giant in his field of nuclear science and engineering, held in awe, respect and admiration by all those who knew him and worked under him. This year's winner is in the same league! The recipient is considered to be without equal internationally in the development of nuclear methods for the study of ion-solid interactions.

Dr. John Arthur Davies is the co-discoverer of "ion-channeling", a unique kind of ion steering between rows and planes of crystal atoms, and he has gone on in his career, not only to develop the theoretical basis of interactions in solids, but to utilize this phenomenon experimentally, together with a battery of applied nuclear techniques using radioactive ions and low voltage accelerators, to study solid surfaces, near surface ion penetration and implantation.

Dr. Davies has pioneered ion implantation work worldwide with active collaboration at Chalk River, McMaster University and in Denmark. His work has had important ramifications for the study of materials, radiation damage, surface layers, modification of specialized solids and crystals, and for microelectronics.

His work has directly benefitted CANDU technology through studies of deuterium and tritium interaction with nickel, zirconium and other metals, and the mechanisms of oxide formation on metal surfaces.

Not only is John Davies himself an excellent 'hands-on' experimentalist as well as theorist but he also built effective research teams for his burgeoning studies and attracted high quality international solid-state researchers to Chalk River and McMaster University, and thereby spun-off international collaboration that has flourished for more than three decades.

He has authored and co-authored more than 225 quality publications, including six authoritative books, and has been honored with two honorary doctorates, two international medal awards and two royal fellowships. He was awarded the Noranda Medal for outstanding physical chemistry while under the age of 40.

Without doubt, John Davies has made outstanding achievements and discoveries in applied nuclear science and engineering in Canada, and has established Canada as being in the forefront of the use of nuclear accelerators for ion implantation and channeling.

The high level of John's accomplishments clearly exemplify the standard embodied by Dr. W.B. Lewis, and he is a deserved recipient of the W.B. Lewis Medal.

Ian McRae Award

The Ian McRae Award recognizes individuals for their outstanding contribution to the general advancement of nuclear energy in Canada, through such fields of activity as management, administration, public service, medicine, communication and the arts.

The 1998 winner of the Ian McRae Award was **Bernard Michel.**

Following is the citation:

This year's recipient of the Ian McRae Award has been a leader in the development of nuclear energy in Canada for more

than 20 years through his involvement in the Canadian uranium industry.

A graduate of Ecole Polytechnique in Paris, our recipient came to Canada in 1977 with what was then known as Amok Limited. He first gained our attention when his leadership and meticulous attention to detail were ably demonstrated during hearings before the Cluff Lake Board of Inquiry, which ultimately led to the approval and subsequent development of the Cluff Lake uranium operation in northern Saskatchewan.

In 1988, our recipient joined Cameco Corporation, which was the product of a merger of two Crown companies, one federal and one provincial. Since then ***Bernard Michel*** *has forged the largest, publicly traded uranium producer in the world, supplying 15% of the western world's uranium requirements and 20% of its uranium hexaflouride conversion needs.*

Bernard Michel (L) receives the Ian McRae Award from CNA chairman Ernie Card, May 5, 1998, during a special luncheon at PBNC '98.

As President, Chair and CEO of Cameco, Bernard Michel has recently advanced the development of high-grade uranium projects at McArthur River and Cigar Lake in northern Saskatchewan, which will ensure that Cameco, and Canada, continue their leading role in world uranium supply into the next century.

Importantly, Bernard has made Cameco a leader in managing aboriginal issues that are vital to uranium mining in northern Canada. He is also a dedicated supporter of university education and research. Under his leadership, Cameco has provided funding for innovative teaching programs for northerners, and for important research programs at the University of Saskatchewan.

Bernard is a tireless promoter of nuclear power as the safest, most environmentally benign source of electricity, frequently pointing to the countryside of his native France as the best example of how kind nuclear power is to the environment.

In his dealings with government, Bernard is known to be straightforward, articulate, balanced and forceful. He understands the responsibilities of government and the intricacies of public policy, but he also knows how to present the needs of an industry faced with the realities of the market place, its northern work force and associated communities.

The nuclear industry, like most industries, begins with mining, to provide the raw materials that allow the energy of the nucleus to be harnessed. Bernard Michel has played, and continues to play, a vital role in this important aspect of our industry. He is truly deserving of the Ian McRae Award.

Bill Hancox

Outstanding Contribution Awards

There were three Outstanding Contribution Awards granted for 1998. The **Outstanding Contribution Awards** were created in 1989 to recognize individuals, organizations or parts of organizations which have made significant and obvious contributions to the nuclear industry over a long period of time and / or who have made specific individual outstanding contributions that have had a significant positive impact on the Canadian nuclear industry.

The first Outstanding Contribution Award went to **Dr. Bill Hancox**

His citation read:

The recipient of the ***first Outstanding Contribution Award*** *is an individual who has made a number of key analytical, experimental, organizational and business contributions, over a period of 25 years, of critical importance to our industry.*

During the 1970s, the recipient contributed to the analytical, experimental and project management of an AECL/COG program to establish an analytically-sound and experimentally-validated, loss-of-coolant accident capability for CANDU reactors. This was of particular importance to CANDU operators and licensing bodies because of the uniqueness to the CANDU system.

The recipient went on to direct AECL's program on the disposal of spent fuel bundles from CANDU power plants at a critical period in the program's definition and evolution. Under his direction, the program developed and demonstrated the above-ground, dry-cannister concept, and established the criteria necessary for underground final disposal.

In 1989, as a Vice President of AECL, ***Dr. Bill Hancox*** *took on the responsibility for strategic planning within AECL, plus the provision of scientific and technological support and advice, within both AECL and the nuclear industry. In 1995, he also took over responsibility for AECL's planning and review process.*

During the period 1993 to 1996, ***Bill Hancox*** *lead discussions with MDS Nordion to restructure and strengthen the Canadian isotope business by consolidating its commercial activities under MDS Nordion. These discussions led to an agreement to build two MAPLE reactors and an isotope processing facility at Chalk River, which Nordion would own, and AECL would operate.*

Bill Hancox *has personally contributed to the dissemination of CANDU technology with 44 open literature publications and*

18 reports which, in turn, have been cited over a hundred times in open literature. He is also the holder of two patents on CANDU reactor technology.

Bill's numerous contributions with a specific focus on issues critical to the safety, environmental and economic viability of the CANDU reactor, have had a significant impact on the viability of the Canadian nuclear industry.

The second Outstanding Contribution Award went to a team of three people: **Ken Dormuth, Phyllis Gillespie and Sid Whitaker**

Ken Dormuth

Their citation read:

***Our second Outstanding Contribution Award** goes to three individuals who, as a team, had prime responsibility for the preparation and defense of AECL's proposed Concept for the Disposal of Canada's Nuclear Fuel Waste during the recently completed environmental assessment and review process.*

Specifically, this team of three:

- *wrote the Environmental Impact Statement and its Summary detailing information developed in the Canadian program between 1978 and 1994;*
- *they prepared the response to the environmental Panel's request for information to address issues raised about long-term safety, and they participated actively in the first phase of the Public Hearings;*
- *they managed the development of responses to other issues raised during the review; and*
- *they served as the Proponent at the Public Hearings and, in this role, managed the presentation of information by AECL at the Hearings, presented much of this information themselves, clarified and explained the information presented, and supplied additional information as requested.*

***Ken Dormuth, Phyllis Gillespie,** and **Sid Whitaker** conducted themselves with decorum throughout the Hearings and represented AECL and the Canadian nuclear industry in an exemplary manner. In the words of one nominator, "they consistently maintained their calm and objectivity, responding only to matters of relevance to the Hearings in a respectful and understandable manner".*

Other nominators observed their mastery of both voluminous data and a wide range of scientific concepts, their through professional knowledge, their sensitivity to the manifold issues arising, and their integrity.

Clearly, the effort expended, and the results produced, by Ken Dormuth, Phyllis Gillespie and Sid Whitaker are truly exceptional.

Richard Bolton (L) receives a CNA "Outstanding Achievement Award" on behalf of the team at Tokamak de Varennes, from CNA Chairman Ernie Card at the special luncheon, May 5, 1998, during PBNC '98.

The third Outstanding Contribution also went to a team, that of the **Tokamak de Varennes,** led by **Dr. Richard Bolton.**

The citation for that award read:

***Our third Outstanding Contribution Award** goes to another Canadian team, which has made significant contributions in the field of fusion science and technology, over a period of some 20 years.*

In 1977 the National Research Council of Canada (NRC) established the National Fusion Program, with the objective of establishing a foothold for Canadian industry in this new technology. Hydro Quebec and the Institut National de la Recherche Scientific (INRS), with Canatom and MPB Technologies, and the Université de Montréal, then agreed to participate with NRC in a significant tokamak experiment.

*Studies in 1979 led to the First Plasma in the **Tokamak de Varennes** (TdeV) in 1987. Nothing similar to the Tokamak de Varennes exists in Canada and only a score or so of comparable installations exist in the world.*

*It is the **Tokamak de Varennes** team of the **"Centre Canadien de Fusion Magnétique"** (CCFM) that we would like to honour today with this Award. CCFM is truly a unique and important Canadian achievement.*

Upgrades to the tokamak and the addition of Radio Frequency Heating have kept the Team at the leading edge of research in its chosen niches. The Team has made a number of significant contributions to fusion science and technology, which are part of the data-base for future large experiments such as ITER (the International Thermonuclear Experimental Reactor project).

*The **Tokamak de Varennes** team, consisting of some 100 members, has published nearly 300 papers in the world's leading scientific journals, as well as 500 additional scientific reports, over the 20-year period.*

*Without question, the **Tokamak de Varennes** team at the **Canadian Centre for Magnetic Fusion** is highly deserving of the CNA's Outstanding Contribution Award.*

***Dr. Richard Bolton,** co-author of the original proposal in 1977, and the Team's Project Manager and Director of CCFM from 1987 to 1997, will accept the Award on behalf of the team.*

People

Obituaries

Two early members of the Canadian nuclear program died in the period covered by this issue of the *CNS Bulletin.* Both were among the authors of the book ***Canada Enters the Nuclear Age:*** *A technical History of Atomic Energy of Canada Limited as seen from its research laboratories,* which was published last year. (See Vol. 18, No. 2, of the *CNS Bulletin.*)

Geoffrey C. Hanna died May 13, 1998, in Deep River, in his 78th year. A graduate of Cambridge, Geof Hanna joined the Montreal Laboratory in 1945 after a period as a physicist with the British Ministry of Supply during WW II. His early research at Chalk River included pioneering the use of high gain proportional counters to study low-energy radiation, investigations of the properties of transuranic nuclides and measurements of nuclear data for reactors. Over the years he became, successively, head of Nuclear Physics, director of the Physics Division, and Director of Research..

Robert G. Hart died May 30, 1998, in Ottawa, after a long bout of cancer. A chemistry graduate from the University of Toronto, Bob Hart joined the Chalk River laboratories in 1948. After working on various projects, including heavy water purification and fuel reprocessing at Chalk River, he moved to the newly created Whiteshell Laboratories in 1965 as head of the Reactor Core Technology Branch. In 1969 he was appointed director of the Applied Science Division and in 1973, managing director of the Whiteshell site. In 1979 he became executive vice-president in charge of the Research Company of Atomic energy of Canada Limited in 1978. For his many scientific achievements Bob was awarded the W. B. Lewis Medal by the Canadian Nuclear Association in 1981.During his retirement Bob was an active member of the CNS Ottawa Branch.

A special memorial service was held for Bob Hart in Ottawa on June 6 to which many of the pioneers of the Canadian nuclear program attended, Among those offering special comments were former colleagues, Ralph Green, Doug Breckon, and Ted Thexton.

Michael R. Hoare, formerly Product Engineering Manager at Zircatec Precision Industries, died March 20, 1998. after a long battle with cancer.

(The following note was provided by Roger Steed, one-time chair of the CNS New Brunswick Branch.)

A Londoner, Mike had been on the staff of Westinghouse, now Zircatec, in its Port Hope nuclear fuel manufacturing plant in Port Hope, since the early sixties, and was a highly competent engineer.

I had the very great pleasure of first meeting Mike about ten years ago while on a CNA-sponsored tour of the Key Lake uranium mine, as part of a CNA conference. We met while being taken through the mill at Key Lake, and I immediately felt I'd met a kindred spirit. As a representative of a customer of Zircatec for the greater part of the last ten years I found Mike to be most responsive to any concerns I might have, always insisting that I not hesitate to ask any questions which might occur to me. He wasn't content until he'd fully answered my questions and satisfied my concerns.

But more than being a colleague, Mike was a true friend. He will be greatly missed by his friends in Zircatec and throughout the fuel community.

Retirements

Reid Morden, the president of Atomic Energy of Canada Limited, has announced his decision to retire at the end of his current four-year appointment on July 31, 1998, Immediately prior to joining AECL he had been Deputy Minister of Foreign Affairs. He had held various posts with that Department from 1963 to 19866. During 1986 -87 he was Assistant Secretary to Cabinet for Foreign and Defence Policy and from 1987 to 1991 he was director of the Canadian Security and Intelligence Agency.

Frank Fraser has retired from MDS Nordion, after 35 years with that company and its predecessors, AECL Commercial Products and AECL Radiochenmcial Company. He worked for the organization part-time in the early 1960s while pursuing a temporary career as a professional football player with teams in Ottawa, Montreal and Winnipeg, and then joined as a full-time engineer in 1964. From 1977 until 1989 he was vice-president, Industrial Division, before becoming vice-president Market Development when that group was formed.

He has been a strong advocate of food irradiation and was instrumental in the establishment of the world's first dedicated, commercial, food irradiation facility in Florida. During his term with the Industrial Division he was involved in most of the full-scale irradiators sold by the company.

Frank has had a strong commitment to the community. As chair of the MDS Nordion Celebrity Golf tournament he has helped raise large sums of money for the local community resource centre.

Although officially "retired", Frank will continue as chairman of the Association of International Industrial Irradiation.

Symposium on Low Dose

Most experts at the first large symposium by International Centre for Low Dose Radiation Research question the LNT hypothesis

The **International Centre for Low Dose Radiation Research,** which was officially established the University of Ottawa on December 15, 1997, held a one-day symposium in Ottawa on June 8, 1998, its first large public meeting.

Associate Director of the Centre, and primary symposium organizer, Dr. Elagu Elaguipillai, took advantage of the presence of the international experts on the Centre's *Scientific Advisory Board,* who were convening, in Ottawa for the first time. The result was an intense day with eleven detailed papers, and a round table discussion, all related to the broad theme of the Symposium, *Research Directions into the New Millennium.*

The papers were divided into three sessions: Health Effects of Low doses; Low dose effects A Biological Approach; and, Applications, Regulations and Implications. Starting, the day was an overview of the Report of the French Academy of Sciences on *Effects of Low Doses of Ionizing Radiation,* prepared by Dr. R. Masse, president-directeur-general, Office de Protection contre les Rayonnements Ionisants, but read by Centre director Dr. Phillipe Duport, since Dr. Masse was detained by the Air France strike. The report observed that the effects of low doses of radiation are very small. It concluded that the "single hit" model was over simplified; that dose rate is important and that the linear, no-threshold, hypothesis (LNT) was not supported by data and should not be used to calculate effects of wide spread low exposures.

Somewhat in contrast, Dr. Dan Krewski, from the University of Ottawa, reported that there was good agreement between residential and mining, studies of exposure to radon. and that these studies supported the LNT model.

Dr. W. J. (Jack) Schull, of the University of Texas, a specialist in the effects of *In Utero* exposures, noted that the greatest danger to the fetus was in the 8 to 15 week period. .

Dr. Marvin Pollcove, an associate with the USNRC and probably the most outspoken critic of the LNT hypothesis, emphasized the repair mechanisms which come into action and argued that low doses of radiation could be beneficial. Dr. Ron Mitchell, reported that biological research at the Chalk River Laboratories basically supported the concept.

The idea of "hormesis", that low doses of radiation can have beneficial effects, was presented strongly by Dr. Dan Luckey, of the University of Missouri, and supported by Japanese studies reported by Dr. S. Hattori.

Stan Frost, of Cameco Corporation, pointed out the expenditures required to meet extremely low dose regulations were excessive in comparison to that spent on other hazards. However, Murray Duncan, of the Atomic Energy Control Board, stated firmly that the regulatory agency would follow the recommendations of the International Commission on Radiological Protection (based on LNT) until there was widespread scientific support for a different model. The AECB, or its successor organization, the Canadian Nuclear Safety Commission, will be issuing revised regulations this fall with lower dose limits.

The day wrapped up with a panel of most of the speakers amplifying their views. Most of the 120 or so attendees agreed with the comment by one of the panelists that this Symposium was a "Historic occasion".

The Canadian Nuclear Society was sponsor of the Symposium and the first Canadian organization to support the newly created Centre.

New Regulations – on Web

It will be possible to preview the proposed Regulations under the Nuclear Safety and Control Act on the Web.

Before the Nuclear Safety and Control Act is put into force the associated Regulations must be published in the Canada Gazette. The Atomic Energy Control Board has announced that it intends to publish its proposed new Regulations early this fall as the penultimate step before the new Act is proclaimed .

To provide interested parties additional time for comment or input over and above the required sixty days after publication in the Gazette, the AECB has promised to post the new Regulations on its Web page as soon as they are ready.

The Nuclear Safety and Control Act was passed in early 1997 but will not be proclaimed until all of the associated Regulations are ready to be put into force.

The AECB web page address is; www.gr.va/aecb.

The government has also announced that the Canada Gazette will be posted on the Web at: www.canada.gc.ca However, the printed version will remain the official one.

Wolsong 3 declared "in service"

The Korea Electric Power Company (KEPCO) declared the Wolsong Unit 3 to be in commercial service as of July 1, 1998.

This milestone was achieved on schedule and created some new records for CANDU 6 plants:

- from first concrete to in service, approximately 51 months
- fuel loading to first criticality - 52 days
- first criticality to full power - 59 days.

Wolsong units 1 and 2 continue to operate well and construction on Unit 4 is nearing completion, with commercial operation scheduled for June 1999.

ENGINEERING OPPORTUNITIES

Atomic Energy of Canada Limited (AECL) is a federal Crown corporation at the forefront of environmentally conscious companies exploring the peaceful applications of nuclear energy. AECL develops, markets, sells and builds CANDU power reactors, MAPLE research reactors, MACSTORTM waste storage facilities and provides engineering and other technical services to nuclear utilities. Several junior, intermediate and senior level positions are now available to support CANDU station operations, and design and development work. Locations include Mississauga and Chalk River, Ontario and operating stations in Canada and abroad.

Positions are available in the following areas:

PROCESS SYSTEM, EQUIPMENT and MECHANICAL DESIGN
Along with performing process system design including system flowsheets, equipment sizing, design calculations, specification of system requirements, preparation of equipment specifications, environmental qualification and test requirements, you will design mechanical components and mechanisms for reactor and fuel-handling equipment. Experience with system design or equipment design and manufacturing is essential, as is good knowledge of process or mechanical equipment, valves, pumps, heat exchangers, pressure vessels, piping and fittings. File No. PS

SAFETY and LICENSING
Your primary responsibility will be to perform design basis accident and licensing analysis for CANDU reactors on heat transport, containment and moderator systems using state-of-the-art computer codes. You will also prepare computer models of reactor systems, run
simulations, prepare analysis reports in support of new and existing licenses, prepare proposals, and interact with client safety staff. File No. SL

CONTROL , INSTRUMENTATION, and ELECTRICAL
Your role will be to review and specify C and I design, performance and operational requirements at the device and system level. Good knowledge of nuclear/process control systems and instrumentation or electrical system fundamentals is essential. Experience with some of the following is desirable: qualification of instruments for hostile environments, computer control systems, electrical power systems design, selection of electrical equipment, and real-time computer systems control. File No. C&I.

COMPUTER SOFTWARE
You will review computer software used in a variety of applications to ensure that it is Year 2000 compliant, and will specify and produce software for real-time applications. Demonstrated knowledge of and practical experience with computer software processes, including software analysis and testing, is essential. Experience with some of the following is highly desirable: computer control systems, development of high reliability software and database engineering. File No. CS

ROBOTICS
Carrying out conceptual and detailed instrumentation, control and electrical design for a large, intricate, robotics system that performs the on-line refuelling of a CANDU reactor is central to this function.
Demonstrated theoretical and practical experience in the detailed design and documentation of precise, high-accuracy, electrical and hydraulic drive systems for large, heavy mechanical equipment is essential. File No. RE

To be eligible for employment with AECL, applicants must satisfy both immigration and enhanced security clearance requirements.
All positions require a bachelor's degree or higher in Engineering or Applied Sciences, the ability to work effectively in a team environment, and excellent oral and written skills. For the junior positions, a minimum of 2 years' related work experience is required, preferably in the nuclear field.

AECL has an Employment Equity Program and encourages applications from women, aboriginal people, visible minorities, and people with disabilities. AECL provides a smoke-free workplace.

For consideration, please forward (preferably electronically) your resume, with a covering letter quoting the appropriate file number to:

opportunity@aecl.ca

or mail/fax to:
Brenda L. Hall
AECL
Sheridan Park
2251 Speakman Drive
Mississauga, Ontario L5K 1B2
Fax: (905) 823-2584

For further information on AECL, please visit our web site at www.aecl.ca

We thank all applicants, however, only those candidates selected for an interview will be contacted.

AECL EACL

CNS news

Annual General Meeting(s)

The 1998 Annual general Meeting of the Canadian Nuclear Society actually turned into two meetings because of the incorporation of the Society (see page 2) and it (they) were unusual in other ways.

Held Sunday, June 21 at the Marriott Hotel in Toronto (just before the CNS sponsored *3rd International Steam Generator and Heat Exchanger Conference*) it was the first time in the 19 year existence of the Society that it had not been held during the Annual conference. Further, the "normal" AGM, the 19th, was the last for the Society in its historic format.

On opening the 19th Annual general Meeting of the CNS, President Ben Rouben announced that the Letters Patent for the incorporated Society had just arrived from Industry Canada and therefore, "CNS Inc." was in existence. Consequently, he proposed that immediately following the close of the 19th AGM, which would be the last for the unincorporated Society, the 1st AGM of the incorporated CNS would be held.

Incoming CNS preident, Paul Thompson (R), presents a plaque to retiring president Ben Rouben for his efforts during his tenure, including achieving incorporation of the Society, at the Annual General Meeting, Toronto, 21 June 1998.

The 19th AGM followed the usual pattern. After approval of the Minutes of the 18th AGM held June 9, 1997, at the Inn on the Park, Toronto, president Ben Rouben gave his report (which is presented elsewhere in this Section).That was followed by the Treasurer's report, presentation of the audited financial statements Then there were short reports from most of the Committees and Divisions.

As a final act, a motion was passed to transfer all of the assets of the unincorporated Society to the newly incorporated Canadian Nuclear Society.

That AGM was adjourned, and immediately, the President called to order the 1st Annual general Meeting of the incorporated Canadian Nuclear Society.

The first action was to approve the auditors, the firm of Grant Thornton, the new name for the firm Doane Raymond which the Society has used for several years.

Then past-president Hong Huynh, chairman of the Nomination Committee presented the nominated slate of officers and Council members-at-large. There being no further nominations these people were declared elected by acclamation. (See the box listing.)

A motion was passed that all members in good standing of the unincorporated Canadian Nuclear Society, as of that date, would be declared members in good standing of the newly incorporated Society.

At this point outgoing President Ben Rouben handed over the traditional gavel to the CNS president for 1998-99, Paul Thompson who gave a short address and then presented Ben Rouben with a plaque to recognize the extraordinary effort he made in achieving incorporation of the Society.

Following the requisite banking motions the 1st Annual General Meeting of the newly incorporated Canadian Nuclear Society was adjourned.

The next AGM will be held in June 1999 during the Annual Conference in Montreal.

The 1998-99 Executive of the Canadian Nuclear Society pose following the Annual General Meeting, 21 June 1998. Left to right: Ben Rouben, past president; Andrew Lee, treasurer; Paul Thompson, president; Ian Wilson, secretary; Krish Krishnan, 1st v.p.; Ken Smith 2nd v.p.

President's Report

Following is the report by outgoing President Ben Rouben to the 19th Annual General Meeting of the Canadian Nuclear Society, Toronto, 21 June 1998

I am happy to say that these are very good times for the Canadian Nuclear Society.

This past year has been a very busy one for your Council, certainly a year of "firsts". The one extraordinary event, which took much effort and has just seen completion, is the attainment of our incorporation as a not-for-profit corporation. Many steps were involved in this:

- lengthy discussions within Council (over many years, incidentally) about the merits of the idea,
- the drafting of our proposed by-laws, which took an untold number of iterations (but which then passed Industry Canada without a single change, even a minor one),
- the balloting of the membership, with an overwhelming vote of 97% in favour of incorporation,
- co-ordination with the Canadian Nuclear Association [since we were in fact all these years "the Technical Society of the CNA"] for amendment of its by-laws and gracious permission for us to legally keep using our name,
- and application to Industry Canada for our Letters Patent, which arrived just a few days ago.

Incorporation is a major step for the Canadian Nuclear Society. It marks the full attainment of our maturity. While we enjoy, and will enjoy in the future I'm sure, a continuing excellent relationship with the CNA, we are now in law as well as in fact "the captain of our ship and the master of our fate". We are a separate entity, an independent technical and scientific society, on the same footing as all our sister societies world-wide. What we make of our future is now up to us, and us alone.

The CNS has organized many conferences in the past year, and the Steam Generator Conference is starting today, as you well know. You will hear about these from the Divisions, so I will not repeat this information here. I only want to thank all our organizing committees for their tremendous efforts for the quality and success of our conferences. I also want to remind you about, and invite you to, our 19th Annual Conference, to be held this year October 18-21 in Toronto. I also want to recognize our Branch Executives, who organize interesting seminars and local events; Branches are often the primary point of contact with the Society for our members.

I hope you all received and are proudly displaying your CNS membership certificate. Creating the certificate was another initiative of your Council this past year, and this also took a lot of planning and effort. I find the certificate quite attractive, and hope you do too. If for any reason you have not received yours or your 1998 renewal sticker, please let the CNS office, or me personally, know about it, so that we can correct the situation.

Another first this past year was the creation of our exciting CNS website. You will hear about it from the Internet Committee. I am very happy with this accomplishment, and am convinced that the website will increasingly become another excellent communication vehicle to our members.

Another initiative this year, one which will come to fruition this week in fact, is the course which we have organized for High School teachers, on the Science of Nuclear Energy and Radiation. We think this course, which will be given at McMaster University as a pilot project, will be extremely useful for teachers and will allow them to pass on to their students good information about nuclear technology. In the area of communication, the CNS has also provided partial assistance to Dr. Hans Tammemagi for the production of a book he is writing on nuclear technology, with particular emphasis on the Canadian perspective.

The CNS continues to reach out to sister nuclear societies. We have signed or renewed several agreements of co-operation. Our involvement on the international scene was never more evident than in our underwriting, along with the CNA, of the recent and extremely successful 11th Pacific Basin Nuclear Conference, organized by Dr. David Torgerson and his team.

Yes, the CNS is enjoying much success on the technical front, and you will also hear from our Treasurer, Ken Smith, that we are financially very healthy, which will allow us to do even more good things.

And yet, I must say that there is one point which does concern me, and that is membership. Paradoxically, in the face of all our success, it seems to be more difficult to ensure prompt payment for membership renewal, even though our membership fee is

CNS Council for 1998-99

Executive

President	Paul Thompson
1st vice-president	Krish Krishnan
2nd vice-president	Ken Smith
Secretary	Ian Wilson
Treasurer	Andrew Lee
Past president	Ben Rouben

Members at Large (Voting members)

Parviz Gulshani	Kris Mohan
Glenn Harvel	Jad Popovic
Hong Huynh	Ed Price
Peter Laughton	Duke Segel
Vincent Langman	Harold Smith
Raymond Leung	Judy Tamm

In addition, the president of the Canadian Nuclear Association (Murray Stewart) is an ex-officio, voting member of Council.

really almost nominal. Efforts to contact members for renewal take an undue amount of our office staff's time. This difficulty baffles me personally. Membership and active participation in the CNS gives members opportunities to tremendously increase their contacts and network and their perspective. I know from experience how rewarding this is. I believe that the CNS provides good service, and that anyone with a stake or interest in nuclear science and technology in Canada should be joining the CNS. I think this is one challenge which is still in front of Council: how to better convince our colleagues to join the CNS and renew early every year. I also count on each one of you, loyal members, to be a good ambassador and salesman for the Society.

However, I certainly do not intend to end on a pessimistic note, quite the contrary. The CNS is a healthy and vibrant society. It was extremely exciting for me to be President this past year. And from my many years of acquaintance with Paul Thompson, I know that the CNS will remain in good hands, and that with the Council which will be installed today, the CNS will continue always towards bigger and better things.

Ben Rouben
CNS President 1997-1998

Women in the CNS

Following is the report by Jad Popovic on the work of the "Women in CNS" committee.

The mandate of the committee is to stimulate and encourage membership of women in the CNS, and to encourage their full participation in the Society. The creation of this committee was based on a review of membership information which indicated a low number of women in the membership.

The committee consisted of two CNS Council members, Jad Popovic, chair, and Judy Tamm, deputy chair, both of AECL.

The committee has been involved in a number of activities. Some of these include:

- information sessions to explain the role of the CNS to encourage greater women membership and participation
- recruiting women to become members of the branch executive, and serve on various committees
- involvement in debates on anti-nuclear motions initiating in various women's groups such as the Canadian Federation of University Women

The Committee organized a communication meeting with women in Sheridan Park branch and explained them a role of the CNS. The meeting was well attended and succeeded in recruitment of several women to work in the CNS SP branch as members of the executive, members of the sub-committees, in particular in the educational sub-committee. For example, the educational sub-committee was very active in the Science Fair in the Peel-Dufferin and Hamilton-Wentworth regions including women in judging and awarding young elementary and high school participants of these fairs. Another activity included women engineers in the career fair for the high school students held at AECL.

Women in the CNS worked with members of the Canadian Federation of University Women (CFUW) in order to defeat anti-nuclear motion on "Disposition of plutonium from dismantled nuclear weapons" being presented by the CFUW Subcommittee On Global Peace And The Environment at their AGM. Although the motion was defeated at this meeting, the lobbying within CFUW and by the CFUW within Parliament was still going and the motion resurfaced in the CFUW meeting in Fredericton in April this year where the Committee of Women in the CNS worked with members of the CFUW and succeeded for it to be defeated again.

A lot more can be done in future by the Women in the CNS Committee to provide incentives to attract women to the CNS.

Intersociety Affairs

Following is the essence of the report by Parviz Gulshani, chairman of the CNS Intersociety Committee at the CNS Annual General Meeting.

Contacts with two societies were established.

One of these is the **Canadian Radiation Protection Association** (CRPA).

- CNS proposed to CRPA the signing of an agreement formally recognizing the establishment of closer ties between the two societies and establishing rules of conduct for collaborative activities. This activity is ongoing.
- A joint CNS-CRPA session was held on May 24 1998 at the 1998 CRPA Annual Conference in Ottawa and three paper were presented by CNS members on:

CNS-CRPA, a possible symbiotic relationship, by F. Boyd.

Prediction of reactor-face dose rates for full-system decontamination of a heat transport system, by D. Taylor, et.al.

Radiation dose-reduction measures in CANDU reactors, by K. Aydogdu, et.al.

These papers were well received.

- A joint CNS-CRPA session will be held on October 18 1998 at the CNS Annual Conference and seven papers will be presented by CRPA members.
- These activities were reported in the *CNS Bulletin* and the CRPA Bulletin.
- A link between the CNS and CRPA web sites was established.

The second society is the **Canadian Association of Physicists** (CAP).

- A joint CNS-CAP session was held on June 16 1998 at the CAP Congress in Waterloo. The session was a great success with full house attendance from the student body, university staff, and industry staff including retirees of AECL. Four papers were presented on:

Three decades of CANDU Reactors by Jasper S.C. McKee, member of the board of AECL.

A Concept for Disposing of Canada's Nuclear Fuel Waste, by Ken Dormuth, director of CANDU Environmental Studies of AECL.

Application of Nuclear Physics, by Jim Jury, Professor and chair of Physics Department at Trent University

Physics Modeling Methodology for Analysis of MAPLE Reactors, by Harold J. Smith, Section Head, Physics Section, MMIR Project, AECL.

There were lively discussion after each presentation.

- The possibility of a joint CNS-CAP session at the 1998 CNS Annual Conference is being discussed with CAP.
- The above activities will be reported in the *CNS Bulletin* and CAP *Physics in Canada.*

Paul Thompson, CNS President 1998-99

Paul D. Thompson beGame the president ofthe Canadian Nuclear Society at the Annual General Meetin2 in Toronto June 21. 1998.

Paul is currently the acting Nuclear Safety Manager at Point Lepreau. He is a member of the COG Safety & Licensing Technical Committee, a member of the steering group of the industry exercise on code validation and toolset qualification and on the committee which developed CSA standard N286.7.

Pau] joined Atomic Energy of Canada Limited at Sheridan Park in the late 1970s, after graduating from the Engineering Mathematics program at Queen's University, in which he specialized in the fields of Thermal Sciences and Nuclear Engineering. At AECL, he initially worked in the area of high temperature fuel channel behaviour, including R&D support, model development and safety analysis. Paul was involved in a number of analyses required for Point Lepreau and Gentilly-2 to be licensed for full power operation.

Subsequently, he was appointed Licensing Supervisor tor the domestic CANDU 6's. In that role he led the development of the team approach for safety analyses. ln 1984, Paul introduced a restructuring of the CANDU 6 Satety Report that is the basis tor current reports. Paul was later involved in the CANDU 6 improvement program, the CANDU 3 development team, and worked in support of various key (CANDU 6 marketing activities.

In 1986, Paul joined NB Power at the Point Lepreau Generating Station, where he has been responsible for safety analysis, reactor physics and fuel. In addition to his regular responsibilities, he has been active in the integration of design, operation and analysis (DOA), in the study of the satety aspects of plant ageing, and in the promotion of a more unified and co-ordinated safety analysis community.

Paul has been active in the Canadian Nuclear Society at both the local and national level, having been chairman of the New Brunswick branch, the Nuclear Science and Engineering Division. and the Program Committee. He has also been involved in the organization of several conferences..

On the personal side, Paul lives in the town of Grand Bay, N.B., with his wife, Sue, and their three children (who will probably see even less of him now that he has taken on the mantle of CNS President). In his earlier years Paul played hockey at the competitive level and now, when he has time, can be seen on the squash court or, occasionally, jogging.

Paul Thompson has already made many contributions to the Canadian Nuclear Society and will, undoubtedly make many more during his tenure as president.

Incoming President's Message
to Annual General Meeting 1998 June 21

Last year was a busy and exciting time for the Canadian Nuclear Society. Under the fine leadership of Ben Rouben supported by a hard working council, we were able to accomplish incorporation, set up a CNS Web-site, hold three major conferences, support the organization of PBNC '98, and issue grand membership certificates. This is clearly an impressive list of achievements and sets high expectations for the coming year and for our new council.

This year, in addition to holding the 3rd International Steam Generator and Heat Exchanger Conference, we are also organizing the annual CNS conference which is slated for October 18-21 in Toronto. In response to the demand, we are also planning to hold a number of topical courses. A CANDU Reactor Safety Course and a CANDU Lattice Physics Course will be given in the fall. Consideration is also being given to organizing a CANDU Fuel Course and possibly one on Chemistry. Planning is also underway for the 1999 annual CNA/CNS conference which will take place next June in Montreal.

Further to our busy slate of courses and conferences, we expect to continue to develop our popular Web-site. The council believes this is a very important endeavor as it allows us to both communicate better with our membership as well as reaching a wide body of the population who are now actively using this medium. We will also continue our efforts in the education and communication areas. An example is our involvement in the upcoming course being given to high school science teachers on the Science of Nuclear Energy and Radiation. Our membership committee is also working on a number of innovative initiatives.

In terms of upcoming opportunities, I would like to see an increased level of activity at some of the branches, as the role of the CNS becomes even more important in times of change.

I look forward to the challenges that lay ahead and hope that I can count on your support to maintain a strong and active learned Society.

Paul D. Thompson

Treasurer's Report
to the 1998 Annual General Meeting

The Auditor's Report for 1997 is attached. Page 3 indicates that Members' Equity (Surplus) at the end of 1997 was $311,000, slightly lower than the level at the end of 1996, but well above the $221,000 at the end of 1995. Thus, the CNS continues to maintain a strong financial position.

Detailed revenue and expense data for 1997 are shown on Page 2. As in previous years, membership fees (at close to $39,000) accounted for about 1/5 of total revenue. The total revenue from Conferences and Courses came to $117,458, mainly due to a very successful Maintenance Conference. Conference revenue was less than in 1996, but more than in 1995. Note that 1996 was an exceptional year for conference revenue, and we cannot expect to repeat that performance very often. In all cases, the conference organizing committees deserve our considerable appreciation for their hard work. Total revenue for 1997 was $170,372, less than for 1996, but above the 1995 level.

Operating expenditures in 1997 totalled $154,994, which is higher than in 1996. Nevertheless, revenue exceeded operating expenditures by $15,378. After accounting for expenditures from the Special Projects Fund (see below), we ended the year with a net deficit of $9,004.

Because of the exceptional 1996 results and the resulting large increase in Members' Equity, we decided at last year's AGM to create a Special Projects Fund, to be used solely for unusual and unbudgeted projects. This turned out to be fortuitous, as we later received requests for financial support for the examination of the effects of low-level radiation. You will see that we allocated a total of $20,322 for this purpose. We also decided to spend $4,060 on the one-time procurement of new Membership Certificates for all of our members.

Since 1991, our Auditor has been the firm of Doan Raymond, which recently changed its name to Grant Thornton. We are satisfied with the work of this firm, and I recommend that Grant Thornton be contracted to handle the audit duties for 1998.

K.L. Smith, CNS Treasurer - 1997/98

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, 1997 and the statements of operations, surplus and changes in financial position for the year then ended. These financial statements are the responsibility fo the Society's Council. 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 and 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, 1997 and the results of its operations and changes in its financial position for the year then ended in accordance with generally accepted accounting principles.

Doane Raymond, Chartered Accountants
Toronto, Canada, March 4, 1998

Canadian Nuclear Society
Financial Statements for 1997

Statement of Operations

Year Ended December 31	1997	1996
Income		
Membership fees	$ 38,645	$ 38,916
Publications	7,181	6,017
Interest	7,088	10,243
	52,914	55,176
Society projects – excess of income over expenditures		
Annual conference	7,629	15,918
Adjustments from 1995 Conferences/Courses	2,206	–
1995 Reactor Physics Course	–	490
1996 CANDU Fuel Handling Conference	–	10,536
1996 Inter'l Conf. on Simulation Methods	2,593	40,807
1996 Geological Disposal Conference	904	56,743
1996 Symposium on Radiation Impacts	1,135	7,809
Environmental Assessment - Fuel Disposal Concept	–	(597)
1997 Simulation Symposium	8,342	–
1997 CANDU Maintenance Conference	65,858	487
1997 CANDU Fuel Conference	14,953	–
1997 Reactor Safety Course	13,838	24,477
	117,458	156,670
Total income	170,372	211,846
Operating Expenses		
Net expenditures by branches	10,013	6,138
Committees	17,946	15,448
Office support	60,000	50,000
Office services	17,580	21,693
Canadian Nuclear Society Bulletin	32,070	30,852
Other items	17,385	5,298
Total operating expenses	154,994	129,429
Excess of income over operating expenses	15,378	82,417
Expenditures from Special Projects Fund (Note 4)	24,382	–
(Deficiency) excess of income over expenses	(9,004)	82,417

Balance Sheet

Year Ended December 31	1997	1996
Assets		
Current		
Cash		
Bank accounts	$ 259,179	$ 204,046
Nuclear Operations Division	1,793	1,793
Branch bank balances	16,476	18,314
Receivables	15,775	36,878
Accrued interest	500	749
Prepaids	–	260
Conference advances	24,803	23,000
Due from Canadian Nuclear Association	4,715	–
	323,241	285,040
Marketable securities (market value - $54,111; 1996 - $51,810)	53,427	52,108
Equipment (Note 2)	1,666	–
	378,334	338,148
CNS share of Education Fund assets (Note 3)	17,000	17,000
	395,334	355,148
Liabilities		
Current		
Payables and accruals	$ 65,080	$ 29,643
GST payable	3,526	65
Subsequent year's membership fees received in advance	13,826	528
Due to Canadian Nuclear Association	–	4,317
Due to Education Fund	1,311	–
	83,743	34,553
Surplus (Members Equity)		
Unrestricted	268,973	303,595
Restricted		
Education Fund (Note 3)	17,000	17,000
Special Projects Fund (Note 4)	25,618	–
	311,591	320,595
	$ 395,334	$ 355,148

Notes to the Financial Statements
December 31, 1997

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) **Marketable securities**
     Marketable securities are carried at cost adjusted for amortization of premiums or discounts.
   - (c) **Equipment**
     Computer equipment is recorded at cost and depreciated over its estimated useful life on a 30% declining balance basis.

2. **Equipment**

	Cost	Accumulated Depreciation	1997 Net Book Value	1996 Net Book Value
Computer equipment	$ 1,960	$ 294	$ 1,666	$ –

3. **Education Fund**

From 1988 to 1991, annual contributions amounting to $3,000 from the Society and $7,000 from the Canadian Nuclear Association (CNA) were allocated from the income from the annual conference. In 1995, the Society made an additional contribution of $5,000. The principal remains the property of the CNA and the Society. The interest on these funds is available for education purposes to local branches of the society.

		1997		1996
The total fund is composed as follows:				
Principal contributions				
Canadian Nuclear Association	$	**28,000**	$	28,000
Canadian Nuclear Society		**17,000**		17,000
		45,000		45,000
Accumulated interest available for education activities, beginning of year		**7,540**		7,500
Fund assets as of beginning of year		**52,540**		52,500
Interest earned during the year		**2,995**		3,090
Allocations during the year		**(4,750)**		(3,050)
Fund assets as of end of year	$	**50,785**	$	52,540

4. **Special Projects Fund**

During the year, the Society appropriated $50,000 from its accumulated members' equity surplus for a Special Project Fund which is to be used for non-budgeted and unforeseen projects. During 1997, Council approved expenditures of $24,382 from the Fund.

Allocation to fund during the year		$	**50,000**
Expenditures during the year:			
US Conference on Low Level Radiation Effects (US $7,500)	**10,322**		
University of Ottawa, Centre for Low Level Research	**10,000**		
Membership certificates	**4,060**		24,382
Fund balance, end of year		$	**25,618**

BRANCH ACTIVITIES

1. BRUCE Branch (Eric Williams)

On April 28th, 1998, Dr. Gary Kugler, VP AECL Commercial Operations, addressed the Bruce Branch of the CNS on the topic of AECL's challenges at Home and Abroad. Dr. Kugler left the audience with an accurate update of the CANDU picture world wide, and optimistic outlook for CANDU for the future. Twenty-two were in attendance at the presentation.

- June 1998, Mr. Jim Ryder, VP Bruce Nuclear, Ontario Hydro, addressed the Bruce Branch of the CNS on the New Organization at the Bruce Nuclear. Despite the challenges which lie ahead, the meeting left us reassured of the future of the Bruce Nuclear and the leadership team which will take us there. Twenty-one were in attendance at this presentation.
- Three local high school teachers will be attending the CNS - MacMaster University Seminar, June 22-25, 1998 on "Radiation and Nuclear Energy For High School Teachers". The Bruce Branch CNS thanks the CNS for their support in offering this opportunity to local teachers.
- The next meeting will take place on September 24, 1998 with Mrs. Beth McGillivray, Ottawa General Hospital, who will address the Bruce Branch on the top of "Nuclear Medicine". While at the Bruce she will also make presentations to local senior High School students on the subject of Nuclear Medicine and career opportunities.

2. CHALK RIVER Branch (Jeremy Whitlock)

The Chalk River Branch has held four public seminars since our last report in The Bulletin.

On March 26 **Phil Davis,** of the Environmental Research Branch at CRL, gave an interesting presentation on "Establishing the Credibility of Model Predictions: The Human Factor". The focus of Phil's talk was a recent international project to determine how results from computer modelling can vary depending on the user.

On April 4 **David Lee,** also of CRL's Environmental Research Branch, presented "An 'Underground Plan' to Capture Radioactivity", which discussed the problem of groundwater contamination, and AECL's state-of-the art technology of mitigating it. Dr. Lee repeated the presentation on May 7 in Pembroke at a public seminar sponsored jointly by the Chalk River Branch and Algonquin College.

On May 26 AECL Engineer Emeritus **Gordon Brooks** visited the Chalk River Branch, and gave a public presentation with the title, "Why CANDU is the way it is". Gordon shared his knowledge of the history behind some of the essential design decisions made in the evolution of the CANDU reactor.

On June 18, **Paul Lafrenière,** AECL's recently-appointed head of Facilities & Nuclear Operations, presented an account of "Nuclear Operations at Gentilly-2 NPP", which is where Mr. Lafrenière worked before AECL.

As usual, summaries of all these presentations are published on our branch webpage.

The Branch was also a participant in AECL's Science for Educators Seminar, April 16-18, with a static display and the ever-popular Hands-On Radiation Workshop. A scaled-down version of the workshop (more of a demo) was presented to a high-school chemistry class on May 26 at the AECL visitor's centre. During CRL's Open House, June 20, the branch again had a static display, and Radiation Workshop demo that ran all day long. Many thanks to the volunteers who donate their time and energy to these very worthwhile events.

3. MANITOBA Branch (Morgan Brown)

The Manitoba Branch showed the video of Ralph Hart's talk on "Know Your Reactors", spread over two lunch hours. The video was quite well attended. For the second day the overheads were projected at the same time the video was played, since the video did not show the overheads clearly. This "multi-media" presentation worked very well, and greatly improved the presentation for the second day. The tape and overheads have been sent to the Underground Research Laboratory for a showing, and several people have requested borrowing the tape.

4. GOLDEN HORSESHOE Branch (Dave Jackson)

The Manitoba branch showed the video of Ralph Hart's talk on "Know Your Reactors", spread over two lunch hours. The video was quite well attended. For the second day the overheads were projected at the same time the video was played, since the video did not show the overheads clearly. This "multi-media" presentation worked very well, and greatly improved the presentation for the second day. The tape and overheads have been sent to the Underground Research Laboratory for a showing, and several people have requested borrowing the tape.

5. NEW BRUNSWICK Branch (David Reeves)

On Saturday, May 23rd, 1998, CNS-NB Chapter members and their guests were treated to a lobster boil dinner provided by the Saint Mark's Venturers, held at the Rockwood Park Interpretation Centre in Saint John. This was a well attended and successful event. Dr. Murray Stewart, President and CEO of the CNA gave a talk on the future of CANDU technologies with an emphasis on the consequences of the Kyoto conference. Clair Ripley from AECL summarized AECL's educational initiatives in the Maritime provinces. Attached are several photos from the event, one showing our guest speaker in action and the other showing the presentation of the NB Chapter outstanding contribution award to Dr. Keith Scott of Atlantic Nuclear Services Limited. The following summary of chapter activities was presented by David Reeves, CNS-NB Chairman :

Summary of CNS-NB Chapter Activities for the year May 1997 to May 1998.

May 1997: **Dr. John Hilborn** (CRL) & **Dr. Bashkar Sur** (CRL), Historical Development of Incore Flux Detectors, The Sudbury Neutrino Observatory

Oct 1997: **Dr. Roger Humphries** (CANDESAL), The application of Nuclear Energy for Seawater Desalination - The CANDESAL Nuclear Desalination System

Nov 1997: **Dr. Doug Boreham** (CRL), Radiation Cancer Risk: Thank Mom and Dad

Mar 1998: **Trevor Collins** (British Energy), Nuclear Energy in a Competitive Market, Deregulation of the Electricity Market - the British Experience.

April 1998: **Patrick Reid** (ALARA), CANFLEX Fuel Design

April 1998: **Bryan Patterson** (Human Factors Practical), **Dr. Bradley** (UNBSJ), Human, Error and Psychological Error Mechanisms

Additionally, we have provided sponsorship, through the Education Fund, of a high school science teacher to attend the course "Science of Nuclear Energy and Radiation" on June 22-25, 1998 at McMaster University. The attendee will be Mr. Darren White, science teacher at KV High School. It is hoped that this experience, which includes development of a Nuclear Science lesson plan for use in high schools, will provide a very positive learning experience which can be passed on to students under Mr. White's instruction.

As a consequence of our increased activities this year, membership in the NB Chapter has grown by an additional five members. The executive intends to improve on our existing program by increasing the number of activities. In past years we have discontinued our speakers presentations during the summer months due to low attendance. However, for this year, it is our intent to continue with the speakers presentations for July and August. Presentations will be as follows :

July 9, 1998: **Dr. E. Hussein** (UNB), Low Dose X-rays and Public Dose Exposure

July 29, 1998: **Dr. D. Cox** (AECL), Plutonium Dispositioning

Aug. ?, 1998: To be announced, Motor Operated Valves at PLGS

Specific announcements will be posted in the usual manner.

6. OTTAWA BRANCH (M. Lamari)

Four seminar meetings were held in the 1997/98 period as follows:

Roger Humphries, CANDESAL Enterprises Ltd., November 1997. The CANDESAL Nuclear Desalination System: The Application of Nuclear Energy for Sea Water Desalination.

Brian T. Debs, Ontario Hydro, January 22, 1998, Findings and Recommendations of the Independent, Integrated Performance Assessment of Ontario Hydro Nuclear..

Joe Borsa, MDS Nordion, February 26, 1998.
New Developments in the Food Irradiation Industry.

Jim Harvey, AECB, April 30, 1998.
Canada's Nuclear Program - A Regulator's View.

In addition the Branch held a dinner meeting in conjunction with the banquet of the 23rd Annual CNA/CNS Student conference at RMC, Kingston. March 27, 1998.at which Dr. Paul Fehrenbach, CRL, AECL, was the guest speaker. (CNS members at RMC are attached to the Ottawa Branch.)

Education Activities

Annual Regional Science Fair

The Ottawa Branch participated in the annual Ottawa Regional Science Fair through a donation and as a special award sponsor. The award criteria was: "Best Project in any category (junior or senior), displaying or explaining beneficial effects of the use of ionizing radiation or the application of nuclear science and technology." Four (4) projects related to nuclear science and engineering were judged. This year's award winner was Chris Longair of Hopewell Avenue Public School for his project explaining a nuclear power plant.

Educational Field Trip

On June 19, 1998, 8 high school students participated in a guided tour of the Departments of Nuclear Medicine and Radiology, and the Cancer Clinic of the Ottawa General Hospital. Several more had indicated their wisah to perticipate but a number of factors reduced the actual numbes. The tour was organized by Sadok Guellouz, executive member of the Ottawa Branch of the CNS.

7. PICKERING BRANCH (Marc Paiment)

Activities for the past year:

- Pickering Nuclear Open House
- sponsorship of local student to Deep River Science Academy for 1998

Some of our plans for the next year

- resume seminars once Auditorium becomes available
- Dinner Evening with Darlington CNS Branch
- Pickering Nuclear Open House this Fall
- promotion of Nuclear Science course for local teachers for next year's course
- prize for local Science Fair

CNS presidents – past and present – gather during the PBNC '98 Conference in Banff, May 1998. Left to right: Ed Price, Jerry Cuttler, Hong Huynh, Ben Rouben, Paul thompson

8. SHERIDAN PARK BRANCH (K. Tsang)

We had three seminars since our last council report. The speakers are J. Jovanovich (Professor at the University of Manitoba), M. Stewart (President of the CNA), and P.G. Boczar (Director of Fuel & Fuel Cycle Division, AECL). All three seminars were well attended with over 40 members each.

On May 19, 1998, Professor Jovanovich gave an overview of the greenhouse effect from a physics point of view. Topics of his speech ranged from gaseous emission to solutions on how to avoid and reduce the greenhouse effect.

On May 21, 1998, Dr. Stewart gave a review of the current issues and challenges facing all facets of the Canadian nuclear industry. He highlighted actions that the industry would take to ensure success in the 21st century. The presentation included uranium mining and processing, nuclear power generation, reactor activities and isotopes generation. Special emphasis was on the impact of the Kyoto Protocol and the unique opportunity that it gave to the nuclear power. The impact on the Canadian and global CANDU industries and markets due to the IIPA results on Ontario Hydro was also addressed.

On June 18, 1998, Mr. Boczar gave a presentation on the flexibility on the CANDU fuel cycle detailing on the CANFLEX (with natural uranium and recycled uranium), MOX (mixed oxide fuel), thorium, and DUPIC fuel cycles. The new recycling technologies that may be developed to exploit the unique CANDU cycle flexibility allowed CANDU to be envisaged as an indispensable part of any LWR system.

New members of the CNS

Guy A. Arbour
Michelle L. Bickerton
Dany Boivin
Mustapha Boubcher
Ghislain Boudreault
Lou W. Champagne
Johnathan R. Costa
Martin Daigneault
Marie Di Marco
Ottman El Hajjaji
Alexander C.F. Hadfield
Yanjie Han
Donald R. Hoffman
Siamak Kaveh-Khorie
Monica M. King
David M. LeBlanc
David Robert Lee
Jean-Francois Legault
John A. McDonald
Joanna McFarlane
Eleodor Marian Nichita
Stephen Edward Oliver
Mohammed Ousmoi
Marc Perusse
Sergei M. Petouknov
Duong Pham Van
Fariborz Taghipour
Alexander C. Wolski
H.H. Wong
Metin Yetisir

Neutrons for the Next Fifty Years

H.A. Rose and WmJ.L. Buyers

Ed. Note: *It is now over a year since the National Research Council took over the reins of Canada's neutron-scattering materials research program (in April 1977). The following is a report on a public seminar by Dr. William Buyers of the NRC, hosted by the CNS Chalk River Branch in February 1998. The report was prepared jointly by Al Rose of the Chalk River Branch, and Dr. Buyers.*

On February 26, 1998, the Chalk River Branch hosted a talk by Dr. William J.L. Buyers, F.R.S.C., Past President of the Canadian Institute for Neutron Scattering and Principal Research Officer of the Neutron Program for Materials Research with the National Research Council. Dr. Buyers spoke on the subject of "Neutrons for the Next Fifty Years".

The theme relates to Canada's need to retain its place in materials development in order to compete successfully in future economic development with the rest of the world. Neutron scattering is a major measurement tool in this field, and a capability in this field is supported in all the developed nations. In Canada, however, the NRU reactor, which currently provides the neutron source, is scheduled for retirement by 2005. In order to continue neutron scattering work a new reactor source will be required.

Materials research using neutrons is not limited to engineering materials, but ranges from that to biophysics, chemistry and earth science. It is applicable to the study of everything from jet engine components and nuclear fuels, to magnetism and the lipid structures in biological cell walls. An AT&T study has shown a direct link between materials research and economic development in countries participating in this activity. A US report concluded that every dollar invested in research in general had produced a return of 28% since the end of the second world war. That is an absolutely amazing return on investment.

The problem is the measurement of distance between atoms packed at 100 million to each centimeter. Neutrons are neutral particles that act like waves, with wave lengths short enough to see these gaps between atoms. Since they are neutral particles, neutrons can also penetrate dense material. The technology in Canada is the legacy of Dr. Bertram Brockhouse, who pioneered the field in the 1950's. Brockhouse shared the 1994 Nobel Prize in physics for his development at Chalk River of neutron spectroscopy, so as to see "how the atoms move".

The technique can study phenomena in real time and under realistic wet electrochemical conditions. An example is the real-time measurement of thin corrosion films growing on titanium samples. These interfaces and surface effects can be seen by reflecting neutrons at a very small angle from the metal as it corrodes. A good neutron window is provided by silicon which is transparent to neutrons thus allowing scientists to look at what is going on inside a working electrochemical cell. Any material that is a candidate for seclusion of toxic wastes, including nuclear wastes, needs to be examined by neutron reflectometry so as to ensure that the oxidation and hydrogen ingress processes are well understood for the long term. Information is got with a resolution as small as 5 atomic layers and as large as 5000 layers (2 microns).

Neutrons can also be used to look into the interior of massive machinery. Scientists can study materials at high temperatures or highly radioactive sources because the neutrons easily pass through containment vessels and shielding. For more information see http://www.sims.nrc.ca/sims/neutrn_e.html

Passing on to the politics of the subject, one should recall that AECL dropped funding for neutron scattering one year ago as a result of financial restraints resulting from Program Review decisions. Fortunately bridge funding of the direct program costs from several sources, including Natural Resources Canada, was routed to the National Research Council which now manages the program. NRC's Neutron Program for Materials Research. operates in a form of partnership with AECL, which provides in-kind contributions including laboratory space and neutron beams.

Obviously, to go forward with this in the future you need to have a plan for a new neutron source. AECL has indicated it will not run the NRU reactor beyond 2005 and unplanned events could shut it down before that date. There are certainly strong plans to build a replacement research reactor in Canada, using MAPLE technology (see the Bulletin, vol.17, no.4, and also vol.16, no.1).

To provide some perspective, an OECD study projects that steady-state reactor neutron sources world wide would decrease by a factor of five over the next twenty years. Over the same period the capacity of accelerator based neutron sources (spallation sources) to perform neutron beam research was expected to increase. However, these spallation sources are not suitable for in-core testing of materials and fuels for power reactors such as the CANDU.

A new US initiative is to build a one megawatt $1.3 billion Spallation Neutron Source (SNS) at Oak Ridge. President Clinton had just placed it in his budget with first year funding of $ 157 million. In announcing that Oak Ridge was to be the site of the SNS, Vice_-President Gore said, "this new facility will help us to reclaim America's position as the world leader in a technology we invented." The US is playing catch-up in trying to remain competitive with European and other world capabilities in this field. See http://www.ornl.gov/sns/sns_intro.htm.

There are three other spallation source proposals worldwide, one in Europe and two in Japan. Germany is building a new research reactor, the FRM2, largely dedicated to neutron beam research on materials, Australia has said it will provide $US220M for a new research reactor to replace the aging HIFAR, China has plans for one (CARR), and of course Korea

is already benefiting from its new Hanaro research reactor, which has a core based on MAPLE technology.

As for the Canadian future, the proposal for a new Irradiation Research Facility (IRF) would require, according to AECL's 1994 Case and Concept Study, some $400 million for the reactor with its CANDU-related in-core test facilities and external loops. The present cost for the reactor and its CANDU facilities is estimated to be somewhat lower, and AECL would be responsible for this portion of the funding. An additional $80 million, for which the Canadian neutron-scattering community is responsible, is now estimated would provide a cold neutron source of some ten times the brightness of present NRU beams and a set of modern instrumentation placed in a large hall to which neutrons are delivered by internally coated neutron guides. This would open up many new fields of measurement and ensure a competitive advantage for Canada in the world.

The concept of a cold neutron source is simple enough. You run "warm" neutrons from the reactor moderator into a container of liquid hydrogen cooled to -250 degrees C. This slows the neutrons down by about a factor of three and increases their wave length, which in turn expands the kind of measurement you can make with them. The cold neutrons are emitted from the liquid hydrogen into an evacuated neutron guide for transport to the instrumentation in the guide hall.

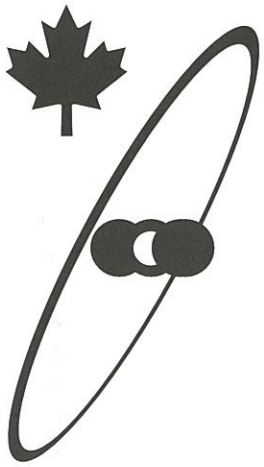
Canadian scientists presently have free access to neutron facilities in other countries, when a more powerful source or specialized instrument is needed, but in order to retain that privilege it is necessary to have our own facilities in Canada and to be able to offer reciprocal privileges to foreign scientists. International access would leverage the Canadian investment.

Most questions after Dr. Buyers' talk were of a technical nature except for the last, in which a young boy asked how cold a cold neutron really was. The reply was that if one were to stand naked in January in Northern Canada one would probably not notice the difference between that and standing in a bath of cold neutrons. You would freeze to death very rapidly in either case!

Assurances were given to the audience that the NRC believed in this project and wanted to work cooperatively with AECL to develop a viable proposal. The NRC has recently completed a major forecast called "Future Prospects for Neutron Beam Research and Technology in Canada", which highlights the need to retain the neutron beam capability for Canada, and places the program in the international and national context. The findings of the report supporting this conclusion can be summarized as follows:

- ***Science and Technology are essential factors of future economic growth in the emerging knowledge-based global economy.***
- ***There is a clear role for government policy to support the development and enhancement of a nation's research infrastructure.***
- ***The National Research Council has a clear leadership role to play in the support of Canada's knowledge-based economy.***
- ***Materials technologies are universally recognized as strategic priorities for future economic growth.***

  Materials technologies, along with information technologies and biotechnologies have been identified by virtually all OECD nations as well as leading emerging economies as strategic technologies for the 21st century. It is widely predicted that progression up the supply chain will depend more and more on the access to and utilization of key materials and process technologies as well as the design skills to convert the materials into world-class components, products and systems.
- ***Trends affecting the future development of materials technologies include miniaturization, increased performance and functionality, weight savings, cost effectiveness and environmental pressures.***
- ***Neutron beam sources are part of an essential suite of materials probes to which advanced industrial economies must have access in order to respond to the challenges of materials research.***
- ***Canada has a long-standing, internationally recognized reputation for excellence in neutron scattering research.***
- ***Neutron beam research will continue to grow in the traditional disciplines of condensed matter physics and solid state chemistry. The coming decade will see a much broader range of applications.***
- ***Future access to high flux neutrons is a critical issue for the future growth of the Canadian neutron scattering and materials research community at large.***
- ***There is a projected future shortage of neutron beam sources world wide and in particular on the North American continent.***
- ***Steady-state reactor sources and new spallation sources are complementary and each has its area of strength.***
- ***Therefore, the development of a high-quality, medium-flux cold neutron source would position Canada at the forefront of materials research on the North American continent and open new emerging fields for materials research.***



Deep River Science Academy

Tutor and Students Win Award

by Morgan Brown

Three students at the Whiteshell Campus of the Deep River Science Academy (DRSA) won the Manitoba Sustainable Development Award of Excellence for 1997. The award was presented by Manitoba Premier Gary Filmon to DRSA tutor Philip Kiazyk (a University of Manitoba engineering student), and DRSA high-school students Lei Gu (Saskatoon) and Scott McCamis (Pinawa).

The students helped develop and test a way to determine the moisture content in an air-steam mixture, when some of the moisture is in a mist. Normally a relative humidity probe would be used, but such a probe can only detect moisture in the form of water vapour and the mist component is not included. The new probe design passes the moist gas through CaC2 (calcium carbide), which converts all the water to C2H2 (acetylene). Early miner's lamps used the same principle, dripping water onto calcium carbide to produce acetylene which was then burned. In the humidity probe, however, the acetylene concentration was measured, which was directly proportional to the water in the sampled air.

The project was supervised by Syd Jones and Calvin Chan, with chemistry work by CNS-member Terry Howe. The CNS has been donating to the DRSA for several years, as part of its educational outreach, and it's great to see such accomplishments made by tomorrow's scientists, engineers and technologists.

Course for Teachers

Attendees enthusiastic about first CNS sponsored course for high school teachers

Ed. Note: the following is drawn from a report by Prof. Bill Garland, of McMaster University and chairman of the CNS Education Committee on the first course for high school teachers organized by the Canadian Nuclear Society which he coordinated.

Teachers make good students. From the outset, questions and comments flowed from the 13 eager high school science teachers who attended the pilot course on Science of Nuclear Energy and Radiation held at McMaster University on June 22-25, 1998. Most of the attendees came from Ontario schools with one came from New Brunswick and one from Manitoba.

Earlier this year, the teachers were mailed a copy of the book *"Bluebells and Nuclear Energy"*, upon which this course was based. It came as bit of a pleasant shock to find out that they actually did their homework and came prepared for the lectures on radiation, nuclear energy concepts, health physics, biological effects of radiation, reactor concepts, reactor safety, risks and risk perception, fuel cycles, the environment and nuclear medicine, labs in detection and activation analysis, and facility tours.

They loved the hands-on workshop put on by Ross Getsinger, a teacher from Trafalgar High School in Oakville. With balloons that soaked radiation from brick walls and easy to use software for the classroom, Ross had them captivated.

So did the other presenters. The quality of the presentations was excellent.. The presentations all ran over their allotted times, but the teachers didn't seem to mind. The speakers were keen to communicate and the teachers were eager to learn. It was a teacher's dream and an organizer's nightmare.

Eight took the tour to AECL and Pickering on the last day, including Ian Hore-Lacey from the Australian Uranium Information Centre, fresh (?) from the recent uranium conference.

The banquet dinner and the presentation by Beth MacGillivray from the Nuclear Medicine department of Ottawa General Hospital were very favourably received. Beth took time out of her very busy schedule to deliver a superb multimedia show on nuclear medicine.

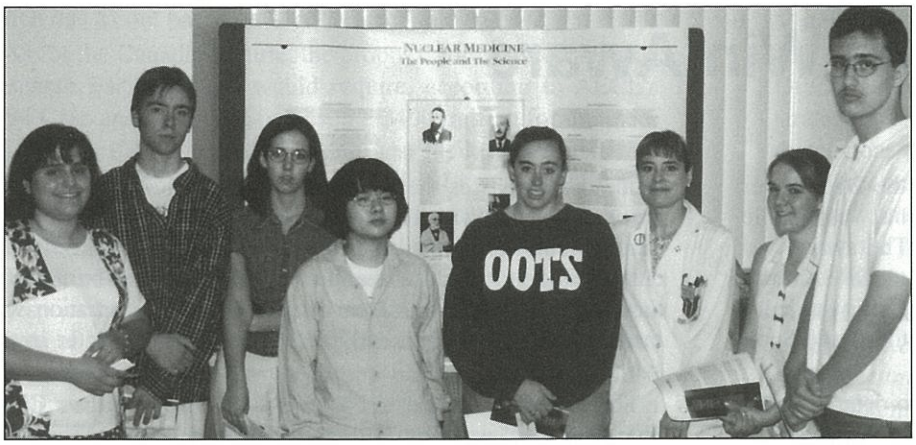
There are some things to be changed for next time, like cutting out some of the overlapping material and allowing much more time for these gregarious "students" to vocalize.

This course was a definite success. Special thanks to Jerry Cuttler, Ben Rouben, and Victor Snell of AECL; David Chettle, David Tucker, Colin Webber, Dave Jackson, Barry Diacon, Frank Saunders, Mike Butler, Bob Hudspith and Jan Nurnberg of McMaster; Hans Tammemagi of Oakhill Environmental, and, of course, Beth MacGillivray and Ross Getsinger. And were would we be without our sponsors: the CNS (who underwrote the event), the CNA (who generously agreed to cover half the net cost), AECL (the lab tour, the dinner and speakers), Ontario Hydro (the plant tour) and McMaster University (speakers, reactor staff and organization).

If we in the Canadian nuclear program are really serious about the business we are in, we need to ensure a healthy supply of enthusiastic high school, college and university graduates. To do that we need to interact with the high school teachers. They don't want a hard sell; they don't want to be given industry propaganda. They want the real low-down, based on facts and reason. They want to interact meaningfully.

Some teachers said they interact with more than a hundred students each year and they will surely return back to their own classroom next year to relate how they watched the blue glow of radiation as McMaster Nuclear Reactor started up before their very eyes.

This course should be given yearly at key sites across Canada. With continued corporate sponsorship and the volunteer help so generously given this year, we can do it again and again;. and, with a Canadian version of *Bluebells,* thanks to Hans Tammemagi.



Beth McGillvary, an ardent spokesperson for nuclear technology poses with students on a tour of the Nuclear Medicine and Radiology sections of the Ottawa General Hospital sponsored by the Ottawa Branch of the CNS.

1998 R.E. Jervis Award

Evon Reynolds, an M.A.Sc. candidate at the University of Toronto, is the recipient of the 1998 R.E. Jervis Award.

Evon Reynolds graduated with honours from the B.A.Sc. program of the Department of Chemical Engineering and Applied Chemistry, University of Toronto, in 1997. He received the Mackay Hewer Memorial Award, given to the best Environmental B.A.Sc. thesis, for his work on measuring and modelling the volatility of organic iodides. Evon has continued this research under the supervision of Prof. G.J. Evans, as the topic of his M.A.Sc. thesis.

Evon's experiments involve radio-labelling organic iodides using atom exchange and radiochemical separation, and evaluating their air-water partitioning using a temperature regulated stripping column. These partition coefficient measurements are then used to extend a structure-based model developed to estimate the behaviour of organic molecules, primarily organic chlorides, in the environment. Through this project, Evon has produced new measurements of the Henry's Law Constants of a number of organic iodides. He has also provided some preliminary values for a few very hydrophobic organic iodides, demonstrating that this method can be extended to these hard to measure compounds.

The R.E. Jervis award was created in 1992 by former students and the CNS to honour the research achievements, numerous professional activities and teaching of Professor R.E. Jervis. The award, which has a value of $500.00, is given annually to a graduate student at a Canadian university pursuing research involving radiochemistry or the use of nuclear research reactors in applied chemistry or chemical engineering studies.

"Hands-On" Ionizing Radiation Workshop

The Chalk River Branch of the CNS conducted an "Ionizing Radiation Workshop" as part of AECL's annual Science for Educators Seminar (April 16 - 18, 1998). The seminar, which receives financial support from the CNS, has been an annual event at Chalk River Laboratories for over two decades, and in recent years the "Ionizing Radiation Workshop" has been one of its most popular events.

In the Workshop, teachers from across Canada were introduced to four table-top demonstrations of radioactivity. These included portable cloud chambers, attenuation experiments, half-life determination, and a smoke detector demonstration. "Hands-on" participation is encouraged, and many teachers are delighted to "see" radioactivity first-hand. They also express an interest in implementing some of the experiments in their classrooms, and information is provided to assist them in this regard. The goal of the Workshop is to remove the "mystery" surrounding radioactivity, enable teachers to communicate what they've learned to their students.

This year the demonstrators from the Chalk River Branch were Jeremy Whitlock, Alan Lane, Bryan White, and Aslam Lone (who created the Workshop a few years ago, under the auspices of the CNS Education and Communication Committee). A total of thirty teachers took part in the workshop.

A group of teachers at the "Hands On WorkshoP' watch as Bryan White demonstrates the use of AM-241 in domestic smoke alarms.

CALENDAR

1998

October 5 - 8

International Conference on the Physics of Nuclear Science and Technology
Long Island, H.Y., USA
contact: Dr. David Diamond
Brookhaven National Laboratory
Tel: 516-344-2604
Fax: 516-344-5730
Fax: 416-979-8356
e-mail: diamond@bnl.gov

October 11 - 14

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

October 18 - 20

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

October 25 - 28

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

Nov. 15 - 19

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

Nov. 15 - 19

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

Nov. 30 - Dec. 4

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

Fall '98

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

Fall '98

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

1999

January 24 - 27

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

February ??

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

March 26 - 27

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

June 6 - 10

ANS Summer Meeting
Boston, MA
contact: ANS Office
La Grange Park, Illinois
Tel: 708-579-8258

June 13 - 17

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

September ??

International Symposium on the Radiological Effects from Nuclear Facilities on Non-Human Biota
contact: R. Maloney
AECB, Ottawa
Tel: 613-995-5116
e-mail: maloney.r@atomcon.go.ca

October 3 - 8

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

Nov. 14 - 18

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

?? 1999

International Conference on Effects of Radiation on In-Reactor Corrosion
contact: V. Urbanice
AECL-CRL
Tel: 613-584-4676

?? 1999

6th International CANDU Fuel Conference
TBD
contact: Joseph Lau
AECL - SP
Tel: 905-823-9040
e-mail: lauj@aecl.ca

CNS Annual Conference

Toronto, Ontario
18-21 October 1998

This year, for the first time, the Annual Conference of the Canadian Nuclear Society will be held separately from that of the Canadian Nuclear Association. As usual, however, the CNS Annual Conference will focus on technical developments in all subjects relating to nuclear technology.
Topics will range from simulation to waste management, from plant ageing to reactor physics, encompassing the entire range of the application of nuclear science and technology.

This is THE annual technical meeting for the Canadian nuclear program - plan to attend

To register, contact:	Sylvie Caron	CNA/CNS office, Toronto, Ontario Tel. 416-977-6152 ext 18 Fax: 416-979-8356 E-mail: carons@cna.ca
For program information, contact:	D. A. Jenkins	AECL - SP Tel: 905-823-9060 ext. 4656 Fax: 905-822-0567 E-mail: jenkinsd@aecl.ca

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CNS Office / *Bureau d'ANC*

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

CNS Bulletin Editor / *Rédacteur du Bulletin SNC*

Fred Boyd . . . . . (613) 592-2256
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- organizes courses, conferences, symposia
- holds branch meetings with interesting speakers
- communicates with:
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  teachers, students, people
  governments and media
- publishes CNS Bulletin (quarterly)
- cooperates with many international nuclear societies

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Canadian Nuclear Society
Société Nucléaire Canadienne
144 Front St. W. Suite 475, Toronto, Ontario M5J 2L7
Tel: 416-977-7620 Fax: 416-979-8356
e-mail: carons@cna.ca