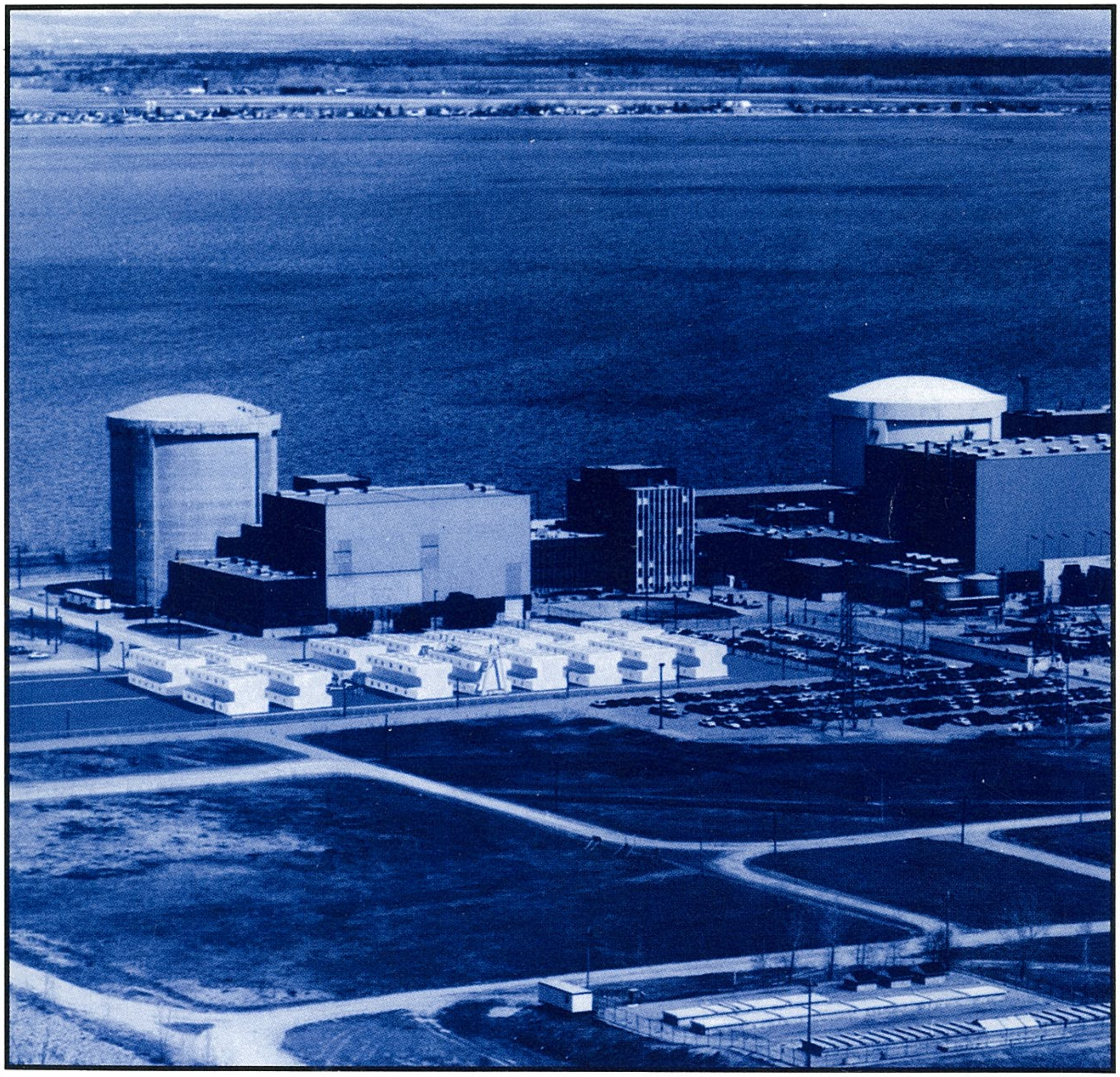
CANADIAN NUCLEAR SOCIETY
bulletin
DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE
Autumn / l'automne 1994
Vol. 15, No. 3



- Ageing of NPPs
- Tunney's Pasture Decommissioning
- Burning Actinides in CANDU
- CANSTOR at Gentilly

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Cover photo

This aerial view of the Centrale Nucléaire Gentilly on the south shore of the St. Lawrence River incorporates an artist's conception of the CANSTOR facility in the middle foreground. *(Photo courtesy of AECL CANDU Montréal)*

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ISSN 0714-7074

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

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

CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee is $55.00 annually, $30.00 to retirees, $20.00 to students.

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

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Printed by The Vincent Press, Peterborough, ON

Editorial

How Lean Is Lean Enough?

As we go to press there are reports that Ontario Hydro intends a further cut in staff (from 1200 to 2500 positions according to different sources) with 400 coming from Ontario Hydro Nuclear.

We had not intended to comment further on the adequacy of the size of staff running the Ontario's nuclear power plants but at some point enough is enough. There has been already a great loss of "corporate memory" resulting from the layoffs or early retirements of personnel with long experience. This move will only exacerbate that situation.

For those of us with a particular concern for safety this is worrisome. Despite the basically good design of CANDU plants there have been many modifications to them over the years. Further the original operations plans have evolved. While these may be documented in a basic way the rationale for the changes, important in understanding their implications, is often not.

With the widespread, international, concern about the ageing of nuclear plants (as discussed in this issue of the *CNS Bulletin)* there is even more apprehension over the ability of the reduced staffs to deal adequately with this impending problem while trying to continue operating the plants safely and efficiently. OH already has one of the lowest staff/MW ratios of any nuclear utility.

This does not imply any doubts about the quality of the remaining staff. Nevertheless, there is a limit to what any person can do, regardless of their ability. And to the work load can be added the emotional stress of a continual threat of layoff.

Reportedly the Atomic Energy Control Board will be examining the cuts closely and trying to evaluate whether or not there is any detrimental affect on safety. It will be interesting to see, in the event that the AECB rules that the number of operating staff may not go below a certain level, if the OH Board, in its cost-cutting zeal, decides to shutdown some of the nuclear plants. That might meet their narrow objective but it would not help Canada's nuclear industry, nor be truly economic, nor help the environment, since the replacement power would undoubtedly come from fossil-fuelled sources.

It may appear self-serving for a representative of a society of nuclear professionals to declaim cuts but there is much evidence that nuclear power is an efficient, economic, environmentally-friendly source of electricity and that the nuclear industry has made, and is making, a significant economic, as well as technological, contribution to the country. Is it too much to ask that a large publicly-owned organization such as Ontario Hydro look at the broader issues, over a longer time frame, and not just respond in what looks like a knee-jerk reaction to arbitrary targets.

In This Issue

Probably the most topical topic in nuclear circles over the past year or so is "ageing". Anyone who has been at nuclear conferences recently and observed the predominance of greying (or non-existent) hair will readily acknowledge this phenomenon. We will avoid that sensitive issue and deal with the official concern which is "ageing" of nuclear power plants. It has spawned a whole new field called "plant life management". To reflect this concern and interest we present two Canadian perspectives on the issue, one by a don of the Canadian nuclear fraternity, Michel Ross, in his paper **"Plant Life Management – and the single reactor utility,"** the other by Pierre Charlebois on **"Plant Life Management in Ontario Hydro."**

In a completely different vein there is considerable international interest (and local optimism) about the use of CANDU for burning spent LWR fuel, for using the plutonium coming available from de-militarization, and for destroying radioactive actinides in spent fuel. Another pair of papers deal with this broad subject: **"The Role of CANDU in Actinide Annihilation"** and **"CANDU Fuel Cycle Flexibility."**

There is a report on a new form of dry spent fuel storage (or, more precisely, on the difficulties of obtaining approval for the facility) in the article **"CANSTOR at Gentilly-2."**

Then to recognize an achievement in the non-reactor area there is an account of the successful decommissioning of AECL's former radioisotope facility that had been located in the middle of a park of government buildings close to downtown Ottawa in **"Tunney's Pasture Decommissioning."**

Associate editor Ric Fluke has assembled considerable information on the disturbing proposal by an Ontario committee to drastically reduce the allowable concentration of tritium in water, which is presented in **"Regulating Tritium in Drinking Water."**

There are reports on the successful **18th Simulation Symposium** and on the large international conference **ENC '94**. A few miscellaneous bits of information are included and, of course, news of our Society.

We thank Willem Joubert for his special contributions and hope that you will find something of interest. Your comments, suggestions and even (mild) criticism are always appreciated.

Letter to the Editor

Plasma gasification for waste

Ed. Note: *The original letter from Mr. Carter has been shortened for publication.*

The Editor:

It was with great interest that I read the paper by Hans Tammemagi of Oakhill Environmental, viz. "A waste crisis – two perspectives," in the Summer issue Vol. 15, No. 2 of the CNS *Bulletin*. The dichotomy portrayed between the disposal requirements of nuclear and municipal solid waste (MSW) clearly identifies a tremendous need for a radical culture shift in the management and regulation of MSW disposal practices.

We have been actively involved in this field for a number of years and are acutely aware of the difficulty in trying to reach through particular mindsets to initiate such a cultural shift. We have an alternative solution to landfill which promises to help regulatory authorities set new and more stringent standards for disposal of such materials and provides a methodology for cleaning up the existing landfills with their potentially horrendous leaching problems.

We have spent the last 15 years perfecting a waste disposal process for MSW, among many others, which converts the waste material into commercially usable by-products, a low to medium grade fuel gas and a non-leaching slag. Our technology, plasma gasification, is a non-incineration thermal process which uses extremely high temperatures to completely decompose input waste material, thereby providing substantially less contamination of all environments than either landfill or other state-of-the-art disposal technologies. Plasma gasification can achieve volume and weight reductions of 184:1 and 9:1 respectively with shredded MSW, a rate unimaginable with traditional methods of waste processing. This volume reduction would also increase substantially with as-received MSW.

The plasma generators used by RCL provide for the complete gasification of all volatiles while non-combustibles are reduced to a molten glassy substance with a very tight matrix which solidifies into an inert, non-hazardous solid. Free carbon from the gasification process reacts with the moisture content, either inherent in the waste or added through steam injection, forming additional combustible gases. The resultant products, therefore, are a combustible gas and an inert slag.

Unfortunately, for all of its promise, plasma gasification has been slow to enter the commercial or industrial mainstream as an economical and technically sound option for substantially reducing, if not entirely eliminating, the environmental problems caused by the more traditional disposal practices with MSW. Our main hurdle remains the low confidence / high risk perception inherent towards new technologies advancing into the marketplace.

My primary aim through this letter is to stimulate an interest in your readership towards plasma gasification. If this technology could be brought to the forefront of solid waste processing methods by applying it to nuclear-related issues, such as the volume reduction of Low Level Radioactive Waste, the nuclear industry could offer not only a safety culture but also a demonstrated technology with which the MSW problems could be resolved.

To this end, we would be most pleased to discuss this subject further with members of the CNS and provide tours of our operational facility in south Gloucester.

G.W. Carter
President
Resorption Canada Ltd.
Gloucester, ON

CALL FOR PAPERS

The organizers of the 1995 **Annual Conference of the Canadian Nuclear Society**, which will be held in Saskatoon, 4-7 June 1995, have issued a Call for Papers.

Papers are invited on technical developments in all subjects related to applications of nuclear technology. Papers on advances in the state of the art and on future developments are encouraged.

To be considered, summaries of 750 to 1200 words must be submitted before **16 December 1994**. Notification of acceptance will be provided by 28 February 1995.

Summaries should be submitted to: Dr. A.L. Wight,
Canadian Nuclear Society,
Saskatchewan Branch,
P.O. Box 932,
Saskatoon, SK S7K 3M4.

Plant life management

how a single reactor utility can face the PLM issues

by MICHEL H. ROSS
Hydro-Québec

***Ed. Note:** Ageing, or more precisely, overcoming ageing to extend plant life has become THE topic in nuclear power conferences. This paper by Michel Ross is one of the best overall discussions of the problem that we have come across. It is a slightly condensed version of his presentation to the CNA/CNS conference in Montreal last June.*

Introduction

Ageing is a phenomenon that no one can escape, not even a high-tech nuclear generating station. There are many aspects and many issues to cope with when a utility considers a station plant life management (PLM) program: economics, nuclear safety, technical assessment, knowledge and know-how.

To maintain the long-term availability and capacity factor with controlled and reasonable generating costs during the whole service life is a prime concern. Safety is also a major issue. The deterioration, with time, of the safety level and the rise of uncertainty with regard to safety are real concerns.

A single reactor utility has much to gain in seeking cooperation, in order to share its limited experience and resources with others.

1. Ageing

Getting Old

ageing should receive early attention

Equipment performance, station reliability and capacity factor are expected to drop during the late middle and latter years of a nuclear station nominal life.

Different degradation mechanisms may affect the systems, structures and components (SSCs) to such an extent that they may not fulfill adequately their function any more. Ageing mechanism will manifest itself, with time, in functionality and performance. Factors that affect SSCs can be fatigue, wear, temperature, humidity, pressure, chemistry variables, vibration, flow erosion and corrosion, neutron bombardment, gamma radiation, etc.

IAEA defines ageing as a "continuous degradation of components, systems, structures resulting from cumulative changes with time under normal service conditions, including normal operation and transient conditions."

Ageing issues and their impact on the nuclear station's reliability should receive early attention in the station's life so that proper planning and proactive maintenance and programs can be put forward to manage the effects of age related degradation.

One of the main features of a plant life management program is to demonstrate that the stresses of time have not degraded the physical conditions of the station, especially the passive SSCs. The most vulnerable SSCs beyond 40 years of operation are the containment, the concrete structures, the pressure tubes, the supports, the steam generators, the piping and the cabling.

Any signs that Gentilly 2 is Turning into an Old Folk?

pressure tubes may force the station into premature shutdown

The design life of our pressure tubes is 210,000 hours at 100% FP or 30 years at 80% capacity factor. This is significantly less than the nominal 40 years for the reactor pressure vessels of the light water reactors.

CANDU-6 pressure tubes have a good tolerance to flaws, debris fretting, fuelling scratches, crevice corrosion, fuel bearing pad fret marks or manufacturing flaws both in the body of the pressure tube and the rolled joint. They are, however, prone to hydride blister formation. The current strategy for fuel channel maintenance and inspection addresses this major issue.

In the long run, dimensional changes may prove to be the pressure tubes' life limiting factor. Monitoring, to date, of axial elongation has shown that the fastest growing tubes could run out of bearing travel before the end of their design life. Pressure tube fuel channel sag can lead to several limits that could be reached before the end of design life: contact with horizontal mechanisms, contact between pressure tube and calandria tube, and fuel bundle pressure tube interference.

In spite of very significant R & D and inspection efforts, pressure tubes may force the station into premature shutdown, because there is still so much uncertainty on many aspects.

Other early ageing signs include: tighter margins on the regional overpower trip setpoints; practically no margin left on the inlet header temperature (increasing primary side and secondary side fouling in the steam generators); increasing containment leak rate, increasing corrective maintenance rate for the important valves, etc.

AECB Generic Action Item

to provide the assurance of continuing station safety

On October 4, 1990 the Atomic Energy Control Board (AECB) sent us a letter about the assurance of continuing nuclear station safety. This is now known as Generic Action Item No. 90-G-03. This generic action item expresses the well-founded concern that safety-related SSCs may become less reliable with time. The effects of ageing may eventually challenge the design safety margins, if not detected nor corrected.

This issue is twofold: assurance that the physical changes affecting the SSCs are not compromising their functional ability to perform their safety task, and assurance that these physical changes are not compromising the safety analyses themselves.

To provide this assurance of continuing nuclear station safety to protect ourselves and to the regulator, a variety of ageing management activities and programs are performed over the life cycle of the station in order to anticipate, detect, prevent, correct and mitigate the effects of ageing.

2. The PLM Options

to retube or not to retube: that is the question

The Do-Nothing Option

the original investment at risk

The do-nothing option does not mean that we are actually to do nothing. On the contrary, we would try to get as high a return as possible out of the original investment in the station. This station is amortized over a 30-year period, so we would try to get 30 years of production out of it, while keeping O & M costs as low as possible.

The do-nothing projection reveals that availability would most probably decrease significantly if no special action is taken. Even for a patch and run program, the station would only barely maintain a 60% level of availability during the last years of operation. And the cost of a patch and run maintenance program would skyrocket to a point where it would be so prohibitive that we would most probably shut the station down prematurely, say after 27 years of operation, to be optimistic.

This is well illustrated in Figure 1. The 80% capacity factor is the design target. The reversed bath tube shape curve is what one would normally expect. The solid line curve is what would most probably happen. The left hand side curve is what one wants to avoid but is hanging over his head if maintenance is neglected.

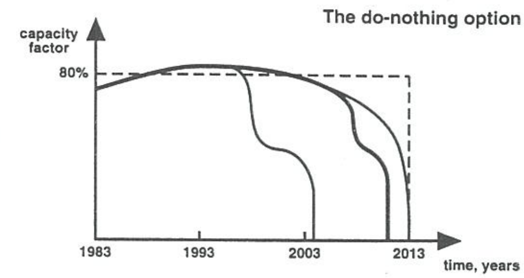
There is a definite possibility that the do-nothing option will not allow a maximum return on investment, nor will it protect the original investment.

The Life-Assurance Option

a life-time capacity factor enhancer

The life-assurance option is the very first objective of a plant life management program. It is aimed at getting the expected return on original investment, i.e. first, to get to the end of the station design life of 30 years and, second, to maintain the capacity factor as high as possible while keeping the station safe.

The life-assurance option is designed to keep a good record as far as electric production and nuclear safety are concerned, to avoid any station early retirement because we have neglected maintenance or have not been using the right maintenance programs or the proper operation methods.



Gentilly 2 lifetime projection of capacity factor

Figure 1. The "Do-Nothing" Option at Gentilly-2

Also, this option should provide the utility with a reasonable assurance against any unexpected "catastrophe" or any unforeseen major flaw or disruptive event that may threaten station life or be overly costly, such as having to replace the steam generators without warning.

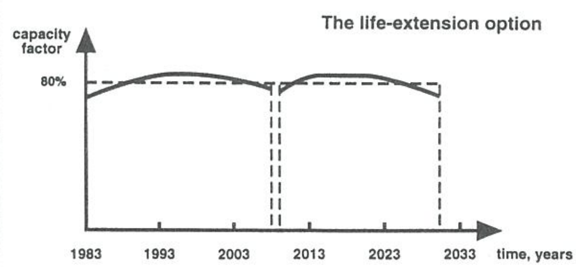
This option should allow us to set long-term performance-based goals for critical and for important SSCs, and to document that the SSCs are meeting their goals with either the existing or corrected maintenance programs or with modified operation methods. To do so, nearly the same assessment studies as for the life-extension option would have to be performed.

Not only should the station avoid premature shutdown, but this option should allow for a substantial increase in the capacity factor during the last ten years of design life.

The Life-Extension Option

a lucrative opportunity

As it is not clear that the station will operate for even its total design life without having to replace the pressure tubes, the life-extension option implies a scenario where reactor retubing and station refurbishment take place after, say, 25 years of operation, and station life is extended for say another 20 to 25 years, for a total service life of 45 to 50 years, as shown in Figure 2 (below).



Gentilly 2 lifetime projection of capacity factor

Figure 2. The "Life-Extension" Option at Gentilly-2

This is not much more than the expected 40-year "design-life" of the US or French reactors or much more than the expected 40-year "strategic life" of the CANDU stations in Ontario.

For the foreseeable future, technical obsolesence would probably not affect the CANDU-6 stations because they are of a generation of relatively mature commercial power plants with a high basic safety level.

To maintain the life extension potential of the station, studies and vigorous implementation of their recommendations would be necessary, to improve or maintain production reliability, to enhance or maintain safety margins and to provide greater assurance that the design operation period can be achieved.

Geriatrics

the international experience

Almost every country where there are operating reactors has an ageing and plant life management program of some sort aimed at determining the safety, economical and technical feasibility of continued station operation while maintaining or improving safety, availability and O & M costs. Most of these programs seek to identify and better understand ageing mechanisms and the necessary mitigating measures.

In the *U.S.A.*, DOE and EPRI have demonstrated, back in 1984, that it was economically profitable to invest in licence renewal and life extension of nuclear plants; the Licence Renewal exercise with the two lead plants (Surrey and Monticello) demonstrated, as early as 1987, the feasibility of life extension up to 70 years for essential SSCs (with some replacement and repairs).

The NPAR (Nuclear Plant Ageing Research) phase II program is still moving ahead and the odds are that most stations will continue to operate through their first 40 years, as a minimum.

Électricité de France (EDF) has had a Life Maintenance Project ("Projet Durée de Vie") since 1985; this project studied eighteen essential SSCs and concluded in the "Rapports de Constats," the topical reports, that the technical potential for life extension to 50 years or more was excellent. In addition, seven generic studies have been done on the degradation phenomenon or technique, such as vibration, fatigue, bimetal joints.... The program is completed by an evaluation of out-of-service equipment such as the Dampierre steam generators or the Chooz A reactor pressure vessel.

EDF expects to run its PWRs for at least 35 years and up to 40, 50 and maybe even 60 years. So far, the reactor lifetime limiting factor is the reactor pressure vessel embrittlement.

Ontario Hydro has almost completed the scoping phase of its Nuclear Plant Life Assurance (NPLA) program started in 1987. The goal of the program is "to improve plant productivity in the longer term by improving maintenance to offset the effects of plant ageing." The program aims at providing 40 years of station service life, avoiding major surprise failures and preserving the option of life extension beyond the assumed nominal service life (40 years). To achieve this goal, the program has developed a basis for operation, inspection and maintenance of the critical components (with respect to cost, safety or reliability) and for managing the effects of ageing.

The *OECD Nuclear Energy Agency* PLM Group was created in 1990 to achieve a systematic and high level of collaboration between the many different countries involved in these issues of ageing and life management. They have identified a model PLM program composed of many elements related to sound management, technical issues, safety issues and economic issues. Also, an *IAEA* NPP Ageing Program has been in existence since 1985.

3. The PLM Features

looking for the show-stopper

International studies over the last five years or so have demonstrated that there is probably no such thing as a single component being life limited to the station; for example, CANDU reactors have been fully retubed, steam generators are being replaced, and studies show that a light water reactor pressure vessel can be replaced at a cost lower than steam generator replacement.

In the U.S., the expected service life is 40 years for BWRs and PWRs; in France, it is 40 years for PWRs; in Ontario, it is 40 years for CANDU stations. Design service life and the financial amortization period for the Gentilly 2 station is 30 years.

Economic

a steam generator replacement for every three years of extended life

The optimum service life of Gentilly 2 has to be assessed in relation with the Hydro-Québec system, existing and planned. A very preliminary exercise has been performed. The calculation was based on the value of the energy at system marginal cost in the existing generation mix versus the production cost. It is the calculation of revenues versus investment and O & M costs. It is a comparison between the value of the service to the grid and the cost of maintaining the station in operation.

The results of this exercise are very encouraging. According to the current reference scenario calling for station retubing and refurbishment after 25 years of operation, less than 15 years of extended service life would be necessary to justify the investment, for a total service life of less than 40 years.

For the time being, it appears that station life extension (beyond 27 or 30 years) expenditures are a justifiable and competitive alternative to new station construction including site approval.

Safety

cost-benefit criteria should be introduced in regulatory decision making

Safety should be a major feature in any plant life management program. The deterioration with time of the safety level and the raising of uncertainty in safety are real concerns. Demonstration has to be made that the station is maintaining its current level of safety.

It should be accepted that the station has to comply with its original licensing basis. Older stations should not be asked to comply with later standards and undertake massive backfits.

The judgment as to whether the current safety level is enough should be based on criteria measuring the gain in safety against cost. Cost-benefit criteria should be introduced in AECB regulatory decision making. One should not spend considerable amounts of capital on supposed low probability accident situations.

We must find a way to slow down the inclination of our regulator to have unduly high requirements. These ever increasing requirements can be found in the protection against serious accidents such as in the Secondary Side Break Accident or in the protection against external attacks such as floods and earthquakes, or in the future as demonstrated by the C-6 Requirements for the Safety Analysis of CANDU Nuclear Power Plants or the C-98 Reliability Requirements. These new requirements are far from the original licensing basis and would have very little net benefit for the safe operation of the station, while introducing a very significant financial overburden in analysis and modifications.

In extreme cases, over-regulation or undue requirements by regulatory agencies can become counterproductive even with respect to safety. One of the best ways to deal with the safety issue would be to establish a constructive day-to-day dialogue with the regulator and help them regain trust in the utilities. With that trust we would show them that, for us, good safety is good business.

Public attitudes towards ageing nuclear stations and public feelings towards the nuclear industry in the years 2010-2020 may eventually be key in terms of gaining public acceptance for continued or extended operation. Safety issues should be addressed in a transparent way and the solution readily understandable. An open dialogue on the impacts of continued operation versus other energy options should be promoted.

Technical Assessment

the non-committing aspect of PLM

Technical SSCs life assessment requires:
- the knowledge of the actual conditions (including transients) in which the components operated;
- the verification that these conditions and their associated degradation mechanisms are compatible with the design envelopes or hypotheses;
- the definition of functional life indicators or the identification of margins left, or remaining service life.

The technical assessment is discussed in greater detail below.

The Knowledge and the Know-How

to count on a sufficient number of qualified workers and staff

As stations age, the relative importance of maintenance increases, and the difficulty to perform maintenance tasks becomes increasingly complex; hence, the necessity to rely on a sufficient number of technically trained workers and qualified supervisory personnel. It is not easy to attract personnel to older plants or to keep them there.

Some of the technology will become obsolete. Overcoming technical obsolescence will exert increasing pressures on technical training programs intended for various categories of personnel; operators, trades, technicians and engineers. Often, those responsible for providing the training are themselves hardly equal to the task.

The PLM Objectives

The objectives of our PLM are:

a) To maintain the long-term reliability and safety of Gentilly 2 during the nominal design life of 30 years (life assurance);
b) To maintain the long-term availability and capacity factors of Gentilly 2 with controlled and reasonable generating costs during the nominal design life of 30 years (life assurance);
c) To preserve the option of extending the life of Gentilly 2, with good safety and availability at reasonable costs, beyond the nominal design life of 30 years, up to 50 years or more (life extension).

4. The Hydro-Québec Approach

the single reactor utility strategy: to team up and to go step by step

Even though the Gentilly 2 station is only eleven years old, it is necessary to undertake a life assessment now and to initiate in-depth thinking about plant life management, to evaluate the impact on station life of decisions taken today on operation methods as well as on maintenance.

It is highly desirable that any decision to decommission or extend the life of the station be taken on the basis of sound technical and economic data. To do so, a good way to proceed is to go step by step. Each significant advance in the program will lead to a decision by management to go further or to step back.

Even though technical life assessment is station dependent, there are so many similarities between CANDU-6s that we have every reason to look for partnership in this area.

This is why we have been looking for partnership with New Brunswick Power and AECL. There are other reasons to get into a teaming agreement:

- N.B. Power has to answer to the same AECB generic action item about "Assurance of Continuing Nuclear Plant Safety";
- there is a need to provide the information with respect to available remaining life of major components necessary to support the evaluation of the merit of performing a reactor retube;
- this is an opportunity to spend smarter dollars in maintenance and in R & D;
- a credible scenario that the stations can run for more than 30 years could eventually be used in the marketing of CANDU internationally;

- to pool our scarce resources (manpower and dollars);
- to pool our experience in station design and operation;
- to add to the credibility of the assessment for:
  - the regulator
  - the senior management of our companies
  - the existing and potential customers.

The mission statement of our joint team for the assessment part of the PLM for CANDU-6 will be: "To perform the assessment phase of a program to manage the effects of ageing degradation to ensure continuing safe, reliable and cost effective operation of our existing CANDU-6 stations."

5. The Partnership Agreement

every partner represents 1/3 of the team

Scope of the Agreement

This three-party agreement (Hydro-Québec, N.B. Power and AECL) provides for the performance of phase one of the Plant Life Management program, i.e. the Plant Life Assessment of Gentilly 2 and Point Lepreau, including the CANDU-6 generic issues.

Terms of Reference

rules for a healthy cooperation

The teaming agreement encompasses the following terms of reference, among others:
- to work by consensus of the three parties;
- every partner will share 1/3 of the total cost of the studies and will assume its share of the management of the agreement;
- to not reinvent the wheel, and to keep the costs of the studies as low as possible.

The agreement and the studies will be managed by a Steering Committee composed of one representative from each partner.

Guidance of the technical activities will be done in consultation with a Technical Review Committee. It will be composed of up to two representatives, named by each partner, in addition to the members of the Steering Committee.

Deliverables and Milestones

topical reports and a four-year schedule

The project is expected to last four years and it starts with two pilot studies. These pilot studies will be reviewed by the utilities management before going ahead with the three-year full scale project. At the same time, a screening methodology and criteria will be developed and applied to the station safety-related SSCs, and to any non-safety related important SSC to draw up the list of the critical SSCs that will be subject to a topical study under this project.

The Definition of the Critical SSCs

the trickiest part of the assessment phase

There is no simple single list of equipment defined as critical SSCs because SSCs differ from plant to plant, and operating histories and physical environments further compound differences among plants.

Critical SSCs may be defined as the ones for which the difficulties, the cost and the plant shutdown time for refurbishment or replacement cannot be included in the normal maintenance program.

Criteria for the screening methodology used to assess the station SSCs in terms of ageing mechanisms may include elements such as:
- high impact on costs
- high impact on safety
- high impact on reliability
- high impact on plant availability

Only those SSCs not sufficiently covered by the existing programs or revised existing programs, generally not focusing on long term ageing issues, would be the subject of PLM assessment. These SSCs are the ones that we want to study in our PLM assessment phase.

The selection of adequate screening criteria is probably the trickiest part of such an assessment phase. If one sets these criteria too low, then too many components will require a full-blown analysis of ageing mechanisms, and program costs will skyrocket. On the other hand, if one sets the criteria too high, most of the components will undergo only a qualitative ageing analysis.

Conclusion

There are many obstacles on the road to life extension. Knowledge and know-how have to be maintained over the entire period. Annual O & M costs as well as refurbishment costs have to be controlled. Technical issues have to be mastered, such as the adequate definition of critical SSCs, the proper identification of degradation mechanisms and their effects on various components, and the sound assessment of remaining service life.

Even if human, budget and technical challenges are met, the life extension of a given station has to fit within utility planning, according to electrical demand and other energy options. For example, despite the same technical evaluation, N.B. Power and Hydro-Québec may eventually reach opposite decisions as far as the service life of their CANDU-6 stations.

Ultimately, the regulator's requirements may have life-or-death consequences for nuclear stations.

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Plant life management at Ontario Hydro

by PIERRE CHARLEBOIS
Ontario Hydro

Ed. note: The following is extracted from a presentation by Pierre Charlebois, Director of Pickering NGS, to the CNA/CNS Annual Conference in June 1994.

This presentation outlines Ontario Hydro Nuclear's approach to life cycle management. It's a term that has been interpreted in a variety of ways, though I prefer the EPRI definition: "The integration of ageing management and economic planning to:

Figure 1

1. optimize the operation, maintenance and service life of systems, structures and components (SSCs);
2. maintain an acceptable level of performance and safety;
3. maximize return on investment over the service life of the plant."

Life management is a major, if recent, concern of Ontario Hydro Nuclear as we've shifted our focus away from the construction of new generating units.

For almost three decades we've had one of the largest nuclear expansion programs of any utility in the world. With the abrupt and prolonged slowdown in power demand growth in Ontario – and the significant surplus in generating capacity that has resulted – we are now focusing on optimizing performance of our existing units over their service lives.

Ontario Hydro Nuclear now has 20 large nuclear units at three generating sites: Darlington NGS, Bruce NPD, and Pickering NGS (the station I represent). Those units are at various stages in their life cycles. Pickering A and Bruce A are middle-aged plants, while the Pickering and Bruce B units are still relatively young. Darlington, as you know, is our newest station.

Our oldest unit, Pickering Unit 1, is scheduled to come to the end of its planned life span in the year 2011. At the present time, we are operating with the understanding that our nuclear units will be shut down once they reach the end of their scheduled 40 year financial lives.

The challenge is to ensure those units reach that ripe old age safely, reliably, and competitively – which is basically what life cycle management is all about.

Ontario Hydro Nuclear has recognized that life cycle management must be managed at three broad levels.

1. Manage the Investment – by that I mean you must have a clear strategic plan for each unit, that includes a revenue stream and year by year capital stream. That plan should guide appropriate investment decisions.

2. Learn from Experience – Here we are talking about the "plan, do, check, act," model of maintenance and inspection to ensure long-term safety and reliability of the units overall. Experience tells us what potential problems to look for, and how we can avoid or correct them.

3. Avoid Surprises – The Holiday Inn approach of no surprises has value when it comes to high cost components – such as steam generators – whose untimely failure could mean high repair or replacement costs. The cost could be such that it results in a premature shutdown – as we've seen with Bruce Unit 2.

Let us look at each of these three levels of life management.

Manage the Investment

This is an area we are still developing. To be perfectly frank, it is one that has been forced on us by the financial and surplus capacity challenges that Ontario Hydro is now facing with the downturn in power demand growth.

We are currently planning to develop a target economic life and a strategic plan for each of our 20 units, and then use these plans to guide appropriate investment decisions. While this may seem like simple common sense in the management of any large asset, it is a relatively new approach in the nuclear industry.

The closest we've come to doing the analysis and developing a strategic plan for any of our units was in the Bruce A economic assessment, which was conducted back in September 1992, and the Capitaland Capacity Study, which ultimately led to the decision to shut down and lay-up Bruce Unit 2 in September 1995.

In both cases, detailed economic assessments were done, though only in the latter was the information used to develop an actual plan. That plan looked at cost of rehabilitating the boilers and retubing Unit 2 in the context of Ontario's predicted electricity surplus over the next decade and determined that the investment could not be justified. The decision to shut the unit down in 1995 reflected the advanced deterioration of the boiler tubes, which is the result of a lead blanket being left in one of the boilers during maintenance back in 1986. The blanket interfered with chemical control in the boilers and accelerated the resulting corrosion.

Developing strategic plans for the other Bruce A units will be key in making capital investment decisions when those units come due for retubing. Again, this plan will have to consider expected energy demand and balance the retube and rehabilitation costs with other supply options.

We are now beginning work on developing initial plans for each of our units. We expect to develop a methodology for unit lifecycle plans by the end of 1994 and expect to implement the plans in 1995.

Learning from Experience

The second level of lifecycle management can also be understood as program management – putting programs in place to manage long-term safety and performance at each of the units as they age. It also involves defining what to expect from these programs, based on experience.

The AECB has given all nuclear operators a generic action item on how to manage the long-term safety of their units. This is obviously a major focus of our efforts. But while long-term safety is an important concern for obvious reasons, we also have to manage the long-term economic performance of our units.

The OHN Ageing Management Team is currently developing an ageing management program designed to anticipate, detect and mitigate potential ageing degradation before it has any serious adverse effect on plant safety, reliability or economic viability. The program will be based on an integrated and disciplined approach.

While Hydro has not had a formal ageing management program in the past, many of our routine maintenance and inspection activities could collectively be defined as ageing management. The majority of these activities were initiated based on good practices of the day and communication of operating experiences between stations and utilities – hence my title, learning from experience.

Ageing Management Model

There are four basic objectives – following the "plan, do, check," model – which are being incorporated into our formal program:

1. Screen station systems, equipment and structures to ensure that the components critical to safety, reliability and economic viability are assessed for physical ageing.
2. Establish and maintain ageing management programs for all critical components to detect and correct age-related degradation.
3. Monitor and periodically review overall program effectiveness.
4. Incorporate the results of operating experience and research to continuously improve the ageing management program.

Although all nuclear plants – like anything else – are designed with the assumption that any component may eventually fail, operational safety and long term economics require carefully managed programs to address ageing. The "Plan, Do, Check, Act" approach is very effective in staying on top of potential problems provided there is discipline and commitment.

Overall Component Screening Method

Let me expand on the screening method briefly. The systems important to plant safety and reliability are first identified. All components are then assessed on each system for possible ageing or degradation mechanism. This category includes many components which should last the lifetime of the plant. However, this doesn't mean that they will. As a result, it is necessary to put a strong emphasis on inspection to verify that materials are behaving as they should.

We have a number of special programs which generate maintenance and inspection tasks based on this assessment. These programs typically have specialist groups devoted to them who are responsible for the maintenance and inspection programs; such as: pressure tube inspections, other periodic inspection programs and the equipment strategy manuals that we use for major components such as heat exchangers.

Thousands of components do not fall into one of these special equipment programs. For these, we rely on our preventive maintenance program. Screening here is intended to identify those critical components which can produce an unacceptable result if they fail in service. Without maintenance attention, many critical components would undoubtedly fail. So far, our preventive maintenance program has been based largely on experience, and time based. More and more, though, we are moving towards the use of predictive methods such as valve diagnostics, thermography, vibration analysis, lubricant analysis....

We don't attempt to produce a single list of all critical components in the plant. Our efforts are directed to ensuring that the individual component programs and our preventive maintenance program are collectively identifying the components that need to be on a regular maintenance regime of some kind.

It is essential once a program component has beenidentified as critical, that the various maintenance and inspection tasks assigned to it be properly carried out. That's the "Do" part of our model. A good quality assurance program will provide the necessary instructions and controls to ensure that work will be done correctly the first time.

Overall program effectiveness must be periodically reviewed – or checked – through quality assurance audits and by collecting reliability data on individual components (particularly those related to safety) on a continuous basis. This plant performance monitoring will determine if any components are failing to meet reliability targets, and whether corrective action is required. This may be a redesign change in task, a change in maintenance frequency or some other method of improving component reliability.

Finally, in spite of our best efforts at prevention, some unexpected failures will inevitably occur. Failures with potential safety or economic consequences must be properly incorporated in the plant experience base that is used to defined needed maintenance and inspections tasks. In that way, we are continually learning and benefitting from experience, and thus making our plants safer and more reliable.

Ageing Management Programs

The result of all this is that there is no single program in Ontario Hydro Nuclear that we can label our ageing management program. There are many programs that collectively manage ageing in our plants. In response to the AECB's generic action on ageing, we have asked a team with technical representatives from all our plants to identify those programs required for the long-term management of ageing. Their preliminary list is given in Figure 2.

Figure 2

Ageing Management Programs

Preventive Maintenance
Corrective Maintenance
Safety System Testing
Periodic Inspection
In-service Inspection
System Surveillance
Nuclear Plant Life Assurance
Environmental Qualification
Fatigue & Transient Monitoring
Quality Assurance
In-house Operating Experience Review
Industry Operating Experience Review

No Surprises – The Critical Component Level

The objective under this level is to ensure that optimum economic life is achieved for all cost-critical components such as steam generators, reactor assemblies and pressure tubes. In the past, we have faced major unexpected problems; our intent is to avoid surprises in the future.

The challenge is that for many large components, ageing mechanisms may be slow and their progress difficult to predict. Some degradation mechanisms may be overlooked, considered too expensive to monitor, or may need to be accompanied by initiatives in inspection research, design, and operation.

For obvious reasons, Ontario Hydro has been concerned about major component breakdowns. In 1987, a steering committee with wide representation from different areas of the corporation was formed to oversee the scoping of large critical components. In 1991 a full-time team was given the task of preparing scoping reports for each plant.

Only a small group of components, highly critical to reliability and cost, was reviewed. The list varies slightly from plant to plant. The team examined each of these critical components, and has recommended actions required in order to achieve a 40 year life. They also found that for most of these components there are a number of unknowns or concerns for end-of-life, which is not unexpected given our lack of operating experience over such a long time frame.

The tasks undertaken by the team can be grouped into three broad questions:
(1) What do we have?
(2) What can go wrong?
(3) What can we do to prevent it?

Methodology for Component Scoping

Let's consider each. First, what do we have? As you know, there are literally thousands of components in a CANDU reactor. But only a small number have a major impact on long-term reliability. Although there are some objective criteria for determining critical subcomponents, some of the decisions tend to be subjective. Obviously, the turbine casing is a concern for end of life, whereas the lube pumps, which are easily replaceable, are not.

Secondly, what can go wrong? Identifying and evaluating all potential degradation mechanisms requires a complete review of the operating and maintenance history, of all inspections conducted, and finally, of international experience. This was a large and very complicated task. In some cases, the team also found it necessary to return to design and construction data – for example, to ensure the steam generators of a given design do not have susceptible crevices for corrosion attack.

The third set of tasks revolved around the question, what can we do to prevent potential problems or failures? There is no single or simple answer. It depends on how much we know about the potential problem, and the level of degradation. In some instances, new research will be necessary. In others, increased inspection may be adequate. And in still others, it may be necessary to develop a repair or replacement program.

The scoping reports are being reviewed by staff at each of the stations and are being incorporated into our equipment strategy manuals.

Life cycle management means taking a multilevel approach.

- First we have to manage our large assets at the plant level and have a clear idea of their life expectancy and the investment plan to achieve it.
- Secondly, we need a good overall "plan, do, check, act" approach to integrating all of our maintenance programs.
- Finally, we need a strong emphasis on major components to ensure that they don't surprise us and force a premature shutdown decision.

If we do all those things well, we should effectively manage the life cycle of our plants.

CANSTOR at Gentilly-2

Winning approval for a new spent fuel dry storage at Gentilly-2 is not easy

by A.M. GIRARD
AECL CANDU Montréal

Ed. Note: *The following is primarily an account of how AECL and Hydro Québec personnel, with patience and persistence, worked through the maze of regulatory approvals needed for the new CANSTOR dry spent fuel storage system for Gentilly-2. The story is not yet over but the end is in sight. The paper has been sightly edited for the Bulletin.*

Introduction

Since the beginning of its commercial operation in October 1983 until the end of 1992, Gentilly-2 Nuclear Generating Station has produced a total of 41.5 TWh. By June 1993, the Gentilly-2 spent fuel bay contained 41,000 spent fuel bundles or about 90% of its design capacity. Based on planned operation, the bay will reach its design capacity this year. However, in August 1992, the Atomic Energy Control Board (AECB) approved a request from Hydro-Québec to temporarily optimize the spent fuel bay in anticipation of the commissioning of the Spent Fuel Dry Storage Facility in 1995.

The CANSTOR module concept, which is based on natural convection cooling of the stored spent fuel, has been chosen over canisters, based mainly upon its economical and space saving advantages. However, Hydro-Québec is still requesting a license for both concepts (canisters and CANSTOR) to increase the flexibility of the installations.

As this project is the first of a nuclear nature to be submitted to new provincial environmental regulation there were several joint provincial/federal public hearings. Also, as the first CANSTOR facility in Canada or elsewhere it is subject to a complete review by the AECB.

The CANSTOR Module Concept

Following the success of the ongoing concrete canister dry storage programs, AECL developed the more advanced, high performance MACSTOR (**M**odular **A**ir-cooled **C**anister **STOR**age) technology. With this new technology, users can accommodate higher burnup fuels, such as PWR fuel, while reducing the storage site dimensions and the amounts of construction materials required.

The new storage module design consists of a monolithic, shielded concrete vault structure containing several spent fuel storage cylinders.

This technology was adapted to CANDU spent fuel dry storage under the name of CANSTOR. While retaining the same design principles as the MACSTOR module, the CANSTOR module geometry is perfectly adapted to existing AECL-designed dry storage systems. It can efficiently replace concrete canisters at an operating site, offering a substantial reduction in the site surface requirements while continuing to use the same fuel handling equipment. Based on its economic and space saving advantages, the CANSTOR module has been chosen over the concrete canister method as the preferred dry storage method at Gentilly-2.

Each CANSTOR module accommodates 12,000 CANDU fuel bundles, stored in 200 sealed stainless steel storage baskets holding 60 fuel bundles; with ten (10) baskets per storage cylinder.

The higher thermal performance of MACSTOR and CANSTOR modules is achieved by using a continuous passive convection process to cool the fuel storage cylinders inside the concrete vault.

The Overall Licensing Process

The CANSTOR module for Gentilly-2 will be the first of its kind in Canada or elsewhere. Consequently, it is subject to a complete review by the AECB. In terms of the project's impact on the environment, the AECB works closely with the Federal Environmental Assessment Review Office (FEARO). At the same time, the project is the first nuclear project to be submitted for review under Quebec's environmental regulations. In order to avoid delays in the implementation of the Spent Fuel Dry Storage Facility at Gentilly-2 and to avoid and/or minimize the overlap between the federal and the provincial jurisdictions, the efforts of all the entities involved in the review process have to be coordinated to the maximum extent possible. AECL is assisting Hydro-Quebec with the preparation of all required documentation for all these processes.

The first step in the whole process was to notify the AECB and the Québec's Ministry of Environment (MENVIQ) of Hydro-Québec's intent to build an interim dry storage facility at Gentilly-2. In Québec, this is a formal process called "request for an authorization certificate" and it has to be done prior to the feasibility study ("rapport d'avant-projet"). This notification was done in June 1992. It was accompanied by a general information document ("document de renseignements généraux") presenting the project along with its justification. The project was also subject to the preparation of an environmental impact study.

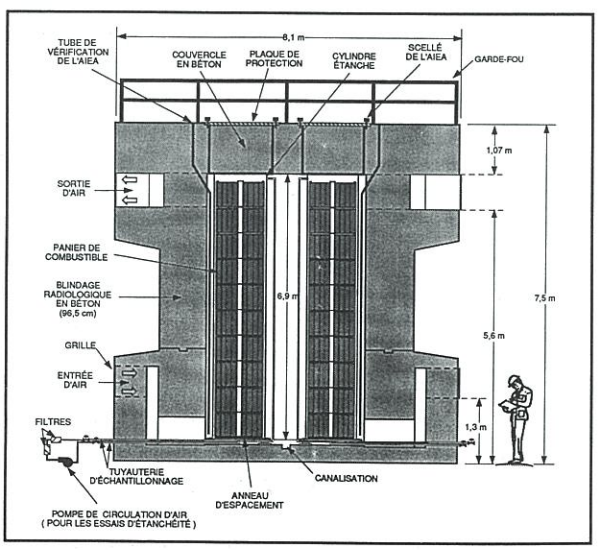
Right in the beginning, Hydro-Québec made some efforts to bring all parties to the same table as it believed that it was important that everybody's role was well defined and well understood. Interministerial meetings took place early to inform all parties at the same time. These meetings were also very important since most of the MENVIQ staff had little or no nuclear background.

Work started early to prepare the Preliminary Safety Analysis Report (PSAR) of the proposed facility with the intention of obtaining as soon as possible AECB's approval of the CANSTOR concept. Such an approval was seen as a positive argument in favour of the project by the recognized authority in the nuclear field. The PSAR was submitted to the AECB in November 1992 as part of a formal request for a Construction Licence for the interim dry storage facility.

In the meantime, the MENVIQ was preparing the preliminary guidelines that would form the basis for the preparation of the feasibility study which would also incorporate the impact study. The preliminary guidelines were discussed with Hydro-Québec and the final version of the guidelines issued to Hydro-Québec by the end of March 1993. These guidelines have to be followed carefully for the feasibility study to be acceptable ("recevable").

The guidelines covered but were not limited to the following items:

1. justification of the project;
2. description of the project (including decommissioning and schedule);
3. site selection;
4. impact identification and assessment (including socio-economic impacts);
5. risk identification and assessment (including health risks);
6. physical security measures and emergency procedure;
7. mitigating measures;
8. surveillance and follow-up.



Cross-section of a CANSTOR module.

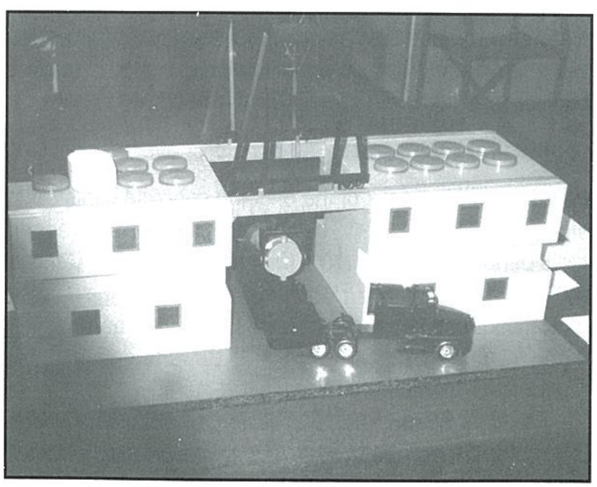
Hydro-Québec was in fact invited to incorporate as much information as it judged relevant for the approval of the proposed project. It is important to note that the instigator of the project has to consider more than one site in its study.

A risk study was also prepared as part of the process. It forms an integral part of the feasibility study ("rapport d'avant-projet") in the provincial environmental review process. The report presents the methodology of the risk study including a definition of risk, the risk acceptance criteria and the Canadian standards in this matter. Then, it exposes the Canadian and international experiences with similar spent fuel storage facilities and gives Hydro-Québec's particular experience in fuel handling. The safety of the installations is also presented along with a complete risk evaluation of all aspects of the operation of the facility covering natural as well as man-made events.

As part of the study on the social impacts related to the risk perception, there was a review of the documentation available on the subject of spent fuel management specially with respect to the Canadian long term disposal concept as there was a lot of information easily accessible with some compilation already done. Public consultation has been done early in the long term disposal concept development and given the similarities in certain aspects of both projects, this information was very valuable as a first examination of the public perception in terms of the interim dry storage concept. Some focus group meetings took place to gather some more specific information and the results of these meetings were incorporated and analyzed in the social impact study.

Since all documentation is made accessible to the public, a great deal of effort was put in the preparation of all reports mainly in terms of the level of language used as well as in the terminology.

In parallel to the preparation of all these documents, Hydro-Québec had to put in place a communication program to inform the public about its project of a Spent Fuel Dry Storage Facility at Gentilly-2. The program was very extensive. It was initiated by mid-September 1992 with a press conference to announce that information and consultation meetings will take place in the area around Gentilly-2 about the project. There were 12 meetings that reached a total of 30 different groups of all kinds, from ministries to



A model of a MACSTOR model which is very similar to CANSTOR.

municipalities, economic associations, health organizations, Indian community, and environmental groups. During these meetings, information on the project was provided such as its justification, the technical aspects of the interim dry storage concept proposed, the extent of the impact study, the schedule, etc. This was followed by discussion. An information brochure specially prepared for the project was distributed to the participants as well as other general brochures about Gentilly-2 and the nuclear energy. A video presentation specially prepared for the project was also presented.

There were also four press releases to cover the approval request submitted to the MENVIQ, the launch of the communication program, the open house days at Gentilly-2, and the request for a Construction Licence to the AECB. Advertisements were placed in two local newspapers and sent to approximately 8,000 families in municipalities around the nuclear station. Notices were also broadcast by four local radio stations and one local community television.

The two open house days at Gentilly-2 were very successful. The public was invited to watch the video presentation followed by a more formal presentation given by the project team members. Then, they were given a tour of the station with special emphasis on the spent fuel management area and activities. They also visited the Gentilly-1 Spent Fuel Dry Storage Facility. The special information brochures prepared for the project were made available.

During all the communication program activities, Hydro-Québec gathered all the public questions and concerns to refine the information to give to the public for a better understanding of the project and to get prepared for the forthcoming public hearings.

After internal approval, the feasibility study ("rapport d'avant-projet") including the impact study was issued to the MENVIQ. Another interministerial meeting took place to present the report and facilitate its further review by the MENVIQ. The MENVIQ staff analysed the report for its conformity to the MENVIQ's guidelines and an acceptance notice ("avis de recevabilité") was issued to Hydro-Québec by the Minister of Environment. It is important to note that other licences have to be obtain prior to the acceptance notice from the MENVIQ.

Following this step, all the documentation was made available for public consultation for a period of 45 days in the area around the station and in other strategic locations in the province. During that period, anybody that has relevant concerns can request public hearings. A total of six groups, including Greenpeace and le Mouvement vert de la Mauricie, requested such public hearings. The "Bureau des audiences publiques en environnement" (BAPE) was therefore mandated by the minister of Environment to hold the public hearings, prepare a report and present recommendations. This is a 4 month mandate. Three commissioners were nominated to execute the mandate. Given the federal involvement in the review of the project because of its nuclear nature, there was an agreement that one of the commissioners would be a person recommended by the federal Minister of Environment. AECB and AECL representatives were also present during the public hearing sessions as well as representatives from different provincial ministries.

The public hearings are held in two steps. The first one, which took place at the end of August 1994, lasted six days (seven sessions) where it would usually last three to four days. A formal presentation of the project by Hydro-Québec was followed by questions from the public and the commissioners. The intervenors were always the same ten to twelve persons, almost all of them being members of some kind of organizations. Most of their concerns related to the justification of the project in the context where the province of Québec has excess electricity. They claimed that Gentilly-2 should be shutdown and decommissioned so it will not produce spent fuel and there will be no need for a spent fuel dry storage facility. Other concerns related to the malformations found in the area years ago, safe operation of Gentilly-2, pressure tube replacement, emergency plan application, and the fact that the interim spent fuel dry storage facility could become permanent if the long term disposal concept under study by AECL is not accepted. The AECB was questioned on its role as the regulatory agency. Most of the questions on the project itself came from the commissioners. The whole process went quite well within the rules settled at the beginning and Hydro-Québec is confident that the project will be accepted.

The second step took place during the last week of September and lasted four days. The commissioners now will analyse the information, write their report and submit it to the Minister of Environment by December 15. The Minister must then confer with the Council of Ministers before the authorization certificate cna be issued. Together with a Construction Licence by the AECB, this will form the first important step of the implementation of a Spent Fuel Dry Storage Facility at Gentilly-2. The Final Safety Analysis Report (FSAR) will then have to be prepared and issued to the AECB as part of the formal request for an Operating Licence for the facility.

Conclusion

The overall licensing process for this CANSTOR Spent Fuel Dry Storage Facility at Gentilly-2 has gone well to date thanks to the concerted efforts of all the parties involved in the environmental review process. The efforts to minimize the potential federal and provincial jurisdictions overlap have been successful and the challenge of many public hearings has been met. It is hoped that the facility will be built in 1995.

CANSTOR

CANSTOR is a system using air-cooled concrete modules housing a numebr of metal canisters containing spent fuel. A typical module is about 8 m wide, 20 m long and 6 m high and stores 20 canisters in two rows.

Ventilation is provided by ports near the base of the module and by large outlet ports located just below the top slab. Protective covers are placed over each canister port in the top slab of the module.

Tunney's Pasture decommissioning project

by W.-M. JOUBERT
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Abstract

AECL's Tunney's Pasture facility located in Ottawa was used for research, production and worldwide shipping of radioisotopes. After thirty years of operation it was shut down in 1984 and decommissioned in two phases. During the first phase which began in 1985 and lasted until 1987 staff moving to the new Kanata facility, now the property of Nordion International, removed the bulk of the equipment. After a three year period of storage under surveillance AECL initiated in 1990 the second phase of decommissioning which was completed in August 1993. In January 1994 the AECB unconditionally released the facility for unrestricted use.

The paper provides an overview of the second phase decommissioning project and a summary of a few lessons learned for the benefit of future endeavours of the same kind.

Historical Background

AECL's Tunney's Pasture facility is located just south of the Ottawa River and west of the Parliament buildings on a 2 hectare property in the heart of the nation's capital. It consists of a 2-storey building with a basement covering an area of approximately 3000 m^2 in an "H" configuration. The facility, with its 9000 m^2 of working space, was used for research, production and worldwide shipping of radioisotopes. It had operated for approximately 30 years when it was closed down in 1984 and its staff was transferred to a larger and more modern facility in the municipality of Kanata outside the capital city. The complex was operated by the Radiochemical Company, a former division of AECL, until it was privatized by the Government of Canada in 1988 and divided into two companies, Nordion International Inc. and Theratronics International Ltd. both presently headquartered in Kanata.

The Radiochemical Company moved into its new office and laboratory at Tunney's Pasture in 1954 as the Commercial Products Division (CPD) of the Eldorado Mining and Refining Limited. In 1958, the first laboratory research irradiators were delivered and in 1964 the company installed its first industrial units, to sterilize medical supplies. In 1971 a 20 kW Slowpoke reactor was installed in the facility to locally produce radioisotopes. By 1983, the growth in the sale of bulk radioisotopes and finished radiopharmaceuticals for medical diagnostic purposes necessitated the construction and opening of the more modern Kanata Isotope Processing Facility. The Tunney's Pasture complex was by then outdated and had outlived its usefulness.

Following the shutdown of the plant in 1984, the first phase of decommissioning at Tunney's Pasture began in 1985 and lasted until 1987. In this stage, staff moving to the Kanata facility removed the bulk of the equipment, including the Slowpoke reactor and hot cell manipulators, which were used to remotely handle the radioisotopes. Radioactive waste such as ducting, piping, and miscellaneous equipment was shipped to Chalk River for disposal. At the completion of the first phase of decommissioning, the plant was in such a stable state that its nuclear ventilation system could be safely shut down and that continuous radiation monitoring was no longer required. In this condition the facility could be left inoperated for several years without possible spreading of residual contamination. Only intermittent inspections for the purpose of determining necessary maintenance interventions were then required. The building was hence vacated of operating personnel but remained under active surveillance for three years with the continuous presence of security personnel in order to meet the regulator's requirements pertaining to a nuclear facility possession license.

In 1990 AECL initiated the second phase of decommissioning activities with the goal of obtaining from the regulating Authorities an unconditional release of its facility for unrestricted use or reuse. Authorized to begin in 1991 by the Atomic Energy Control Board (AECB), the project was completed in August 1993.

Second Phase Decommissioning Project

The second phase decommissioning project consisted mainly in the dismantling and removal of the building nuclear ventilation system and of the various hot cells utilized for the processing of radioisotopes, and in the general and thorough cleanup of the entire complex.
The total radioactive inventory facing the second decommissioning phase was less than 4 Ci. The principal radioisotopes responsible for this inventory were: Am-241, Th-228, Ra-226, Cs-137, Cs-134, Co-60, Eu-152, Eu-154, C-14, Ni-63, Cl-36, Sb-125, U-235, Cd-109, and I-129.

Willem Joubert, Walter Dicks, Rick Fedorowicz and John Stapleton pose in front of a partially dismantled hot cell during the decommissioning of AECL's former radioisotope facility in Tunney's Pasture, Ottawa.

Ventilation System

As more of the radioactive inventory was deposited in ventilation equipment, dismantling efforts were concentrated in the "fan room" area first. An auxiliary ventilation system was temporarily installed to replace the services provided by the systems normally in place and slated for decommissioning. The dismantling task was not technically demanding in terms of tooling but did require great personnel discipline in terms of work habits in an area contaminated with many of the above listed radioisotopes. This work was done fully suited and lasted 9 months including the temperature record-breaking summer months of 1991.

Hot Cells

The next major undertaking at Tunney's Pasture was the removal of the 8 hot cells. The 3 largest ones consisted of a single concrete structure 10 m long by 4 m wide and 3 m high. 13 mm thick steel cladding was applied to the cells' exterior and interior surfaces. An additional stainless steel cladding of 4 mm was fixed to the interior steel cladded surfaces. The walls were 1 m thick and the roof 0.8 m thick. More than 65 steel lined penetrations were distributed here and there. Finally, all ventilation systems were routed through the supporting concrete base pad which was 10 m long, by 10 m wide and 2 m deep. The concrete density was 3830 kg/m^3. The decommissioning of the cells was performed in two steps. During the first stage, all contaminated components were removed by trained AECL staff. During the second stage the entire remaining structure was methodically cut down in pieces by Ontario Cutting and Coring, an outside contractor specialized in diamond wire cutting of large concrete masses. The contractor performed his task under the continuous supervision of radioprotection staff. After verification, a large quantity of concrete waste was released to the local landfill as ordinary industrial waste. The task was completed in 3 months. 2000 tons of concrete waste were disposed of and 30 tons of lead were decontaminated and recycled.

Decontamination techniques adopted during the project were mechanical in nature and consisted mainly of scrubbing, shaving or vacuuming. Wet decontamination was not implemented in order to avoid the production of secondary radwaste and chemical decontamination was rejected in order to avoid the generation of mixed hazardous waste.

Radwaste Characterization

Up to September of 1992 decommissioning work had generally progressed relatively well but an inventory of radwaste had also sufficiently accumulated on site to affect the background fields of radioactivity and thus hamper further progress of work in several areas. The ability of available instruments to discriminate contaminated material in the areas of the building close to where radwaste was stored was diminished by the influence of the high background activity levels emanating from the storage areas. This inventory developed on site for several reasons, the principal one being the length of time it took for site personnel and for AECL research personnel to develop a mutually acceptable protocol of waste characterization prior to disposal. The characterizing of radwaste in the field away from established assaying facilities draws upon science, art and a fair dose of common sense. It is an end of cycle activity which has yet to reach its maturity as acceptance criteria for waste disposal facilities are evolving in unison with the materialization of the facilities themselves. The scope of this endeavour had not been fully realized at the initiation of the project.

From September 1992 to May 1993 a major waste characterization effort was thus deployed in order to dispose of the backlog radwaste inventory off site. This effort involved extensive searches into past operating records, verification of radiological surveys performed during decommissioning activities, the development of a comprehensive sample archiving system for quality assurance, direct and smear measurements, spectrometry, and finally chemical analyses. This undertaking allowed decommissioning work to resume and to proceed earnestly until completion with background activity levels diminishing with each shipment of radwaste off site. After segregation, a project total of 300 m^3 of radwaste in various packaging forms was finally shipped off site.

Unconditional Release of the Facility

Following the removal of all buried drains in the licensed area of the basement floor, specific training sessions for the final survey were provided towards the end of May. The final survey began in early July and was completed in late August with an application to the AECB for the removal of the license governing the utilization of the facility. The survey required a complement of seven field workers and surveyors, an administrative assistant, and three management personnel for supervision and analysis functions. The Board audited the building, and AECL's survey records in early September and were satisfied with their findings. In January 1994, the Board unconditionally revoked the operating licence of the Facility with the acknowledgement that AECL was henceforth unrestricted in its plans concerning the future of its property with respect to the Atomic Energy Control Regulations.

Final Survey

The final survey was comprised of the following types and approximate numbers of individual measurements in the licensed and unlicensed areas of the facility (see table, page 16.):

MEASUREMENTS IN THE FACILITY

Type of Measurement	Number of Measurements	
	Licensed	Unlicensed
Surface Contamination		
Direct beta-gamma	7992	2174
Direct alpha	7991	2173
Loose beta-gamma	1962	2172
Loose alpha	1959	2172
Ambient Gamma		
Aluminum Oxide TLD	108	72
Dose Rate Meter	216	144
Airborne Rn/Th Daughters		
Radon Canister	9	21

The submission to the AECB for de-licensing was based on a building release at an average ambient dose rate level of 13 μR/h which was found challenging considering the contribution of natural components such as insulation material or the various forms of clay bricks used for the construction of the building. Ambient gamma dose rate measurements were performed by exposing approximately 2000 Al_2O_3 thermoluminsecent dosimeters placed throughout the building.

The final release survey criteria for residual contamination levels were adopted from the unconditional exemption levels recommended by the IAEA which identifies limits for five groups of radionuclides in three different circumstance categories. The specific criteria selected were for the two most restrictive radionuclide groups and in the mid-range use category.

The criteria are arbitrarily specified in ^{137}Cs equivalent Bq/cm^2 for beta-gamma emitters and ^{241}Am equivalent Bq/cm^2 for alpha emitters, two of the isotopes listed in the most restrictive groups. In the case of ambient gamma radiation levels, it was decided to opt for conditional exemption levels based on assumed occupational use of the premises of 2000 hours/ annum. In the case of naturally occurring airborne Rn/Th daughters, the criterion selected was the United States Environmental Protection Agency corrective action guideline of approximately 150 Bq/m^3.

The specific values adopted in each category are presented in the following Table:

FINAL RELEASE SURVEY CRITERIA FOR UNIDENTIFIED NUCLIDES

CATEGORY	LIMIT
Ambient Gamma Dose-Rate	13 μR/h
Total Beta-Gamma Surface Activity	1.0 Bq/cm^2
Loose Beta-Gamma Surface Activity	0.2 Bq/cm^2
Total Alpha Surface Activity	0.2 Bq/cm^2
Loose Alpha Surface Activity	0.01 Bq/cm^2
Airborne Rn/Th Daughter Concentration	150 Bq/m^3

Organization

A staff of 30 was employed by the decommissioning project when it reached its peak during the summer of 1992. This number included about 5 summer students who, although useful, imposed a very large burden on the radio protection group at a time when their services were urgently required elsewhere. The work force reached an optimally performing minimum of 15 at the end of decommissioning operations. It was divided in 3 groups: decommissioning, radioprotection, and health physics. Radioprotection ended the Project with 5 staff members, decommissioning with 4, and health physics with 2 (a fully qualified senior man and a professional trainee). The rest of the staff was reserved for licensing, quality assurance/-control, security and administration duties.

Equipment

The main "out-of-the-ordinary equipment" which the project purchased in order to facilitate the work was a state of the art drum monitoring instrument. In November of 1992, as mentioned earlier, radwaste characterization had identified itself as an imposing task both in terms of effort and of time consumption. It was thus decided to procure a Chambers rocure a Canberra Q^2 low level waste assaying system with 3 Ge detectors and a PC-based computer to rapidly and accurately characterize the inventory of 575 drums in terms of gamma activity (pure beta emitters were identified by separate chemical analyses). The equipment, with its sensitivity allowing the detection of about 10nCi per drum, performed satisfactorily and allowed the segregation of the equivalent of 187 drums of de-minimis waste below regulatory concern for disposal at a local landfill site. The device thus began to pay for itself through reduced radwaste disposal costs and at the end of the project, after a few months of good service, was temporarily moved to the Gentilly-1 for a similar application. The procurement of a dedicated trailer to facilitate redeployment of the equipment from site to site across Canada is presently being investigated.

Lessons Learned

As with any project some experience was gained during the decommissioning of AECL's Tunney's Pasture facility which should be beneficial to future endeavours of the same kind. A few observations based on this experience follow.

Radwaste disposal being such a controlling parameter of decommissioning it is recommended that waste disposal protocols be established between future waste generators and their waste custodian(s) as early as possible in the planning phase of any decommissioning project. Protocols of this kind have a direct effect on virtually all aspects of waste management and in characterization, packaging, segregation, etc. Such protocols are also necessary in order to keep control of costs within an established budget.

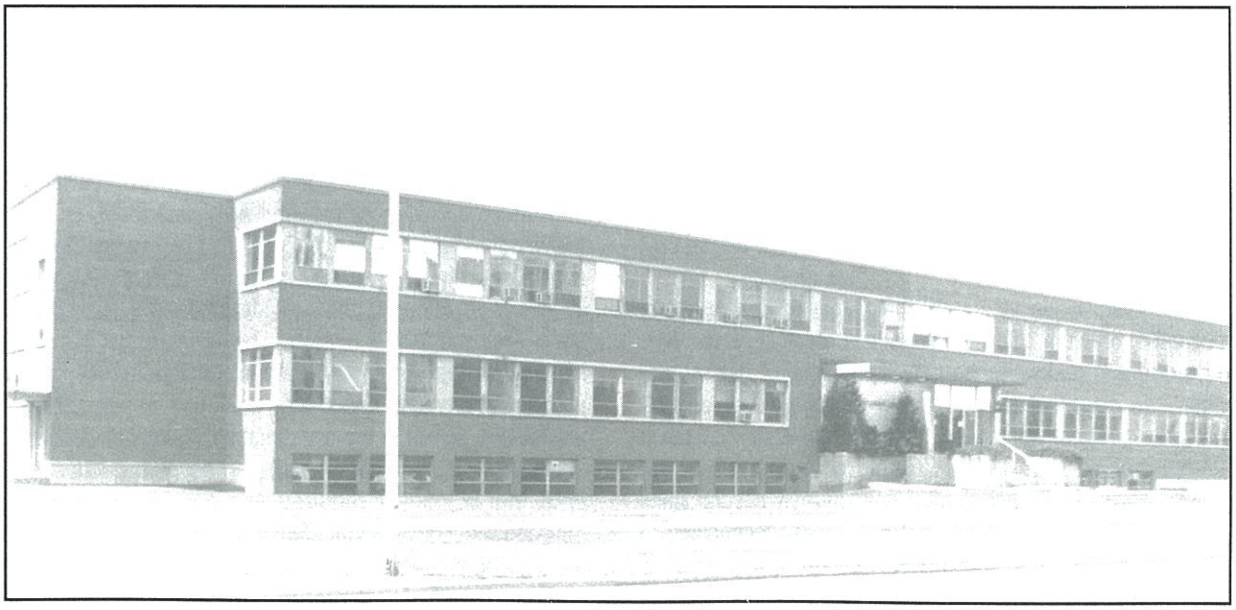
Optimum performance in the field was reached when staff level was lower and a proper balance was reached between radioprotection personnel and dismantling crews. Training in radioprotection knowledge and skills increased the self esteem of workers and in turn increased their productivity. It also provided the best of foundations for assuring the quality of work performed during the decommissioning project.

The personnel working at Tunney's Pasture was not syndicated. This allowed flexibility in the use of various tradesmen and was beneficial both in terms of work flexibility and productivity. The field staff performed satisfactorily in this environment which is considered particularly well suited for decommissioning operations.

Conclusion

The decommissioning of AECL's radioisotope processing facility at Tunney's Pasture to a state allowing an unrestricted site release defines the first enterprise of the kind and of this magnitude of scope in Canada.

The successful completion of the project in an urban environment particularly subject to external scrutiny should provide Canadians with the confidence that other nuclear decommissioning undertakings can and will be similarly conducted and concluded anywhere in the country.



The front of the one-time AECL Commercial Products building in the Ottawa office park "Tunney's Pasture".

The Role of CANDU in Actinide Annihilation

ADI DASTUR and NATHALIE GAGNON
AECL CANDU

Introduction

During the first decade of commercial nuclear power, the CANDU reactor has been established as the option that permits the use of natural uranium fuel. In fact, the major marketing advantage of CANDU has been its role in the fuel cycle strategy of countries that did not have access to enrichment or reprocessing technology.

The aftermath of the cold war has seen substantial changes, with repercussions on the availability of high-grade fissile material. At the time of the first CANDU sale overseas, less than a dozen countries had access to enrichment and reprocessing technologies. Today, it is difficult to identify as many countries without such access.

It is, therefore, prudent to consider the strategy that will ensure CANDU sales in the future. The goal is to extend the uniqueness of CANDU such that it will be strategically as indispensable as in the past in the new environment of accessible enrichment and reprocessing technologies. In this context, the first option that comes to mind is the exploitation of CANDU's ability to extract energy from spent fuels. The ability of CANDU to use spent LWR fuel at various stages of reprocessing is a well advertised feature. The LWR/CANDU tandem fuel cycles will extend uranium resources and reduce waste volume. Recycling the plutonium and uranium from LWR spent fuel in CANDU will yield an additional 80% of energy, compared to an additional 28% if it is recycled in LWR. Recycling just the uranium recovered from LWR spent fuel in CANDU will provide up to an additional 50% of energy, whereas recycling this in LWR would require re-enrichment. Synergy even between FBR and CANDU is conceivable during the first few decades after year 2000 if the high capital cost of FBR is considered.

However, a role for CANDU that is based on the improvement of uranium utilization is not a strategically indispensable one and makes sense only if the price of natural uranium can be offset by the saving in energy that an LWR owner or operator will realize if he recycles fissile material in CANDU instead of in LWR. A simple cost analysis of the options shows that uranium price must multiply several times before an LWR operator will invest in CANDU technology to save on fuelling costs. This has not been the traditional view but it is supported by the decision of LWR utilities to develop MOX fuels that will permit them to recycle plutonium. It is further supported by the decision of such utilities to recycle U-235 through enrichment of recovered uranium.

For utilities that own both reactor types, the option to choose is obvious; recycling in CANDU will provide higher savings.

A role for CANDU in the future that is strategically as indispensable as burning natural uranium has been in the past, can be envisaged on the basis that countries that reprocess fuel are being legislated to adopt a policy of radiotoxicity reduction as part of the disposal process. CANDU can be developed to have an indispensable role in this disposal process. This role is the subject matter of this article.

Actinide Annihilation

Radioactive actinides are heavy elements which are produced by the use of uranium in nuclear reactors. Many actinides are long-lived; for example plutonium-242 has a half-life of 376,000 years. some of them are highly toxic; for example, neptunium-237 and americium-241 are implicated in cancer. Safe disposal of actinides is a high profile issue being studied jointly by several countries, especially those that reprocess spent fuel. The solutions being suggested involve capital intensive projects such as accelerators and fast reactors. The separation of the main component, which is plutonium, is followed by repeated reprocessing that requires separation of individual minor actinide isotopes as these require specific treatment such as irradiation in either fast or thermal neutron reactors.

The CANDU Option

The CANDU reactor has a remarkable ability to use transuranic actinides as fuel and annihilate them. Uranium fuel is not required for this process. This eliminates the main source of actinides. A CANDU reactor of current design can, in one year, consume the actinide production from 3 to 4 LWRs each rated at 1 GW(e).y. The actinide fuel bundle is identical to the current 37-element design except for the absence of uranium. The energy produced from the actinide annihilation results is the conservation of uranium resource. The CANDU AB (Actinide Burner) can be perhaps designed such that whenever required, the actinide fuel can be replaced with conventional CANDU fuel without repercussions on reactor operation. The above features make CANDU reactors particularly relevant to LWR owners that intend to reprocess the spent LWR fuel as part of their fuel disposal program. They also point to the role of CANDU in sustainable energy growth.

CANDU Neutron Economy

The ability of CANDU to destroy actinides stems from the economic use of neutrons. The latter is achieved by the use of heavy water as moderator and by an on-power refuelling system. Neutron absorption in burnable poisons is almost nil as on-power refuelling eliminates the need for reactivity suppressions. As a result of its high neutron economy, the CANDU reactor can operate with low-grade fuels such as natural uranium. As the fissile content of the fuel is low, the neutron flux level to achieve the rated power density is relatively high; between 1E14 and 1E15 n/(cm^2.s) in operating CANDUs.

The extent of CANDU's fissile economy is illustrated in Table 1, where the fissile inventory for several reactor types is compared for 1 GW(e) cores. The inventory needed for CANDU is between 2 and 4 times lower. This is the case for a reactor that is fuelled with natural uranium.

The CANDU Actinide Burner

As the fissile content of the transuranic mix from the reprocessed spent fuel is more than sufficient to serve as fuel in the CANDU AB, uranium is no longer required. The fuel consists of a mixture of plutonium and minor actinide isotopes is a neutronically inert matrix. The absence of U-238 eliminates the main source of higher actinides. It also eliminates the main neutron absorber of the lattice resulting in a further remarkable improvement in neutron economy. The loss of the neutron absorption in U-238, which comprises 30 to 40% of the neutron absorption in the CANDU lattice, reduces the fissile requirement of the CANDU AB to 50 kg for a 1 GW(e) core. (Table 1).

A lower fissile inventory requires a correspondingly higher operating neutron flux level to produce the rated power. The higher operating neutron flux level is the basis for the CANDU superiority in the annihilation process. In particular, the on-power refuelling system is used to move the fuel into regions of higher flux as its fissile content depletes during irradiation. Through proper fuel management of this type the last traces of the higher actinides can be eliminated before the fuel is discharged.

In order to appreciate the extent of the CANDU flux advantage, the thermal neutron flux levels in the fuel for the reactor types of Table 1 are compared in Table 2. Note that the flux level in the CANDU AB is comparable to that in some FBRs.

To understand the annihilation process, the capture and fission cross sections of the actinide isotopes in thermal and fast neutron spectra must be considered (Table 3). In a fast neutron spectrum, all the isotopes are fissionable, but the fission cross section is relatively small; about 3 barns for 0.8 (and above) mev neutrons. In a thermal spectrum, only the isotopes with odd/even (even/odd) neutron/proton combinations are fissionable, but the fission cross sections are large; several hundred barns.

Table 1. Fissile Inventory (te) of 1 GW(e) Cores

FBR	PWR	CANDU	CANDU AB
3 to 4	2 to 3	1	0.05

Table 2. Neutron Flux Level in Fuel

Reactor Type	Neutron Flux (n/cm^2.s)	
	Thermal (<0.625 ev)	Fast (500 keV)
FBR	–	0.5E+16 – 1.0E+16
PWR	8.0E+13	3.0E+14
CANDU	1.4E+14	0.7E+14
CANDU AB	5.0E+15	0.7E+14

Table 3. Neutron Cross Sections (barns)

Isotopes	Thermal		Fast	
	σ_c	σ_t	σ_c	σ_t
Np237	176		0.05	2.0
Np238		2088		
Np239	68			
Pu238	540	18		2.5
Pu239	269	748	0.02	2.0
Pu240	290			2.0
Pu241	358	1011		2.0
Pu242	19			1.5
Pu243	87	196		
Am241	587	3		2.0
Am242		2100		
Am242m	2000	6950		2.0
Am243	75			2.0
Am244		2300		
Am244m		1600		
Cm242	16	5		1.0
Cm243	130	617		2.5
Cm244	15	1		2.0
Cm245	369	2145		2.5

The annihilation process in CANDU involves first, neutron capture to convert to thermally fissionable neutron/proton combinations and then fission by thermal neutrons. The high thermal neutron flux level provides an appreciable annihilation rate in spite of the neutron capture required first. Reaction rates (per nuclide) of the higher actinide isotopes in CANDU and FBRs of current design are compared in Table 4. The reaction rates in CANDU are between one and two orders of magnitude higher.

Fuelling the CANDU AB

The absence of U-238 has a major impact on the fuel management strategy that is used in the annihilation process. As formation of Pu-239 is eliminated, the reactivity of the lattice drops rapidly with fuel burnup. The refuelling rate required to maintain criticality is significantly higher compared with the reactor that burns natural uranium.

The lattice reactivity drop with irradiation for a transuranic mix with an initial Pu-239 content of 76 g in each CANDU fuel bundle is shown in Figure 1. The excess reactivity averages to 4.5% over 150 days of irradiation. This is the required value to sustain reactor operation. The rate of fuelling the reactor to achieve this fuel lifetime is within the capability of current fuel handling technology.

Table 4. Comparison of Reaction Rates (Relative Units)

Isotope	FBR		PWR		CANDU AB	
	capture	fission	capture	fission	capture	fission
Np 237	2.50+14	1.00+16	1.41+16	-	8.80+17	-
Np 238	-	-	-	1.67+17	-	1.04+19
Np 239	-	-	5.44+15	-	3.40+17	-
Pu 238	-	1.25+16	4.32+16	1.44+15	2.70+18	9.00+16
Pu 239	1.00+14	1.00+16	2.15+16	5.98+16	1.35+18	3.74+18
Pu 240	-	1.00+16	2.32+16	-	1.45+18	-
Pu 241	-	1.00+16	2.86+16	8.09+16	1.79+18	5.06+18
Pu 242	-	7.50+15	1.52+15	-	9.50+16	-
Pu 243	-	-	6.96+15	1.57+16	4.35+17	9.80+17
Am 241	-	1.00+16	4.70+16	2.40+14	2.94+18	1.50+16
Am 242	-	-	-	1.68+17	-	1.05+19
Am 242m	-	1.00+16	1.60+17	5.56+17	1.00+19	3.48+19
Am 243	-	1.00+16	6.00+15	-	3.75+17	-
Am 244	-	-	-	1.84+17	-	1.15+19
Am 244m	-	-	-	1.28+17	-	8.00+
Cm 242	-	5.00+15	1.28+15	4.00+14	8.00+16	2.50+16
Cm 243	-	1.20+16	1.04+16	4.94+16	6.50+17	3.09+18
Cm 244	-	1.00+16	1.20+15	8.00+13	7.50+16	5.00
Cm 245	-	1.25+16	2.95+16	1.72+17	1.85+18	1.07+19

Figure 1. **Lattice Reactivity Depletion**

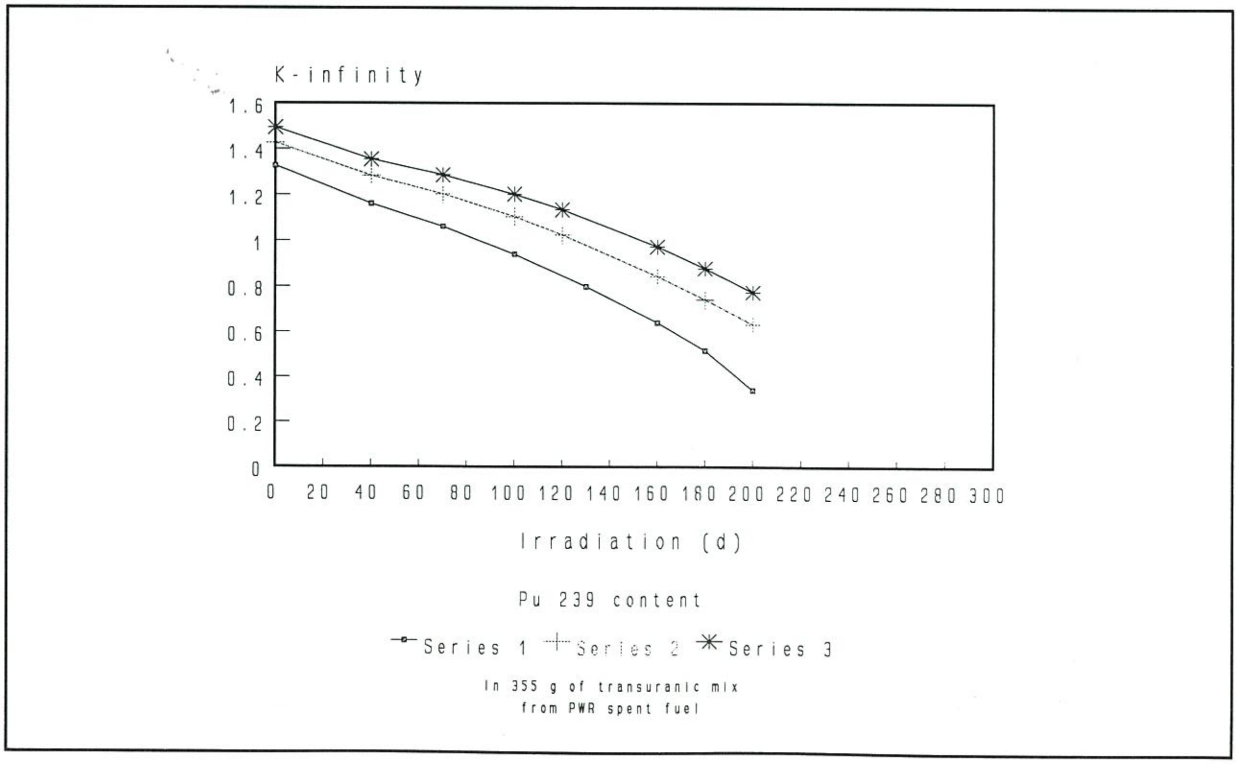


Table 5. Initial Bundle Inventory (g)

Total	300 (55% Total Pu)	3000 (70% Total Pu)
Np 237	61.31	408.72
Pu 238	2.72	34.65
Pu 239	95.00	1209.09
Pu 240	44.35	564.48
Pu 241	14.33	182.42
Pu 242	8.57	109.12
Am 241	62.79	418.62
Am 243	10.90	72.66
Total	300.00	3000.00

Table 6. High vs Low Inventory Option

Bundle Inventory	300 g (55% Total Pu)	3000 g (70% Total Pu)
Reduction in total Pu	47.9%	55.9%
Reduction in M.A.	38.6%	51.9%
Energy from M.A.	40.0%	29.0%
Annual M.A. Annihilation for 1 GW(e) Reactor	675 kg	483 kg
Fuelling Rate for 1 GW(e) Reactor	51 b/FPD	3 b/FPD

The refuelling rate is kept within the capability of the Fuel Handling System by adjustment of the initial fissile content of the bundles. An increase in fissile content to lower the refuelling rate, however, reduces the thermal neutron flux level and subsequently increases the actinide content of the discharged bundles.

The fuel management strategy used is, therefore, a balance between the fissile content and the refuelling rate to obtain the optimum benefit from the fuel handling capability that is available. The optimization includes the option of shuffling the fuel between bundle positions and/or between channels.

The annihilation rates for two levels of bundle fissile inventory, (bundle compositions shown in Table 5) are given in Table 6. With 300 g of actinide mix per bundle, 38.6% of the minor actinides are annihilated during fuel life (150 FPD) and contribute 40% to the energy production. The refuelling rate required for a 1 GW(e) reactor is 51 bundles/FPD. The annual annihilation of minor actinides is 675 kg in a 1 GW(e) reactor.

With a higher initial inventory, (3000 g/bundle), 52% of the minor actinides are annihilated during fuel life (2533 FPD) and contribute 29% to energy production. The refuelling rate required is 3 bundles/FPD for a 1 GW(e) reactor. The annual annihilation of minor actinides is 483 kg in a 1 GW(e) reactor is 51 bundles/FPD. The annual annihilation of minor actinides is 675 kg in a 1 GW(e) reactor.

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The Once-Through Cycle

The actinides remaining in the discharged fuel can be recycled after reprocessing and refabrication into bundles. This is a major cost component of the annihilation process.

Table 7. Reactivity Coefficient for the CANDU Lattice

	Bundle Plutonium Content			Natural
	76 g	100 g	122 g	(Current CANDU)
Fuel Temperature Coefficient (micro-k/Deg C)	-1.1	-1.1	-1.1	-4.5
Coolant Void Reactivity (milli-k)	+2.6	+2.3	+2.0	+11.0

The once-through fuel cycle minimizes cost by avoiding reprocessing and refabrication of the fuel. The key requirement for this cycle is to achieve a neutron flux level of about 1E16 n/(cm^2.s). There are two approaches being considered for this. In one, a CANDU fuel bundle that can operate at higher than current power density is proposed. This is the less desirable of the two approaches as it uses technology that is currently unproven.

In the second approach, the fuel bundle is passed through the reactor once in the outer (low flux) channels that are located towards the core edge and then again through the central channels where the neutron flux is higher. This type of fuel shuffling is required to annihilate the actinides remaining in the bundle at the end of the first pass through the channel. This approach exploits the on-power refuelling feature of CANDU. The lower fissile content of the fuel during the second irradiation stage allows operation at a higher flux level without exceeding power density limits. One additional pass (or at most two) is sufficient to reduce the actinide content of the discharged bundle to a level that is comparable to the losses experienced in fuel reprocessing.

The additional pass would entail reservation of specific fuel channels in the core for the irradiation of second pass bundles and an increase in the fuelling machine duty. It is expected that some modifications will be required to the design of the Fuel Handling System to achieve this capability. However, the conceptual design of the system will remain unchanged.

Reactor Dynamics and Control

The use of plutonium-239 in the transuranic mix raises the issue of reactor dynamic behaviour and its implications on reactor control, through the effect on feedback reactivity and neutron kinetics. The versatility of CANDU to use several alternative fuel cycles without having to make significant changes in the reactor design is based on the predominance of heavy water, which is the most abundant material in the lattice, in determining the neutronic behaviour of the CANDU lattice. To illustrate this, parameters relevant to reactivity feedback effects are compared in Table 7. The reactivity coefficients for fuel temperature and for coolant voiding are relatively insensitive to plutonium content.

The absence of uranium increases the prompt neutron generation time of the lattice. This offsets the lower delayed neutron fraction of plutonium-239 in affecting dynamic behaviour.

Development of the CANDU AB

This study has, as of yet, not uncovered any neutronic issues that would prevent the use of higher actinides as fuel in CANDU. It is expected that with current fuel handling technology, the fuelling strategies that are envisaged for the use of this type of fuel can be implemented. This makes actinide annihilation feasible with the current CANDU concept.

The main task is to develop a neutronically inert matrix that is compatible with the actinide mix in a reactor environment at power densities that are currently achievable. If the CANDU AB is to operate at current power densities, the fast neutron flux level, which affects the life of the CANDU plant remains unchanged.

Summary

A strategically indispensable role, comparable to the one of operating with natural uranium, is proposed for CANDU as an incentive to ensure future CANDU sales in an environment where enrichment and reprocessing technology are globally available.

Because of their high neutron economy, CANDU reactors can operate with minimal fissile content and consequently at high neutron flux. This is especially so in the absence of uranium, i.e. when transuranic actinides are used as fuel. The low fissile requirement and the on-power refuelling capability of CANDU can be exploited to achieve a once-through cycle for actinide annihilation. This avoids recycling and refabrication costs and makes CANDU an indispensable component of the fuel cycle in countries that have a policy to dispose spent fuel through reprocessing.

In addition, CANDU's ability to operate without uranium and extract energy from the minor actinides makes it the ultimate resource conserver and gives it a unique role in sustainable energy growth.

CANDU fuel cycle flexibility

by D.F. TORGERSON, P.G. BOCZAR, AECL Research, Chalk River Laboratories,
and A.R. DASTUR, AECL CANDU

Introduction

Fuel cycles have always been of key strategic importance to the nuclear industry. Keen interest in fuel cycles that improve uranium utilization was originally driven by a belief that uranium resources would not support the requirements of a growing nuclear system. Reprocessing technology was developed to provide plutonium for fast breeder reactors to extend fuel resources. Similarly, early work in the thorium fuel cycle was motivated by uranium resource considerations. Interest in effective uranium utilization is now motivated by other considerations, such as environmental concerns for the front- and back-end of the fuel cycle, and national policies to secure the maximum benefit from nuclear energy resources, or to increase energy self-reliance. Reprocessing, and recycling the recovered uranium and plutonium back into thermal reactors, is a means of increasing the energy derived from the original mined uranium.

The fuel cycle is being increasingly viewed in the context of the overall waste management strategy. Hence, there is currently interest in actinide burning and transmutation as waste management options, even though disposal concepts, such as geological disposal, have been shown to effectively eliminate the radiological risk from long-lived actinides. A related interest in fuel cycles stems from the end of the Cold War, and the enticing possibility of burning weapons-origin plutonium or high enriched uranium in nuclear power stations to generate electricity while enhancing world security.

This paper examines some of the CANDU fuel cycle options that are currently of interest to AECL and its customers.

SEU

The use of slightly enriched uranium (SEU) in CANDU has many attractions. A U-235 content of 1.2% would increase the burnup in CANDU by a factor of three, and hence result in a three-fold reduction in the quantity of spent fuel produced.

While the natural-uranium-fuelled CANDU is the most neutron-efficient of all commercial reactors in operation today, SEU would further improve the uranium utilization (the energy derived from the mined uranium). An improvement of about 30% in uranium requirements is achieved for an enrichment of 1.2%. Uranium utilization is an important consideration for some countries that have few indigenous uranium resources, and which have a strategic interest in energy self-reliance.

In operating CANDU stations, significant cost reductions can be achieved by using SEU fuel. Fuel cycle costs are about 30% lower than with natural uranium fuel. Both front- and back-end fuel cycle costs would be reduced with SEU.

SEU offers greater flexibility in reactor design. In new reactors, or in existing reactors where there is sufficient heat removal capacity, SEU can be used to uprate reactor power without exceeding existing limits on bundle or channel power, by flattening the channel power distribution across the reactor core.

The use of enrichment in CANDU also offers greater flexibility in fuel bundle design. One example is the Low Void Reactivity Fuel (LVRF) bundle, in which the use of enrichment and neutron absorber materials allows any value of void reactivity and discharge burnup to be designed. This has the potential for increasing the degree of passive safety in the CANDU design, as well as reducing capital costs (by allowing a simplification of the PHTS).

CANDU's on-power refuelling offers flexibility in fuel management that facilitates the use of SEU and other advanced fuel cycles. This flexibility extends from the equilibrium core, where, for example, different fuel management strategies could be used to accommodate different levels of enrichment, to the transition from one type of fuel (such as natural uranium) to another (such as SEU). Fuel management strategies have been identified for both the equilibrium core, and for the transition from natural uranium to SEU.

No reactor physics obstacles have been identified, and no significant changes are required to accommodate SEU in CANDU. An advanced fuel bundle is being developed as the optimum carrier of enriched fuels in CANDU. This new bundle, called CANFLEX (**CA**NDU **Flex**ible Fuelling), is more subdivided than other CANDU bundles, having 43 elements with two pin sizes.

The use of enrichment is the logical first step from natural uranium fuel in CANDU.

CANDU/PWR Synergism

The basis for synergism between CANDU and PWR arises from the fundamental characteristics of the two reactor types: PWR fissile requirements are higher than for CANDU, because of the good neutron economy of the latter. PWR spent fuel has a high fissile content – about 0.9 wt% U-235, and about 0.6% fissile plutonium, depending on the initial enrichment and exit burnup. CANDU fresh natural uranium contains 0.7% U-235, while the spent fuel contains 0.2% U-235 and 0.2-0.3% fissile plutonium. Hence, spent PWR fuel has about 1.5% fissile material, compared to about 0.4% fissile material in spent CANDU fuel and therefore, can be viewed as a source of fissile material for CANDU. About twice as much energy can be extracted from the fissile material in spent PWR fuel by recycling it in CANDU rather than in a PWR.

In conventional reprocessing, fission products are removed, and the uranium and plutonium are separated. The plutonium can be mixed with uranium (either natural, depleted, or the recovered uranium from the reprocessing plant) to form MOX fuel, which can be effectively utilized in CANDU. AECL has performed extensive studies on the use of MOX fuel in CANDU. There is considerable potential for optimizing the plant design to reduce capital costs through the use of MOX, as with SEU.

The uranium from reprocessing is referred to as "recovered uranium" (RU). It has a U-235 content of around 0.9%, and its use in CANDU without re-enrichment is a very attractive fuel cycle option.

A chemical decontamination process could be used to separate fission products and unwanted actinides from the unseparated uranium/plutonium mixture, which would then be co-converted into MOX fuel, and used either "as is" in CANDUs, or diluted with natural or depleted uranium (depending on the desired burnup). This is the conventional TANDEM fuel cycle. The advantage of chemical decontamination over conventional reprocessing lies in the potential of a cheaper, simpler process that is more proliferation-resistant and easier to safeguard, since plutonium is not separated from uranium.

The use of CANDU to maximize the energy potential of the fissile material from spent PWR fuel offers several benefits, including increased overall uranium utilization, and a reduction in the total quantity of spent fuel.

Recovered Uranium (RU)

RU is a by-product of conventional reprocessing of LWR fuel. With a nominal U-235 concentration of 0.9%, RU is a subset of SEU that is particularly attractive for currently operating and future CANDU reactors. Its use without re-enrichment in CANDU offers many of the benefits of SEU. Uranium utilization (the amount of energy derived from the mined uranium used in the original PWR fuel) would be improved by about 25%. Double the energy can be extracted from the RU by burning it in CANDU rather than re-enriching it as fuel for a PWR. Fuel burnup in CANDU would be about twice that of natural uranium, resulting in a two-fold reduction in the volume of spent fuel and a commensurate reduction in back-end disposal costs. By flattening the channel power distribution across the reactor core so that all channels produce nearly the same power, RU offers a power uprating capacity.

Fuel cycle economics were recently assessed for RU and SEU in CANDU, and for re-enriched RU in a PWR. The potential savings in CANDU fuel cycle costs with RU are striking. Over a range of reasonable cost assumptions, front-end fuellings costs for RU are reduced relative to natural uranium by between 28% and 67%, and by 15% to 30% compared to fuelling costs for 1.2% SEU.

In summary, excellent neutron economy and fuel cycle flexibility creates a niche in which CANDU is uniquely suited for burning RU without re-enrichment.

DUPIC

The DUPIC fuel cycle exploits the CANDU neutron economy and fuel cycle flexibility in a manner that maximizes the safeguardability of recovered fissile material from spent PWR fuel. The various DUPIC options do not use reprocessing or wet chemical processes, only dry processes, to utilize the energy content of spent PWR fuel in CANDU.

In 1992, AECL, KAERI and the U.S. Department of State completed Phase I of an assessment of the DUPIC cycle. Five mechanical reconfiguration options were assessed, involving rearranging the spent PWR elements into CANDU bundles, with or without double cladding. Two conceptual CANDU fuel-bundle designs were evaluated to maximize fuel utilization: 61- and 48-element bundles having either single- or double-clad element sheaths. These bundles were chosen to make use of the smaller PWR-size elements while maximizing the fuel content of CANDU bundles.

Two powder-processing concepts were also evaluated. In the OREOX option (**ox**idation, **re**duction of enriched **ox**ide fuel), spent PWR pellets would be subject to successive oxidation/reduction cycles to produce a sinterable UO_2 powder that would be pressed into pellets, sintered, loaded into CANDU sheaths, and fabricated into conventional CANDU bundles. The second powder-processing option was "VIPAC" (**vi**bratory com**pac**tion), in which PWR pellets would be ground into small, dense granules and vibratory-packed into sheaths.

All of the options were assessed against a set of selection criteria, which included retrofitability to CANDU and to PWR, safeguardability, licensability, reactor physics, fuel performance, fuel handling, fuel fabrication, and waste management.

It was concluded that OREOX is the most promising option, largely because of the homogeneity of the resultant powder and pellets. One of the advantages of this process is that it removes a high fraction of gaseous and volatile fission products, thereby improving fuel burnup. The CANDU burnup with the OREOX option is about 18 MWd/kg, using spent fuel from the reference Korean PWR, which has an average discharge burnup of 35 MWd/kg (initial U-235 enrichment of 3.5%).

The DUPIC cycle is particularly attractive in Korea, which has both CANDU and PWR reactors. In an equilibrium system in which the spent PWR fuel would provide the fuelling needs of CANDU, the DUPIC cycle would improve uranium utilization by about 25%, compared to an open cycle in which CANDU was fuelled with natural uranium. In this scenario, the total quantity of spent fuel produced by both CANDU and PWR could be reduced by a factor of three.

Although a large fraction of the gamma radioactivity would be removed from the recycled fuel, fields would still be high enough to require all refabrication and handling to be done remotely in a shielded facility. While this makes the fabrication of the CANDU fuel bundles more costly and difficult, it increases the diversion-resistance of the cycle.

The workscope for Phase II of the DUPIC program is now being defined. This is a multi-year experimental verification program, involving optimization of the OREOX process, and fabrication of DUPIC elements and bundles from spent PWR fuel for subsequent test irradiation in a research reactor, followed by post-irradiation examination, development of remote fabrication technologies, and development of appropriate safeguard technology.

Actinide Burning and Plutonium Destruction

Fuel cycle options are being proposed internationally that reduce the radiotoxicity of spent fuel arising from the long-lived actinides. Radiotoxicity is a measure of the hazard of ingesting or inhaling a substance. Radiotoxicity is not a measure of long-term risk from spent fuel in a waste management system, in which natural and man-made barriers are designed to isolate the waste from the biosphere. In fact, the environmental review of the Canadian geological disposal concept shows that the actinides pose negligible risk, because of their immobility in the disposal vault.

Nonetheless, there is interest internationally in assessing the feasibility of burning the plutonium and transuranic actinides from reprocessing in-reactor, as a waste management option. Because of its high neutron economy, CANDU can be effective in this role. The traces of fissile material in the transuranic mix from the reprocessing of spent LWR fuel provide sufficient reactivity in a CANDU lattice for use as fuel. The absence of uranium in such fuel prevents the formation of plutonium and the higher actinides. Without plutonium formation, the fissile content of the mix depletes rapidly with irradiation and constant reactor power output is maintained by using the on-power refuelling feature of CANDU to shift the targets into increasing flux. The high neutron flux facilitates the transmutation and annihilation of the higher actinides. About 3.6 GW(e).a of LWR actinide production could be annihilated annually in a CANDU 6 reactor of current design. No adverse effects on reactor dynamic behaviour have been identified.

High operating neutron flux, high neutron economy and on-power refuelling also make CANDU particularly suitable for the annihilation of weapons-grade plutonium. The plutonium would be irradiated in an inert matrix, such as zirconia or beryllia. The fissile content is maximized by using gadolinium to suppress excess reactivity. Calculations show that an annihilation rate of 2.5 kg/FPD (Full Power Day) can be achieved in a CANDU 6 reactor that is rated at 680 MW(e).

Another option being proposed for disposing of weapons-grade plutonium is "spiking": burning the plutonium in the form of a mixed oxide fuel, with the result that the radiation field from the resulting fission products is high enough to discourage diversion.

Thorium Fuel Cycles in CANDU

Thorium is an alternate fuel to uranium, but since it has no fissile isotopes, it is necessary to provide fissile material (uranium or plutonium). The U-233 produced by irradiation of Th-232 has the highest eta value (ratio of neutrons produced to neutrons absorbed) for thermal neutron fission of any of the fissile nuclides. It is thus a very good fuel in the soft CANDU spectrum. Moreover, the equilibrium concentration of U-233 in spent thorium fuel (about 1.5% U-233) is about five times that of fissile plutonium in spent natural uranium fuel, and so it should be a cheaper source of recycled fuel than plutonium (although this will be offset by higher fuel fabrication costs with recycled U-233, compared to recycled plutonium).

The fissile material can be provided in several ways, and these options define the various thorium fuel cycles. In most variants of the conventional once-through thorium cycle, ThO_2 and SEU are burned in separate channels, and the U-233 that is produced from neutron capture in Th-232 is burned in-situ. The conventional once-through thorium cycles require high thorium burnups, 40-100 MWd/kg Th (compared to 7 MWd/kg U for natural uranium fuel). Re-insertion of the spent ThO_2 fuel after a cooling period can further utilize the energy from the decay of Pa-233 to U-233 while in storage. A major challenge in the once-through thorium cycle is to devise appropriate fuel management strategies.

Other thorium fuel cycles employ reprocessing to optimize the energy potential from U-233, and these are of longer-term strategic interest. These reprocessing cycles mix ThO_2 with either enriched uranium, or plutonium. U-235 can be provided as either high enriched uranium (around 92% U-235, as a vehicle for burning weapons-material U-235), or as medium enriched uranium (less than 20% U-235, for non-proliferation considerations). If plutonium were used to initiate the cycle, it would be obtained from reprocessing conventional PWR or CANDU spent fuel, or from dismantled weapons.

Conclusions

Several options are being examined for exploiting the ability of CANDU reactors to burn a variety of fuels. The direction of CANDU fuel cycle developments will be driven largely by local considerations, such as the availability and cost of fuel resources (uranium and thorium), the presence (or lack) of a high-technology infrastructure, and the reactor mix in the particular country. The flexibility exists with CANDU technology to optimize the fuel cycle to meet the needs of our customers.

Regulating Tritium In Drinking Water

by Ric Fluke

Tritium is produced in the Great Lakes which is the source of drinking water for many Ontario households. There are three main sources of tritium: natural production caused by cosmic rays; detonation of nuclear weapons; and, operation of nuclear power plants. Nuclear weapons tests in the 50's and 60's remains the dominant source of present day tritium in Lake Ontario. The concentrations are about 10 Bq/l, or ten times the natural levels, and had reached 150 Bq/l during the peak of the weapons testing programme. The current limit on tritium in drinking water is 40,000 Bq/l.

The Advisory Committee on Environmental Standards (ACES) has recommended that the Ontario Drinking Water Objective for tritium be set immediately at 100 Bq/l and further recommends that this level be reduced to 20 Bq/l in 5 years. This has surprised many scientists and individuals and has prompted responses to the media as well as the provincial Ministry of Environment and Energy.

According to Ken Nash, Director, Nuclear Waste and Environment Services of Ontario Hydro Nuclear, his staff have reviewed the ACES recommendations and find a number of concerns about methodology as well as discrepancies in the proposed limits compared to accepted practice by international and national agencies. Although the proposed limits are being met, Ken feels that the issue needs to be put in proper perspective. The radiation dose to individuals from natural background sources far exceed that due to continuously drinking water that contains tritium, at even the present limit, let alone the proposed limit.

The following two articles shed some light on the issue. First is a technical summary prepared by Ernie Koehl, Health Physicist at Darlington Nuclear Generating Station; second is a portion of a private submission to the Minister of Environment and Energy (Bud Wildman) by the Joint Committee on Health and Safety of the Royal Society of Canada and the Canadian Academy of Engineering.

[*Note: The following article was published in the June issue of Darlington Nuclear Generation Division News. It was prepared by Ernie Koehl, Health Physicist at Darlington.*]

Tritium in Drinking Water

by Ernie Koehl

Recently there has been a lot of publicity regarding tritium and the recommendations of a Provincial Advisory Committee on Environmental Standards (ACES). The advisory group was commissioned by the Ontario Ministry of the Environment and Energy to conduct a public hearing on the MOEE's proposed standard of 7,000 Bq/L for tritium in drinking water. This new value represented a considerable reduction from the previous standard of 40,000 Bq/L in the "Guideline for Canadian Drinking Water Quality" (1978) and was intended to bring Ontario standards in line with those recommended by the international community.

Following consultation with the public, ACES surprised the nuclear community by recommending an immediate reduction in the tritium standard to 100 Bq/L with a further reduction to 20 Bq/L over the next five years. ACES implied that water supplies should be restricted whenever this limit is exceeded, ie. no provision was made for averaging tritium concentrations over time. In arriving at this standard, ACES used a model which is applied in setting limits for man-made chemical carcinogens which unlike tritium are not produced naturally. Most chemical risk assessments are based on the results of animal tests where chemical doses are thousands of times those expected in the environment.

Radiation scientists have an advantage over chemical scientists in that they have the benefit of over a hundred years of documented evidence on the biological effects of ionizing radiation. They are also armed with knowledge about natural background radiation and the fact that it varies widely across the face of the earth with no discernible effect on the exposed populations. Based on this information, the radiation scientists have set what they consider to be safe limits on exposure which are associated with acceptably low level of risks. The work of these scientists is published in numerous documents such as those produced by the world renowned International Commission on Radiological Protection (ICRP).

The recommendations from ACES pose a dilemma. The ACES standard is well below what is considered safe by the radiation scientists. It requires monitoring and control at levels that are very close to natural background and below the normal range of doses that people receive from naturally occurring radiation inside their bodies as well as in the world around them. Below is a summary of tritium in the environment that may help put the ACES recommendation in perspective.

First of all the Becquerel (Bq) is a very small unit of measure used to quantify radioactivity. It describes the situation where a radionuclide is decaying at a rate of one atom per second. (One Curie is equal to 37,000,000,000 Bq.) For illustration purposes, the moderator system of Unit 1 at Darlington contains heavy water with a tritium concentration of about 300,000,000,000 Bq/L.

Tritium is produced by:

- cosmic ray interaction with the earth's atmosphere,
- detonation of nuclear weapons,
- operation of nuclear power plants

Before atmospheric nuclear weapons testing and before nuclear reactors, the tritium concentration in Lake Ontario was about 1 Bq/L. At the peak of atmospheric testing (the early sixties), the tritium concentration in Lake Ontario reached levels in the range of about 150 Bq/L. Today, the tritium concentrations measured at water supply plants around Darlington have gone as high as 25 Bq/L but are typically in the range of 5 – 10 Bq/L.

Nuclear generating stations emit small amounts of radioactivity to air and water in the course of their operation. The regulatory limit for tritium released in Darlington liquid effluent is 440,000,000,000,000,000 Bq per month with the operating target set at 1 percent of this level. The underlying principle behind these numbers is that Darlington's impact on a member of the public should be As Low As Reasonably Achievable (ALARA) and MUST be less than the legal limit of 500 mrem per year. The fact that Hydro has done a very good job on ALARA is demonstrated by the fact that in 1993, Darlington's radiological impact (as measured by our environmental monitoring program) on the most exposed member of the public via tritium in drinking water was 0.003 mrem.

A typical resident of Ontario receives about 240 mrem per year from natural background radiation. This annual dose total will vary with elevation above sea level and with proximity to naturally occurring radioactivity such as up in Bancroft where there is more radioactivity in the rocks. In addition to travel credits, frequent flyers also get the added bonus of more radiation exposure due to higher levels of cosmic radiation at normal flight altitudes. The dose to a person drinking water with a tritium concentration of 100 Bq/L for a whole year would be about 0.14 mrem. A resident of Ontario would receive this dose in about five hours from natural background radiation.

In the absence of further atmospheric detonations of nuclear weapons, *chronic* tritium levels in drinking water are expected to remain below 100 Bq/L and will likely remain below 20 Bq/L after the full impact of Hydro's tritium removal strategy is felt. The problem with the ACES standard is that it has been applied to small short term spikes which have no biological consequence. For example, the 1992 moderator heat exchanger leak at Pickering resulted in a peak tritium concentration of 840 Bq/L in the finished water at the Ajax water supply plant. This led authorities to close the Ajax plant for 6 hours and caused a lot of concern among the public. In the final analysis, it was estimated that the maximum potential dose to a member of the public as a result of drinking this water was only about 0.010 mrem – a very small incremental dose above natural background.

Recent media articles have tended to sensationalize the issue by quoting hypothetical numbers of deaths at various tritium levels and suggesting that water supply plant shutdowns are a possibility. Ultimately the issues surrounding the standards recommended by ACES are political in nature in that they deal with perception of risk rather than real risk. While the standards do not add appreciably to public safety, they do have the potential for adding enormous (and costly) implementation burdens as well as unnecessary stress to local citizens. For example, not only would the government need contingency plans for shutting down water supply plants, it would also need to be prepared with sophisticated analytical techniques in order to measure such low levels of radioactivity.

The ACES recommendation is now in the hands of Environment Minister Bud Wildman. Ontario Hydro has assembled a team to evaluate the ACES recommendations and to develop a strategy for responding to the MOEE.

[*Note: Following is a letter by the Joint Committee on Health and Safety of the Royal Society of Canada and the Canadian Academy of Engineering, submitted to The Honourable C.J. (Bud) Wildman, Minister of the Environment and Energy in July 1994. Some highlights of their supporting arguments are also given.*]

The Honourable C.J. (Bud) Wildman,
Minister of the Environment and Energy,
Queen's Park,
Toronto, Ontario

Dear Mr. Wildman:

Subject: *"A STANDARD FOR TRITIUM - A Recommendation to the Minister of the Environment and Energy", ACES Report 94-01, May 1994.*

The Advisory Committee on Environmental Standards (ACES) in the above report recommends that the Ontario Drinking Water Objective for tritium be set immediately at 100 Bq/l and further recommends that this level be reduced to 20 Bq/l in 5 years. The members of our committee have considered these recommendations and, unfortunately, are in broad consensus that they conflict with fundamental principles for good management of risk to health and safety.

The ACES report is concerned about a minimal risk to human health, in isolation and out of context. It is not a good prescription for public policy. The recommendations of the ACES report "A Standard for Tritium", should be rejected.

The ACES recommendations are fundamentally flawed, first because the main conclusion rests on a dubious extrapolation of the relevant scientific data. Scientific evidence, casting doubt on the empirical and theoretical basis of this extrapolation has accumulated. The risk to the people of Ontario from tritium in drinking water is known to be undetectably small, and that will continue to be the case if no change is made. This would be serious enough if it were the document's only fault.

Regulation entails social and economic costs and the government ought to ensure that the benefits clearly exceed the costs. There must be clear evidence that a problem exists, that intervention is justified and that regulation is the best alternative open to government. "A Standard for Tritium" fails on all counts.

The ACES report employs no coherent rationale or a defendable philosophy for managing risk in the public interest. (See Annex I to this letter.) The recommendations can be understood only in terms of a hidden agenda. The document in effect demands an infinitesimal level of risk without any recognition of benefits or the fact that such risk reduction will come with a price tag. To demand extraordinary safety is to succumb to an illusion that can be enormously costly for the people of Ontario. The costs in turn translate into nothing less than wasted opportunity to save lives in other ways.

It is a matter of record that society's resources for reducing risk are being poorly allocated when we judge such efforts against the criterion of the life-saving that is possible. Since the ACES report relies heavily on pronouncements from the U.S. Environmental Protection Agency, we quote from the 1992 Budget of the United States Government (Section IX.C "Reforming Regulation and Managing Risk Reduction Sensibly") as follows:

"Many cancer risks from environmental exposures (excluding smoking and diet) are very small relative to other threats to human health. Nevertheless, about half of the significant regulations listed are aimed at reducing these small cancer risks... The many regulations targeted at occupational, environmental and dietary cancer risks have been extraordinarily costly."

Mr. Wildman, the recommended "Standard for Tritium" would contribute in a negative way to the general social well-being of the people of Ontario. The risk from tritium is negligible by any reasonable measure in relation to the many real risks we face. A concern over hypothetical risk from tritium ought not to place an unnecessary demand on our scarce resources. The proposed standard is so far from reasonable that it will be seen by many as a veiled intentional impediment to nuclear power production.

We bring to your attention an anomaly. The Ontario Ministry of Health was unable, in the recent past, to marshall a $6 million vaccination programme for teenagers at risk from meningitis, a risk that health professionals would consider as both real and deadly. Yet attention and large resources are diverted to addressing trifles such as the tritium risk. We should be able to do better than that. Managing the total burden of risk in our society responsibly is an important objective of government. There now exists a coherent approach and some guiding principles that can be used for setting priorities and managing the total burden of risk responsibly (see Annex II). These tools, developed by the risk analysis profession in Canada and internationally, are operational, to help matters – but their availability places an obligation on the government to perform a thorough and rational analysis of the costs and benefits of regulatory proposals.

As chairmen of this committee, we would be happy to provide any further assistance or advice if required.

Sincerely,

[Signed]	*[Signed]*
Niels Lind	Jatin Nathwani
Chairman	Co-Chairman
Joint Committee on Health and Safety	Joint Committee on Health and Safety

[Note: Annex 1 to the above letter provides support for the contention that the ACES Report "A Standard for Tritium" is a "fundamentally flawed document". Annex 2 is an attempt to provide a guiding and coherent internal rationale which the authors claim is lacking in the ACES report.]

Excerpts from "Annex 1"

"In determining an acceptable level of tritium in drinking water, the calculation of dose and estimates of the significance of that dose in terms of resulting expected mortality are of central importance.

"There are five main points that must be made on this topic. They are:

Estimates of the annual dose due to tritium are low, even when these estimates are made as high as possible. These doses due to tritium are within the variation in background.

Estimates of the actual dose and risk to the most exposed individual as a result of living near an Ontario Hydro nuclear station are very small. The attendant risk is so low that it would be undetectable.

The lifetime risk due to this exposure to tritium is low.

The lifetime risk of cancer incidence and mortality (all causes) is very large compared to the risk resulting from exposure to tritium.

Low doses of radiation, at levels near the background level, are not extra-dangerous."

[Each of the above points is supported by the authors. For example, point 4 above is explained below.]

" (4) In comparison with even these high estimates, *the lifetime risk to an individual of dying from cancer is very much higher*. The lifetime risk of dying from cancer (all causes) in Canada is 26.8% for males and 22.4% for females (Canadian Cancer Statistics 1993, ISSN 0835-2976). There is no doubt about these risks. They are a fact and the largest contributors to them are well known. Recall the estimated lifetime individual risk of mortality (high estimate) due to tritium: 0.034%. This risk from tritium would be impossible to detect at such a low level since it is a very small component of an otherwise larger but varying risk to populations from cancer in general."

[The authors outline four major problems with the ACES report.]

"There are four major problems with the ACES report.

ACES has failed to demonstrate the need for any new tritium limits in drinking water, let alone the draconian ones they propose.

ACES has misapplied Dr. Waight's calculation of risk. This introduces an over-estimation error of almost two orders of magnitude into their risk numbers.

ACES has failed to take into account any consideration of the cost, the feasibility or even the viability of its proposals.

The arguments in the ACES document are not guided by any coherent internal rationale and, as a result, the report lacks perspective."

[Again, the Authors elaborate on the problems with the ACES report. On their last point, the Authors propose "A Framework and Guidelines for Managing Risks", outlined in their Annex 2. Three principles are given below from their Annex.]

"There are three principles for managing risk in the public interest that provide a general framework of reasoning for the management of activities involving risk.

Principle #1: *Risks shall be managed to maximize the total expected net benefit to society.*

The principle that net benefit is to be maximized across society as a whole is argued to be a sufficient and rational guide to assessing the effectiveness of efforts directed at reducing risk and thus improving health and safety. The net benefit of an activity is the excess of the totality of benefits over the totality of detriments. Since the benefits and detriments are usually of different kinds and fall to different degrees on different members and groups within the society, it is necessary to arrive at a common basis of measurement. In addition, the important philosophical issues related to the distribution of the burden of risk on individuals versus the benefit to the collective must be faced squarely.

Principle #2: *The safety benefit to be promoted is life-expectancy.*

The goal is to ensure that risk mitigation efforts maximize the net benefit to society in the specific terms of length of life for all individuals. This can be further adjusted to include health expectancy and other factors that affect the quality of life, generally referred to as the quality adjusted life expectancy (QALE). The effect of an activity on life expectancy is proposed as the proper basic measure of its net safety impact. In most cases, at least some of the benefits and some of the detriments of an activity are indirect, widely spread and uncertain. Thus, the measurements and comparison are statistical and sometimes probabilistic in nature. Life expectancy is a universal measure valid for comparisons both within and among countries. It allows a dispassionate accounting of the good and the bad inherent in any proposal or activity that is in the public interest but has some impact on life and health.

Principle #3: *Decisions for the public in regard to health and safety must be open and apply across the complete range of hazards to life and health.*

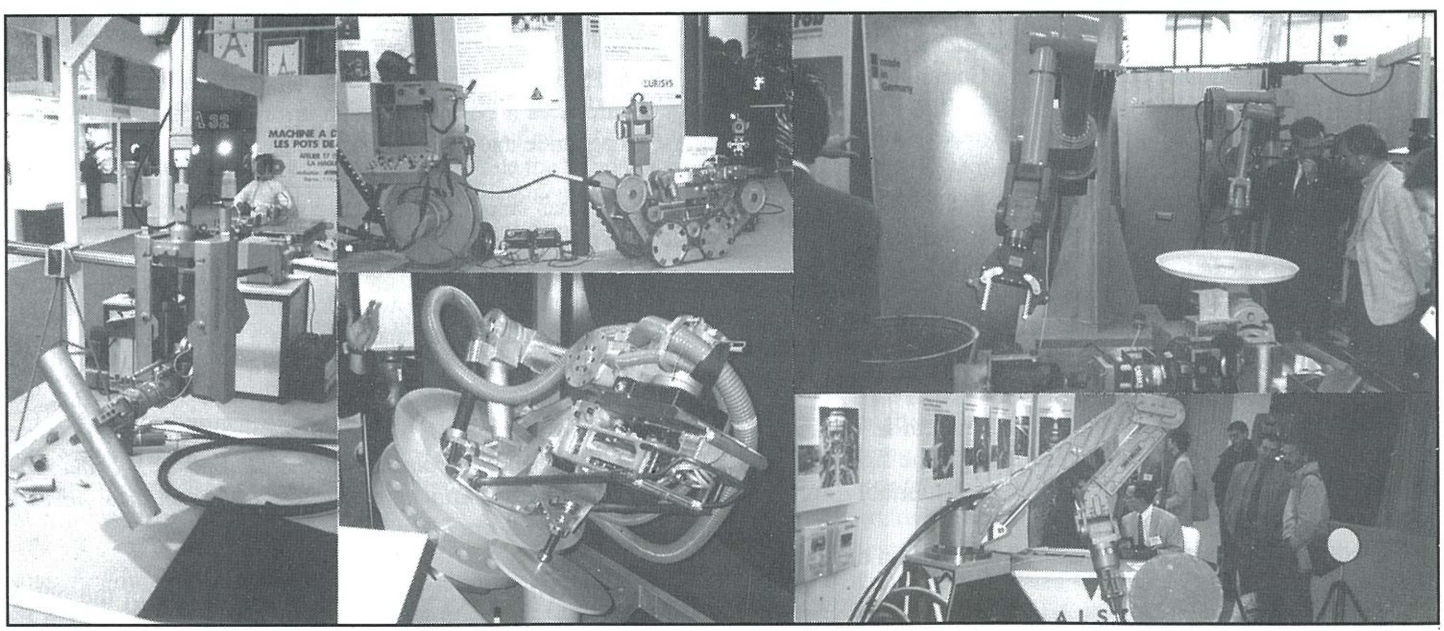
Systematic efforts to evaluate *all* the important health and safety consequences, both direct and indirect, are required to improve the basis for risk management in society. Balancing of the detriments *and* the benefits of any given initiative is the key aspect of the undertaking. Safety may well be an important objective in society, but it is not the only one. Thus, the allocation of society's resources devoted to safety has to be continually appraised in light of other competing needs because there is a limit on the resources that can be expended to save lives.

[*Note: More information on these principles and their application can be found in the following references:*]

1. Joint Committee on Health and Safety of the Royal Society of Canada and the Canadian Academy of Engineering, "Health and Safety Policies: Guiding Principles for Risk Management", Report JCHS 93-1, July 1993.
2. Lind N.C., J.S. Nathwani, E. Siddall, *Managing Risks in the Public Interest*, 2nd Edition, Institute for Risk Research, University of Waterloo, Waterloo, 1993.
3. Nathwani, J.S., E. Siddall, N.C. Lind, *Energy for 300 Years: Risks and Benefits*, Institute for Risk Research, University of Waterloo, Waterloo, 1992.

Deadline

The deadline for the next issue of the CNS *Bulletin*, Vol. 15, No. 4, Winter 1994-95, will be 9 January 1995



Many types of robotic or remotely-operated equipment for the maintenance of nuclear facilities were displayed at the exhibition of ENC '94 at Lyon, France, in early October.

ENC '94

The major international nuclear conference this year was **ENC '94** which took place in Lyon, France from October 2 to 6.

An abbreviation for European Nuclear Congress, 1994, ENC '94 was organized by the European Nuclear Society in collaboration with the American Nuclear Society and the European Industrial organization Foratom. The CNS, along with the Chinese Nuclear Society, Japan Atomic Industrial Forum and the Korea Atomic Industrial Forum, was a co-sponsor (in the sense that the CNS and others publicized the event).

Despite its location and European organization the conference was conducted entirely in English (at least officially), a further testament to the ubiquitous nature of our language.

The theme of ENC '94 was **"Atoms for Energy,"** (a deliberate paraphrase of the "Atoms for Peace" slogan of the 1950s) with a sub-theme of "a dialogue with the industry's young generation nuclear's future". Regardless of the latter theme there were few "young" people at the conference – only ABB as an organization responded to the call. By sending about two dozen young engineers and scientists from their Swedish operations and providing them with attractive red pullovers (sweaters) ABB achieved a PR coup.

As a conference the meeting was staid, generally boring, with only plenary sessions in which there were no opportunities for questions or discussion. Attendance at the sessions was generally less than 200 (often as low as 100) of the 1500 registered delegates attending.

The associated exhibition, however, was another matter. With over 400 companies from over 20 countries represented, this was the largest nuclear showcase in recent years. The EUROEXPO facility drew praise from exhibitors for its spaciousness and organization but required a bus ride of up to 45 minutes from the centre of Lyon. With Lyon's historic gallic charm the majority of those staying in the city accepted the inconvenience. Reflecting the state of the nuclear power industry almost everyone was demonstrating services or special equipment to keep plants operating.

According to the organizers there were about 2,000 people associated with the exhibition and they claimed another more than 6,000 visited for a total of about 10,000. Many were sceptical of that figure.

The conference sessions were divided into six – an opening, four topical ones, and a closing session. The topical sessions covered: (1) need for nuclear energy in different parts of the world, (2) safety of operating nuclear power plants, (3) back end of the fuel cycle: recycling and direct storage of fuel elements, and, (4) need for new reactors to improve safety and economics.

Session (3) on recycling appeared to draw the most interest with obvious differences between countries which have reprocessing plants and other countries concentrating on burying spent fuel. This was reflected at the AECL exhibit where the most frequent inquiry was about the use of CANDU to burn LWR fuel to derive more energy from it and/or to destroy the radioactive actinides which some countries feel are particularly difficult to manage. (See paper by Dastur and Gagnon elsewhere in this issue.)

Despite the obvious public relations opportunities of such a major conference only one formal press conference was held - on the Monday following the opening session. Collette Lewiner, past president of the ENS acted as convenor with speakers Dr. Hans Blix, Director General of the IAEA and Dr. Yoshihori Ihora of the Japan AEC on stage. Blix repeated his assertion that the nature of nuclear waste was an "asset" for nuclear power since it was so concentrated it could be dealt with thoroughly compared to the millions of tonnes of waste from fossil-fuelled generation which are untreated and a burden on the environment.

As always with nuclear meetings of the past several years there was considerable introspection on why nuclear remains so negative in the public consciousness while events such as the chemical plant catastrophe in Bophal (whose 10th anniversary passed that week without notice) and the Baltic ferry disaster of a few days previously are quickly forgotten. One proposed approach to this conundrum was presented by a speaker from BNFL who argued that instead of defending the "nuclear industry" each company should concentrate on gaining a favourable image for itself. He noted that although the chemical industry as a whole is still suspect in the public mind the value of Union Carbide stock had risen five times since the Bophal disaster.

There were two "embedded" meetings – one sponsored by WIN (Women in Nuclear) on Public Acceptance and Risk Communication, the other on Occupational Radiation Protection. The former was open to all while the latter required a separate registration (and extra fee). The WIN meeting did not draw large numbers but several of the men who attended complemented the women speakers for providing new insight into the communication problem.

The organizers inserted a touch of culture with a concert on the Wednesday afternoon after the sessions by a group called Camerata Nucleaire composed of nuclear professionals from several countries. In addition an ensemble from BNFL presented light classics at the UK exhibit area.

Compared to meetings such as the annual CNA/CNS conference or the bi-annual ANS meetings, ENC '94 left much to be desired, as reflected in the low attendance at the sessions. The exhibition, however, was very popular and there were, reportedly, a large number of "private" meetings. Given the high registration fees (about $1,000 Cdn.) and the lack of any meals or other tangible benefits it is not surprising that the organizers declared that ENC '94 was a financial success.

(see photographs on page 30, opposite)

18th CNS Simulation Symposium

When an activity has gone on for 18 years it is obvious a need exists and an appropriate format has been found. The successful 18th CNS Simulation Symposium held October 13 and 14 at Pembroke, Ontario (near the Chalk River Laboratories) once more demonstrated these attributes.

The advanced state of computer simulation was well illustrated by the 27 papers given over the two days. They were loosely grouped into three categories: reactor physics, thermal-hydraulics, fuel and fuel channels (with one lonely paper related to geologic waste disposal. Each paper was received with close attention and subjected to incisive questioning by the more than 50 analysts and researchers attending.

The papers dealt with diverse topics. Even within one category, reactor physics, papers ranged from generation of cross-section databases, to lattice calculations, to simulation of trip tests. A paper on the use of neural networks for the prediction of critical heat flux in the thermalhydraulics category, suggested a possible future direction of computer simulation.

Delegates were provided with a vision for the future and presented with a challenge to help achieve by AECL Research V.P. Dr. David Torgeson in his talk after the dinner the first evening. Torgeson foresaw a great future for CANDU because of its fuel cycle flexibility. But to achieve CANDU's potential, he asserted, would require advanced thinking and he called on his audience to provide that. Much more analyses of evolutionary concepts will be needed he told the roomful of analysts. Do not fear the future but help create it, he challenged.

Dave Torgeson

The symposium was organized by a group from CRL headed by Peter Laughton, and included Rhonda Cheadle, Aslam Lone and Norm Spinks. Organization was obviously very thorough, sessions ran on time, proceedings were available at the symposium, and there was ample time for that most important aspect of such gatherings, meeting and discussing with others in the same game.

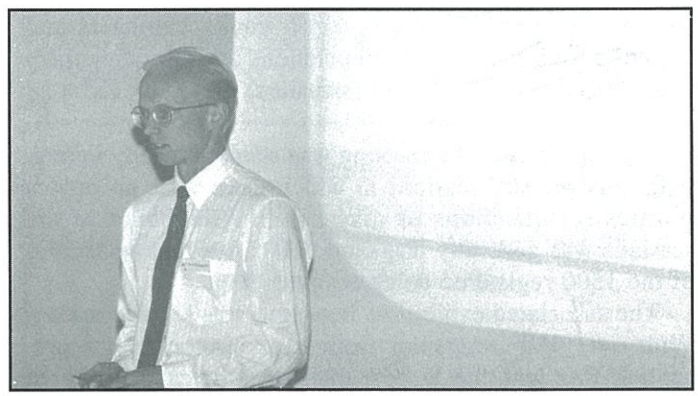
To give some flavour of the meeting, three abstracts, drawn subjectively from the three broad categories, are reprinted below.

A Simplified Heterogeneous B1 Model with Isotropically-Reflected Neutrons on Assembly Boundary

I. Petrovic, École Polytechnique de Montréal
P. Benoist, Paris, France
G. Marleau, École Polytechnique de Montréal

Abstract

This model is based on the heterogeneous B1 theory and accounts for heterogeneous effects on the neutron streaming. To the price of some approximations, it yields an iterative scheme to simultaneously compute the multigroup scalar fluxes and the directional currents in a heterogeneous geometry. Although a similar simplified model, called TIBERE, has already been proposed for specularly-reflected neutrons on the assembly (or cell) boundary, there was a need to develop this new model, called TIBERE-2, for isotropically-reflected neutrons on the boundary. This new model requires the classical and directional escape and transmission probabilities in addition to the classical and directional first flight collision probabilities calculated for an open assembly. Consequently, considering the specific geometry of the CANDU reactor lattice, calculations with the TIBERE-2 model are as appropriate but less time consuming than those with the TIBERE model. Moreover this new model circumvents the divergence, leading to infinite leakage coefficients, appearing in the TIBERE model in the case when a PWR assembly is completely voided. The TIBERE-2 model has been introduced, for 2D geometry, in the multigroup transport code DRAGON, in order to evaluate space-dependent leakage coefficients.



Kevin Kamerman presents the paper he co-authored on "Application of a Neural Network in the Prediction of Critical Heat Flux" at the 18th CNS Simulation Symposium, October 13.

Application of a Neural Network in the Prediction of Critical Heat Flux

K.J. Kamerman, R. Sollychin, S. Doerffer, E. Zariffeh, J. Scott and V. Iyengar

Abstract

Critical heat flux (CHF) is an important limiting parameter for nuclear reactor operation. A substantial amount of CHF data has been obtained experimentally throughout the world. Traditionally, the value of CHF is predicted by using an empirical correlation of CHF data. Such methods are capable of predicting CHF within a reasonable degree of accuracy within limited conditions. However, the objectivity of the methods is often questionable, as they are formulated to conform with a set of generally acceptable physical models. The other common

method of predicting CHF is by numerically formulated mechanistic CHF models. Assumptions on physical phenomena are usually made and hence an even stronger human preconception is involved in the development of such models.

A neural network is a simple computer simulation of the way information is processed in the human nervous system. Once appropriately trained on the system under study, a neural network can produce a result that is independent of any preprogrammed mathematical model. It is therefore hoped that using a neural network to predict CHF will eliminate the subjectivity associated with the traditional CHF prediction methods.

In this feasibility study, a back-propagation type of neural network has been developed and trained using experimental data from a tube test section. Various architectures of the neural network and various combinations of input parameters were tested. Results indicate that a well-designed neural network can predict CHF with a root-mean-square error of less than 4%. Several characteristics of the neural network were studied, such as the increase in error when the neural network is used within ranges that have scattered data during training.

Sensitivity Analysis of Crack Leakage Predictions of Leak-Rate Version 1.0 Code

S.I. Osamusali, R.Y. Chu and W.C. Chan
Ontario Hydro

Abstract

Pipe-wall crack leakage predictions coupled with fracture mechanics analysis of the crack sizes provide a correlation between the crack sizes and leakages for leak-before-break (LBB) analysis. The predicted crack leakages of two-phase mixture from steam generator tube-wall cracks can be used to estimate the total number of cracked tubes required to give a leak rate of 15 kg/h at which the reactor is to be shutdown. Accurate predictions of crack leakages are therefore required for these applications. The sensitivity of pipe-wall crack leakage predictions using LEAK-RATE Version 1.0 code to changes in the various input parameters have been analyzed. The crack leakage is initially predicted for a set of reference conditions. By varying the input parameter of interest (e.g., pressure, temperature or initial degree of subcooling, crack opening displacement, crack shape, etc.) while holding all other variables constant, the uncertainty in the predicted crack leakage for a small change in the specified variable has been determined. On a plot of the percentage change in the crack leakage versus the change in the input parameter being varied, the sensitivity of the crack leakage to the input variable is represented by the slope of the plot.

The reference conditions being used for this study have been based on the experimental leak rate tests conducted at the Ontario Hydro Technologies. A series of sensitivity analysis has been conducted by varying each of the LEAK-RATE input parameters, while keeping all others constant, and calculating the leak rate for the new condition using LEAK-RATE Version 1.0 code. The results obtained for the reference conditions used here show that the predicted crack leakage is most sensitive to the stagnation pressure, crack shape, crack opening displacement, and the crack length, and least sensitive to entrance geometry and surface roughness of the crack. By using the same reference conditions for the sensitivity analysis of the predicted leak rate to the various input parameters, and analyzing the results in terms of the percentage changes, the sensitivity of the predicted leak rate to the various input variables have been compared.

CNS Applies for Intervenor funding

The CNS Council has submitted an application to the Federal Environmental Assessment Review Office for funding, in the amount of $28,000 as an intervenor in the upcoming hearings on AECL's Deep Geologic Disposal Concept.

The application states that the CNS will develop inputs for each of the three phases of the hearings, respond to questions raised by the Panel, provide independent technical comment on the relevance and completeness of AECL's EIS, and, to the extent practicable, provide comments on the technical validity of other submissions.

IAEA Safety Convention

The Convention on Nuclear Safety, developed by an international group under the auspices of the International Atomic Energy Agency, was signed in Vienna in September by 47 countries.

Canada, represented by Dr. Agnes Bishop, recently appointed president of the Atomic Energy Control Board, was the first country to sign. That honour was at least partially due to the leadership of Zig Domaratski of the AECB in chairing the large international committee that drafted the Convention.

All of the major nuclear power countries have signed, including the Ukraine and the Russian Federation.

The text of the Convention, including the final act and an Annex entitled "some clarification with respect to procedural and financial arrangements, national reports and the conduct of review meetings, envisaged in the Convention on Nuclear Safety," is available from IAEA or its agencies for a price of 400 Austrian schillings.

The convention will come into force when 22 of the signatories have ratified it. This is expected some time in 1995.

Under the Convention countries obligate themselves to maintain high standards of safety for nuclear power plants and to conduct a peer review every three years.

Branch News

Chalk River

Bob Andrews continues as chair. Other members of the '94 / '95 executive are:

vice-chair	Rhonda Cheadle
secretary	Helen Griffiths
treasurer	Suli Adams
program	Aslam Lone
public affairs	Bernie DeAbreu

Darlington

A new branch executive was elected at the general meeting held in June:

chairman	Jacques Plourde
past-chairman	Dan Meraw
vice-chairman	Rick Murphy
treasurer	Mike Dymarski
secretary	Eric Jelinski

In keeping with an objective to build interest in the CNS a program has been planned which combines recruitment efforts and informal gatherings.

To kick off the season a luncheon talk will be held on Wednesday, October 26, with Shayne Smith of Wardrop Engineering speaking on the International Thermonuclear Experimental Reactor (ITER) the next large fusion project.

Other topics planned for the coming season include: long term storage of irradiated fuel in December; update on Cernavoda in February; and nuclear medicine in April.

Golden Horseshoe

Dr. Bill Garland, director of the McMaster research reactor is the new chairman of the Golden Horseshoe Branch.

A successful "careers" night was held September 29 and members have created a computer nuclear information service (see separate articles).

New Brunswick

Dave Reeves has taken on the chair of the New Brunswick Branch for 1994/95 and a full executive of 10 members has been established.

At press time the 1994/95 program was still being developed.

Manitoba

Judy Tamm has taken over the Branch chair from Chuck vanderGraff. Other members of the new executive include Dave Wren (vice-chair), Peter Hayward (sec./treas.), Morgan Brown (publicity).

Last year was an active one with five presentations (some of which were repeated in Winnipeg), a trip to the Winnipeg Health Sciences Centre and participation in the Whiteshell Campus of the Deep River Science Academy.

This year's program includes:

October 3, Keith Dinnie, "Pickering - A Risk Assessment Study"

late October, Ralph Hart, "Options for CANDU 9"

November 10, David Iftody, MP, "Importance of nuclear energy to Canada"

November 29, Robert Nixon, AECL chairman

February 7, Dr. Merv. Billinghurst, "Radiopharmaceuticals in nuclear medicine"

March 8, Jim Johnson, "Manitoba Hazardous Waste Management Facility - Go or no go ?"

late March, Claudio Chuaqui "The Phoebus program at Cadarche, France"

The Branch is assisting in the organization of the 1995 CNS Student Conference which will be held at the University of Manitoba in Winnipeg March 9 to 11, 1995. It is also involved in the CNS conference on deep geologic waste disposal which will be held next year in Winnipeg.

Ottawa

Jeff Lafortune continues as chair of the Ottawa Branch. Three new members of the branch executive are Mohamed Lamari, Rob deWit, and Jiri Slabi.

The first event of the year will be in conjunction with the Canadian Radiation Protection Association with the CNS Ottawa Branch sponsoring a talk by Dr. Paul Unrau on "Evolution, Genetics and Risk Assessment" as part of a CRPA one-day symposium in Ottawa on October 20.

The Branch is participating in a low-level waste management seminar to be held at Carleton University in November.

Pickering

The recently formed Pickering Branch, chaired by Wally Cichowlas, has lined up a full program for this fall.

In September the Branch heard from Pickering director Pierre Charlebois on "Challenges for the Pickering Nuclear Division" and on October 19 Robert Nixon, chairman of AECL, was slated to speak.

On November 23, Dr. Conrad Nagel will provide some insight into another application of nuclear technology when he will give a talk on "Recent developments in nuclear medicine".

All meetings are held in the Pickering Information Centre auditorium at 3:30 p.m.

Quebec

The Quebec Branch has a new secretary-treasurer, Costas Pappas. The former incumbent Raphael Kouyoumdjian resigned when he changed employment.

At the time of writing, the Branch has not finalized its program. Some of the executive are still recovering from the intensive work associated with hosting the CNA/CNS Annual Conference which was held in Montreal last June.

Saskatchewan

David Malcolm is continuing as chair of the Saskatchewan Branch. Secretary Anis Dagher will take on temporarily the added duties of treasurer since Merv Hollingsworth was transferred.

The branch participated in the organization for the W.B. Lewis memorial lecture which was held in Saskatoon, September 16, 1994.

Sheridan Park

A new branch at Sheridan Park was created in July with Roman Sejnoha in the chair.

Although just formed the branch is preparing an active program for the year.

Toronto

The once strong Toronto Branch has fallen on hard times and at the time of writing was not sure of its future. Anyone in the Toronto area concerned about the CNS or nuclear science and technology in general could help by calling Dr. Greg Evans at (416) 978-1821.

Nuclear Operations Division

Recognizing that the needs and interests of operators of nuclear facilities were not being fully met by the existing programs of the CNS a new **Nuclear Operations Division** was created last April.

The new division is co-chaired by Martin Reid, Pickering NGS, and Ernie Aikens, AECL-CRL and has a large executive of 14 representing all of the nuclear generating sites in the country.

As an objective the Division executive has chosen:
"to advance the skills and knowledge of its members in all aspects of nuclear operations through:
- networking to share experience and lessons learned;
- the organization of appropriate conferences and seminars;
- the organization of specialized programs of interest to its members."

The Division has taken on the responsibility for the next CANDU Maintenance Conference which will be held in Toronto in November 1995. It is also considering a seminar for next spring.

CNS members (and others) wishing to be involved with this division are invited to contact either co-chairmen or:
Rick Murphy (Darlington); John Marczak (Pickering); Paul Thompson (Pt.Lepreau); Henri Bordeleau (Gentilly-2); Karel Mika (Bruce).

Officers' Seminar

Over the past several years the CNS Council has held "officers' seminars" in September, intended to give Branch representatives further insight into the operation of the Society and to gain from them ides for the future.

This year's seminar, held at Pickering NGS on September 28, was one of the most successful ones, with 22 Council and Branch members participating. A special feature of the day was a talk by Glenn Litzenberger from the Ginna nuclear power plant near Rochester, N.Y., who described their arrangement of a local group affiliated with the American Nuclear Society. Members of the local group receive information and some support from the ANS but local members (whose fee is only $5 or $10) are not full members of the ANS. The local group concentrates on local programs such as education, public service and social activities.

Litzenberger's talk led to a lively discussion about the pros and cons of a similar arrangement at Canadian nuclear power plants, with an agreement to study the question further.

The format of the day followed a traditional pattern, with presentations by Council members in the morning and a workshop type of discussion in the afternoon. With the afternoon partially taken up with discussion on Litzenberger's talk the gathering went on long after the intended 3:30 closing. Apparently no one minded the "overtime".

A Focus on Women

A special CNS committee "Women in the CNS" was established at the September meeting of the CNS Council to be chaired by Frances Lipsett.

The objectives of the new committee are: to increase the participation of women in the CNS and to work with education and public affairs experts to bring facts of the nuclear industry to women. The latter would be done in conjunction with the international organization Women in Nuclear (WIN).

An initial event of the committee will be a special meeting in Ottawa this fall at which the special speaker will be Dr. Agnes Bishop, recently appointed president of the Atomic Energy Control Board. A WIN event is being planned to coincide with the CNA/CNS Annual Conference in Saskatoon next June.

As Frances Lipsett noted, women tend to be more critical of the nuclear industry than men. However, experience shows that when presented with appropriate information by other women they become more supportive.

Internet and the Canadian Nuclear Listserv

Glenn Harvel

The internet is a rapidly expanding network of computer links. Every day, more and more people encounter the internet through E-mail and special software such as MOSAIC. Every day, more and more nodes, listservers, and software are added to the existing network.

You can find almost anything you want on the internet, from discussion groups on aquariums and environmental issues in central and eastern Europe to photographs of the Jupiter and Levy 9 comet collision. The newcomers to the internet are mostly the young ambitious students you find in universities. Why? University students usually get free access and once hooked on the internet, they are there to stay.

The internet and E-mail communication will definitely play a major role in the communication methods of the future and it is part of our responsibility in the CNS to use these methods to communicate with the public. To fulfill this responsibility, the Golden Horseshoe Branch of the Canadian Nuclear Society has cooperated with McMaster University to set up a Listserv for issues related to Canadian Nuclear Technology.

Our list is called CDN-NUCL-L@mcmaster.ca. The list acts as a forum for discussion on issues related to nuclear energy, nuclear research, and nuclear education. Any nuclear topic is fair game, from current P.R. issues to technical matters, but please make the content of the message clear in each subject heading.

The list is open to members of the nuclear industry, nuclear academia, and the general public. Although a Canadian focus is encouraged, discussion is not restricted to the Canadian nuclear scene. Everyone is welcome to join. You only need an E-mail account with off-site access.

The use of this list is by individuals and the opinions and messages placed on this list are those of the sender and do not necessarily reflect the opinions of any companies or organizations. To this end, the list owner requests that each subscriber include a disclaimer in their signature line if an affiliation is also provided and to restrict their signatures to four lines. Please join and enjoy the discussions on this list and try to keep emotions under control!

To subscribe, send the following command in the body of an E-mail message to LISTPROC@MCMASTER.CA while leaving the subject line blank:

SUBSCRIBE CDN-NUCL-L Yourfirstname Yourlastname

For Example: SUBSCRIBE CDN-NUCL-L Glenn Harvel

You will then be added to the list and will receive a welcome message explaining the basic commands.

For assistance, contact the "listowner":

Glenn Harvel <g8512580@mcmaster.ca>

Golden Horseshoe Branch sponsors Nuclear Career Information Night

Jeremy Whitlock and Glenn Harvel

On September 29 the Golden Horseshoe Branch sponsored an information night on careers in the nuclear industry for students at McMaster University. Representatives from key areas of the industry were invited to make short presentations and take part in a panel discussion. Sixty-six people attended the event in total, and responses were favourable from panel members and attendees alike.

The goal of the evening was to inform students in the engineering and science disciplines of the diverse occupations that apply to the nuclear industry. The initiative came from Leslie Jennings, an undergraduate liaison officer for the Branch, who had raised the issue that many students simply do not know what a degree in nuclear engineering can lead to. Often the "industry" is equated with "Ontario Hydro," with predictable consequences for morale given the well-publicized upheaval that Ontario Hydro is currently experiencing.

Branch Chair Dr. Bill Garland moderated the discussion with five panelists from the Canadian nuclear industry. The speakers were Dr. Stan Hatcher, formerly of AECL and now a private consultant, Dr. Ralph Hart of AECL-CANDU, Dr. George Field representing Ontario Hydro, Mr. Bill Schneider of Babcock and Wilcox International, and Dr. Armando Lopez of Advanced Measurement and Analysis Group, Inc. (AMAG).

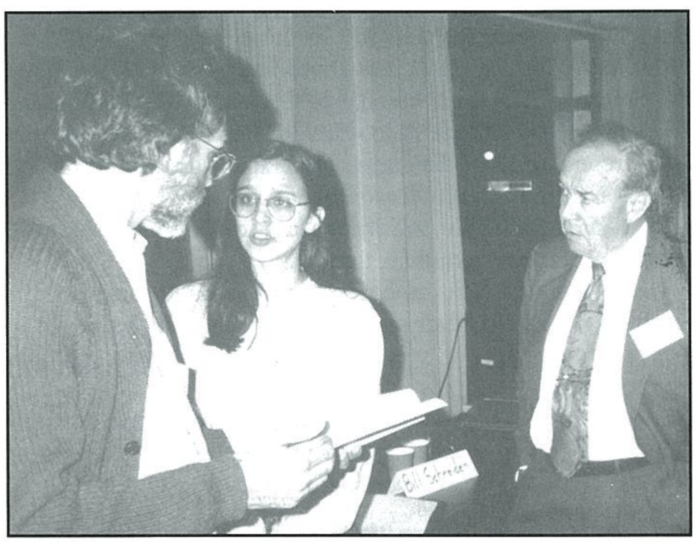
Stan Hatcher provided a vision of the next fifty years of nuclear power including the challenges that await the western world and the third world. He explained that the future demand for nuclear power would be significant and that the employees and students of today would be able to play a major role in the future of nuclear power. Stan finished this talk by summarizing the careers that one finds at AECL Research.

Ralph Hart followed Stan with a brief description of AECL-CANDU's current projects in the Republic of Korea. Ralph described AECL-CANDU from a design perspective and outlined AECL's plans for the CANDU 9 and other advanced concepts.

George Field outlined Ontario Hydro's past, present, and future. George placed emphasis on careers related to the maintenance and life extension of the existing 20 CANDU nuclear reactors Ontario Hydro is operating.

Bill Schneider then discussed the work of Babcock and Wilcox International and his views on careers from the manufacturing perspective. Bill discussed B&W's steam generator work at the Cambridge facility and their international operations in China, Indonesia, India, Turkey, and Mexico.

Armando Lopez discussed life in the small engineering and research companies as well as life after Ontario Hydro. Armando made it very clear in his presentation that nuclear engineers and scientists can go beyond nuclear to work in many fields and fill many niches, especially in small companies as opposed to large companies.



Bill Garland, director of the McMaster research reactor (L) and Stan Hatcher, former president of AECL (R) converse with a student at the CNS Golden Horseshoe Branch's Career Information Night, September 29.

Bill Garland then closed the panel presentation with a summary and made connections to the non-power sectors of the industry, such as medical isotope technology, radiation processing, and advanced detection tools.

At the end the floor was opened to questions, which centred on realistic appraisals of future opportunities and the level of education most suitable for advancement in a nuclear related career. Some members of the audience challenged the forecasts made by the panel, specifically the future demand for nuclear power in the third world, the career opportunities at Ontario Hydro, and the current prospects of the CANDU-3 design work. The informal discussions between the students, other audience members, and the panel were lively.

Each individual drew his own conclusions from the event, although in general it was agreed that pursuit of either a PhD degree or an MBA degree was a useful addition to the bachelor degree. Another general conclusion was that although Ontario Hydro and AECL are currently not interested in new employees, this may change in the future and that even so, a career in nuclear was definitely still viable.

This evening was the first of its kind and its successful reception is a clear indication of the need for this kind of focused information event. The profile of both the nuclear industry and the CNS was raised among students, and many valuable contacts were made that would not otherwise have been possible. The organizing team, Jeremy Whitlock and Glenn Harvel, would like to thank the five panel guests and Bill Garland for their participation, as well as those who assisted invaluably behind the scenes: Rob Leger, Leslie Jennings, and Wayne Seto.

Anyone interested in the organization details or a list of interested students who attended is welcome to contact the Branch for a copy of the official report on the event: Bill Garland (Chair), McMaster Nuclear Reactor, McMaster University, Hamilton, ON L8S 4K1, (905) 525-9140 ext 23278.

CNS issues news release on Pickering 7

Ed. Note: *Following is the text of a "News Release" issued by the executive of the CNS on October 7. The Council took the precedent-setting decision to issue a news release to try to achieve some media recognition of this record-setting performance.*

Engineers and scientists of the Canadian Nuclear Society congratulated Ontario Hydro for the record-breaking performance of reactor unit 7 at the Pickering Nuclear Generating Station, which will be shut down today for scheduled maintenance, after **894 days** of continuous power production. Last April, Pickering-7 surpassed the previous world record of 713 days, held by Oldbury, Unit 1 in the United Kingdom.

"Continuous operation of a facility for 894 days (about 2.4 years) is a fantastic achievement in any industry," said Ed Price, President of the Canadian Nuclear Society. "It is even more impressive when one considers that inspection and maintenance of equipment inside the reactor building is limited by the reduced accessibility during plant operation."

Mr. Price stated today that the staff at Pickering NGS are to be congratulated for achieving this outstanding record, without sacrificing safety standards. "It speaks well for the high quality of the operating and maintenance staff. All Canadians should be proud of this highly significant technical achievement."

The Canadian Nuclear Society also recognizes the efforts of the design teams that created the "Pickering B" design in the mid-1970s in the offices of Atomic Energy of Canada Limited and Ontario Hydro, and the work of the manufacturing and construction teams that supplied and installed the equipment in the early 1980s. (Unit 7 entered service in January 1985.)

Mr. Price indicated that this new world record is one more indication of the effectiveness of the CANDU reactor design. In a listing of the 441 power reactors around the world, the CANDU reactor at Point Lepreau in New Brunswick is number one in terms of lifetime performance, while Pickering-7 is ranked fourth and Pickering-8 is ranked eighth. The CANDU reactor at Wolsong in South Korea recorded the best performance in the world in 1993, with a capacity of 100.8 per cent.

Mr. Price noted, "It is unfortunate that most Canadians are unaware of the world-beating performance of the CANDU line of reactors, as well as their exemplary safety record."

International Containment Conference

As this issue of the CNS *Bulletin* is going to press a very successful CNS sponsored **3rd International Containment Conference** has just completed its three-day gathering in Toronto, October 19-21.

With almost 250 delegates, many of whom were from other countries, and 83 papers in 13 presentation sessions, with another 24 papers in the poster session, chairman Duane Pendergast and his committee were justifiably pleased.

As well as the technical sessions there were two luncheons with excellent speakrs from Ontario Hydro, a dinner, and a night out at the theatre. An accompanying small exhibition provided a focus for discussions between sessions.

From all accounts it was a very well organized, well run meeting.

The CNS *Bulletin* intends to run a full account of the conference along with some of the plenary papers in the next issue.

News of Members

Roxanne Summers, former vice-president of communications at the CNA, has moved to the United States where she is with the USNRC associated with the Advisory Committee on Reactor Safeguards.

Egon Frech, who had been involved for several years in the nuclear waste management public affairs programs, has left his post as manager, corporate communications with AECL and opened a consulting firm in Washington, DC.

OEB applauds OHN

Ric Fluke

On August 31, 1994, the Ontario Energy Board issued its report on Ontario Hydro's Restructuring and Proposed Electricity Rates for 1995 in which it rejects Hydro's proposed 1.4% rate increase, recommending instead that the overall average rate remain unchanged for 1995.

This is not surprising since rates had already sky-rocketed by 31% between 1991 and 1993, halted only by a major corporate restructuring. The result was a zero rate increase for 1994 and a long term commitment by Hydro to hold rates at

(continued on page 40)

The CNS Education and Public Affairs Program

Aslam Lone

The **Education and Public Affairs Committee (EPAC)** of the CNS was established to facilitate exchange of information pertaining to nuclear-related issues amongst CNS members and the general public, and to develop and administer educational and public information programs in this regard. A key objective of the Committee is to encourage CNS members to be proactive and become involved in speaking out and writing on nuclear issues and to participate in education and public information programs.

The EPAC activities are funded from two sources.

First there is the annual interest earned on the capital of the Education Fund jointly established by CNA and CNS. This Fund was established at the 1987 CNA/CNS Annual Conference in New Brunswick when it was decided that $10,000 from the conference profits would be allocated to a special account, from which the accumulated interest could be used by the local branch for the purpose of education. Similar amounts were allocated from the surplus of each of the Annual Conferences until 1991. As of June 1994 there was $48,000 in the Fund.

The second source of revenue is an annual budget allocation of CNS Council for EPAC programs.

CNA/CNS Education Fund

In 1992 the administration of the Education Fund was delegated to the newly established CNS Committee on Education and Public Affairs. In 1993 the Council requested that a separate accounting be kept of the Education Fund and instructed the Education and Public Affairs committee to prepare a CNS Policy Statement on the administration of the Education Fund. CNS Council has approved the following guidelines for education programs.

Objective

The program should promote energy-related science and technology for a greater understanding of:

- energy choices for the benefit of our environment,
- direct benefits of energy-related nuclear technologies to medicine
- non-energy related industrial applications of nuclear technology
- job prospects for science and technology students in Canada

Scope

The maximum annual cost of the program should not exceed $1000 per branch. CNS Branches are encouraged to develop education and public information programs for approval by the CNS Council on the recommendation of the Education and Public Affairs Committee.

Programs

The types of programs branches could establish can include, but are not limited to:

- student grants at an established educational institution.
- awards for science and technology related competitions.

The program may be continuous but should be submitted for review and approval every year. Official and prominent recognition of CNS and CNA as sponsoring organizations should be given. The CNS and the CNA shall have right to use, *e.g.* publish, material produced as part of the program.

Funds

Requests for funds should be submitted to the Education and Public Affairs Committee preferably by September 1 of each year. Later submissions may be considered if funds are still available.

In 1994 allocations have been made to the Chalk River, Manitoba, Saskatchewan, Toronto and Ottawa branches for a total of $4800.

- The Chalk River Branch is collaborating with high schools in setting up science experiments for students. The Branch has contributed $500 towards the purchase of a dual-beam oscilloscope for Fellow High School in Pembroke. For curriculum development the Branch is helping EPAC in acquiring materials for teacher's resource kits. The CR Branch is sponsoring the Deep River Campus of the Deep River Science Academy (DRSA) and the Science for Educators Program of AECL.
- The Manitoba Branch supported the Whiteshell Campus of DRSA with a bursary assistance of $1000.
- The Saskatchewan Branch provides watches with CNS logo for prizes at eleven provincial science fairs. The watches are awarded by school principals that the winning students attend.
- The Toronto Branch sponsors speakers honoraria in the form of $100 awards to Canadian high schools. Each year, a nuclear facility tour for University of Toronto students is also sponsored.
- The Ottawa Branch organized a tour of Chalk River Laboratories for Ottawa area students and supported the regional Science Fair.

EPAC is establishing a resource centre and training program to help teachers and local branches in organizing tutorials and demonstrations on Ionizing Radiation, Nuclear Technology, and Nuclear Waste Management.

The Committee sponsored two sessions on "Hands-on Experiments With Ionizing Radiation" at the 19th Annual Science for Educators Seminar held at Chalk River Laboratories on 1994 April 14-16. A total of 112 teachers from all over Canada attended the seminar and about 50 participated in the workshop.

The EPAC in partnership with the Curriculum Department of Renfrew County Board of Education is arranging a workshop on its October 21, 1994, Professional Development day for training on the use of EPAC's Teacher's resource kits. Material from these kits were loaned for use by AECL CANDU's Atlantic Region Public Information Program.

The current inventory of the Teacher's Resource Centre includes:

Video Library

1 Radiation Reality and Myth (US DOE 20 m)
2 Radiation and Environment (AECB 21 m)
3 Biological Effects of Ionizing Radiation (ANS 30 m)
4 Canadian Nuclear Associations Food Irradiation (CNA 23 m)
5 Cocaine and Brain (12 m)
6 How Safe is Enough (P.J. Spratt & Associates Inc/AECL 17 m)
7 The Benefit to Society of Activities which Produce low-level Radioactive Waste (20m)
8 Management of Nuclear Waste (US DOE 80 m)
9 Energy a First Look (AECL)
10 Are We Scaring Ourselves to Death (ABC)

Laboratory Demonstration Kits

1 Cloud Chamber and associated kits for visual demonstration of radiation tracks
2 Smoke detector kits to demonstrate application of ionizing radiation
3 Digital Geiger radiation monitor for demonstration of radioactivity
4 PC based Geiger radiation monitor for laboratory experiments
5 ^{137}Cs-^{137}Ba radioactive source generator for demonstration of 3 min half-life of ^{137}Ba

Teaching Aid Literature

1 Energy Matters . A series of teaching aid for grades 9-11 (AECL)
2 1993-1994 Edition of Catalogue of Audio-Visual Lending Library (ANS)
3 Nuclear Chronicle Poser (ANS)
4 Four unit set on Science, Society, and America's Nuclear Waste (DOE)
5 RAYS – Radiation Activities for Youth Series (Pennsylvania State University)
6 EOS NASA's Earth Observing System (NASA)

Further initiatives of EPAC are:

- establishment of a CNS Writers Club to respond to press articles on nuclear issues;
- compilation of a reference list of individuals to serve as media sources on nuclear issues;
- a reference list of speakers on nuclear technology;
- establishment of an Internet (MOSAIC) Nuclear Facts; and,
- training of teachers on the use of teacher's resource kits and Internet data bases on Nuclear Technology Information.

The EPA Committee members (1994/95) are:
Chair: Aslam Lone; Fred Boyd, Jerry Cuttler, Mary Fehrenbach, Leslie Gosselin, Glen Harvel, Hong Huynh, Bill Kupferschmidt, Frances Lipsett, David Malcolm, Kristin Platter, Shayne Smith.

For further information, comments, suggestion for new initiatives, and for loan of resource kit items contact Aslam Lone (phone 613-584-3311-ext. 4007, fax 613-584-1849, EMAIL LONEA@CRL.AECL.CA).

Student Conference

The **1995 CNS Student Conference** will be held in Winnipeg at the University of Manitoba, March 9-11, 1995.

Darryl Dormuth, of AECL's Whiteshell Laboratory is assisting in the organization of the conference on behalf of the CNS Manitoba Branch, and would welcome suggestions, expressions of interest, offers of help, etc.

Call him at 204-753-2311.

Miscellany

Nobel Prize for physics shared by Canadian AECL physicist

The *CNS Bulletin* joins with other Canadians in saluting Dr. Bertram Brockhouse on his award, with Dr. Clifford Shull, of MIT, of the 1994 Nobel prize for physics.

The two won the prize for pioneering work conducted more than 30 years ago, using neutron beams to study the properties of solids and liquids. The citation read: "For pioneering contributions to the development of neutron scattering techniques for studies of condensed matter." "In simple terms, Shull has helped answer the question of where atoms 'are' and Brockhouse the question of what atoms 'do'", the announcement from the Royal Swedish Academy said.

Brockhouse, now physics professor emeritus (retired) from McMaster University, was at the Chalk River Laboratories (NRC's Atomic Energy Project as it was called then) from 1950 to 1962 and conducted the prize-winning research at that time.

According to associates of the time Brockhouse virtually single-handedly developed the triple axis spectrometer. the most powerful instrument for thermal neutron inelastic scattering measurement. It is now in use at every major neutron laboratory in the world.

Dr. Brockhouse also produced the first convincing evidence that well-defined phonons occur in metals and analogous excitations occur in magnetic materials. Work in this area is still being pursued at CRL.

Noting that this is the first Nobel prize for physics for work done in Canada, AECL president Reid Morden congratulated Dr. Brockhouse, and commented that AECL was proud that he worked at Chalk River Laboratories when he developed the neutron scattering technique.

Incident at McMaster Nuclear Reactor

by Jeremy Whitlock and Bill Garland
CNS Golden Horseshoe Branch

An error in judgement and a violation of certain safety procedures during a routine refueling operation at the McMaster Nuclear Reactor (MNR) in January of this year caused a power excursion that peaked at about 6.3 MWth, or about three times the operating power level. The excursion was terminated by the automatic shutdown system, which tripped when the power level reached 2.5 MWth. The shutoff rods began their drop less than 25 msec after the trip initiation, and were fully inserted by about 0.5 seconds. The total energy produced has been estimated at about 0.7 MWth-seconds. There were no health consequences from the incident, and no fuel damage is expected. However, the incident sparked an administrative and regulatory review that will continue for months ahead. Additionally, media coverage of the event exaggerated some of the facts of the incident.

MNR, which marked its 35th anniversary in April 1994 (CNS *Bulletin*, vol. 15, no. 1), is a pool-type research reactor at McMaster University in Hamilton, Ontario. It is used for neutron experiments, radiography, activation, and isotope production, as well as being a teaching tool for the university. Immediately following the incident in January MNR staff reported the occurrence to the AECB, as required by the operating licence. McMaster administration was not informed, however, and learned of the incident for the first time when the media was alerted to the story by an official AECB follow-up in June, five months later.

Unfortunately, in the flurry of media coverage that followed certain misrepresentations of the event received widespread attention. The two most significant of these were: (1) that MNR staff "covered up" the incident, and (2) that a "near nuclear disaster" had taken place. The first misrepresentation stems from the focus of the MNR staff on reporting to the AECB, and its disregard for the importance of reporting internally – a situation that has received the most attention in the internal review that followed. The staff perception was that the proper procedure (i.e. the licence requirement) had been followed, and that the positive outcome of the incident did not warrant further action. The second misrepresentation stems partially from a statement by an AECB board member, taken out of context, that MNR staff could have been "scraping [their reactor] off the walls." Even if the automatic shut-down had not tripped, the highly negative feedback properties of this type of reactor would have terminated the power rise. The core sits in about 400,000 litres of pool water surrounded by a negative-pressure concrete containment building, and therefore any evolved steam from the pool of radionuclides from damaged fuel would not have posed a danger to the public.

Dr. Geraldine Kenney-Wallace, president of McMaster University, convened an investigative committee that made several recommendations which the university is instituting, including:

- revising the procedure of incident reporting
- disciplinary action and management changes
- putting greater emphasis on safety culture
- reviewing and reviving administrative policies
- revising detailed operating policies and procedures
- emphasizing the importance of training in human factors and reactor safety
- initiating an extensive technical review

The current operating licence is due for renewal in December 1994.

OEB applauds OHN

continued from page 33

or below inflation for the remainder of this decade. Needless to say, the OEB and major customer groups such as AMPCO argue that Hydro needs to take further actions to reduce costs, retire its debt and thereby reduce electricity rates.

In past hearings, the OEB blasted the nuclear programme for its poor performance, high cost and low capacity factors. However, since the restructuring and creation of OHN, this has changed. The OEB has recognised the efforts and their results, and are encouraged by this turn-around in nuclear performance. To quote the OEB,

> "The restructuring of Hydro's organisation, financial affairs, corporate objectives and priorities is a solid step in the right direction," and
>
> "The Board is impressed by the progress OHN has made in resolving its technical problems and is encouraged by its latest operating and financial performance."

Most of their recommendations affecting OHN are for further study rather than any significant departure from current plans.

For example, (Recommendation 4.6) the Board recommends that Bruce A Unit 1 be made the subject of a special review by Hydro's Depreciation Review Committee, and that the Committee's recommendations regarding depreciation and provisions for decommissioning related to this facility be filed in the next Hydro hearing. In other recommendations, the Board wants to be kept informed about the profitability of heavy water sales (4.13), and they want the Bruce Heavy Water Plant to pay the same electricity rates as do external customers (7.8). They also want other alternatives to be studied in conjunction with any review of rehabilitation of Bruce A Unit 2 (7.7).

Recognising the turn-around in nuclear performance and the key issue of costs (i.e. "price-drives-costs"), the Board made several references to "benchmarking" in OHN. [Note: Benchmarking is the new-wave speak for comparing one's activities with those of the best, looking for ways to improve business processes.] OHN has initiated benchmarking programmes and the Board is supportive of this, but feels that much more effort is needed. Hence, their recommendation (7.11) to file a report on OHN's progress in establishing benchmarks for its activities. However, although cost is a key issue, reliability and performance is also an issue. In recommendation 7.13, they want OHN to critically examine their expenditures on services to ensure that they can make available sufficient resources for maintenance programmes.

Perhaps the Board's bottom line is best expressed by their comment, "The Board expects that Hydro's senior management will ensure, in its business planning process, that OHN is providing sufficient resources for maintenance programs, recognizing that nuclear performance is a key factor in achieving Hydro's goals.".

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Calendar

1994

November 12-13 — **2nd Workshop on Safety of Soviet-Designed Nuclear Power Plants**
Washington, DC
contact: Dr. David J. Diamond
Brookhaven National Laboratory
Upton, NY, USA
Fax: 516-282-5730
E.Mail – diamond@bnl.gov

November 13-17 — **ANS Winter Meeting**
Washington, DC
contact: American Nuclear Society
La Grange, Illinois
Tel: 708-352-6611
Fax: 708-352-6464

November 16-18 — **CANDU Safety Course**
Toronto, Ontario
contact: Lou Fernandes
OH Darlington
Tel: 905-623-6670 Ext. 7889

1995

March 9-11 — **CNA/CNS Student Conference**
Winnipeg, Manitoba
contact: Sylvie Caron
CNA/CNS office
Toronto, Ontario
Tel.: 416-977-6152 xt18
Fax: 416-979-8356

April 24-28 — **Safety Culture in Nuclear Installations**
Vienna, Austria
contact: Ms. A. Carnino
c/o IAEA - NENS
Vienna, Austria
FAX 43-1-334-564

May 8-12 — **Two-phase Flow and Heat Transfer Course**
Hamilton, Ontario
contact: Prof. M. Shoukri
McMaster University
Hamilton, Ont.
Tel. 905-525-9140 Ext. 24881

May 7-12 — **International Conference on Isotopes**
Beijing, China
contact: Prof. Lin Qiongfang
Chinese Nuclear Society
P.O. Box 275-12
Beijing, China, 102413
Fax: 86-1-935-7195

May 16-18 — **Annual Meeting on Nuclear Technology**
Nuremburg, Germany
contact: Dr. K.G. Bauer
INFORUM GMBH
Bonn, Germany
Tel.: 49-02-28-507-0
Fax: 49-02-28-5072-19

May 23-26 — **Mass Transfer in Severe Reactor Accidents**
Cesme, Turkey
contact: Dr. J.T. Rogers
Carleton University
Ottawa, Ontario
Tel: 613-788-5692
Fax: 613-788-5715

May 28-June 3 — **5th Topical Meeting on Tritium Technology in Fission, Fusion and Isotopic Applications**
Ispra, Italy
contact: Dr. H. Dworshak
Joint Research Centre,
Ispra, Italy
Fax: 39-332-789-108

May 29-31 — **Topical Meeting: Managing Plant Life**
Nice, France
contact: Dr. Serge Charbonneau
Paris, France
FAX 33-1-47.96-01-02

June ??? — **Workshop on Management and Operation of Nuclear Power Stations Using Digital Computers**
Fredericton, New Brunswick
contact: Roger McKenzie
Maritime Nuclear Ltd.
Fredericton, N.B.
FAX 506-453-1356

June 4-7 — **CNA/CNS Annual Conference**
Saskatoon, Saskatchewan
contact: Sylvie Caron
CNA/CNS office
Toronto, Ontario
Tel.: 416-977-6152 xt18
Fax: 416-979-8356

September 10-15 — **NURETH-7 — International Meeting on Nuclear Reactor Thermalhydraulics**
Saratoga, NY
contact: Dr. Michael Z. Podowski
Rensselaer University,
Troy, NY,
Tel.: 518-276-6403
Fax: 518-276-4832

September 17-23 — **International Topical Conference on the Safety of Operating Reactors**
Seattle, WA
contact: Dr. D.J. Senor
ANS, Richland, WA
Tel.: 509-376-5610

September 25-29 — **GLOBAL '95, on the Back End of the Nuclear Fuel Cycle**
Versailles, France
contact: Dr. J. Y. Barre
CEA, Saclay Gif-Sur-Yvette, France
FAX (33.1). 69.08.90.93

October 1-4 — **Fourth International Conference on CANDU Fuel**
Pembroke, ON
contact: Dr. Peter Boczar
Chalk River Laboratories
Tel.: 613-584-3311

November 20-21 — **3rd Conference on CANDU Maintenance**
Toronto, ON
contact: Mr. Tim Andreef
Ontario Hydro
Tel.: 416-592-3217
Fax: 416-592-7111

1996

March 25-29 — **Nuclear Industry Exhibition**
Beijing, China
contact: Xu Honggui
Chinese Nuclear Society
Beijing, China
FAX 86-1-852-7188

April ?? — **Conference on CANDU Fuel Handling**
location TBA
contact: Ron Mansfield
Mississauga, ON
Tel. 905-823-2624

September ?? — **Deep Geologic Disposal of Radioactive Waste**
Winnipeg, Manitoba
contact: C. Vandergraaf
AECL Research,
WL Pinawa, Manitoba
Tel. 204-753-2311 Ext. 2592.

Waste disposal reports issued

AECL Research has now issued all nine "background" reports to support its application for approval of the deep geologic disposal concept for spent nuclear fuel. Distributed in September was the report on "The Disposal of Canada's Nuclear Fuel Waste: Public Involvement and Social Aspects".

AECL is scheduled to submit an Environmental Impact Statement to the Environmental Assessment Panel established under the Federal Environmental Assessment and Review Program by the end of the 1994. An EIS summary will be issued at the same time. Augmenting that submission are nine "primary reference" documents, all with the initial title "the disposal of Canada's Nuclear Fuel Waste:

- Public Involvement and Social Aspects (just issued)
- Site Screening and site Evaluation Technology
- Engineered Barriers Alternatives
- Engineering for a Disposal Facility
- Preclosure Assessment of a Conceptual System
- Postclosure Assessment of a Reference System
- The Vault Model for postclosure Assessment
- The Geosphere Model for Postclosure Assessment
- the Biosphere Model, BIOTRAC, for Postclosure Assessment

Each of these "primary reference" documents is a detailed, technical report ranging in size from about 250 to over 500 pages. they are being reviewed by a Scientific Review Group appointed by the Environmental Assessment Panel. The Panel was established in 1989 when the concept was referred to EARP.

Following receipt of the EIS the Panel will take about nine months to review it. If the Panel is satisfied with the adequacy of the submission it will conduct public hearings. Those hearings are proposed to be divided into three phases: (10 broad societal issues; (2) general and technical issues; (3) alternatives, criteria, etc.

Copies of the background reports are available from AECL Research, Whiteshell Laboratories while the EIS and summary will be available from the Federal Environmental Assessment Review Office.

Bruce "A" Relicensing

On June 23, 1994, the Atomic Energy Control Board granted renewal of the Operating Licence for the Bruce "A" NGS for a period of two years. The new licence will run until June 30, 1996.

This was great news for staff at Bruce A and throughout OHN. They had worked hard over the past year to remove uncertainties surrounding pressure tubes and steam generators, as well as to make many other improvements since their last licence application.

In recent years, licence renewals at Bruce A had been limited to a one-year term or less, a clear message that the AECB was not pleased with performance at the station. The two year licence is an acknowledgement by the AECB of the efforts put forth by OHN to improve performance.

The new licence does have a special clause that requires Unit 2 to be maintained in a safe, approved shutdown state after its stated shutdown September 1, 1995.

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