CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

DECEMBER 2009 DECEMBRE VOL. 30, NO.4

- 6th CNS International Steam Generator Conference
- Expert Panel on Medical Isotopes
- Canadian Science Policy Conference 2009
- New President for the CNA

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Junk Science

The Sierra Club of Canada published a report called "Tritium on Tap", to frighten the public into believing that our drinking water is contaminated with dangerous cancer-causing tritium released from nuclear reactors. When our regulator, the CNSC, responded by providing factual information in proper perspective and referring to the Sierra Club report as "junk science", Tyler Hamilton of the Toronto Star accused the CNSC of bias.

In Saskatchewan, the Canada Centre for Policy Alternatives and the Saskatchewan Union of Nurses commissioned epidemiologist Mark Lemtsra to "provide an evidence-based epidemiological review on the impact of exposure to radiation on subsequent health outcomes." He "concluded" that nuclear power workers have a 97% dose-related excess relative risk (ERR) of all cancer mortality, and that living near a nuclear power facility is associated with leukaemia in young children. As a result, the Saskatchewan Union of Nurses, who are trained and dedicated to providing health care, were mislead and voted overwhelmingly against a medical isotope reactor being built in that province.

Afterwards, critiques were posted on the Canadian Nuclear Association website. Dr. Douglas Chambers states "The combination of incorrectly presenting ERR projection factors as ERR, the lack of considering actual doses, the inclusion of irrelevant materials and the incorrect representation of the scientific materials result in a misleading report that overstates the risk from nuclear power generation. Other sources of radiation exposure to the public, including that from natural background, are much higher than that from nuclear power generation."

Similarly, Dr. Richard Osborne states "The superficiality of the review, together with the errors, misinterpretations of study findings, and failure to take into account the basic considerations of epidemiologists in reviewing evidence for causal relationships, make the document a travesty of an evidence-based review."

Junk science is propagating like an annoying weed. It is easy to produce since no real research, study or thinking is required. It makes the headlines and ordinary people, who are not educated in nuclear physics, take it as gospel. Why wouldn't they? Mark Lemstra holds eight university degrees. The Sierra Club purports to represent our best interests for the planet. Isn't the CNS also concerned about the planet?

CNS members are educated and rational people who can present factual information, and can debate the facts and debunk the myths that junk science produce. A good example is the recent debate on Nuclear Power in Peace River with Dr. Helen Caldicott, representing Citizens Against Nuclear Development and CNS member Dr. Duane Bratt. The debate is posted on youtube, which can be viewed at the Peace River Environmental Society website, http://peaceriverenvironmentalsociety.org/.

More CNS members need to join the debate. Although the CNS is not an industry advocacy group (that is the role of the CNA), CNS members should indeed advocate telling the truth! Put junk science where it belongs – in the rubbish bin!

In This Issue

The 6th CNS International Steam Generator Conference took place in November attracting 300 delegates. This was very much an operations focus as utilities consider replacing these major components as part of refurbishment programs, and operating experience has proven invaluable for the selection of materials and chemistry and design features to improve performance. We include in this edition a conference report and two technical papers selected from the conference. (And a special thanks to CNS member and conference initiator Bill Schneider for obtaining the cover photo for this edition.)

There has been a lot of attention lately about medical isotopes, or more specifically, the lack of them due to the long outage of NRU. The Expert Panel on Medical Isotopes released its report to the minister of natural resources and was made public a few days later. This was followed by a CNS Workshop on Medical Isotopes that included several expert speakers from governments, universities and industry and included representatives from the medical profession, isotope business and isotope producers. We include a workshop report as well as the Executive Summary of the Expert Panel Report.

Also included is a report on the Canadian Science Policy Conference 2009.

The Canadian Nuclear Association has a new president, Denise Carpenter. An interview with the new president is included in this edition.

There is growing interest in reducing greenhouse gas emissions, and at the same time increasing concerns about the introduction of wind turbines and their impact on greenhouse gas emissions and overall grid reliability. See the Letters to the Editor in this edition, which suggest that the Green Energy Act may not be as "green" as politicians want us to believe.

In our regular sections we have compiled some General News and CNS News. Also, two obituaries are included.

And last but by no means least, the evolutionary Jeremy Whitlock looks back to the future, or forward to the past, or something like that.

Your contributions, letters, comments and suggestions are always welcome! Also, I would like to extend my personal wishes to all for a safe and happy holiday.

Cheers!

FROM THE PUBLISHER

My comments for this issue stem from four events that I attended over the past few months. The focus of those gatherings ranged from the very broad question of a Canadian science policy to the detailed design and operation of steam generators for nuclear power plants.

At the end of October the *Canadian Science Policy Conference 2009* drew over 400 attendees, from graduate students to senior level government officials to heads of commercial companies conducting research. (There is a short report on that conference in this issue of the *Bulletin*.) The discussion at this conference highlighted the lack of interest of our current federal government in matters of science.

A couple of relevant messages came out of the event. Perhaps the most germane was the call for those in, or concerned about, science to communicate better with the public and to get involved in the political process. As one speaker commented, there are no more than 10 MPs with a science background.

In early November, the *6th CNS International Steam Generator Conference* was held in Toronto. Despite the specialized focus of this meeting it drew a large attendance, indicating the importance of these key components for the successful operation of nuclear generating stations. Like all CNS events it was well planned, well organized and well executed, almost all by volunteers. Not having a background in that subject, the point that registered on me was the attention to detail necessary to ensure that complex components such as steam generators function as intended. *(See the report in this issue.)*

Later in November I attended the *Winter Meeting of the American Nuclear Society* and associated meetings of two international organizations to which CNS belongs: the Pacific Nuclear Council (PNC) and the International Nuclear Societies Council (INSC). The focus of both of those groups attempt is cooperation between their many member societies. From time to time each has prepared statements on topics of common interest. One of the roles of the PNC is to authorize the country and society to hold the biennial Pacific Basin Nuclear Conference (PBNC).The next one of these, PBNC 17, will be held in Cancun, Mexico in late October 2010. (The deadline for abstracts for that conference has been extended to January 15, 2010. So, if you are looking for a reason to visit Cancun, jump to the keyboard and submit an abstract. See "Calendar" for their website)

One aspect of the ANS meeting that intrigued me was to hear, in that capital city of the most "free-market" country, repeated cries for more government money and more loan guarantees. Along with those demands were complaints about the bureaucracy of the US Nuclear Regulatory Commission. An interesting message was that current NPP designs are too large and too costly. There were several recommendations and a couple of proposals for small, modular, simplified plants.

Then, in early December, just before this issue of the *Bulletin* "went to bed", there was the *Workshop on Medical Radionuclide Production Methods* in Ottawa. Proposed and organized by CNS president Dorin Nichita, together with Adriaan Buijs and Ben Rouben, this also had a focussed objective, to bring together experts from the different organizations proposing methods of producing medical isotopes, particularly Molybdenum 99.

Initially I was hesitant about this proposed event. In May, the Minister of Natural Resources Canada had invited "Expressions of Interest" for the production of such isotopes and had set up an Expert Panel to review those submissions, with a deadline of November 30. To hold a Workshop on the same topic only days after that scheduled date seemed to be inviting political backlash. Surprisingly, the Expert Panel was submitted on time and the Minister released it only a few days later. Subsequently, several senior government officials agreed to participate in the Workshop. The result was a good attendance, excellent presentations and incisive discussion. (See the short report in this issue.)

After that extended "trip" report, I urge you to read the booklet, enclosed with this issue of the *Bulletin*, on the joint *Honours and Awards* program of the Canadian Nuclear Association and the Canadian Nuclear Society. Look around, you undoubtedly have colleagues who have contributed significantly to our Canadian nuclear program. Take the time to nominate them for an appropriate award.

A new year is approaching. Make a resolution to speak out when you hear or see erroneous criticisms about nuclear energy or radiation effects. And, get involved politically so that some day we can have a government that understands the role of nuclear science and technology in a world concerned about climate change.

In closing I extend my wishes to all for a healthy and satisfying 2010.

Fred Boyd

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~ Cover Photo ~

A replacement steam generator, manufactured by Babcock & Wilcox Canada, is lifted into place at Bruce Power.

– Photograph courtesy of Bruce Power

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6th CNS International Steam Generator Conference

Steam Generator meeting focuses on operation

by Fred Boyd

Reflecting the importance of steam generators to the successful operation of nuclear power plants, close to 300 delegates assembled in Toronto, November 8 to 11, 2009 for the *6th CNS International Steam Generator Conference*. With representatives from 13 countries other than Canada, it was truly an international event.

The theme of the conference was: *"Management of Real-Life Equipment Conditions and Solutions for the Future"*.

Keeping with that theme the invited papers and the technical sessions combined reviews of the past, current best practices, and thoughts of the future. In addition to the oral presentations, there was a poster competition with 33 entries and a display with 18 exhibitors. The conference ran in plenary fashion, there were no parallel sessions.

A pleasant reception on the Sunday evening, combined with opening of the exhibition area, opened the event. The conference proper began early the next day with greetings from **John MacQuarrie** of Babcock & Wilcox Canada, the honorary chair, **Bill Schneider**, the initiator of the conference, and **John Roberts**, the actual chair. Roberts then opened the first session, which was on the topic *Life Cycle Management.*

Setting the tone for the rest of the conference, **Paul Spekkens**, vice-president, science & technology at Ontario Power Generation, gave the opening address, entitled, *Steam Generator Life Cycle Management Challenges -Ongoing and New Build*. He began by providing two definitions of life cycle management (LCM):

- A decision-making process to choose the best, balanced option for asset management.
- A process which provides for timely detection and mitigation of significant ageing effects in systems, structures and components important to plant safety, reliability and economics.

He went on to describe programs and procedures for conducting all the elements of LCM and emphasized that it can not be "done" by one person or one group but by the whole organization. Among the challenges in conducting LCM are the facts that some degradation mechanisms are not well understood and that new degradation mechanisms continue to emerge, even late in life.

LCM plans can be complex, he noted, and efforts must be made to make them "user friendly" and to integrate them with other aspects of the overall business. For the future he saw the opportunity to avoid some of the problems that have been experienced. He recommended that LCM programs should be started at the design stage. Tremendous progress has been made, he said in conclusion, but new challenges continue to emerge.

Spekkens full written paper is reprinted in this issue of the CNS Bulletin.

Spekkens' presentation was followed by a report by **Gary Newman**, vice-president engineering at Bruce Power, who focussed on the challenging operation of replacing the steam generators in Bruce A units 1 and 2 as a major part of the refurbishment of those plants.

Then followed the first of an innovative exercise called "45 second Poster Snap-Shots" in which four or five poster authors each had 45 seconds to "sell" their poster. This was repeated throughout the conference until all poster authors had their turn. These "snap-shots" proved to be popular and resulted in more attention being given to the many posters.

Another invited paper was presented by **Jeffrey Gorman**, co-founder of and continuing consultant with Dominion Engineering Inc. of Virginia, USA. Reflecting his work in Canada, the paper was co-authored by John Slade of NB Power and Tracy Gendron of AECL, and was titled, *Performance Based Inspection Plan for Steam Generators at Point Lepreau.*

Gorman reviewed the development of the performance based inspection plan at Point Lepreau, noting it was based on guidance in reports of the Electrical Power Research Institute (EPRI). It takes into account:

- results of previous inspections
- tube degradation experience of all steam generators with Alloy 800 tubes, and,
- tube degradation experience of Alloy 600 tubes

To assess the plan the probability of flaws in the tubes initiating and growing was analysed using a Monte Carlo process. The conclusion was that an inspection interval of greater than six years would result in acceptably low probability of tube rupture and leakage.

The final paper of the first half of the morning was on Russian experience, titled, *Vertical Steam Generators for VVER: Myths and Reality,* presented by **Nikolay Trunov** of OKB Gidropress.

Much of his presentation dealt with the experience with horizontal steam generators before discussing analyses of possible benefits of using vertical ones. The concept plan for VVER 1220 A involves the vertical design.

After a break, three more papers completed the first morning's focus on "life cycle management".

The first was a report on the experience at the CANDU units at Qinshan, China, titled: *Investigation of Ageing Status Assessment and Lifetime Evaluation Based on Actual Operation conditions of QNPC NPP,* by Gui Chun and Chen Yinqiang. They reported that after 18 years operation their assessment indicated that the steam generators could operate for 50 years, and, therefore, will not be a negative factor in life extension.

Another international perspective was presented by Thierry Sollier and co-authors from the French regulatory organization, Insitut de Radioprotection et de Sureté Nucléaire in a paper entitled *Recent Safety Issues Concerning Steam Generators in France and their Analysis by IRSN.*. They reported that from 2004 to 2008 a number of leaks developed in the steam generators at three stations. Part of the problem was determined to be water chemistry.

Steve Sills and Richard Wilkerson provided a review of steam generator replacements in the USA over the past five years in their paper *Steam Generator Replacement – a Story of Continuous Improvement*. No two situations were exactly alike, they reported, noting the number of different manufacturers as well as different operators. However, they stated, performance is improving.

The afternoon of the first day focussed on *Flow Induced Vibration , Fretting Wear and Design*. It began with another invited paper, by **Michel Pettigrew** of Ēcole Polytechnique de Montréal, titled *Advancements in Flow-Induced Vibration Research and Design Criteria.* He reported on extensive research into the vibration problem, concluding with the statement that while these studies have yielded interesting results they have also raised questions.

Other papers in that session were:

- *Fluideleastic Instability Model for Steam Generator Tubes Subjected to Two-phase Flows* by Nyukie Mureithi et al from Ēcole Polytechnique
- *Advanced Non-Linear flow-Induced vibration and Fretting-Wear Analysis Capabilities* by Mohammed Tooranni et al from Babcock & Wilcox Canada
- *Tube-support Effectiveness in Steam generators: Dynamic Interaction Between Tube and Anti-Vibration Bar* by Isabelle Nowlan et al from Ēcole Polytechnique
- *Experimental Modelling of Flow-Induced Vibration of Multi-Span U-Tubes in a CANDU Steam Generator* by Atef Mohany et al of Atomic Energy of Canada Limited
- *CFD Simulation of Particle Entrapment of Steam Generator Sludge Collector /Loose Parts Weir* by Chunyun Wang et al of Westinghouse Electric Company
- *Development of a Nuclear Steam Generator System for Gas-cooled Reactors for Application in Oil Sands Extraction* by James Smith et al from SNC Lavalin Nuclear

The morning of the second day was devoted to the topic *Alloy 800 Tubing Material* and began with the following invited paper:

- *SG Life Cycle Management, Replacement and OpEx Sharing,* by Gary Newman of Bruce Power.

Other papers in the session were:

- *Alloy 800 Steam generator Tube Performance* by Jeffrey Gorman, Dominion engineering Inc.
- *Embalse Steam Generators – Status in 2009* by Pablo Luna of Nucleoelctrica Argentina S.A.
- *Replacement of steam Generators for Embalse NGS – the Steam Generator Cartridge Design and Manufacturing Issues, Localization and Site Assembly Challenges* by Jerzy Parkitny, Shankar Subash, AECL, Pablo Luna, Nucleoelctrica Argentina
- *Effect of Surface Cold Work on Corrosion of Alloy 690TT in High Temperature Water* by Jianqiu et al of Chinese Academy of Sciences
- *Degradation of Alloy 800 Steam Generator tubing and Its Long-Term Behaviour Predictions for Plant Life Management* by Yucheng Lu, Robert Tapping, AECL, Mahesh Pandey, U of Waterloo
- *Degradation Susceptibility of Steam Generator Tubing Materials Under ACR Steam Generator secondary Side Crevice Conditions* by Sue Liu, CNSC
- *Effect of Thermal Treatment on Microstructure of Inconel 690 and Incoloy 800* by XianChao Hao et al, Chinese Academy of Sciences
- *Predicting Steam Generator Tube Failures* by Romney Duffey and Robert Tapping, AECL

The afternoon was devoted to *Nuclear Plant Chemistry* with the following invited presentations:

- *Operating Experience Driven Advancements in Plant Chemistry Practice and Standards* by Keith Fruzzetti of EPRI
- *Modes and Influences of Possible Future Processes of Degradation of Tubes in Steam Generators* by Roger Staehle, Staehle Consulting

Other papers in the session were:

- *Extended Lay-up of Steam Generators During a Refurbishment Outage* by Chuck Marks et al
- *Advanced Scale Conditioning Agent Applications: 2009 Experience Update* by Michael Little et al, Dominion Engineering Inc.
- *Singular Deposit Formation in PWR Due to Electrokinetic Phenomena – Application to SG Clogging* by Michael Guillodo et al, AREVA
- *Time Domain Models for Damping-Controlled Fluidelastic Instability Forces in Multi-Span Tubes with Loose Supports* by Marwan Hassan et al, University of New Brunswick

All of the third day focussed on *Materials, Degradation and Inspection.* It began with another invited paper

- *Steam Generator Tube Integrity Requirements and Operating experience in the United States* by Kenneth Karwoski of the United States Nuclear Regulatory Commission.

The other papers were:

- *Update of the SG tube Intergranular Attack / Stress Corrosion Cracking in Bruce Unit 4* by Ken Sedman and David Durance, Bruce Power
- *An Overview of Ultrasonic Achievements and Experience with CANDU Steam Generators* by John Huggins et al of Kinetrics Inc. and Tom Malkiewicz et al of OPG
- *State of the Art Review of OPG Steam Generator Tubing Degradation Mechanisms* by Alex Brennentuhl, OPG, Sridhar Ramamurthy, G. Good, UWO

- *Mechanized Inspection of Steam Generator Components During Manufacture* by Heinz-Josef Otte et al, Cegelec AT GmbH & Co.
- *The Current Status of Mitigation, Experience and Repair Regarding Alloy 600 Issues on Japanese Steam Generator Nozzles* by Takafumi Hiro et all, Mitsubishi Heavy Industries
- *Advances in Automatic Data Analysis Capabilities* by James Benson et al, EPRI
- *Lab Assessment of Bruce Unit 4 SG Top-of-tube-sheet Cracking* by John Jevec et all, Babcock & Wilcox Canada
- *Localized Corrosion of Nickel-based Steam Generator Tubing Alloys in Sodium Sulphate Solutions Containing Thiosulphate* by William Zhang and Roger Newman, U of T
- *Oxide formed on Steam Generator Tubing Materials in Lead Containing High temperature Aqueous Solution* by Dong-Jin Kim and Hong-Pyo Kim, Korea Atomic Energy Research Institute
- *Pressurization Rate Effect on Ligament Rupture and Burst Pressures of Cracked Steam Generator Tubes* by Saurin Majumdar and K. Kasza, Argonne National Laboratory
- *Data Analysis Algorithms for Flaw Sizing Based on Eddy Current Rotating Probe Examination of Steam Generator Tubes* by Sasan Bakhtiari and Thomas Elmer, Argonne National Laboratory
- *NDE Errors and their Propagation in Sizing and Growth Estimates* by Dag Horn et al, AECL
- *Performance Evaluation of KANUPP Steam Generators for Operating During Plant Life Extension* by Afaque Shaikh et al, Karachi Nuclear Power Plant.

After the dinner on the second evening, **Roger Staehle** gave an engaging talk about Admiral Hyman Rickover, the founder of the US nuclear navy, with whom he worked as a young naval technical officer. With numerous slides of the considerable memorabilia that he has collected, he provided a verbal portrait of this remarkable man who began the US nuclear navy and oversaw its growth to 232 nuclear powered ships, mostly submarines.

Rickover, he said, not only had a strong knowledge of engineering but also a sense of politics and management that enabled him to combine a senior position in the US Atomic Energy Commission with that of the head of the Navy's Bureau of Ships. Two prototypes were built, one with a water-cooled reactor, the other sodium cooled. When the water-cooled one, the Nautilus, worked well, the other program was discontinued.

Indicative of his character, Staehle remarked, Rickover went on the first dive of every nuclear submarine built during his reign. There have been no nuclear accidents on any of the US navy's nuclear-powered fleet. That, said Staehle, reflects Rickover's insistence on excellence in engineering.

The conference was initiated by Bill Schneider, recently retired from but still associated with Babcock & Wilcox Canada and chaired by John Roberts, also recently retired from but still associated with Bruce Power. Graham MacDonald, of GE Hitachi, chaired the technical program. John MacQuarrie, General Manager of Babcock & Wilcox Canada was the Honorary Chair.

The conference CD will include all of the papers and a record of the discussions. It will be soon available from the CNS office.

James Smith. chair of the poster session presents a plaque to Keith Fruzzetti for the best poster at the conference.

Bill Schneider, initiator of the confernce (L) and John Roberts, conference chair (R) pose with Frank Doyle, vice-president of the Canadian Nuclear Society.

A view of a part of the exhbits.

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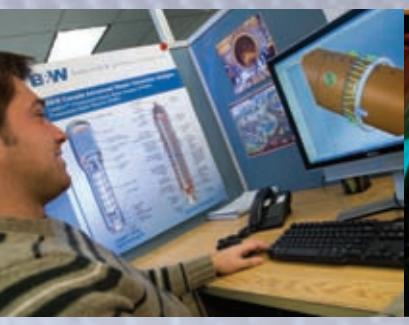


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Workshop on Medical Radionuclide Production Methods

Isotope Workshop provides more questions than answers

by Fred Boyd

On December 10 and 11, 2009, the Canadian Nuclear Society held a forum for proponents of different methods of producing isotopes for medical diagnosis, especially Molybdenum 99, to present the details and proposed benefits of their particular method.

Formally titled *CNS Workshop on Medical Radionuclide Production Methods* it drew a surprising 80 + attendees, well beyond the expected number. Even so, some of the organizations that have declared an interest in the topic did not participate, most notably Atomic Energy of Canada Limited.

CNS president **Eleodor (Dorin) Nichita** first proposed such an event in the early fall of 2009. That was a couple of months after the Minister of Natural Resources had issued a call for "Expressions of Interest" from organizations or individuals for alternative methods of producing Molybdenum 99 or directly its daughter product Technetium, 99m, the isotope most widely used for diagnosis. The Minister also established an Expert Panel to review the submissions with a deadline for its report of November 30.

With the support of CNS Council, Nichita, with **Adriaan Buijs** and **Ben Rouben**, quickly put together the basic structure of the Workshop, chose a date and a hotel in Ottawa as the venue, and began contacting representatives of organizations interested in producing the desired isotopes. **Murray Stewart** and **Fred Boyd** joined the team to work on non-program matters. By mid November 14 speakers had been confirmed. A few days after the Expert Panel report was released on December 3, Murray Stewart obtained the agreement of **Serge Dupont** to speak at the Workshop dinner. Dupont is Deputy Minister of Intergovernmental Affairs in the Privy Council Office and is currently serving as Special Advisor to the Minister of Natural Resources on Nuclear Energy Policy.

The first day began with an overview of the regulatory requirements by **Terry Jamieson**, Vice President, Technical Support Branch, at the Canadian Nuclear Safety Commission. He noted that all of the proposals would be subject to CNSC licensing. There are CNSC regulatory documents covering the requirements for both small reactors and accelerators. He noted that specific certification was necessary for targets. He concluded with a quick review of the process for the return to service of NRU. Two protocols have been signed to clarify the regulatory steps.

Most of the rest of that day was devoted to non-reactor methods of producing Mo 99 or TC 99m directly.

The first speaker, **Frederic Stichelbaut**, from the Belgian firm, Ion Beam Applications, spoke about proton-induced fission. He stated that a 200 MeV accelerator with a 1.5 mA beam could produce 2000 curies per week of Mo 99 from low enrichment uranium (LEU) targets.

He was followed by the first of two representatives of TRIUMF (the large cyclotron at UBC), **Tim Meyer**, who described some of the capabilities of TRIUMF. His colleague, **Tom Ruth**, who is also associated with the BC Cancer Agency, spoke of the process for direct production of Tc 99m by proton bombardment of Mo 100, one of the isotopes of natural molybdenum. Since the cyclotrons in Canada are located in large urban centres the short (6 hr) half-life of Tc 99m can be accommodated, he stated.

After lunch, **John Barnard**, of ACSION Industries, Pinawa, Manitoba, presented the process of producing Mo 99 by electron bombardment of Mo 100. He contended that the cost would be about $50 per typical dose compared to about $40 presently.

Kennedy Mang'era, from the Health Sciences Centre in Winnipeg, offered the perspective of the user. It is imperative, he said to develop and evaluate alternative production processes for Mo 99 to ensure a reliable supply.

Another advocate for the use of accelerators for the production of Mo 99 was **Carl Ross** from the National Research Council and mentioned the excellent machines manufactured by the company Mevex of the Ottawa suburb of Stittsville. He argued that an operation with two powerful accelerators Tc 99m could be produced for 25 cents a millicurie compared to a current price of about $1 a mCi. Ross gave some of his time to **Peter Brown** of Mevex who noted that they have produced 22 accelerators still operating around the world.

Completing the presentations for the day was **Tom Burnett** of MDS Nordion who offered an overview of the production and use of Mo 99. Mo 99 / Tc 99m is currently used in about 80 % of the nuclear medicine scans around the world, he said. The major producers are: Petten (Belgium), 33 % ; NRU 31%; Safari (South Africa), 13%.

Then followed an hour of open discussion with all of the speakers sitting as a panel. Although there were suggestions for an agreed statement from the Workshop the consensus was that there was no obvious solution.

At the dinner, **Serge Duport**, noted that the supply of Mo 99 was a global problem and Canada is taking a leadership role in developing international cooperation. Domestically, he emphasized, there are no answers yet. The Minister (of NRCan) and others in the government are studying the Expert Panel report. The restart of NRU remains a very high priority.

The second day was devoted to reactor-based Mo 99 production. Two of the speakers were from Saskatchewan. **Richard Florizone**, vice-president, University of Saskatchewan, presented an overview of their submission to the Minister, which is centred on a combined research reactor and isotope producer, similar to the OPAL reactor in Australia, which they call the Canadian Neutron Source.

Dean Chapman, also of U of S, speaking later, pointed out how the proposed Canadian Neutron Source reactor would complement the Canadian Light Source cyclotron. An objective would be to develop an Institute of Nuclear Studies.

A view from the USA was presented by **Richard Coats**, of Sandia National Laboratory. He noted that there is no Mo 99 production currently in the USA. After looking at all processes he concluded that the only practical approach was dedicated reactors.

Another outside perspective was provided by **Marcelo Salvatore**, of the company INVAP, Argentina. INVAP is a state owned company that operates on a strictly commercial basis, he stated, and has built research reactors, in Algeria, Australia and Egypt. It is currently working with B & W in the USA about a possible project. However, for isotope production he favoured a dedicated reactor.

After lunch, **Chris Heysel**, director of the McMaster Nuclear Reactor, pointed out that MNR had produced Mo 99 back in the mid-1970s when NRU (and NRX) were shutdown. "We have bridged the gap [in Mo 99 supply] before", he said, "and can do it again". To the inevitable question, how soon, he replied, "Within 18 months".

The final speaker of the Workshop, **Robert deKemp**, of the Ottawa Heart Institute, injected a different perspective. He asserted that for cardiovascular examinations the use of Rubidium 82 and PET (Positron Emission Tomography) provides better images than Mo 99/ Tc 99m with SPECT (Single Photon Emission Computed Tomography) and will gradually take over. Since heart scans make up about half of all scans that could reduce the demand for Mo 99 significantly.

The Workshop finished with another open discussion and a panel of all of the second day speakers. Again there was no consensus of the path forward. Nevertheless, many of the participants expressed their appreciation for the Workshop.

Canadian Science Policy Conference 2009

"Grass roots" conference draws large attendance

by Fred Boyd

When a conference organized by a "grass roots" group of mostly young researchers draws close to 400 attendees from all levels, government ministers to graduate students, and support from a wide range of organizations, the topic is obviously enticing.

Chair of the conference, Mehrdad Hariri, is seen with special guest Preston Manning, former leader of the Reform Party, now head of Manning Centre for Building Democracy.

The genesis of the *Canadian Science Policy Conference2009*, held in Toronto, October 29 – 30, 2009, was about two years earlier when **Dr. Mehrdad Hariri**, then a post-doctoral researcher at the McLaughlin-Rotman Centre for Global Health, began discussing the state of science in Canada with colleagues. Very soon he had a sizable group, including a number of senior advisors, which conceived the idea of a large national discussion on the state of science (including technology and implementation) in Canada. They began reaching out and soon had support from industry, academia, research centres and even government. The result was a well-organized, well-run, conference with many animated participants.

Held in downtown Toronto, the conference ran from Wednesday evening October 28, through all day Thursday and Friday, October 29 and 30.

The opening session on the Wednesday evening was held in the Marriott Eaton Centre hotel, well known to attendees of CNS conferences. The full days were held in the nearby University of Toronto's Chestnut Conference Centre.

At the opening session, Dr. Hariri, chairman of the organizing committee, welcomed the roomful of delegates and introduced the Ontario Minister of Research and Innovation, **John Milloy**, who began by congratulating the organizers for a bold and innovative agenda.

Milloy then went on to note that his relatively new ministry is the only one of its kind in Canada. It was created in 2005 by Premier Dalton McGuinty, who served as its minister until 2009, with a mandate to develop a new basis for Ontario's economy. A meeting had been held with the federal government in 2008 but that was not followed this year.

Then, Dr. Christopher Paige, vice-president research, University Health Network, introduced the keynote speaker, **Dr. Bruce Alberts**, Editor-in-Chief, *Science* magazine and chair of the US National Academy of Science.

Alberts began by commenting that if we want to get our federal leaders interested in science send them to China. All the Chinese leaders, he said, are focussed on science.

His talk, he said, was about "Getting science policy right – a view from the USA". Then he diverted to describe the National Academy of Science. It has a staff of about 1100 and is an independent organization, not funded by government, although, he said, they often do contract studies for the government. Those studies, he said, can usually be considered as "science for policy" as distinct from "policy for science".

His main message was that there is a need to have science more widely understood. He urged those in science and related areas to get involved in politics and government. Scientists need to get organized, he said.

The next two days had an intense agenda of plenary panels, parallel panel sessions, and two keynote addresses by Preston Manning and Gary Goodyear, Minister of State (federal) for Science and Technology.

The first plenary panel was on the topic *Canada's National Science & Technology Strategy*, with panellists: **Alain Beaudet**, president of the Canadian Institutes of Health research; **Peter Singer**, director, McLaughlin-Rotman Centre for Global Health; **Heather Munroe-Blum**, president of McGill University; and **Christopher Paige**, vice-president research, University Health Network (that embraces three large downtown hospitals in Toronto). Each tended to focus on the strengths and weakness of the Canadian science scene.

Munroe-Blum started by noting we have a good university system and applauded the program of "chairs of excellence". However, she noted, we are weak in transferring research into applications and have few commercial supporters of science. With a relatively small population we have difficulty creating a "critical mass" in any area, she said, then urged more centres of excellence. We should take advantage of our multi-lingual, multi-cultural society, she stated in closing.

Excellence should be the primary focus, stressed Alain Beaudet. Canada is relatively high in the number of publications in the health area and a good university system, he noted. More multi-disciplinary research should be pursued, he recommended, especially for "big" projects.

Hospitals are a key part of cities, engaging many researchers and can be economic engines, Christopher Paige claimed. However, the system for funding and governance is fractured, he stated.

We need to identify our "brand", said Peter Singer, and look beyond our dependence on the USA.. He noted the high diaspora of scientists from overseas (which was evident in the audience) and suggested that Canada should focus on the needs of the developing world. Have broad dreams and ambitions, he urged in closing.

Another plenary panel session followed after the morning break, focussed on *The Canadian Economy – from Resource-Based to Knowledge-Driven.* Panellists were: **Suzanne Fortier**, president, Natural Science and Engineering Research Council (NSERC); **Peter Hackett**, director, National Institute of Nanotechnology at the University of Alberta; **Peter Nicholson**, president, Canadian Council of Academies; and **Mark Lievonen**, president, Sanofi Pasteur Limited.

Peter Nicholson began with a reference to a report from his organization on the lack of innovation in Canadian industry. Then he showed a slide depicting the decline in Canadian productivity since 1984. They are related, he said, and offered three possible reasons: small domestic market; emphasis on resource based and foreign owned industry, and the fact that corporate profits had remained high, leading to a lack of incentive for innovation. More investment in technology is needed, he said, along with a focus on new ventures. The government needs a better understanding of the role of science and technology, he said in closing.

Canada has a good [research] system, Suzanne Fortier commented, but we are "stuck in low gear". There is a need to increase innovation, which requires more connections between disciplines. Academia and industry must come together, she stated, and all must pursue excellence.

The need to move from an "extractive" to a "creative" economy, was echoed by Peter Hackett. He said he is encouraged that young people are prepared to take risks. Institutions are generally not innovative, he observed, but he is encouraged by the work at his institute. He closed by deploring the fact that Canada has the lowest number of PhDs per capita of the developed world.

Mark Lievonen brought the view of science in the business world, describing how his firm (Sanofi Pasteur Limited) grew out of the beginnings of the Connaught Laboratories of the University of Toronto in 1913 to a global enterprise with annual sales over $1 billion. *(Ironically, his company was not among the sponsors of the conference.)*

At lunch, **Preston Manning**, former head of the Reform Party, now president of the Manning Centre for Building Democracy, was the special guest speaker. He drew a laugh with a quip about originally studying physics but when he could not handle the mathematics he went into economics. He then went on to offer some specific proposals to improve the state of science in Canada:

- get involved in the political process (there are no more than 10 members of the entire Commons and Senate with any background in science, he stated);
- urge the establishment of a senior federal office of science and technology
- work to increase business investment in science

The scientific community must improve its communication with the public, he stated. And, to the organizers of the conference, he urged them to take a few good ideas that arise and pursue them. "Do something", he emphasized, "and stop endlessly analyzing."

When he offered to respond to questions there was quickly a long line-up at the microphones.

In the afternoon there were two sets of three parallel panel sessions.

The first session featured panels on:

- Lessons learned and new models for implementing scientific knowledge in decision making processes
- Governance of emerging technologies
- The democratization of science

The three topics of the second session were:

- Best practices in science policy from other nations
- Private sector research and development: Role of R & D in the global economy
- the next generation of scientists : Science education and a new culture of civic engagement

Rather than a set conference dinner, arrangement were made with a number of restaurants in the area for those interested in a number of listed topics to gather in groups small enough to allow discussion. About half of the attendees, primarily those from out of town, participated in this experiment which, reportedly, most enjoyed.

The Friday morning began with an address by **Gary Goodyear**, federal Minister of State for Science and Technology who began by complimenting the organizers for a unique and groundbreaking meeting.

Then he turned to the current government's science and technology strategy as set out in the report of 2007, *Mobilizing Science and Technology to Canada's Advantage.* Since elected, he said, the government had increased spending on science and technology by $7 billion, including increases to the industrial research program, the granting Councils, and the Centres of Excellence. He noted, however, a recent report from the Council of Canadian Academies that identified the lack of business investment. The private sector must do more, he stated, and the government is prepared to help.

The rest of the morning was devoted to another set of three parallel panel sessions, on:

- Meeting the challenges ahead: Canada's policies on environment and energy
- Who speaks for science ? Stakeholder communication in the Canadian scientific community
- Science journalism, media and communication

In the last one it was noted that there are very few science reporters but also that surveys indicate that less than 20% of the public are interested in science. One participant noted the difference in the UK where there are 20 science journalists in London alone.

After lunch there were two parallel sessions on:

- Science diplomacy and international cooperation
- Innovation and commercialization: from bench to market

The latter focussed on a topic that had arisen throughout the conference – our poor record of transferring scientific discoveries into practical applications. Innovation is lacking, was the common theme. One speaker stated that there are more than 20,000 companies in Canada that do R & D but most are, and remain, small. Academics do not understand commercialization, he stated, and investors are impatient. Noting that two US programs for small businesses on innovative research and technology transfer have a total funding of $2 billion per year, he urged something similar in Canada.

The conference ended with an animated open question period with a panel of all of the presenters. There were calls for a follow-up meeting in a year or so.

All of the presentations and much of the discussion will be placed on the website the organizers created for the conference: www.sciencepolicy.ca.

The group of young researchers that organized the Canadian Science Policy Conference 2009.

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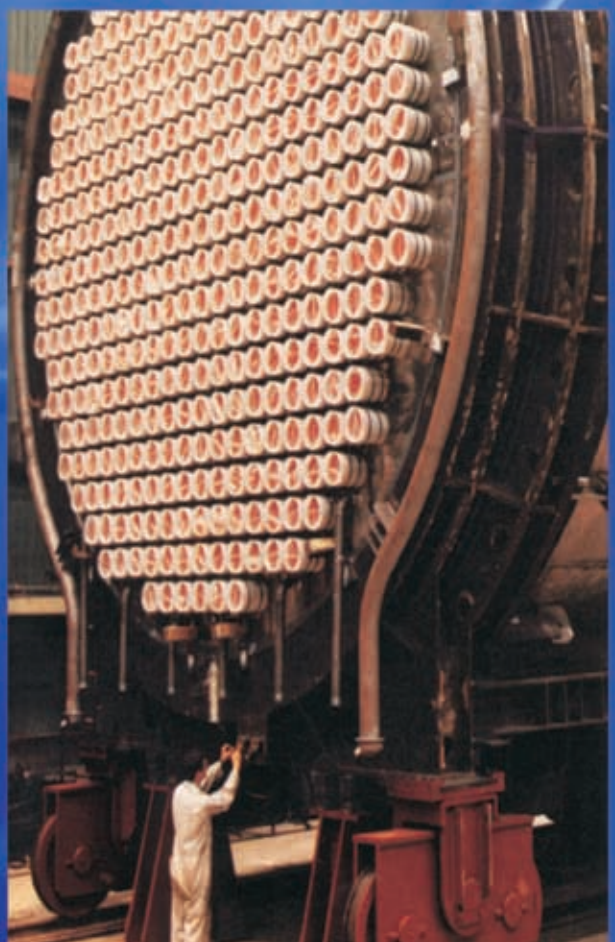

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New president for CNA

The Canadian Nuclear Association has a new president who brings a fresh and positive view of the future of nuclear activities in Canada.

Denise Carpenter assumed the critical role on November 23, 2009, some six months after Murray Elston left to join Bruce Power after five years at the helm.

Just a few days after taking on the challenging position, Ms. Carpenter graciously agreed to meet with the CNS Bulletin, given our deadline for this, the December 2009, issue. Understandably, the conversation was general but her optimism for the CNA and the Canadian nuclear program generally was very evident.

As background, Ms. Carpenter brings years of experience dealing with public and political issues faced by the Alberta energy industry. Over the past six years she was Senior Vice-President, Public and Government Affairs with EPCOR Utilities Inc., a municipality owned corporation based in Edmonton. Up until recently it included both municipal water systems and electricity generation and distribution. The power generation facilities EPCOR had owned were spun off in April 2009 to an openly traded company, Capital Power Corporation.

She has been very active in diverse community activities, including being vice-chair of the Alberta College of Arts and Design and a Board member of the Edmonton Oilers Community Foundation.

Prior to joining EPCOR Ms. Carpenter was Executive Vice-President and General Manager of Western Canada operations for Weber Shandwick Worldwide, a global public relations company, from 1985 to 2003. During her time with that organization she consulted with a number of Canadian companies to help them with their public communications and government relations. She mentioned particularly her long involvement with Syncrude.

Regarding nuclear power she remarked that she sees a very positive future as a clean and economic source of electricity. The Canadian nuclear industry is in a transition, she commented, in some ways parallel to those of the energy industry with whom she has worked in the past. That intrigued her and was a major factor in accepting the role as president of the industry association.

While the major players may have some differences, she observed that they all recognize the challenge of regaining public and political support. That is, she said, an obvious role for the CNA. The industry is at a precipice, she commented, and must develop a solid strategy for dealing with the current and future challenges. The major focus of the CNA over the next six months, she remarked, will be on the development of a strategic plan process.

She observed that there are some parallel aspects with the energy industry as being a large industry in need of public and political support. When she joined EPCOR, she noted, it was a time of deregulation which brought many challenges not the least of which was dealing with very vocal "interest" groups.

The other major components of the Canadian nuclear industry, radioisotopes and uranium mining, still have, she observed, a relatively positive image that needs to be preserved and enhanced. They also provide an opportunity to emphasize to the public and government the diversity of the nuclear industry, she added.

Ms. Carpenter commented that her first task was to get to know as many of the 90 CNA member organizations as she can. Over the next few months she expects to be on the road extensively, remarking that she already had many warm welcomes and invitations.

When asked if CNA might send someone to observe the Kyoto Accord COP meeting in Copenhagen in December, she commented that she had not really considered it but observed that she questioned the value to the CNA of such attendance.

Regarding the relationship between CNA and CNS she saw the two organizations being mutually supportive. She noted that she had been informed of the many individual members of the Society who had been very helpful in developing the CNA education program and in providing technical advice. When informed about the CNS 2010 conference she said she would plan to attend.

On a personal note, she commented that she and her family had already purchased a house in central Ottawa, with the obvious implication that she intended to stay for some time.

On behalf of the CNS we welcomed her to the challenging role of president of the CNA and thanked her for the meeting.

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Report of the Expert Panel on Medical Isotopes

[Ed. Note: The Expert Review Panel on Medical Isotope Production issued its report to the Minister of Natural Resources on November 30, 2009. The Executive Summary of the report is published below.]

Executive Summary

The Expert Review Panel on Medical Isotope Production (the Panel) was established on June 19, 2009, to advise the Government of Canada on the most viable options for securing a predictable and reliable supply of the key medical isotope technetium-99m (Tc-99m) in the medium to long term. This report is the culmination of that work, and presents recommendations that, in our opinion, will move Canada toward a new model for sustainable and secure long-term production of medical isotopes. We recognize that the government must ultimately select the best path forward for Canada, taking into account the broader nuclear energy and health care policy considerations that are outside the mandate of the Panel.

As part of this work, an expression of interest (EOI) process was launched to solicit ideas for alternative production of molybdenum-99 (Mo-99)/technetium-99m (Tc-99m) for the Canadian market in the medium to long term. We received 22 EOIs from a range of public and private sector organizations and reviewed the EOIs against specified criteria:

- Technical Feasibility;
- Business Implementation;
- Timeliness;
- Regulatory Issues; and
- Benefits to Canadians.

The EOIs proved very useful in identifying broad classes of technology options available. We greatly appreciated the time and effort invested by the proponents — we reviewed and assessed every EOI, and they played an important role in forming the content and recommendations presented here.

We also engaged medical, technical and regulatory experts to enhance our understanding of the many considerations involved in a long-term plan to secure medical isotope supplies. Among others, we received information from:

- Atomic Energy of Canada Limited;
- the Canadian Association of Medical Radiation Technologists;
- the Canadian Association of Nuclear Medicine;
- the Canadian Association of Radiologists;
- the Canadian Association of Radiopharmaceutical Scientists;
- the Canadian Institutes of Health Research;
- the Canadian Medical Association;
- the Canadian Society of Nuclear Medicine;
- the Canadian Society of Senior Engineers;
- individual nuclear medicine specialists;
- International Safety Research Inc.;
- the Ontario Association of Nuclear Medicine;
- the Royal College of Physicians and Surgeons of Canada - Nuclear Medicine Specialty;
- SECOR Inc.;
- SNC Lavalin Inc.;
- 15 independent and internationally known technical experts;
- other national and international stakeholders; and
- a Tc-99m generator manufacturer.

Throughout, our focus and attention remained on the best interests of patients and their families and the health care needs of Canadians.

Our report is structured around major classes of technology, with each technology option assessed against the specified criteria. The technologies are:

- **Reactor technology**
  1. New multi-purpose research reactor — fission option
  2. Dedicated Isotope Facility — fission option
  3. Existing reactors — fission option
- **Accelerator technology**
  4. Linear accelerator — photo-fission option
  5. Linear accelerator — Mo-100 transmutation option
  6. Medical cyclotron — direct Tc-99m option

Sustainability and Security

Through our work and our assessments, we established parameters to define a sustainable and secure supply of Tc-99m in the medium to long term. A sustainable supply of Tc-99m to serve the needs of Canadian patients would:

1. be viable for the foreseeable future, likely for at least 15 to 20 years, and may include options that begin producing in the short to medium timeframe but that promise to remain viable;
2. comprise options that could each meet a meaningful portion of the Canadian demand, but that would not necessarily be exclusively Canadian-based and may or may not serve the U.S. or other markets;
3. have a sound business model that may or may not include government involvement; and
4. be free of highly enriched (weapons-grade) uranium (HEU) because of Canadian and global commitment to non-proliferation.

A **secure** supply of Tc-99m would:

5. improve redundancy at all points in the supply chain to

avoid the "single point of failure" risk associated with a linear supply chain;

6. use diverse technologies to hedge against a failure that could arise if all suppliers used the same technology;
7. collocate irradiation and processing facilities to minimize decay losses and avoid shipping losses and risks; and
8. ensure sufficient capacity to accommodate short-term outages of some sources.

Establishing these parameters for sustainable and secure supply helped to frame how we assessed the likelihood of various technology options contributing to a stable isotope supply in the long term.

Key Findings for Technology Options

The most significant findings for each technology are given below. A full assessment of each technology option against all established criteria is given in Chapter 5.

1. New Multi-purpose Reactor Option

The lowest-risk path to new Mo-99/Tc-99m production capacity is to build a new multi-purpose research reactor. The research reactor also promises the most associated benefits to Canadians based on its multiple purposes.

Research reactors are shared facilities that have all the benefits associated with multi-use facilities, including the benefit of costs being spread over a large base of activities. However, this is the most expensive of the options, with high capital and operating costs. Costs associated with the processing facility, training, licensing requirements, security, and waste management are also very significant.

Revenue from isotope production would likely offset only approximately 10–15% of the costs of the reactor; building a new reactor would have to be justified, in large part, based on its other missions.

Given the established parameters for sustainability, any new reactor-based source of Mo-99 should be based on low enriched uranium (LEU) targets; some research and development (R&D) would be required to optimize the process and deal with the increased volumes of waste.

Of all the technology options, this one has the highest potential for concomitant benefit to Canadians based on the promise of the broad-based research that would be undertaken, and its associated potential for generating intellectual property, job creation and training.

2. The Dedicated Isotope Facility (DIF) Option

This option involves restarting the DIF project, which included two Multi-purpose Applied Physics Lattice Experiment (MAPLE) reactors, the New Processing Facility (NPF) and associated waste management structure. These facilities were never fully commissioned, and are in an extended shutdown state.

The DIF was designed and optimized to use HEU targets. Moreover, the design of the MAPLE reactors, the NPF and the associated waste management structure was heavily customized and dedicated to isotope production. This customization would pose significant challenges for possible modification and conversion to LEU, which, in our opinion, is mandatory for any medium- to long-term plan.

Furthermore, even if the existing infrastructure were to come at no cost, the ongoing economics for this project remain questionable because high operating costs cannot be shared across multiple uses. The fact that no dedicated isotope production reactors have been built and operated or are in planning anywhere in the world (with the exception of the DIF) suggests that others recognize the economic difficulties of this option.

Estimates for the timeline range from two to eight years. Although the best-case scenario of two years to market is attractive, we expect the timeline to be longer given the challenges with the processing facility, in addition to the licensing challenges.

3. Existing Reactor Option

Other existing research or power reactors, either domestically or internationally, could be used to irradiate targets for the production of Mo-99. Generally, projects associated with existing reactors are based on the use of modified processing facilities at AECL and the existing supply chain. Because research reactors are less powerful and consequently less efficient for isotope production, they require the use of HEU targets to achieve worthwhile yields.

While conversion to LEU would be possible, it may not be justifiable based on the limited remaining lifespan of the facilities. Nonetheless, HEU-based options in this category should be considered as options to address short-term supply shortages.

4. Linear Accelerator — Photo-fission Option

A particle accelerator is a device that uses electric fields to accelerate ions or charge subatomic particles to high speeds in well-defined beams to bombard targets for research and isotope production.

In this option, a high-power electron linear accelerator is used to bombard a converter to produce an intense photon beam to generate Mo-99 through nuclear interactions with natural uranium.

The required accelerator is not currently available, but the development is technically low risk. Substantial R&D is needed for the target and converter design, the cooling capacity and overall process optimization.

To meet the required production levels, the accelerators would be dedicated to isotope production, and would not be available for research or any other purpose. This option suffers from poor economics because capital investment is relatively high and cannot be shared across multiple missions.

Although the cost of an individual accelerator is much less than that of a reactor, as many as four accelerators would be needed to meet Canadian demand, and they would be relatively expensive to build and operate based on the high power requirement. When costs associated with processing and waste management are included, the total costs of the option could exceed $500M.

As a fission-based approach, this option would likely fit well into the existing supply chain; however, significant quantities of nuclear waste would be generated.

5. Linear Accelerator — Mo-100 Transmutation Option

An electron linear accelerator can produce Mo-99 through the transmutation of enriched Mo-100.

The Mo-100 option requires significant R&D regarding targetry and cooling capacity, as well as the development and marketing of a new type of generator. There is some concern that hospitals may not accept the new generators, and that this new product may not be able to compete with the traditional generators, presenting significant business risk.

Currently, there is no commercial production of purified Mo-100. The cost of the quantity needed could be substantial and may prove to be a barrier to commercialization. A full recycling of Mo-100 could reduce the cost substantially by minimizing loss, but recycling is yet to be demonstrated, and significant R&D would be required.

As in the case of photo-fission, the accelerators used for Mo-100 transmutation would likely need to be dedicated to isotope production to achieve the desired production levels, making this a single-use option. Return on investment would be difficult given the current price for Mo-99 and the significant costs, which cannot be shared across multiple missions.

A significant advantage of this option from an environmental and cost point of view is that it does not generate nuclear waste.

6. Cyclotron Option

A cyclotron is also a particle accelerator device. This option is based on bombarding Mo-100 with protons to extract Tc-99m directly from the irradiated product.

This is the only option in which Tc-99m is produced directly without first generating Mo-99.

Because the production of Tc-99m using cyclotrons is at an early stage of development, it is difficult to say how much of the Canadian market could be or would be served by cyclotrons. However, it is attractive because the cyclotron infrastructure could be in place and used for other purposes, but could still offer surge capacity to augment other sources.

Although significant R&D is required, the infrastructure to undertake the research, demonstration and initial production is presently available. Therefore, costs are relatively low and timelines for the R&D are relatively short.

This option can be implemented on a gradual basis since the model is for a distributed system with each cyclotron serving only local radiopharmacies and nuclear medicine departments. Communication and collaboration between medical cyclotron operators could ensure redundancy in supply and avoid single point of failure in the supply chain.

The cyclotron option is not a complete solution; because the half-life of Tc-99m is short, only hospitals and radiopharmacies close to a cyclotron would be served. More remote locations would continue to be served by Tc-99m generators, likely through existing supply chains. As a result there will be a need for Mo-99 to meet Canadian needs for the foreseeable future, although this could coexist with direct Tc-99m production.

Difficulties with this option include the requirement for R&D associated with target design and Mo-100 recycling. This option may require more validation from a Health Canada regulatory perspective. Currently, there is no commercial production of purified Mo-100. The cost could be high and may prove to be a barrier to commercialization.

An important consideration is that this option does not produce nuclear waste, which results in economic and environmental benefits over fission-based options.

The cyclotron option has the potential to be the timeliest option. Commercial production of Tc-99m could begin between 2011 and 2014, depending primarily on results of R&D and health regulatory issues.

General Recommendations

1. Strive for diversity and redundancy throughout the supply chain.

We recommend adopting a supply strategy offering technological diversity, and redundancy at every step in the supply chain.

2. Leverage multi-use infrastructure.

We recommend investing in infrastructure that is designed to have multiple purposes and is more likely to remain useful over the long term, regardless of how the use of medical isotopes evolves.

3. Continue with international coordination, and seek processing standardization within North America.

We recommend that the government continue to inform itself of all international isotope initiatives, and work with other countries to better coordinate worldwide efforts around isotope production and distribution. We also encourage the government to start laying the groundwork now for establishing target and target processing compatibility, especially for any new sources developed in North America.

4. Recognize that HEU options are viable only in the short to medium-term.

We recommend that any option reliant on HEU be dismissed as a long-term solution. As a proponent of non-proliferation, Canada must work to eliminate HEU from civilian use. Because many options associated with existing reactors are based on using HEU targets, they should be considered only within a short-term context.

Technology-specific Recommendations

1. Make policy decisions on the requirement for a new research reactor.

We recommend that the government expeditiously engage in the replacement of the NRU reactor as we believe a multi-purpose research reactor represents the best primary option to create a sustainable source of Mo-99, recognizing that the reactor's other missions would also play a role in justifying the costs. With the National Research Universal (NRU) reactor approach-

ing the end of its life cycle, a decision on a new research reactor is needed quickly to minimize any gap between the start-up of a new reactor and the permanent shutdown of the NRU. If the decision is to not build a new research reactor, the issue of securing supply of Tc-99m will have to be revisited in light of how cyclotron/accelerator options are advancing, and what new foreign sources of isotopes have materialized.

2. Support an R&D program for cyclotron-based Tc-99m production.

We recommend that the cyclotron option for direct production of Tc-99m, which has many attractive features, be explored further. Although this option requires significant R&D, the infrastructure and know-how to undertake that work is readily available in Canada so costs associated with the R&D remain relatively low. Assuming technical viability, the infrastructure necessary to demonstrate this approach in selected centres across Canada is already in place. Indeed, Canada has an opportunity to be a leader in this area and strengthen its existing related businesses.

3. Achieve better use of Tc-99m supply through advanced medical imaging technologies.

We recommend deployment of newer single photon emission computed tomography (SPECT) technologies (software and hardware), as well as investment in positron emission tomography (PET) technology, to reduce demand for Tc-99m now and over the longer term, which would reduce the impact of future shortages of reactor-produced isotopes.

Other Considerations

1. Linear accelerator options

The two linear accelerator options have limited prospects for multi-purpose use, require significant R&D, and may not have significant cost advantages over reactor technologies. Nonetheless, a modest R&D investment could be considered as a hedge against the risk of failure of other options. Of the two linear accelerator options, we prefer the technology based on Mo-100 transmutation since the projected economics appear better, and it largely avoids nuclear waste management issues.

2. Dedicated Isotope Facility (DIF) infrastructure

Cost and timeline estimates associated with the commissioning and licensing of the DIF varied widely. Although it may be possible to bring them into operation, the business case is such that even if the DIF facilities could be licensed immediately at no cost, the ongoing revenues from isotope sales would be insufficient to cover the ongoing operating expenses, particularly with the anticipated reduced throughput from future conversion to LEU targets. A dedicated isotope facility based on a private sector cost-recovery model would be a good solution assuming a private sector organization would be willing to accept the full commercial risk associated with this model.

The importance of teamwork when things get tough

by Neil Alexander, President, OCI

In the last issue I wrote about the problems caused by the Federal and Provincial Government batting balls backwards and forwards over a net rather than working together. In this issue I continue the sporting theme but make some observations on our own teamwork and for that we need a team sport. Those that know me will know that my sport is rugby but I expect this analogy also works well for football (any of the kinds) and hockey (field and ice) for those not lucky enough to follow the king of all sports.

In rugby games, when everyone has been trying really hard but the game is still being lost, the team structure often breaks down and individuals try "new ideas" that they think will turn the game around. Typically this happens late in the game when everyone is a little tired.

The breakdown of discipline rarely achieves anything positive and most often it leads to a loss turning into a rout.

But I have also seen successful turnarounds. They typically come when a team recognizes the challenge and then returns to the team strengths with a renewed effort.

The Canadian Nuclear Industry appears to be deep into the second half of the game and presently things are not going well. While much of the rest of the world is recognizing the importance of nuclear power in a sustainable future and is re-establishing its nuclear programs, Canada, one of the leading nuclear nations, is bucking that trend and is dithering while its nuclear industry stares decline in the face.

Obviously we have some work to do but instead of returning to our strengths individual groups are beginning to think up their own new "game winning" ideas. Some are seeking to find innovative solutions to the "problems" on the Darlington decision. Others are focused on the details of the AECL restructuring. Still more have advice for the Government on isotopes, new research reactors, reprocessing, small reactors etc etc.

Likely all of them are good ideas in their own right but cumulatively they are causing confusion and creating more and more opportunity for the opposition to score against us. To turn this game around we need to stop these panic driven actions and return to consistent, clear and simple messages such as;

1) Nuclear is making a comeback because it is proving to be the only safe and sustainable form of large scale electricity production for regions that do not have hydro opportunities
2) Nuclear is one of Canada's anchor industries and one in which we continue to be world leaders in design, fabrication, construction, uranium production, fuel supply and reactor operation.
3) The nuclear renaissance is a huge opportunity for Canada.

There will of course be individual skirmishes, other issues will be raised and we will have to deal with them but if we can keep shifting the subject back to these core points we will strengthen our industry's overall position and progressively win the possession and territory our team needs if it is to turn this game around.

So let's take a deep breath and get back out there doing the one thing that really does separate the Canadian nuclear industry from the rest and that is our ability to work together as a team.

A Few Alternate Words to Make Us Greener and Less Frightening to the Public

Recently, the President and CEO of Westinghouse, Aris Candris, revealed at the World Nuclear Association annual conference in London that they had just completed a survey about what the public thought of their AP-1000 features. To their astonishment, the public believes that the words "passive safety" and "modular construction" are interpreted to mean to "lazy" and "shoddy construction"!

So why does that matter? What the public thinks is important because in a democracy their votes and perceptions define our political landscape, which politicians interpret in order to make decisions guided by that same public opinion. This is all the more important in minority government situations and we seem to be in a perpetual minority cycle right now.

During the initial startup of Darlington I placed a notice telling everyone in the plant at Zircatec that the initial unit had "gone critical". Within minutes staff came into my office and asked if they could go home!

Our energy cousins in the coal industry have now coined the words "clean coal". Maybe we need to start changing our technical jargon and lingo so our real customers, which is the public at large, are less frighten by words like criticality. Just ask our colleagues at Cameco about how just using the word "criticality" galvanized the residents of Port Hope against their license application for an enriched facility.

We must communicate clearly and succinctly, and avoid alarmist phraseology that can be misinterpreted or is technical jargon. I know this is asking a lot, but we really do ourselves a disservice when we use words that conjure up fear within the lay public. Here are some examples and some alternate suggestions.

1) Poison – a substance known to cause sickness or kill, or a term used to describe a substance added into either the fuel or moderator to suppress reactivity. So I guess we could call it just that – a suppressant.
2) Burnup – this term is somewhat unique to the nuclear industry and indicates the consumption or rather depletion of U235 during fission. When used by us in public, it is interpreted to mean that uranium burns like coal – a wrong and potential dangerous understanding. So instead of fuel burnup we could use consumption or depletion.
3) Nuclear Waste – It's true that spent fuel contains some waste, but it also still contains U235 and U238. The Nuclear *Waste* Management Organization has unfortunately used the word "waste" in its name and hence its funding is literally perceived as going to waste too. However their proposed Adaptive Phased Management of spent fuel allows retrieval for future recycling of this energy store. It seems prudent to say spent fuel and not nuclear waste.
4) Reprocessing – this term is used within our industry but it's a favorite word for the antis as it is so closely associated with weapons production. "Recycling" is viewed by everyone as a good thing and so much more amendable and correct if we are to use the word recycling to describe advanced fuel cycles like Recycled Uranium.
5) Critical and Criticality – these words are by definition a worry to anyone outside the industry. Since we are trying to say that a reactor is operating with sustained nuclear fission, perhaps when a reactor starts up, instead of saying it has "gone critical", we should simply say it has "started up" or has just "begun operation".
6) Dose – most people do not want to receive or have a "dose" of anything, let alone radiation. Why do we not use "amount"?
7) Allowable atmospheric and environmental discharges – these again make it seem that polluting the planet and the local ecology is happening routinely, whereas the industry seems to be afraid itself of using words like "small", "miniscule" or "totally insignificant"
8) Emergency evacuation – these words need no further discussion as the many connotations and misperceptions are awful. "Relocation" is used by realtors every day seemingly without unduly raising concern.
9) Reactor – it seems almost a shame that the word implies there is a "reaction' of some sort, which of course technically it does. But perhaps "nuclear plant" is better

Maybe there are other words we use that can mislead or frighten the public. So as friendly as these words are to all of us, I believe we should begin to start using greener and less frightening alternatives in our everyday use, especially when speaking to and communicating with the public.

Martyn Wash
CNS Member

Ontario's Green Energy Act not so green

Ontario's Green Energy Act is not so green. The transition from coal to natural gas and wind will not necessarily reduce greenhouse gas emissions.

Wind is not replacing coal; gas is. Natural gas will need to be burned in gas-fired power plants whether the demand on the grid is high or low and whether or not the wind is blowing. Gas, less flexible in operation than coal, is replacing coal, to be burned to provide base load (together with run-of-river hydro and nuclear) and intermediate load (together with stored water hydro). Gas responds to the normal load-following dispatches

needed to balance the grid, albeit made more difficult by erratic wind generation, because the present nuclear plants cannot respond quickly enough and stored water is a valuable operating reserve not to be wasted. This means that when demand is low, and or wind generation is high, expensive wind energy will displace the clean, cheap electricity from the nuclear plants that will have to power down or even shutdown for several days or weeks, and cannot displace the electricity from the polluting, greenhouse gas (GHG) emitting gas-fired plants that are needed to meet the varying demands of the grid. This is happening now even though at present there is a relatively small amount of wind on the grid.

Shutting down and powering down nuclear stations in order to run the gas-fired generators makes a mockery of Ontario's Green Energy and Green Economy Act and certainly does not improve the reliability of the grid if a demand for more power arises. More wind generation will make an already bad situation worse. To reduce the burning of gas new nuclear units in Ontario will have to have load-following capability, that is, be able to vary output up and down by significant amounts in accordance with dispatches.

Even though GHG emissions from gas-fired units are around half that from coal-fired units, for the same electrical output, the replacement of coal-fired power plants by natural gas-fired plants will not reduce GHG emissions as much as would be thought. This is because the minimum operating power output of the gas-fired units is a lot higher than that of the more flexible coal-fired units. This means that in periods of low demand, and or high wind generation, the output from nuclear plants would have to be decreased more with gas-fired units on the grid than would have been the case with the coal-fired units, in order to keep the units above their minimum loading level. Thus GHG emissions from an Ontario gas-fired grid could be even more than from a coal-fired grid, depending on the demand and the amount of wind generation.

It is simplistic to think that adding windmills to the grid will significantly reduce GHG emissions. Why is the Ontario Power Authority not pointing this out to the government before many more billions of dollars are wasted on wind and gas?

Don Jones
Mississauga, Ontario

Demand Control vs. Supply Control

Nuclear power stations can handle small fluctuations in power demand but are unable to handle large daily demand fluctuations or the even larger seasonal fluctuations. That problem is exacerbated by the introduction of wind power which adds involuntary supply variations. In Ontario natural gas fired power stations are presently used to handle such fluctuations but that is undesirable because of their CO_2 production. A better answer may be to control the demand instead of trying to adjust the supply. The demand can easily be varied by storing part of the electric energy by converting it into heat that is stored in the ground. The heat is subsequently used to heat buildings so it ends up being usefully employed. The ground storage is capable of retaining the heat for long periods of time, enabling seasonal demand fluctuations to be handled.

Seasonal storage of heat is an attractive practice for heating buildings because it can utilize heat collected from the summer air, which provides a virtually unlimited source of energy, and can also handle energy from excess power production as well as waste heat from sources like large buildings that use a lot of power. Atmospheric Energy (AE) systems using these sources are described in the web journal Sustainability-Journal.ca. For power management the advantages are the ability to instantaneously match supply and demand, the potential to cope with thousands of megawatts of excess power, the low energy loss, and the very low cost of storage. There is a major benefit for the AE systems as well. To be universally applicable such systems must work even in areas that are not suitable for long term storage because of unsuitable ground conditions, and in that case short term storage of excess nighttime power can supply those sites.

A very large part of the electricity supply is currently used for heating and cooling applications that peak in the winter and the summer, creating the very problem that we need to solve. By using the ground as the heat sink for air conditioning systems the power demand of the air conditioners can be minimized, greatly reducing the summer demand peak. In the winter the ground heat can replace electric heating (and fossil fuel heating as well). Levelling the loads makes nuclear power more practical and dealing with the current nighttime power excess would make it possible to expand the baseload generation.

There is a great deal of flexibility in deciding when and where the heat will be stored, which is useful for both the supply side and the consumption side. The AE storage sites can be placed under city streets (they do not require subsequent access) and the injection process could be controlled by the municipal power distributors, which are commonly city owned. Typically a storage site would supply heat to about 50 homes and could handle up to 500 kW of heat injection. The sites can be linked together to form networks that can grow to handle any number of buildings. Such systems have the potential to reduce Canada's CO_2 production by up to 100 million tonnes and would open up the options for eliminating the use of fossil fuels for power generation.

Ron Tolmie
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http://sustainability-journal.ca

Steam Generator Life Cycle Management Challenges – On-going and New Build

by Paul Spekkens[1]

[Ed. Note: The following paper was the keynote address to the 6th CNS International Steam Generator Conference, held in Toronto, November 8-11, 2009.]

1. Introduction

Ontario Power Generation (OPG) is committed to the safe, reliable, and cost-effective operation of its fleet of CANDU plants. Steam Generators (SGs) are a major component of the heat transport system in these plants and maintaining their health is an essential element to achieving plant safety, reliability and economic performance. OPG has been actively engaged in formal life cycle management of its SGs for about 15 years. Over this time, we have developed stable, mature, detailed life cycle plans for each of our plants on a unit by unit, and in some cases, SG by SG, basis. These plans have been externally reviewed over the years by our regulator and by other third-party experts, and they've been acknowledged as being among the best life cycle plans anywhere.

I want to start by acknowledging the folks who currently work in this function at OPG. Life cycle planning of SGs at OPG is led by a group in our corporate Nuclear Engineering centre. Life cycle planning is not "done" by one group or one person. The effort has been led by our corporate Nuclear Engineering Division, but there are many individuals at the sites, in the site engineering organization and in Operations and Maintenance, in our internal inspection service provider, IM&CS, along with several external vendors who have a major role to play in life cycle management.

Although we are pleased that our life cycle plans are as detailed and mature as they are, we certainly aren't fully satisfied because they're not perfect. Even if they were perfect at any point in time, they wouldn't be for very long because the environment is constantly changing, both the technical environment and the business environment.

This paper presents some of these challenges and offers some possible solutions or suggestions based on OPG's experience. The paper describes the background on SG life cycle management in OPG, i.e. what it is and how we do it. Then it presents challenges in the following areas:

- Despite having some very detailed and technically strong life cycle plans, we still face some technical issues. In addition, we face challenges in integrating these plans into the overall business processes within the company.
- Up until now, our life cycle planning has been aimed at early- and mid-life in our units. But our units are aging and we are now within sight, at least in a life cycle management sense, of a point at which decisions need to be made on refurbishment, life extension or retirement of the units. We need to adjust our life cycle management approach as we approach those major milestones in the lives of our units.
- In Ontario, we're still some years away from a New Build project, but nevertheless it's a good time to reflect on how we're going to approach the "new beginning" opportunity that New Build provides for us - an opportunity to learn from the past and avoid some of the design and operating shortcomings that have caused us considerable pain in the current generation of reactors.

2. Definitions of Life Cycle Management

There are many definitions of Life Cycle Management in the literature and two that describe what we do quite well are the following:

- A decision-making process to choose the best, balanced option for asset management
- A process which provides for timely detection and mitigation of significant aging effects in systems, structures and components (SSCs) important to plant safety, reliability and economics

In the broadest sense, life cycle management is a decision-making process to allow a company to choose the best balance of options to manage its assets. This definition works at any level. We can apply this to the entire plant, or to the fleet as a whole. We can also apply it to sub-sections of the plant such as the SGs. In each case, the objective is to choose the best option for asset management.

For components like SGs, the focus of life cycle management is almost always related to aging. So an alternate definition of life cycle management is a process that provides for the detection and mitigation of aging effects in systems or structures or components that are important to plant safety, reliability and economics. This definition has some things in it that are pretty self-evident. A system has to be important for safety, reliability or economics before you would spend a lot of time and energy trying to manage its life. Otherwise, it may be more effective to allow it to run to failure and replace it when required. For those items that have significance, the timely detection of degradation is critically important.

These are two effective definitions of life cycle management and are the basis for what we do in OPG.

3. SG Life Cycle Management at OPG

Life cycle management is a conceptually simple: Plan, Do, Check, Adjust, cycle. It starts with knowing what the objectives are. Based on knowledge of the current condition of the plant, we

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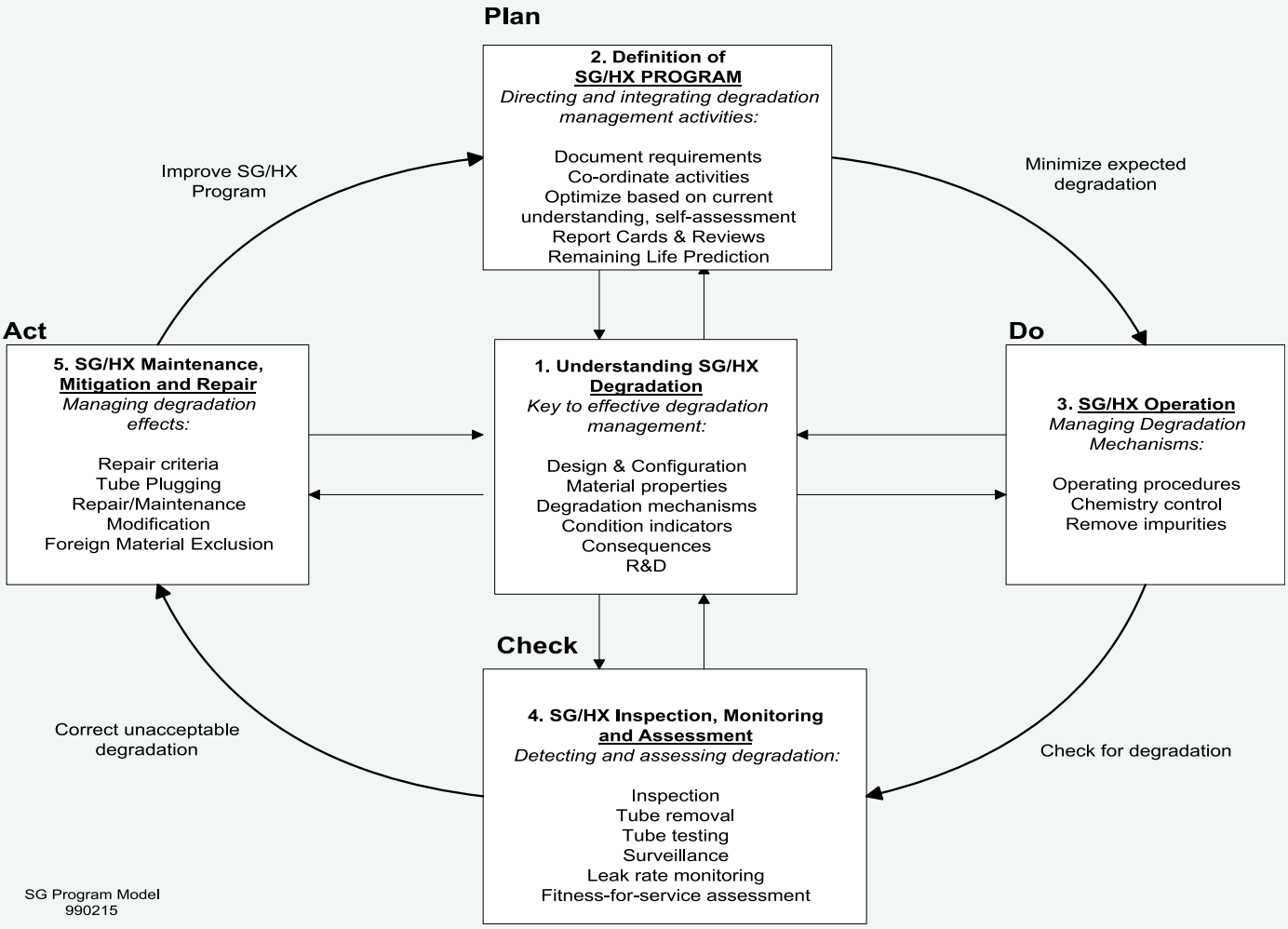


can implement work in the plant to take us where we want to go. And we monitor along the way. As we go around this cycle, any one of these elements can change. We may decide that we want to go somewhere different. We may discover that the condition of the plant has changed and, as a result, we need to change our implementation plan. We may need to step up our monitoring activities somewhere. It is clear that life cycle management is a very dynamic process. That's why I said at the outset, you may be perfect on any given day but odds are that a short time later your plans will become out of date.

The model depicted in the drawing is based on guidance provided by documents issued by the Nuclear Energy Institute and the Electric Power Research Institute in the US, and the International Atomic Energy Agency. This is the life cycle management model that we use for our SGs in OPG. It's the same Plan, Do, Check, Adjust cycle where you define the objectives and requirements, operate the SG, monitor its performance (through inspections, tube removals, leak rate monitoring, etc.), maintain the SG and then go back through the cycle again.

The important difference in this model is the box in the middle. You can't effectively manage something you don't understand, so understanding the mechanisms of degradation is absolutely critical to being able to manage the SGs appropriately. This is where R&D becomes so important because you seldom develop an understanding of a mechanism just from field observations. It takes work in a laboratory to get ahead of the mechanism and to understand how its course is going to change with time, which is the key ingredient for making life cycle management work.

At OPG we have a detailed program and procedures for conducting all elements of life cycle management. This program provides clear accountabilities and internal interfaces. We try to use a consistent methodology and criteria across the plants and components to provide effective support for business decisions. Our integrated aging management program is sustainable and we intend it to be a continuing program going forward.

It's very clear that life cycle management is not done by one person or one group – rather, the whole organization has to participate. The process may be led by a single group, but no single group can effectively carry out all the steps in the life cycle planning cycle. It just won't work unless everyone has bought into the process. At OPG, everybody acknowledges the importance of life cycle management. The debate now is around the content of the life cycle plans, not whether it's a necessary thing to be doing.

We build a lot of information into the SG life cycle plans in OPG, as follows:

- Component performance objectives and design requirements
- Understanding of degradation mechanisms and consequences
- Assessment of current condition and life predictions

- Strategies for managing degradation mechanisms
- Inspection and maintenance (repairs, cleaning, etc) plans for 6-10 years
- Issues and risks

The chosen stategy takes the form of a detailed inspection and maintenance plan which extends between 6 and 10 years into the future, depending on the specific plant (essentially three operating cycles). Finally, there's a discussion of issues and risks with the plan. The life cycle plans in OPG for SGs capture pretty much everything we know about our SGs and become an important resource for knowledge retention.

We maintain our LCM plans by doing annual updates based on: results we get from our regular inspections, from other OPEX, and from the results of the R&D programs that are being carried out within the CANDU community and elsewhere. We also benchmark what other people are doing. In some cases, the plan is updated as a result of a Business Plan decision, i.e. a business decision made to either do something or not do something. We get a lot of sharing of information across the CANDU industry and more broadly through the Electric Power Research Institute, and we use all this to update the plans. Of course, if there are events between the major updates, they are incorporated immediately into the outage plans for our units, without waiting for the next update cycle.

4. SG Life Cycle Management Challenges

There are some degradation mechanisms which are poorly understood and this poses a challenge because it's difficult to plan with certainty for things that we don't fundamentally understand.

An illustration of this is that individual SGs within a unit sometimes behave quite differently from each other, for unknown reasons. A related issue is that even though we've been operating SGs for four decades and monitoring them quite closely for two decades, we're still encountering new degradation mechanisms late in life. For example, in our Darlington SGs, we have recently detected volumetric wall loss on the OD of the tubes in the internal preheaters. This finding was unexpected and is not well understood. It appears to be due to a hydrodynamic process rather than a corrosion process, and it appears to be growing relatively slowly.

Another example that has received significant attention lately is the apparent cracking degradation of Incoloy 800 in some units in Europe. What these findings illustrate is the importance of continuing to inspect our SGs even after they're well into their life. We need to continue to look in places where we may not expect to see the degradation - just because we don't expect it doesn't mean it won't happen, because our understanding of SG tube degradation is far from complete.

Although both these examples involve Incoloy 800, this is not just an I 800 issue. Every SG tube material which the industry has ever used has surprised us at one time or another, and this pattern is likely to continue even with the newer materials. As an industry, we need to keep inspecting and doing R&D to better understand how these materials behave in the complex environments in our SGs.

Two other issues that we're working on within OPG have to do with the complexity of our life cycle plans. Our LCM plans contain a tremendous amount of history and record our understanding of what's going on. As a result, they've grown to be documents of several hundred pages.

While they are excellent as a repository of knowledge, they are not always user-friendly. We expect a broad range of people to consult our life cycle plans in order to understand what we're doing and why we're doing it. We need to make it easier for them to get the critical information which they need without having to work their way through a lot of detail which they don't need. A related issue is that revising long and detailed documents requires a significant amount of work and consumes a lot of resources at a time when our resource levels are constantly being challenged.

We're currently working on two initiatives to improve our SG life cycle management practices:

- Streamlining the life cycle plans to isolate the critical, strategic and operational information in a concise, user-friendly document and moving the background detail to a companion reference document which the SG specialists can consult.
- Reducing the frequency of major updates to every 2 years to reduce the level of effort required.

Another challenge is the issue of integrating life cycle management with other business processes.

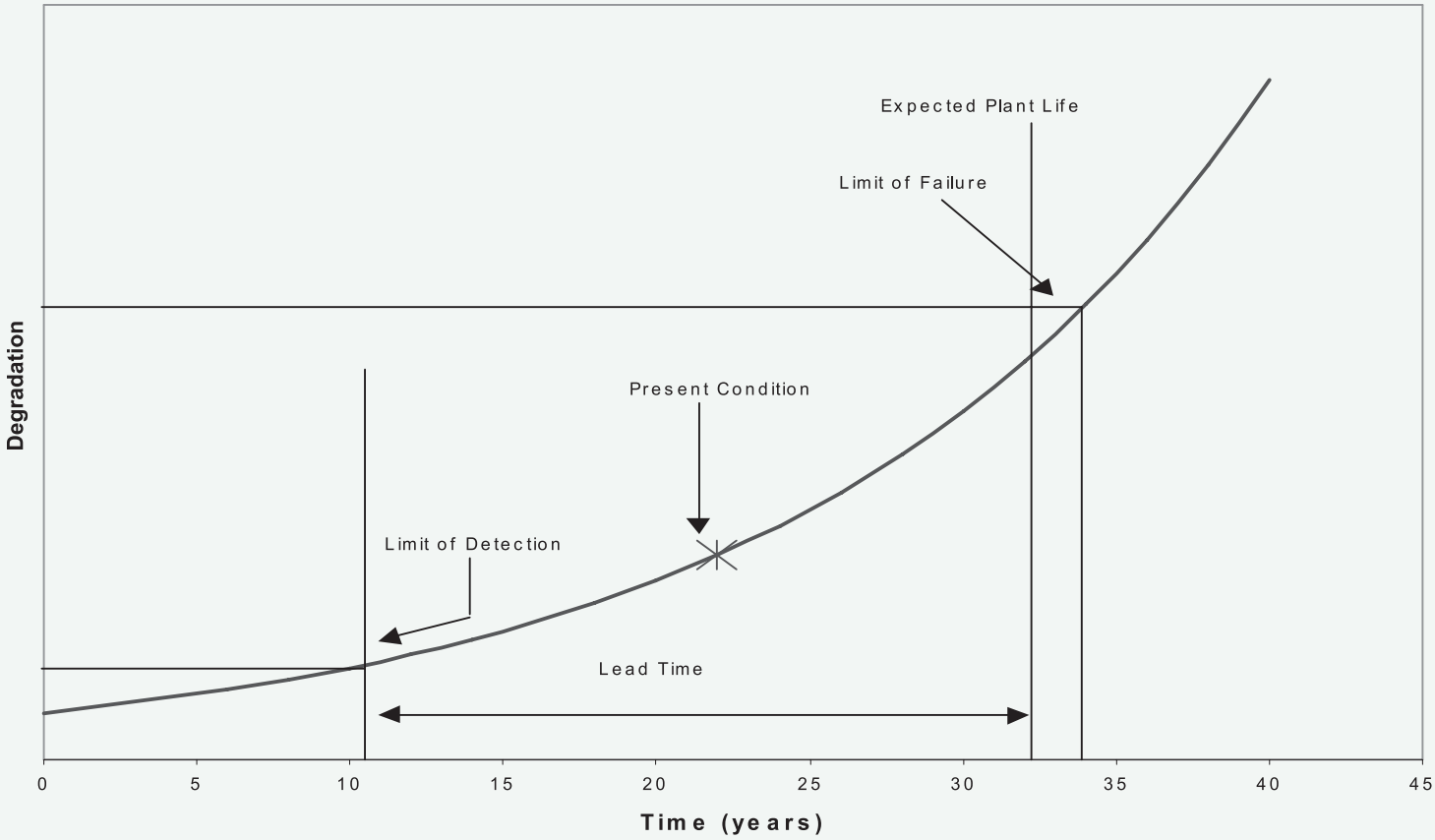
We use life cycle management plans for two types of activities. The first is to define the inspection and maintenance scope in an upcoming outage. This is very important, but it looks only a year or two into the future. The second is that life cycle plans are an essential element of our business planning process which looks at least 5 years into the future.

The activities in the life cycle plans for the major components essentially define the outage and generation plan for the plant. Because there are major costs associated with these activities, our cost planning must effectively recognize the life cycle plans. In some cases, there are major investment decisions to be made, for example tooling acquisitions or planning for major campaigns for chemical cleaning or waterlancing.

Finally, the business planning process is all about managing risks. It starts with a vision and objectives, a condition assessment and a discussion of technical options. The analysis of the options needs to include financial and risk considerations, not just a technical ones. This should be the basis for deciding what will be included in the life cycle plan. The life cycle plan needs to feed the Business Plan, because work can not be accomplished in a station unless the money for it is included in the Business Plan.

In actual fact, there are a number of feedback loops that are part of this cycle.. The feedback loops have caused us some difficulty in OPG and we are still working to streamline them.

The first feedback loop is the interplay between what the life cycle plan says should be done, and what affordability, cash flow and do-ability considerations of the Business Plan say is able to be done. It is important to iterate this until there is consistency between the two. If they are out of step, it is unlikely that the work in the life cycle plan will be accomplished. These iterations need to take place during a busy business planning season when there isn't a lot of time available.



We are trying to make it easier for Business Plan authors to recognize the impacts of the activities which are prescribed in our life cycle management plans. Our current plans are detailed on the technical rationale for the prescribed activities, but they are relatively cryptic on the cost and outage duration of these activities. This makes it difficult to effectively carry out financial and outage planning in the Business Plan. We are currently working on adding more cost and schedule information in the life cycle plan, to achieve the right balance of technical and business data.

The other feedback loops happen when the life cycle plan is being implemented and we see the impacts of what we're doing. We are not as nimble as we need to be in looping back to adjust the Business Plan or the life cycle plan on the basis of results from the field. We are working on more effective ways of introducing this feedback into the life cycle plan or Business Plans without having to go around the full loop.

5. Life Cycle Management and Expected Plant Life

As plants approach their planned life, life cycle management plans need to be adjusted. This shows a schematic of degradation vs time: time along the X-axis; degradation measured in some quantitative fashion along the Y-axis.

When our plants were designed they had an expected plant life as shown (the fact that this line happens to intersect the time axis at 32 years has no significance, this is just for schematic purposes). As the plant ages, a degradation mechanism reaches its detection limit and begins to be monitored. The degradation needs to be managed so that the condition of the plant stays below the "limit of failure", the point at which the plant fails to satisfy a requirement of some sort. This could be a fitness for service requirement or a business requirement on outage frequency or duration. The objective of life cycle planning is to ensure that the degradation does not exceed that limit of failure before the plant reaches its expected life.

SG life cycling planning has focussed on the early- and mid-life periods of our units. However, the OPG plants are less than 6-10 year from their originally expected lives. As such, our life cycle plans need to be adjusted. The expected plant life is currently believed to be defined by the life of the fuel channels. Concerns that some of our units might have their lives determined by the SGs have been allayed by aggressive life cycle management which brought about a number of improvements in the way those SGs are operated. We currently don't believe that the SGs will be life-determining for any of our units.

When a CANDU plant reaches its expected life, there is an option to refurbish the plant by replacing the fuel channels (and whatever else is required) so that the plant can operate for a further 25-30 year period. When a plant approaches the decision point on refurbishment, it is necessary to assess whether the steam generators need to be replaced or not. In the hypothetical example in the figure, if this degradation curve represents the SGs, they will need to be replaced. If, on the other hand, degradation in the SGs is minimal as the plant reaches its expected life, it may be decided that they will continue to perform adequately through the second life of the unit. In that case, the decision may be made not to replace the SGs in order to avoid

the capital costs and extended outage duration required in order to undertake such a big replacement project.

In the OPG fleet, we have examples of both scenarios. At Pickering B, the SGs are not life- limiting but it's clear that they have suffered sufficient damage that we cannot be confident of another 25-30 years of reliable operation. So the reference plan for refurbishment of Pickering B, if the decision were made to refurbish Pickering B, would be to replace the SGs. At Darlington, on the other hand, SG degradation has been minimal, and a detailed assessment has concluded that there is a sufficient degree of confidence that performance will be strong for a further 30 years. As such, we currently intend to retain the SGs through the refurbishment, should the Darlington units be refurbished.

The decision on the fate of the SGs at refurbishment is very important. Getting it wrong in either direction will cost the company a great deal of money. Replacing SGs needlessly puts an unnecessary cost burden on the business case for refurbishment. Conversely, attempting to operate SGs for an extended period of time and then finding later on in life that they can't reliably operate through the refurbished plant life would also cause a large financial penalty to the utility. Consequently, the assessment of whether to replace the SGs needs to be carried out very carefully and in sufficient detail to provide a high confidence estimate of future performance. This is where the difficulty of not understanding some of the degradation mechanisms that are emerging later in life becomes particularly difficult to accommodate.

There's a real need in the industry to continue to aggressively pursue a better understanding of SG degradation. We have recently created an Incoloy 800 Users Group to help utilities evaluate the available technical information upon which the decision must be made. In OPG, we are comfortable that we have a clear path forward for the SGs should we decide to refurbish our units, but it still represents a risk.

Another aspect of life cycle management of plants approaching their expected life is an expected change in the nature of the activities in the plan. Life cycle management is a decision-making tool to allow an organization to choose the best, balanced option for the management of the SGs. The life cycle plan includes elements that are required for safe operation of the SGs and others that are required for asset preservation or economic optimization. We should expect that the balance between these two will evolve over time.

The life cycle plan has to maintain the SGs in a condition where they are fit for service plus an adequate margin through to the end of life of the station. As result, the activities associated with the fitness for service aspect of a life cycle plan would be expected to be maintained right through to the end of operation of those SGs.

There is another set of activities in the life cycle plan which is aimed primarily at preservation of the asset to enable extended operation. These activities are not required for short-term fitness for service. As SGs approach the point at which they will be taken out of service either for replacement or retirement, life cycle management plan activities should become biased towards fitness for service.

Asset preservation activities would be expected to diminish as the components approach the point at which replacement or retirement is imminent. Clearly, if the decision is made to retain the SGs beyond the refurbishment of the unit, one would expect that the asset preservation activities in the life cycle management plan would be significantly enhanced to reflect the fact that degradation needs to be maintained at exceptionally low levels in the long term. In OPG, we are just starting to adjust our life cycle plans to reflect the changing balance of activities. This requires some urgent attention as the potential refurbishment dates are within the timeframe that our life cycle plans.

6. Life Cycle Planning and New Steam Generators

New Build provides an opportunity to "wipe the slate clean" from a SG life cycle management point of view.. Although the slate isn't wiped quite as clean in the case of replacement SGs in a refurbishment, there is a lot of common ground between SG issues for a New Build and for replacement SGs in refurbished plants that can be grouped together for purposes of this discussion.

The industry collectively started SG life cycle management too late for the current plants. Our units were able to operate safely and reliably to their projected lifetimes only because of some aggressive life cycle management actions that were taken, for example major chemistry improvements, secondary side cleaning operations, divider plate repairs, installation of additional anti-vibration bars in large number of units, primary side cleaning, and so on. These activities have cost the utilities hundreds of millions of dollars. Even with aggressive LCM, there were a number of SGs around the world which were prematurely replaced, well before the rest of the plant reached its expected lifetime.

We have the opportunity in the new SGs to start over again. The question we should ask ourselves is, "When should life cycle management start?". Clearly, it should be as early as possible. Ideally, it should start at an early design stage, although there are some factors which limit the extent to which this can be accomplished. Replacement SGs need to fit within an existing reactor structure, so there will necessarily be design compromises to achieve the desired improvements within the constraints of the existing plant. For new build, the constraints are contractual. Designs need to be far advanced before a project can be committed, and design choices the SG vendor makes can not drive up the capital cost of the overall design to the point where it becomes less attractive in a very competitive marketplace.

It is highly desirable for SG vendors to be closely linked to the current operating plants to become aware as early as possible of the shortcomings of the current SGs, whether inherent in the design or operation-induced. That will allow as many of the shortcomings as possible to be designed out of the next generation. The most obvious design decision for new SGs is the choice of tube material. There are currently two candidates, Incoloy 800 and Inconel 690. One of the objectives of the Alloy 800 Users Group mentioned earlier is to provide utilities with the best available information to make this choice.

From the utility's point of view, life cycle management needs to start as early as possible, largely because aging starts early. Some damage may be produced at the commissioning stage

when systems are not fully in service, and chemistry is not as well controlled as it will be during normal operation. A strong life cycle management plan starting at turnover of the major systems is an important element of preserving the SGs. Monitoring needs to start early. The number of transients, their type and their duration need to be recorded so that the cumulative impact can be monitored from the very start.

In our units, there were some very bad practices early in the operating life that proved to be quite detrimental. Our understanding of the consequences of bad chemistry was limited and our procedures were not fully mature.

It should be our objective that any new SGs "hit the ground running" with fully developed chemistry and other operating procedures, as well as a fully developed monitoring program. We realize now that knowledge of the early conditions that SGs may have been subjected to can be important later on in assessing the origin and rate of degradation discovered later on.

Finally, it is clear that the earlier that degradation is identified, the more lead time there is to take action to bring the degradation under control. We need to resist the temptation to believe that the new designs will be free of any problems because we have designed them all out and because we're much smarter about operating practices. Instead, we need to continue to inspect the new SGs from an early time in their lives and with persistence and regularity. It will not be intuitively obvious that this is the right approach to take, as there is a natural tendency to believe that when something is shiny and new, it should not require inspections. If we intend for these inspections to happen, we have to plan for it and our life cycle management plans are the ideal vehicle.

7. Conclusions

We've come a long way in life cycle planning for the SGs in OPG. However, there are still a number of challenges and opportunities associated with our current operations, with the approach of the expected life of our plants, and with new build.

Embalse Steam Generators – Status in 2009

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ABSTRACT

The Embalse Nuclear Generating Station (ENGS) is a CANDU 6®[5], a pressurized heavy water plant, with a net capacity of 648 MW. The primary heat transport system at Embalse includes four Steam Generators (SGs) manufactured by Babcock & Wilcox Canada (B&W). These steam generators are vertical recirculating heat exchangers with Incoloy 800 inverted U-tubes and an integral preheater.

Embalse SGs performed very well until the late 1990s, when an increase in tube fretting was noticed in the U-bend region. In-service inspection in 2002 and 2004 confirmed that the cause of the tube fretting was flow accelerated corrosion (FAC) damage of scallop bar supports in the U-bend region. The straight leg tube support plates (TSPs) have also been degrading. Degradation was worst at the top support plates, and it was in the form of material loss on the cold leg. The hot leg TSPs were heavily fouled with deposits and flow areas were blocked. Visual inspections and subsequent studies showed that the cause of the TSP degradation was also FAC. The Embalse SGs have carbon steel supports that make them susceptible to FAC.

To mitigate the effects of degraded tube support structures, three additional sets of anti-vibration bars were installed in the U-bend regions of all four steam generators in 2004. In 2007, an improved secondary-side chemistry specification was implemented to reduce the FAC rate and the hot leg TSPs was waterlanced. A root cause analysis and condition assessment was performed for the tube supports in 2007. Fitness for Service (FFS) evaluation was completed using the Canadian Industry Guidelines for steam generator tubes. The steam generators were returned to service and the plant has operated without another forced outage to date. The FAC degradation of the carbon steel U-bend tube support systems has had the most significant impact on the plant operation causing a number of forced outages. The discovery of the extent of TSP degradation and difficulties to repair TSPs without major intervention led to a decision to replace the steam generators.

This paper identifies the active degradation mechanisms affecting the steam generator performance and actions taken since 2004 with an emphasis on the activities of 2007 to mitigate their impacts. The processes followed the actions taken in 2007 leading to return to service. The results of the root cause analysis along with the recommendations to change the secondary side chemistry are included. The tube inspection data were used in the development of a successful condition assessment tool to

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5 CANDU is a registered trade-mark of Atomic Energy of Canada Limited

characterize the tube support plates.

This characterization was the key step in the completion of a successful FFS evaluation. Additional actions implemented by Embalse to ensure safe and continued operation of the steam generators are also included.

1. Introduction

The Embalse Nuclear Generating Station (ENGS) is a CANDU 6™, a pressurized heavy water plant, with a net electrical capacity of 648 MW. The primary heat transport system at Embalse includes four Steam Generators (SGs) manufactured by Babcock & Wilcox Canada (B&W). These SGs have been in operation since 1983 and they have performed well until the late 1990s with very few known issues. In the late 1990s, it was recognized that the SG thermal performance and structural integrity has been negatively affected by component degradation.

The reduction of SG thermal performance has been reversed with a series of maintenance activities in early 2000s:

- SG tube ID surface, coated with magnetite deposits (transported corrosion products from the feeders), was mechanically cleaned in 2000,
- The bolted primary divider plates were replaced with welded plates (2002) to eliminate flow by-passing and

Sludge deposits were removed from the secondary side of the SG tubesheet (2002) [1]. The reduction and the recovery of Embalse SG thermal efficiency paralleled the experiences of other CANDU 6 SGs.

In 1996, in-service inspection of SG tubes revealed an increased occurrence of tube fretting in the U-bend region of in one of the SGs. In-service visual inspection in 2002 revealed that the reason for tube fretting was the flow accelerated corrosion (FAC) damage of scallop bar supports in the U-bend region and all SGs were affected. Further inspections in 2004 indicated that, in addition to the U-bend supports, tube support plates (TSPs) have also been degrading. Degradation was worst at the top support plates, and it was in the form of material loss on the cold leg. The hot leg TSPs were heavily fouled with deposits and blocked to the flow. Visual inspections and subsequent studies showed that the cause of the TSP degradation was also FAC. Among all CANDU 6 stations, Embalse SGs are the only SGs that have carbon steel supports that make them susceptible to FAC.

A review of Embalse SG operating experience, degradation mechanisms and management of degradation mechanisms up to year 2006 is provided in Reference [1]. The present paper provides an update of the status of Embalse SGs including the condition assessment of tube support structures, recent mitigating actions and degradation management strategy employed since 2006.

2. Design overview

The ENGS primary heat transport system includes four identical SGs. These SGs are manufactured by Babcock & Wilcox Canada (B&W) and are vertical recirculating heat exchangers with Incoloy 800 inverted U-tubes. In Figure 1, a general sketch of the SG is shown. The U-bend anti-vibration bars (AVBs) shown in the figure are retrofitted supports installed in 2004.

The primary side of the SGs consists of the head, the primary side of the tubesheet and the tube bundle. A primary divider plate separates the inlet half of the head from the outlet half. The Incoloy 800 tubes are seal welded to the primary side of the carbon steel tubesheet and rolled into the tubesheet.

The primary side of the SGs is designed and manufactured to the requirements for Class 1 components in Section III of the ASME Boiler and Pressure Vessel Code.

The secondary side of the SGs consists of the shell, the steam separating equipment, the tube bundle shroud, the preheater baffles, straight leg TSPs and scallop bars for U-bend supports. Two-stage steam separators, located in the steam drum at the upper end of the shell, separate water from steam producing dry steam with less than 0.25% moisture content.

Every SG includes approximately 3500 U-tubes. These tubes are supported by eight TSPs in the straight sections of tubes and six sets of scallop bars in the U-bend region. The TSPs are broached plates in which broached holes with "tri-lobed" geometry and with three equally spaced lands provide support to SG tubes. The flow regions provide space (in the lobes) for the secondary steam and water mixture to rise through each tube support plate (TSP). The array of tri-lobed holes in the TSP forms ligaments that are 2.8 mm thick.

The secondary side of the steam generators is designed and manufactured to the requirements of CSA Class Special.

The four SGs generate 1033 kg/sec of dry steam at 260°C temperature and 4.69 MPa(a) pressure at the SG nozzle.

The ENGS SGs are similar to other CANDU 6 SGs of the same vintage, such as those at Point Lepreau Generating Station (PLGS) and Gentilly-2 (G2) Generating Station with the following notable exceptions: (1) the Embalse SGs have slightly shorter tube bundles as compared to the PLGS and G2 SGs, (2) the Embalse SG have carbon steel tube-support structures (TSPs and scallop bars) whereas these components are made from stainless steel at PLGS and G2.

3. Condition assessment and mitigating actions

A previous paper [1] summarized all known Embalse SG degradation mechanisms. These degradation mechanisms are grouped as follows based on their consequences.

1. Loss of heat transfer efficiency: The loss of SG thermal efficiency is identified by a rise in reactor inlet header temperature caused by the reduction in heat transfer from the primary-side to the secondary-side [2]. In Embalse, the reduction in SG thermal efficiency was a result of (i) the flow by-passing divider plate that had degraded because of FAC, (ii) reduced heat transfer because of the deposition of magnetite layers on the ID surfaces of SG tubes (magnetite transport was a result of the FAC of outlet feeders), and (iii) reduced heat transfer area caused by the thick sludge deposits on the tubesheet (this was viewed as a minor effect). Heat transfer efficiency has been restored with a series of maintenance actions that included a mechanical clean-

ing (shot-blasting) of tube ID surfaces in 2000, replacement of the primary divider plates with welded divider plates in 2002 and the water lancing of sludge pile from the secondary side of the SG tubesheet in 2002 [1]. Non-recoverable thermal efficiency loss due to tube plugging has not been significant. To date, between 2% and 3% of the SG tubes are plugged out of 15% fouling margin allocated by the design.

2. Structural Integrity of SG Supports: Superficial micro-cracks were detected in 1995 at the weld joints of anti-seismic lateral supports. These cracks were later ground out during the 1998 and 2000 outages. A fracture mechanics study indicated that any postulated defects at the welds could not propagate to a size that would endanger the structural integrity of the supports and the SG. The crack inspections of lateral support welds are currently included in the In-Service Inspection Program. So far the cracks have not reappeared [1].
3. Tube Performance: Incoloy 800 tubing used in Embalse SGs have excellent operating record worldwide. However, FAC degradation of tube supports in the U-bend region (scallop bars) has been a major concern for Embalse because of their impact on tube integrity. A number of SG tubes have been plugged pre-emptively or due to through wall perforations because of fretting-wear of tubes caused by broken and degraded U-bend supports. This is discussed in Sections 3.1 and 3.2 below.

Degradation mechanisms of the first two groups have been successfully managed with inspection programs and maintenance activities. The effects of FAC of carbon steel tube supports on tube performance are discussed in more details in later sections. As it will be discussed below, degradation of tube supports due to FAC and resultant tube fretting has been the major concern for SG tube integrity.

3.1 U-Bend condition and its impact on tube performance

Figure 2 shows the number of plugged tubes since 1983, when the ENGS was commissioned. In the early years, some tubes were plugged because of manufacturing defects or loose parts damage at the top of tubesheet or at the thermal plate. The first U-bend tube defects were detected in 1991 [1]. As shown in Figure 2, the rate of tube plugging has increased noticeably since 1996. The main reason for tube plugging was the fretting-wear damage of SG tubes in the U-bend region. A map of all SG tubes plugged (as of 2008) due to U-bend fretting-wear damage is shown in Figure 3 as indicated by circular yellow markers. As seen in this figure, U-bend fretting is distinctly noticeable in three regions corresponding to three different groups of U-tubes with one, three and five scallop bar supports.

The tubes shown in green, blue and red in Figure 3 (figure on the right) represent the largest radii U-bend tubes with one, three and five U-bend supports, respectively. Specifically, the green tube has only one support (support 18), the blue tube has three supports (supports 16C, 18 and 20H), and the red tube has five supports (supports 15C, 17C, 18, 19H, 21H).

Viewed from the side, yellow-filled rectangles at the left of Figure 3 illustrate the extent of U-bend supports (scallop bars). The three distinct regions of plugged tubes, shown in green, blue and red rectangles correspond to those tubes with largest U-bend supports with one, three and five scallop bar supports, respectively. Dashed circles in the right figure show the locations of detected fret marks, which are all located at the tips of U-bend supports. These observations are consistent with the findings of later inspections where extensive FAC damage of scallop bars was observed at these locations (Figure 5) and a link between U-bend tube fretting and U-bend support FAC was established. In some cases, the FAC damage thinned the U-bend scallop bars to a point that they broke (Figure 5 (b)).

Plugged tubes in 2007 and 2008, shown in Figure 4, show that most plugged tubes were fretted at the U-bend support 15C and some at U-bend support 16C, indicated that the U-bend support degradation is progressing, especially at the 15C support position.

FAC of U-bend supports cause tube fretting-wear in two ways:

- Clearances between tubes and the scallop bars enlarge, resulting in reduced support effectiveness, increased tube vibration levels and hence tube wall loss.
- If corrosion of the scallop bars is very severe, the scallop bars can break at the ligaments (Figure 5). The broken bar may have a sharp edge that contacts the tube causing a small deep fret.

3.2 TSP condition and its impact on tube performance

During the scheduled outage of 2004, visual inspection of the U-bend region of the four SGs was performed after the AVBs installation in order to detect any foreign object resulting from the activity. Because TSP FAC degradation had occurred in another CANDU station, a visual inspection of the upper TSP was carried out. The results showed signs of advanced FAC degradation of TSPs on the cold leg side and even ligament breach on the periphery.

Following this finding, detailed inspections were performed during the scheduled 2005 outage. In that outage, new TSP inspection ports were installed and extensive visual inspections of TSPs were conducted. The inspections showed that TSPs have degraded. On the cold leg, the ligaments of the broached TSPs were thinned significantly and, in some cases, completely breached.

To characterize the conditions of the TSPs, bobbin probe and X-probe were used. The X-probe is an array Eddy Current Testing (ET) probe with multiple detection units in a single probe head. This permits good circumferential coverage, high defect detectability and sizing accuracy, in addition to excellent characterization capabilities with discrimination between axial and circumferential flaws in a single scan. A new ET signal analysis technique was developed to quantify broached hole ligament degradation by measuring ligament thickness. Using this technique, TSP degradation was mapped for the most degraded TSPs in terms of ligament thinning, breaching and TSP blockage. A classification of ligament degradation was specified as shown in Figure 6 and the analyzed data was mapped as in Figure 7. Figure 7 shows the TSP with the most severe degradation in 2005. Such TSP degradation maps were used for thermal hydraulic and stress analyses as

part of the tube and tube support structural integrity assessments. For analysis purposes, TSP degradation maps were discretised in simple rectangular and triangular regions as shown in Figure 8.

On the hot leg, fouling deposits were observed at the top TSPs. At some locations, sufficient deposits were present to classify the broach holes to be partially or completely blocked. Using visual inspections using video cameras, TSP blockage maps were developed that are analogous to the TSP degradation maps. The blockage of the hot leg tube support plate diverted riser flow to the cold leg side resulting in high velocity. This in turn caused thinning and in some cases breaching of the of the broach ligaments in the top two support plates.

Thinned or breached TSP ligaments resulted in loss of support, potentially increasing the risk of fretting wear of tubes at the tube-support interface under normal operating conditions. Fatigue or rupture of the tubes is also a possible scenario under postulated transient blowdown conditions, such as that caused by a steam line break. Engineering analyses below considered these possibilities.

3.3 Engineering analyses

Engineering analyses were carried out to show compliance with the Fitness for Service Guidelines in support of returning the steam generators to service. Structural models of degraded TSPs were developed based on the inspection results and were used in the models for stress analysis of TSPs. The engineering analyses are described in the following sub-sections.

3.3.1 Initial analyses, 2006

The 2006 scope of analyses started with the TSPs Condition Assessment and included tube flow induced vibration (FIV) analysis, structural analyses of the tube supports under design basis earthquake (DBE) loading as well as under a postulated seismically induced steam main failure. A Root Cause Analysis of the TSP FAC Degradation along with the identification of a change in secondary side chemistry to mitigate FAC was also part of the scope of work.

The root causes identified for the TSP FAC degradation [1], which are listed below, are also considered valid for the U-bend support degradation.

1. Susceptible material: broach plates and scallop bars are carbon steel with low chromium content of 0.07 to 0.08 mass % Cr. Carbon steel materials with less than 0.3% Cr are considered FAC-susceptible.
2. Water chemistry conducive to FAC: specification for the pH-controlling amine (morpholine) concentration was low; the amine used for pH control was suboptimal (other amines could provide a higher pHT in the SG).
3. Suitable thermo-hydraulic conditions: relatively high flow velocity on the SG cold leg, caused by a partial blockage of the broach holes by fouling deposits at the SG hot leg, due to heavy localized fouling of TSPs.

The thermalhydraulic analysis showed that the recirculation ratio of the SG was reduced to 3.8 from an original design value of 5.6 (as calculated by using the 3-dimensional SG thermalhydraulic analysis software THIRST), and the flow velocity had increased by 40% at the cold-leg (where FAC damage was observed) because of crud deposits at the hot-leg side of the top TSPs. Low recirculation ratio associated with flow blockage was a concern, because, in extreme cases, it can lead to flow instabilities in the SG making it difficult to control the SG water inventory. Waterlancing of the TSPs was recommended and performed in the April to May 2007 outage.

It was concluded that the TSP degradation had not played a major role in tube plugging and that FAC degradation of U-bend scallop bar supports and the resultant fretting-wear damage of tubes in the U-bend region is the main contributor to tube plugging.

It was also concluded that the broken U-bend supports are the main threat to SG tube integrity because of potentially high rates of fretting-wear.

The study recommended chemistry changes to reduce the rate of FAC degradation of TSPs and U-bend supports. Also, it recommended to waterlance hot-leg TSPs to restore a more uniform flow distribution.

3.3.2 Follow-up analyses, 2007

In early 2007, NASA was requested by the regulator to analyse the progress of the TSP degradation and the new condition of the SGs. In response to NASA's request, AECL proposed a larger task team including B&W Canada to investigate the condition of the steam generators and fitness for service. Follow-up analyses were carried out in late 2007 to evaluate the progress of the degradation mechanisms and their impacts on SG tube integrity. In response to NASA's request, AECL proposed a larger task team including B&W Canada to investigate the condition of the steam generators and demonstrate compliance with fitness for service requirements. The analyses made use of the most recent inspection data collected during the 2007 schedule outage. Video images of TSPs obtained after the waterlancing campaign in 2007 indicated that waterlancing have been effective in general. Videos indicate that most broached holes that were previously filled with crud deposits were unblocked with only a thin layer of crud (<1 mm) remaining on broached hole surfaces, see Figure 9. Post-cleaning inspections indicated that 50% to 60% cleaning effectiveness was obtained. TSPs and tubes seemed in good shape after crud removal. Inspections also showed that the FAC has further progressed in the TSPs and resulted in complete breach of all three ligaments in a small number of broached holes.

To characterize U-bend support degradation, a new inspection technique has been developed using X-probe data. With this inspection technique, it has become possible to characterise U-bend support condition and to detect broken scallop bars so that they can be removed in planned outages, if possible. Figure 10 demonstrates how a broken scallop bar can be seen with X-probe data. Two localized fret marks as a result of broken scallop bar can be seen in the 3D carpet plot at the top of the figure.

The 2007 analysis included a Condition Assessment of Embalse SGs with degraded supports, Thermalhydraulic Analysis, Blowdown Analysis for Main Steam Line Break (MSLB) Accident, Fretting and Fatigue Analysis, Seismic Analysis, Seismic+MSLB Analysis and Fitness-for-Service Assessment with Degraded Supports.

These analyses primarily dealt with the effect of the TSP and

scallop bar support degradation on the integrity of the tubes and support structures. Both normal operating conditions (100% power) and postulated accident conditions for the combined MSLB and seismic event were considered. Structural analyses utilized a detailed finite element (FE) modeling of the Embalse SG including U-bend supports (Figure 11), degraded TSPs (Figure 12), baffle plates, and tie-rods (Figure 12). A total of 285 equivalent tubes were used to model all steam generator tubes. Figure 13 shows the U-bend section of the structural model and the out-of-plane response of SG tubes to seismic loading. The analyses showed that the steam generator tube integrity would not be impaired as a result of the identified operating and design basis postulated accident transients under the conditions existing at the time of unit restart in 2007. The stresses in the TSPs were found to remain below the appropriate ASME B&PV Code Section III, Subsection NB allowable in all but localized areas. A plastic collapse load analysis conforming to the applicable rules indicated that the TSPs would remain intact during a seismic plus MSLB event without damaging the tubes. The tube stresses, including the forces and moments due to FIV, resulting from a combined MSLB and seismic event were within ASME B&PV Code Section III, Subsection NB Level C allowables for all cases. The maximum range of stresses in the tubes due to seismic loading alone and seismic plus MSLB loading were evaluated per CAN/CSA N289.3 [5]. It was concluded that no crack initiation in the presence of a fretting wear flaw would occur.

The assessment evaluated the conditions existing at the time of the unit restart following the completion of the May 2007 outage and found that the Embalse SGs were fit for service in their condition as of May 2007.

The 2007 report included a series of recommendations that led to a more aggressive tube plugging criteria. In addition to 100% tube inspections and plugging on detection of fret marks, all tubes with TSP degradation Level 5 and Level 6 (see Figure 6) were plugged proactively. With the use of X-probe data, inspection techniques have been developed to characterize the conditions of U-bend supports.

3.4 Corrective and mitigating actions

Compared to other CANDU 6 Units, Embalse has plugged SG tubes at a higher rate. This is attributed to the selection of tube-support material and U-bend supports, which is carbon-steel in Embalse and stainless steel in other CANDU 6 units, and to the hot leg fouling which is a consequence of high magnetite transport from the feedwater system, caused by sub-optimum pH at temperature. Most tubes are plugged as a result of fretting-wear damage in the U-bend region that was a consequence of support degradation caused by FAC.

To mitigate and manage scallop bar degradation and resultant tube fretting in the U-bend region, the following actions were taken:

- Improvement in SG Chemistry: In 2004, the pH of the secondary side water was increased to the range 9.5 to 9.6 for the purpose of reducing FAC rate based on a National Nuclear Energy Commission (CNEA) study [3]. A later review in 2005 [3] agreed with the implemented chemistry changes in general, but proposed additional chemistry actions and recommended practices. In particular, it proposed the use of ethanolamine in place of morpholine for secondary-side pH control. These recommendations were implemented in 2007. Currently, values of pH25° of about 10.2 are obtained at the SG blowdown with a concentration of ethanolamine of 7 ppm.
- Installation of new Antivibration Bars: To mitigate the effects of degraded scallop bars, three sets of anti-vibration bars (AVBs) were installed in all four SGs in 2004. Each set of AVB support consists of a series of flat bars inserted between the tube lanes and mounted on a slotted bar which is fixed to the existing tie rods. After the AVB installation in 2004, six tubes were plugged in 2005, three tubes leaked in 2006 July, 2007 February, and 2007 January due to broken or loose scallop bars forcing ENGS to outage. It is believed that the new AVBs have restored the U-bend support effectiveness, and, hence, reduced U-bend fretting that was caused by enlarged support clearances. However, broken scallop bars continue to be a threat to tube integrity, see the bullet below.
- Adoption of a more Aggressive Inspection Scope and Plugging Criteria: Because a broken scallop bar may form a point contact with a tube and can result in through-wall wear within a few years, in 2007, ENGS adopted a more aggressive plugging criteria to inspect 100% of SG tubes at every outage and to plug tubes with the first detection of a fret mark in the U-bend region. Also all tubes with TSP degradation L5 and L6 were plugged proactively. These criterion led to the plugging of some ~200 tubes in 2007 and 2008 outages (see red markers in Figure 2).
- Broken scallop bar retrieval: Broken scallop bars from the periphery of the U-bend are retrieved in every outage in all four SGs since 2006. Removed scallop bars have similar characteristics as that in Figure 5.
- Improvement in Flow Distribution via Waterlancing: The root-cause analysis [1] of TSP and U-bend scallop bars support degradations identified that one of the reasons for the high FAC rates on the cold-side of the SG was the fouling deposits that plugged the TSP clearance holes on the hot-side of the SG. These fouling deposits were cleared in 2007 with an effective waterlancing campaign to restore the flow field. It is estimated that about 50% to 60% cleaning effectiveness was obtained. As a result of waterlancing, maximum flow velocities at cold-leg TSPs 14C, 13C, 12C and 11C were estimated to be reduced by a factor of 1.2, 1.4, 1.4 and 1.5, respectively.
- Leak Detection Limits: As a consequence of the operating experience in the last three years (2007 to 2009) related to the leakages originated by U-bend fretting, not only a more conservative plugging criteria was adopted, but also the leak detection and tracking procedure has been modified. A new leak rate upper limit of 7 kg/h (the original limit was 5 kg/h) was adopted for cases of leak evolution similar to that of the July 2006 leak, in which detection after shut down was very difficult to locate due to the flaw characteristics (broken scallop bar with sharp edges pinching on the tube surface).

4. SG replacement

The SGs at ENGS were placed in service in 1983. These steam generators have a design life of 30 years, which would end in 2013. The FAC degradation of TSPs and scallop bars,

increasing requirements of inspection and degradation monitoring, and the desire to increase the plant power output during the life extension of the station, resulted in the strategic decision by Embalse NGS to replace the SGs instead of life extension. The replacement is planned to be implemented when a major refurbishment outage will take place for fuel channel replacement.

Several options were considered for SG replacement:

- Removal and replacement of the entire SG including the steam drum.
- Removal and replacement of the SG tube bundle. The original pressure boundary (including primary head, tubesheet, and shell, including the steam drum) will be re-used.
- Replacement of the bottom portion of the SG, i.e., the shell, the tube bundle, the tube sheet, the primary head and its internals and the primary nozzles (collectively called the "SG cartridge") with a factory-assembled cartridge. In this option, the original steam drum would be retained for the extended life.

The final decision is to replace only the SG cartridge with as much participation of local suppliers in Argentina as possible. The specified requirements include [4] the critical dimensions of the cartridge, additional heat transfer surface area, more corrosion-resistant internals for components such as TSPs and scallop bars, fully-welded divider plate in the primary head to eliminate leakage across the plate, vessel design for higher seismic forces, nozzle openings for water lancing of secondary side deposits, and TSP inspection ports.

5. Summary

TSPs and U-bend supports have been degrading in Embalse SGs, potentially affecting SG tube integrity. Detailed inspections showed that TSP degradation is highest in the cold side of the top two TSPs, with the top TSP being the worst affected. U-bend scallop bar support degradation is also highest on the cold side. U-bend supports 15C and 16C, particularly on the outer edge of the support blocks, display the most severe degradation. Visual and eddy current inspection using specialized probe (X-probe) indicate that sections of some scallop bars thinned to a point that they were completely severed.

Correlation of the most severe TSP degradation sites with the locations of plugged tubes due fretting wear indicated that straight leg supports (TSPs) degradation is not a significant contributor to tube fretting at this time. Similar analyses with U-bend supports showed that U-bend support degradation was primarily responsible for tube fretting wear (and plugging) in the U-bend region.

FAC of U-bend supports cause tube fretting-wear in two ways:

1. Clearances between tubes and the scallop bars enlarge, resulting in reduced support effectiveness, large tube vibrations and fretting-wear of tubes. After the installation of additional U-bend supports (AVBs), this contribution of this mechanism on tube fretting has been mitigated. With 100% tube inspections, the success of this action is being monitored. Inspections in 2008 outage showed that fretting rate at supports 18, 17C and 16C were reduced, but some fretting is still occurring at support 15C. In general tube vibration levels as well as preventive plugging rate have improved (see Figure 2).
2. If corrosion of the scallop bars is very severe, the scallop bars can break at the ligaments. The broken bar may have a sharp edge that contacts the tube causing a small deep fret. These broken scallop bar sections are identified to be the main reason for through-wall tube failures in Embalse SGs that led to unplanned outages. Fretting damage of this nature is not considered to be safety significant since it produces a localized flaw of limited circumferential extent that will leak before the flaw becomes large enough to put a tube at risk of rupture (leak before break).

To manage degraded and broken U-bend supports, inspection techniques have been developed to characterize the conditions of U-bend supports. In addition to 100% tube inspections and plugging on detection of fret marks, some tubes adjacent to broken or damaged U-bend supports were plugged proactively. These measures have resulted in no forced shutdown had occurred since the 2007 outage.

AECL and B&W prepared a series of reports to support the operational strategy of Embalse steam generators. The analyses performed following the 2007 outage indicated that the SGs were fit for service at the time of return to service.

To mitigate TSP and U-bend support degradation, the hot side of TSPs was waterlanced during the 2007 May outage. When returning to operations, the recommended chemistry changes were also implemented. The effectiveness of these measures in reducing TSP and U-bend support degradation rates were evaluated based on the conditions of these components in the 2008 outage. Using the maps of ligament thickness data from the 2007 and 2008 outages, a noticeable reduction has been observed in the rate of TSP material loss. Repeat inspections in future outages will provide additional information to evaluate the rate of progression of TSP and U-bend degradation.

Continued support degradation, albeit at lower rate, has led to the conclusion that the SGs should to be replaced in the near future, possibly during the major refurbishment of the ENGS. Condition monitoring of the SGs and additional corrective action implementation if needed are expected to continue until then.

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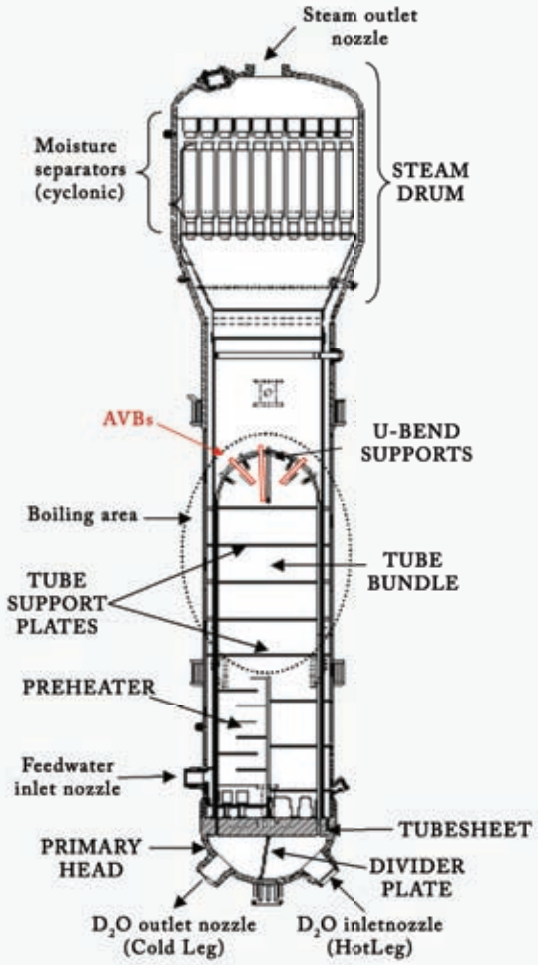


Figure 1. Embalse SG sketch.

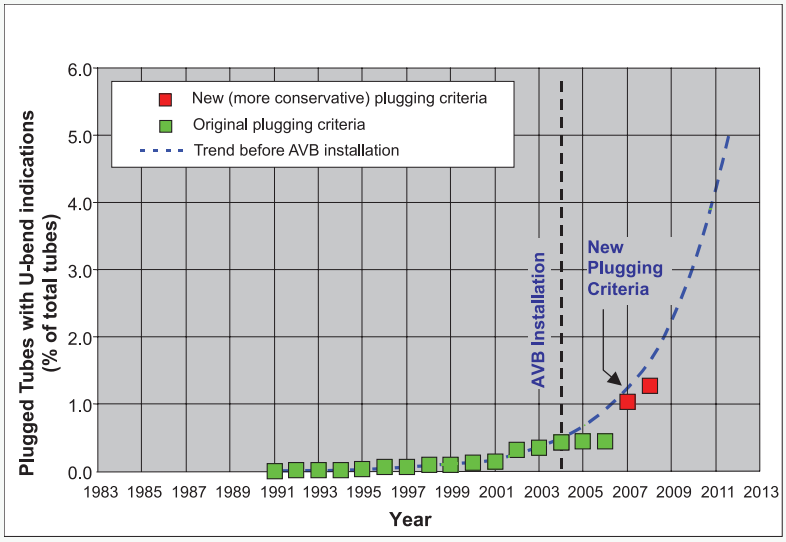


Figure 2. Embalse SG tube plugging trend.
The figure includes data from all four SGs up to and including the 2006 inspection campaign. The sudden increase in plugging rate in 2002 is due to the extensive inspection and plugging campaign that included most tubes in SG#1 and SG#3. AVBs were installed in 2004. The sudden increase in 2007 is due to the adoption of a new and more aggressive plugging criterion.

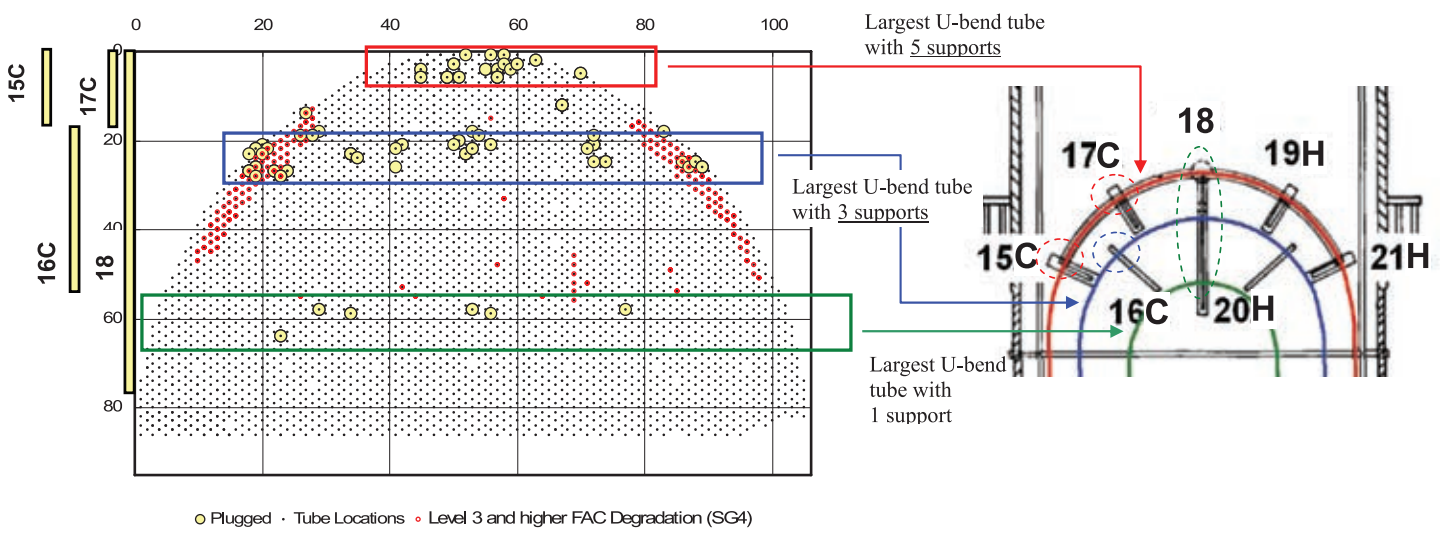


Figure 3. A map of plugged tubes due to U-bend fretting prior to 2007 outage (all four SGs).
Yellow markets show the locations of the plugged tubes. Red markers show locations of TSP broached holes with Level 3 and higher FAC degradation in SG#4. A small group of plugged tubes are coincident with the high TSP degradation locations. Most fret marks are on the cold leg because of higher FAC damage on the cold-bend scallop bars.

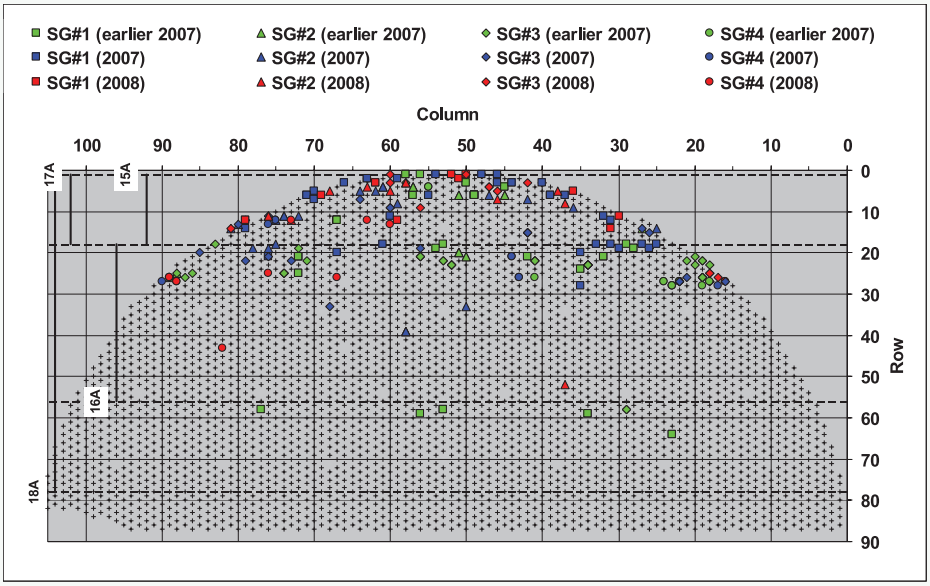
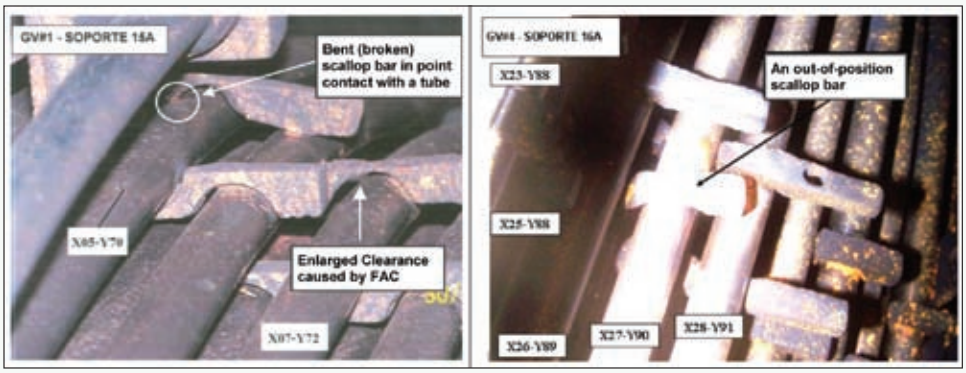


Figure 4. A map of plugged tubes due to U-bend bretting including 2007 and 2008 outages (all four SGs).



(a) Top of the U-bend-bend tube bundle and degraded scallop bars as a result of FAC.

(b) An extracted piece of broken scallop bar

Figure 5. U-bend support degradation as a result of FAC.

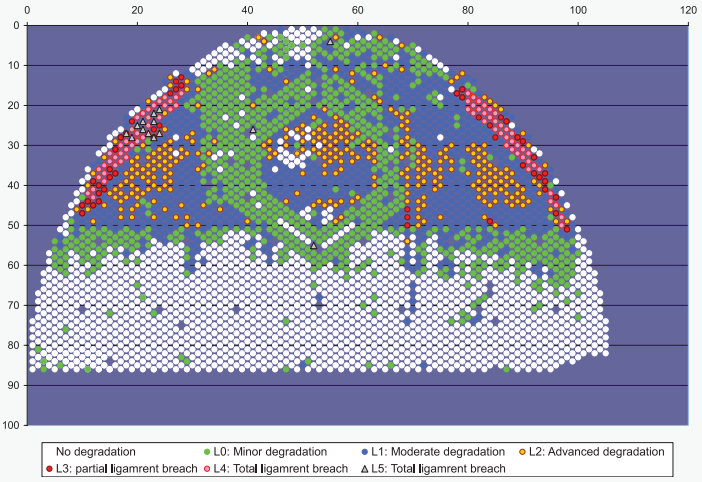


Figure 7. A broached hole degradation map on the cold-side of an embalse steam generator TSP.
The figure shows the TSP with worst degradation. The hexagonal shape at the center of TSP is the temporary manway cutout when the SG was re-built at the time of commissioning (data in this area is not reliable).

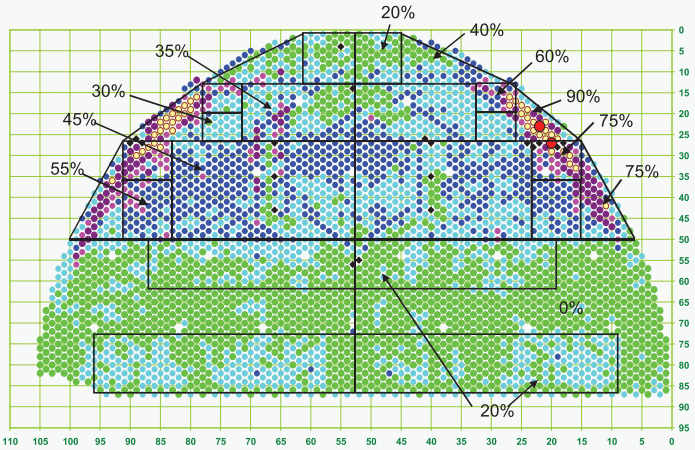


Figure 8. Idealized degradation distribution used in the analyses (the percentage refers to the local ligament area lost).

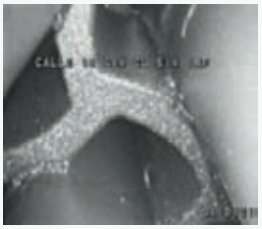
Level 0	Less than 20% ligament design-thickness loss or no degradation. Average FAC Rate < 13 µm/year.1	
Level 1	20 to 40% ligament design-thickness loss. Average FAC Rate = 13 to 25 µm/year.	
Level 2	40 to 80% ligament design thickness loss. Average FAC Rate = 25 to 51 µm/year.	
Level 3	80 to 100% ligament design thickness loss. (Partial ligament breach, supports are effective). Average FAC Rate = 51 to 64 µm/year.	
Level 4	100% breach of one ligament. Land regions have not disintegrated yet. Average FAC Rate > 65 µm/year.	
Level 5	100% breach of two ligaments. (One missing land). Average FAC Rate > 64 µm/year.	
Level 6	100% breach of three ligaments. (All lands are missing).	No support left

Figure 6. Classification of the tube-support degradation.

6 FAC rates are calculated using the broached hole land thickness of 0.1 inch and 20 years of operation.

(a) Before waterlancing (b) After waterlancing

Figure 9. Effectiveness of the 2007 spring waterlancing campaign (hot leg).

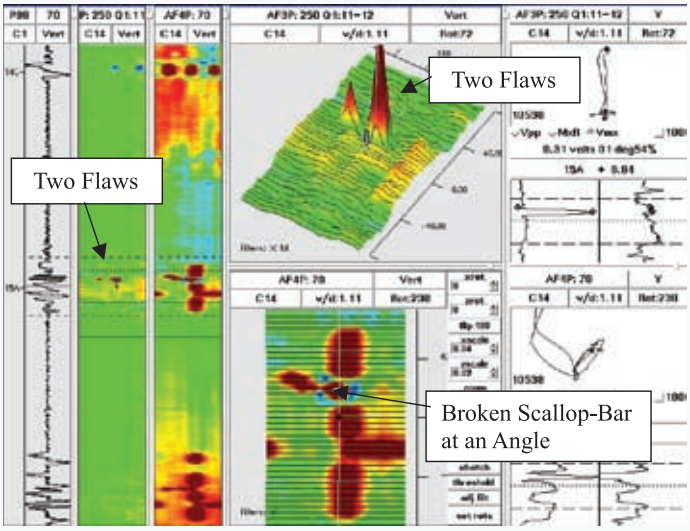


Figure 10. X-probe signals from a U-bend support with a broken scallop bar. Two flaw indications can be seen under the scallop bar.

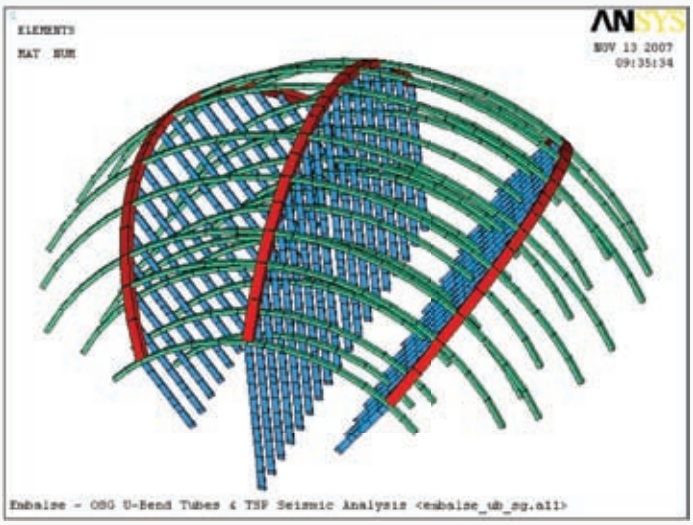


Figure 11. Finite element model of AVB U-bend supports.

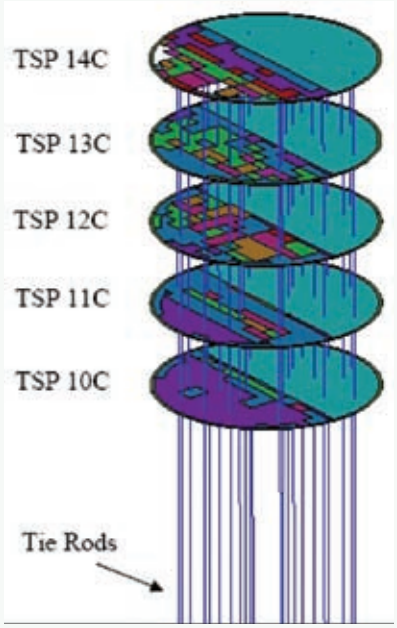


Figure 12. Finite element model of degraded TSPs and tie-rods. (Colored rectangles show regions with varying TSP degradation).

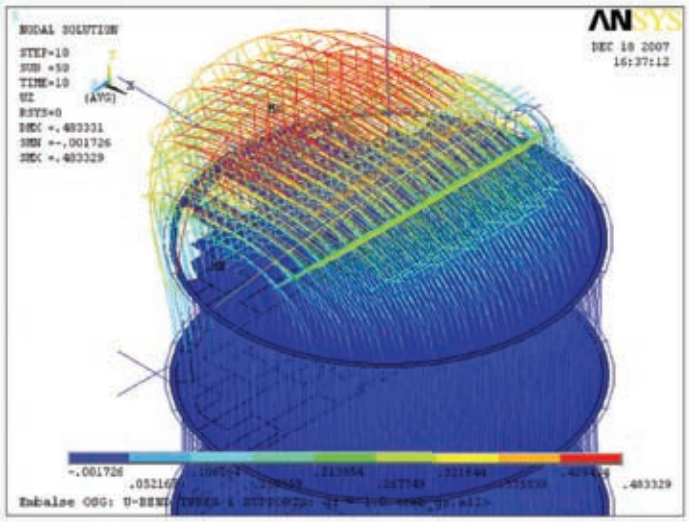


Figure 13. Out-of-plane response of tube bundle under seismic loading.

The figure shows the deflection of SG tubes under seismic loading. Colors indicate the stress level. It was found that out-of-plane tube bending in the U-bend region is responsible for almost all of the tube stresses.

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GENERAL news

(Selected by Fred Boyd from open sources)

Expert Panel recommends new NRU

In May 2009 the Minister of Natural Resources Canada, Lisa Raitt, called for "Expressions of Interest" from groups with proposals for producing medical isotopes, especially Molybdenum 99 or its daughter Technetium 99m which is widely used for diagnosis. Shortly thereafter she appointed an Expert Panel to review the submissions. That Panel submitted its report on schedule on November 30, 2009 and the Minister released the report on December 3.

In its "key findings' the Expert Panel lists as its first option the construction of a "New Multi-purpose Reactor". It states that this is the "lowest-risk path" to new Mo-99 / Tc-99m production capacity. However, it acknowledges that revenue from isotope production would offset only approximately 10 -15 %of the costs of such a reactor, with the rest to be justified by the many other uses (such as NRU).

The Panel's second recommendation is for a research and development program for cyclotron-based Tc-99m production. This would involve bombarding Mo-99 with protons to produce Tc-99m directly. It acknowledges that given the short (6hour) half-life of Tc-99m such facilities could only serve nearby medical centres.

The Expert Panel can be obtained at the website: www.isotopes.nrcan.gc.ca

PM Announces Agreement with India

At the close of the 2009 meeting of the Commonwealth Heads of Government, in Trinidad & Tobago, November 29, 2009, Prime Minister Stephen Harper announced that he and the Prime of India, Manmohan Singh, had reached an agreement on civilian nuclear cooperation.

This had been discussed during his visit to India earlier that month but not concluded. The Prime Minister's Office said both countries would now pursue the steps to prepare the agreement for signature and implementation. Although details had not been released at the time of writing, the Prime Minister was quoted as saying that the agreement would allow Canadian firms to export and import controlled nuclear materials, equipment and technology.

Nuclear trade between Canada and India was terminated in 1974 following the detonation by India of a nuclear explosive device using plutonium produced in a research reactor, similar to NRX, that Canada had given India in the 1960s.

Cameco tackles Cigar Lake flooding again

On October 26, 2009 Cameco Corporation reported that it had resumed pumping out water from the partially flooded Cigar Lake uranium mine in Saskatchewan. It added that it may still take up to a year to fully dewater and secure the mine.

In October 2006, a rockfall in the underground production area of the mine led to flooding. Cameco, as operator of the mine, expected that closing bulkhead doors would contain the water inflow and protect mine shaft No.1, the future processing area, pumps, a refuge station and a heat exchanger for ore freezing.

Unfortunately one of the doors did not seal properly, allowing water to enter the processing area while worker attempts to fully seal the door were unsuccessful. Furthermore, the rate of water ingress far exceeded the speed water could be pumped out. Finally, Cameco managers decided there was no option but to allow the water to overtake the mine.

Cameco began a five-phase remediation programme in early 2007 to remove water from the Cigar Lake mine. The company had originally expected to complete dewatering No.1 shaft in the second half of 2008. By August 2008, the shaft had been pumped down to 430 metres below the surface when an increase in water flow, to 600 cubic metres per hour, was reported. Such an inflow rate was "beyond the range that can be managed while sustaining work in the shaft," the company said. It therefore decided to suspend the remediation work.

Cameco has reported that the inflow of water at the 420-metre level that led to the suspension of dewatering activities has been remediated by remotely placing an inflatable seal between the shaft and the source of the inflow and subsequently backfilling and sealing the entire development behind the seal with concrete and grout.

The company noted that it is expected to take 6-12 months to dewater and secure the mine depending on what conditions are found in the shaft and the underground workings.

Cigar Lake has estimated reserves of 113 million pounds of U_3O_8 at grades as high as 20.7%. Led by Cameco, holding 50% of the project, a consortium of AREVA Resources Canada (37%), Idemitsu Canada Resources (8%) and Tepco Resources (5%) has been developing the deposit. The mine was originally expected to begin operating in early 2008.

Progress reported on NRU repairs

AECL continues to provide reports on the progress of repairing the calandria of the NRU research rector on a special website: www.NRUCanada.ca.

Following is part of its report at the end of November 2009.

Welder training and weld equipment testing and verification in the NRU facility mock-up is now complete. Preparations are underway to disassemble the weld tooling for relocation to the top of the NRU reactor for installation. Once the equipment is in position, a test weld will be conducted. The test weld will be inspected and assessed prior to initiating the actual repairs. This is a pivotal step prior to commencing the weld repair at the actual repair sites.

Analysis and testing of the "scoop" samples taken from the wall of the reactor vessel in October is complete. Results from the analysis have been incorporated into the detailed weld plan. Analysis of the recent sample "coupon", taken from one of the planned repair sites, continues. A team of experts in corrosion and metallurgy continue their examinations and testing of this sample in order to verify the corrosion mechanism and material properties prior to commencing weld repairs.

Conducting remote inspection from top of NRU

CNSC Issues Licence for Port Hope Waste Management Project

In mid-October 2009 the Canadian Nuclear Safety Commission (CNSC) announced its decision to issue to Atomic Energy Canada Limited (AECL) a Waste Nuclear Substance Licence for the Long-Term Low-Level Radioactive Waste Management (LTWM) Project in Port Hope, Ontario.

The licence will be valid from the effective date of the land transfer of the Welcome Waste Management Facility (WWMF) property as set out in the Agreement of Purchase and Sale between Her Majesty, the Queen In Right Of Canada and Cameco Corporation and Canada Eldor Inc., until December 31, 2014.

As noted in the September 2009 issue of the *CNS Bulletin* this comes after more than two decades of studies and arguments about the radioactive contamination in Port Hope arising from the activities of the predecessor operators of the facilities now owned by Cameco Corporation. These were Eldorado Gold Mines who extracted radium from uranium ore during the 1930s and the crown company Eldorado Mining and Refining (1944) Limited that used the facility to refine uranium during the Second World War until the 1960s

The CNSC has ordered AECL to present all the documentation required before the start of Phase 2 of the project, the actual construction of new long-term waste facilities, scheduled for 2011. AECL is also expected to apply for a licence amendment as soon as practicable after the new water treatment system is implemented and operational, so that the list of the contaminants and related release limits included in the licence is updated.

NWMO issues five-year plan

The Nuclear Waste Management Organization has issued its five year plan, titled Implementing *Adaptive Phased Management 2010 to 2014 as* a draft for review.

NWMO states that the report presents its five-year strategic plan for implementing Canada's plan for the safe, long-term care of used nuclear fuel. The document is available on the NWMO website: www.nwmo.ca/implementationplan. The Plan provides an overview of the Adaptive Phased Management concept and presents highlights of NWMO's work program in seven key areas. Activities are proposed in each area to support continued progress on this important national initiative.

NWMO invites "interested Canadians and Aboriginal peoples" to become involved in the process by reviewing its plans and submitting comments. To guide their review, NWMO has issued four short questions and asks those interested to the questionnaire through their website (www.nwmo.ca) before January 29, 2010.

Three Regulators Question EPR Design

In early November 2009 the nuclear regulatory authorities of three European countries, Finland, France, and the United Kingdom, issued a joint statement on their concerns with the design of the EPR Pressurized Water Reactor.

The joint statement said that, from individual assessments, each had raised issues regarding the EPR Control and Instrumentation (C&I) systems, which the proposed licensees and/or the manufacturer (AREVA) were in the process of addressing.

Although the EPR design being developed for each country varies slightly, the issues raised with the current C&I system were broadly similar. The issue is primarily the adequacy of the safety systems and their independence from the control systems.

The Joint Statement continued with the following words:

> *"Independence is important because, if a safety system provides protection against the failure of a control system, then they should not fail together. The EPR design, as originally proposed by the licensees and the manufacturer, AREVA, doesn't comply with the independence principle, as there is a very high degree of complex interconnectivity between the control and safety systems."*

"As a consequence of this, the UK nuclear safety regulator (Health and Safety Executive's Nuclear Directorate), the French nuclear regulator (Autorité de Sûreté Nucléaire), and the Finnish nuclear regulator (STUK – Radiation and Nuclear Safety Authority) have asked the licensee and manufacturer to make improvements to the initial EPR design. The licensees, and AREVA, have agreed to make architectural changes to the initial EPR design which will be reviewed by the regulators."

"It is for the licensees and the manufacturer, AREVA, to respond to its regulator's issues. However, as designs are similar, it is likely that the solution will be similar, although not necessarily identical, taking into account individual licensees' requirements and national regulatory requirements or practices. As an example, in providing defence-in-depth, different solutions could be proposed to back-up safety systems. In all cases, however, the solutions will lead to equivalent high levels of safety."

Further Five-Year Licence for Bruce A and B

On October 31, 2009 the Canadian Nuclear Safety Commission (CNSC) issued a renewed Operating Licence for both Bruce A and Bruce B nuclear generating stations for a further five-year term.

The Commission also approved Bruce Power's request to load fuel into Units 1 and 2 once the current refurbishment project at Bruce A reaches that stage. That means the specific approvals for the various stages are delegated to the CNSC staff.

The CNSC decision followed three days of public hearings, on December 11, 2008 in Ajax, Ontario, and September 30 and October 1, 2009 at the CAW Family Education Centre in Saugeen Shores, Ontario (near the Bruce site). During those final two hearing days, commissioners heard from several interested parties, including delegations from the local community.

Calandria Tubes being installed in Bruce A Unit 1

The Bruce AECL Retube Team positioned the first new calandria tube into the Unit 1 reactor on

Nov. 15. In Unit 2, calandria tube installation was expected to be completed by the end of November. Following leak testing they will then be ready for the insertion of new fuel channels

The crew is working in parallel with a team from E.S. Fox that is preparing the ends of feeder tubes that were severed around the reactor face earlier in the project for replacement after retubing.

Other activities on Unit 2 include working on the reactor face to complete interior calandria inspections and debris sampling. When complete, the same work is planned for Unit 1.

In early November, Ion Chamber 5 of Unit 2 was successfully removed. The removal and replacement of IC5 was critical for the completion of the commissioning of Shutdown System No. 2 (SDS2). During an inspection in 1981, corrosion was found in the ion chamber shutter access tube, indicating a small leak into the ion chamber assembly. Since that time, a number of unsuccessful attempts to pull IC5 had taken place. The leakage is suspected to have seized the ion chamber in its access tube.

IAEA releases final report on CNSC review

In late ovember the International Atomic Energy Agency (IAEA) released the final report of its Integrated Regulatory Review Service (IRRS) Peer Review of the Canadian Nuclear Safety Commission (CNSC) conducted in June 2009.

The review team determined that, overall, Canada has a mature and well-established nuclear regulatory framework and that the nuclear regulator does an effective job in protecting the health, safety and security of Canadians and the environment.

The final report outlines 19 best practices, and 32 recommendations and suggestions for improvement. The CNSC has reviewed the report in detail and prepared a response that outlines the actions that will be taken to address each recommendation and suggestion.

Highlights of the IAEA - IRRS report include:

- the Canadian legislative and regulatory framework is comprehensive, with an appropriate range of instruments allowing for an effective application of the legal regime.
- the CNSC has done extensive and commendable work over the last years to develop a management system in order to make the organization more process-based.
- the CNSC's on-line sealed source tracking system provides an excellent model for other Member States.
- the CNSC should initiate a periodic strategic planning program to define both short-term and long-term research activities with a view to supporting regulatory decisions.
- sufficient resources for research activities should be allocated to support the outcome of the strategic planning program.
- the CNSC should ensure that non-safety significant changes to licences for nuclear installations and uranium mines and mills do not generate disproportionate regulatory work.

English versions of the IRRS report and CNSC's Management Response are available on the CNSC's Web site.

Daniel Rozon

Daniel Rozon, professor emeritus at Ēcole Poly Technique and internationally recognized for his work on reactor physics died in Montréal of cancer on September 25, 2009 at the age of 64.

Daniel received his B.Eng. from École Polytechnique de Montréal in 1969 and his PhD from McMaster University in 1985. He joined École Polytechnique as a professor in 1977, became a director of le Groupe d'Analyse Nucléaire in 1981, was director of l'Institut de Genie Nucléaire from 1994 to 2001, held the Hydro Québec Chair in Nuclear Engineering from 1988 to 2006, and, on retiring in 2006, was named Professor Emeritus.

His key areas of expertise, in which he was a world leader, were reactor physics, and nuclear fuel and fuel cycles. He was the author of the reactor physics "bible" *"Introduction à la cinétique des réacteurs nucléaires"*, Les Editions de l'École Polytechnique, Mai 1992, which was translated into English in 1998 by Ben Rouben and still used throughout the nuclear industry.

He was the recipient of many awards, including the W.B. Lewis Medal, the most prestigious Canadian nuclear scientific award in 2007. He was named a Fellow of the Canadian Nuclear Society in 1994. He was a member of the Research and Development Advisory Panel to the Board of Directors of Atomic Energy of Canada Limited since its inception in 1991 and was chair in 1996/97. He also served on an advisory panel to the Nuclear Waste Management Organization (NWMO), which proposed the adaptive phased management approach to nuclear waste, now adopted by the Canadian Government.

Following are excerpts from the eulogy delivered by Dr. J. T. (Terry) Rogers, a long time colleague of Daniel Rozon and a fellow original member of the AECL R & D Advisory Panel, at the memorial service for Daniel in Lachute, Québec, October 4, 2009.

I am greatly honoured to have been asked by Daniel to say a few words at his memorial service about his many contributions to the field of nuclear energy in Canada. I have been very privileged to have served as a colleague of Daniel on the Research and Development Advisory Panel to the Board of Directors of Atomic Energy of Canada Ltd. since its inception in 1991.

Daniel is recognized worldwide as a leading authority on CANDU reactor physics and reactor fuel performance and advanced fuel cycles. He led the development at Ēcole Polytechnique of the reactor physics computer programs DONJON and DRAGON, both of which are now used in the design and safety analysis of CANDU reactors around the world.

Daniel was the author of the book "Introduction a la cinetique des reacteurs nucleaires", published by Les Editions de l'Ēcole Polytechnique in 1992, and translated into English in 1998. This book is widely used in the nuclear industry today. He also played an important role in developing analytical tools for the DUPIC fuel design project. This joint project of AECL and the Korean Atomic Energy Research Institute demonstrated the feasibility of the direct use of discharged fuel from Pressurized Water Reactors in CANDU reactors.

Daniel also played an important societal role in explaining and defending nuclear energy applications to the public on radio and TV.

Serving with Daniel on the AECL R & D Advisory Panel made me fully appreciate his thorough understanding of all aspects of CANDU reactor technology and his outstanding ability to explain technical issues clearly and, especially, his ability to write clearly and concisely about them. I know that I speak for my colleagues on the Panel when I say that his sound knowledge of all aspects of reactor technology was indispensable to the Panel's work.

His dedication to the work of the Panel was particularly demonstrated over the last few months when, in spite of his failing health, he participated actively by e-mail in the Panel's work.

Above all, Daniel was a good friend and great colleague and I, and I know my Panel colleagues also, will miss him greatly. Indeed, the whole nuclear industry in Canada will miss him, but his significant contributions will live on and will continue to enable it to flourish.

John Sommerville

(The following note is by Sardar Alikhan a long-time friend.)

John Douglas Sommerville, former Manager of the Point Lepreau Nuclear Generating Station, passed away peacefully at home on November 7, 2009 at the age of 66 with family at his bedside.

John was born and raised in Kilmarnock, Scotland. He graduated with a degree in Applied Chemistry from Glasgow University before moving to Canada in 1966 to work with Atomic Energy of Canada Limited at the Chalk River Laboratories in the Chemical Engineering Branch. Subsequently he joined Ontario Hydro at NPD station, Rolphton, Ontario where, after a few years be became a Shift Supervisor.

In 1975 he joined N.B. Power as a member of the Nuclear Operation Group of the Point Lepreau Generating Station. Starting off as one of the lead commissioning engineers, he was later promoted as the Technical Manager. In this capacity he worked diligently through the challenging phases of commissioning, licensing and initial operation. Following a brief assignment as the Production Manager he was appointed Station Manager in 1989. During this period, Point Lepreau enjoyed an excellent operating record as one the top performing nuclear power plants in the world for several years in a row.

In 1992, John left N.B. Power to take on another exciting position with AECL as Station General Manager on the Cernavoda-1 project in Romania. He successfully led a team of Canadians, Italians, and Romanians to commission the plant to achieve full power in 1996. With this challenging assignment successfully completed, he and Eileen decided to move back to Canada to build their dream home on the shores Georgian Bay, at 128 Ashgrove Lane in Annan, Ontario, an ideal spot to fulfill his love for the outdoors and water sports.

John loved downhill skiing and enjoyed his travels around the globe. For several years before he suffered his first seizure, later diagnosed as a brain tumour, he worked as a senior consultant in the nuclear industry, as the pioneer President of CANDU Owners Group, and as a member of the Board of Directors of Bruce Power.

John was an eloquent speaker and a hilariously witty entertainer with his characteristic sense of humour. He had a powerful way with words, metaphors and one-liners that charmed his audience. His analytical skills were par excellent; he had a special talent of getting to the crux of the often convoluted arguments going around the table and summarizing them at the end in a clear, concise and understandable manner.

He was a great team leader, an accomplished communicator, a great mentor, extremely courageous, highly confident and a very charming friendly person who will be sorely missed by us all.

My last visit with him and his wife Eileen took place on the evening of October 14, 2009. Even though he was not able to speak at the time, he thoroughly enjoyed our conversation around the dinner table. He kept holding my left hand firmly in his left (right side did not function that well) and would not let it go as I was talking. A couple of times he let out a loud laugh which was characteristic of John's courage in the face of adversity. At last when it was time for me to leave, he managed to whisper a faint good night, a voice that keeps ringing in my ears ever since.

John was indeed another true Scot and a dedicated family man. He was most happy in the company of his lovely grandchildren. Throughout his three years' fight with his brain tumour he was never heard complaining about it. He took it all courageously and stoically. John will be remembered for his courage, enthusiasm for life, and-most importantly- for his characteristic sense of humour.

John is survived by his loving, caring wife Eileen; his brother Robert; his daughter Shiona and son Ryan; grandchildren Nila and Arran; and mother-in-law Janet Parker.

John Sommerville (L) with colleague Sardar Alikhan at Point Lepreau circa 1989.

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Creating the Future of Chalk River

In response to the restructuring of AECL and to the need for a new, multi-purpose research reactor, the Chalk River Employees *Ad hoc* TaskforcE for a national laboratory (CREATE) was formed. CREATE is a grass-roots, non-partisan group of volunteers that includes current and former employees at Chalk River, including Blair Bromley, CNS Membership Chair of the Chalk River Branch. These volunteers developed a concept for a future Chalk River National Laboratory (CRNL), consulted with CRL staff, and obtained their support.

CRNL will be Canada's premier laboratory for nuclear and related sciences (illustrated in figure 1). It will be a resource for researchers from across a broad spectrum, from fundamental sciences to industrial applications, rather than being restricted to research and development that is mainly focused on supporting CANDU nuclear power reactors, as is the case today.

The new mission of CRNL will be very outward looking, partnering and impacting at all levels of Canadian society. That outward focus includes several new functions: leading diverse research programs beyond nuclear energy; partnering broadly with universities, industries, and government; commercializing knowledge; providing a training ground for Canada's future generation of research scientists and engineers; and fostering an science and technology culture in Canada. By serving as a unique, major resource for science and industry, CRNL will deliver enduring value for Canada.

CREATE submitted its report to Natural Resources Canada and Cheryl Gallant, Member of Parliament for Renfrew-Nipissing-Pembroke (figure 2). More information including the full report is available at www.futurecrl.ca.

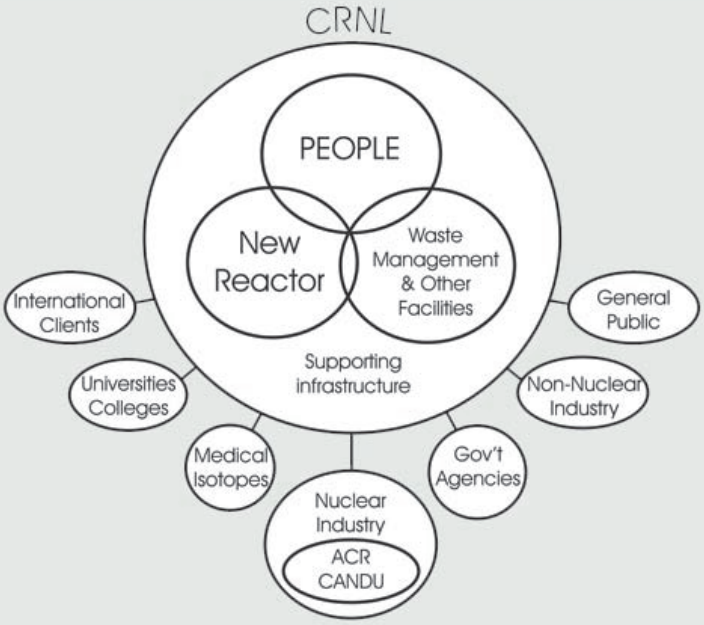

Figure 1. A functional diagram of the proposed, illustrating key points, including the following: CRNL will serve Canada, proactively seeking partners with universities and industries. Clients in the nuclear industry will continue to be very important, including CANDU and other nuclear technologies. Expert people at CRNL are directly accessible to clients to streamline the flow of knowledge to clients. A new multi-purpose research reactor is an essential component of the new CRNL, with capabilities equal or better than the current NRU reactor.

Figure 2 CREATE presents its report proposing its concept for the future of Chalk River to MP Cheryl Gallant (centre). Gallant said, "CREATE has provided Canadians with a vision of what the future of science at Chalk River could be, by evolving its mission to one of a national laboratory. I intend to make sure the report is widely circulated among my colleagues on Parliament Hill." Left to right: John Hilborn, Gordon Tapp, Zin Tun, and Blair Bromley.

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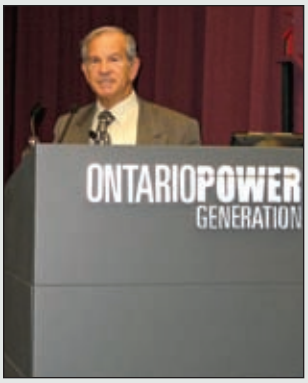
AP1000 Rendering

Sanmen AP1000 project photos used with permission of site owner.

18M122008D

CNS Public Seminar – Toronto Branch prepared by Ric Fluke



Dr.Jerry Cutler, D.Sc., P.Eng. (past-president of the Canadian Nuclear Society) made a public presentation organized by the Toronto Branch of the CNS on November 3, 2009 at the Ontario Power Generation auditorium describing his report "*Nuclear Energy and Health, And the Benefits of Low-Dose Radiation Hormesis*". The report is co-authored by Dr. Myron Pollycove, M.D. (formerly of the U.S. Nuclear Regulatory Commission) and is published in the journal Dose-Response, Volume 7, Issue 1. The report was commissioned by the American Council on Science and Health (ACSH).

Utilities around the world are considering nuclear energy as a means of providing its customers with low-emission electricity that is reliable and affordable, but fear mongering headline seekers are propagating unwarranted worries about low doses of radiation. The long-held presumption is that the risk of radiation has no threshold and decreases linearly as the dose decreases. It has driven regulators to impose strict limits on exposure to radiation and has led to policies that radiation should be "as low as reasonably achievable" (ALARA). The theory is difficult to assess because the entire planet is exposed to low doses of radiation from natural sources (cosmic from the sky, radon from the soil, etc.). However, Dr. Cuttler presents convincing evidence that the linear no threshold theory is wrong and in fact there is a beneficial effect on health from low doses of radiation.

The term "hormesis", Cuttler explained, is from the Greek verb meaning "to excite". He explained, "Low doses of stressful activity stimulate adaptive responses that increase function and resistance of the cellular organism to moderate to severe levels of stress, in contrast to inhibitory responses to high doses that decrease resistance and function." In other words, low doses of radiation "excite" biological functions making the body more immune to harmful effects. Prior to the development of antibiotic medicine, radiation was routinely used to treat medical problems such as gangrene and ill health.

His presentation was clear and simple and extremely interesting as questions went into over-time. Unfortunately, many of us working folks had to return to our offices to perform billable work.

http://www.acsh.org/publications/pubID.1790/pub_detail.asp

CNS in Washington

A number of CNS members descended on Washington D.C. in mid November for the Winter meeting of the American Nuclear Society, November 14 - 18 and some associated meetings of international groups with which the CNS is associated. Most are also members of the ANS.

On the Saturday evening prior to the official opening of the full meeting the ANS typically hosts a reception for representatives of the many nuclear societies having agreements with it. A number of the CNS members attended.

On the Sunday, there was a meeting of the Pacific Nuclear Council, one of the two international organizations of nuclear societies of which CNS is a member. Unfortunately, because of the serious illness of Mike Diekman, executive secretary of PNC, the meeting was limited due to the lack of minutes and background documents.

Late the next day there was a meeting of the international organizing committee for the 17th Pacific Basin Nuclear Conference to be held in Cancun, Mexico, in October 2010. The PNC is the authorizing body for the PBNC events. Following past practice each member country is invited to have a plenary speaker. The CNS and CNA usually collaborate on choosing the Canadian speaker at PBNC.

Following the PBNC program meeting there was an impromptu meeting of the other international organization of which CNS is a member, the International Nuclear Societies Council. It was called when it was recognized that a number of its executive members were present. The INSC has been relatively inactive the past couple of years but the new executive is determined to re-energize it.

The large International Committee of the ANS also met on the Sunday. Two active CNS members are on that committee, Jeremy Whitlock and Ben Rouben. Not content to just be a member Ben also co-edits a publication of the committee called "The ANS Globe".

Several of the CNS members attending also presented papers or were on panels at the ANS meeting.

Dorin Nichita and Jeremy Whitlock at ANS International Reception.

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ALBERTA – Duane Pendergast

1) A debate organized by Cosmos Voutsinos and Brenda Brochu of the Peace River Environmental Society (PRES) took place on October 21 in Peace River. Duane Bratt represented the CNS and Helen Caldicott the PRES. Cosmos prepared an extensive handout, which was provided to the audience with the assistance of Donna Voutsinos and Tom Tarpey.

   The debate was very well attended with standing and sitting room only. Cosmos and the local paper both estimated 500 attended. Written questions were submitted by the audience and some selected for the debaters by Brenda and Cosmos during intermission. Unlike some other events in the area, a civil discussion took place under the control of an able moderator. The debate is posted on Youtube by PRES.

   The Peace River Record Gazette published an editorial prior to the conference indicating citizens need to learn more about nuclear energy and this would be a great opportunity. An article describing the results was published the Tuesday following the debate. It seemed quite even-handed. These are available via the WWW.

   Quite a few written questions were submitted and not all questions could be covered by the debaters. The moderator suggested Brenda Brochu and Cosmos Voutsinos provide answers for these. That process is creating some hiccups as apparently questions for Ms. Caldicott went missing.

   Overall, it seems the debate went as planned. Thanks to Cosmos, Duane, Donna, and Tom for all their considerable effort in putting this on.
2) Laurence Hoye and Duane Pendergast met (Wednesday 2009 10 21) with MLA Bridget Pastoor for about an hour concerning electricity in Alberta and then a subsequent meeting (Friday 2009 10 23) of about 1.5 hours with MLA Dave Taylor (Liberal Energy Critic) and MLA Hugh Macdonald in which we mostly discussed the Transmissions Plan for Alberta as well as nuclear power in Canada.
3) Paul Hinman submitted a letter to the Lethbridge Herald of September 24 in which he pointed out that Alberta is not "Nuclear Free" The hasty leader of the new environmental group GREENSCENCE" mistakenly attributed the letter to MLA Paul Hinman and went off on a rant against a Bill before the legislature to approve transmission line between Edmonton and Calgary. (These lines would help enable the supply of electricity from northern Alberta to southern Alberta)
4) Paul Hinman, Aaron Hinman, Rob Varty and Peter Lange are preparing for the ATA Science conference in November.
5) David Malcolm has agreed to attend the Yellowknife Mining Conference in November on behalf of our Branch. Energy is on the agenda and the NWT & Nunavut Chamber of Mines has proposed infrastructure, which includes four small reactors.
6) Bill Olsen, Cosmos Voutsinos and Duane Pendergast have all responded to a suggestion from the editor, Jason, of Zero Mile News for a written debate on nuclear in his paper and other papers in Peace River country. It was suggested it serve as a follow-up to the Bratt-Caldicott debate. Jason has established a format and recently sent an email indicating he is looking for participants for January and February. Cosmos has solicited support through the Google Group and already has several offers. On the anti-nuclear side a Pat McNamara, once from Port Hope is so far the only volunteer. He apparently moved from there to Peace River to get away from radiation hazards. He offered to organize the anti-nuclear side. I don't recall him from my days in the industry, but suspect some CNS members do.

CHALK RIVER – Ragnar Dworschak

Evening Seminars:

- Gina Strati – AECL spoke on NRU outage instrumentation design & fabrication on October 09
- WIN co-sponsored Gina Strati's talk and we are exploring more collaboration with WIN for upcoming talks
- Daniel Bradley from Natural Resources Canada is scheduled to speak on GenIV reactors on December 3

The 2009 Annual General Meeting was held in conjunction with Gina Strati's talk, 26 October 2009.

Executive as of the conclusion of the AGM:

Chair:	Ragnar Dworschak
Treasurer/Secretary:	Ruxandra Dranga
Program Coordinator:	Geoff Edwards
Education and Outreach:	Alex Rauket
Membership:	Blair Bromley
Members-at-Large:	Bryan White, Marcel Heming, Jintong Li, Uditha Senaratne, Amirabbas Sartipi

New proposed initiatives include:

- Increase in support for Algonquin College Radiation Protection Program Scholarship
- Support for high school academic contests
- Increase in Renfrew County Science Fair sponsorship
- Encounters with Canada Sponsorship
- Increase in number of scholarships for high school students
- Deep River Science Academy sponsorship increase
- ZED2 Celebration participation

GOLDEN HORSESHOE – Dave Novog

The CNS Golden Horseshoe had an excellent speaker, David Mosey, to discuss the topic of institutional failures, i.e., failures in senior management and the boardroom, which lead to downstream failures of equipment and the plant. In particular he discussed how these failures, which are remote in time and space from the actual failed equipment, are usually foreseeable based on the habits of the company. The talk included highlights of the challenger, TMI and

ferry accidents as well as the Pickering SBLOCA event. The talk was very well attended by local members, McMaster reactor staff, and even some CNSC staff who were in the neighbourhood.

OTTAWA Branch – Mike Taylor

On October 6 the branch enjoyed a presentation by Frank Doyle, COG director of research and 2nd V.P. of the Society, on the activities of COG. He described the organization of COG and its programs with emphasis on COG's support of research and development, primarily to meet the needs of the member utilities operating and refurbishing CANDU units.

On November 19, Daniel Brady, a senior advisor at Natural Resources Canada, described Canada's role in the international GenIV program which is aimed at developing the "fourth" generation of nuclear power designs with the aim to make them safer, more reliable, and proliferation resistant.

Scheduled for December 9 is Dr. Chris Hubbard, of Curtin University of Technology in Western Australia who will be reviewing Australia's nuclear past, present and future.

The 2009 - 2010 executive was confirmed at the October 6 meeting.

Chair	Mike Taylor
Past Chair	Jim Harvie
Secretary	Ted Thexton
Treasurer	Fred Boyd
Program	Ron Thomas
Web master	Satyen Baindur
Member	James Levesque

UOIT Branch – Ashley Milner

Members of the UOIT Branch assisted the CNS public information session held October 15 in connection with National Science and Technology Week program. *(See separate report.)*

Membership Note

It is time to renew your CNS membership. **Take advantage of the low early-bird-renewal fees by renewing now, before the end of the calendar year**.

You can now conveniently and securely renew on-line and receive your receipt immediately! It is a very fast and convenient process. Just log on to https://www.signupmaster.com/cns-membership and follow the very easy steps. Be an early-bird and don't delay. Renew now!

A feature of the on-line renewal is that the renewal fee will be increased from the early-bird discounted fee to the regular fee on 2010 January 1, so it is in your interest to renew early.

If you are signed up for automatic renewal, the CNS Office will do the work for you each year in good time, so you will never miss the discounted early-bird renewal rate, without lifting a finger ! **If you are not yet signed up for automatic renewal, but would like to take advantage of this convenient service, please get in touch with the CNS office at 416-977-7620 or cns-snc@on.aibn.com.**

Also, remember to always keep your individual CNS ID number handy. You will need it to identify yourself as a CNS member when registering for a CNS Conference or Course, to receive the member rate! Your ID number is shown on your annual CNS membership card. You may like to keep this in your wallet. The CNS ID number is now also shown on certificates to new members.

Ben Rouben
Chair, Membership Committee

Note d'adhésion

Il est déjà temps de renouveler votre adhésion à la SNC. **Bénéficiez d'un escompte en renouvelant tout de suite, avant la fin de décembre.**

Vous pouvez maintenant facilement et en toute sécurité renouveler en ligne et vous recevrez votre reçu immédiatement ! C'est vraiment très facile et rapide. Branchez-vous au https://www.signupmaster.com/cns-membership et suivez les instructions. Renouvelez dès maintenant !

Le renouvellement en ligne fera le changement aux frais standard le 1er janvier 2010 ; c'est donc dans votre propre intérêt de renouveler tôt !

Si vous êtes inscrit(e) au renouvellement automatique, le bureau de la SNC fera le travail pour vous à temps chaque année, et vous profiterez ainsi toujours des prix réduits de renouvellement, sans vous préoccuper ! **Si vous n'êtes pas encore inscrit(e) au renouvellement automatique, mais aimeriez profiter de ce service très commode, veuillez contacter le bureau de la SNC à 416-977-7620 ou à cns-snc@on.aibn.com.**

Et souvenez-vous de toujours garder votre numéro de membre à portée de la main. Vous en aurez besoin pour vous identifier en tant que membre quand vous vous inscrirez à une conférence ou à un cours de la SNC ! Votre numéro de membre de la SNC apparaît sur votre carte annuelle de membre. Ce serait peut-être une bonne idée de garder la carte dans votre portefeuille. Le numéro de membre apparaît maintenant aussi sur les certificats des nouveaux membres.

Ben Rouben
président du comité d'adhésion

CNS holds public information event

Prompted by Ben Rouben, the Canadian Nuclear Society held a pubic information event at the University of Ontario Institute of Technology (UOIT) in Oshawa, on October 15, 2009, in conjunction with the National Science and Technology Week program.

The event involved two presentations:

The first was by Jeremy Whitlock, a review of the historyof the Canadian nuclear program, including an introduction to nuclear reactors, which he title: "Splitting Atoms: Canadian Style". He described it as a "journey through over 100years of nuclear achievement in this country of hewers of wood and drawers of water".

The other was by Dan Meneley, titled, "Turning Rocks into Gold" in which he outlined the various sources of energy with an emphasis on the vast potential energy in uranium. He succinctly described the nuclear fuel cycle from uranium mining, through the building and operation of nuclear power plants to deailng with spent fuel.

The UOIT venue was chosen partly because of the choice of the near-by Darlington site for new nuclear plants in Ontario. Further, three of the four people who were primarily involved are associated with the university: CNS president Dorin Nichita, an associate professor; Dan Meneley and Ben Rouben, adjunct professors.

There were, reportedly, over 70 members of the public in attendance.

BOOK REVIEW By Peter Schanke

*[**Ed. Note:** Peter Schwanke is a CNS member and a professor at UOIT.]*

Sun in a Bottle

The Strange History of Fusion and the Science of Wishful Thinking

Author: Charles Seife; **Publisher**: Viking Penguin

Publication Date: October 2008 (Hardcover) / October 2009 (Softcover)

The title says it all. Indeed, the goal of achieving controlled nuclear fusion is nothing short of capturing the heart of the sun and confining it in bottle, all be it a magnetic bottle if current approaches prove successful. But what a struggle this pursuit has been, and continues to be! Since the early 1950's when serious attempts were first directed at controlling nuclear fusion to bring us to the promised land of boundless energy, humanity continues to wait for the Prometheans of our time to deliver on that promise. Is the pursuit of fusion energy wishful thinking? This is the conclusion readers of Charles Seife's latest work, recently released in softcover, are led to believe after a detailed historical overview of the triumphs and failures of fusion research.

Seife's work starts by juxtaposing two key individuals in the history of nuclear weapons development: Robert Oppenheimer and William Teller. A study in contrasts, these two individuals became bitter enemies during Teller's dogmatic pursuit to create the world's first fusion bomb, which would also become the first demonstration of fusion's unrivalled energy release. Following the acquisition of what amounts to the "Sword of Michael" by the United States, work on fusion shifted from secrecy to openness as the nations of the world began to share information, especially in light of the challenges that early attempts at controlled fusion presented. Having written for *Science* magazine, *New Scientist*, *Scientific American*, and *The Sciences*, Seife clearly explains the physics needed to appreciate why fusion would be such an energy boon and why it has been so difficult to attain. The reader is led though the evolution of various fusion schemes which fall into two basic categories: magnetic confinement of hot plasmas and compression of solid fuel-pellets by lasers. Seife traces the evolution of magnetic confinement from the early work by Lyman Spitzer using stellarators to today's multi-national collaboration on the ITER project. In parallel, Seife also reviews the evolution of laser fusion at Lawrence Livermore National Laboratory starting with the double-beam Janus experiment and culminating in the recently completed National Ignition Facility. Fusion requires energy to allow reacting nuclei to overcome their mutual electrostatic repulsion. The ultimate goal of fusion research to create a self-sustaining reaction in which the energy released by fusion exceeds that required to initiate it. As Seife reports, each historical milestone has moved slightly closer to achieving this goal, but they have also uncovered a host of new issues. One is thus left wondering how many gremlins are left lurking in the shadows and if one of them may yet prove fatal for the entire enterprise.

Furthermore, as if the technical issues weren't problematic enough, fusion research is marred by a number of highly-publicized, false claims of fusion via unconventional means. Beginning with the claim in 1951 by an Argentinean scientist to have successfully fused deuterium with lithium in a "solar reactor furnace", Seife examines a number of headline-stealing moments in the history of fusion, including the exploits of cold fusion in 1989 and bubble fusion in 2002. Politics, scientific misconduct, and outright fraud make for a very interesting read indeed!

In the end, Seife offers a rather pessimistic outlook for the future prospects of fusion (certainly in the immediate future), however his work does present a well-narrated overview of past and present accomplishments from which I would invite the reader to draw his/her own conclusions. I personally would recommend this book for anyone interested in acquiring a succinct big-picture perspective on fusion research. As for whether the pursuit of fusion energy is truly wishful thinking, only time will tell.

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31st Annual Conference of the Canadian Nuclear Society

Hilton Bonaventure Hotel, Montréal, Québec, Canada
2010 May 24 – May 27

"Atoms for Power, Health, and the Environment-
Les atomes: pour l'énergie, la santé et l'environnement"

Call for Papers

The 31st Annual Conference of the Canadian Nuclear Society and the 34th Annual CNS/CNA Student Conference will be held in Montréal, Québec, Canada, 2010 May 24 – May 27 at the Hilton Bonaventure Hotel. **Note that the conference starts with a Conference reception on Monday evening May 24, Victoria Day.**

The central objective of this conference is to provide a forum for exchange of views and ideas and information relating to application and advancement of nuclear science and technology, and nuclear-related issues in general.

- Invited speakers in **Plenary sessions** will address broad industrial and commercial developments in the field.
- Speakers in **Technical sessions** will present papers on their work related to nuclear technology. **This call for papers is to solicit papers in Technical sessions** covering, but not limited to the following **Technical Topics:**

- Reactor Physics, Radiation Physics and Health Physics
- Thermalhydraulics
- Safety and Licensing
- Safety Management and Safety Culture
- Medical Isotope Production and Applications
- Environment and Waste Management
- Process Systems
- Chemistry and Materials
- Instrumentation and Control
- Control Room Operations
- Advanced Reactors and Applications
- Plant Life Management and Refurbishment
- Operation and Maintenance
- Oil Sands Applications

Important Dates

- First Call for Papers: 2009 August 31
- Deadline for submission of **full papers:** 2010 January 8
- Deadline for submission of revised final papers: 2010 March 31
- The early registration date: 2010 March 31

Guidelines for Full Papers

Papers should present facts that are new and significant, or represent a state-of-the-art review. They should include enough information for a clear presentation of the topic. Proper reference should be made to related published information. The name(s), affiliation(s), and contact information of the author(s) should appear below the title of the paper. A short abstract of 50-100 words must be placed at the beginning of the paper. A length of ~10 pages with an electronic file size of less than 5 MB is suggested for a typical paper.

Paper Submission Procedure

Please note that ONLY FULL PAPERS are to be submitted and peer-reviewed for this conference (abstracts or summaries will not be accepted). **Please plan accordingly as 2010 January 8 is fast approaching!** Submissions of full papers should be made electronically, preferably in MS Word format, through the Annual Conference electronic submission system at: **http://www.softconf.com/s08/CNS2010Technical**

To help with planning, authors are kindly asked to log onto the electronic submission system and input the title and main author of their planned paper even before making the full submission.

Technical Program Co-Chairs
Guy Marleau, Ecole Polytechnique de Montréal
e-mail: **guy.marleau@polymtl.ca** Tel: 514-340-4711 x 4204

Wei Shen, Atomic Energy of Canada Limited
e-mail: **cns2010@aecl.ca** Tel: 905-823-9060 x 33335

Information regarding paper template, copyright of papers, publication methods can be found at the conference website: **http://www.cns-snc.ca/conf2010.html**

General inquiries regarding the Conference may be addressed to

Conference Executive Chair
Adriaan Buijs, McMaster University
e-mail: **buijsa@mcmaster.ca** Tel: 905-525-9140 x 24925

Denise Rouben, CNS Office Manager
e-mail: **cns-snc@on.aibn.com** Tel: 416-977-7620

34th Annual CNS/CNA Student Conference

Hilton Bonaventure Hotel, Montréal, Québec, Canada

2010 May 24 – May 27

"Atoms for Power, Health, and the Environment – Les atomes: pour l'énergie, la santé et l'environnement"

Call for Papers

The 34th Annual CNS/CNA Student Conference will be held at the Hilton Bonaventure Hotel, Montréal, 2010 May 24 - 27 **in conjunction with the 31st Annual Conference of the Canadian Nuclear Society.**

Conference executive chair:
- Adriaan Buijs

Student Conference Chairs:
- George Abdul-Nour

Suggested Topics

- Reactor, Radiation and Health Physics
- Thermalhydraulics
- Safety and Licensing
- Process Systems
- Chemistry and Materials
- Instrumentation and Control
- Operation and Maintenance
- Advanced Reactors and Applications
- Environment and Waste Management
- Plant Life Management and Refurbishment
- Medical Isotope Production and Applications
- Safety Management and Culture
- Control Room Operations
- Oil Sands Applications

General Guidelines

Please submit full papers (in English or French) that present new, significant, and relevant research in the fields of nuclear engineering. Papers should include enough information for a clear presentation of the topic. Proper reference should be made to related published information. These papers are NOT peer-reviewed. Papers will be presented at the conference in a special Poster session (Posters in English and French will be accepted). There is a competition process at the Student Conference, and prizes are awarded for best student poster(s). Students presenting a poster at the Student Conference receive complimentary registration to the Annual Conference and to the Student Conference.

Note that students can also submit papers to the Annual Conference. These papers are peer reviewed and are presented at a regular session of the Annual Conference. Students presenting at the Annual Conference are required to pay the (very low) student registration fee.

Paper Format

- Writers are required to use the following template: **http://www.cns-snc.ca/CNS_Conferences/CNS2010/CNS_FullPaper_Template.doc**
- The title of the paper should not exceed 10 words.
- The name, affiliation, and contact information of the author should appear below the title of the paper.
- A short abstract of 50-100 words must be placed at the beginning of the paper.
- A maximum length of 10 pages with an electronic file size of less than 5 MB is required.
- The papers should be submitted using the following website: **https://www.softconf.com/a/CNS2010Student/**

Important Dates

- March 19, 2010 Submission of full papers to conference
- April 16, 2010 Notification of paper acceptance to authors

CALENDAR

2010

Feb. 24-26
CNA Annual Conference and Tradeshow
Ottawa, Ontario
website: www.cna.ca

Mar. 21-24
NREC '10 – 1st Inernational Nuclear & Renewable Energy Conference
Amman, Jordan
website: http://inrec10.inrec-conf.org
email: inrec10-conf@illinois.edu

Apr.25-28
2nd Canada – China Workshop on Supercritical Water-Cooled Reactors (CCSC-2010)
Toronto, Ontario
website: www.cns-snc.ca

May 9-14
PHYSOR 2010, "Advances in Reactor Physics to Power the Nuclear Renaissance"
Pittsburgh, PA, USA
website: http://www.physor2010.org

May 17-21
ICONE-18 18th International Conference on Nuclear Engineering
Xi'an, China
Call for papers
website: www.icone18.org
email: icone18@ans.org.cn

May 24-27
31st Annual Conference of the Canadian Nuclear Society and 34th CNS/CNA Student Conference
Montreal, Québec
See Call for Papers
website: www.cns-snc.ca

June 13-17
ANS Annual Meeting
San Diego, CA, USA
website: http://www.ans.org/meetings

Aug. 15-18
Uranium 2010 – 3rd International Conference on Uranium;
40th Annual Hydrometallurgy Meeting
Saskatoon, Saskatchewan
Call for papers
website: www.cns-snc.ca

Sept. 26-29
DD&R 2010 International Meeting on Decommissioning, Decontamination and Re-Utilization
Idaho Falls, Idaho, USA
website: www.ans.org

Oct. 3-8
PATRAM 2010: 16th International Symposium on the Packaging and Transport of Radioactive Materials
London, United Kingdom
Call for Papers
website: www.PATRAM2010.org

Oct 3-10
International Conference on Water Chemistry of Nuclear Reactor Systems (NPC 2010)
(organized by CNS)
Québec City, QC;
website: cns-snc.ca

2011

Oct 24-30
17th Pacific Basin Nuclear Conference
Cancun, Mexico
website: www.pbnc2010.org.mx

June 5-8
32nd CNS Annual Conference
Niagara Falls, Ontario
website: cns-snc.ca

Sept. 11-14
Waste Management, Decommissioning & Environmental Restoration for Canada's Nuclear Activities
Toronto, Ontario
website: cns-snc.ca

NPC 2010

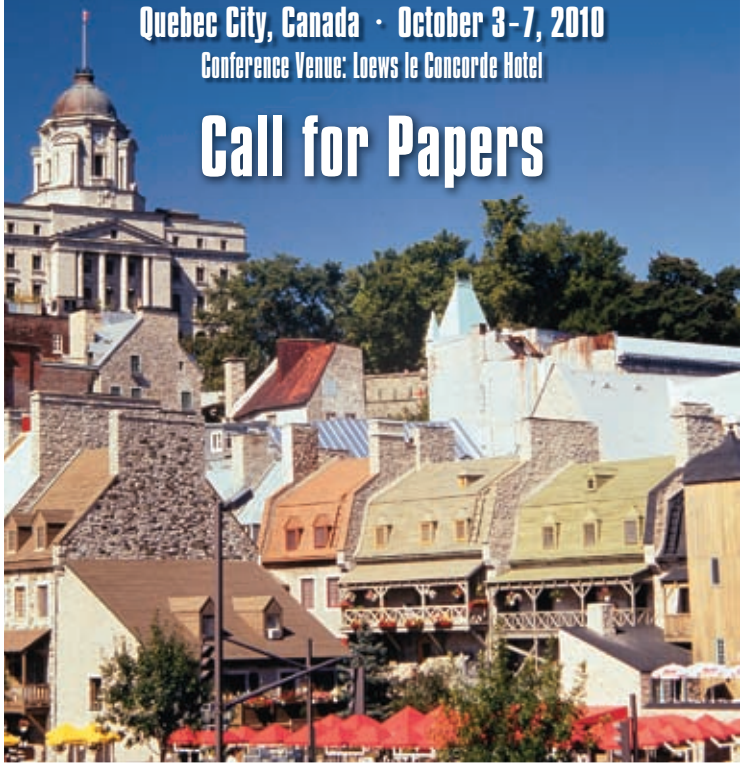
Nuclear Plant Chemistry Conference 2010

(International Conference on Water Chemistry of Nuclear Reactor Systems)

Quebec City, Canada · October 3-7, 2010

Conference Venue: Loews le Concorde Hotel

Call for Papers



The next **International Conference on Water Chemistry of Nuclear Reactor Systems** focuses on the latest developments in the science and technology of water chemistry control in nuclear reactor systems. What began in the UK in 1977 as the Bournemouth Conference Series has of late been held biennially under the organization of a host country. For 2010, that country is Canada. The Conference is a forum where utility scientists, engineers and operations people can meet their counterparts from research institutes, service organizations and universities to address the challenges of chemistry control and degradation management of their complex and costly plants for the many decades that they are expected to operate. In 2010 the focus will be on operating experience and the subsequent lessons to be learned, with supporting material on new developments and research.

Features of the Conference

Quebec City – the Conference will be held in the heart of Old Quebec City, which in 2008 celebrated its 400th anniversary. The city is renowned for its old-world charm, history, fine cuisine and as the centre of the Province's unique and very dynamic culture.

Loews le Concorde Hotel – located within minutes walk from the heart of old Quebec City, is the perfectly located and appointed venue.

Conference Format – four days of single session presentations with Poster Sessions that will be promoted as part of the Technical Sessions. All Proceedings will be in English.

Walking Tours of Old Quebec City – in various themes and languages; and possibly for your consideration, a **Canadian Forests in Autumn Excursion**.

Call for Papers

Technical Paper Abstracts are invited in the following topic areas. There is special interest in the experience of plants with Alloy 800 as well as of those with Alloy 600 and Alloy 690 steam generator tubing.

Chemistry and NPP Performance
PWR, VVER Operating Experience
CANDU/PHWR Operating Experience
Pressurised Water Scientific Studies
Steam Cycle Operating Experience

BWR Operating Experience
Boiling Water Scientific Studies
Water and Waste Treatment, Cooling Water Systems, Auxiliary Systems
Materials Aging and Mitigation of Degradation
Chemistry and Fuel Performance

Cleaning and Decontamination
Lifetime Management
Chemistry Optimization Programs
Chemistry Compliance Management
Future Developments (GEN IV), Supercritical Water

Radiolysis, Electrochemistry & Materials Performance Workshop

The 8th Int'l Radiolysis, Electochemistry & Materials Performance Workshop will be held as an associated, but otherwise free-standing, event on Friday, October 8, 2010. Requests for "Invitation to Present" should be submitted as for NPC 2010 but specifically for the Workshop. Separate Workshop Proceedings will be issued. For organization and registration information regarding this Workshop, see the website at **www.cns-snc.ca**

Milestone Dates

NEW Abstracts Due	extended to 2010 January 15
Author Notifications	2010 January 29
Advance Program	2010 January 29
Papers Due	2010 June 25
Conference	2010 October 3 to 7
Workshop	2010 October 8

Abstract Submission

All prospective Authors are invited to submit a 500-word Abstract by the above date. Abstracts may be submitted via the link at **www.cns-snc.ca**. All Abstracts MUST be submitted electronically in Microsoft Word format.

All Papers are due by the above date. Authors will be provided guidelines for full Paper presentation and submission at the time of author notification.

If you have technical questions about abstracts for NPC 2010 please contact: Peter Angell, Technical Program Chair (angellp@aecl.ca).

For technical inquires regarding the Workshop please contact: John Roberts, Workshop Chair (alchemy@tnt21.com).

Event Administrator – The Professional Edge

If you require assistance with submissions or anything else related to NPC2010, please contact: Elizabeth Muckle-Jeffs (Elizabeth@theprofessionaledge.com)

Conference Sponsor and Organizer

The Canadian Nuclear Society is pleased to serve as the sponsor and organizer of the NPC 2010 Conference, which is held in cooperation with the International Atomic Energy Agency.

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The Curious Case of CANDU

by Jeremy Whitlock

Ladies and gentlemen, our next subject is a curious case indeed. At the time of CANDU's birth in 1962, it was readily appreciated that it was an odd creature with certain needs - but nobody suspected that it was, it seems, inverted in time. That is to say, it was born advanced, with features of a mature and progressive industry, and as it aged the rest of the global industry caught up with it.

When first encountered, CANDU had not yet been named. It was simply "Nuclear Power Demonstration", and it lived in a deep hole at the top of a cliff near a hydro dam. It was small (about 20 megawatts electrical), much like designs only now being proposed for distributed or small-grid applications. It had passive safety features - slow kinetics, low energy density, low excess reactivity, distributed pressure boundary, large heat sink - and as you've just heard: earthen (in fact, bedrock) containment. These are all features you will note are finding their way into design proposals today.

NPD, as it was called, was designed with replacement of individual fuel channels (if required) in mind. Aging management, in fact, has been a natural part of CANDU operation from the beginning. With its pressure boundary in the high neutron flux of the core, it was required at an early age to know as much about the longevity of the boundary material as possible. Much later, such concerns came to light in the rest of the global industry as it naturally aged.

As CANDU grew it retained many of its passive safety features, but it moved above ground like the rest of the world's designs. It always used natural uranium however, and therefore required none of the enrichment technology that decades later would cause considerable consternation in the hands of questionable state nuclear programs. Its natural uranium design also allowed it to make the most efficient use of the earth's fissionable ores, in particular uranium or thorium. Resource efficiency and thorium usage have emerged as topical items only recently, as plans for expanding the global reactor fleet lead to dour projections of uranium supply.

Similarly, CANDU's lack of a pressure vessel has always decoupled it from the planet's large forging capabilities, the importance of which became clear as the first orders for new LWRs were placed at the outset of the nuclear renaissance.

By the time CANDU had grown to its Pickering size it was being controlled by digital computers, long before this became commonplace in the rest of the global nuclear industry. Digital control is of particular benefit to CANDU with its more distributed control system, but it's a good idea with any large reactor as everyone else soon realized.

Other things were realized as the world's nuclear industry aged. Intermediate storage of spent nuclear fuel delays the need for a repository while freeing up space in the storage pools. A particularly useful and long-practiced activity in CANDU due to its high fuel throughput (and quite easily implemented), dry storage transfer will now see increasing interest as the rest of the world runs out of storage space with few long-term options ready to go.

Another area is safeguards, where the world must yet come to grips with how it will protect the variety of advanced technologies and fuel cycles - some on-load refuelled - against proliferation efforts. CANDU has much to offer in this respect, having dealt with similar issues for decades and emerging as the most comprehensively safeguarded commercial reactor on the planet.

Ladies and gentlemen, at this stage in its development CANDU finds itself still slightly ahead of its cousins, but the gap is closing. Meanwhile there are signs of crossing, as the mainstream nuclear industry is just now waking up to the value of a neutron-efficient machine with on-load refuelling capability, plus the non-proliferation benefit of natural uranium fuel cycles, while CANDU is taking evolutionary steps away from these fundamentals.

A curious case, to be sure.

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