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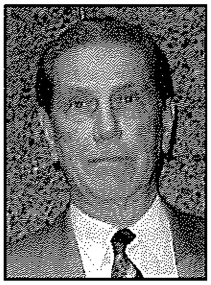
- Wolsong PSA
- New Fuel for Bruce
- CNA Seminar
- Progress at OPG
- Challenges for Regulator

EDITORIAL

Different Perspectives



Attendance at two events, reported in this issue, provides the background for the following comments.

The first was the *CNS Workshop on Ageing* (of heat transport systems in CANDU reactors, not of we mortals). Those attending had strong technical backgrounds, were keenly interested and involved in their work, and participated actively in the sessions of the Workshop. They represented, to us, the strength of our nuclear power program. It was impossible to come away from that exercise having any doubt that the problems associated with feeders, fuel channels and steam generators (the three specific subjects of the Workshop) will be solved - if those directly involved are given the support and means to do so.

Further, despite their concentration on the immediate problems before them (often, apparently, to the detriment of their personal life), most of the participants seemed to have a reasonably sound perspective of our nuclear industry as a whole.

The other event was the Canadian Nuclear Association's *Nuclear Industry Seminar 2005*. This attracted over five times as many delegates at the Workshop above but the participation was markedly different. The involvement of the audience at the Seminar was dismally poor, possibly partially due to the different format and objective. Only a handful of people asked questions of the presenters and few of those were penetrating. With many delegates coming from various government departments and embassies, a substantial number of the delegates may have had only a peripheral connection with our nuclear program.

The lack of open participation may have also been due partially to the superficiality of some of the presentations. Few provided any substantial information. A couple, such as those from AREVA and AECL, could be put into the category of marketing. Despite the AREVA chairman's pointed comment about a European Nuclear Reactor being built in Ontario no one questioned it. Nor, after AECL's president extolled the virtues of his company, did anyone ask about the omission of any mention of the MAPLE project. (Perhaps that is a forbidden subject.)

There were, however, long coffee breaks that provided time for conversation and an opportunity to learn about the products and services of the various companies and organizations that had displays.

We are probably biased, but these two experiences reinforce our belief that the future of our ongoing nuclear power program lies largely with those who are actively and directly maintaining and improving the performance of our existing plants. As has been said by many, and has been demonstrated in the USA, the best way to obtain public acceptance of nuclear power is to have the current plants run very well. If there is intelligent management those on the front line can deliver that goal.

Fred Boyd

IN THIS ISSUE

Much of this issue is drawn from two quite different events held over the past month. One was the *CNS Workshop on CANDU Life Cycle Management*; the other the recent *2005 Nuclear Industry Seminar 2005*. But we also have two more papers from last fall's Simulation Conference.

Up first is our report on the workshop mentioned above, under the title **First CNS Workshop Proves Successful**. That is followed by a report from Korea closely linked to the specific topic of the workshop, *Ageing Management of Heat Transport Systems of CANDU Nuclear Power Plants*, titled **Periodic Safety Review for Wolsong Unit 1**. (Unfortunately, the nature of the Workshop precluded the preparation of papers.)

Then follow two papers from the *6th International Conference on Simulation Methods in Nuclear Engineering*, which was held in Montreal last October. The first was one of the plenary presentations, **Implementation of Low Void Reactivity Fuel in Bruce B**. The second one is **Evaluation of Safety Margins During Storage of CANDU Fuel in MACSTOR / KN 400 Modules**.

Our report, **CNA Nuclear Industry Seminar 2005**, reflects the quite different nature of that event from the Workshop above. It is followed by two of the presentations given, the first that from Linda Keen, president of the Canadian Nuclear Safety Commission, entitled **Canada's Changing Nuclear environment - the Challenges Ahead for Canada's Nuclear Regulator**. That is accompanied by the perspective of Jake Epp, chairman of Ontario Power Generation, which we have titled **OPG Chairman Reports on Nuclear Progress**.

There is a short report on the second annual meeting of **Women In Nuclear Canada**, which was held just prior to the CNA Seminar.

General News follows; with our usual eclectic choice of news items that we hope will be of some interest, and then the **Obituaries**.

The **CNS News** section is expanded thanks to Associate Editor, Bryan White.

And then there is Jeremy Whitlock's satirical comment in **Endpoint**.

Again we hope you find something of interest and welcome your feedback.

Contents

Cover Photo

The photograph on the cover shows the simulator for the twin CANDU units at the Qinshan site in China. It is courtesy of L-3 MAPP, the successor company to CAE that designed and built the simulator.

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First CNS Workshop proves successful

Workshop on CANDU Life Cycle Management focuses on HTS Ageing

The first "workshop" organized by the Canadian Nuclear Society proved to be very successful. The CNS has held and continues to hold many conferences, symposia, and courses, but the **Workshop on CANDU Life Cycle Management**, held in Oshawa, Ontario, February 21 and 22, 2005, was the first of that format.

About 90 people (a dozen or so from overseas) assembled at the Holiday Inn in Oshawa to compare notes on **Ageing Management of Heat Transport Systems of CANDU nuclear power plants**, the first chosen subject of a proposed series of workshops on CANDU Life Cycle Management. Original plans were to hold the workshop at the Darlington station, about 20 km east, which would have limited numbers to 60, but a number of factors precluded the use of that venue.

Although the title referred to the heat transport system the Workshop focussed on three major components; fuel channels; feeders; steam generators.

The format involved four short presentations at the beginning of the first morning followed by six "breakout" sessions. After lunch there were two more presentations and a further four "breakout" sessions followed by a dinner.

The second day began with reports from the "breakout" sessions, each of which elicited further discussion. Closing the Workshop were two presentations, one providing a look forward on Life Cycle Management of other components, the second an overview of the relevant work of the CANDU Owners Group (COG).

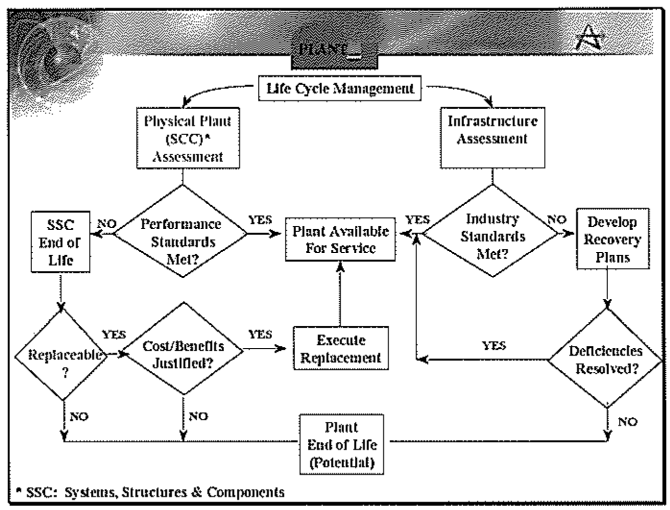
Prabhu Kundurpi, the principal organizer of the Workshop, greeted the delegates and then invited **Bill Schneider**, CNS president and a very recent retiree from Babcock and Wilcox Canada, to formally open the Workshop. Schneider brought greetings from the Society and noted the intention to hold further ones. **Brian Duncan**, Director of Operations at Darlington, added his welcome and emphasized the importance of the topics to be discussed. Feeders may be the limiting component of current CANDU reactors, he commented.

OVERVIEW

Jim Nickerson, of Atomic Energy of Canada Limited, opened the session with an overview of Life Cycle Management (LCM), which he also referred to as Plant Life Management (PliM). He gave three descriptions of LCM:

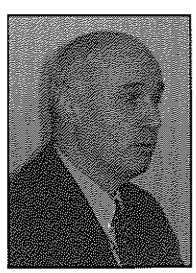
- engineering, operations and maintenance actions to control within acceptable limits, ageing degradation and wear of systems, structures and components (SCCs).
- a structured and comprehensive ageing managment program to assist in ensuring physical asset life targets are met and that signidficant ageing effects are detected as early as possible and mitigated
- the integration of ageing and economic planning to optimize the operation, maintenance and service life of SCCs, maintain an acceptable level of performance and safety, maximize return on investment over the service life of the plant.

He presented the following chart to illustrate the concept.



We can't stop ageing, he said, but, if we understand it, we can manage it gracefully and predictably (and then commented that people and organizations also age).

An organized approach is needed, he said, since some ageing issues may be overlooked. A proactive approach rather reactive should be followed, he argued, and many groups need to be involved, including operations, maintenance, and engineering. The role of AECL, he said is to provide services, such as retubing, and develop new designs.



Regulatory position

A view from the regulator was provided by **Andrei Blahoianu**, of the Canadian Nuclear Safety Commission, who titled his presentation, "Canadian Regulatory Approach Towards Ageing Management Programs and Critical Component Condition Monitoring and Evaluation".

During earlier operating years, Canadian CANDU plants operated with good capacity factors, he noted, but, as plants aged, degradation mechanisms that were not previously identified began to have an effect.

For the fuel channels, he noted that pressure tubes had experienced creep, delayed hydride cracking, and property changes that could lead to failure and subsequent inadequate fuel cooling and impairment of SDS 2. That leads to requirements for inspection, leak detection, chemistry control and monitoring.

Regarding feeders he cited stress corrosion cracking, low temperature creep cracking and other phenomenon that could lead to failure of feeder piping and resulting primary coolant leaks. More chemistry control, chemical inhibitors and inspection is needed and, if necessary, repairs or replacement.

Steam generators can experience corrosion, erosion and wear which could lead to tube leaking or rupture and the possible release of primary coolant. Chemistry control, primary side cleaning, anti-vibration supports are needed.

In response to the discovery of these degradation mechanisms, CNSC staff made use of the *"regulation-by-feedback"* model. This process is primarily reactive, responding to in-service inspection results and in-service failures. Because the regulation-by-feedback process was developed on a case-by-case basis for certain systems it lacks a systematic, proactive, and comprehensive approach. As a result, CNSC initiated a generic action item (GAI) to address the concerns. That GAI, "Assurance of Continuing Nuclear Station Safety", required licensees to demonstrate that:

- potentially detrimental changes in plant condition are identified & addressed;
- ageing-relate programs are integrated;
- steady-state and dynamic analyses remain valid;
- reviews of component ageing are being conducted;
- reliability assessments remain valid; and,
- planned maintenance programs are sufficient to ensure safe operation of the plant.

Licensees responded by developing programs based on guidelines from the International Atomic Energy Agency that cover ageing management of special safety and safety-related systems. Based on the submissions from licensees the CNSC closed the generic action item in 2003. Effectiveness of the programs will be monitored through the CNSC ongoing compliance program.

Age related regulatory requirements are also included in a several regulatory documents, e.g.

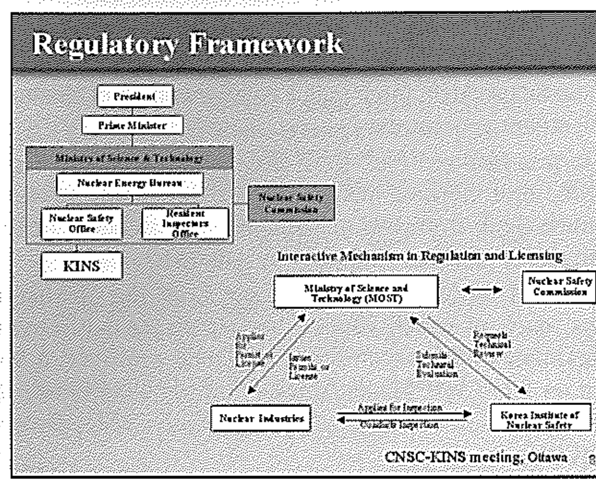
- Class I Nuclear Facilities Regulations
- Regulatory documents R-7, R-8, R-9
- S-98, Reliability Programs for NPPs
- specific Power Reactor Licence Conditions, e.g. 5.2 and 7.1

Because the lack of explicit regulatory requirements hampers effective regulatory oversight of ageing management programs, he said CNSC staff are planning to develop a regulatory standard outlining requirements for such programs. In addition CNSC staff foresee the need for further development in the areas of risk-informed operation, using probabilistic tools for condition assessments and condition monitoring.

Korean perspective

Dr. Seong Kim, from the Korea Institute for Nuclear Safety (KINS), began with an overview of the nuclear power program in Korea, noting the remarkable growth since the first commercial operation of Kori Unit 1 in 1978. Korea has now 20 operating nuclear power units: 16 PWRs and 4 PHWRs with a total licensed output of 18,716Mwe, which is 33% of the generation capacity of the country. Six PWRS are currently under construction and 28 units are planned to be in operation by 2015.

He then described the Korean regulatory system. The Ministry of Science and Technology (MOST) is the regulatory authority. It develops regulatory policy and makes rules. Reporting to MOST is the nine member Nuclear Safety Commission (NSC) whose principal function is decision-making on major nuclear issues. The Korea Institute of Nuclear Safety (KINS) is a regulatory expert organization



that provides technical support to MOST.

His spoke specifically on Periodic Safety Reviews. *(He referred to, and made available, the report on the Periodic Safety Review of Wolsong 1 conducted in 2003, which is reprinted in this issue of the* CNS Bulletin.)

Noting that PSRs are required under the international Nuclear Safety Convention, MOST issued guidelines in 2000. KHNP, the operator, submitted a PSR plan for Wolsong 1 in 2001 using 11 safety factors identified in the IAEA guide. the regulators added three additional topics: plant design; PSA; external hazard analysis. The PSR report for Wolsong 1 was submitted in 2003. The regulators accepted the licensee's self-assessment but identified 27 safety requirements, 24 of which were to be fulfilled by the licensee on a voluntary basis. The other three were:

- need for an integrated managment program for pressure tube ageing
- need for a management program for feeders
- need for a quantitative reanalysis of postulated accidents.

Dr. Kim closed by commenting that KINS is studying the application of PSR to plant life management.

The Workshop then broke into six "breakout" sessions where delegates compared notes on the topic of their choice. The six sessions were:

- fuel channel life cycle management
- feeder life cycle management
- chemistry control
- PHT activity and magnetite transport and PHT side of boilers
- PHT equipment and support systems
- life cycle management to Nuclear Asset Management

After lunch there were two more presentations, one from Ontario Power Generation, the other on CANDU 6 units.

OPG

Paul Spekkens, vice-president, special projects, at Ontario Power Generation, provided the OPG perspective. He defined Life Cycle Management as:

- a decision-making process to choose the best, balanced option for asset management
- that includes elements required for safe operation (e.g. inspection) and for economic optimization (e.g. cleaning) and, evolves over time.

He spoke of LCM governance in OPG, which includes:

- Detailed Program & Procedures for conducting all elements of LCM
- Clear accountabilities and internal interfaces
- Consistency in methodology and criteria across plants and components
- Support for business case
- Sustainable and continuing program
- Integrated Aging Management (IAM) Program
- IAM Procedures for identifying IAM Program Systems, Structures & Components
- Aging Management Review
- Station Condition Assessment
- Obsolescence Identification & Evaluation
- Links to related governance
- Systems & Component Programs
- SG, FC, Feeders...
- Engineering Programs
- Licensing basis, OPEX, ECC
- Inspection & Maintenance Programs
- System surveillance, PM
- Chemistry Program
- Outage & Generation planning process

LCM is carried out at different levels, he noted:

- Component - aging effects on integrity or performance
- System - cumulative effect of individual component aging
- Unit - overall unit aging strategy integrating all systems
- Fleet - optimal strategy for plant-level investments

At the unit level he reported that there are separate LCM plans for Fuel Channels, Feeders, and Steam Generators. These are maintained by a "Technical Authority" in the engineering support group; approved by the Chief Nuclear Engineer; and updated on a regular schedule based on the maturity of the plan (Feeders, FCs: annually; SGs: every 2 years).

The LCM program for steam generators started "late in life", he said, but aggressive inspection campaign has almost "base-lined" all the boilers. Major maintenance programs planned include:

- Secondary side cleaning: P'A' & P'B'
- Primary side cleaning: Darlington
- Divider plate repairs: Pickering
- AVB installation: Darlington

For pressure tubes there are three principal issues, he said:

- D2 uptake
- Deformation/contact with calandria tube
- Flaws

On all of these there needs to be a strong link between LCM priorities and the industry's R&D program. OPG has a detailed, mature LCM strategy and plan for every unit, he stated, which is based on all known degradation mechanisms and identifies knowledge gaps to be closed by R&D. Inspection and maintenance plans extend for 10 years.

There are two main degradation mechanisms identified for feeders, he noted, thinning and cracking. The LCM for feeders is not fully mature; the extent of thinning is not fully understood, and, the extent and mechanism of cracking is poorly understood. The development of solutions is underway but an optimal long-term strategy is still not available. An industry-wide common Technical Basis for feeder LCM is being developed.

He commented that "end of life" will be determined by the "fitness for service" of the major plant components. If all units reach "end of life" at the same time we will have an impossible situation, he observed.

CANDU 6

The perspective of CANDU 6 owners was presented by Marc Aubrey of Hydro Quebec.

HQ began life studies on Gentilly 2 back in the mid 1990s, he noted. In 2000 they began a pre-project study for the replacement of the pressure tubes. That study has been extended to 2005 with a target of 2010 to 2011. Related environmental reviews have been conducted.

Aubrey also gave the presentation from Point Lepreau that had been prepared by Paul Thompson. Phase 1 of the rehabilitation plan has been completed and it is hoped that Phase 2, detailed planning, will begin in the spring of 2005. The current proposal is for a major outage between 2008 and 2009. A proposal from Bruce Power to lease Point Lepreau is still being studied by the New Brunswick government.

The afternoon "breakout" sessions continued four of those of the morning:

- feeder life cycle management
- PHT activity and magnetite transport and PHT side of boilers
- PHT equipment and support systems
- life cycle management to nuclear asset management

In introducing the dinner speaker, **Dan Meneley**, CNS 2nd vice-president and chairman of the Design and Materials Division (the sponsors of the Workshop) stated two "facts" about today's nuclear industry: (1) engineering and technology services will be needed for the whole life of current stations which could be 60 to 100 years, and (2) the "centre of gravity" of the industry has moved from research labs to engineering offices to operating stations.

Dinner speaker, **Sandy Stock**, Director of Engineering, Darlington Nuclear, Ontario Power Generation, gave a personal overview with emphasis on the need to combine technical planning with business planning. We can take business risks, he said, if the technical knowledge is adequate, but not safety risks. Noting the small size of the Canadian nuclear industry he urged cooperation between all parties. He closed by asserting that together we can sell the next plant based on successful operation of our existing ones.

In the summary sessions the next morning, the rapporteurs attempted to identify points under four headings: issue; management; limitations; integration strategies. It was evident that the small group discussions had been animated and, in the limited time available further discussion developed following presentation of the summaries..

The Workshop closed with two short presentations:

- Extending Life Cycle Management Techniques to components other than boilers, pressure tubes and feeders ➪ by **Larry Bird**, of Bruce Power
- COG program ➪ by **Malcolm Lightfoot**, of CANDU Owners Group.

After the closing lunch most of the overseas delegates participated in a "mini" tour of the Darlington station.

The Workshop was organized by Prabhu Kundurpi, Jack Nickerson and Jacques Plourde. A report with a digest of the summary reports is being prepared.

"Badge-Draw" Winners at 2005 Plant-Life-Management Workshop

At the end of the 2005 Plant-Life-Management Workshop, on February 22, 2005, in Oshawa, Ontario, 2 prizes were drawn from among badges returned by Conference attendees.

The winners were:

Neil Allen of Ontario Power Generation won a miniature Inukshuk.
Shigeo Hattori of Hitachi Ltd. Power Systems won a CNS membership good to the end of 2005.

Congratulations to the winners!

Gagnants de prix au tirage des porte-insigne à l'Atelier 2005 sur la prolongation de vie des centrales

À la fin de l'Atelier 2005 sur la prolongation de vie des centrales, le 22 février 2005, à Oshawa (Ontario), 2 prix ont été tirés au sort parmi les porte-insigne retournés par les participants à la conférence.

Voici les gagnants des prix:

Neil Allen d'Ontario Power Generation a gagné un Inukshuk en miniature.
Shigeo Hattori de Hitachi Ltd. Power Systems a gagné une adhésion à la SNC jusqu'à la fin de décembre 2005.

Félicitations aux gagnants!

Moving Forward

L-3 MAPPS

On February 3rd, 2005, L-3 Communications Corporation acquired CAE's Power Systems and Simulation business. As L-3 Communications MAPPS Inc., we continue operating out of our headquarters in Montreal, Canada.

Our parent company has changed, but we are the same group of people that you have entrusted to deliver high-end power plant simulation and plant computer systems technology for more than 30 years. Continuing as L-3 MAPPS with the same management team, know-how and technology, we remain at the forefront of our business areas and will continue to invest in and to further develop our product offerings to address our customers' challenging needs – now and in the future.

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Periodic Safety Review for Wolsong Unit I

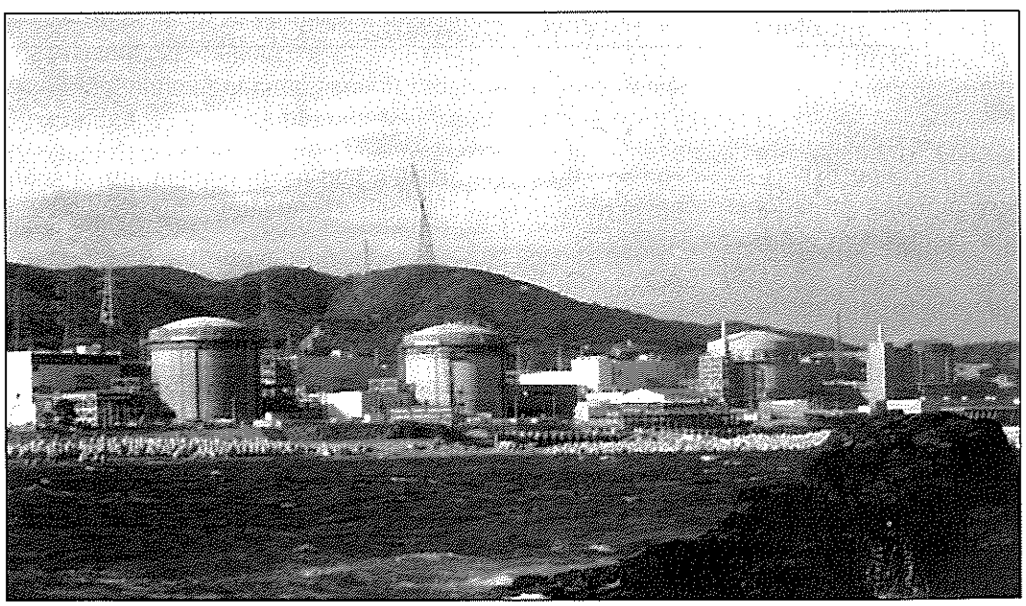
Ed. Note: *Following is an extract from the 2004 Annual Report of the Korea Institute of Nuclear Safety on the first Periodic Safety Review of the Wolsong 1 unit. It was provided by Dr. Seong Kim of KINS following his participation in the CANDU Life Cycle Management Workshop held in Oshawa, Ontario, February 21 and 22, 2005.*

I Up-to-date Progress

Of the 19 nuclear power plants [in Korea] nine units have been in operation for more than ten years as of the end of 2003. In compliance with the Article of the Convention on Nuclear Safety (CNS), the necessity for the Periodic Safety Review (PSR) was reviewed by the Nuclear Safety Commission (NSC) for legislation.

The NSC decided to adopt the Periodic Safety Review as a safety evaluation process during the lifetime of nuclear power plants. The Commission requested that the regulatory body and operators prepare a comprehensive plan necessary to implement the PSR, such as work scopes to be conducted by each institution, legislative processes, schedule of future performance, etc.

MOST [Ministry of Science and Technology] issued 'Implementing Guidelines for PSR' on May 30, 2000. The Atomic Energy Act was revised to include basic direction and framework for the implementation of PSR in July 2001. Detailed provisions including review scope, method, procedure, and applicable technical standards are stipulated in the Enforcement Decree of the Atomic Energy Act.



A view of the Wolsong site showing all four units

KINS [Korea Institute of Nuclear Safety] has completed the development of Review Guidelines for PSR of PHWR [Pressurized Heavy Water Reactors].

2 PSR Implementing Method

PSR should be undertaken every 10 years after issuance of an operating license. The first PSR for the NPPs now beyond 10 years of operation will be completed within 4 years. The schedule for each NPP is prescribed in the Notice No. 2002-05 of the Minister of Science and Technology. The operator of NPPs, KHNP, has the prime responsibility of performing the PSR. The regulatory body specifies PSR requirements and reviews the PSR results performed by the operator. Review scope is specified clearly in the Enforcement Decree, but detailed scope may vary depending on the plant age. The PSR for twin plants should be separately considered in the area of the ageing of structures, systems and components and the physical status of each plant.

3 PSR Review Standards and Criteria

The PSR is performed based on technical requirements for the location, structures, components and performance of reactor facilities and for the safety measures for the operation of reactor facilities prescribed under the nuclear legislative and regulatory framework. Detailed technical requirements can be referenced to those applied to the operating license of a NPP issued near the beginning of the PSR such as Wolsong Units 2, 3 and 4. Exemptions may be possible, if the technical requirements are deemed inappropriate to be applied with differences in the design principles or the operational characteristics of the nuclear reactor. Justification for the exemptions should be provided taking into account; physical possibility, safety significance, and cost-benefit.

PSA could provide useful insights for the justification.

4 Safety Review Guidelines for PSR

The safety review guidelines (SRG) of the PSR for CANDU reactors consist of the review principles, review areas and methods, technical standards, and methods of constructing review reports that are needed to implement the PSR. These guidelines can be used for efficient and consistent reviews and evaluations of the PSR by regulatory body and applicant. It was developed in reference to the aging evaluation experiences for CANDU reactor, Standard Review Plan for license renewal and generic ageing lessons learned reports of NRC including the ageing management programs in IAEA technical documents.

The SRGs are composed of general guidelines and detailed guidelines to keep the consistency with LWR review guidelines. The general guidelines include background, evaluation methods, review areas, technical standards, reporting system, and corrective measures for PSR. The detailed guidelines deal with 11 safety factors and consist of six chapters as shown in Table 1. The format of the detailed guideline is composed of the following items: 1) Area of Review, 2) Acceptance Criteria, 3) Review Procedure, 4) Evaluation Findings, and 5) Implementation.

Table 5-1 Structure of PSR Safety Review Guidelines for CANDU Reactors

Part	Chapter	Article	Clause
I. General Guidelines	1. Introduction		
	2. Periodic Safety Review Implementation Methods		
	3. Evaluation Area and Methods		
	4. Technical Standards		
	5. Basic Directions for the Report Organization System		
	6. Corrective Measures for the PSR		
II. Detailed Guidelines	1. Plant Description	1.1 General Considerations	
		1.2 Site Characteristics	
	2. Aging Management and Safety Performance Evaluation	2.1 Scoping and Screening	
		2.2 Structures	2.2.1 Reactor Building
			2.2.2 Safety-Related Structures
		2.3 Reactor Assemblies	
		2.4 Reactor Process Systems	2.4.1 Fuel Channel Assemblies
			2.4.2 Feeders
			2.4.3 Primary System Piping
			2.4.4 PHTS Pumps
			2.4.5 Steam Generators
			2.4.6 Pressurizer
			2.4.7 Valves
			2.4.8 Pumps
			2.4.9 Heat Exchangers
			2.4.10 Piping & Comp. Supports
			2.4.11 Fuelling Machine
		2.5 Safety System Components	2.5.1 Valves
			2.5.2 Pumps
			2.5.3 Pressure Vessels
			2.5.4 Heat Exchangers
		2.6 & 2.7 Electrical and Instrumentation & Controls	
		2.8 Auxiliary Systems	2.8.1 Valves
			2.8.2 Pumps
			2.8.3 Pressure Vessels
			2.8.4 Heat Exchangers
			2.8.5 HVAC Systems
			2.8.6 EDG Systems
		2.9 Turbine Generators, Auxiliary Systems	2.9.1 Secondary System Piping
	3. Equipment Qualification	3.1 Environmental Qualification	
		3.2 Seismic Qualification	
	4. Radiation Protection and Waste Management	4.1 Radiation Management	
		4.2 Radioactive Waste Management	
		4.3 Environmental Impact	
	5. Safety Analysis	5.1 Safety Analysis	
		5.2 Safety Performance	
		5.3 Fire Protection	
	6. Plant Operation	6.1 Organization and Administration	
		6.2 Procedures	
		6.3 Human Factors	
		6.4 Emergency Planning	

4.1 SRG for Ageing Management and Safety Performance Evaluation

Ageing management program should predict and detect the timing when required safety functions are threatened and adequate corrective actions or mitigation measures should be taken. Nuclear power plant should have systematic ageing management programme and feedback mechanism consisting of all relevant activities, such as surveillance, maintenance, chemistry controls, and operating experiences to ensure that required safety margins of SSCs [systems, structures, components] important to safety are maintained throughout plant service life.

Ageing management program should include both managerial aspects, for example, program policy, procedures, performance indicators, staffing, resources, record keeping, and technical aspects, for example, ageing management methodology, extent of understanding of relevant ageing phenomena, SSC specific acceptance criteria, ageing detection and mitigation methods, and actual physical condition of SSCs.

The guidelines for ageing management and safety performance evaluation of chapter 2 in detailed SRGs are composed of nine articles and again divided into a scoping/screening guideline and 41 guidelines for major SSCs.

4.2 Guidelines for the Other Items

Guidelines for plant description, equipment qualification, radiation protection and waste management, safety analysis, and plant operation were developed based on the domestic and oversea regulation experiences referring IAEA safety series. The detailed guidelines were composed of 23 articles. Now, the PSR draft guidelines for CANDU reactor are being reviewed along with Canadian Nuclear Safety Commission (CNSC) to reflect Canadian experiences.

5 PSR Progress for Wolsong Unit 1

The PSR report on Wolsong unit 1 was submitted to the regulatory body in June 2003 and the review was completed in June 2004. It took 12 months to review the PSR report. The review results are summarized as follows:

Self-assessment of licensee was effective and permissible. Current state was satisfactory and maintained within current applicable codes and standards. However, it was recommended to take some actions to enhance the safety of plant using current operational experiences and results of study.

A total of 27 safety improvement items were identified from the PSR review for various safety factors and some items are listed in Table 5-2. The safety improvement items are composed of two categories, 'complementary item' and 'recommendation item', depending on the follow-up actions by regulatory body or licensee.

Table 5-2 Example of Safety Improvement Items of Wolsong Unit 1

Safety Factors	Safety Improvement Items	Remark
1. Actual Conditions of Plants	- Addition of trip parameter related to the temperature of moderator system	
2. Aging Management and Safety Performance Evaluation	- Establishment of integrated management program for pressure tube aging, and feeders and weak parts of main feedwater pipe - Modification and refurbishment of electrical and control systems	Complementary
3. Equipment Qualification	- Improvement seismic and environmental qualification programs	
4. Radiation Protection, Waste Management and Environmental impact - Use of Experiences	- Modification of calculating method for radiation exposure using recent guidelines - Periodic modification of dilution factor of sea water	
5. Safety Analysis and Safety Performance	- Quantitative re-analysis of postulated accidents - Monitoring primary coolant temperature to check the degradation of performance of steam generator	Complementary
6. Plant Operation - Procedures - Organization/Administration - Human Factors - Emergency Planning	- Modification of EOP by using of human factor considerations - Strengthen MMI review process - Update the assumption of evacuation time of public	

Three items belong to 'complementary item' which requires the follow-up review of regulatory body. For example, the function of pressure tubes, some feeders and weak parts of main feedwater pipe could not be guaranteed for the designed life time. Based on the current analysis, most of pressure tubes could contact with feeders due to expansion in 2007 and reach the expansion limit in 2010.

Thus, the items were selected as complementary item for follow-up actions before the

designed lifetime. The followings are 3 complementary items identified during the PSR review:

1) Establishment of integrated management program for pressure tube aging
2) Establishment of management program for some feeders and weak parts of main feedwater pipe
3) Quantitative reanalysis of postulated accidents

After the results of Wolsong unit 1 PSR review are endorsed by Nuclear Safety Commission (NSC), licensee shall prepare and submit the schedules and specify follow-up actions for complementary items to the regulatory body within 3 months. The regulatory body will review the adequacy of planned schedules and follow-up actions of the licensee.

A total of 24 items of the safety improvement items belong to 'recommendation item' category These items are drawn from current operational experiences and analytical evaluations. Basically, recommendation items do not require the review of regulatory body in processing follow-up actions. These items are carried out by licensee as voluntary activities. It is expected that the safety of Wolsong unit 1 would be enhanced if recommendation items are adopted as planned.

Now, the final review results of Wolsong unit 1 PSR report are under the review of Nuclear Safety Commission and will be finalized in near future.

6 Application of PSR Results to Plant Life Management

The PSR review results are possible to be utilized in verifying the safety for plant life extension, i.e. continuous operation beyond the plant designed lifetime. Korea has performed the research on how to link the PSR with continued operation. According to the present result of the research, there seems to be no significant technical safety issues on utilizing the PSR results for life extension. However, additional requirements should be assigned for regulatory position for continued operation such as review of aging management, impact on environment, updated Technical Specifications, and supplemented FSAR. Currently, there is no plan to extend the lifetime of a power plant because a domestic model for plant life management is not established. However,

Government recognizes the importance of plant life management and began research for establishment of plant life extension. This research includes specification of the documents for submittal to regulatory body, detailed review procedures, process of public hearing and so on. The preliminary results of the research will be shown in the end of this year and final results will be shown next year.

Implementation of Low Void Reactivity Fuel in Bruce B

by R.M. Chun and F.C. Iglesias and G.H. Archinoff

***Ed. Note:** The following paper was presented in the opening plenary session of the 6th International Conference on Simulation Methods in Nuclear Engineering, held in Montreal, October 2004. See Vol. 24, No. 4 issue of the CNS Bulletin for a report on that conference.*

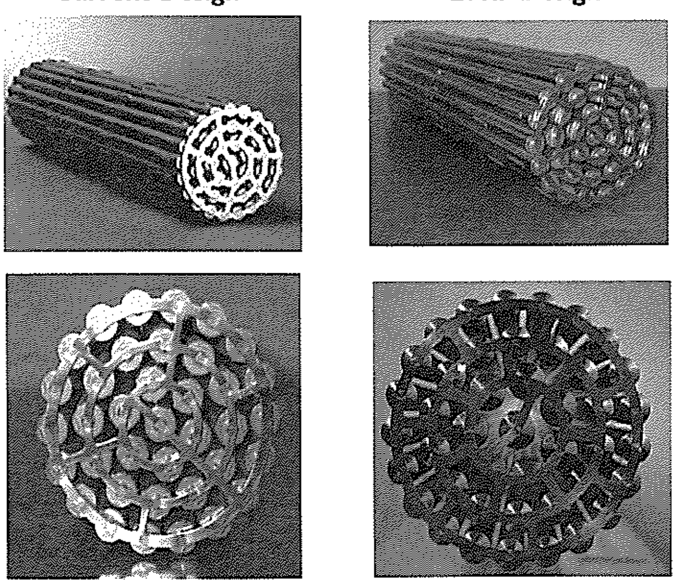
Introduction

In order to return all operating units to 100% Full Power (FP) to end of life, Bruce Power is planning the implementation of design changes in all units to increase the robustness of safety margins and mitigate the effects of core ageing. One of these design changes is the replacement of the current 37-element fuel bundle by the Bruce-LVRF (Low Void Reactivity Fuel) fuel bundle. This new bundle has been designed to reduce the core void reactivity by the addition of burnable poison and to enhance the critical heat flux (CHF) characteristics by increasing the sub channel flow mixing.

To ensure successful implementation of this design change, Bruce Power has established a dedicated project organisation to manage all the necessary activities under the New Fuel Project. The new fuel implementation will be performed in two stages. In the first stage 24 LVRF bundles will be fuelled into two pre-selected channels to confirm that these bundles performed as expected and that the bundle channel interaction is similar to the current bundle design. During the second and final stage, the normal fuelling operation of the Bruce reactors will use LVRF bundles, thus initiating the gradual conversion of each core to low void reactivity fuel.

Figure 1 shows the current Bruce 37-element and the LVRF 43-element fuel bundle designs.

Current Design | **LVRF Design**



The Bruce LVRF bundle design introduces several main modifications to the current 37-element design.

- 43-elements instead of 37 with two distinct element diameters rather than one;
- A burnable poison, Dysprosium (Dy), is added to the central fuel element;
- The uranium dioxide in the 42 remaining elements is enriched in 235U; and
- Bundle geometry improved to increase CHF characteristics and decrease element linear power, particularly in the outer elements.

In order to obtain concurrence from the Canadian Nuclear Safety Commission (CNSC), Bruce Power is preparing a Safety Case that describes the analysis, assessment and plant modifications required to confidently demonstrate the safe operation of the Bruce reactors with this new bundle design. A major part of the Safety Case is the Safety Analysis of relevant Design Basis Accidents (DBAs).

Prior to conducting the safety analysis, a review has been completed to address the qualification of the Safety Analysis Software (SAS). This work was performed to ensure that the computer codes used are suitably qualified to model the LVRF fuel bundle design.

This paper provides a brief overview of the New Fuel Project, a description of the implemented SAS qualification process, a discussion of the core characteristics with the new fuel, and a summary of the preliminary safety analysis results.

Overview of New Fuel Project

Bruce Power is managing the overall project with a number of key services provided by the following external organizations:

- Atomic Energy of Canada Limited (AECL) is managing the design and qualification testing of the fuel.
- A consortium formed by Nuclear Safety Solutions (NSS) and AECL is performing analysis of accidents, system performance, and the potential for out-reactor criticality of the fuel.

1 Bruce Power, Toronto, Ontario
2 Candesco Research Corp. Toronto, Ontario

- Cameco and Zircatec are managing the production of the new fuel bundles.

Various agreements are also in place for specialized services such as assessing impact on the fuel handling system, developing an in-house criticality program, designing and testing transportation containers and enhancing the performance of a limited number of existing support systems where required.

The major activities in the New Fuel Project are summarized as follows:

a) Determine the optimum composition of the new fuel, i.e., the amount of Dysprosium in the central element and the percentage of 235U in the other elements.
b) Customize the CANFLEX bundle design for use in Bruce B reactors.
c) Qualify the new fuel for use in Bruce B reactors.
d) Prepare a Safety Case to obtain regulatory approval for use of the new fuel.
e) Conduct an environmental assessment to an appropriate level as required by the Canadian Environmental Assessment Act.
f) Identify the optimal scheme for introducing the new fuel into the reactor core.
g) Identify and implement design changes, revised procedures and training programs to accommodate safe and economical use of the new fuel, covering from receipt of fresh fuel in the station to transferring irradiated fuel to the dry fuel storage facility for retention in a dry fuel storage facility.

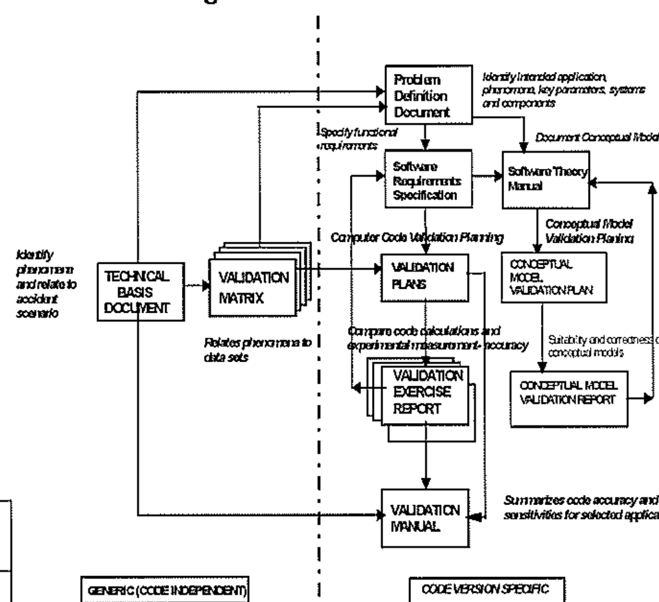
Completion of the above activities will allow Bruce Power to first conduct a demonstration irradiation of the new fuel followed by full core loading, and subsequent power raise to 100% FP.

In the following sections, some of the performed tasks in support of the preparation of the Safety Case, including the work on SAS qualification, are described.

Software Qualification

All SAS used for the safety analysis of DBAs must be qualified for the appropriate range of conditions expected for those accidents. Each SAS has a defined domain of applicability that mirrors the expected range of conditions of the DBAs for which the code will be used. The domains of applicability covers ranges of temperature, burnup, pressures, etc. and other relevant parameters. The process used by Bruce Power for SAS qualification follows that established by the Canadian nuclear industry and concurred by the CNSC.

Figure 2: Validation Process



Application of these SAS to the safety analysis of the different DBAs for the Bruce B reactors fuelled with the LVRF design requires that only certain domains of applicability need to be modified and only in a subsets of the codes. If a particular code requires changes related to LVRF, additional qualification effort is required as stated by the SAS qualification process. This additional qualification work includes modifications to the software, verification of these modifications, related changes in software documentation and performance of new validation exercises if required. All this additional qualification to extend the generic qualification is called 'Incremental Qualification'. Table 1 presents some of the major computer codes used in the safety analysis.

Table 2: Major Computer Codes Used in Safety Analysis

Technical Discipline	Safety Analysis Software	Description
Reactor Physics	WIMS-IST	
	RFSP-IST	
	DRAGON	Calculates reactivity mechanisms incremental cross-sections.
	ORIGEN	Solves the equations for isotope generation and provides inventories for fission products, actinides and fissile materials.
Thermal Hydraulics	TUF	Simulates the primary heat transport system and channel behaviour. Iterates with RFSP. Provides information to FACTAR 2.0.
Fuel and Fuel Channel	FACTAR 2.0	Estimates the fuel and fuel channel behaviour during accidents. Requires imputs from FACTAR_SS, RFSP and TUF. Provides information to SOURCE.
	FACTAR-SS	Estimates the fuel behaviour during normal operation conditions. Provides information to FACTAR 2.0 and SOURCE.
	SOURCE-IST	Calculates fission products inventories and releases. Require input from FACTAR_SS and FACTAR 2.0. Provides fission product source term in the primary heat transport system.

Validation

The safety analysis validation process as developed by the Canadian nuclear industry is the result of a co-operative development of information relevant to safety analysis computer code verification and validation. It is consistent with international practice, complies with applicable quality assurance requirements [1], and takes into account regulatory guidelines [2].

The computer code validation methodology is organised as a multi-stage process associated with a structured set of documents, as shown in Figure 2. The first two stages are implemented by the preparation of a Technical Basis Document and Validation Matrix Documents, which are prepared in an manner to remain applicable to any specific computer codes (Generic Activities). The remaining stages of the process involve the completion of Validation Plans, Validation Exercises and Validation Manuals for specific computer codes (Code Specific Validation).

The introduction of the LVRF design and required changes in SAS were implemented in compliance with this process. Both activities, generic and code specific, were reviewed and updated as necessary. These revisions focused on the impact of the design changes introduced by the new fuel design. The role of the main validation documents is briefly described below.

Technical Basis Document

The Technical Basis Document (TBD) provides a technical breakdown of each of the accident categories relevant for CANDU accident analysis. The main objective of a TBD is to provide a foundation for selecting physical phenomena of importance for the validation of computer codes. Primary phenomena involved in each accident scenario are identified and grouped into technical specialities or disciplines for which computer code validation will have to be provided. The document focuses on the phenomena and disciplines involved, however it does not specify the computer codes to be employed in the analysis.

Validation Matrices

Validation Matrices (VM) are prepared to relate, by discipline and for each accident sequence, the phenomena identified in the TBD to data sets that exhibit the phenomena. The data sets are taken from operational data, experimental measurements, analytic solutions, single effect tests, integral effects tests or results from other validated computer codes.

Validation Plans

Validation Plans are specified for a particular computer code version. The plan identifies the intended applications for which a computer code version is being validated, and uses the validation matrices to identify data sets for validation and any gaps in the data available for validation. The plan details what will be performed to demonstrate that a particular computer code version accurately represents the phenomena occurring in selected accident scenarios for the intended range of application.

Validation Exercises

The Validation Exercises compare the computer code results (modelling of governing phenomena) to the relevant data sets and assesses, if possible, the uncertainties and biases in the identified key safety output parameters over the range of application.

Validation Manuals

Validation Manuals summarise the results of validation exercises in the context of the validation plan. They document how the technical basis for validation of a particular computer code has been covered. Each document also summarises the accuracy and uncertainty associated with computer code predictions of the identified key safety output parameters for the range of intended applications. These documents are intended to be a guide to users in practical applications of the computer code.

Code Configuration Control

Under this activity all required software modification were performed following the current established procedures and Standards [1, 2]. All these activities are code specific and must be performed for each individual code. The main tasks in this area are: Software Modification, Software Verification, Configuration Control, and Software Release.

The set of qualified SAS for LVRF application were used to perform preliminary analysis to assess the key characteristics of an LVRF core.

Characteristics of an LVRF Core

Analysis was performed to determine the characteristics of an equilibrium fuelled LVRF core. One of the key requirements of the new fuel is that the average discharge burnup be similar to that for the current fuel. The fuel composition established to meet this requirement also ensures that the overall characteristics of an LVRF core are similar to those for 37-element fuel.

The reactor physics analysis was performed with the WIMS-DRAGON-RFSP toolset, which is the same toolset used in analysis of 37-element fuel. The calculation of fission product inventories was performed with ORIGEN-S, with a cross-section data set generated with WIMS specifically for LVRF. The calculation of fission product inventory distributions was calculated with the SOURCE code.

Time Average Core Model

An RFSP time average core model was developed, based on WIMS-generated cross sections, in turn based on data from the ENDF-B/VI library augmented to account for burnable Dy isotopes. The reactivity device incremental cross-sections were generated specifically for the LVRF core using DRAGON. The RFSP model is for a 12-bundle-per-channel, fuelling-with-flow core, with a "water bundle" at the channel inlet to reflect removal of the 13th bundle. The key characteristics of the LVRF core are compared to those for a 37-ele-

Parameter	37-element NU fuel	Reference Design LVRF
Maximum Channel Power (kW)	6539	6537
Maximum Bundle Power (kW)	757	755
Average Cell Flux (n/cm^2.s)	1.86E+14	1.72E+14
Reactivity Decay Rate (mk/FPD)	-0.413	-0.510
Average Fuel Exit Burnup (MWh/bundle)	3620	3730
Average Fuel Exit Burnup (MWh/kgU)	188	200
Feed Rate (channels/FPD)	4.39	4.25
Feed Rate (bundles/FPD)	18.8	18.2

ment Natural Uranium (NU) core in the following table:

The table indicates that the key characteristics of an LVRF core are very similar to those of a 37-element NU core. The maximum channel and bundle powers are very comparable. The cell average flux is somewhat lower, which is to be expected with slightly enriched fuel. The average discharge burnup is slightly higher with LVRF, meaning that the feed rate of bundles will be slightly lower. All of these small changes are in the positive direction with respect to improved safety and operating flexibility.

Bundle Radial Power Profile

The bundle radial power profile as a function of burnup was generated using the WIMS code. The following table compares the fuel element linear ratings for LVRF to 37-element NU fuel at three different burnups. In all cases, the ratings are normalized for a nominal bundle power of 1000 kW.

Ring Number	Linear Rating for Fresh Fuel (kW/m)		Linear Rating for Mid Burnup Fuel (kW/m)		Linear Rating for Discharge Burnup Fuel (kW/m)	
	LVRF	NU	LVRF	NU	LVRF	NU
1	11.3	43.0	17.0	43.5	22.0	44.8
2	46.9	45.1	49.6	45.6	51.9	46.7
3	42.0	51.4	42.7	51.5	43.1	51.9
4	54.6	63.9	53.0	63.6	51.7	62.9

The table shows that, as expected due to the presence of Dy, the central element linear rating (ring number 1) is very low in comparison to that for NU fuel. The table also shows that at high burnups, the linear rating of the inner ring is very similar to that for the outer ring. The maximum linear element rating for LVRF occurs for fresh fuel, but it is still significantly less than the outer element linear rating for NU fuel.

Reactivity Device Worths

The RFSP model was used to generate static worths of the reactivity devices. The results are compared to those for a 37-element NU core in the following table:

Device	Calculated Device Static Reactivity Worth (mk) for a LVRF Core		Device Worths for a NU Core
	*TIME-AVER	*SIMULATE	
ZCR fill change from 0% to 100%	-6.45	-6.45	-7
All adjusters withdrawn	17.4	17.2	18
All control absorbers inserted	-8.72	-8.7	-9
All shutoff rods inserted	-65.3	-64.9	-68.1

Results for an LVRF core are presented for both the time average core (using the *TIME-AVER module of RFSP) and the time average equivalent model (generated using the *SIMULATE module of RFSP). In both cases, the device worths are predicted to be lower than for an LVRF core, although not significantly so. This result is expected because of the lower thermal flux associated with the LVRF core.

Decay Power

A method based on the ANSI/ANS-5.1-1994 standard [3] was used to derive the LVRF decay power curve for times up to 100,000 seconds. WIMS was used to generate cross-sections specific to LVRF, as well as the fission rate fractions for the fissile isotopes.

One aspect of LVRF that is unique to LVRF is the Dy contained in the centre element. The effects of neutron capture in poison during operation at power are implicitly included in the methodology, since all reactions that have a significant impact on the neutronic balance are accounted for in the reaction rates provided by the WIMS lattice cell calculation. Hence, capture gamma energy contributions as the result of neutron capture in 160Dy, 161Dy, 162Dy, 163Dy, 164Dy, 165Ho, 166Er, and 167Er are considered. However, this does not account for the energy contributed to decay power due to radioactive Dy after shutdown. The decay of 165Dy accounts for about 80-90% of contributions due to Dy activation products, and all these contributions together account for less than 1.6% of the total decay heat power in the time period considered. The reaction 164Dy (n,γ) 165Dy is explicitly modelled in the WIMS lattice cell calculation, and so the associated reaction rate (relative to other absorption events within the lattice cell) is extracted as a function of burnup. The decay power from the activation product 165Dy is then evaluated in an analogous way to the manner in which the decay power contribution from 239U, formed the reaction 238U (n,γ) 239U, is treated in the ANSI/ANS5.1-1994 standard.

The ratio of decay power for LVRF to that used in the Safety Report for 37-element NU fuel is shown in the following table:

Cooling Time (s)	Ratio of LVRF Decay Power to Safety Analysis Decay Power Fraction for 37-Element Fuel (both with one sigma uncertainty)
1	1.003
10	0.986
100	0.964
600	0.967
1000	0.975
3000	0.99
10000	0.988

The table shows that, except for the first second after shutdown, the decay power for LVRF is less than that used in the Safety Report for 37-element fuel.

Fission Product Inventories and Inventory Distributions

The ORIGEN-S code was used to calculate fission product inventories for radiologically significant nuclides. The SOURCE 2.0 code was used to calculate the distribution of fission products among the grain, grain boundary and free inventories.

The inventory of the most radiologically significant nuclide, I-131, is about 8% lower in a high power (7.2 MW) LVRF fuel channel compared to NU fuel. The results for other nuclides show wide variations, with some having lower inventories for 37-element fuel, and other having higher inventories. In terms of the impact on fission product releases under accident conditions, an important consideration is the free inventory of fission products, as the free inventory is readily available for release from the fuel element following fuel sheath failure. The free inventory is significantly lower for LVRF compared to NU fuel, due to the lower fuel temperatures caused by the lower fuel element ratings. The free inventory fraction in a high power channel (7.2 MW) for Xe, Kr, I and Cs isotopes is 15.5% for NU fuel, and 4.3% for LVRF. The reduction in free inventory fraction dominates the impact of LVRF on the fission product inventory available for release upon fuel sheath failure.

Key Safety Improvements of an LVRF Core

The key attributes of LVRF that contribute to enhanced safety are:

- Reduced coolant void reactivity – This reduces the power pulse following a Loss of Coolant Accident (LOCA), and is the primary reason for adopting LVRF. The lower power pulse results in reduced fuel sheath and fuel centerline temperatures following a LOCA.
- Increased critical heat flux – The LVRF design results in increased critical heat flux, which in turn results in increased critical channel power. These effects help to mitigate the effect of plant ageing, including the effect of pressure tube diametral creep.
- Lower fuel element ratings – Fuel element ratings are lower in the LVRF design, due to the larger number of fuel elements. This reduces the initial fuel element average and centerline temperatures, thereby providing increased margin to fuel centerline melting. The lower fuel temperatures also result in a reduction in the free fission product inventory, which reduces the quantity of fission products available for release upon fuel sheath defect or failure.

	60% PD Break		100% RIH Break	
	Reference LVRF	37-Element Fuel	Reference LVRF	37-Element Fuel
Reactor Power (% FP)	100	90	100	90
Credited Trip Time (s)	0.495	0.353	0.328	0.214
Peak Reactivity (mk)	3.91	5.75	3.87	5.67
Prompt Criticality Reactivity Threshold (mk)	5.8	N/A	5.8	N/A
Peak Reactor Power (Relative)	2.71	5.27	2.83	5.37
Enthalpy of the outer elements of the hottest bundle at 5 s (kJ/kg)	573	752	578	776
Hot channel energy deposition at 5 s (MJ)	33.4	63.9	33.8	67.3
Peak Fuel Centreline Temperature (°C)	1970	2260	19903	2310
Peak Fuel Sheath Temperature (°C)	1210	1440	702	1350

Large LOCA analysis was performed and results compared to those from analysis for the current fuel design that supports operation up to 90% FP and which defines the current acceptable safety envelope. Two break sizes and locations were considered:

- 100% Reactor Inlet Header (RIH) Break – This double-ended guillotine break leads to rapid voiding of the Heat Transport System coolant and hence a very large positive reactivity transient.
- 60% Pump Discharge (PD) Piping Break – This partial break leads to a period of low flow in the fuel channels downstream of the break which, combined with the overpower transient, results in fuel heatup prior to injection of emergency coolant.

Both breaks were analysed to confirm that the acceptance criteria for large LOCA analysis are met. The primary criterion is demonstration that fuel channel integrity is maintained, which is in turn achieved if fuel centreline and fuel sheath melting are avoided. Previous analysis indicates that if these criteria are met, public doses will be well within the regulatory limits.

Key results of the large LOCA analysis are shown in the following table.

The results indicate the following:

a) The trip times for the 37-element fuel analysis are earlier than for LVRF because the reactor power increase for 37-element fuel is more rapid due to the higher coolant void reactivity. Therefore, the trip setpoints are reached earlier. However, although the trip is initiated later for LVRF, the peak power and the integrated power are significantly smaller compared to 37-element fuel.

b) Prompt criticality is avoided with large margin. Peak relative bundle and channel powers are significantly reduced. Fuel centreline and sheath temperatures are also significantly reduced and are well below the respective melting points.

c) The results indicate that LVRF fuel design will result in acceptable large LOCA consequences and will provide increased operating margins for the key parameters at 100% FP.

Conclusions

This paper has described key aspects of the New Fuel

Project that will implement LVRF in Bruce B. The new fuel will reduce coolant void reactivity significantly, resulting in reduced large LOCA consequences and supporting operation at 100% FP with increased operating margins. Improved critical heat flux will mitigate the effect of pressure tube diametral creep.

The characteristics of an equilibrium fuelled LVRF core have been quantified. In general, many of the key characteristics are essentially unaffected by the introduction of the new fuel design, or are more benign.

This work represents only initial phase of the analysis needed to support the new fuel design. Additional analysis will be performed to support a demonstration irradiation of LVRF in two fuel channels, transition of the core from NU to LVRF while at power, and the equilibrium LVRF core.

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Acknowledgements

This paper is a summary of work performed by the NSS-AECL Safety Analysis Consortium in support of the New Fuel Project. The authors acknowledge the significant contributions of the many staff who were involved in the analysis described in this paper. Contributing staff are from the following organisations:

- Bruce Power
- Nuclear Safety Solutions
- Atomic Energy of Canada Limited
- Candesco Research Corporation
- Bruce Power, Toronto, Ontario
- Candesco Research Corp. Toronto, Ontario

More recent analysis for the current fuel design was performed to support operation at 93% FP, however that analysis was not available at the time the present work was performed and therefore, is not included here.

Waste Management, Decommissioning and Environmental Restoration For Canada's Nuclear Activities: "Current Practices and Future Needs"

Crowne Plaza Hotel, Ottawa, Ontario • May 8-11, 2005

The Conference: The objective of this conference is to provide a forum for discussion and exchange of views on the technical, regulatory and social challenges and opportunities in radioactive waste management, nuclear facility decommissioning and environmental restoration activities in Canada. The conference is organized into several plenary sessions and eight technical tracks:

- Low-and intermediate-level wastes
- Uranium mining and milling wastes
- Used nuclear fuel
- Decommissioning
- Environmental restoration
- Policy, economics and social issues
- Licensing and regulatory issues
- Radioactive materials transportation

This three-day conference will interest waste management, decommissioning and environmental technology practitioners; delegates from industry, academia, and government agencies and regulators; consulting engineers; financial and legal experts; and other specialists working in the field. While the conference is focused on the Canadian scene, some submissions have been received from foreign and international organizations, which will provide insights into how other countries are dealing with similar issues.

Equipment and Services Exhibition: An equipment and services exhibition will be held in conjunction with the Conference.

Technical Visits: Four technical visits are being organized to several nuclear facilities: AECL's Chalk River Laboratories; the Low-Level Radioactive Waste Management Office initiative at Port Hope; Elliot Lake uranium mines; Hydro-Québec's Gentilly-2 nuclear generating station, and AECL's shutdown Gentilly-1 prototype reactor.

Guest Program: A guest program will take advantage of various attractions in the Ottawa area.

Further Information: For further information on the conference and associated activities, or to register, please visit our web site at **http://www.cns-snc.ca/waste_05.html**

Evaluation of Safety Margins During Dry Storage of CANDU Fuel In MACSTOR/KN-400 Module

by R. Beaudoin, R. Shill[1] *and Kyung-Ho Lee; Sung-Hwan Chung; Jeong-Hyoun Yoon; Byung-Il Choi; Heung-Young Lee; Myung-Jae Song*[2]

Ed. Note: *The following paper was presented at the CNS sponsored 6th International Conference on Simulation Methods in Nuclear Engineering, held in Montreal, Quebec, in October 2004.*

Summary

This paper covers an evaluation of the available safety margin against fuel bundle degradation during dry storage of CANDU spent fuel bundles in a MACSTOR/KN-400 module, considering normal, off-normal and postulated accidental conditions.

Korea Hydro and Nuclear Power (KHNP), in collaboration with Atomic Energy of Canada Limited (AECL), are developing a new module for the dry storage of spent fuel from the four CANDU 6 nuclear reactors at the Wolsong site in South Korea. The module provides the benefit of occupying significantly less area than the concrete canisters presently used. The modules are designed for a minimum service life of 50 years. During that period, the spent fuel bundles shall be safely stored. This imposes that failure of a fuel bundle element or unacceptable degradation of an existing defect (from reactor operation) does not occur during the dry storage period.

The fuel bundles are stored in an air-filled fuel basket that releases 365 Watts on average and a maximum of 390 Watts when rare fuel loading conditions are postulated. In addition, specific accidental air flow cooling conditions are postulated that consist of 100% blockage of all air inlets on one side of the module. These conditions can generate a peak daily fuel temperature of up to 155°C during a reference hot summer day during the first year of operation. The fuel temperature decreases over the years and also fluctuates due to daily and seasonal temperature variations. At this temperature, fuel elements with intact Zircaloy sheathing will not experience damage. However, for the few fuel bundle elements that are non-leaktight (less than 1 per 37,000), some re-oxidation of UO_2 into higher oxides such as U_3O_7 / U_4O_9 and U_3O_8 will occur. This latter form of Uranium oxide is undesirable due to its lower density that results in a volumetric increase of the pellet that can overstress the fuel element sheathing. The level of fuel pellet oxidation is best evaluated as a percentage weight gain. To prevent overstressing of the Zircaloy sheathing, the amount of oxidation has to be maintained below 0.6% weight gain.

The evaluation of the fuel safety margin required calculating the total UO_2 weight gain during the entire dry storage period, for comparison with the allowable weight gain. This required the integration of:

1. Data from fuel bundle heat decay assessment;
2. Heat transfer model in fuel basket for normal and off-normal loading conditions;
3. Heat transfer model in MACSTOR/KN-400 module for normal, off-normal and accidental operating conditions;
4. The fuel oxidation (UO_2 to U_3O_8) kinetics; and
5. The seasonal ambient air temperature using local meteorological data.

Figure 1 provides a summary of the main results. The safety margins, available before the allowable fuel oxidation is reached, are provided as a function of the fuel basket power when normal, off-normal or accidental events are postulated to occur. The oxidation process mainly occurs during the first few years, becoming negligible thereafter. For the operating conditions considered, the total fuel oxidation would only reach about 1/4 of the allowable, even when an accidental operating condition is postulated to

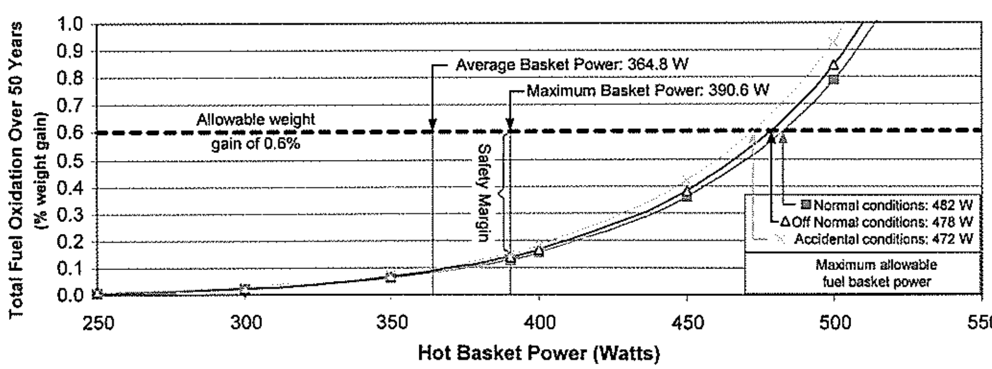

Figure 1 MACSTOR/KN-400 UO2 Pellet Oxidation as a Function of Fuel Basket Power for Normal, Off-Normal and Accidental Conditions

1 AECL Montréal, Montréal, Québec

2 KHNP, Nuclear Environment Technology Institute, Taejon, Korea

occur. Due to the excellent cooling provided by the diverse and redundant air circuit used, the fuel will be safely stored in the MACSTOR/KN-400 storage module.

1. INTRODUCTION

Korea Hydro and Nuclear Power (KHNP) and Nuclear Environment Technology Institute (NETEC), in collaboration with AECL, are developing a high capacity MACSTOR (Modular Air-Cooled STORage) storage module, the MACSTOR/KN-400. It is intended for dry storage of irradiated fuel bundles from the four operating CANDU 6 reactors at the Wolsong site in South Korea. The design parameters of the reference MACSTOR/KN-400 storage module are provided in Table 1, while Figure 2 provides an illustration of the module. The new storage module is designed to contain 400 fuel baskets while a MACSTOR 200 holds 200 identical fuel baskets. The new storage module uses the same passive air cooling circuit but has to dissipate 146 kW of heat, twice the power the MACSTOR 200 module has to dissipate. The MACSTOR 200 modules have been in service since 1995 with five modules in operation at Gentilly 2 (Canada) and one at the Cernavoda station (Romania) as of 2003.

The spent fuel bundles have to be stored safely. The principal safety design criterion applied for the design and licensing is that deterioration of the intact or defective fuel bundles during the service life of the facility be prevented. A specific evaluation of safety margins for the new MACSTOR/KN-400 module design is necessary as the fuel temperatures reached in this larger capacity module are about 12°C higher than in a MACSTOR 200 module, thus slightly increasing the expected total oxidation of the fuel.

Table 1: Generic Design Parameters for MACSTOR200 and MACSTOR/KN-400 Storage Modules

ITEM	MACSTOR 200 PARAMETERS	MACSTOR/KN-400 PARAMETERS
Plant applicability	Gentilly 2 Cernavoda	Wolsong 1-4
Design lifetime of structure	50 years	
Size Length (m) Width (m) Height (m)	 21.6 m 8.1 m 7.5 m	 21.7 m 12.7 m 7.5 m
Capacity:		
• Number of fuel bundles per module	12 000 bundles	24 000 bundles
• Number of fuel baskets per module	200 fuel baskets	400 fuel baskets
• Number of storage cylinders per module	20 storage cylinders per module (2 x 10 array)	40 storage cylinders per module (4 x 10 array)
• Storage cylinder capacity	10 fuel baskets (each holding 60 bundles)	
Air cooling circuit	10 air inlets (5 on each side) 12 air outlets (6 on each side)	
Total module heat release:	73 kW (Analysed at 78 kW)	145.9 kW (Analyzed at 146.7 kW)
Ambient air temperature	40°C daily average temperature	40°C daily peak temperature

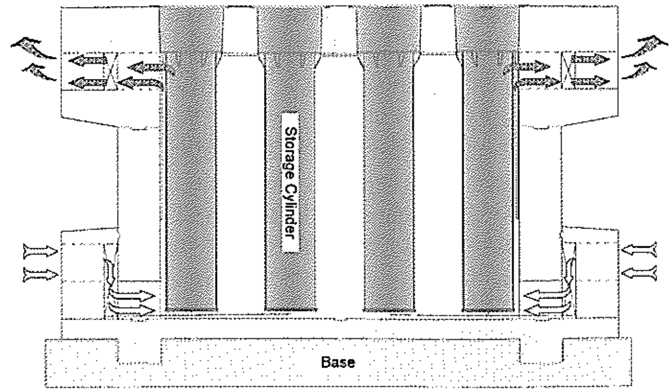

Figure 2 Illustration of MACSTOR/KN-400 Storage Module

The bundles in a MACSTOR module are stored in a fuel basket holding 60 bundles. The fuel basket acts as a primary confinement barrier to the fuel bundles. 10 such fuel baskets are stacked in a storage cylinder. The storage cylinder acts as a containment barrier to the fuel basket and thus provides a secondary confinement barrier to the fuel bundles. The two modules use an identical air circuit made of 10 air inlets in the lower portion of the module and 12 air outlets in the top portion. The MACSTOR 200 has two rows of ten cylinders each, while the MACSTOR/KN-400 has four rows of ten cylinders.

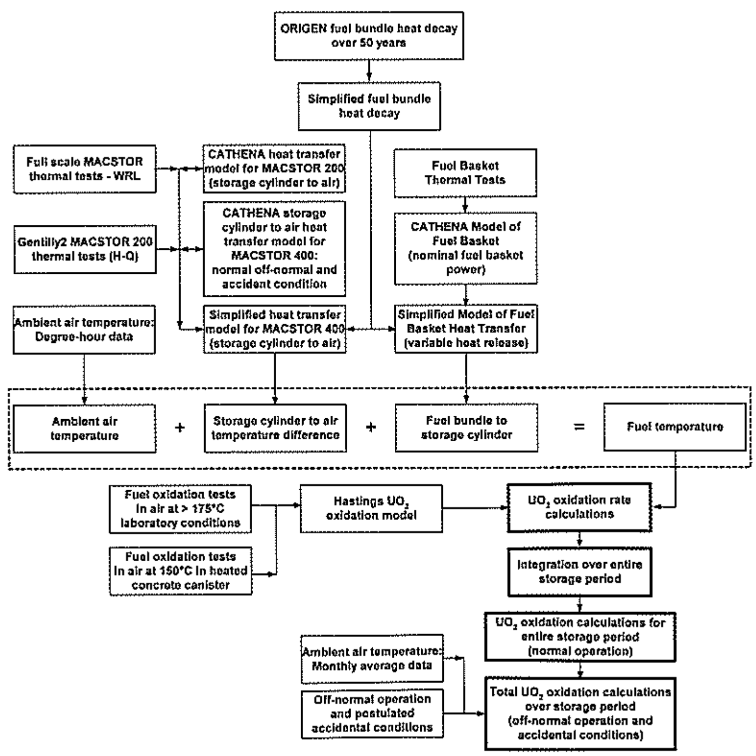

Figure 3 Diagram of Calculations for MACSTOR/KN-400 Fuel Oxidation

2. General Calculationnal Methods for Evaluation of Fuel Oxidation

The task of evaluating the total fuel oxidation over the planned 50 years service life requires the calculation of the fuel bundle heat release over time, the fuel temperature, the fuel oxidation rate, the integration for the fuel oxidation and the evaluation of off-normal and accidental conditions. As detailed calculations are time consuming, simplified models were used. These were derived from various test programs at AECL and from detailed computer models using the AECL's developed CATHENA [1] heat transfer code. The calculation method is depicted in Figure 3.

2.1 Test Programs

The heat transfer characteristics and fuel bundle temperatures reached in a fuel basket stored in a section of storage cylinder are obtained from a series of thermal tests performed at AECL's Whiteshell Laboratories. The tests involved a full-scale mock-up of a fuel basket positioned in a section of a storage cylinder. These tests can be used to predict the temperature difference between a fuel bundle and the storage cylinder. AECL has also performed a series of full-scale thermal tests of the MACSTOR module air circuit at AECL's Whiteshell Laboratories. These tests can be used to predict the temperature difference between a storage cylinder and ambient air. The test results were used during the implementation phase of the MACSTOR 200 module and various thermal models were made of the test apparatus [2]. Hydro-Québec has also made temperature measurements on the first two MACSTOR 200 modules constructed at Gentilly 2. This data has also been used to further develop improved heat transfer models, including a detailed CATHENA model of the MACSTOR 200 module air circuit [3]. The heat transfer model for the MACSTOR/KN-400 module was derived from this MACSTOR 200 CATHENA model, modified to take into account the features specific to the MACSTOR/KN-400 design [3]. These CATHENA models can provide the vertical storage cylinder and concrete temperature distribution created by the air flowing upwards. Only the storage cylinder temperature near the top is used for fuel oxidation assessment.

2.2 Calculation Tasks

The evaluation of the total fuel oxidation first requires calculating the fuel bundle heat release, followed by an evaluation of the fuel temperature for the initial cooling period (6 years). Using the fuel temperature and a fuel oxidation model developed by AECL, the oxidation rate at this temperature is then obtained. Multiplying the rate by the time increment provides the oxidation over the period. The process is repeated for each time increment considered and the oxidation integrated over the entire service life of the facility. Supplementary effects from postulated events are then considered.

As the heat release from the spent nuclear fuel decreases over the storage period, the fuel temperature decreases with time. The fuel oxidation rate is greatly influenced by the temperature reached by the stored fuel and decreases quickly. Oxidation of Uranium oxide (UO_2) in air has an exponential behaviour: a fuel temperature decrease of approximately 8°C will reduce the oxidation rate by a factor of two. At the end of the storage period, the fuel heat release and fuel temperature have decreased significantly. Following 50 years of dry storage, the fuel bundle heat release decreases by a factor of approximately 3. This power reduction significantly reduces the fuel temperature that in turn reduces the oxidation rates by nearly two orders of magnitude, making further contributions negligible thereafter. The fuel temperature is also influenced by daily and seasonal ambient air temperatures variations. The oxidation rate can vary by one order of magnitude due to seasonal variations. It is thus important to consider ambient air temperature variations to correctly evaluate the total effect on the fuel. The temperature data is obtained from various historical air temperature statistics for the nuclear plant.

The fuel temperature evaluation is made by two separate heat transfer calculations: one to evaluate the temperature difference between the fuel and storage cylinder and one to evaluate the temperature difference between the storage cylinder and ambient air. The two results are then added to the ambient air temperature. Each of these two calculations would require a specific CATHENA simulation. An adequate stabilization of the concrete and fuel temperatures requires a computer simulation that may last several hours depending on initial conditions. The ambient air temperature variations over a year can be expressed from a set of degree-hours spanning from minus 12°C to plus 33°C, a span of 45°C. The evaluation of fuel oxidation over a 50 years storage period would thus imply 2250 temperature evaluations that would require 4500 CATHENA simulations to evaluate the fuel oxidation for normal operating conditions. Fuel oxidation analyses for off-normal and accidental conditions have to consider increased fuel temperature over a short period of time. Such evaluations are best made using monthly average ambient air temperatures that requires 12 fuel temperature evaluations

Table 2 Reference Fuel Bundle And Fuel Basket

PARAMETER	VALUE
Reference fuel cooling period	6 years for reference fuel
Fuel age spread in module	None (All bundles are conservatively assumed to have the reference cooling period)
Reference average fuel burnup	187.2 MWh/kgU
Bundle heat release for reference average fuel burnup	6.08 Watts
Reference maximum fuel burnup	290 MWh/kgU
Bundle heat release for reference maximum fuel burnup	9.76 Watts
Reference hot basket configuration	53 average burnup/power fuel bundles 7 high burnup/power bundles in a central cluster
Fuel basket heat release: • Average basket • Hot basket:	 364.8 Watts 390.6 Watts
Configuration of fuel bundle analysed for oxidation • Bundle condition • Bundle power • Basket power • Bundle position in cluster • Cluster position in basket	 • Defective (non-leaktight) • 9.7 Watts • Hot basket of 390.6 Watts • Center position in cluster • Near center

per year; such an approach would require of the order of 1200 CATHENA evaluations for each off-normal and accidental case. As the design of the MACSTOR/KN-400 evolves such sets of evaluations would be required for each design configuration considered. The above methodology would be prohibitively time consuming to perform, particularly for parametric calculations. Thus the fuel oxidation was obtained from simplified heat transfer models that were derived from detailed ORIGEN and CATHENA calculations and/or simplified models derived primarily from tests. Figure 3 provides an illustration of the relationship between the test programs, the calculations using detailed and simplified models used for the assessment. This paper describes the calculationnal methods used to perform the various fuel oxidation evaluations during the design phase of the MACSTOR/KN-400 module.

3. Fuel and Fuel Basket Reference Conditions

3.1 Reference Fuel Bundle and Maximum Fuel Basket Heat Release

The reference fuel is a standard natural Uranium CANDU 6 bundle that has benefited from a cooling period of 6 years. Table 2 provides the reference fuel bundle parameters. The MACSTOR/KN-400 is designed to dissipate a reference average power of 6.08 W per fuel bundle. This typically corresponds (for the reference burnup case) to a fuel bundle that has been cooled for approximately 6 years in the storage bay. Bundles do not all achieve the same burnup. The characteristics of a fuel bundle that has reached a high burnup are provided in Table 2. A CANDU 6 reactor typically produces less than 1% of such high burnup bundles. It would be unlikely that a larger number of high burnup bundles find their way into a specific fuel basket. To ensure that a conservative fuel oxidation assessment is made, the analysis considers off-normal loading conditions maximizing the fuel temperature in a fuel basket that would contain some high burnup bundles dispersed in the fuel basket. The series of tests conducted at AECL's Whiteshell Research Laboratories established that maximum fuel temperatures were obtained in a cluster of 7 high burnup bundles. Maximum fuel temperatures were also observed to reach their highest value when the cluster was located near the center of the basket. This occurs because the center position does not contain fuel as it is occupied by the center post used to lift the fuel basket.

3.2 Decrease of Fuel Bundle Heat Release With Time

The heat release of a fuel bundle decreases monotonically with time due to the disintegration of its radionuclides. The total fuel bundle heat release from fission and activation products is calculated using the ORIGEN code. The available heat release calculations were made for specific cooling periods representative of the service life of the facility. An accurate evaluation of the heat release for a specific cooling time can be obtained from interpolation from the reference calculations to limit the calculation time.

A simplified interpolation model of the type shown in the following Eq. 1:

$$Q_{\text{fuel bundle power}} = a + b * \exp^{(-cT)} + d * \exp^{(-eT)} \quad \text{(Eq. 1)}$$

is used, where T is the time expressed in years and the constants a to e are constants developed from the ORIGEN calculations. This model provides an accuracy in reproducing the ORIGEN data of the order of ± 0.5% over the time range. During the service life of the module, the fuel power decreases by a factor of approximately 3, resulting in a negligible oxidation rate within a decade after loading.

4. Oxidation Process of UO_2 Ceramic Fuel Pellets

Fuel bundles are made of 37 fuel elements that contain a large number of UO_2 ceramic fuel pellets sealed within a thin walled tube sheathing made of Zircaloy. The behaviour of an intact fuel bundle and of a non-leaktight fuel bundle is quite different from one another. The design of the MACSTOR/KN-400 is made to ensure that all (either intact or non-leaktight) fuel bundles operate at a temperature that is sufficiently low to conservatively prevent damage to the fuel bundle. The reference bundle conditions for which the weight gain is calculated, are listed in Table 2.

The behaviour of Zircaloy sheathing under an air cover gas has been studied during the development of Zircaloy sheathed fuels in the 60's and 70's. The MACSTOR/KN-400 is projected to operate the fuel at a maximum initial temperature below 150°C and decreasing thereafter. At those temperatures, there is no concern for the Zircaloy sheathing to fail due to oxidation in an air cover gas.

4.1 The UO2 Ceramic Fuel Pellet Oxidation Process

A bundle that is dry stored with a fuel element having non-leaktight sheathing may be susceptible to oxidation of the UO_2 pellets from the air (from the O_2 molecules) contained inside the basket. An intact fuel bundle will not oxidize and will not degrade at typical dry storage temperatures. A basket contains sufficient Oxygen to fully oxidize one or several non-leaktight fuel elements. When UO_2 oxidizes, it gains weight in the process. The weight gain provides a practical measure of the oxidation. For several decades, the UO_2 pellet oxidation process in air at various temperatures and conditions has been the subject of studies at AECL and at several other laboratories worldwide. The experiments of I.J. Hastings (an AECL researcher) and coworkers, involved exposing non-irradiated and irradiated UO_2 samples to air at various temperatures representative of storage conditions of CANDU fuel bundles.

The UO_2 oxidation is a multi-step process that can be summarized by the following reactions described in the following Eq. 2.

$$UO_2 \Rightarrow U_3O_7 / U_4O_9 \Rightarrow U_3O_8 \quad \text{(Eq. 2)}$$

Fluorite cubic type crystal — no volume change — swelling (orthorhombic)

The oxidation of UO_2 first proceeds by diffusion of Oxygen atoms in the UO_2 crystalline matrix producing U_3O_7 and U_4O_9 that have similar crystallographic characteristics (density and structure) to UO_2 . The presence of those materials in the pellet is of no consequence as it does not generate swelling and does not overstress the Zircaloy sheathing. The U_3O_7 /U_4O_9 materials then proceed through a slower process of nucleation and growth by oxidation to generate U_3O_8 . This rate of reaction is slower and requires a higher temperature to reach a given rate. The U_3O_8 phase has an orthorhombic crystalline structure that has a much lower density. The production of U_3O_8 thus results, when it occurs, in a significant swelling of the order of 25% to 30%. This swelling breaks the ceramic pellet into smaller pieces. As long as UO_2 converts only to U_3O_7 /U_4O_9, and U_3O_8 is kept in trace amounts, there is no further degradation expected to the fuel pellet and fuel bundle element sheathing. The complete conversion of the UO_2 to U_3O_7 /U_4O_9 would correspond to a weight gain of the order of 2% while a complete conversion to U_3O_8 would correspond to a 3.9% weight gain.

The general fuel safety criterion applied for dry storage is that no further degradation of intact or defective fuel sheathing should occur during the planned storage period. This conservative criteria is set to minimize the release of contamination inside the fuel basket and to ensure that fuel bundles can be retrieved from the fuel basket. To inhibit fuel degradation during storage, the strain on the fuel element sheathing has to be limited to below 2% to prevent opening of an already existing crack in the sheathing. This criterion is met when fuel swelling is limited to less than 2%, which occurs when about 15% of the ceramic would be converted to U_3O_8 [4]. This conversion corresponds to a fuel pellet weight gain of 0.6%. This weight gain is thus used as the limit criteria.

4.2 The UO_2 Weight Gain Model

AECL's laboratories and others in various countries have investigated UO_2 oxidation as a function of the temperature and irradiation level. The tests have indicated that over a wide temperature range the reaction rates generally follow an Arrhenius type reaction [4 and 5]. The chemical reaction rate is a positive exponential function of temperature. A simplified and conservative UO_2 weight gain model can be expressed by an Arrhenius type equation (such as Eq. 3), taken from [5]. This empirical equation is named the Hastings' equation, from the name of the AECL scientist, Ian. J. Hastings who developed the empirical model. The hourly weight gain can be expressed as:

$$\text{Weight gain per hour (\%/h)} = 1.53 \bullet 10^{10} \bullet e^{\left[-\frac{Ea}{RT}\right]} \quad \text{(Eq. 3)}$$

Where:

E_a = Activation Energy = 120 000 J/ mol;

R = Gas constant = 8.3145 J/°K – mol;

T = Fuel temperature in °K.

The reaction rate predicted by the equation generally doubles with an increase of approximately 8°C in the fuel temperature. The total weight gain over the entire 50 years service life of the MACSTOR/KN-400 module can be calculated by integrating (summing up) the incremental oxidation over periods of time. The ambient temperature data used for evaluation of normal operation are the degree-hour data that provides how many hours in a year the temperature was within a specific 1°C range. The integration is thus made over the range of temperature for the specific number of hours and the process is repeated for each of the 50 years of storage. The fuel bundle decay heat is conservatively assumed to have remained at its maximum during the entire year.

Over the years, the fuel temperature decreases due to the decay of radionuclides and the fuel oxidation rate decreases even more quickly as it decreases with a steep exponential function. Figure 4 illustrates the yearly weight gain and the cumulative weight gain as a function of the storage period. Most of the oxidation occurs in the first few years of dry storage. Storage beyond the first decade produces little extra oxidation. Storage beyond 50 years would produce a negligible increase in oxidation.

5. Fuel Temperature in MACSTOR/KN-400 Module

The temperature reached by the fuel in the MACSTOR/KN-400 storage module is the sum of:

- The ambient air temperature
- The storage cylinder to ambient air temperature difference.
- Fuel to storage cylinder temperature difference;

The ambient air temperature:

The actual yearly ambient air temperature data near Wolsong is used. The air temperature can be expressed as a set of degree-hour data that represents the number of hours the air temperature spends at a particular temperature. Alternatively, monthly average temperatures are used (with a small factor to correct for the effect of the different temperature database) for off-normal and postulated accidental events.

Storage cylinder to ambient air temperature difference:

The storage cylinders of a MACSTOR/KN-400 are laid out in a 4 by 10 array. The storage cylinders located in the two middle rows are surrounded by four other storage cylinders. This decreases the infrared heat dissipation capability and increases the temperature of the middle rows of storage cylinders. The maximum daily average temperature of the central storage cylinders has been calculated in the CATHENA thermal evaluation as 80.5°C [3]. Only the maximum storage cylinder temperatures that are reached near the top of the storage cylinder are considered. Since the fuel bundles decays with time, the storage cylinder temperature has been calculated for a set of reduced fuel bundle heat release, down to 2 Watts.

The CATHENA data results can be reproduced within an accuracy of 0.1°C using a simplified heat transfer model of the type $\Delta T = a\, Q_{HB}^{b}$ where a and b are constants derived from the results of the detailed CATHENA simulations and QHB is the hot basket heat release in Watts.

Fuel to storage cylinder temperature difference:

The temperature difference between the warmest fuel bundle in the test basket and the storage cylinder has been evaluated by a series of tests made at AECL's Whiteshell Research Laboratories at powers of 360 Watts (average bundle power), 390 Watts (various cluster position in hot basket) and 585 Watts (average bundle power). The temperature difference between the warmest fuel bundle in a hot basket and the storage cylinder can be modeled as the following Eq. 4:

$$T_f - T_{sc} = a\, Q_{HB}^{b} + c\,(Q_{HB}/390.56)^{d} \quad \text{(Eq. 4)}$$

Where values a to d are constants developed from the test data, and:

T_f : is the fuel temperature in (°C);

T_{sc} : is the storage cylinder temperature (°C);

Q_{HB} : is the hot basket power in Watts for a specific time period;

390.6 Watts : is the maximum hot basket power.

From Eq. 3, the fuel to storage cylinder temperature difference can be obtained for the hot basket power reached during the various years of the storage period.

6. Fuel Weight Gain

The fuel weight gain can be evaluated by integrating the Hastings equation over the entire dry storage period using the methodology depicted in Figure 3. A sub-integration cycle is made for each year of storage. The fuel bundle heat release for a particular year is calculated separately and is conservatively kept constant during the year at its maximum initial value.

For normal operation of the module and normal ambient air temperature conditions, the integration of the lifetime oxidation results in a 0.13% weight gain (see Figure 4). A slightly higher total oxidation is reached when accidental conditions are postulated.

A parametric evaluation of the safety margin has been made to evaluate how the safety margin varies until the fuel oxidation limit is reached. The fuel temperature can be increased by increasing the fuel basket power until the maximum allowable fuel weight gain of 0.6% is reached. Results are shown in Figure 1. The maximum initial temperature that would still be acceptable for the MACSTOR/KN-400 storage module to safely store the reference spent fuel is 169°C assuming normal and off-normal operating conditions. A similar parametric evaluation has also been made

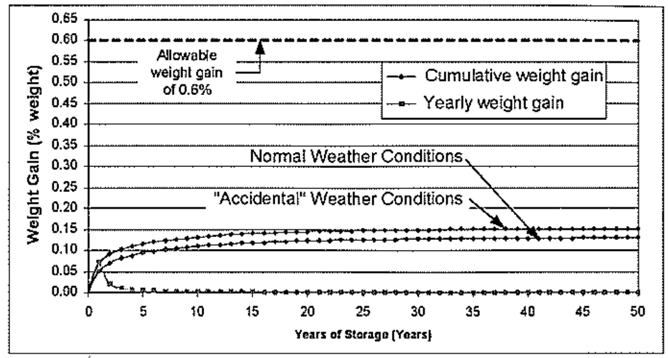

Figure 4 MACSTOR/KN-400 Fuel Weight Gain as a Function of Time

for accidental conditions and indicates that such events would not significantly decrease the maximum allowable initial fuel temperature, as indicated in Table 3.

The MACSTOR/KN-400 design thus provides a fuel temperature margin of 19°C with respect to the allowable initial fuel temperature. This indicates that it is not essential to evaluate the fuel temperature to a substantial accuracy as the design provides ample temperature margin. Thus the accuracy of the heat transfer models is not critical to support the conclusion that the fuel safety is unaffected by the use of air as the cover gas. Table 3 provides a summary of the data from the Wolsong site specific fuel weight gain analysis for the MACSTOR/KN-400 storage module assuming the fuel has gone through normal, off-normal and accidental storage conditions. The table also provides the maximum hot basket power at which it is safe to store the fuel.

7. Off-normal and Accidental Thermal Conditions

The MACSTOR module is equipped with 10 large capacity air inlets and 12 large capacity air outlets. Cooling of the fuel is made by passive means that do not require active devices or power. The postulated temporary blockage of one air circuit air inlets and outlets by debris can be considered credible during the lifetime of the facility. Such an event would be classified as an off-normal event and would be a thermally benign event that would be bound by the accidental air flow blockage event. The worse case accidental cooling condition that is considered credible consists of a 100% blockage of all air inlets on one side of the module for 5 days. Such a blockage has been analyzed with the CATHENA code and would increase the fuel temperature by 4°C. This very small effect is simply due to the high degree of redundancy built into the passive cooling air paths. It is thus expected that large ambient air temperature variations over an entire summer will have a more significant effect on fuel oxidation. The postulated off-normal weather event consists of 3 consecutive summer months with record ambient air temperatures. The available weather data indicates this event corresponds to an ambient air temperature increase of 3.8°C but for a 3 month period.

Table 3 Summary of Fuel Oxidation Results for a Non Leaktight Bundle

Ambient Air Temperature Conditions	Normal	Off-Normal	Accidental Ambient Air Temperature Conditions
Total fuel oxidation reached (% weight gain)	< 0.13%	< 0.14%	< 0.15%
Safety factor	> 4.6	> 4.3	> 4
Maximum initial fuel temperature for reference conditions of 40°C peak daily temperature – hot basket power varied	> 170°C	> 169°C	> 168°C
Ambient air temperature margin	≥ 17°C	≥ 16°C	≥ 15°C
Maximum power of hot baskets	> 482 Watts	> 478 Watts	> 472 Watts

The postulated worse case "accidental" weather event consists in 12 consecutive months with record ambient air temperatures. Such an event however translates into a relatively small increase in the overall fuel oxidation as seen in Figures 1 and 4. The MACSTOR/KN-400 design thus maintains large safety factors before the 0.6% weight gain limit would be reached even when worse case events are postulated to occur.

8. Conclusion

This evaluation of the fuel weight gain indicates that there is ample margin to protect the reference fuel against degradation. The storage of the reference fuel in the MACSTOR/KN-400 during the planned 50 years of storage is thus safe as long as the total power of a postulated hot fuel basket does not exceeds 478 Watts. This power cannot be reached by spent fuel generated by the Wolsong 1 reactors that has been cooled for at least 6 years.

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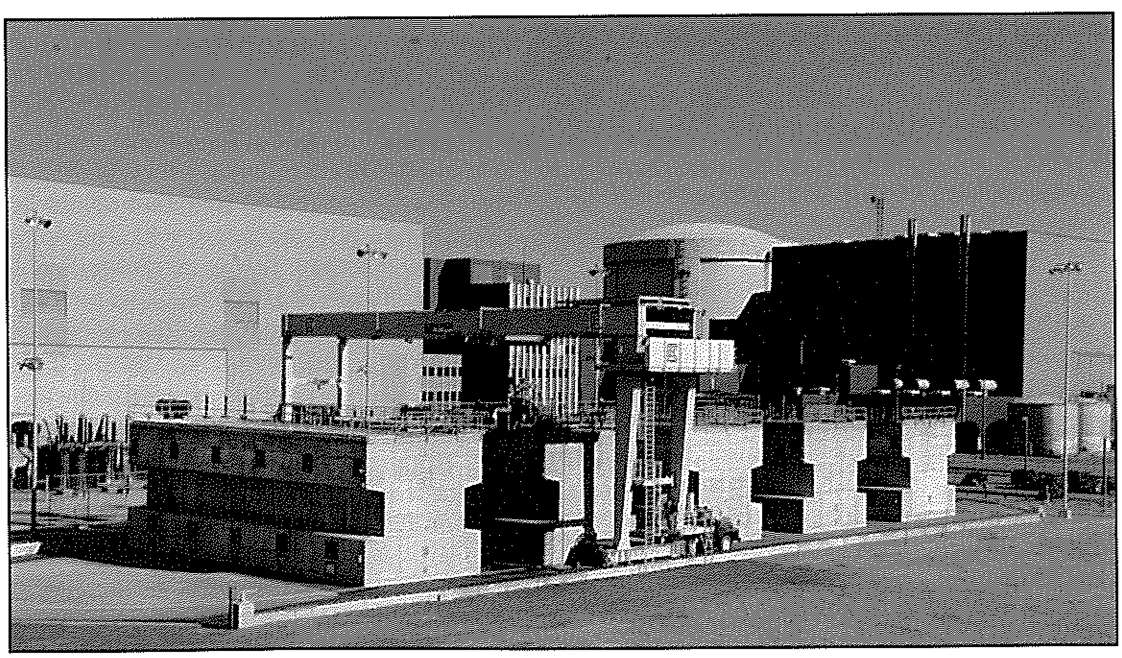


A view of the MACSTOR units at Centrale Nucléaire Gentilly

CNA's Nuclear Industry Seminar 2005
- changed venue, modified program, record attendance

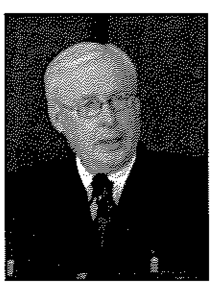
Whether it was due to the changed venue, a modified program, or the renewed interest in nuclear, or all three, this year's Nuclear Industry Seminar held by the Canadian Nuclear Association drew a record attendance of close to 500.

The Seminar, with the theme *"The Nuclear Renaissance - Powering Up"*, was held on the evening of March 9 and all day March 10, 2005, at the Westin Hotel in Ottawa, a change from the past several years,. It was accompanied by an exhibition with displays from many of the organizations associated with the Canadian nuclear program. The program focussed entirely on nuclear power with some emphasis on the international scene and the relationship of nuclear power and environmental concerns.

On the afternoon of March 9 **Women In Nuclear Canada** (WIN Canada) took advantage of the gathering to hold its second annual meeting. (*See a separate report on that meeting in this issue of the* CNS Bulletin.)

The evening of March 9 was devoted to an excellent reception at which **John Efford**, Minister of Natural Resources Canada brought greetings and comments from his role as Canada's minister of "energy". He reiterated his remarks of a year ago that he was a strong supporter of nuclear energy and noted that the federal government is providing financial support for the development of the Advanced CANDU Reactor (ACR). He also noted that Canada was one of the first five countries to sign the International Generation IV Nuclear R & D Agreement [along with France, Japan, UK, USA].

Looking to the future for nuclear power the Minister said, "We have the demand, we have the resource base and the capacity. The final crucial condition is public support. This has always been a challenge and is one that you must address."



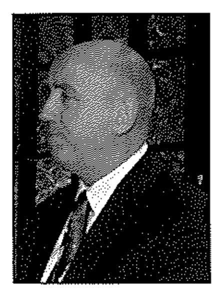
Prior to the actual seminar the next day there was a breakfast with a presentation by **Jake Epp**, chairman of Ontario Power Generation. He commented that the past year, since his appointment as chairman in April 2004, had been "challenging". OPG is being renewed, he stated, including the appointment of a new Board of Directors on which there are four members with nuclear experience. (*See the last issue of the* CNS Bulletin, *Vol. 25, No. 4, December 2004, for an article on those appointments.*)

OPG has been under a microscope, he noted, referring to the Manley report that cited the cost and schedule overruns on the rehabilitation of Pickering unit 4 and the KPMG review that concluded that the project, and the earlier nuclear performance improvement program, jeopardized the financial future of the company. In contrast, he said, the rehabilitation of Pickering unit 1 is essentially on cost and schedule with a predicted completion date of July and cost of $1 billion.

Operation has improved, he reported, especially at Darlington, as have relations with the regulator (the Canadian Nuclear Safety Commission. A few years ago CNSC had limited the term of Operating Licences to 6 months, he commented, now OPG is seeking a five-year licence for Pickering A, similar to those for Darlington and Pickering B.

Referring to the importance of people he noted that OPG's nuclear operations employs two thirds of OPG's total staff while it produces 40% of the electricity generated. He acknowledged improved relations with unions and noted OPG's support for universities and colleges. In closing he expressed appreciation of the work of senior management (several of whom were in the audience) and of all OPG employees. (*The full text of Jake Epps' presentation is reprinted in this issue of the* CNS Bulletin.)

Murray Elston, president of the CNA, opened the official program, which, unlike previous years, had only eight main speakers. He then turned the chairmanship of the morning session over to **Duncan Hawthorne**, president of Bruce Power and chairman of the CNA. Hawthorne introduced a video presentation by **James Lovelock**, an author and Visiting Fellow at Oxford University. Lovelock originated the Gaia theory in which he considers the surface of the earth, with its atmosphere and biosphere as a single self-regulating organism. Lovelock was unable to attend in person because of poor health and offered to present his talk by video.



Global warming presents dire consequences, he stated, noting the slow progress on the Kyoto accord. "Green" energy sources are not sufficient to meet our needs, Lovelock asserted, we need appropriate nuclear energy. He asserted that nuclear energy could buy time in our fight against global warming. (*An extract from his talk was published in the Globe and Mail newspaper as an OpEd piece on March 10 and the video can be seen on the CNA website* <*www.cna.ca*>.)

He was followed by **Anne Lauvergeon**, chairman of the executive board of AREVA, the huge French nuclear conglomerate, who began with an overview of her company, noting the two main subsidiaries in Canada, Cogema and Canberra. AREVA has sales of $18 billion dollars annually and employs about 70,000, she reported.

Although new plants are proceeding or planned in several countries such as China, Japan, Finland, France she commented that not everyone was convinced about the need or appropriateness of nuclear power. Political leadership and public support are needed, she said. Noting Ontario's decision to close its coal-fired plants, she observed that, on a mid-term perspective, it paved the way for new plants to be built. "I trust Canadian utilities will have several technologies to choose from", she said, and mentioned the EPR design being built in Finland and France.

To a question she commented that she was impressed with the approach taken in Finland both for the decision to build a new nuclear plant and the process for waste management.

Next was **Joe Colvin**, who was introduced as "President emeritus" of Nuclear Energy Institute, having very recently retired from the role of president and CEO. There is considerable optimism within the nuclear community in the USA, he reported. In less than a decade there has been a remarkable improvement in the operation of US nuclear plants, he noted, Together with upratings this has resulted in added generation equivalent to the output of 18 new plants. Noting that the US Nuclear Regulatory Commission had originally issued licences for 40 years, he stated that 30 plants have received licences for extended life, with 18 under review and 23 proposed. He acknowledged that the USNRC had streamlined its process and was now approving licence extensions in two years.

Colvin claimed that public support was greater than most of us perceive and is greatest near existing plants. The risks associated with licensing and financing are improving but there is still concern about future markets. Nevertheless, he said, there are 19 corporations looking seriously at new nuclear plants. "I expect a new proposal in 12 to 18 months", he said in closing.

Elston then introduced **Linda Keen**, president of the Canadian Nuclear Safety Commission, noting that she had just been elected president of the Third Review Meeting of the Convention on Nuclear Safety to be held this year. She

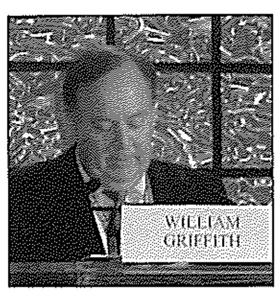
is the immediate past-president of the International Nuclear Regulators Association.

Keen began with reciting the challenges she presented at the 2004 Seminar: provide specific input; develop a strategic communication plan; develop standards beyond regulatory requirements. The progress on the last two has been poor, she said. She then referred to the pressures on the CNSC, noting the demands of various stakeholders: government; international; industry; and the public who, she stated, are the CNSC's primary clients. She then reviewed progress in various areas: nuclear power plants, nuclear medicine, uranium mines and mills, waste management, safeguards. (*The prepared text of Ms. Keen's presentation is reprinted in this issue of the* CNS Bulletin.)

The luncheon speaker was **Jesse Ausubel**, director of the Program for Human Environment, and a senior research associate at the Rockefeller University, who titled his talk, "Renewable and Nuclear Heresies". So called "renewables" are not really "green", he asserted. After noting the "decarbonization" of energy sources through increase of the hydrogen to carbon ratio, he showed the immense land space that would be required for biomass, wind, or solar to supply all of our electricity. To a question he commented that because nuclear is too identified with electricity other applications should be sought.

After lunch the first speaker was **Robert Van Adel**, president of AECL, who gave a strong recital of his company's capabilities. AECL has a total life cycle approach, he said, involving: refurbishment; reactors; services; waste management; and delivery capability. He showed an illustration of retubing machines taken from a 30 minute video.

He noted that while other vendors may offer one-off projects they do not provide on-going benefits to Canada such as sustaining the domestic industry. To keep the new build option open we must start the approvals process now, he asserted. Starting a site-specific environmental assessment now could make a convincing public case for a new CANDU plant. In his concluding remarks he stated, "It is my firm belief that Canada will remain CANDU country."



William Griffith, vice-president of Bechtel Power Corporation, provided an overview of nuclear activities in countries around the Pacific basin, which he named as: USA, Canada, Mexico, Japan, China, Korea, Taiwan and Russia.. This is the greatest growth market for nuclear , he commented, with 20 units under construction and between 40 and 60 units planned. He gave operation data showing capacity factors ranging from 64% for Canada to 92% for Korea and the USA.

He then went into some detail on the situation and prospects in USA, Japan, Korea and China. US plants have had outstanding performance, he stated, but no new plants are planned. Japan proposes 11 new units by 2011 but is facing public opposition because of a series of accidents and incidents. Korea has 18 units operating and 8 under construction, including two 1400 MW plants of Korean design. China has issued an invitation to bid on 8 units to three foreign companies: Westinghouse; AREVA / Framatome; and Atomstroexport of Russia, with a decision scheduled for the end of 2005.

In closing he repeated the dominance of the area in nuclear construction. Many of the countries are striving to be less dependant on energy imports, but all are facing the need to resolve the spent fuel disposal issue.

The final speaker, **Philip Prince**, president of the Canadian Energy Research Institute, began by noting that a new review of energy in Canada by his institute would be issued soon. He observed that if all the world used as much energy per capita as in North America the world's energy consumption would increase by five times. After briefly surveying various energy sources he concluded with these "guesses" for the future:

- oil production will peak then decline
- gas production will grow in the short term, peak, then decline
- coal production will remain stable
- all fossil fuels will increase in price
- there will be more stringent environmental rules
- renewables and nuclear will face off.

Following a brief closing message from CNA president Murray Elston the remaining delegates gathered for final conversations while enjoying the closing reception.

Several companies and organizations provided significant support through sponsorships; such as AECL for the opening reception, AREVA for the lunch, Bruce Power for the breakfast. Other sponsors were: OPG, Wardrop, Babcock & Wilcox Canada, Zircaloy Precision Industry, GE Canada, NB Power, MDS Nordion, Cameco, Aecon, Hydro Quebec, Kinetrics Ian Martin, Canatom NPM, Comstock, RCM Technologies, UOIT, Dameco and the CNS. Many of those had booths in the exhibition.

Scenes from the CNA Nuclear Industry Seminar 2005

Canada's Changing Nuclear Environment
– The Challenges Ahead for Canada's Nuclear Regulator

by Linda J. Keen

***Ed. Note:** Following is the basic text of the presentation by Linda Keen, President and CEO of the Canadian Nuclear Safety commission to the CNA 2005 Nuclear Industry Seminar held March 10, 2005 in Ottawa.*

As the title for your seminar implies – *The Nuclear Renaissance – Powering Up* – the Canadian nuclear industry seems poised to experience significant growth in all segments of the nuclear cycle and in virtually all areas where nuclear substances are used for industrial, medical or other purposes. And this growth has obvious implications for the Canadian Nuclear Safety Commission, as the regulator.

The CNSC exists to protect the health, safety and security of our client, Canadians, to protect our environment and to ensure that Canada's commitments on the peaceful use of nuclear energy are respected. It is the very essence of our mandate – and it's a commitment that we will never lose sight of whatever new growth or new demands are put upon us in the future.

I would like to outline for you some of the challenges that the CNSC faces as the industry moves forward on a path of growth and development, however I would like to take a few minutes to speak about three challenges that I put before the industry last year, at your Winter Seminar:

The first challenge was for the industry to provide specific input into the CNSC's planning process. Through our environmental scanning, we had identified a range of potential changes in the nuclear industry over the next ten years.

I explained last year, that as a regulator, our ability to respond to future challenges depended on a better dialogue with the industry on the specifics of your plans. And that only by having clear indications of where the industry is planning to make changes or additions could the CNSC plan to regulate these facilities effectively and efficiently.

I am pleased to report that we have received an excellent response by the industry. Individual licensees, under the protection of commercial confidentiality, have cooperated and provided us with full and appropriate details of their future plans. However, in most cases, the decisions regarding reactor refurbishment and new builds rest with respective provincial governments, and licensees are often not in a position to indicate to us their firm plans. This lack of concrete information remains the biggest area of uncertainty for the CNSC in planning for future projects, which would require significant planning, and significant resources.

The second challenge I put before the CNA last year was for your industry to develop a strategic approach to both proactive and reactive communications. The CNSC, as a regulator, cannot communicate on industry issues as we must remain neutral. Our role is, and must remain, to ensure that nuclear operations in Canada are safe and secure and this is what we communicate to our stakeholders.

In my opinion [CNA president] Mr. Murray Elston has been very proactive in addressing the issues that have been raised by the public. Communication and consultation are extremely important elements in winning and keeping the public's trust – in fact, I would say this is key to your future development.

I note however, that communication efforts by individual companies have been mixed. Some companies are very active in maintaining an ongoing dialogue in their communities – others are not. I would suggest to the CNA that there is more work to be done in benchmarking your members' communication activities and practices. You could benefit greatly in sharing with each other your best practices when it comes to your communications and consultation programs.

The communications efforts by individual companies have been mixed.

The third and final challenge that I put before you last year, was for the industry to develop approaches that exceed regulatory standards. The CNSC standard is the standard required for health and safety. I indicated that you should be striving to exceed this level in your day-to-day activities – a need for you to implement your own standards for safety and security, for environmental protection and for stakeholder engagement. I regret to say that my assessment of your success in this area is lower than in the other two areas. We are told that the industry is prepared, on a voluntary basis, to reach standards that would be in place with, or without the presence of the CNSC. Yet, in terms of progress, we see only modest steps of the industry working together to develop your own standards.

A positive sign is the industry response following the events of 9/11, which required a number of enhanced physical protection measures be implemented at major nuclear facilities. In order to achieve a standardized approach in implementing these new security requirements, the industry formed the Inter Utility Security Working Group. This group, which includes representatives from the nuclear power reactors and the major research establishments, has been meeting on a regular basis to discuss topics of mutual interest such as developing standardized approaches to physical protection measures as well as reviewing proposed regulatory security standards and guides. The CNSC has participated on a regular basis at these meetings.

Another positive indicator of industry moving to higher standards is the work of the CNA's Regulatory Affairs Committee on regulatory matters. The committee has become much more strategic and more proactive in working with our Regulatory Affairs and Operations groups. They have been working on areas where both the regulator and the industry have identified opportunities to improve our effectiveness and our efficiency. As an example your Regulatory Affairs Committee has prioritized several areas for future discussion with the CNSC.

However, more could be done, for example, in working together to have clear integrated plans on waste management.

Now, let me turn to the question of Nuclear Renaissance and share with you the challenges that confront the CNSC in this period of increased activity.

Here are some of the key pressures and decisions that both industry and government are facing:

Increased demand for electricity arising from economic growth, environmental pressures to pursue emissions-free electricity supplies as well as aging nuclear power plants have placed the restart and refurbishment of Canada's fleet of nuclear reactors high on industry and government's energy priorities;

The possibility of new fuel designs and fuel mixes;

- Rising prices and demand for uranium is resulting in accelerated exploitation of existing uranium ore reserves and exploration for new uranium resources;
- Governments and industry are addressing legacy waste issues by constructing nuclear waste management facilities;
- Facilities to treat cancer using nuclear medicine technologies are expanding as the population ages and cancer rates rise; and
- International obligations with respect to verification of the use of nuclear substances for peaceful purposes have extended to other facilities in the nuclear fuel cycle, and new verification measures have been introduced.

This represents our early assessment of potential industry developments.

Balancing Demands

The CNSC is faced with demands from four groups of stakeholders:

- government / parliament
- public and other stakeholders
- industry / licensees

All of these groups, including licensees, believe that their demands are the most important. What are those demands?

From Government/Parliament:

There has been an unprecedented demand from central agencies and Parliament for increased accountability. I believe the CNSC is well governed and we have illustrated this in all areas where we are accountable: from our financial and auditing obligations, to official languages, to human resources, to privacy matters, to access to information. This excellence and this high level reporting are not without cost in time and resources. The CNSC will endeavour, through proactive streamlined reporting such as our RPP and our Annual Report, to address these requests efficiently.

But, there is definitely a need by Parliament to see tangible reporting of accountability and good governance. The CNSC has shown its commitment to improving its effectiveness as reflected in the OAG's report released in February. The December 2000 report of the Office of the Auditor General stated that the CNSC needed to improve its regulatory regime to ensure that it continued to protect the health and safety of Canadians. In response, the CNSC embarked on an improvement program to address their recommendations but with the bigger objective of being "best in class." I am very pleased to report that the OAG released a report last month that was a follow-up to the 2000 findings and Mrs. Fraser, Canada's Auditor General stated in a press briefing that "the CNSC has made significant progress in acting on the recommendations we [the OAG] made in 2000 on the licensing and regulation of nuclear power reactors. She added "the [CNSC stood] out as an example of an organization that took [the OAG's] recommendations very seriously..."

I would also like to point out that the CNSC is very supportive of the Government's Smart Regulation initiative. The CNSC's regulatory regime will continue to evolve to meet new understanding of risks, changing expectations of governments and the public, and an expanding nuclear industry. As an independent regulator, the CNSC has been implementing the principles of smart regulation and will continue to do so.

The Public and other Stakeholders

And this leads me to the public - the Canadian citizens who are our only clients. They expect us to deliver on our obligations to protect their health, their safety and their environment with regards to Canada's use of nuclear energy and materials. They also want a greater opportunity to voice their concerns directly to decision makers as we licence and regulate nuclear activities. We have a limited budget to communicate widely with Canadians but we do undertake crucial communications activities for industry stakeholders including licensees, the public, interest groups and others. These include our web site and new publications on the CNSC.

The CNSC itself has been active this past year in meeting stakeholders, including community leaders, environmental groups and union officials, to assure them of our consistent oversight of the nuclear industry. Our Outreach Program is targeted to areas where we are able to identify clear value to our mandate. For the CNSC, outreach is communication with stakeholders on issues or information of mutual interest, listening to the views received, and acting where appropriate. This type of effective communication and consultation helps to achieve the CNSC's strategic objective of transparency and helps us work towards one of our goals of attaining public confidence in the nuclear regulatory regime's effectiveness.

From Industry/Licensees

Licensees have several expectations from the CNSC. These include:

- an efficient organization which carries out its responsibilities and respects the value of financial and human resources.
- an organization that provides a clear regulatory framework so that licensees have a clear understanding of our expectations.
- an organization that has been structured and is managed in such a way that it is ready to handle the necessary workload in a timely manner.

How is the CNSC responding to these industry/licensee expectations?

Nuclear Power Plants

In the area of nuclear power reactors, the CNSC has realized that the current management structure and processes would not provide the necessary support for our regulatory work. We have embarked on what I would describe as our largest and most ambitious improvement program since I became President of the CNSC more than four years ago. We have set in motion the development of the Power Reactor Regulation Improvement Program - or PRRIP – which was launched in November of last year. The first major initiatives of the program which involve major organizational and management changes will be completed by the end of this month.

The program focuses on five key areas:

- Planning and Reporting;
- Process Management of Compliance;
- Process Management of Licensing;
- Risk-informed Approach; and
- Information and communication.

Although there is a significant amount of work required in addressing these, we believe, and through our consultations with licensees, we know you believe, that this work is worth the effort to increase our effectiveness, our efficiency and our common approaches, which include the development of performance standards.

We expect that improvements in the power reactor program will continue for the next two or three years.

Nuclear Medicine

Licence applications from Class II nuclear facilities – principally cancer treatment facilities – have grown 86% over the past four years. We are expecting another increase of nearly 15% again this year. This increase is in response to increased funding by governments to reduce wait times for critical illnesses provided in the recent health accord. The use of nuclear substances for diagnostic purposes and procedures, which need to be reviewed and licensed by the CNSC, have also increased significantly.

Environmental Assessment

Two years ago, the CNSC began to streamline some areas of our regulatory oversight related to environmental assessments which resulted in an improved CNSC-CEAA program – the February 2004 *Canadian Nuclear Safety Commission – Guidelines for Environmental Assessments pursuant to the requirements of the Canadian Environmental Assessment Act.* Following that, we began two additional activities: the tracking of three projects against the revised CNSC-CEAA process and a comprehensive independent review of how the CNSC conducts environmental assessments. CNSC staff believes there is room for improvement within both the *Canadian Environmental Assessment Act* (CEAA) *and the Nuclear Safety and Control Act* (NSCA) and to that end, this will be discussed with the Commission at our March 23rd meeting.

New Reactor Projects

Although the CNSC has not received an application to licence a new nuclear power plant, CNSC staff have taken the unprecedented move of developing a new licensing basis, starting with the new document *Licensing Requirements for the Design of New Nuclear Power Plants* which will be finalized for trial use this year. This document is based on IAEA document NSR 1 and will provide clarity for the licensing of new and existing NPPs through a closer alignment of Canadian requirements with international practices and the adoption of a more risk-informed approach to licensing.

The CNSC is prepared to engage in technical reviews such as the current AECL Advanced CANDU Reactor (ACR) which will provide a statement indicating whether there are any significant issues that would potentially prevent granting a licence to prepare a site, construct or operate such a reactor in Canada. This statement will also indicate under what conditions a licence could be issued, if technical issues were identified. To the extent practical, all reviews are conducted against a new set of technology-neutral requirements developed by CNSC staff and final choices will remain with the operator. The regulatory review is paid for by the vendors.

Uranium Mines and Mills

For mining projects the CNSC has decided that it must devote more resources to project planning so that we can continue to document the progress and proposed schedules on mining projects. In the long term, it will result in a more formal record for consultation and tracking of progress, to identify what is working well and determine the areas where either the CNSC or licensees need to improve effectiveness. This development is in response to a lack of clear understanding by the licensee of the regulatory oversight requirements and of our timelines.

Waste Management

In the area of waste management, we could see over the next few years, some large projects that will place heavy demands on regulatory planning and oversight. These projects could include the low-level and medium-level waste sites at Kincardine and the work at the Whiteshell and Chalk River Laboratories. Further work will also be needed at the Port Hope low-level waste site.

Also, the Nuclear Waste Management Organization's Draft Study Report will be released this Spring and will include the NWMO's recommendations to the Government of Canada and allow for public review and comment before the final Report and its recommendation are submitted to the Minister of Natural Resources Canada by November 15, 2005.

We lack in Canada a forum or mechanism to consider all areas of waste management. There is a need for clear integrated plans on how spent fuel and radioactive waste will be managed in order to ensure continued safety into the future. This must be consistent with the expectations laid out for Canada in the report from the *Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management.* I believe that key industry leaders share my view that the initiative to create and implement an integrated waste management strategy must be taken by industry, in cooperation with Natural Resources Canada.

International Stakeholders

Safeguards

In the face of almost daily media reports on the dangers of nuclear proliferation, it came as no surprise last month when Prime Minister Paul Martin recognized the "serious" nature of this threat in his remarks in Brussels to the Summit of NATO leaders. For this audience, the implication is clear: For nuclear energy programs to grow and to prosper, there must be confidence that all countries and all aspects of the worldwide nuclear industry are meeting their international commitments to use nuclear energy solely for peaceful purposes. Canada is subject to this enhanced scrutiny in ensuring peaceful uses of nuclear energy.

The CNSC is responsible for implementing the necessary regulatory systems to ensure that the Government of Canada's international obligations are respected in this regard. For a country with significant export in nuclear materials and radioactive substances and with a significant domestic dependence on the supply of electricity from the peaceful uses of nuclear energy, we cannot afford complacency.

From the front-end of the nuclear fuel cycle to nuclear power plants and waste management facilities, both the CNSC and industry must design better approaches to meet our needs for a national safeguards system that is better than present approaches, that is a made-in-Canada solution and that meets our international obligations.

Convention on Nuclear Safety

As you may know, I was asked by my peers in the international nuclear regulatory community to accept the appointment of the Presidency of the Review Meeting of the Convention on Nuclear Safety to be held in Vienna next month. It was an honour for me to accept this nomination, but more importantly, I feel it is a validation of Canada's long history of commitment to ensuring a safe nuclear regime. I wish to state the importance I place on Canada being ready to subject itself, both regulator and industry together, to the rigorous peer review of the other 58 signatory countries to the Convention.

Canada's delegation will be led by the Director General of Power Reactor Regulation, Ian Grant, and will involve industry as well. Canada has already placed its report and the answers to the peer questions received from the other delegations on the CNSC Web site and also linked this information to the IAEA Web site in Vienna. And for the first time ever the head of Canada's delegation will hold a press briefing at the end of the meeting to discuss with the media the results of our peer review. I want to state clearly to you that my vision for this Convention and for this process is one of transparency. I fervently believe our willingness to be transparent throughout this entire process will determine how citizens of Canada and citizens of the world perceive us and whether the public is prepared to confide their trust in us.

I have tried to briefly outline for you the many issues that face the CNSC as a result of licensee activity and expectations. To get a more comprehensive view of the CNSC's plans for the next few years, I encourage you to obtain and read a copy of the CNSC's 2005-2006 Report on Plans and Priorities when it is tabled in Parliament later this spring.

The CNSC

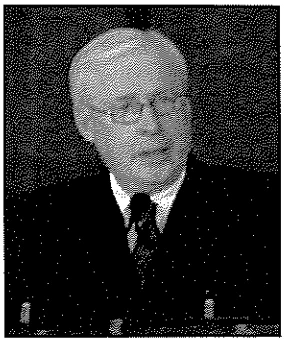
As you can see, we have many demands from our various stakeholders. The CNSC's vision, strategic objectives and work plans all seek to find a balance between these multiple and sometimes conflicting demands.

The growth in nuclear activities that I have described to you today is placing pressures on the CNSC that cannot be met with existing resources. The CNSC will be seeking to address these pressures. It is a vigorous and challenging agenda for the CNSC. Allow me to conclude my remarks by saying I strongly believe that the CNSC is a world-class regulator that is prepared to meet international standards, that is prepared to commit to effectiveness without equivocation, yet still maintain clear objectives of transparency, efficiency and continuous improvement. The CNSC's vision and strategic objectives have a purpose. That purpose is to ensure safety.

For further information on the CNSC go to its website <www.nuclearsafety.gc.ca>

OPG Chairman Reports on Nuclear Progress

Ed. Note: Following is a slightly edited version of the text of the presentation by Jake Epp, Chairman of the Board of Directors of Ontario Power Generation to the CNA Nuclear Industry Seminar, March 10, 2005, in Ottawa.



Jake Epp

Introduction

The past year at Ontario Power Generation has been challenging, intense, and generally positive. We are in the process of renewing OPG. This includes the creation of a new Board, which is almost fully constituted. We now have 11 of 12 Board members in place who bring to the company impressive business credentials, including significant nuclear operating experience.

OPG's three major priorities over the past year have been cost control; Pickering A Unit 1 return to service; and improving the performance of our generating stations. They remain our priorities today.

We generate electricity from nuclear, hydroelectric and fossil-fuelled stations. Nuclear generation represented 40 per cent of our production in 2004. Almost two thirds of our employees work at our nuclear stations, or directly support them. Nuclear is an area of our business where we have made improvements, but where there are further opportunities to improve.

Efficient and safe nuclear operations are key to our success. Good nuclear performance is also extremely important to the province. Ontario is the engine of the Canadian economy, representing more than 40 per cent of the country's GDP. Over the next few years, the province will need more power, to support its growth and to replace coal-fired generation, which the provincial government intends to phase out. Ontario needs nuclear power to help keep the price of electricity competitive.

OPG's nuclear generators are very well positioned to help the province meet its electricity needs – by increasing production from our existing stations; by returning laid-up units to service; and by rehabilitating and extending the lives of the stations as they reach their current retirement dates.

Our priorities remain: cost control; return Pickering A-1 to service; improve performance.

A successful nuclear program puts safety first, and then seeks to maximize production while controlling costs. A successful program is also socially responsible.

The new regulated price for the output from our nuclear stations makes these nuclear objectives even more important. Our facilities will receive a price of $49.50 per megawatt hour. We have a clear motivation to keep the lid on costs and to continually improve our production of terawatt hours, while also maintaining good public and employee safety performance.

OPG will also eventually be subject to annual public reviews of our costs and our operations. We welcome a new emphasis on openness and transparency.

Progress

To review the progress we have made towards becoming a successful nuclear operator I'll begin with a brief discussion of our 2004 results and some early results for this year to date. Then I will give an update on how we are meeting our commitments on the Pickering Unit 1 return to service. I'll conclude with a few comments on our efforts to reach a social consensus on the question of nuclear waste management.

A year ago, OPG was under the microscope. We were responding to the recommendations of the Pickering A Review Panel, which I chaired. We were also working with the OPG Review Committee, chaired by the Honourable John Manley, whose mandate included a review of the potential return of Pickering Unit 1. I also served on this panel, along with former Scotiabank Chairman Peter Godsoe.

The two reviews clearly highlighted the poor performance of the company's nuclear operations, and each focused on cost and schedule overruns at the Pickering A Unit 4 return to service project.

Another review of OPG, this one by KPMG early in 2004, looked at how the company's poor performance in the nuclear area – specifically the Pickering A Unit 4 project and the nuclear performance improvement program initiated in 1997 – had jeopardized the financial future of the company.

It was clear from all these reviews that we had to improve our nuclear operations – specifically in the areas of production and cost control – while maintaining our already very good safety performance.

Our 2004 nuclear results show that we made some very good progress.

Production was up at each station. Darlington led the way with an increase of 7 per cent in electricity production, and a capability factor of 87.5 per cent – up from 81.7 per cent in 2003. Darlington Unit 2 led all Canadian nuclear units in terms of capability factor, at 96.2 per cent. Darlington Unit 4 was only slightly behind, at 95.1 per cent. The Darlington station had the highest capability factor of any multi-unit nuclear station in Canada last year.

Pickering B increased production by 4 per cent, and increased its capability factor from 67.5 per cent to 69.7 per cent in 2004. Unit 5 had a very good year with a capability factor of 92.6 per cent.

Last year was the first full year of operation for Pickering A Unit 4 since it was returned. Its capability factor improved from 70.3 per cent for the last four months of 2003 to 73.3 per cent last year, indicating that we are getting the kinks out after the long shutdown.

Our biggest challenge is to improve our forced outage performance

Our employee safety performance was strong again last year. Both the Accident Severity Rate and the All Injury Rate, which measure days lost and frequency of injury, were solidly in the top quartile according to Canadian Electricity Association statistics. As of early this week, Pickering A Unit 4 has gone more than a year, and Darlington almost a year, without a lost time accident. Pickering B had a lost time accident last month, but before that it went close to a year and a half without such an occurrence, its best safety performance ever.

We now have a much better understanding of the material condition of our stations, following a comprehensive inspection program. We track the physical condition of each major system through each station's Plant Condition Index. We have a good handle on where we need to invest money in routine maintenance and during planned outages to improve performance.

Our biggest challenge is to improve our forced outage performance. Last year we improved performance on planned outages. While the number of planned outage days exceeded our business plan, this was mainly because we advanced fuel channel work into the 2004 planned outages. Without the added work, we were close to delivering the planned outages on schedule and cost. That's better than previous years.

Our goal is to fix the equipment that needs to be fixed, and to eliminate other problems that cause forced outages. At Pickering B, for example, we have developed more than 3,000 work orders that are ranked in order of importance. Each one is to be completed over the next three years. This will lead to more dependable and predictable performance.

Our employees know that this is a destiny issue for them. If we can get the performance at each station to where we want it, then we can make a case to extend the lives of the stations. If we fail, then our Board and our shareholder are unlikely to authorize investments in life extension.

Across the nuclear business, our employees have improved their performance over the past three years, as measured by a human performance metric we employ. The number of human performance events – in other words, errors that can lead to lost production – continued the steady decline achieved over recent years, and amounted to only half the number expected in 2004.

Through our nuclear workforce planning, we have projected an increased rate of retirements as many employees reach retirement age. To offset the retirements, we have put in place a multi-year recruitment campaign for operators, maintainers, and engineers. We have also had some very constructive input from our unions in this very important issue.

In support of our workforce planning, we continue to build relationships with major universities and colleges. For example, we work closely with Durham College and the University of the Ontario Institute of Technology on the design of their courses, which prepare their students for a career in the electricity industry. We have also established six research chairs at Ontario universities, and with our industry partners we helped the universities to create a Masters degree in Nuclear Engineering. We are now attracting a number of top engineering graduates to OPG. They tell us they chose to work in the nuclear industry because of our emphasis on training and professional skills development.

I mentioned the support of our unions: Power Workers' Union; society of Energy Professionals; Canadian Union of Skilled Workers. The leadership of these unions is committed not only to its members, but also to the health and prospects of OPG going forward. In my conversations with the union leadership over the past year, I know that they fully understand the connection between strong nuclear performance and a strong OPG.

I also want to acknowledge the importance that we place on our relationship with the regulator, the Canadian Nuclear Safety Commission. Recently we applied for a five-year license for Pickering A, the same term that we have for Pickering B and Darlington. I recall that back in 1996 the performance at Pickering resulted in only a six-month license. In recent years, OPG has worked hard to improve the safety and operating performance across the nuclear fleet. We recognize that we have the principal accountability for nuclear safety. We also respect the oversight role of the CNSC, which encourages us towards continuous improvement.

A final area of nuclear performance that I want to address is cost control. In 2004, we delivered our program, including the additional outage work, while remaining below budget. We also decreased our cost of production in 2004. In the new, regulated price environment, cost management – while meeting production targets – will be the key to our financial success and the future viability of OPG going forward.

The performance of our nuclear stations for the first two months of 2005 has been encouraging. To the end of February:

- Darlington had a gross capability factor of 96.7 per cent,
- Pickering B was at 89.2 per cent (which is all the more impressive given that Unit 5 has been in a planned outage since February 10), and
- Pickering A Unit 4 was at 99.6 per cent.

Pickering A, Unit 1

Now I would like to turn to another area where we have made good progress – the Pickering A Unit 1 project.

During the first half of 2004, we completed all the necessary planning work for the Unit 1 return to service. In July, the Ontario government endorsed our Board's decision that we proceed with Unit 1. The target date for completion of all construction was June 1 of this year, and the total budget was $900 million.

As of early this week, we are 83 per cent complete. In November, we slightly revised our budget and schedule, with construction expected to be complete between early June and mid July, and the total budget forecast to increase by $75 to $100 million.

The push on budget and schedule resulted from delays in mobilizing the construction force during the busy summer construction season. We also experienced lower than expected productivity during the fall. As a result of the close partnership between management and contractors, productivity levels have improved significantly since then.

Our schedule continues to see commissioning beginning in the summer and for Unit 1 to be fully back on line in the early September to mid October period. Given the size and complexity of the project, and a certain amount of new work that has been identified during construction in the almost thirty-five year old Unit 1, we feel we have remained close to budget and schedule on this project.

This must be one of the most complex construction projects in Canada. The project consists of more than 20,000 construction tasks. We have purchased more than 18,000 unique parts, and almost 3 million individual parts. We are installing 204 kilometres of new electrical cable, and 26 kilometres of new pipe to house the cable. Our scaffolding includes 6 kilometres of ladders.

Pickering A is the oldest nuclear station in Canada, and was designed with much more equipment inside nuclear containment compared to later stations. This means that for many of the tasks performed in the project, our workers have to be protected from radiation. That makes the job tougher, and productivity lower. It takes a lot of time to suit up, bring materials through airlocks, and work while encumbered in a plastic suit and a breathing apparatus.

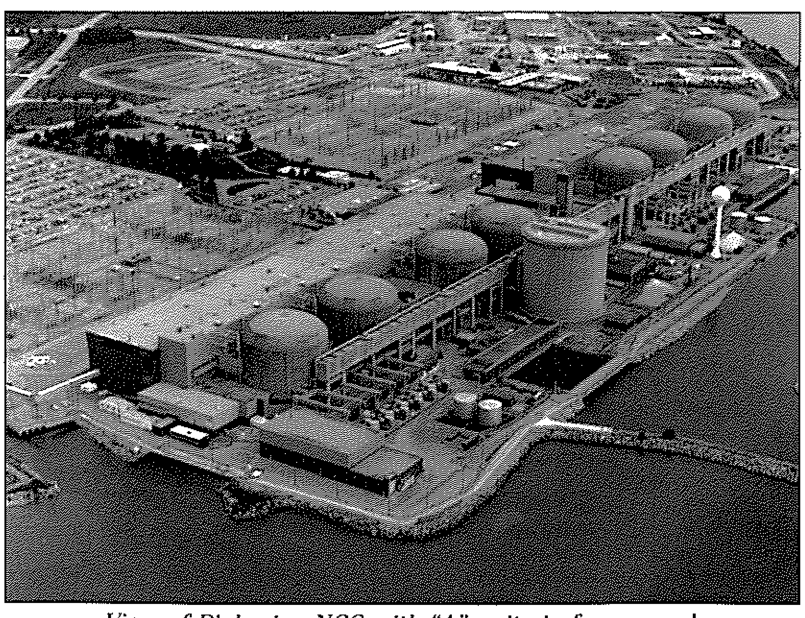
To ensure that we keep to the current budget and schedule, we have a very high level of project tracking and oversight at Pickering 1. This is one of the biggest changes in the Pickering 1 project compared to the earlier Pickering 4 project.

OPG's project management tracks progress using a number of metrics. The three main metrics are a Schedule Performance Index, a Cost Performance Index, and an Earned Value report. These are updated daily, and consolidated weekly, for management reporting.

The project's schedule, budget, and risks are discussed at weekly meetings involving the senior management of the company and the independent auditors. Project management and the independent auditors also make reports to each meeting of the Pickering A Oversight Committee of the Board, and the project is discussed in detail at each full Board meeting.

The next two months will be critical as we complete individual projects and begin to tie everything together. This is the most intense part of the schedule. Work areas are getting congested, as various crews converge to tie systems and equipment together. This makes scheduling and work execution a challenge.

We remain cautiously optimistic that we will have this unit operating in the fall. There are still risks, but we are managing them. The performance metrics that we have put in place for the Unit 1 project have



View of Pickering NGS with "A" units in foreground.

worked well. The determination of our project managers to execute the project has been unwavering. The teamwork and commitment of our employees and our contractors has been remarkable.

Social responsibility

A third area that defines nuclear success is demonstrating social responsibility. This is an area that we work hard on each day, especially at our station communities.

In the communities around our Pickering stations, for example, we have partnered with more than 225 local groups over the past three years. In the Darlington communities, our partnership has extended to 190 local initiatives over this period. We also keep community leaders informed about our activities, and we communicate regularly with our station neighbours through a newsletter and advertisements. We encourage our employees to be active in the community and to support local charities through our annual charity campaign.

> Waste management is a destiny issue for our industry

We also strive to have a positive economic impact on our host communities. In the Pickering community, for example, we recently opened a new office building near the Pickering stations. We are moving 400 employees from our head office in Toronto to be closer to the generating stations. In the process we are benefiting the local economy.

One aspect of our social responsibility I particularly want to comment on is the work of OPG and others in the nuclear industry to develop a social consensus on managing radioactive wastes.

There are two processes underway. The first is headed by the Nuclear Waste Management Organization, known as the NWMO, which is an entity set up under federal legislation and led by Elizabeth Dowdeswell. The NWMO's mandate is to consult the Canadian public, to propose approaches for the management of nuclear fuel waste, and to submit a recommendation to the Canadian Government on long-term used fuel management. This is a destiny issue for our industry.

Senior executives of OPG, Hydro-Quebec and New Brunswick Power constitute the Board of Directors. OPG is taking a strong interest in the work of the NWMO through our participation on the Board.

The second waste management process is unfolding in the host community of our Western Waste Management Facility, adjacent to the Bruce nuclear stations. The Municipality of Kincardine and OPG have completed a three-year study of alternatives for the long-term management of low and intermediate level waste.

This resulted in the selection of a Deep Geologic Repository as the preferred alternative, as well as an agreement between OPG and Kincardine to move forward to the regulatory review phase. The Municipality polled its residents and received a strong endorsement. I would like to congratulate the Mayor and his Council on their farsightedness in considering the health and well being of their community and working with OPG on this difficult issue. I would also like to thank the other communities involved for their participation and support.

Concluding comments

The past year has been generally positive. The progress made to date towards a societal consensus on the management of nuclear waste is certainly a major positive. Our experience on the Pickering A Unit 1 project, as we approach the final stages of construction, has been very good. And finally, we are encouraged by the improvements we have made in the areas of production, maintenance, and cost control at our nine operating nuclear units, while maintaining high safety levels.

I won't say that we have turned the corner yet. But I will say that we have achieved much over the last year that gives me hope and confidence for the future.

I would like to make two final observations..

- First, on behalf of the OPG Board of Directors, I want to express my appreciation to the senior management of the company, our nuclear executives and all our nuclear employees for the excellent job they have done over the past year.
- Second, I want to make a general observation about the Canadian nuclear industry.

Canada is a small country in population. Yet, despite our small size, we are home to a number of major, world class industries – industries such as telecommunications; financial services; transportation; resource exploration and development; and, of course, our nuclear energy industry.

Nuclear energy is a major Canadian success story. It's a homegrown technology. It has delivered significant benefits to this country in terms of jobs, economic growth, technological innovation and international prestige. It's been a source of vast quantities of safe, reliable, affordable energy that are free of emissions contributing to smog and global warming.

I urge you to continue to work together for the good of the nuclear industry. We all share a common goal – to ensure that nuclear energy continues to play a major role in meeting Canada's energy needs. That is an important and worthy task, and we at OPG are proud to be associated with it.

WIN Canada holds second meeting

Cheryl McCulloch speaks to the meeting of WIN Canada in Ottawa, March 9, 2005. The organization's new logo can be seen on the screen.

The fledging organization of Women In Nuclear Canada (WIN Canada) took advantage of the Canadian Nuclear Association's Nuclear Industry Seminar in Ottawa March 9 and 10, 2005 to hold their second annual meeting.

About 60 women and a smattering of men turned out for the gathering which was held on the afternoon of March 9, prior to the opening reception of the Seminar.

Susan Brissette, from Bruce Power, who is also a member of the Board of WIN Global, opened the meeting by welcoming everyone and quickly turned to the proposed Terms of Reference for WIN Cananda. Comments, she said were requested within a week. She then referred to the proposed "logo" (see photo) which quickly won approval on a show of hands.

She was followed by reports from the two WIN branches that have been established, at Bruce and at Darlington. Cheryl McCulloch reported for the Bruce group and went on to note that polls had shown the different approach of women to nuclear compared to men. In particular, she said, women are concerned about the potential effect on children. We must explain, she urged her listeners.

Helen Spencer reported for the group at Darlington, which now has 40 members. They have supported the relicensing of Pickering A, WIN Global to be held in the Czech Republic in April 2005 and the proposed WIN Global in Canada in 2006. The branch is concentrating on career development and outreach.

Yvette Amor, with Babcock & Wilcox Canada, gave an upbeat outline of plans for WIN Global 2006 to be held in Canada. The chosen venue is "Canada's Technology Triangle" centred on Cambridge, Ontario, and the dates, May 29 to June 2, 2006. Hotel space has been reserved and a number of tours and other events planned.

The meeting then broke into "brainstorming" to discuss four topics: speakers; sponsors; Canadian themes; Canadian nuclear landscape. The participation was enthusiastic giving the organizers many pages of ideas.

For more information on WIN Canada contact Susan Brissette, e-mail: susan.brissette@brucepower.com

Climate Change Technology:
Engineering Challenges and Solutions in the 21st Century

May 9-12, 2006 - Ottawa Congress Centre, Ottawa, Ontario Canada

Call for Papers

The Engineering Institute of Canada (EIC) and its member organizations (which includes the Canadian Nuclear Society) are organizing the 2006 EIC Climate Change Technology Conference - Engineering Challenges and Solutions in the 21st Century. This conference will examine engineering solutions that either mitigate, or adapt to, climate change.

Interested authors/panelists are invited to submit a proposal for a manuscript for presentation at a Paper or a Poster Session or for an electronic presentation to be part of a Panel Discussion.

Conference Tracks:

1. Policy, Strategy and Regulations; 2. Monitoring & Recording GHG Emissions and Climate Indicators; 3. Engineering for Mitigation (Reductions and removals of GHG.); 4. Engineering for Adaptation (Allowing for CC in infrastructure design); 5. Financial and Risk Management; 6. Continuing Education and Engineering Roles; 7. Standards and Protocols; 8. Modeling and Analysis.

Full information and guidelines for proposals are available on the Conference website: www.ccc2006.ca

GENERAL news

CAE sells power plant simulator business to L-3 MAPP

In February 2005 Montreal based CAE sold its Marine Controls Division to L-3 Communications. The new company will be headquartered in Montreal under the name L-3 Communications MAPPS Inc. (Marine Automation and Power Plant Simulation). CAE will concentrate on its aviation training and simulation business.

The business acquired from CAE has operations in the United States, the United Kingdom, Norway, Italy, India and Malaysia and is a leading global supplier of integrated marine control systems and products for warships, submarines and high-end ocean-going commercial vessels worldwide. Since 1973 the former CAE Power Systems and Simulation team has established itself as a leader in power plant simulators for the energy sector, with over 50 utilities worldwide benefiting from this technology. Most of the simulators for CANDU units around the world have been supplied by CAE, including the most recent one for the Qinshan station in China. (See the cover photograph.) The group has also upgraded numerous simulators.

The former CAE business unit will be transformed into a stand-alone company within L-3 Communication. MAPPS has retained the entire employee population (some 460+ people) that served the organization while part of the CAE group, and is hiring more personnel to support expected growth. This includes CAE's former executive vice president of the business unit (Mr. Rashid Khan), who is now president of MAPPS, and his entire management team. Other former CAE operations, now MAPPS units, are located in Bangalore (India), Burgess Hill (England), Drammen (Norway), Genoa (Italy), Leesburg, Virginia (USA) and Kuala Lumpur (Malaysia).

Headquartered in New York City, L-3 Communications provides intelligence, surveillance and reconnaissance (ISR) systems, secure communications systems, aircraft modernization, training and government services and is a merchant supplier of a broad array of high technology products. Its customers include the U.S. Department of Defense, Department of Homeland Security, selected U.S. Government intelligence agencies and aerospace prime contractors.

For further information go to the company's web site at www.L-3com.com/mapps

MOU and Agreement with China

In January 2005 David L. Emerson, Minister of Industry, Robert Van Adel, President and CEO of Atomic Energy of Canada Limited (AECL), Mr. Zhang Guobao, Vice Minister of China National Development and Reform Commission (NDRC) and of China National Nuclear Corporation signed a Memorandum of Understanding that will result in greater nuclear energy co-operation between the two countries. Canadian Prime Minister Paul Martin and Chinese Premier Wen Jiabo witnessed the signing. The MOU will establish a framework for collaboration on research and development programs, projects and activities aimed at furthering a basic understanding of nuclear energy and its applications, and improving cost and safety of nuclear energy systems. It will facilitate uranium resource development.

Two days earlier Atomic Energy of Canada Limited (AECL) and the Shanghai Nuclear Engineering Research and Design Institute (SNERDI) agreed to undertake joint programs in the development of advanced CANDU technology and products.

AECL and SNERDI will undertake the following:

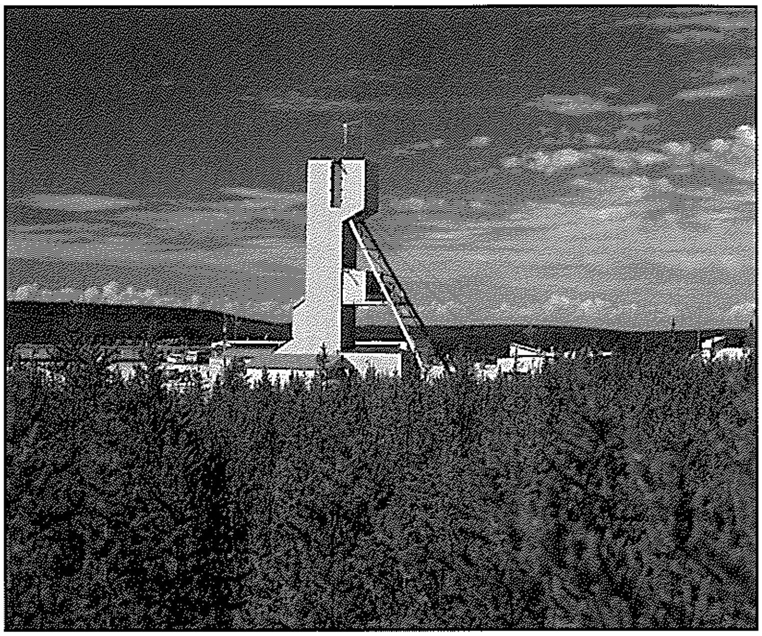
- joint engineering work on CANDU operational support areas including plant life management, maintenance, and inspection;
- cooperate on joint development projects on operation of CANDU reactors, including fuel management and fuel cycle studies for existing and future CANDU fuel designs;
- jointly refine and apply the advanced engineering tools used by AECL to engineering tasks in CANDU design, construction, and operation.

In 2003 SNERDI established a CANDU Engineering Centre (CEC) in cooperation with AECL to provide technical service for the Qinshan project and to participate in the design of ACR.

Cameco Proceeds with Cigar Lake Mine Construction

Cameco Corporation has announced that construction of the Cigar Lake project will begin this year. This is the world's second largest, high-grade uranium deposit after McArthur River.

Cameco will operate Cigar Lake on behalf of a joint venture consisting of Cameco (slightly larger than 50%), COGEMA Resources Inc., a subsidiary of AREVA (37%), Idemitsu Uranium Exploration Canada Ltd. (8%) and TEPCO Resources Inc. (5%). On December 20, 2004, the Canadian Nuclear Safety Commission (CNSC) announced that it had approved a construction licence for Cigar Lake located about 660 kilometres north of Saskatoon.



Located in northern Saskatchewan. Cigar Lake is the world's largest undeveloped uranium deposit.

Cameco anticipates construction will begin early in 2005 and take approximately 27 months to complete. Production could begin in 2007 followed by a ramp up period of up to three years before the mine reaches full production of 18 million pounds per year.

In making the development decision, the Cigar Lake joint venture approved a construction budget of about $450 million that includes surface and underground facilities at Cigar Lake as well as changes to the milling facilities at McClean Lake and Rabbit Lake. Cameco expects to fund its share of construction costs with operating cash flow and debt.

Initially Cigar Lake ore will be processed at the mill located at Cogema's McClean Lake operation, 70 kilometres to the northeast. As Cigar Lake production ramps up to full capacity, just over half of final uranium processing will be completed at Cameco's Rabbit Lake mill facility, pending regulatory approval.

During construction, a maximum of about 350 workers will be employed at the Cigar Lake site. Approximately 250 people will be permanently employed after production begins.

The Cigar Lake deposit was discovered in 1981. Test mine development began in 1987 and was completed in 2000. An environmental impact statement was filed with the relevant regulatory authorities in 1995. After a thorough environmental assessment, in April 1998 the federal and provincial governments accepted the recommendations of a joint-review panel and authorized the project to proceed to the regulatory licensing stage. In 2003, a further screening level environmental assessment was required before construction and operating licences could be issued. The environmental assessment study report was filed in February 2004 and accepted by the CNSC in July 2004, allowing the project to proceed to construction licensing.

AECL and MDS engage mediator for MAPLE

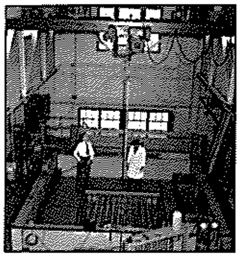
MDS Inc. and Atomic Energy of Canada Limited (AECL) have agreed to seek a mediated resolution of the issues related to the construction, commissioning and operation of the MAPLE facilities in Chalk River, Ontario. These facilities, when commissioned, will exclusively produce medical isotopes used globally for the diagnosis and treatment of disease.

Ontario Appeals Court Judge Stephen Goudge has been appointed as the mediator and will work closely with the two parties. The Government of Canada has agreed to have a representative be a formal observer in this process.

Robert Van Adel, President and Chief Executive Officer of AECL was quoted as saying, "We are entering into this voluntary mediation process with the spirit and intent of arriving at a satisfactory resolution to all of the outstanding issues and we look forward to the successful commissioning of the MAPLE reactors."

MDS Nordion, a subsidiary of MDS Inc., commissioned the design and construction of the two MAPLE reactors at AECL's Chalk River Laboratories to be dedicated sources of radioisotopes for medical use. The reactors have not yet gone into service and are five years behind schedule. The almost 50-year-old NRU research reactor has continued to supply the radioisotopes during this period.

ZEEP to be rebuilt at museum for 60th anniversary



This year, 2005, marks the 60th anniversary of the start up of ZEEP (Zero Energy Experimental Pile). On September 5, 1945 at the Chalk River Nuclear Laboratories, then part of the National Research Council of Canada, the small reactor sustained the first nuclear fission reaction outside of the United States. This event has come to be known as the beginning of Canada's nuclear program. ZEEP was decommissioned in 1973 and then further dismantled and put into storage in the late 1990s.

To commemorate ZEEP's 60th anniversary Atomic Energy of Canada Limited has arranged for the reactor to be partially reassembled at the Canada Museum of Science and Technology in Ottawa as part of its Mega Science exhibit, that opened in mid February. ZEEP will be unveiled in June and will be an important component of the Museum's collection for at least the next two years.

The Museum's website is:
http://www.sciencetech.technomuses.ca/

Mega Science and the ZEEP exhibit coincide with the 2005 World Year of Physics (WYP2005). Canada, along with countries from around the world, is hosting events to mark the year. 2005 was chosen in celebration of the 100th anniversary of Albert Einstein's three famous publications in physics: on the theory of relativity; quantum theory; and the theory of brownian motion. The Canadian Association of Physicists (CAP) is organizing Canada's WYP2005 events with fundraising and public awareness campaigns. AECL is a major sponsor of the event to bring recognition of Canada's significant accomplishments in physics over the last century.

To find out more about the 2005 World Year of Physics, visit http://www.cap.ca/wyp/aboutWYP.asp.

Canada signs Generation IV agreement

Canada was among the first five countries to sign in February 2005 a Framework Agreement for International Collaboration on Research and Development of Generation IV Nuclear Energy Systems. under the Generation IV International Forum, along with France, Japan, United Kingdom and the United States. Six other countries are expected to sign.

The Agreement is a significant step in the development of the Generation IV International Forum (GIF), a group whose member countries are interested in joining their efforts to carry out the R&D needed to develop the next generation of nuclear energy systems. The driving force behind GIF is to develop nuclear reactor designs for use beyond 2025 that address the challenges facing nuclear technologies today. Canada has played a prominent role in developing the policy framework and providing technical expertise and leadership.

The Framework Agreement, for which the Secretary-General of the Organisation for Economic Co-operation and Development (OECD) is the Depositary, allows the participating countries to move forward on joint research projects on the six reactor concepts that the GIF participants have selected for development. These are: gas-cooled; lead-cooled; molten salt; supercritical-water-cooled and very-high-temperature reactor systems. These advanced technologies offer the promise of advantages in the areas of economics, safety and reliability, sustainability, physical protection and proliferation resistance and could be deployed commercially by 2020-2030. Canada is taking the lead in the work on supercritical water-cooled reactors (SCWR).

The six other GIF members (Argentina, Brazil, Euratom, the Republic of Korea, the Republic of South Africa and Switzerland) are expected to accede to the Agreement in the coming months. Pending their accession, all GIF members will continue to participate in the group's activities over the next year.

The Nuclear Energy Agency of the OECD serves as Technical Secretariat to the Generation IV International Forum.

NRC President appointed

In February 2005, the Honourable David L. Emerson, Minister of Industry and Minister responsible for the National Research Council of Canada (NRC), announced the appointment of Dr. Pierre Coulombe as President of the National Research Council of Canada. He succeeds Dr. Arthur Carty, who was named Science Adviser to the Cabinet last year

As former Chairman of the Board and CEO of the Centre de recherche industrielle du Québec, Dr. Coulombe developed strong experience as a leader of a research organization committed to commercialization. In addition, he was President and CEO of Infectio Diagnostic Inc., where he helped showcase Canada's leadership in medical research and diagnostic technology, completing two rounds of private equity financing and negotiating major research contracts for the company.

In the public sector, Dr. Coulombe held the office of Assistant Deputy Minister (Technology) with the Government of Québec. He earned Bachelor degrees in arts and physics engineering, as well as a PhD in experimental medicine at Université Laval, and was Assistant Professor of Medicine at Université Laval.

CNSC Responds to 2005 OAG Report

The February 2005 Report of the Office of the Auditor General of Canada stated that, "The Canadian Nuclear Safety Commission has responded to our observations and informs us that it is continuing with the improvements it began in response to the December 2000 recommendations." The Report also states that, "Overall, the Canadian Nuclear Safety Commission has made satisfactory progress in response to our recommendations from our December 2000 audit of power reactor regulation."

The December 2000 report recommended areas where the CNSC needed to improve its regulatory regime for power reactors to ensure that it continued to protect the health and safety of Canadians. The report made a number of recommendations for improvements.

The OAG conducted a follow-up audit in 2003-2004 to assess the progress the CNSC had made to improve the regulatory regime for power reactors since the 2000 audit. The follow-up audit notes that the CNSC has made satisfactory progress in responding to almost all recommendations stemming from the 2000 audit.

On the OAG's recommendation to implement a systematic, risk-informed approach to the regulation of power reactors, the CNSC states that it is achieving steady progress in the area and an improvement plan to implement a risk-informed approach to power reactor regulation will be prepared by March 2005.

The CNSC further stated that it recognizes that there is room for further improvement and that it remains strongly committed to ongoing improvements in all areas of regulation within the CNSC's mandate. The CNSC's plans are contained in its Report on Plans and Priorities and are reported to Parliament in its Annual Report.

To obtain a copy of the 2005 Report of the Office of the Auditor General, visit http://www.oag-bvg.gc.ca/domino/reports.nsf

CNSC invites comments on proposed documents

The Canadian Nuclear Safety commission has issued, for review and comment, a list of proposed regulatory documents the list sets out the purpose and scope for the proposed documents.

In March 2004 the CNSC published a list of High Priority Documents. Since then three additional proposed regulatory documents were added to the list:

- P-324 Safety Goals for Nuclear Power Plants
- P-325 Nuclear emergency Management
- P-336 Reporting Requirements to Satisfy IAEA Safeguards and Canadian Nuclear Non-Proliferation commitments

Three regulatory documents were published:

- S-260 Making Changes to Dose-Related Information Filed with the National dose Registry
- G-129 Revision 1, Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable (ALARA)"
- P-290 Managing Radioactive Wastes

The revised Proposed Regulatory Documents can be viewed on the CNSC website <www.nuclearsafety.gc.ca>

Comments are requested by April 22, 2005

Over the period since last year 29 draft regulatory documents have been issued by the CNSC for review and comment. The most recent ones were:

- S-98 Revision 1 Reliability Programs for Nuclear Power Plants
- S-106 Revision 1 Technical and Quality Assurance Requirements for Dosimetry Services
- S-310 Safety Analysis for Nuclear Power Plants

The closing dates for comments on those three were in March 2005

Obituary

Howard B. Newcombe

Dr. Howard B. Newcombe, an influential pioneer in radiation genetics and long-time researcher at the Chalk River Nuclear Laboratories, died on February 14 in his 91st year.

A Nova Scotian, Howard obtained degrees from Acadia University and the Imperial College of Tropical Agriculture, Trinidad, before completing his Ph.D. in genetics at McGill University in 1939. He spent a year as a Research Scholar in cytogenetics at the John Innes Horticultural Institution, in Surrey, England, followed by a short period with the British Ministry of Supply, before joining the war effort as a Radar Officer in the Royal Navy Volunteer Reserve. In 1946 he came back to North America as a research associate with the Department of Genetics of the Carnegie Institute, working at Cold Spring Harbor on Long Island. In 1947 he came to Chalk River and was Head of Biology Branch from 1949 to 1970 and Head of Population Research Branch from 1970 until his retirement in 1979.

Howard's work on the genetic effects of radiation and on applying computers for medical record linkage led to international recognition. In 1949 he introduced what has become widely referred to as the Newcombe Fluctuation Test. His experiment, which involved the statistical analysis of the distribution of colonies of mutant cells, showed that mutations in bacteria arose randomly and spontaneously and were not an adaptive response to environmental conditions; a finding that contributed to the end of Lamarckian biology. In a 1957 paper on the biological hazards of 90Sr, he suggested a non-threshold linear model for cancer induction by radiation, an extension of the view, by then generally held, that genetic mutations followed this model. Such a model became the basis, still in place, for recommendations by the International Commission on Radiological Protection. That same year he pointed to the implications for population health research that the application of computers to analyzing records could make. He went on to develop computer-based probabilistic linkage models for health records; essentially a way of bringing together two or more items of separately recorded data about a person. The approach has proved to be an extremely powerful tool for public health research including epidemiological studies of the effects of radiation. His work in genetics and in medical record-linkage made him well-known internationally; he collaborated in the early 1960s with Nobelist Hermann Muller at Indiana University and, throughout his career, he lectured extensively in North America and Europe on record-linkage techniques.

Recognition of his scientific achievements included election to Fellowship in the Royal Society of Canada in 1963; a 1967 Centennial medal; the International Scientific Achievement Award in the Area of Medical Information Processing in 1974; and the Genetics Society of Canada Annual Award of Excellence in 1975. Honorary D.Sc. degrees were awarded him by McGill University in 1966 and by Acadia University in 1970.

Howard was the secretary of the Genetics Society of America from 1956 to 1958 and was instrumental in starting the Genetics Society of Canada, serving as its President in 1965. He was President of the American Society of Human Genetics in 1965, a member of the Board of Directors of the Society for the Study of Social Biology from 1971 to 1974 and a member of the editorial boards of Radiation Botany, Mutation Research and Human Genetics Abstracts.

He was a member (and served two terms as chairman) of the committee on radiation effects of the International Commission on Radiation Protection from 1962 to 1972 and a member of the main commission of the ICRP from 1965 to 1977. He served on the Expert Advisory Panel on Human Genetics of the World Health Organization and he was one of the earliest members of the Canadian delegation to the United Nations Scientific Committee on the Effects of Atomic Radiation.

Howard continued to write and advise after his retirement from Chalk River, maintaining a lively interest in radiation genetics and population health. Even in recent years, a chance encounter with him on his daily excursion to pick up the mail could lead to a stimulating exchange of ideas.

Our thanks to Dr. Richard Osborne for the above note.

Terence John Carter

Dr. John Carter, a former nuclear fuel scientist at the Chalk River Laboratories of Atomic Energy of Canada Limited, died November 18, 2004 at home after a brief illness, at age 70.

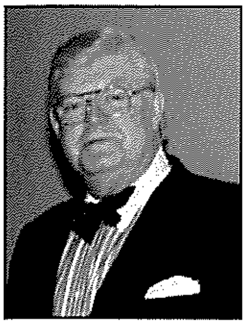
Martyn Wash provided the following note.

Remembering Our Friend – Terry Carter

Like many people who knew Terry Carter, I was saddened to hear of his passing. When I was sent to Chalk River as part of AECL's program of industry attaches in 1980, Terry was my direct supervisor in the Fuel Engineering Branch. As soon as I met Terry I liked him. Terry participated in many fuel irradiations and made a meaningful contribution to advancing our knowledge base about CANDU fuel. He was never reluctant to share this information with anyone including green horns like me. Terry was a knowledge mentor to so many of us in this industry.

Terry was a gentle giant and always a gentleman. In addition to being my supervisor, he was a fun lunchtime companion on many walks around Chalk River. He was always willing to participate in discussions about on-going experiments, world events or discussions about family or friends. After I left Chalk River, I was fortunate to continue my friendship with him over the phone or at conferences during the intervening years. As a farewell to a good friend, I can easily say that whenever everyone spoke of Terry, they always did so with warmth as a person and respect as a professional.

Obituary



D. Allen Bromley

Dr. D. Allan Bromley, a native of the Ottawa valley and an early researcher at the Chalk River Nuclear Laboratories who went on to become the first person to hold the Cabinet-level rank of Adviser to the President of the USA for Science and Technology, died in New Haven, Connecticut on February 10, 2005, at the age of 78.

Born in Westmeath, Ontario, Bromley received a B.Sc. degree in 1948 and an M.Sc. in 1950 from Queen's University and a Ph.D. degree from the University of Rochester in 1952.

From 1955 until 1960 he served as a Senior Research Officer and head of one of the nuclear physics sections working with accelerators at the Chalk River Nuclear Laboratories (CRNL) of Atomic Energy of Canada Ltd. (AECL).

He moved to Yale University in 1960 and helped create A.W. Wright Nuclear Structure Laboratory which he headed from 1963 to 1989. From 1972 until 1993, he held the Henry Ford II Professorship in Physics at Yale, and from 1970 to 1977, he served as chair of the Yale Physics Department.

In 1989 he was appointed Assistant to the President for Science and Technology. Between 1989 and 1993 He was responsible for the first formal published statement of U.S. Technology Policy and played a central role in expanding cooperation between the federal government and the private sector toward effective use of technology in U.S. society. He also chaired the President's Council of Advisors on Science and Technology and the Intergovernmental Council on Science, Engineering and Technology.

For more than two decades, Bromley was a leader in the national and international science and science policy communities. He served as president of the American Association for the Advancement of Science, the International Union of Pure and Applied Physics and the president of the American Physical Society in 1997. Five years later the APS awarded him its 2002 Nicholson Prize

In 1998 Bromley gave the "keynote" address at a workshop held in Ottawa that had been organized by AECL and the National Research Council to gain support for the proposed Canadian Neutron Facility, a 40MW(th) pool-type reactor with associated neutron bean facilities. Despite his support that project has not proceeded.

Hans Bethe

Hans Albrecht Bethe, the last of the senior physicists of the Manhattan Project and a Nobel laureate in physics, died March 6, 2005 in his 99th year.

Bethe was born in Strasbourg, Alsace-Lorraine, then part of Germany, on July 2 1906. He attended the Gymnasium in Frankfurt from 1915 to 1924. He then studied at the University of Frankfurt for two years, and at Munich for two and one half years, obtaining his Ph. D. in theoretical physics in July 1928.Because his mother was Jewish Bethe was uncomfortable in Nazi Germany and emigrated to England in October 1933 where he held a temporary position as Lecturer at the University of Manchester for the year 1933-1934, and a fellowship at the University of Bristol in the fall of 1934.

In February 1935 he was appointed Assistant Professor at Cornell University, Ithaca, N. Y. U.S.A.. He stayed there until his death, except for sabbatical leaves and for an absence during World War II.

In 1943, Bethe joined the then secret Los Alamos laboratory as head of the theoretical division, and he played a key role in the complex calculations leading to the design of the atomic bomb. He was described as a brilliant man with the steadiness and determination of a battleship

At Cornell University in the late 1930s he had written a brilliant series of papers on nuclear physics which became known as "Bethe's Bible" and which, according to Edward Teller, contained everything there was to know about nuclear physics. In 1938, Bethe developed the theory of the carbon cycle, a nuclear process for generating energy in the Sun, and stars like it, by fusing hydrogen into helium. For this work, Bethe was awarded the Nobel Prize in Physics in 1967. After the Second World War, Bethe returned to Cornell to his first love, teaching and research into the structure of atoms, molecules and condensed matter, and the theory of quantum electrodynamics. In 1961, Bethe received the Fermi Award from the United States Atomic Energy Commission, "for contributions to nuclear and theoretical physics, to peaceful uses of atomic energy, and to the security of the United States."

CNS **news**

Council Activities

Council writes in support of the Advanced CANDU Reactor

In January 2005, Dominion Resources announced its decision to withdraw from the US Department of Energy pre-licensing process involving Atomic Energy of Canada Limited's ACR-700. AECL has announced that it will now direct resources to the development of the ACR-1200 MWe design. The development of a "1000 MWe" CANDU reactor design has been attempted previously however the reactor physics of the larger core proved limiting. The more compact ACR core design will facilitate this increase. The November/December issue of Physics in Canada (Vol. 60, No. 6) contains several articles on the ACR and previous issues of the CNS Bulletin have included papers on various aspect of the design.

In early February 2005, the Council of the Canadian Nuclear Society sent a letter in support of the development of the Advanced CANDU Reactor to 22 Ministers of the Government of Canada and the Government Leader in the Senate. The body of the letter appears below.

We are writing to you on behalf of the Canadian Nuclear Society (CNS). This Society comprises more than one thousand scientists, technical experts, educators, and managers who work in Canadian nuclear science and engineering. The continuing good health of Canadian nuclear technology is a crucial component of both Canada's energy security and its future success as a technologically developed nation. Therefore, we write to encourage your support for continued federal funding of nuclear R&D in Canada, including the development of the Advanced CANDU Reactor (CANDU-ACR).

There is now a real opportunity for the federal government to give a boost to the further development of the CANDU energy system. Canada has already achieved commercial success around the world with the original CANDU design. The CANDU-ACR needs only a few years of final engineering to assure its position as a serious competitor for the massive impending market for new electricity generating capacity, as the price of natural gas, and probably also of oil, rises in response to shortages. Nothing will be more important to the "takeoff" of this improved CANDU technology venture than to have ACR units installed and operating in Canada.

The imminent need for additional electricity generation in Ontario offers a very cost-effective way to achieve this demonstration of advanced Canadian technology. In this regard, a senior member of our Society, Dr. J.T. Rogers of Carleton University, recently prepared a succinct and cogent analysis in support of the installation of more CANDU generating stations in Ontario. Professor Rogers' document is attached. You will see that his recommendation is to install nuclear units to satisfy the long-term electricity needs of Ontario, based on examination of various alternatives for future generation. This recommendation is relevant not only to Ontario, but to the whole of Canada and indeed to the world. Nuclear-electric generation using CANDU reactors can provide environmentally sound solutions to world energy supply problems, as well as major economic benefits to our nation.

The members of our Society have great pride in Canada's world-class CANDU technology, which is not only a technical success story (named in the "top ten" of Canada's engineering achievements of the last century), but an economic driver as well. Nuclear reactors supply about 16% of Canada's electricity usage, including about half the electricity needs of Ontario. According to the Canadian Energy Research Institute (CERI), the nuclear industry is worth about $5 billion annually to the Canadian economy, accounting for about 30,000 highly skilled direct and indirect jobs nationwide. In fact, the industry's influence on Canada's excellent science and engineering infrastructure extends well beyond this, including post-secondary education, advanced materials development, and nuclear medicine and other applications of radioisotopes.

It is our understanding that CANDU-ACR development is co-funded through both federal investment and the re-investment of commercial earnings by AECL. In addition, the non-nuclear "balance of plant" has been optimized for the CANDU-ACR by the Hitachi Corporation, through its own investment. This funding partnership between a crown corporation, the federal government, and the private sector leverages the government's investment.

As the sole shareholder of AECL the federal government will benefit directly from this investment, but the expected return will accrue to Canada as a whole. AECL is the lead company in a broad partnership of Canadian industries *now associated with nuclear energy and related Canadian technologies. Additionally, and importantly, industrial firms will also receive technology and economic benefits in terms of sustained technology development opportunities, profits and jobs.*

In summary, your support for further CANDU-ACR development funding will ensure that the Canadian government will benefit through the continuing prosperity of its citizens, its technological leadership, and the security of our long-term energy supply.

The letter references a study by Dr. J.T. Rogers of Carleton University entitled "Options For Coal-Fired Power Plants In Ontario," and a report "Economic Impact of the Nuclear Industry in Canada", Canadian Energy Research Institute, July 2003.

Dr. Rogers' report is available at: www.cns-snc.ca/media/CNS_Position_Papers/Ontario_coal.pdf

The CERI report is available at: www.cna.ca/english/files/study/CNAStudySept16-03.pdf

Presentation to NWMO

On February 1, 2005 Jeremy Whitlock, past-president of the CNS made a presentation to the Advisory Council of the Nuclear Waste Management Organization (NWMO). This presentation appears elsewhere in this issue of the CNS Bulletin and is available at: www.cns-snc.ca/media/CNS_Position_Papers/NWMO_presentation.pdf

Support for education

The CNS Council has supported the Education and Communications Committee providing sponsorship support to two not-for-profit, charitable organizations in 2005: the Deep River Science Academy, and Scientists in School.

CNS President Bill Schneider presents DRSA National Board Chair Dale Torgerson with the CNS donation for 2005.

The **Deep River Science Academy** has been operating a campus at Deep River for 18 years and at Pinawa for 11 years. Each summer, the Deep River Science Academy provides senior high school students and their tutors the opportunity to participate in real Research & Development projects with supervisors at the facilities of our research partners. In 2004, 60 students enjoyed the unique DRSA experience: 42 at the Deep River, Ontario Campus; and 18 at the Pinawa, Manitoba Campus. The high school student tuition fee includes their accommodation (approximately 6 weeks), while the university undergraduate tutors are employed by DRSA for the summer.

The DRSA program has been recognized for its success in promoting interest in science and engineering careers among Canadian youth. Most recently, the DRSA received a 2004 Michael Smith Award sponsored by the National Science and Engineering Research Council (NSERC) for outstanding achievement in the promotion of science in Canada. Many DRSA graduates and former tutors have successfully pursued careers in engineering, science, and education.

The DRSA receives financial support from the Government of Canada, provincial and local governments, industry, foundations, and individuals. The DRSA program offers students the opportunity to earn credits for their research & development project work, and additionally at the Deep River Campus for an optional science course. To learn more about the DRSA, visit their website www.drsa.ca .

Scientists in School (SiS) is another award-winning program which originated in 1989. Presenters, passionate about science and trained by Scientists in School team leaders go into elementary school classrooms in a growing number of Ontario communities. There, they present one or more of the 77 hands-on, curriculum-aligned workshops in science, engineering, the environment, technology and mathematics. Fun topic titles such as: *Electricity: Get Charged! and Soil: It's Too Important to Treat Like Dirt* help to keep teachers and students intrigued and motivated.

As the largest non-profit science outreach organization in Canada, Scientists in School works with 13 different school boards. This year, the organization's 260 presenters are scheduled to reach 360,000 elementary students, 14,000 teachers and 30,000 parent volunteers. The program originated in the Durham region through an initiative of the Canadian Federation of University Women. It has expanded through Toronto, as far as Halton, with a satellite organization in Guelph and a new branch starting this year in Ottawa. Scientists in School distributes its program catalogue to 1,500 schools in areas served; teachers request specific presentations and pay a fee for the service. SiS is supported by a number of funding partners.

In a recent presentation to CNS Council, Cindy Adams, Executive Director for SiS, advised that students become 'scientists' in their own school through these investigative workshops. She also cited studies highlighting the importance of igniting a passion for science in the early years of childhood in order for long-term interests to develop.

CNS members interested in becoming SiS presenters or wanting more information may wish to explore their website: http://www.scientistsinschool.ca .

In Memorium

Dr. D. Allan Bromley, esteemed nuclear physicist, former science advisor to the President of the United States of America, and the first Sterling Professor Sciences at Yale University died February 10, 2005 at age 79. Dr. Bromley, a native of the Ottawa Valley attended Queen's University in Kingston for his undergraduate and MSc, and earned his PhD at Rochester University. Dr. Bromley worked at the Chalk River Laboratories in what he described as the "golden years" of nuclear physics.

Doris Brockhouse, wife of Nobel Prize winner Bertram Brockhouse donated the medal and certificate to the Canada Science and Technology Museum on February 17. Dr. Brockhouse was awarded the Nobel Prize in Physics in 1994, sharing the award with American physicist Clifford G. Shull for their separate but concurrent development of neutron-scattering techniques. Dr. Brockhouse died October 13, 2003.

Upcoming Events

The 55th Canadian Chemical Engineering Conference will be held in Toronto, October. 16-19, 2005 with the theme: Innovation for a Healthy Planet. There is a focus on energy, and nuclear in particular, in some sessions. For details: www.csche2005.ca .

NEWS FROM THE BRANCHES

Bruce – John Krane

Mr. Ken Talbot, Chief Nuclear Engineer, Bruce Power will be addressing the Bruce Branch of the CNS Monday May 9th and Wednesday May 18th on an overview and lessons learned from his IAEA OSART visit of Kashiwazaki – Karewie Nuclear Power Station, Japan.

Chalk River – Morgan Brown

The Chalk River Branch annual general meeting was held December 7, 2004. The Branch Executive are: Morgan Brown, Chair; Blair Bromley, Vice-Chair; Marcel Heming, Treasurer; Uditha Senaratne, Program Coordinator; Bill Bourns and Bryan White, Members-At-Large; and Michael Stephens, Past-Chair.

The Chalk River Branch second annual essay contest on the Benefits of Nuclear Science and Technology is underway, spearheaded by Blair Bromley. Tied in with that, the Branch will have a display table at the Renfrew County Regional Science Fair on Saturday April 9, 2005. The essay contest entries are due April 30th.

On March 8th CNS President Bill Schneider presented a seminar entitled: "Plant Design Concept Features Over the Years and the Grief as Well as the Excellence that Flowed There-from." In his presentation, Bill first provided an overview of current CNS events and a summary of the initiatives taken during his term of office to increase the services offered to CNS members who work in operating nuclear facilities. He presented a review of the history of Babcock and Wilcox Canada. Bill followed with a spirited review of some of the interesting features of CANDU plant secondary system designs and the lessons that may learned therefrom.

Bob Pollock of AREVA-COGEMA Resources will be the guest speaker on April 7th. As a regular part of Chalk River Branch meetings, Blair Bromley provides a brief "Nuclear News" to the members.

Darlington – Jacques Plourde

The Darlington Branch is interfacing with the new UOIT Branch and is investigating the possibility of a Plant tour in mid-March. Jointly with the CNS, OPG Darlington conducted a 2-day workshop on Heat Transport System Life Cycle Management. This was attended by approximately 90 people, including a significant off-shore contingent.

Ottawa - Jim Harvie

The Ottawa held its first meeting of 2005 with a talk by CNS President, Bill Schneider, on March 10. His presentation was in three parts: an overview of Society activities; a quick picture of the nuclear steam generator work at Babcock & Wilcox Canada (from which he retired earlier this year): and, comments on some aspects of CANDU design that, in his opinion, had not been well based.

The next meeting will be on April 7 when Frank King from Ontario Power Generation will speak about the proposed low and intermediate radioactive waste depository planned for the Bruce site.

Québec – Michel Rhéaume

Un mémoire portant sur la problématique des déchets nucléaires a été présenté en décembre dernier à Bécancour (Qc) par le professeur Daniel Rozon devant la Commission du BAPE dans le cadre des audiences publiques sur le projet de réfection de la centrale de Gentilly-2. Ce mémoire porte sur la problématique à long terme. Il retrace l'historique du programme canadien de gestion des déchets et décrit le plan de l'étude en cours par la Société de gestion des déchets nucléaires (SGDN). L'auteur présente son point de vue sur les mythes entourant la question des déchets nucléaires, et plus particulièrement sur la perception du risque qui limite sérieusement notre capacité à établir une politique nationale de gestion des déchets. Compte tenu des enjeux énergétiques et environnementaux auxquels nous sommes tous confrontés, l'auteur conclut qu'il serait irresponsable de réduire la production nucléaire actuelle si elle est pour être remplacée par des moyens plus polluants, plus chers et beaucoup plus invasifs. Le mémoire peut être obtenu sur le site : http://www.polymtl.ca/nucleaire/docs/documents/BAPE_DR_V2.pdf

À propos de l'auteur : Daniel Rozon est Fellow de la SNC et professeur au département de génie physique de l'École Polytechnique de Montréal. Il est titulaire de la Chaire Hydro-Québec en génie nucléaire à l'École Polytechnique depuis sa création en 1988.

A brief on nuclear wastes was presented last December by Pr. Daniel Rozon in Bécancour (Qc), before the BAPE Environmental Commission on Gentilly-2 refurbishment. This brief deals with the long-term perspective. The on-going study by the Nuclear Waste Management Organization (NWMO) is described in the context of the Canadian nuclear waste management program. The author presents his views on the myths surrounding nuclear wastes, which seriously affect the general perception of the risks and limits our ability to establish a national waste management policy. Considering the enormous stakes involved with future energy supplies, the author concludes that it would be totally irresponsible to reduce current nuclear production if it is to be replaced by more polluting, more expensive and more invasive means. The brief, written in French, can be obtained at: http://www.polymtl.ca/nucleaire/docs/documents/BAPE_DR_V2.pdf

About the author: Daniel Rozon is a Fellow of the CNS. He is a professor of Engineering Physics at École Polytechnique de Montréal, and has held the Hydro-Québec Chair in Nuclear Engineering since its creation in 1988.

The Quebec Branch has prepared a brief to be presented before the Parliamentary Commission entitled: Quebec Energetic Sector: Context, Stakes and Questioning.

On March 8, 2005 in Quebec City M. Gilles Sabourin and Ms Elisabeth Varin will present the brief, supporting the use of Nuclear Energy in the Quebec future Energetic Policy.

M. Guy Marleau obtained an agreement with Université de Montréal to refurbish the Montreal Laboratory Plaque.

Sheridan Park – Adriaan Buijs

The Sheridan Park Branch annual general meeting was held December 15, 2004. The Branch Executive include: Adriaan Buijs, Chair; Olga Jevremovic, Treasurer; Peter Schwanke, Margaret MacDonald, and Raj Jain, Members-At-Large. AECL Senior Scientist Romney Duffey presented a seminar on risk at the meeting.

At a subsequent meeting on January 10, 2005, Prof. Podowski from the Rensselaer Polytechnical Institute gave a presentation on two-phase flow.

University of Ontario Institute of Technology – Spencer Gill

The formation of a new CNS-UOIT Branch was approved by CNS Council on March 4, 2005. The executive for the new branch includes Spencer Gill (Chairperson), Andrew Harrison (Vice-Chair), Mohammad El-Mansi (Treasurer), Ashlea Colton (Educational Outreach) and Ruth MacLeod (Secretary).

The branch is planning activities such as guest speakers, field trips, and educational outreach programs to commence September 2005. The CNS-UOIT branch is not exclusive to students, and the branch welcomes all CNS members to participate in the upcoming activities. More information will be available as soon as the branch has the opportunity to develop its website. In the meantime, if you have any questions, please feel free to contact Spencer Gill at spencer.gill4@mycampus.uoit.ca.

Erratum

There is a typographical error in a website address given on p. 45 of the previous issue of the CNS Bulletin (Vol. 25, No. 4, 2004 December). The website in question is Dr. Archie Robertson's website, where his article on the CANDU cost estimates can be found.

The correct website address is www.magma.ca/~jalrober [NOT www.maga.ca/~jalrober]. This and other interesting references may be found on the CNS web site: www.cns-snc.ca – "Nuclear Links."

CNS Presentation to the NWMO Advisory Council

***Ed. Note:** Elizabeth Dowdeswell, president of the Nuclear Waste Management Organization (NWMO), invited the Canadian Nuclear Society to make a presentation to its Advisory Council. Past President Jeremy Whitlock was chosen by the CNS Council to be the presenter. Following is his presentation, which had been vetted by the CNS executive. The gathering took place in Toronto, on February 1, 2005.*

Although minutes of meetings of the Advisory Council are posted on the NWMO website (www.nwmo.ca) there is no record yet of this February 1 session.

Preamble

The Canadian Nuclear Society (CNS), established in 1979 and independently incorporated in 1998, is a not-for-profit learned society with a nation-wide membership of over 1000. The CNS is dedicated to the exchange of information on the peaceful applications of nuclear science and technology. This encompasses all aspects of nuclear energy, uranium, fission and other nuclear technologies such as occupational and environmental protection, medical diagnosis and treatment, the use of radioisotopes, and food preservation. CNS members join as individuals (there is no corporate category of membership), and are drawn mainly from the various fields mentioned above, including from within the academic community.

The CNS welcomes the opportunity to discuss with the NWMO Advisory Council its views regarding the management of used nuclear power reactor fuel in Canada, and the NWMO process.

I. An Ethically Defensible History of Development

1.1. Nuclear power is an available technology for economical, large-scale electricity generation that has both low public health risk and low environmental impact. CANDU nuclear technology, first developed in Canada in the 1950s, today provides about 15% of Canada's electricity requirements[1] and 45% of the consumption in Ontario[2]. Its net benefit to society makes it an ethical choice as a contributor to Canada's energy needs.

1.2. The used fuel from Canada's nuclear power reactors is managed in a safe and responsible manner, using in-ground water pools and aboveground dry canisters, casks, and modules located at the reactor sites. The volume of used nuclear fuel produced in Canada is not large. For example, the total volume of used nuclear fuel produced by Canada's power reactors from 1962 to 2033 will be roughly equal to the volume of domestic solid waste currently produced by the City of Toronto in one day[3]. The current approach of on-site storage and monitoring is sustainable for many decades, but is not intended to represent a long-term solution.

1.3. The long-term management of used nuclear fuel has been investigated by the Canadian nuclear industry from the outset of nuclear power development[4]. In the early years the research focused upon the reprocessing and subsequent recycling of the useful fraction of used fuel, due to the then-perceived limited availability of uranium ore. In this case, for example, the leftover waste from reprocessing would have been incorporated into glass blocks, which had been confirmed through field tests to be resistant to leaching. Later, with uranium known to be an abundant Canadian resource, the focus shifted to a once-through fuel cycle and the direct disposal of the resulting used fuel without reprocessing. Therefore, whether focused on the reprocessing or the sequestering of its waste products, nuclear power development has proceeded with ethically defensible attention to its long-term liability. In 1975 the industry defined its objective to be to "... isolate and contain the radioactive material so that no long term surveillance by future generations will be required and that there will be negligible risk to man and his environ-

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1 Source: Natural Resources Canada

2 Source: The Independent Electricity Market Operator, Ontario, 2003

3 The Nuclear Waste Management Organization (NWMO) expects that 3.6 million used fuel bundles will exist in Canada by the end of 2033. With a volume of roughly 0.004 cubic metres per bundle, the total volume of used fuel from Canada's CANDU reactors over 70 years would be 14,400 cubic metres (a volume the size of a cosser field to a height of 2.25 metres). The volume of solid domestic waste currently shipped by Toronto to Michigan is about 5 million cubic metres per year, or on average about 14,000 cubic metres per day.

4 The R&D effort in the area of waste management during the earliest days of the Canadian nuclear industry is evident in public reports by Atomic Energy of Canada Ltd. (AECL) dating back to the early 1950s, around the time that planning and early design work for a Canadian nuclear power program were initiated.

ment at any time. ... Storage [sic] underground, in deep impermeable strata, will be developed to provide ultimate isolation from the environment with the minimum of surveillance and maintenance."[5]

1.4. In 1978 the federal and Ontario governments jointly initiated the Nuclear Fuel Waste Management Program (NFWMP), under the aegis of both Atomic Energy of Canada Ltd. (AECL), which developed the science and technology of deep geological disposal for used power reactor fuel, and Ontario Hydro (now Ontario Power Generation), which had responsibility for studies of interim used fuel storage and transportation. In 1988 the Environmental Impact Statement (EIS) developed by the NFWMP was submitted to the federal government, which subsequently referred it to an Environment Assessment Panel (the "Seaborn Panel"). The Seaborn Panel's final report in 1998 found the EIS to be technically sound, but lacking broad public support. The response of the federal government to the recommendations of the Seaborn Panel resulted in the passing of the Nuclear Fuel Waste Act, and the subsequent creation of the Nuclear Waste Management Organization (NWMO), in 2002[6].

2. The Need For A Decision

2.1. A decision on the long-term management of used nuclear fuel is needed under the principle of sustainable development, requiring that the current generation take steps to minimize the liability it transfers to future generations[7]. The low volume and manageable nature of used nuclear fuel are consistent with the principle of sustainable development, inasmuch as these features minimize the future burden of the used fuel. However, a means of long-term management, requiring minimal ongoing human intervention, is needed to fully meet the current generation's obligation to future generations.

2.2. While the principle of sustainable development implies that such a long-term strategy needs to be decided upon and implemented by the current generation, it does not suggest the nature of the strategy. For example, permanent disposal of used nuclear fuel may be considered to be inconsistent with the principle of sustainable development if it prevents future generations from utilizing the remaining considerable energy content of the fuel. On the other hand, surface or near-surface storage imposes a responsibility for ongoing care on future generations.

2.3. A decision on the long-term management of used nuclear fuel is also needed to maintain nuclear power technology as an available energy option for future generations, which the CNS supports as an ethical goal given the technology's net benefit to society as claimed in paragraph 1.1. In general, the public currently sees the lack of a committed, socially acceptable plan for the long-term management of used nuclear fuel as a significant deficiency of the nuclear power option.

2.4. While the above discussion establishes the need for a decision on the long-term management of used nuclear fuel, all the details of the implementation need not be decided upon quickly, nor all at once. Interim storage for decades remains a viable, albeit demanding, practice, provided that serious work also starts and continues steadily on preparing long-term storage or disposal facilities. Step-by-step progression along the chosen route, with full assurance provided at each step, may be necessary to gain the fullest public acceptance. This suggests a more satisfactory strategy, from a sustainable development point of view, of "convertible storage", a hybrid option which is discussed in paragraph 4.4.

3. The Nature of Public Consultation

3.1. Public consultation, involving as broad a representation of various constituencies as possible, is important for the social acceptability of any long-term used nuclear fuel management program. The selection of a long-term management option for used nuclear fuel depends as much upon value judgments, and the establishment of trust and confidence in the organizations that will ultimately implement and regulate the process, as it does on any remaining technical uncertainties.

3.2. While public consultation, such as that currently implemented by the NWMO, may be sufficient to assess the values held important by the public as they apply to long-term used nuclear fuel management, it is inherently insufficient to provide a realistic measure of "broad public support", as described in the Seaborn Report8. Such support should necessarily be based upon a broad public understanding of the issues involved, both technical and social, and would be demonstrated, in part, by an informed and broad public response to public interaction programs such as those of the NWMO. However, it seems unlikely that the NWMO will be able to obtain an informed and broad public response. Failing this, public consultation can still indicate a level of "public

5 Peter J. Dyne, "Managing Nuclear Wastes", AECL-5136, May 1970.

6 The NWMO was created with the purpose *"to develop collaboratively with Canadians a management approach for the long-term care of Canada's used nuclear fuel that is socially acceptable, technically sound, enviornmentally responsible and economically feasible."* (source: NWMO website) The NWMO has been charged with recommending to the federal government by 2005 November 15 an approach to the long-term management of Canada's used nuclear fuel. The NWMO will then implement the approach decided upon by the government.

7 In 1987 the World Commission on Environment and Development (the Brundtland Commission) defined sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

acceptance" (a more passive response) of the prevailing long-term waste-management strategy, as well as the values held important by the public, and this information will be useful to an organization like the NWMO in guiding its recommendations to the government. However, it is essential that a clear definition of "acceptable" be put forth in any assessment of the public consultation process.

3.3. Notwithstanding its importance in determining public values and perceptions, and in establishing public trust and confidence in the implementing organizations, public consultation cannot be used to determine the real level of safety associated with any of the long-term waste-management options. The distinction between public acceptability and safety, clouded in the Seaborn Report by the creation of the concept of "safety from a social perspective", must be made in order for a clear conclusion, with clear responsibilities and a clear path forward, to be established.

4. The Options

4.1. Several options for used nuclear fuel management, including deep geological disposal, are understood well enough technically to be credible and viable. Deep geological disposal, in particular, is in an advanced state of scientific and technical understanding within Canada, while many of the principles and technologies of used fuel storage have been demonstrated for years at reactor sites within Canada. The NWMO on-line documents present the technical and non-technical pros and cons of the options comprehensively enough to capture the important differences between the options. The CNS endorses the NWMO's scrupulously neutral approach to date on which option should be recommended for government decision.

4.2. Deep geological disposal has been investigated by several countries, including Canada, as a promising technology for long-term management of used nuclear fuel. The concept is attractive because it represents a relatively simple isolation strategy that closes the fuel cycle with minimal long-term impact on the biosphere. At the same time it minimizes future dependence on social stability, intellectual and industrial capacity, funding, and commitment. In principle the currently defined process of deep geological disposal is reversible at any point; that is, retrieval of the used fuel is a feasible option, albeit at an increasing cost the further the disposal process has been implemented.

4.3. This concept of reversibility (retrievability) is attractive because it is consistent with the principle of sustainable development: it initiates a process of isolation with the intent of limiting the liability transferred to future generations, while not precluding future generations from either (a) benefiting from the used nuclear fuel if they so desire (e.g. through reprocessing), or (b) applying an alternative waste treatment technology if they deem it preferable (e.g. partitioning and transmutation of the long-lived radionuclides into shorter-lived nuclides).

4.4. The CNS therefore encourages the NWMO to take a more detailed look at an option of "convertible" deep geological storage, which combines the best features of geological storage and disposal. "Convertible" storage could consist of excavating a deep geological repository capable of receiving used fuel either in storage casks for storage (until a decision is made regarding retrieval and treatment of the used fuel), or in disposal containers for immediate permanent emplacement and backfilling of the disposal galleries and connecting tunnels. The decision between implementing storage or disposal need not be taken now in any event, as site characterization, environmental assessments and regulatory authorization processes, and facility construction will extend over a decade or more before the underground facility is ready to receive any fuel. If it is later decided to reprocess the fuel for recycling (and to dispose of only the actual waste fraction of the fuel), or to partition and transmute the long-lived nuclides in the fuel (to shorten or eliminate the required period of waste isolation), the necessary facilities can later be co-located with the repository, as long as those possibilities are borne in mind during the original siting decision. Even if storage is begun, the fuel casks could easily be retrieved and (if necessary) the fuel could be repackaged in disposal containers for re-emplacement and backfilling. Like deep geological disposal, the "convertible" storage approach achieves consistency with the principle of sustainable development, by initiating the steps leading to possible permanent isolation of the waste during the stewardship of the current generation. At the same time it proceeds in a step-wise fashion and is adaptable, deferring important decisions until they must be made.

4.5. Part of the public uncertainty regarding any off-site sequestering strategy for used nuclear fuel concerns the nature of the siting process. It is important for gaining social acceptance, therefore, that the NWMO release for public discussion its proposed siting procedure. The CNS supports a principle of "informed voluntarism" in any siting process; that is, one implemented with adequate preparation, involving clear and factual communication of all risks and benefits, before inviting community participation.

5. Summary And Recommendations

5.1. Nuclear power is an ethical choice for energy generation in Canada, with waste products that have been managed in the short- and intermediate-term in a safe and responsible manner from the outset of the industry. (Ref: paragraphs 1.1 and 1.2)

5.2. Nuclear power development in Canada has proceeded from its outset with ethically defensible attention to the long-term management of its waste products. (Ref: paragraphs 1.3 and 1.4)

5.3. A decision on the long-term management of used nuclear fuel is needed under the principle of sustainable development, although this principle suggests neither the nature of the management strategy, nor the timing of detailed implementation decisions. (Ref: paragraphs 2.1, 2.2, and 2.4)

5.4. A decision on the long-term management of used nuclear fuel is needed to maintain the option of nuclear power technology for future generations, which the CNS believes is an ethical goal. (Ref: paragraph 2.3)

5.5. Value judgments and public trust will be as important as technical considerations in determining Canada's long-term used nuclear fuel management strategy. Public consultation is vital in assessing these value judgments and establishing public trust. (Ref: paragraph 3.1)

5.6. Public consultation, as currently (and practically) implemented, cannot determine a level of "broad public support" for used nuclear fuel management technologies, nor can it be used to determine the safety of these technologies. (Ref: paragraphs 3.2 and 3.3)

5.7. Several options for used nuclear fuel management are understood well enough to be technically viable and credible, and the public information disseminated by the NWMO is sufficiently comprehensive to highlight the main differences between them. (Ref: paragraph 4.1)

5.8. The concepts of retrievability and disposal both have features that make them consistent with the principle of sustainable development. Therefore an attractive compromise strategy is one of "convertible" storage that synthesizes the best features of each (from the point of view of sustainable development). The NWMO is encouraged to consider this concept. (Ref: paragraphs 2.4, 4.2, 4.3, and 4.4)

5.9. Public acceptance of any off-site strategy will need full public discussion of a proposed siting process. The NWMO is encouraged to initiate such discussion, and to incorporate a principle of "informed voluntarism" in the proposed process. (Ref: paragraph 4.5)

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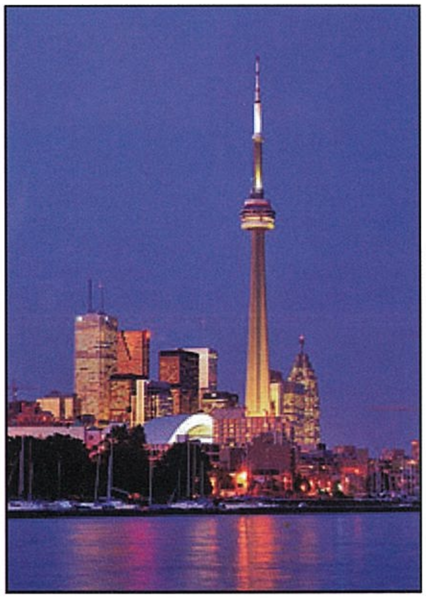
National and international speakers will address many aspects of these challenges, including *long-term security of supply, technical and communication challenges,* and *revitalizing our human resources.*

Presentations in technical sessions will address such topics as *new fuel design programs, advanced reactor designs and new design concepts, thermalhydraulics, reactor physics, control room technology* and *isotope supply to the world.*

- ***2005 W.B. Lewis Lecture/Luncheon:***
  Guest Speaker: Mr. Thomas Isaacs,
  Director of Policy, Planning and Special Studies,
  Lawrence Livermore National Laboratories (USA)
- ***Three plenary sessions + many technical sessions***
- ***29th CNS-CNA Student Conference***
- ***Honours & Awards Banquet***
- ***North American Young Generation in Nuclear Professional Seminar***
- ***Reception, breaks, exhibits, and other networking opportunities***

JOIN US IN JUNE!

For more information and registration, visit www.cns-snc.ca



12-15 juin 2005

La SNC amorce son second quart de siècle alors que l'industrie nucléaire fait face à un renouvellement et à une revitalisation.

Notre 26ième Conférence annuelle jettera un regard en avant, sur les nouvelles technologies, les processus, et les solutions nécessaires pour répondre aux défis du développement et du maintien de nouvelles centrales et ressources humaines.

Des conférenciers nationaux et internationaux toucheront sur divers aspects de ces défis, y-inclus *la disponibilité des ressources à long terme, les défis techniques, les défis de communication,* et *le renouvellement de nos ressources humaines.*

Les présentations techniques discuteront de divers sujets, tels *nouveaux designs du combustible, nouveaux concepts de réacteurs avancés, thermohydraulique, physique des réacteurs, technologies de la salle de commande,* et *production de radio-isotopes pour répondre à la demande mondiale.*

- ***Conférence/déjeuner W.B. Lewis 2005:***
  Conférencier invité: M. Thomas Isaacs,
  Director of Policy, Planning and Special Studies,
  Lawrence Livermore National Laboratories (É.-U.A.)
- ***Trois sessions plénières + bon nombre de sessions techniques***
- ***29ième Conférence étudiante SNC-ANC***
- ***Banquet des prix canadiens pour contributions nucléaires exceptionnelles***
- ***Atelier professionnel de la Jeune Génération Nord-Américaine dans le Nucléaire***
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Soyez des nôtres en juin!

Pour plus de détails et pour vous inscrire, visitez www.cns-snc.ca

Canadian Nuclear Society
26th Annual Conference
(incorporating Student Conference)
"The New Nuclear Generation"
Toronto, Ontario
2005 June 12-15

REGISTRATION FORM

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Name: ______________________________
(Dr./Mr./Ms.) First Last

Title: ______________________________

Organization: ______________________________

Business Address: ______________________________
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City Province/State

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Business Telephone: ______________________________

Fax: ______________________________

E-mail: ______________________________

If you are a speaker, please check this box: ❑

If a speaker at the Student Conference, pls. check ❑

If you would like vegetarian meals, pls. check this box: ❑

This registration form is also available on the CNS web site, at www.cns-snc.ca.

Please mail, fax, or e-mail registration form with payment to
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Toronto, ON, M5G 1V2
Fax: 416-977-8131; e-mail: cns-snc@on.aibn.com
Tel.: 416-977-7620

For further information regarding the Conference, please contact Mrs. Denise Rouben, CNS Office Manager, using the contact information above.

The Conference Hotel will be the Toronto Marriott Eaton Centre, 525 Bay St., Toronto, ON, M5G 2L2. Room reservations must be made directly with the Hotel at 1 800-905-0667. When calling the hotel, you must indicate that the reservation is for the CNS 2005 Annual Conference. A block of rooms is held for the Conference until 2003 May 20; please reserve early. The price of rooms is $199 per night + tax, single or double. Smoking or non-smoking rooms are available upon request.

For Office Use:
CNS Member? Yes ❑ No ❑
ID #:
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Registering: By May 3 After May 3

Note:
1) To register as a CNS member, your membership must be in good standing. Have you paid your 2005 membership fee?
Pls. give your CNS member ID (from membership card):_____
2) All prices include 7% GST (#870488889 RT).

Registering:	By May 3	After May 3
CNS Member	$588.50 ❑	$663.40 ❑
Non-CNS Member	$668.75 ❑	$743.65 ❑

(Includes all CNS Sessions, one copy of Proceedings, Reception, Conference meals including Banquet)

Registering:	By May 3	After May 3
CNS Retiree Member	$171.20 ❑	$214.00 ❑
Full-Time Student	$107.00 ❑	$139.10 ❑

Full-Time Student presenting paper at Student Conf. $0
(Includes all CNS Sessions, one copy of Proceedings, Reception, Conference meals including Banquet)

One-Day Registration (Includes sessions and Conference meals for the day – Luncheon on Mon. or Wed., Banquet on Tues. Does not include Conference Proceedings.)
Note: Monday Luncheon includes 2005 W.B. Lewis Lecture
Please indicate for which day: ❑ Mon., ❑ Tues., ❑ Wed.

Registering:	By May 3	After May 3
CNS Member	$304.95 ❑	$337.05 ❑
Non-CNS Member	$342.40 ❑	$374.50 ❑

Guest accompanying registrant ❑
(Permits complimentary attendance at Reception)
Guest's Name: ______________________________

Additional Luncheon Tickets: ___@ $53.50 = ______
For which day? ❑ Mon (W.B. Lewis Lecture), ❑ Wed

Additional Tickets for Banquet (+ Pre-Banquet Reception + Entertainment) (Tues): ___@ $80.25 = _____

Additional CD-ROM Proceedings: __@ $74.90 = _____
(Price will be $107.00 post Conference)

NOTE: All fees in Canadian dollars
[1 C$ ❑ US $0.80 in 2005 February]

Total Due: $ __________

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Please note Cancellation Policy: A fee of $100 will be charged for all cancellations received after 2005 May 10.

NEW MEMBERS

We would like to welcome the following new members, who have joined the CNS in the last few months.

Nous aimerions accueillir chaudement les nouveaux membres suivants, qui ont fait adhésion à la SNC ces derniers mois.

Francis Allen, RMC Kingston
Neill Allen, Ontario Power Generation
Don Amundrud
Bill Artiss
Ibrahim Khalil Attieh, AECL
Ron G. Barsi, Golder Associates Ltd.
Fiona Bennett, RadSafe Canada, Ltd.
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Christine T. Cosby, Bruce Power
Joseph Anthony Crockett, Framatome ANP
François Claude Cussac, University of New Brunswick
Mark Andrew Danilko, McMaster University
Heather Anne Davis, CNSC
Ninochka Louisa-Ann Dsouza, University of Ontario Institute of Technology
George Epaminondas, Ontario Power Generation
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George H. Foster, East Coast Management Group
Edward Spencer Fox, E.S. Fox Ltd.
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Andrew M. Harrison, University of Ontario Institute of Technology
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Shigeo Hattori, Hitachi Ltd., Power Systems
Heming He, University of Western Ontario
Harley William Hughes, Ontario Power Generation
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Makoto Kikuchi, NTC AECL-Hitachi
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Colleen M. Polley, Zircatec Precision Industries Inc.
Aaron David Quastel, U of Toronto Inst. for Aerospace Studies
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Kazem Rassouli, Ontario Power Generation
Matthew Arnold Roherty, NB Power Pt. Lepreau
Kimberly C.M. Rowsell, U. of Waterloo/Memorial U.
Curtis James Russell, University of Ontario Institute of Technology
Ted Shin, Project Manager
Subo Sinnathanby, Ontario Power Generation
Ajay Sood, Analyst
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Jakub Marian Szymandera, Nuclear Safety Solutions Ltd.
Robert David Taylor, Kinectrics Inc.
Dong V. Tchmshkyan
Samantha Therrien, York University
Elan Thomas, Kinectrics
Pauline Carol Watson, Nuclear Safety Solutions
Syed Zaidi

Membership Deadline

The deadline for renewing your membership in the Canadian Nuclear Society is rapidly approaching.

If you have not yet renewed your membership for 2005 please do so very soon. Otherwise you will no longer receive the CNS Bulletin or other mailings from the Society.

Contact Denise Rouben, e-mail: cns-snc@on.aibn.ca or go to the CNS website www.cns-snc.ca

A Close Call for America

by Jeremy Whitlock

RICHMOND, VA - Almost a century and a half ago, Generals Ulysses S. Grant and Robert E. Lee squared off just north of here in the Battle of North Anna, a typically inconclusive and wasteful engagement of the Civil War.

At the beginning of 2005 a new and different Battle of North Anna again threatened to rend apart America's heart and soul, but unity prevailed and the homeland has emerged the stronger for it.

Canadians, like the Communists before them, have been allowed to creep into the homes and industries of the heartland, let in by apathy, naiveté, and the wholesale bleeding-heart betrayal of traditional American values.

Nowhere are these values entrenched stronger than in the sovereign domain of nuclear energy, the cornerstone of America's God-given right to military and industrial supremacy, bestowed through the sweat and toil of red-blooded American scientists in the middle of the last century.

The CANDU nuclear reactor, a hodge-podge of ideals cobbled together by obstinacy, traces its roots to the desperate attempts of refugee enemy aliens to replicate American innovation during the Second World War.

This pretender to genius came knocking at America's door, and utterly astounded observers by winning the bulk of DOE pre-licensing funding announced late last year. Largesse in hand, Dominion Energy's North Anna expansion vaulted leagues ahead of other nuclear resurrections around the country.

"This just ain't right," protested Budd Snively of the group Keep Atoms American, "we haven't seen a disregard for U.S. birthright like this since the Toyota Corolla."

Snively shakes his head as he recounts an undercover investigation his group undertook, in the guise of NRC safety analysts.

"They just ain't like us up there. All this talk of 'milli-k' and using computer codes we've never heard of. They weren't even applying the ANS standards. They're worse than the French."

Jerry Falwell of the Moral Majority agrees. "The Canadians are Satan's engineers. They speak in tongues and invoke their heathen spirits. I'm told they worship their heavy water like a god. This is blasphemous and unnatural: God intended us to harvest the energy that sustains us from His bountiful elements: the water, the air, and the rocks of our earth."

"American enrichment of uranium is acceptable", Falwell concedes, "After all that makes use of the technology that makes America strong and safe, which is our God-given right."

Budd Snively echoes this criticism of the insurgent Canadian technology: "They lay their reactor on its back and refuel it with these long phallic machines, day in and day out. It's an affront to American decency and family values."

"I'm certainly not surprised," adds Falwell. "We're talking about a country that legalizes abortion, marijuana, and homosexual marriage - but not," he adds with obvious contempt, "atomic weapons."

What happened next was a call to arms worthy of Paul Revere. America awoke and took action long before this technological Pearl Harbour got a chance to progress any further.

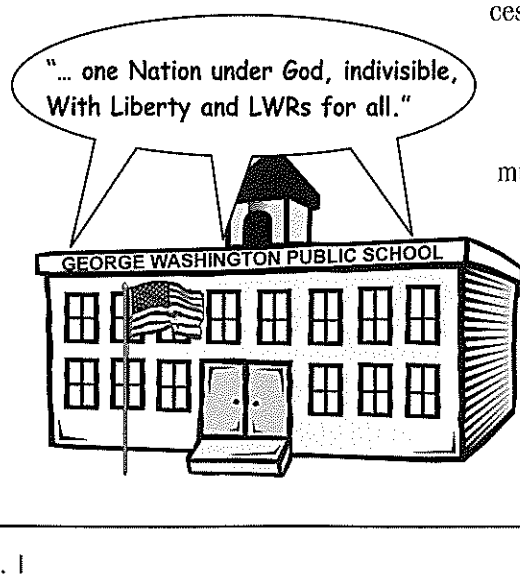
The moral outrage evinced by the likes of Snively and Falwell found resonance in the living rooms and boardrooms of the nation.

In less time than it takes a stuck-open pressure relief valve to uncover a BWR core, Dominion Energy announced that it had decided instead to go with General Electric, a reassuring turn to the old red, white, and blue: familiar to housewives coast to coast and keeping Americans strong since 1892.

The moral underpinnings of this sudden reversal were downplayed in Dominion's official announcement. "We simply told the Canadians," a company spokesman recounted on Larry King Live, "that the Virgin Mary appeared to us over the Christmas break and begged us not to do it."

With the plaid-shirted, monarchist horde successfully turned back at the border for now, time has been found for sober reflection, and even a bit of sportsmanlike concession from the safe vantage point of total victory. Some American engineers have mused aloud about the significantly better fuel efficiency found in CANDU, compared with U.S. designs.

"Ah yes," intones Budd Snively with measured disdain, "that's what they said about the Corolla too."



Most of the above springs solely from the author's mind. Sadly, this includes Budd Snively.

CALENDAR

2005

Apr. 6 - 8 — **6th International Exhibition on Nuclear Power Industry**
Shanghai, China
website: www.coastal.com.hk

Apr. 17 - 21 — **Monte Carlo 2005**
Chattanooga, Tennessee
Contact: Bernadette Kirk, ORNL
email: kirkbl@ornl.gov

Apr. 25 - 29 — **5th Int'l. Conference on Isotopes**
Brussels, Belgium
website: www.jrc.nl/5ici

May 8 - 11 — **National Conf. on Radioactive Waste Management, Decommissioning and Environmental Restoration**
Ottawa, Ontario
Contact: M. Stephens, AECL
email: stephensm@aecl.ca

May 15 - 19 — **International Congress on Advances in Nuclear Power Plants**
Seoul Korea
website: www.icapp2005.org

May 16 - 20 — **ICONE 13 - Int'l Conference on Nuclear Engineering**
Beijing, China
website: www.ns.org.cn.ICONE2005

June 5 - 8 — **American Nuclear Society Annual Meeting**
San Diego, California
website: www.ans.org

June 12 - 15 — **26th CNS Annual Conference and 29th CNA/CNS Student Conference**
Toronto, Ontario
Contact: Denise Rouben, CNS
email: cns-snc@on.aibn.com

June 25 - 28 — **LOWRAD 2005 - Effects of Low Levels of Radiation**
Hamilton, Ontario
email: www.science.mcmaster.ca

Aug. 7 - 12 — **SmiRT 18 18th International Conference on Structural Mechanics in Reactor Technology**
Bejing, China
website: www.smirt-18.org.cn

Aug. 14 - 18 — **Int'l Conference on Environmental Degradation of Materials in Nuclear Power Systems**
Salt Lake City, Utah
email: piking@babcock.com

Sept. 4 - 9 — **4th International Conference on Inertial Fusion Sciences and Applications**
Biarritz, France
website: www.celia.u-bordeaux1.fr

Sept. 11 - 15 — **PSA '05 Probabilistic Safety Analysis 2005**
San Francisco, California
website: www.ans.org/meetings/psa

Sept. 18 - 21 — **9th Int'l Conference on CANDU Fuel**
Belleville, Ontario
website: www.cns-snc.ca

Oct. 2 - 6 — **NURETH 11 Nuclear Reactor Thermal Hydraulics**
Avignon, France
website: www.nureth11.com

Oct. 9 - 13 — **Global 2005**
Tsukaba, Japan
website: www.global2005.org

Nov. 20 - 22 — **7th CNS Int'l. Conference on CANDU Maintenance**
Toronto, Ontario
Contact: Denise Rouben, CNS
email: cns-snc@on.aibn.com

Dec. 11 - 14 — **European Nuclear Conference**
Versailles, France
website: www.sfcn.fr/enc2005

2006

Feb. 12 - 15 — **ANS Topical Meetings - 9th Emergency Preparedness & Response - 11th Robotics & Remote Systems**
Salt Lake City, Utah
website: www.sharingsolutions.com

May. 9 - 12 — **EIC Climate Change Conference 2006**
Ottawa, Ontario
website: www.ccc2006.ca

May. 29 - June 2 — **WIN Global**
Cambridge, Ontario
email: susan.brissette@brucepower.com

June 4 - 8 — **ANS Summer Meeting**
Reno, Nevada
website: www.ans.org

June 11 - 14 — **17th CNS Conference & 30th CNS/CNA Student Conference**
Toronto, Ontario
website: www.cns-snc.ca

Sept. 10 - 14 — **Physor - 2006 Physics of Reactors 2006**
Vancouver, British Columbia
email: roubenb@alum.mit.edu

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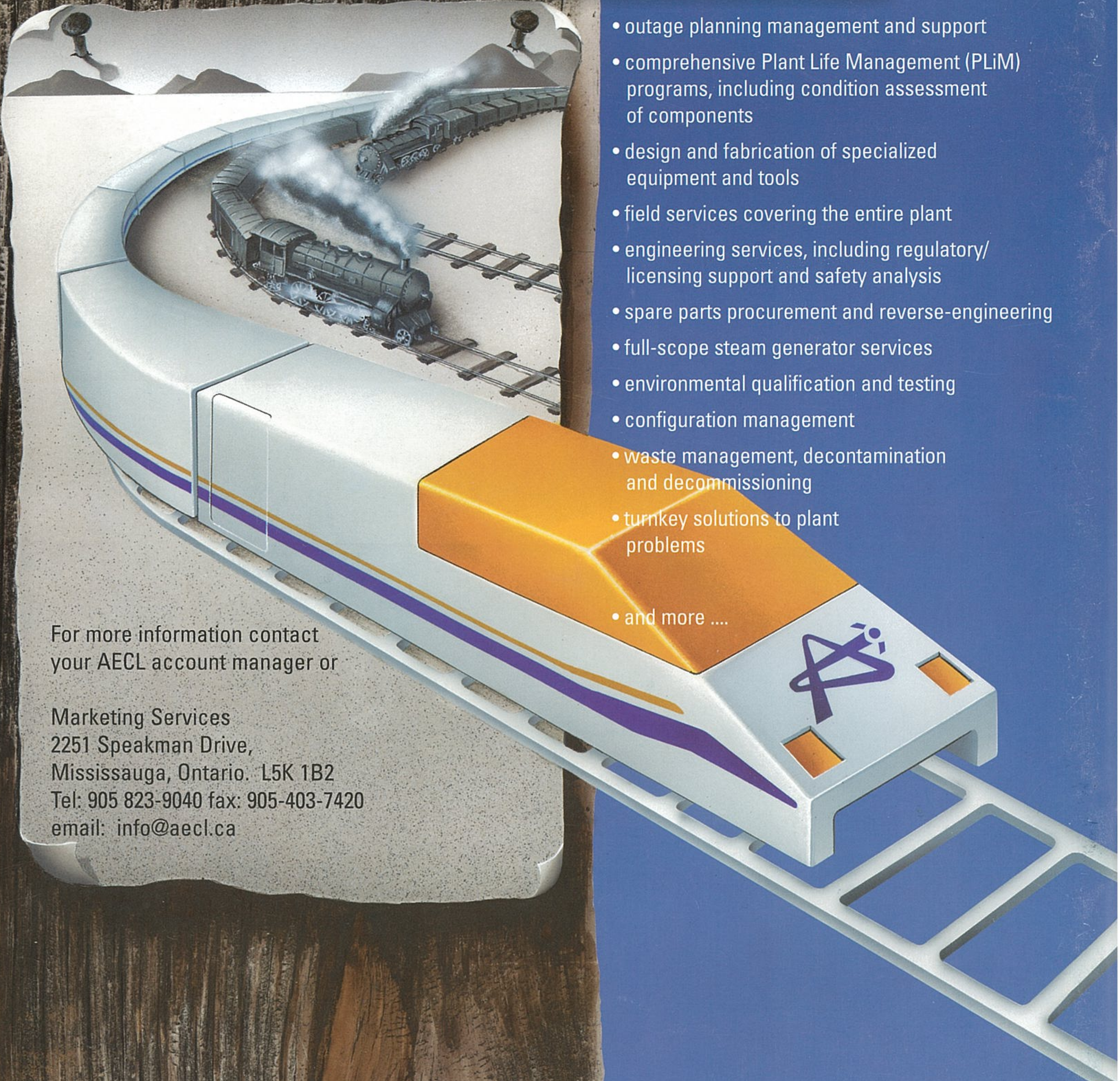

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