CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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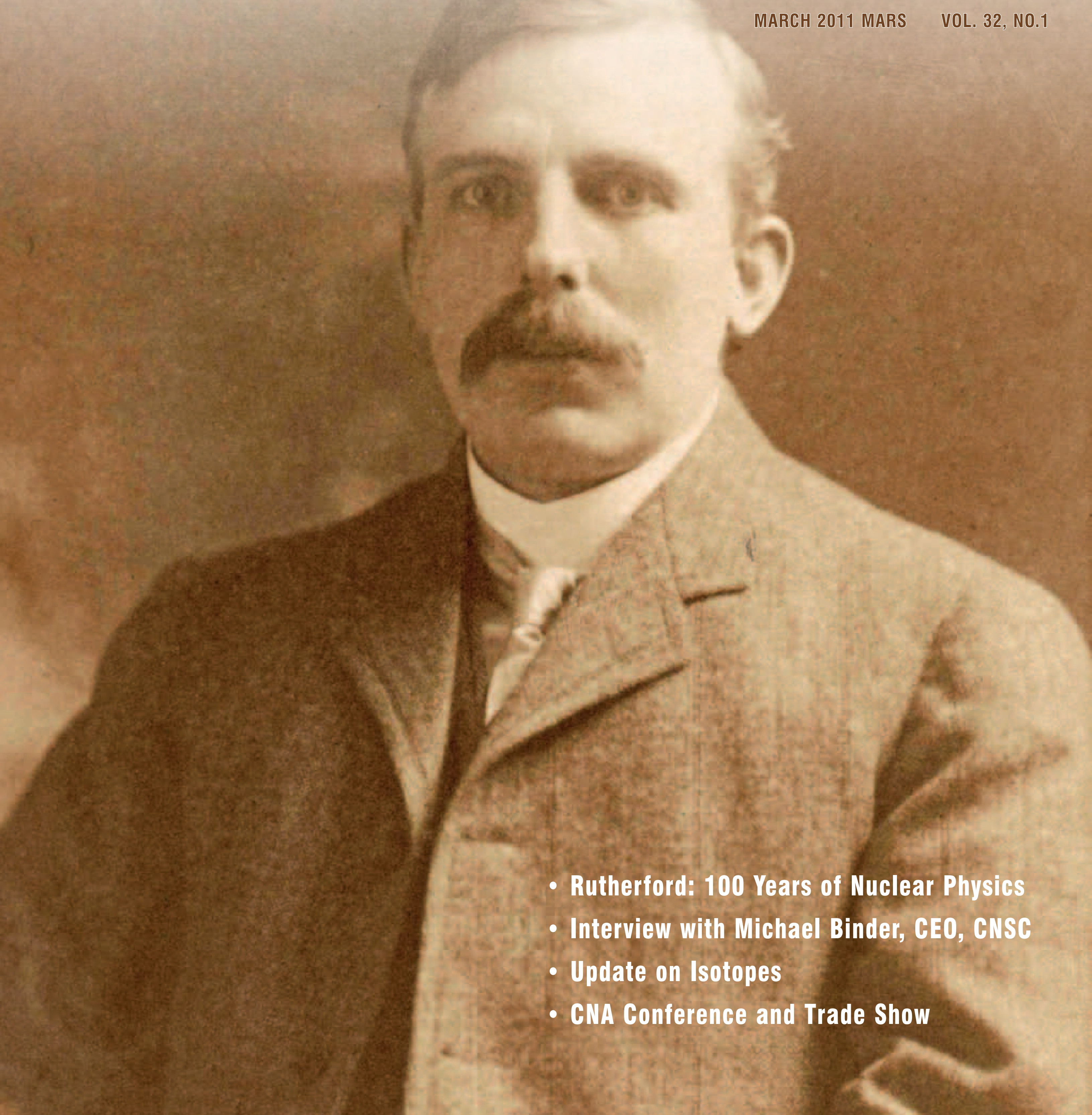

- Rutherford: 100 Years of Nuclear Physics
- Interview with Michael Binder, CEO, CNSC
- Update on Isotopes
- CNA Conference and Trade Show

Misery in Japan

An unprecedented natural disaster hit Japan on March 11, 2011, with nearly 9000 confirmed dead and more than 10,000 missing. Hundreds of thousands are homeless. About one hour after the 9 magnitude earthquake, never before experienced in Japan, a reported 10 metre monster tsunami battered the west coast washing away villages, homes, people and anything else the sea could swallow up. Images of the disaster are unbelievable, and on-going rescue efforts are hampered by snow and sleet and lack of electricity. Our thoughts and prayers go out to the people of Japan.

Despite the human calamity and turmoil, the media choose to focus on a relatively small thing, the problems at Fukushima Dai-ichi. Why? It's a nuclear power station. One worker was killed at the plant because he was trapped in a crane at the time the earthquake hit. Some workers were injured during the earthquake. Now called the Fukushima 50, the 50 or so brave workers on the scene who are trying to keep the situation under control, are the ones at most risk from radiation at the plant. For the rest of the population, risks from the radiation are very small. There have been no deaths or injuries resulting from the radiation at the plant. In context, there could be up to 20,000 lost souls from the earthquake and tsunami.

With hundreds of news stories about the Fukushima nuclear problems, I found only two stories about the Fukushima dam that failed because of the earthquake. A wall of water from the failed dam washed away 1800 homes. And yet the media chooses to focus, out of all contexts, on Fukushima Dai-ichi, as if its problems apply to every other nuclear station on the planet. Politicians in the US are not helping. Senator Markey called for the distribution of potassium iodide pills while NRC Chairman Gregory Jaczko criticized the 20 km evacuation zone, claiming it should be 80 km.

The media has a job to do and tries to provide objective and factual information to its audience. It does this by seeking out experts on the topic, in particular, those who have helped the media in the past by providing timely information to meet their publication deadline or in time for the six o-clock news. The experts influence public opinion, which in turn influences politicians in search of re-election strategies such as proposing new laws aimed at curtailing what troubles the public. Of course, the public at large does not understand the science and technology of nuclear energy, and unfortunately, they can't tell the difference between a real expert and a coercive utopian claiming to be an expert. The coercive utopians have an agenda to stop all things nuclear and would have you believe that solar generators can be used to pump water into a tank in the sky during the day, and use that water to run a generator during the night.

The Government of Canada has tried to reassure Canadians that Japan's radioactive fallout will cause no risk to Canadians, and the Science Advisor to the UK, John Beddington, calls the fear of radiation in Japan a "sideshow" to the real disaster. In a speech he said:

> "The first thing to say about that is do we have any concerns now in terms of human health? Well the answer is yes we do, but only in the immediate vicinity of the reactors. So the 20 kilometre exclusion zone the Japanese have actually imposed is sensible and proportionate."

Indeed, World Nuclear News states (20 March):

> "Despite contradictory comments by the US Nuclear Regulatory Commission to US politicians and media, most observers in nuclear industry and regulation consider the measures taken by Japanese authorities to be prudent."

Although Germany, Switzerland and China have either suspended new build or shut down existing reactors, this does not appear to be the case in most countries. There will, however, be full national and international reviews of the nuclear problems in Japan and lessons will be learned to improve safety. In the meantime, those with real expertise should be explaining to friends, neighbours and the media the safety of nuclear energy in context with the real world.

In This Issue

This year marks the 100th anniversary of Rutherford's discovery of atomic structure. CNS Member **Mike Attas** has kindly provided a historical note on Rutherford's work, while Professor **John Campbell** (University of Canterbury, Christchurch, NZ), who provided the cover photo, gives a description of the soon to be released documentary "Rutherford". More than 750 people attended the annual CNA Conference and Trade Show (see report) and we publish an interview with **Michael Binder**, President and CEO of the Canadian Nuclear Safety Commission (celebrating its 65th anniversary). CNS Member **Nicholas Sion** has provided an update on isotope production, and as usual, **Jeremy Whitlock's** Endpoint makes an interesting read. Enjoy!

Context

This is being written against the backdrop of the news of the huge earthquake in Japan, March 11 and especially the problems at the Fukushima reactors. Those problems emphasize the importance of the auxiliary systems of large nuclear plants, a point that has not always been sufficiently acknowledged in our own program.

Like the Three Mile Island event and the Chernobyl catastrophe, the events at the Japanese plants will inevitably lead to further reviews and introspection of the safety features of our nuclear plants. These should not be taken lightly or in a perfunctory manner. Nuclear power plants are large complicated entities that must be understood thoroughly and operated with great care and attention to detail. *(The CNSC has already asked major licensees to conduct a review.)*

The Society

This is another active year for the CNS in terms of conferences and courses. As this issue goes to press the *5th International Symposium on Supercritical Water Cooled Reactors* is under way in Vancouver. This is the 5th Symposium in the series, in cooperation with the International Atomic Energy Agency, focussing on research and developments for supercritical-water-cooled reactors (SCWR) which are one of the Gen IV concepts being pursued internationally.

During the first week of June the Society will be holding its *32nd Annual Conference* with the embedded *35th Annual CNS/CNA Student Conference*, in Niagara Falls. That will be followed immediately by a one-day forum on *Nuclear Education and Outreach*, as a follow-on to the successful first such event held in Calgary last summer.

Then, in September, there will be the *CNS Conference on Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities* in Toronto. Despite the unwieldy title, this event will focus on the many important aspects of the back end of the nuclear fuel cycle. And, it will have an international flavour with the involvement of IAEA, NEA, ANS and AESJ.

The following month (October) will see a meeting whose title alone should be of interest to many readers: *International Conference on the Future of Heavy Water Reactors*, to be held in Ottawa. Despite the uncertainty (at the time of writing) of the Canadian program, there remains interest around the world in the unique capabilities of HWRs.

Finally, to end the year with a major event, the *9th CNS International Conference on CANDU Maintenance* will be held in Toronto, the first week of December. Previous versions of this conference have drawn large attendance and this one will likely repeat that experience.

Then, interspersed with these major events, three courses are being offered: Reactor Physics, in May; CANDU Fuel Technology, in October; and Reactor Safety in November.

More information on all of these events can be found on the Society's website: www.cns-snc.ca.

In parallel with all of that activity, Dorin Nichita is pursuing a Canadian Nuclear Journal to be published n electronic format. He has recruited a number of volunteers for an editorial board but would welcome additional members. If you are interested, contact him: eleodor.nichita@uoit.ca

The Canadian Nuclear Scene

One issue has dominated the media coverage of the Canadian nuclear program over the past several months – the proposed shipment of old steam generators from the Bruce site to Sweden for recovery of the tons of steel in their shells. Unfortunately, the tubes inside the shells are slightly contaminated with radioactive material the result of corrosion in the primary systems of the Bruce A reactors.

The total amount of radioactivity is minuscule and, if it were in smaller form could be shipped in an internationally approved container without notice. However, because of the physical size of the steam generators, the shipment required "special arrangements" which were pursued and reviewed carefully by the staff of the CNSC. In a rational world that would have been the end of the story.

However, as we all know, when it comes to things "nuclear"; "atomic"; "radioactivity"; logic and rationality disappear. Triggered, reportedly, by the Mayor of Owen Sound who publicly spoke of alarm when presented with the proposal, the media picked up the story and repeated it across the country. Other politicians and anti-nuclear groups from across the continent jumped on the band wagon, with the media reporting every exaggerated claim.

Consequently, the CNSC held a formal hearing on the proposal. Almost all of the 70 odd interventions expressed great concern based on ignorance or, in many cases, distortion of the facts. Sadly there were no submissions from any of the nuclear associations or societies.

At the beginning of March, the House of Commons Standing Committee on Natural Resources held two meetings on the topic. Surprisingly, there were a couple of witnesses, including the Medical Officer of Health for Bruce County, who stated that the risk was insignificant.

There actually are some rational people out there.

Fred Boyd

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~ Cover Photo ~

Ernest Rutherford, c.1909.

Photo courtesy of John Campbell

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CNS provides Canadians interested in nuclear energy with a forum for technical discussion.
For membership information, contact the CNS office, a member of the Council, or local branch executive.
Membership fee for new members is $82.40 per calendar year, $48.41 for retirees, free to qualified students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. Les frais d'adhésion par année de calendrier pour nouveaux membres sont 82.40$, et 48.41$ pour retraités.

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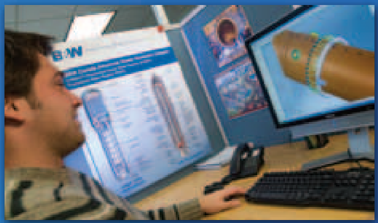


Nuclear Industry Conference and Trade Show 2011

CNA Event Draws Large Attendance for Diverse Program

by FRED BOYD

Well over 700 delegates gathered at the Westin Hotel in Ottawa February 23 to 25 for the Canadian Nuclear Association *Nuclear Industry Conference and Trade Show 2011*, close to the record number last year. They were treated to a diverse program of speakers and enjoyed an expanded trade show. Despite the current uncertainty of the nuclear power program, the number of exhibitors grew from last year, essentially filling the available space.

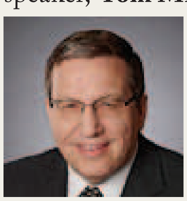
The theme of the conference was *"Competing in World Markets – Strategies for Growth"*

The presentations varied from details of a US research laboratory budget to an inspirational message from the former head of Cirque du Soleil. In between were views from: a political columnist, the former head of the Canadian Council of Chief Executives, our chief regulator, and the leader of the Ontario Progressive Conservative party. Probably the message that reverberated the most was the statement by Tom Mitchell, President and CEO of Ontario Power Generation, that the new reactors proposed for Darlington would be "Enhanced CANDUs".

Following the pattern of the past few years the conference began with an extensive reception on the Wednesday evening, with one variation, there were no opening talks.

The conference proper began early the next morning with a breakfast during which **Wayne Robbins**, CNA Chairman (and Chief Nuclear officer, Ontario Power Generation) welcomed everyone. Robbins stated that the CNA has developed a Strategic Plan to guide activities over the coming five years. It recognizes the need for clear, consistent, messages for the public, media and government.

He then outlined the program and introduced the first speaker, **Tom Mitchell,** President and CEO of OPG.



Mitchell began with three words – Tee, Minus, Twenty-six - which, he explained, means 26 days until March 21, the beginning of the hearing on the environmental assessment for new nuclear units at OPG's Darlington site. New nuclear is becoming a reality, and, he noted, the Darlington community is very supportive.

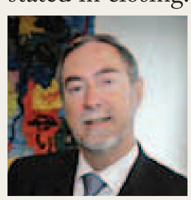
He went on to state that OPG can deliver "new builds" that provide value. The current activity is to ensure that OPG has all the approvals necessary to begin construction when the province gives approval. On the question of "right technology" he made the statement noted above that the units would be "Enhanced CANDUs".

Since experienced operators will be needed for the new plants the plan is to move the operating staff from Pickering in 2020 when the life-extension of that plant is scheduled to end. This, he suggested, should match with the likely completion of the new Darlington units.

After the audience had moved to the main meeting room, the next speaker was introduced, **John Ibbitson,** an author and columnist for the Globe and Mail. He noted that his job was primarily watching the [federal] government, which, he said, is running away from the nuclear issue. Yet, he argued, there is no nuclear program anywhere without government support. The general view in Canada, he suggested, was that nuclear was an economic "sink-hole".

Then he referenced the attack advertisements of the Liberal party. "Negative ads work", he said, and mused about the CNA pursuing attack ads. More specifically he stated that politicians and the public need to know what is at stake in the current lack of support for the nuclear program...

He was followed by another speaker from the political arena, **Senator David Angus**, Chairman of the Standing Senate Committee on Energy, the Environment and Natural Resources who spoke about the study his committee is pursuing titled "Towards a Canadian Sustainable Energy Strategy". It is due to be released in June 2011. A good dialogue about energy is underway, he observed. The Committee believes that Canada must both reduce [per capita] demand and expand production. Although the nuclear power program is in a state of limbo the Committee accepts that it must be part of the energy mix, he stated in closing.



Providing an international viewpoint, **Luis Echávarri**, Director General of the OECD Nuclear Energy Agency, spoke about a series of reports being prepared by the NEA in cooperation with the International Energy Agency under the title of "Technology Roadmaps". The NEA believes that it will be necessary to create 25 GWe of nuclear generation capacity per year by 2020 and 40 GWe /yr by 2040. He commented that IEA doubts such a target is feasible.

Referring to the new designs being pursued he predicted that there would be several "Gen III + " designs operating by 2020 and at least one "Gen IV" by 2030. Over the long term he commented that further technical development is needed and clear, stable commitments by governments. In closing he stated that financing will continue to be a major challenge.

The last speaker of the morning was **Michael Binder**, President and CEO of the Canadian Nuclear Safety Commission, who noted that the CNSC is celebrating 65 years of nuclear regulation in Canada beginning with the Atomic Energy Control Board in 1946 and continuing, since 2000, by the CNSC. He identified four major activities of the CNSC:

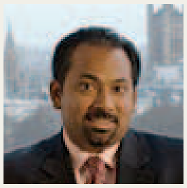
- the core licensing and compliance program
- a renewed but modest research program (to support licensing activities)
- modernizing their regulatory documents
- finding "the right people for the right job"

In addition CNSC is trying to engage Canadians through:

- public outreach and aboriginal consultations
- demonstrating social responsibility
- practising proactive disclosure of information
- dissemination of science-based information

"Where are you ?" he challenged the audience.

He closed with his now famous saying that "The CNSC will not compromise safety – it is in our DNA".



Following the served lunch **Vijay Vaitheeswaran**, a correspondent for The Economist magazine, offered a broader perspective with a wide-ranging address that touched on history, philosophy and culture. His primary message was that the global economy is in a storm. Innovation – fresh thinking - is needed, especially on values. Innovation comes from the bottom up, he asserted, and suggested that the growing web-based information exchange can help.

Turning to the question of nuclear power at the end of his talk he noted the extended time frame of 10 to 20 years required from the time of decision to operation of a nuclear plant. He added that the private sector needs to do more to improve the situation.

He was followed by possibly the most relevant session, a panel of four senior, knowledgeable, persons tackling the question of "Making Nuclear Power More Cost Competitive". The members were: **Tim Gitzel**, President; Cameco Corporation; **Jacques Besnainou**, CEO AREVA Inc.; **Tom Mitchel**, CEO, OPG; **Blair Kennedy**; Vice President, New Brunswick Power.

Tim Gitzel began the presentations by stating he was going to deviate from the stated theme of the panel and talk about

Panel in action: L to R. Jacques Besnainou; Blair Kennedy; Tom Mitchell; Tim Gitzel.

uranium. Cameco's business, he said, is to ensure the availability of complete nuclear fuel services. With the growing nuclear power program around the world it will be hard to supply the demand for uranium, he stated. China is already the biggest market and will be building 40 more units over the next decade. Cameco has contracted to supply China with 52 million pounds of uranium between now and 2025. After outlining Cameco's activities around the world he stated that Cigar Lake was now dewatered and is expected to begin production in 2013.

Mitchell spoke initially about the planned refurbishment of the four units at Darlington. Then he mentioned their approach to the potential down-rating caused by the decreased flow through the pressure tubes when they creep due to ageing. Analysis and tests have shown that, by simply decreasing the diameter of the central pin of the fuel bundle, the required flow can be retained.

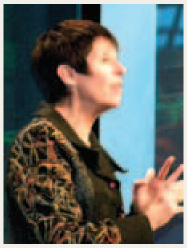
He mentioned that in 2010 Darlington had produced 470 TWHr, which was 20% of Ontario's demand. And, he added proudly, the crew worked 8 million hours without a lost-time injury. In closing he mentioned that for the refurbishment and planned new build OPG can not do it alone and will be depending on suppliers and contractors. However, he emphasized, the objective is to complete every job correctly the first time.

Kennedy stated that, at the Point Lepreau station, safety is their top priority but they also emphasize quality and innovation. He briefly alluded to the leak problem with the new calandria tubes and commented that it had also occurred at Wolsong 1 in Korea (which is also going through a refurbishment). The new tubes will be installed by next year. In closing he commented that there is a need to improve the sharing of information [between CANDU operators] while respecting intellectual property rights.

Besnainou gave a quick overview of the scope of AREVA's activities which include uranium mining (some, like Cigar Lake, in partnership with Cameco) as well as nuclear plants. They are also now into wind and solar. In closing he noted that nuclear can provide enhanced energy security. It was the oil "crisis" of the 1970s that led France to pursue the major nuclear program it has, with nuclear power now providing three quarters of France's electricity. And, he noted, France is exporting much of that nuclear-generated electricity to neighbouring countries which have eschewed the nuclear option.

The last speaker of the day, **Thomas d'Aquino**, former head of the Canadian Council of Chief Executives, brought yet another perspective. Although the National Energy Policy of the early 1980s was divisive he asserted we need a national energy strategy now because Canada has the highest per capita energy consumption in the world. He suggested that the lack of action on new nuclear plants is partly due to our abundant energy resource which leads to a belief there is no urgency. In closing he commented that for energy matters generally and nuclear in particular there is a need for a long time perspective. Therefore decisions should be taken out of the hands of politicians.

That evening there was a reception spread throughout the exhibit area which provided considerable exposure for the many booths and displays.



The final day, Friday, was scheduled as a half day to enable delegates to travel. It began, immediately after breakfast, with an inspirational presentation by **Lyn Heward**, former President of the Cirque du Soleil. With no notes but occasional short video clips she gave a one-hour fascinating insight into the creation and operation of one of the most remarkable and successful companies in the world. She and co-founder Gilles St. Croix opened their first studio in 1992 in an old railway building in Montreal.

She offered several insights on how they keep the performers and all of those back stage fully involved. In their various shows everyone is part of a team and share responsibility. There is a nurturing environment. Performers are challenged to push their limits. Constraints, challenges and customer expectations become creative catalysts, she stated, and gave some examples from recent shows. Despite the number of shows now running around the world (currently 22) she said they always emphasize creativity and team work.

After delegates moved into the lecture room, Heward was followed by a speaker with a very different message and style. **Phillip Finck**, Associate Director for Nuclear Science and Technology at the Idaho National Laboratory in the USA, reported on the extensive program they are planning. INL is the US Department of Energy's major nuclear research centre. Fink referred to a major report entitled "Nuclear Energy Research and Development – A Road Map" and a 10-year vision plan for INL. The plan includes more work on LWRs, a major program to develop small modular reactors, work on high temperature gas-cooled reactors for process heat and continuing efforts on Gen IV concepts. The INL 10 year vision plan calls for $1.5 B investment in new or enhanced facilities.

The closing speaker was **Tim Hudak**, Leader of the Ontario Progressive Conservative Party. He reiterated his public statements in support of nuclear power. "Nuclear power has proven to be a safe, affordable, reliable and emissions-free source of electricity" he said, and a PC government will stop the dithering and delays and invest in nuclear power." He added, "I believe if we want a strong and growing economy, one that will attract investment and create private sector jobs, we must treat energy policy as economic policy and stop treating it like a social program. We need to restore the balance in our energy planning and recognize the role the sector plays in our economic prosperity and ability to compete in the global economy."

Following the closing buffet luncheon, **Denise Carpenter**, President and CEO, CNA, thanked the delegates and exhibitors and offered some summary comments.

"There are exciting developments in Canadian nuclear research and important commitments going forward such as Ontario's plans for new nuclear and refurbishments at OPG's Darlington Station", she noted. "These initiatives along with new and emerging markets for Canada's uranium will continue to engage the more than 70,000 highly-skilled people in our industry", she added.

"Nuclear is here to stay," she said in closing, "Over the past few days we've heard about the global nuclear energy expansion and as a Canadian industry, our members have the competitive edge and opportunity to play a key role in this worldwide renaissance."

The video recordings of all of the presentations are available on the CNA website.

Ben Rouben is shown manning the booth of the CNS at the CNA Conference and Trade Show2011 held in Ottawa February23 – 25, 2011.

Scenes of the Conference

A Conversation with Michael Binder

by FRED BOYD

Foreword: Michael Binder was appointed President of the Canadian Nuclear Safety Commission in January 2008, immediately after the first "isotope crisis" of December 2007 when the House of Commons overturned a ruling by the Commission, then headed by Linda Keen, to allow the restart of NRU and the production of the widely used medical diagnostic isotope molybdenum 99. Initially a temporary move from his position as Assistant Deputy Minister at Industry Canada, he remained at the CNSC and has become one of the most visible persons associated with the Canadian nuclear program. Triggered partially by the CNSC announcing its 65th anniversary, he agreed to an interview, on February 17, 2011, which turned into an extended conversation. Following are quotes from that conversation, necessarily edited for length.

We sat in a new "board" room which immediately led to some insights into his management style.

Binder: In this room, once a week, I like to meet with my management team, no minutes, no record of proceedings, just "chew the fat" for two hours. Many asked "what are we going to talk about for two hours?" I said, we'll see. If we don't need the two hours we will break. Now, I can never complete a round of the table in two hours.

I was surprised at the beginning by comments about "let's not bring that issue to the table". I feel you need to integrate the group to keep the machine running. You can not run an organization by yourself. I must rely on my people. Further, each manager needs to know of the decisions of others and many issues are not in one shop. There was a good team here when I arrived, it just needed fine-tuning. I am pleased at what we have achieved.

CNS: Why are you having a special celebration of 65 years of nuclear regulation?

Binder: I do not remember who came up with the idea but I remember asking how old we were and was surprised to learn that [combined with the former Atomic Energy Control Board] we were approaching 65 years. I understand we were the first national nuclear regulator but beyond that there is no other regulatory body in Canada that old. Also, in keeping with current views, we may be 65 but are not ready to retire.

CNS: You have been quite out spoken about misperceptions and, especially, distorted comments in the media about nuclear safety. That is unusual for a regulator.

Binder: First, our Act explicitly states that we should disseminate scientific information. When I arrived I asked what we were doing in that area. The answer was "nothing". That disturbed me. Then there was the attitude of colleagues, friends and others when I took the job, none of whom, for example, knew how much of the electricity in Ontario came from nuclear. I realized there was a problem. Further, I was appointed during a public and political controversy. We are not promoting nuclear but are not going to let outrageous statements go unanswered and will definitely defend the Commission.

Since most of the major organizations in the nuclear [power] game are owned or controlled by governments they feel constrained about speaking out. But it is disgraceful that organizations like the Canadian Nuclear Society and Canadian Nuclear Association are so silent.

CNS: Your website recently announced that CNSC is offering education materials. Did you feel that the teaching modules the CNA has developed, with the input from several CNS members, are not adequate?

Binder: Our approach is different. I particularly wished to target high school students. Something appears to happen in high school to turn young people off things nuclear because they or their teachers do not understand it. We will refer to good material from the CNA, or USNRC or elsewhere. We want to be the neutral source of scientific information. On this program, or any other matter, we are looking for feed-back. That applies particularly to anything in the social media. We are only at the beginning of this education program.

CNS: Over the later years of the AECB there were repeated questions about the President of the staff being also the Chairman of the Board, with the perception that he or she is advising him/herself. However, the Nuclear Safety Control Act continued that arrangement. What is your view on the arrangement?

Binder: Initially I had the same perception but after living with the arrangement, I have changed my opinion and feel it is working. First, as chair of the commission I do not vote, except to break a tie and that has never happened. In fact we [Commission members] try very hard to reach a consensus. That is done during our deliberations after hearing all of the evidence. It helps that all of the commission members are part-time, i.e. they have day jobs which makes them very independent.

As president I feel it is my responsibility to ensure that all of the staff material for the Commission is thorough, is packaged well, and that all of the information and recommendations are science based. Further, all of the material is publicly available. In that regard, the CNSC is the only [Canadian] regulatory body where the staff appears in public.

In the commercial world I agree that the Chair of the Board and the CEO should be separate. But that is largely for the protection of the shareholders. Our situation is quite different and I am comfortable with the arrangement we have.

CNS: Do you need the size of staff that you have?

Binder: When I arrived the CNSC was on a growth curve. I stopped that and we have remained at about 850 for the past three years. However, there are growing demands on the staff. Issues like the Bruce steam generator shipment proposal are very time consuming. We accept that it is our social responsibility to allow the public to express itself. However, that results in a major demand on the staff to respond.

In another area, when I arrived I found that there were many proposed regulatory documents that had been in a "draft" stage for many years, some for decades. I have insisted that they be updated and formalized or discarded. That has resulted in much work for the staff.

Then there is the need to clarify the licensing requirements. I was shocked when I arrived that there was a fight between CNSC and AECL staff over what was a licence condition and what was not. So, there is a program to clarify and simplify where feasible the major licences.

As a benchmark we can look at the USNRC. The USA has about five times the number of nuclear power units as Canada but NRC has about 6,000 staff and is still growing.

CNS: The Bruce steam generator shipment proposal became a major public issue. Are you still dealing with the extreme public outcry?

Binder: Yes. I consider it an education challenge. We have briefed members of parliament and we held an information session for the media. That received an excellent response. The forum was handled by senior staff, I was not involved. While there was little reporting of the event we believe that those who attended went away with a much better perspective. Hopefully that will result in less irrational material appearing in the newspapers or on television.

A parliamentary committee will be holding two days of hearing in mid March and I will be appearing. Although it is unlikely that they would try to reverse our decision to approve the shipment some of the Committee members may ask some tough questions.

CNS: I believe that NRU is to be shut down for the month of May this year. Is that correct and, if so, has there been any negative reaction from the nuclear medicine community?

Binder: Yes, it was agreed between AECL and us to shut down and conduct a thorough inspection. There are also a number of non-critical items to be done. There has been no reaction from the nuclear medicine community. Those involved have been aware of the shutdown and have made arrangements to deal with the interruption of the flow of molybdenum 99. Since the crisis of three years ago they have learned how to stretch their supplies.

CNS: It appears that you are enjoying the job.

Binder: Yes, I am. There are challenges but we have good staff and will meet them. However, on one basis there is a marked difference. When I was in the telecommunication business and surrounded by new technology all my acquaintances were interested in what I knew about the new communication gadgets. Now, no one is interested in what I am doing.

Nuclear Physics Turns 100: Thank You, Ernest Rutherford

MICHAEL ATTAS[1]

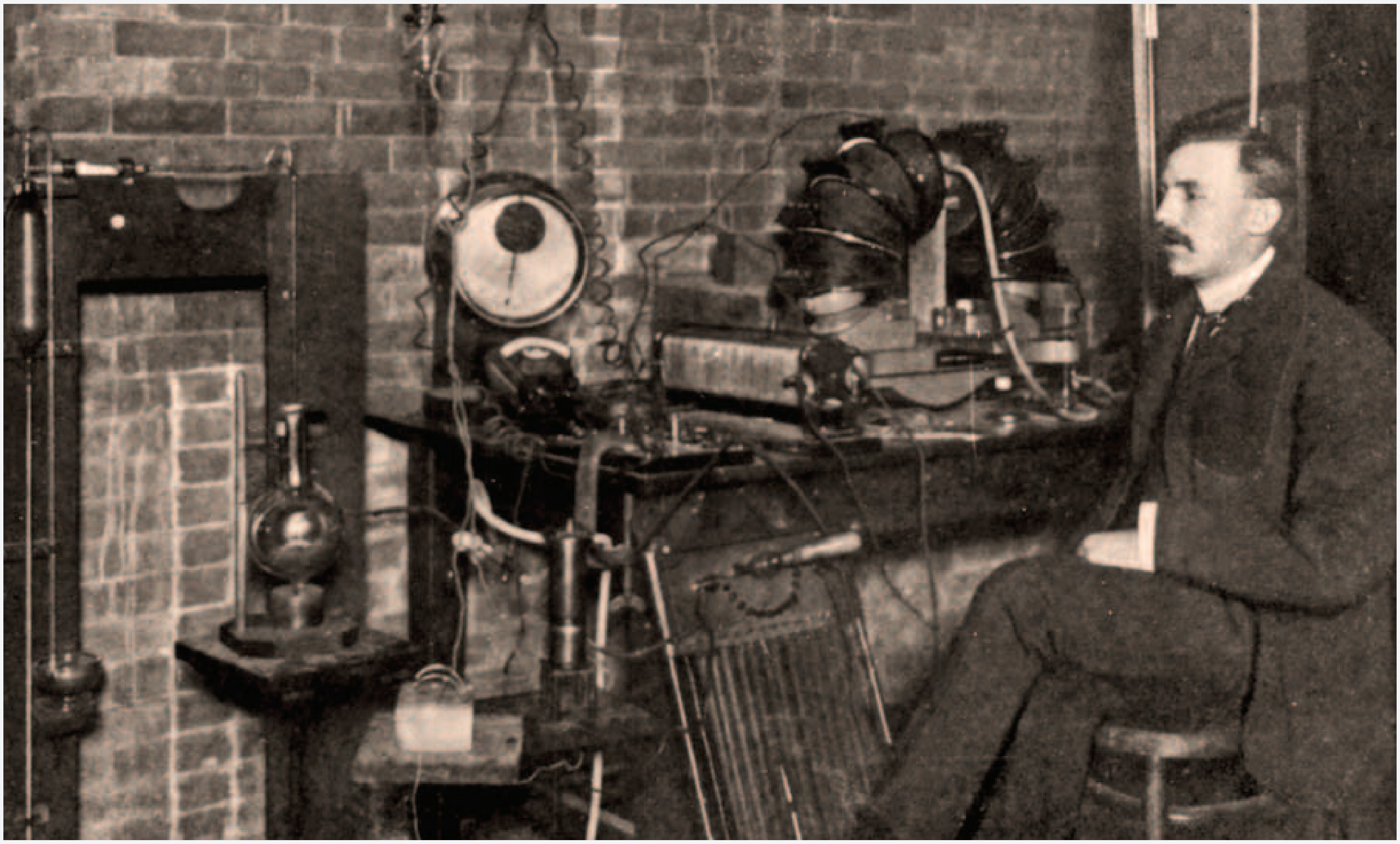


Figure 1. Rutherford at McGill, c. 1905.

Nuclear Physics is celebrating its hundredth anniversary this year, and we have Ernest Rutherford to thank. After all, without his discovery of the atomic nucleus in 1911, where would the Canadian Nuclear Society be? Let us set the stage…

Rutherford is claimed by New Zealand, Canada, and Great Britain as one of our greatest physicists. His talents for ingenious experiments, clear interpretations, and strong sense of where to look for scientific gold were already recognized at the turn of the 20th century. A New Zealander by birth, Rutherford showed great promise in physics early, earning three degrees from Canterbury College in Christchurch. He moved to England in 1895 with a scholarship to continue his studies under J.J. Thomson, director of the Cavendish laboratory of physics at Cambridge University. While there, he helped Thomson with research on the properties of cathode rays, which were generated using high voltages passed through evacuated tubes (such as all televisions and computer monitors until recently). In 1897 Thomson announced that cathode rays consisted of fast-moving negatively charged particles, smaller than atoms. Subatomic physics was born with this discovery of electrons, which earned Thomson the 1906 Nobel Prize in Physics.

Although Ernest Rutherford began his experiments with radioactivity at Cambridge, he was attracted to McGill University in 1898 by an offer of a professional Chair, a solid salary, and world-class experimental facilities in the new Macdonald Physics Building. While at McGill, he worked to establish the reality, incredible at the time, of the natural transmutation of elements in what we now call the uranium and thorium decay series. Many of the pieces of apparatus created for this work have been preserved and are on display at McGill's Rutherford Museum. Rutherford's work in Montreal earned him the Nobel Prize in Chemistry in December of 1908. By then, he had moved to the University of Manchester to continue research on properties of radioactivity. His Nobel award lecture in Stockholm, entitled "The Chemical Nature of the Alpha Particles from Radioactive Substances," described how he had proven that alpha particles were, in fact, fast moving, doubly charged helium atoms.

In Manchester, Rutherford used these energetic particles to

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probe matter. While still at McGill, he had observed that beams of alpha particles were scattered slightly when passing through air or thin mica windows. This led him, as early as 1906, to anticipate that intense electrical forces were at play within the atom. With his Manchester colleague Hans Geiger and student Ernest Marsden, the researchers saw how easily beams of both alpha and beta particles could pass through very thin metal foils. Photographs of the beam spot were slightly fuzzy, indicating that atoms in the foils deflected some particles, presumably by electrostatic forces. The researchers developed a method of counting the particles as they struck scintillating screens positioned in various locations. The alpha results proved very puzzling. Most deflections were very slight, no more than a degree or so, but very rarely (about 1 in 8000 interactions) they observed unexpectedly large deflections. Geiger and Marsden published their experimental results in 1909, without accompanying interpretation. The first explanation published was that of J. J. Thomson, who analyzed the deflection results in the context of his atomic model; namely, that the negatively charged electrons were embedded in a uniform volume of positively charged matter: the so-called plum pudding model. The rare large deflections of alpha particles would be the outcome of multiple small deflections by multiple atoms, using that model. Efforts by others to reconcile the Thomson model with the deflection experiments were partly successful, but doubts remained in Rutherford's mind.

Figure 2. Differential air calorimeter, used to measure heat given off by radium.

Ernest Rutherford pondered the implications of the deflection experiments for almost two years. In August of 1909 he travelled to Winnipeg for the annual meeting of the British Association for the Advancement of Science. Two modern physicist-historians have described this extraordinary meeting as "a significant event in the city's history that has remained largely unexplored…" Well over 1000 scientists converged on Winnipeg, making presentations in Wesley College (now the University of Winnipeg) and the Walker Theatre (now the Burton Cummings Theatre). As President of the Mathematical and Physical Section of the BAAS, Rutherford lectured on the solid evidence to date for the physical existence of atoms. He hinted at the implications of the scattering results by stating that "the atom is the seat of an intense electric field, for otherwise it would be impossible to change the direction of the particle in passing over such a minute distance as the diameter of a molecule." But he hadn't yet realized the consequences of that statement.

Rutherford had realized the Thomson model of the atom could not account for the observed scattering results. The probability of each interaction was so small that multiple interactions, especially in a thin metal foil, were practically impossible. That meant that the rare large-angle deflections could only result from an electric charge concentrated in a very small volume, essentially a point, within the atom.

In the spring of 1911 Rutherford proposed his own theory of the atomic nucleus. He showed mathematically how the observed alpha deflection angles and probabilities were consistent with alpha particles following hyperbolic paths as they were electrostatically deflected by a massive, strongly charged nucleus. The reasoning in his now-classic paper uses two basic principles of physics in a clear exposition of this electrostatic interaction: conservation of energy and conservation of momentum. Supposing the alpha particle is aimed directly at the positively charged centre of the atom, its kinetic energy is gradually converted to potential energy as it approaches and slows down. The inverse-square relationship between distance and electrostatic force determines the minimum distance of approach, which turns out to be very much smaller than the diameter of an atom. Subsequent electrostatic repulsion of the alpha particle returns most of the energy to kinetic form. The transfer of energy to the target atom is a function of that atom's mass, being lowest for gold and highest for aluminum (among the metals used in the experiments), in accordance with the law of conservation of momentum.

Rutherford later expressed his initial amazement at the occasional large deflections with the famous words, "It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you. On consideration I realized that this scattering backwards must be the result of a single collision, and when I made calculations I saw that it was impossible to get anything of that order of magnitude unless you took a system in which the greatest part of the mass of the atom was concentrated in a minute nucleus."

Today we refer to electrostatic interactions between charged particles as Coulomb interactions, and the resistance of the nucleus to absorb an impinging charged particle as the Coulomb barrier. In this way we honour an earlier scientist. But physicists honour Rutherford in another way: the analytical technique of scanning a surface with an ion beam and then measuring the energy of the scattered ions is universally known as Rutherford backscattering. As Rutherford showed, ions scattered from light nuclei lose more energy than those scattered from heavy nuclei. Capturing the scattered ions and measuring their energies can therefore generate a picture of the distribution of elements in a material.

With Rutherford's nuclear theory in place, and quickly accepted, nuclear physics began in earnest. In fact 1911 was a seminal year for nuclear chemistry as well. That anniversary will be marked in an article planned for a later issue of the Bulletin.

Sources:

John Campbell, *Rutherford, Scientist Supreme* (1999) includes many personal details as well as accurate descriptions of Rutherford's scientific accomplishments.

G.K.T. Conn and H.D. Turner, *The Evolution of the Nuclear Atom* (1965) reproduces most of the key papers from this period in whole or in part, with commentary.

Stephen Klassen and Sarah Dietrich, "Physics comes to Winnipeg: the 1909 meeting of the British Association for the Advancement of Science," *Interchange* 41 (2010), pp. 407-423, puts the meeting in its scientific and cultural context, with quotations from Rutherford's address, which was published in *Science*, New Series, 30, No. 766 (September 3, 1909), pp. 289-302.

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Figures (courtesy of Rutherford Museum, McGill University)

The Rutherford Documentary

By JOHN CAMPBELL, University of Canterbury, Christchurch New Zealand

[Ed. Note: Dr. Campbell is a physicist and author of Rutherford - Scientist Supreme, Rutherford's Ancestors, owner of the Rutherford website www.rutherford.org.nz and Producer of the documentary – Rutherford]

This documentary, for which the Canadian Nuclear Society is the sole Canadian Principal Patron, nears completion. It is three one-hour episodes filmed in high-definition digital video. It was to have been completed earlier with the prime delay being early lack of finance and my complete intransigence to allow it to be compressed into one episode. There is only once chance to tell his story so it should be done well and fully.

All episodes are locked off. That just leaves blanks of from 2 to 9 seconds where voice-over is telling a long story short on illustrations, or to hide the jump where an interviewee has been edited down. The final fill-in filming with actors was due to be done last year but the September earthquake had the wardrobe supplier unavailable in the damaged region. A long run of ill-health with the director and her family saw that filming re-scheduled for two weekends starting Feb 26th. The catastrophic aftershock of Tuesday Feb 22nd brought down the two brick buildings it was to be filmed in and the wardrobe supplier is red-stickered so unavailable. This weekend the wardrobe mistress will travel to Dunedin to source the costumes. Filming is now rescheduled to start on April 15th, in a brick building well away from the earthquake zone.

Jeremy Whitlock (CNS Member), seated, drove through a blizzard for his interview for the documentary.

Such are the vagaries of film-making. April was always our hard deadline. Apart from 2011 being the centennial of the Rutherford nuclear atom, this version will be submitted for entry into the documentary category of film festivals and April is the entry deadline. If accepted, then the director is given money to edit to a shorter version for film festivals.

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About the Rutherford Website

I set up www.rutherford.org.nz in 2001 as a compendium of information about Rutherford that was too detailed for my book. The Canadian Nuclear Society was added as one of the patrons of the site due to its immediate support for the Rutherford documentary.

I draw members' attention in particular to the honouring Rutherford section. I will add any scheme missing from this section (Awards, medals, Streets, etc.). Note the Odds and Ends section, which amongst others lists each street named in his honour, with details, where know, of how it came to be given the name and even the council minute reference to when it was conferred.

There is also a sub-section "Not So" for those things with Rutherford in the name but which are named for other Rutherfords.

Update on Radioisotopes and Nuclear Reactors

by NICHOLAS SION

A nuclear renaissance is apparent in several countries. The increasing usage of radioisotopes for medical and industrial applications is of worldwide significance as well as establishing a reliable supply for them. So is the insatiable demand for clean energy.

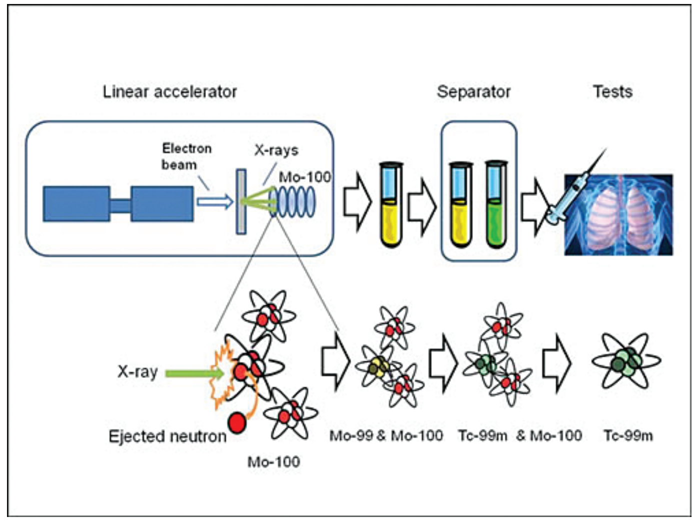
Radioisotopes

In January 2011 the Canadian Light Source (CLS) Facility in Saskatoon, received a \$12 M fund to purchase and operate a 4m long Linac for the production and study of isotopes used in nuclear medicine. This is part of the \$35 million Non-reactor-based Isotope Supply Contribution Program (NISP) to promote research into alternative methods for producing medical isotopes to address the shortage of technetium-99m (Tc-99m). The CLS is a 2.9 GeV synchrotron particle accelerator opened on October 22 2004 at a cost of C\$173.5 M.

In a Linear accelerator, charged particles (electrons or protons) are alternately attracted and repelled by a series of plates by pushing and then pulling them along gaining energy. Alternating electric fields can accelerate particles to velocities to almost the speed of light. The high energy electrons collide with a metal filter, producing extremely intense X- rays. The intense electron beam then hits Mo-100 and knocks off a neutron to produce Mo-99 that begins to decay into Tc-99m. A chemical separator extracts the Mo-99 for therapeutic use. After the Mo-99 has decayed, the remaining Mo-100 in the solution is recovered and recycled into additional targets. It is expected that 20%-30% of Canada's requirements can be met.

The process is called photo-neutron reaction and was demonstrated by scientists at NRC, the National Research Council Canada. The method is referenced in a paper titled "Which Way Radioisotopes" (CNS Bulletin March 2011, Vol.32 No. 1).

The NRC outlined another photo-neutron method of producing Tc-99m using the Vikers electron Linac, a low power variable energy machine to study the process. By scaling up to a single 100 kW machine at a site in Saskatoon, enough Tc-99m can be produced to satisfy Canada's needs of more than 5000 scans per day.



The University of Alberta estimated that current world demand for Mo-99/Tc-99m is at about 70000Ci of Mo-99 production per week. They have produced Tc-99m directly with a medical cyclotron. So far it is still experimental but they were able to build models to study the convective heat transfer and thus be able to predict the target plate temperature, as well as be able to explore target cooling even prior to its construction.

On the issue of nuclear non-proliferation and safeguards, AECL, Atomic Energy of Canada Ltd. (C. Jewitt et al.) considered the use of a near surface detector for measuring anti-neutrinos emitted via β (beta) decay. A typical reactor emits some 10^{20} neutrinos/s and their production rate is proportional to reactor power and isotopic content. Inverse beta decay enhances the sensitivity. Neutrinos cannot be shielded and therefore cannot be hidden. The IAEA, International Atomic Energy Agency is to develop the containment and surveillance methods. This methodology can be used to measure and monitor the power of the reactor core, or to detect for underground reactors in rogue countries.

Other means to produce isotopes for diagnostic imaging via

Technique of Anti Neutrino Detection		
$\nu_e + p \rightarrow e^+ + n$ [neutrino + proton → position + neutron]		
	U-235	Pu-239
Energy per fission	201.7	210.0
Mean ν energy	2.94	2.84
ν per fission (1.8 MeV)	1.92	1.45

accelerators and cyclotrons are found in Technical Reports #465 and 468 of the IAEA. About 90% of nuclear medicine involves diagnostic imaging. Cyclotrons have been used to generate F-18, C-11 positron emitters for radio tracers in PET and SPECT scans; Tc-99m and I-131 for therapy. Lu-177 is therapeutically similar to I-131.

South Africa's isotope reactor SAFARI had converted its targets from HEU (High Enriched Uranium) to LEU (Low Enriched Uranium) with the assistance of the US and by July 2010 had gained approval for isotope shipments to the US. But the NNSA (National Nuclear Security Administration, US Dept. of Energy) aims to establish a reliable US domestic supply by 2013 and would support the private sector in advanced research (1) LEU Target technology; (2) Accelerator technology; (3) Advancing the LEU solution in reactor technology; (4) Neutron capture technology. The NNSA asked ORNL (Oak Ridge National Labs) and ANL (Argonne National Labs) to demonstrate the production of Mo-99 through the reaction Mo-100 (γ, η) Mo-99. The threshold for the reaction was at 9MeV. The peak cross-section was 150 mb (millibarns) at 14.5 MeV. High energy photons were created from a high power electron beam through bremsstrahlung. From this experiment, the lessons learned were: a) the power dissipation from the target was not uniform and was mainly from the target front; b) the beam position, its profile and its energy are crucial; c) the cooling water electrolyzed causing corrosion in the target Inconel shell. In a low power experiment using natural molybdenum, the yield was only 613 μCi of Mo-99. This methodology is still experimental.

Recent developments at the Oak Ridge National Labs (ORNL) were to use alpha emitters (Ac-227, Bi-213, and Ra-223) and Beta emitters (W-188, Lu-177). For the heavier elements, Cf-252 and Bk-249 a higher flux is needed. ORNL, in conjunction with Russian scientist Yuri Oganessian, had synthesized a new super heavy element of Z-117, still unnamed by colliding calcium Ca-48 (20 protons, 48 neutrons) with berkelium Bk-249 (97p, 152n). For such super heavy elements, the $\tau½$ (half life) is only a few msec. Its usefulness is yet to be determined.

The DOE-BES (Dept. of Energy- Basic Energy Sciences) has a mission to produce and distribute radioisotopes, maintain the infrastructure, and conduct R&D on new and improved techniques. It recommends a sustained research program, work force training, and investment in α (alpha) emitters such as Actinium-225 (Ac-225) and Astatine-211. (As-211). They have a biological mean penetrating range of 3 cells (20 μm tumor cells) with potential applications in micro metastases, lymphoma, leukemia, and ovarian cancers.

With the intended strategy of developing a US supply of Mo-99 using LEU, Argonne National Labs are experimenting with LEU foil targets in a flux of $2x10^{14}$ n/cm^2-s. More investigations are needed on target methodology without losing target structural integrity, and to establish its foil mass. To satisfy the US demand of 6000 6-day Ci/week, Sandia National Labs is considering a Target Fuelled Isotope Reactor (TFIR), a 1-2 MW light water reactor of proven technology using a Beryllium (Be) or BeO reflector with graphite as a possible option. B_4C or Co would be the control rods. The cost is estimated at around $47 M. There would be a 7 day target irradiation at 10 kW, plus 2 days for processing and shipping. Targets are designed as pencil tubes of ¼" zircaloy tubes some 30-40 cm long, housing LEU uranium oxide. As per Table, processing 110 targets per week is estimated to be adequate for US demand. This is still in early stages.

% of US Demand	Targets Processed per week
10	11
20	22
50	55
100	110

A feasibility study at Oak Ridge National Labs considered utilizing neutron capture to produce Mo-99 from natural molybdenum that is composed of multiple isotopes. In a thermal flux of <0.4 keV on 13 g of molybdenum, a yield of 2300 Ci/week is attainable with a specific activity of 17 Ci/g of Mo-99, and 0.0247 Ci/g of Nb-92m. But any impurities became activation products such as converting Co-59 to Co-60. This method is still experimental.

A novel concept was developed at Argonne National Labs of using a compact accelerator driven neutron multiplier called CAMI to produce Mo-99. CAMI is a subcritical assembly designed to be an efficient Mo generator and comprises an array of LEU plates forming the subcritical reactor and has a K_{eff} of ~0.95. CAMI is driven by a 200MeV proton beam and has a multiplication factor of ~32 n/p producing about 13 fissions/proton, and can use 300 g of U-235. Production rate is expected to be at 6000 6-day Ci with a burn up rate 4.4% and weekly core replacement. A Patent is pending.

An experiment with a Linac to produce Mo-99 from Mo-100 targets was carried out at Rensselaer Polytechnic Institute using 30 MeV electrons to cause activation. Below 20 MeV, the electron beam would be benign. After 3.5 day irradiation at 30 kW power, the output was 140 Ci.

The ATR (Advanced Test Reactor) of the Idaho National Labs has a flux of $1x10^{15}$ n/cm^2-s and is used for test purposes on Cesium Cs-131, and Gadolinium Gd-153. Other isotopes of interest are Sr-89, W-188, Pu-238, Ir-192 and Pr-147. They can produce Mo-99 but from HEU targets, but the ATR has no hot cells.

The BR2 medical reactor in Belgium has an output power of 50-100 MW, a flux of $2.5x10^{14}$ n/cm^2-s and an operating cycle of 21-28 days. The moderator is a Be matrix + light water. Its primary function is to produce Mo-99 and the secondary function is Ir-192. At the end of its operating life it will be replaced by an accelerator driven MURR (Missouri University Research Reactor) type.

Reactor production at MURR (Missouri University Research Reactor) is on production of beta emitting Yttrium-90 (Y-90) for liver cancer, bone and bone marrow cancers, and for multiple myeloma (Kahler's disease). For the production of Mo-99 (γ, η), 98% enriched Mo metal powder is used and the output is 7 Ci/g. hence MURR assumes that Mo-99 can be produced in commercial quantities.

On the therapeutic applications in nuclear medicine, Kaohsiyung Medical University highlighted the concerns of post-surgical thyroid cancer undergoing I-131 ablation therapy. The dose determination of I-131 was based on a) Post surgical thyroid remnant, b) Patient kidney function. c) The sodium-iodine symporter expression (symporter is a protein membrane involved in moving ions across a cell membrane in the same direction). d) The recombinant human thyroid-stimulating hormone (rhTSH) in use. The effective whole body $\tau½$ was 25.2h ± 12.1h on four tested patients.

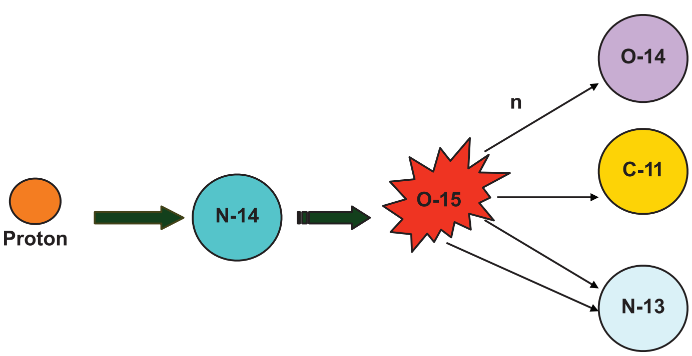
Massachusetts General Hospital uses cyclotrons in medical PET imaging. In 1965 there were only 2-3 cyclotrons. In 2010 that grew to about 300 cyclotrons. Proton beams of 19 MeV are at 120 µA, and produce F-18 at 10 Ci.

Sloan-Kettering Cancer Centre is focusing on positron emitting nuclides (C-11, N-13, O-15, F-18, etc.). About 23% of disintegrations result in positron emissions while the gamma ray abundance is > 90% per disintegration.

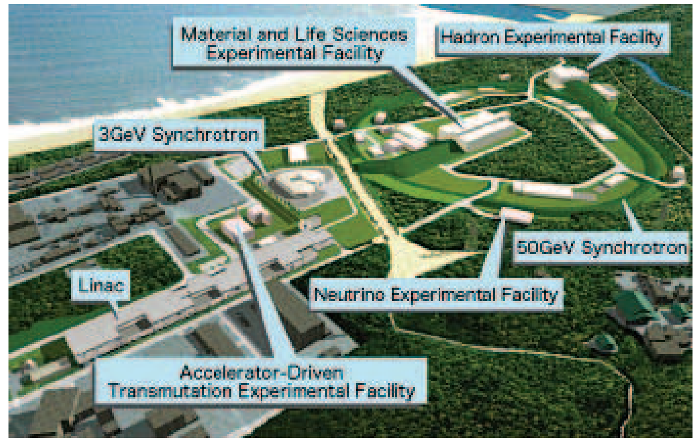
MURR (Missouri University Research Reactor also produced C-11 with a biomedical cyclotron as shown in the diagram.

Nuclear Power Reactors

There are 437 operating nuclear reactors world-wide with 48 of them in the US; and 61 reactors are under construction. China has 30 operating reactors with 25 planned. China's plan is to have 42 operating by 2019 and is aggressively securing uranium supplies. India has 19 operating and 13 under construction. The amount of uranium consumed in 2010 is 170 M lbs. the estimated requirements by 2030 are estimated to be 325 M lbs. The present cost of uranium is $100/lb. New suppliers are Khazakstan, Namibia, and Australia. How much uranium is available? It is more abundant than silver and the world inventory is estimated to be 16 billion lbs. about a 100 years supply. Cameco who supplied the above data, plans to double production over the next few years and currently they have some 200 job positions open. Ref. 1.



The US Nuclear Energy Institute gave an update where US nuclear reactors produce 20% of electrical generation. Industry is now investing in reactor upgrades and their replacements. Some 41 reactors will run beyond 60 years of operation. On licensing, 22 reactors are under active review at NRC with their licenses expected to be granted in 2011-2012. Another 4-8 reactors would be in operation in 2016-2018. Public support for nuclear is growing with polls showing 74% in favour of nuclear energy, 70% in favour of building new reactors, with 77% acceptance of building them at the nearest site. The DOE (Department of Energy) and EPRI (Electrical Power Research Institute) are co-operating on reactor extended operation.

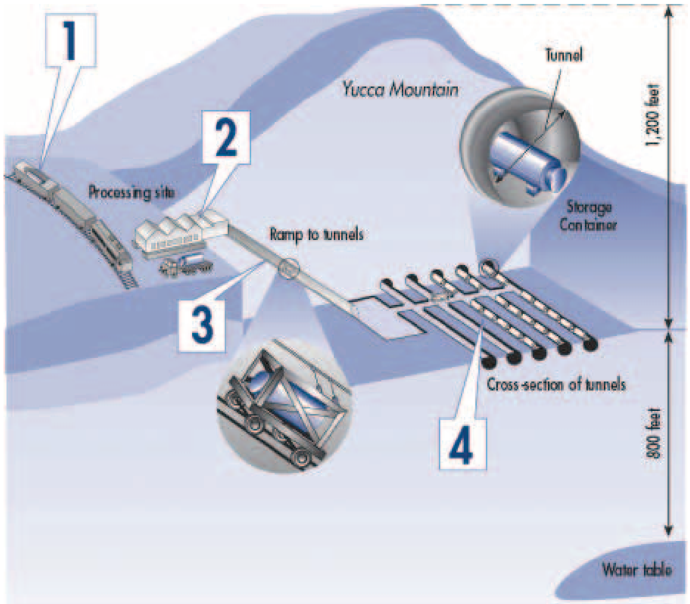


Japan's nuclear renaissance is in full progress with 50 operating nuclear reactors and with another 10 under construction, all of them PWRs. Their Tokai Reprocessing Plant has already processed 1140 tons of Uranium fuel and 29 tons of MOX (mixed oxide, a blend of Plutonium-Uranium). Their Monju fast breeder sodium cooled reactor (280 MW), MOX fuelled, was restarted and reached criticality on May 8, 2010. The HIMAC (Heavy Ion Medical Accelerator in Chiba) synchrotron is a facility for cancer treatment where 5500 patients were treated for bone and soft tissue cancer. Alpha ions of 6 MeV/n and a beam intensity of 600 µA are used and are more suitable for cancer treatment due to high dose localization and high LET (Linear Energy Transfer) characteristics. Other research facilities were enumerated viz. J-PARC (Japan Proton Accelerator Research Complex). Japan's Superconducting Ring Cyclotron at Riken is a high beam intensity accelerator that can propel heavy ions to about 70% the speed of light. Ref. 2.

Russia is promoting a large scale growth in nuclear energy in collaboration with the US. The intent is to accomplish safety and security, prevent proliferation. The Russian focus is towards smaller power reactors, factory built, with fewer operating staff, and cater towards cradle-to-grave life cycle of building, fuelling, operating, and decommissioning. Reactors will have a life span of 60 years. Thorium-Uranium fuels and nano modified steels (Cr-Mo-V) would be used. Future development would be for the Arctic. Floating power plants are intended for Chukotka at the north east corner of Siberia. Ref. 3.

In France and in 15 other countries, there are 48 AREVA designed reactors supplying 30% of Europe's electrical needs, 4 are under construction with another 45 planned to keep up with demand. Opposition to nuclear has decreased from 50% in 2008 to 24% in 2010. The projected energy mix for 2030 for Europe is 30% renewable (solar, wind and water), 44% nuclear, and 28% fossil. To-date nuclear energy has the best performance compared to other technologies with a more stable price than oil or coal, and solar is the most expensive. Therefore nuclear should play a significant part in the energy mix. Ref. 4.

South Korea now has 12 reactors in operation with a projection of about another 100 SMRs [Small Modular Reactors] by 2050. Licensing time is being reduced from four years to two.



The Yucca Mountain Waste Repository Project seems to be in limbo due to much US politicianing. It was intended for storing 77,000 tons of spent radioactive reactor fuel rods and high level nuclear waste, and waste from America's military nuclear programs, Plutonium-239 and including Sarin, a highly toxic liquid poison labeled by the UN as a weapon of mass destruction. [Note: one millionth of a gram would cause cancer if breathed in, or enters the body by way of a cut or other openings in the skin]. Initially, the DOE had stated that the Yucca Mountain area might expect an earthquake about every 10,000 years. To their chagrin, the area was rocked by an earthquake of

5.0 Richter Scale and was followed by another of 4.4 magnitude on 4 June 2002; though with little damage. President Obama has cut the Project funding but his ruling is disputed by the NRC (National Research Council of USA).

References

Some of the data were presented at the American Nuclear Society Winter Meeting, Las Vegas, November 7-12, 2010.

1. Cameco Canada, President Tim Gitzel
2. Tokyo Institute of Technology, Professor Emeritus Yoichi Fuji-ie.
3. Kurchatov Institute, Russian Research Center, Moscow, President Evgeny P. Velikhov .
4. AREVA, Senior V.P. Jean-Pol Poncelet.

Which Way Radioisotopes?

by NICHOLAS SION

Introduction

The cancellation of the MAPLES program and the impending retirement of the NRU reactor in 2016 (all utilizing Highly Enriched Uranium HEU for their targets) plus the rigours of non proliferation treaties, has created an increasingly short supply of radioisotopes. Alternate pathways must be found, even created, to maintain the supply of radioisotopes i.e. Mo-99 (decaying into Tc-99m) as well as to provide the several other types of isotopes used in nuclear medicine in order to maintain Canada's leadership in science, innovation and public health. Medical isotopes help locate cancers with precision, therapeutically treat cancers, and provide physicians the diagnostic tools to save lives.

Why Do We Need and Use Tc-99m?

The main advantages of using Tc-99m therapeutically can be summed up:

- It has particular characteristics in that it is readily absorbed by the body organs and easily attaches to biological compounds making it ideal as a tracer. It emits gamma at 140.5 keV as a single energy that is not accompanied by beta emission. The gamma is easily detected by low level gamma cameras allowing greater precision in the alignment of the detectors for enhanced imaging in the absence of beta.
- Its physical half life and its biological half life are very short and rapidly clear the body after an imaging procedure, Table 1. The patient then, does not linger with a residual radiation dose, and hence its dominant role in diagnostic imaging.

Table 1 Physical and Biological Half Life of Technetium

Isotope	Half Life τ½ in Days		
	τ½ physical	τ½ biological	τ½effective
^{99m}Tc	0.25	1	0.20

The Technetium isotope Tc-99m has a complex decay path-

Table 2 World Suppliers of Isotopes

Reactor	Country	Target Enrichment	% of World Supply	Distributor	Remarks Operating till ( )
NRU	Canada	92%	40 %	MDS Nordion, Canada	National Research Universal [NRU] reactor (2016)
Petten	Nederland	92%	30 %	Covidien, Holland	High Flux Reactor [HFR] (2016 ?)
BR2	Belgium	92%	10 %	IRE, Belgium	Belgian Reactor #2 (2016 – 2020)
Osiris	France	92%	5 %	IRE, Belgium	(2015) then replaced by the Jules Horowitz reactor.
Safari	South Africa	Was 50%	First commercial shipment to USA Sept '10	NTP, South Africa	Has converted to using LEU targets. (2022), to be replaced by a Multipurpose reactor.
OPAL	Australia	< 20%	3-5 % but currently for domestic demand	Locally	Open Pool Australian Lightwater reactor. Processing facility and licensing yet to be completed.

way. Its gamma emitting $\tau^{½}$ is 6.03h, which is quite long for electromagnetic decay (typically 10-16s). Such a long half life in an excited state is labeled metastable and hence the 'm' in the designation Tc-99m.

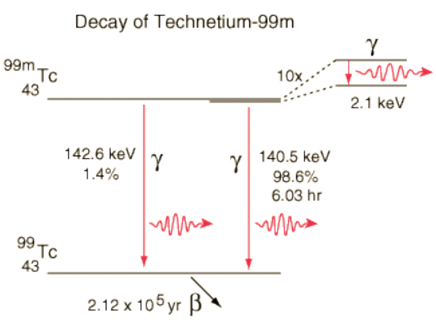


Figure 1 Decay Pathway of Technetium

Fig. 1 shows the decay pathway where the dominant emitted gamma ray is at 140.5 keV, and that is used in imaging. For medical purposes, the Tc-99m is administered in the form of Sodium Pertechnetate NaTcO4, where the pertechnetate anion [TcO4]-1 is the active ingredient.

How Much Technetium-99m is Needed?

About 40 million nuclear medicine procedures are performed world-wide annually, of which some 80% of them use Technetium-99m. But about 70% of the worldwide supply of Mo-99 is produced by two ageing nuclear reactors: the Canadian NRU reactor at Chalk River, Ontario, which has been operating since 1957, and HFR Petten in the Netherlands, operational since 1961. The balance of world supply is made up from three other reactors viz. OSIRIS in France, BR-2 in Belgium and SAFARI-1 in South Africa operating since the 1960's. Soon to come on stream is OPAL in Australia. These are shown in Table 2.

World demand is currently running at some 12000 6-day Ci/week with the United States topping the list with a demand of 6000 6-day Ci/week and Canada at slightly above 500 6-day Ci/week. A 6 day Curie is the amount of material that will yield one Curie after 6 days of radioactive decay.

The Production of Tc-99m

Tc-99m is the daughter decay product of Mo-99 ($\tau½ = 65.94$h) that is currently produced in quantities by neutron irradiation of Highly Enriched Uranium (HEU) U-235 at >90% targets in a nuclear reactor for about a week. The resulting Mo-99 is a fission product created within the target that is then dissolved in acid to extract the Mo-99. This leaves radioactive waste products that can become a target for interception and a security issue. Since Canada is a signatory to the Non-Proliferation pacts, and therefore has no Uranium enrichment facility, the HEU targets required are imported from the USA. And here is the "rub". The US is no longer supportive of this arrangement and has curtailed the exportation of the weapon grade Uranium under the new treaty promulgated in Prague 2009. The US National Regulatory Commission requires that targets enriched to less than 20% U-235 be used for Mo-99 production. This affects the yield of Mo-99-Tc-99m process, and hence the cost.

What are the options?

With the constraints on using HEU to produce the Mo-99m isotope, alternative pathways are considered here to alleviate the isotope shortage. There are the classical ways to produce Mo-99, enumerated in [Ref. 1] that are known to scholars in this field and are briefly described, plus other options that do not use HEU.

Neutron-Capture Process [^{98}Mo (η, γ) ^{99}Mo]

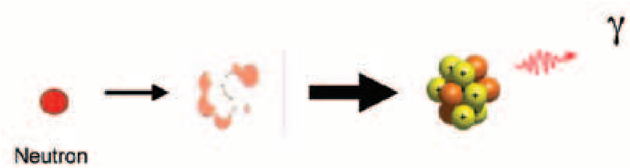


Figure 2 Neutron Capture Process

The process involves irradiating a Mo-98 target in an intense neutron thermal flux of $3.0x10^{14}$ n/s^1 /cm^2 (this is similar to the thermal neutron flux within a CANDU reactor, but better yields are with a flux in the range of 10^{15} n/s^1 /cm^2). The Mo-98, captures the neutron to transmute into Mo-99m in a (η,γ) reaction with the emission of gamma radiation, Fig. 2. The yield from this process depends mainly on the cross section area of the Mo-98 (0.13 barns or 0.13 x 10^{-24} cm^2).

In this process there is virtually no waste, but there are major disadvantages in that the Specific Activity of Mo-99 is low leading to problems in the separation of Mo-98 from Mo-99 plus a modification of generator technique of separating Tc-99m from the Mo-99. The output is about 2.2 six-day curies/g. [Ref. 1]

At the ANS [American Nuclear Society] Winter 2010 Meeting, GE-Hitachi Nuclear discussed the generation of Mo-99 by neutron absorption by direct insertion of Mo-99 into a reactor. An automated insertion mechanism would be required, which their reactors do not have. [Ref. 2]. However, such a plausible idea has already been outlined by J. Cuttler [Ref. 3]. The CANDU fission reactors already have an automated insertion mechanism. The issues here are whether the reactor owners would be agreeable, economics, the building of a processing facility on site (probably adjacent to the used fuel bay), staff training and safety and licensing.

Photo-Neutron Process [^{100}Mo (γ,η) ^{99}Mo]

A high powered electron accelerator irradiates a high Z (atomic number) target, interacts and loses energy. The resulting bremsstralung high energy (intensity) photons knock off a neutron from the Mo-100 to produce Mo-99. Figure. 3.

To produce quantities of isotopes by this method requires a scaled-up accelerator version of what is in current operation. The amount of required energy is high and cooling of the targets would be challenging. But the specific activity output is higher and is in the order of 21 six-day curies/g [Ref. 1].

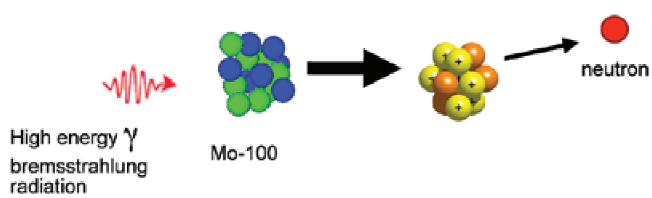


Figure 3 Photo-Neutron Process

This method is also being pursued at Los Alamos Nuclear Labs and by Argonne Nuclear Labs [Ref. 4] where the threshold for the reaction was at 9 MeV and the peak cross-section was 150 mb at 14.5 MeV. The result was a mix Mo-100 and Mo-99 with the Mo-99 having a low specific activity. It is still in the experimental stages.

Theoretical calculations and the test results on the production of Mo-99 were done at the Rensselaer Polytechnic Institute [Ref. 5], agreed within experimental error. A 30 MeV electron beam was used on a Mo-100 target.

Neutron Fission process [^{235}U (η,F) ^{99}Mo]

The process in Fig. 4 requires a U-235 target, preferably enriched, to be irradiated by thermal neutrons in a high neutron flux. This method is in current use. The yield of ~6% Mo-99 is a fission product that is separated from the U-235 leaving a residue in the waste stream.

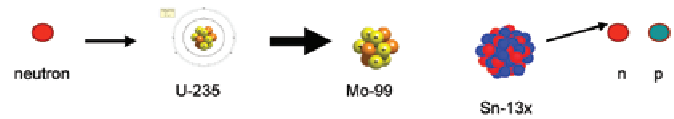


Figure 4 Neutron Fission Process

Photo-Fission Process [^{238}U (γ,F) ^{99}Mo]

This method, Fig. 5, is being explored by TRIUMF [Ref.1] as a possibility to produce Mo-99m without a reactor by using only LEU targets. An intense 50 MeV electron beam from a powerful cyclotron would irradiate an LEU, or even natural U-238 target to produce Mo-99. This high energy beam would split the uranium nuclei with the same distribution of end products including Mo-99 as in a reactor based neutron-fission U-235 target.

Figure 5 Photo Fission Process

This is not yet available and is yet to be designed. Such a method can also be used to produce other isotopes viz. Xe, Sn, Sb, Te.

There are technical challenges to this method in using a very high powered electron beam to impinge on a relatively small target. However this is a photo-fission process where even natural or depleted uranium can be used as the target material, thus much reducing the security and transportation issues, and no reliance on a reactor either. The U-238 photo-fission process offers the same fractional yield of Mo-99 as a neutron-induced fission of U-235.

The advantages are that accelerators can be turned on-off at will, and their licensing is a more straightforward procedure. They are comparatively inexpensive to decommission at end-of-life. On the downside, an accelerator-based production facility will require substantially more electrical power than a reactor-based facility.

Cyclotron Method to Generate ^{99m}Tc [^{100}Mo (p,2n) ^{99m}Tc]

A direct means of generating Mo-99 from Mo-100 using a medical cyclotron and high energy protons was done at the University of Alberta to generate secondary neutrons that, in turn, induce uranium to fission as in a reactor, Fig. 6. The method is complex and expensive. Target design and heat transfer need attention. [Ref. 6].

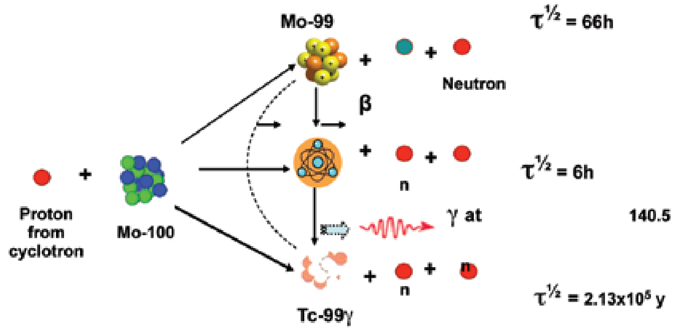


Figure 6 Cyclotron Method to Produce Tc-99m

Replacing the NRU

The projected closure of the NRU (National Research Universal) reactor by 2016 is of concern not just to nuclear medicine but to science and industry in general. The NRU reactor began operating in 1957 as a multipurpose facility producing isotopes that have been shipped to some 80 countries, to 1400 hospitals for about 36000 procedures per day. The NRU has also produced isotopes for non medical purposes and has been the neutron source for the Canadian Neutron Beam Centre. It has also been the test bed for AECL (Atomic Energy of Canada Ltd) to develop fuels for CANDU reactors. Due to its significance the Report on Medical Isotope Production [Ref. 7] also recommended a replacement for the NRU such as a Neutron Scattering facility/reactor, recognizing the importance for Canada to have a Multi Purpose Research Reactor and/or a neutron beam, or a neutron scattering facility for analytical purposes, materials research and isotope production.

The Case for a Neutron Scattering Facility or a Multipurpose Reactor

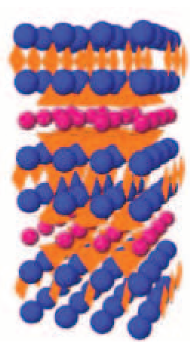


Figure 7 Atomic model of a superconducting ceramic, yttrium-barium-copper oxide, whose oxygen positions were determined

Neutron scattering provides useful information about the positions, motions, and magnetic properties of materials where a neutron flux of >10^{15} n.cm^{-2}.s is required. When a neutron beam strikes a sample, some neutrons will interact with the nuclei and bounce at an angle whilst the others just pass through the material. This diffraction or neutron scattering is measured by detectors. The intensity, diffraction angle and energy levels provide detail of superconducting materials Fig. 7. Neutron scattering can locate moisture in fighter jet wings, signs of microscopic cracking and early corrosion. A neutron acts like a tiny bar magnet. Beams of polarized neutrons whose moments all point in the same direction can probe properties of magnetic materials like on the stripe of a credit card or in compact discs. Neutron scattering is also used in nanotechnology.

In medical applications where a neutron flux of about 6x10^{14} n.cm^{-2}.s is required, the superior ability of neutrons to precisely locate hydrogen atoms in macromolecular structures is crucial. Complex fluids such as blood, and soft tissue such as body cells, membranes composed of hydrogen and other light atoms, the neutron scattering used in high intensity neutron beams are ideal for studying small samples at the molecular level, particularly in the development of time-released, drug-delivery systems that target specific parts of the body.

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Modelling of Aircrew Radiation Exposure During Solar Particle Events

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Abstract

A transport code analysis using the Monte Carlo N-Particle eXtended code, MCNPX, has been used to propagate an extrapolated particle spectrum based on satellite measurements through the atmosphere to estimate radiation exposure during solar storms at high altitudes. Neutron monitor count rate data from stations around the world were used to benchmark the model calculations during a Ground Level Event. A comparison was made between the model predictions and actual flight measurements taken with various types of instruments used to measure the mixed radiation field during GLE 60. A computer-code has been developed to implement the model for routine analysis.

1. Introduction

In 1990, the International Commission on Radiological Protection (ICRP) recognized the occupational exposure of aircrew to cosmic radiation[1]. In Canada, a Commercial and Business Aviation Advisory Circular (CBAAC) was issued by Transport Canada suggesting that action should be taken to manage such exposure[2]. In anticipation of possible regulations on exposure of Canadian-based aircrew in the near future, an extensive study was carried out at the Royal Military College of Canada (RMC) to measure the radiation exposure during flights.

The radiation exposure to aircrew is a result of a complex mixed-radiation field resulting from *Galactic Cosmic Rays* (GCRs) and *Solar Energetic Particles* (SEPs). Supernova explosions and active galactic nuclei are responsible for GCRs which consist of 90% protons, 9% alpha particles, and 1% heavy nuclei[3]. While they have a fairly constant fluence rate, their interaction with the magnetic field of the Earth varies throughout the solar cycles, which has a period of approximately 11 years. The radiation dose absorbed on airplanes due to GCR has been thoroughly studied and the empirically-based PCAire code developed at RMC can predict the radiation dose with good accuracy.

SEPs are highly sporadic events that are associated with solar flares and coronal mass ejections. While contributing less than 1% to the overall career exposure, this type of exposure may be of concern to certain aircrew members, such as pregnant flight crew, for which the annual effective dose is limited to 1 mSv over the remainder of the pregnancy[4]. The composition of SEPs is very similar to GCRs, in that they consist of mostly protons, some alpha particles and a few heavy nuclei, but with a softer energy spectrum.

To estimate the additional exposure due to solar flares, a model was developed using a Monte-Carlo radiation transport code, MCNPX. The model transports an extrapolated flux spectrum through the atmosphere using the MCNPX analysis. This code produces the estimated flux at a specific altitude where ICRP conversion coefficients are applied to convert the particle flux into an ambient dose equivalent. Transporting the flux through the atmosphere to ground level enables calculations of expected neutron-monitor count rates, which can be compared against neutron monitor (NM) data obtained from stations around the world. A cut-off rigidity model accounts for the shielding effects of the Earth's magnetic field.

2. Model Development

2.1 Solar Flare Particle Spectrum

The particle spectrum resulting from a solar flare is highly variable and sporadic. Satellite measurements provide near real-time data. One specific instrument is the Space Environment Monitor (SEM) on the Geostationary Operational Environmental Satellites (GOES). The SEM is capable of measuring the flux of solar and galactic particles and X-rays. The proton flux measurements necessary for our model are provided by energetic particle sensors (EPS) and the high-energy proton and alpha detector (HEPAD), which operate over a large range of energies.

In order to transport the particle spectrum through the atmosphere, the GOES measurements must be extrapolated to a high energy of 10 GeV, which is accomplished by fitting the GOES data to a power-law equation for the differential flux using:

$$\phi(E) = \frac{C}{\beta}\left(\frac{R}{R_o}\right)^{-\gamma} \tag{1}$$

where C and γ are fitting parameters. C is calculated using actual GOES measurements and γ is adjusted until the average variance between the extrapolated flux and the HEPAD measurements falls below 1%.

The particle rigidity R (in MV) is related to its energy E (in MeV) by the relation:

$$R = \sqrt{E\left(E + 2E_o\right)} \tag{2}$$

where E_o is the rest mass energy of the particle (in MeV) and $\beta = R/(R^2 + E_o^2)^{1/2}$ is the particle velocity v normalized by the speed of light c. The parameter R_o = 239 MV in **(1)** corresponds to a particle energy of E = 30 MeV.

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An example of the extrapolated spectrum using satellite data is shown in Figure 1.

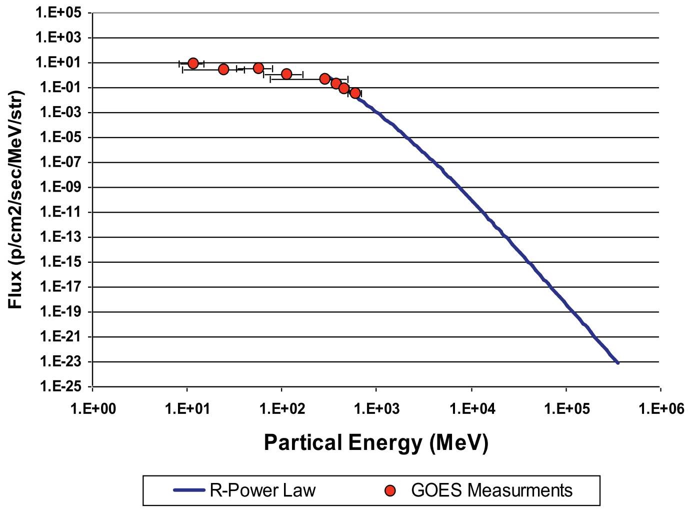

Figure 1 High-Energy extrapolation of differential proton energy data from the GOES satellite for GLE 60.

2.2 MCNPX Analysis

A Monte Carlo simulation refers to any simulation process in which there is a stochastic or random element, normally expressed in a simulation algorithm through the use of random numbers. Since particle physics models are very complex, it may be very difficult or even impossible to solve exactly for the properties of the system. A Monte Carlo simulation can be used for such models as a method for iteratively solving the problem of radiation transport.

Monte Carlo N-Particle eXtended code, MCNPX, is a 3-Dimensional Monte Carlo radiation transport code developed by the Los Alamos National Laboratory. The code is capable of tracking 34 particle types (nucleons and light ions) and 2000+ heavy ions at nearly all energies. It uses standard evaluated data libraries including physically-based models where data libraries are not yet available.

The MCNPX code (version 2.5) was used to determine the particle production and transport in the atmosphere. Although secondary particles are produced by interaction of primary cosmic ray particles with atmospheric nuclei, only the production of neutrons and protons were considered, as those particles are responsible for the majority of the radiation dose at high altitudes. The atmosphere was divided into 36 concentric shells using an average air density for a given shell thickness. Secondary particle energy spectra produced from an incident mono-energetic source particle were tracked in the analysis[5]. Combined particle spectra (at a given altitude) were therefore obtained by summing the secondary particle spectra derived from each mono-energetic primary particle based on the initial proton spectrum and helium spectrum. Dose conversion factors as well as neutron monitor response functions have been incorporated with the MCNPX results for a specific altitude[6].

As a preliminary test, the interstellar GCR spectrum was used

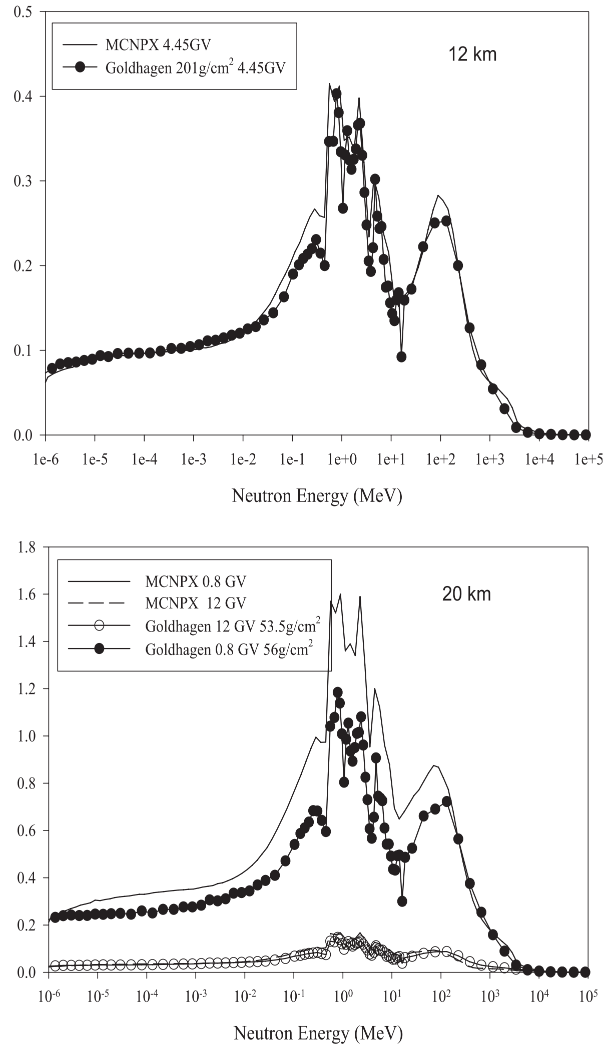

Figure 2 Comparison of predicted and measured neutron spectra at various altitudes and vertical cut-off rigidities.

to predict neutron and proton spectra on the ground and at an altitude of 17 km. These results were compared to those measured by Goldhagen and Gordon and were determined to be in reasonable agreement. [7-9] Further comparisons were made with measured neutron Bonner-sphere results for various altitudes and vertical cut-off rigidities (Figure 2).

Based on this agreement, the MCNPX analysis was applied to the SEP particle spectrum. For the GCR spectrum, a spherical geometry was used, since galactic rays are assumed to be isotropic, arriving from any direction. For the solar flare code, a planer source geometry was used. Figure 3 illustrates both geometries for transporting particles through the Earth's atmosphere.

The coefficients obtained from the MCNPX analysis, P_{ij}, are combined with dose conversion coefficients, K_j, and NM response functions, R_j, using Equations **(3)** and **(4)**. Different coefficients are used for ambient dose equivalent rate () and effective dose rate () for equation **(3)**, while different NM detector type response functions are used in Equation **(4)**. A complete list of tabulated P_A and P_{NM} coefficients are given in Reference 6. The coefficient *c* accounts for the source detector geometry.

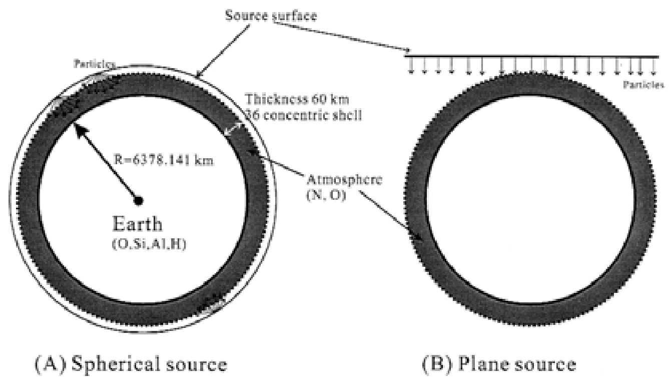

Figure 3 Spherical and planer geometry for MCNPX transport code.

$$\begin{aligned}\dot{E},\dot{H}(\mathrm{Sv\,h^{-1}}) &= \sum_{i=1}^{m}\left[\sum_{j=1}^{n}\left\{c\times\Delta E_{i,i+1}\times K_j\times P_{ij}\times\left(\frac{3600\,\mathrm{s}}{\mathrm{h}}\right)\right\}\ddot{\Phi}_{E,\Omega_i}^{prim}\right] \\ &= \sum_{i=1}^{m}P_A(E_i)\ddot{\Phi}_{E,\Omega}^{prim}(E_i)\end{aligned} \tag{3}$$

$$\begin{aligned}\dot{C}(\mathrm{count\,h^{-1}}) &= \sum_{i=1}^{m}\left[\sum_{j=1}^{n}\left\{c\times\Delta E_{i,i+1}\times R_j\times P_{ij}\times\left(\frac{3600s}{h}\right)\right\}\ddot{\Phi}_{E,\Omega_i}^{prim}\right] \\ &= \sum_{i=1}^{m}P_{NM}(E_i)\ddot{\Phi}_{E,\Omega}^{prim}(E_i)\end{aligned} \tag{4}$$

2.3 Vertical Cut-off Rigidity

The Earth's magnetic field acts as a shield to incoming particles and radiation. Particles that do not have sufficient energy to penetrate the Earth's field are reflected back into space. Therefore, a model of the cutoff rigidity has to take into account the properties of the Earth's magnetic field as well as geographical position.

During an SPE, the Earth is bombarded with energetic particles causing major disturbances in the field. Not only do the particles contribute largely to the already-existing radiation (due to GCR), the solar wind during a geomagnetic storm can perturb the Earth's magnetic field thus lowering the cutoff rigidity.

The cut-off rigidity model used in this analysis is a value obtained by averaging a quiet sun model, R_U, and a noisy sun model, R_L. The quiet sun model uses the vertical cut-off rigidity, R_C (in GV) obtained from standard International Geomagnetic Reference Field (IGRF) maps (1995 model), while the noisy sun model is calculated using[10]:

$$R_L(GV) = \{1 - 0.54\exp(-R_c(GV)/2.9)\} \tag{5}$$

The effect of the cutoff rigidity is taken into consideration in the calculation by summing up only those particles with energies greater than the corresponding energy for a given vertical cutoff rigidity, R_c (using Eq. 2). A low pass energy filter was applied to match the NM data where primary protons with energy less than 430 MeV were ignored in the summation. This filter was chosen by matching predicted results to observed ground-level NM data. This filter accounts for the ability of lower energy particles to reach the neutron monitor at ground level.

Figure 4 illustrates the prediction of the model using various cutoff filters, leading to the final choice of 1 GV. Figure 5 shows a comparison between the predicted NM count rates against data from NM stations around the world for Ground Level Event (GLE) 60.

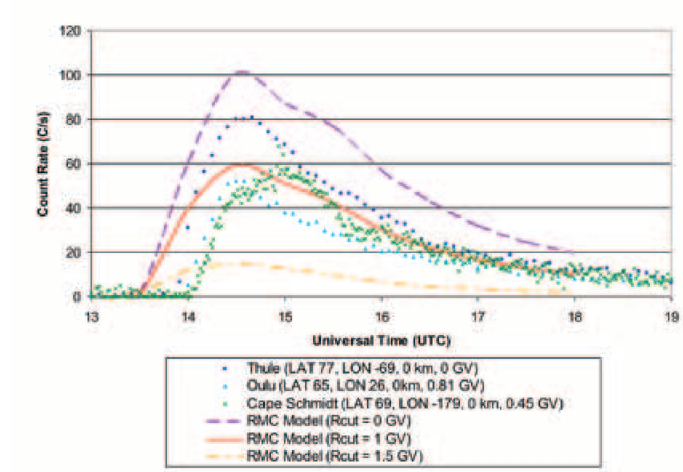

Figure 4 Observed count rate history (minus background GCR) versus model predictions for GLE 60 (April 15th, 2001).

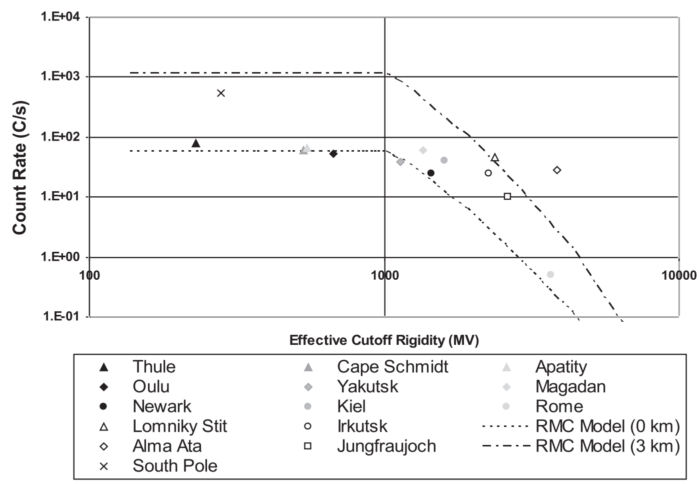

Figure 5 Comparison of the model calculations to the observed peak count rates for various NMs located around the world during GLE 60. (Hollow shapes represent NMs at an altitude of 3 km and solids represent NMs at an altitude of 0 km).

3. Software Development

To perform the calculation on a routine basis, a computer code was developed using C++. The code, compiled as a Dynamically Linked Library (DLL), includes several modules that perform all the necessary input data acquisition and great circle route calculations, as well as the analysis required for estimating the radiation dose absorbed by aircrew at a given altitude.

To simplify the end-user experience, a Graphical User Interface (GUI) was developed using Visual Basic that calls the DLL calculation routine. The GUI allows the user to enter flight data either in "Flight Information" mode or in "Waypoint" mode. In the former, the user provides the departure and arrival

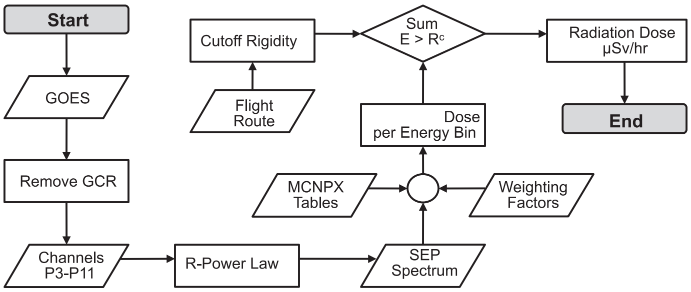

Figure 6 Flowchart describing the general methodology for calculating the radiation dose.

airports, and a great circle route calculator estimates the flight route. In the latter, the user provides a list of waypoints each containing latitude, longitude, and altitude information for the actual flight route. Figure 7 shows an image of the user interface running in “Flight Information” mode.

Figure 7 The graphical user interface used for implementing the solar flare calculation.

4. Results and Analysis

To test the validity of the model, it was necessary to perform the solar flare calculation on GLEs where actual flight measurements exist, allowing direct comparison. One such event is GLE 60, where flight measurements were taken as part of the EU DOSMAX (Dosimetry of Aircrew Exposure during Solar Maximum) project. One flight from Prague to New York (PRG-JFK) employed a MDU-Liulin device[11], whereas a second flight from Frankfurt to Dallas Fort Worth (FRA-DFW) used an ACREM monitor (scaled GM tube measurements) for radiation monitoring[12].

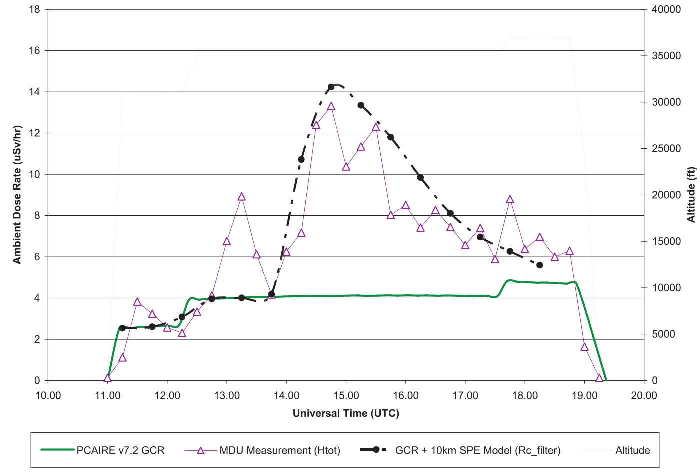

Figure 8 Comparison of calculations and measurements of the ambient dose equivalent rates during GLE 60 for PRG-JFK flight.

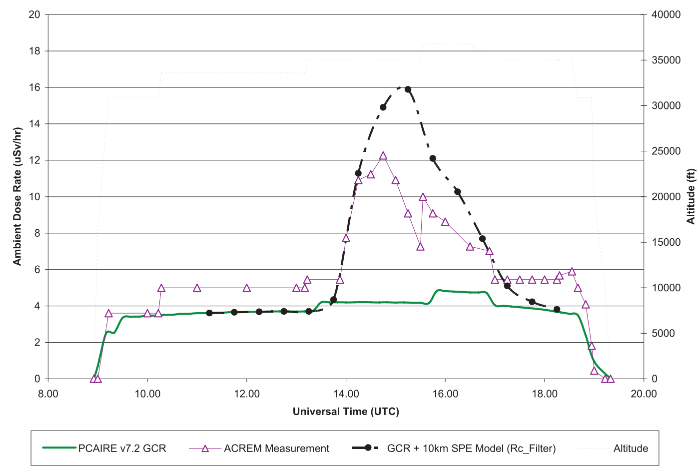

Figure 9 Comparison of calculations and measurements of the ambient dose equivalent rates during GLE 60 for FRA-DFW flight.

To calculate the SEP exposure, the initial proton fluence rates were first obtained by subtracting the GCR component from the GOES measurement. Here, the GCR component was obtained from spectra that were averaged prior to the event. The GCR exposure was estimated from the PCAire code and summed with the SEP estimate to obtain a total determination of the aircrew exposure.

The results are illustrated in Figures 8 and 9. Good agreement is observed with a discrepancy between the model and measurements of typically less than ±25%. As seen in the figure, the solar flare contributed 45% to the total cumulative dose of 54 μSv for the PRG-JFK route.

6. Current Research

6.1 MCNPX Analysis

The MCNPX analysis only considers the production of secondary neutrons due to incoming protons. A review of this approach that involves transporting additional particles may lead

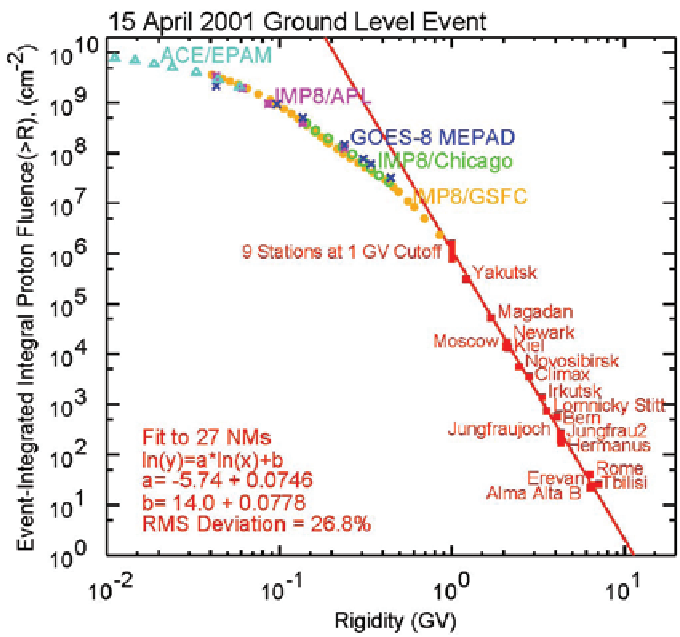

Figure 10 Particle spectrum obtained using the model proposed by Tylka et al.

to improvement in the model. Since neutrons are one of many secondary particles that can be found at high altitudes, new runs of MCNPX that account for other reactions and other particles may be necessary.

6.2 Solar Flare Particle Spectrum

Current research on this project aims at improving various aspects of the model. The current model extrapolates limited satellite data to high-energies to obtain the initial particle spectrum. Improvement to the model can be achieved by combining neutron monitor data, which provide better information of the particle spectrum at high energies, with the satellite data. Collaboration with the US Naval Research Lab is currently under way to implement an improved particle spectrum model. An example of the proposed particle spectrum is shown in Figure 10.

6.3 Particle Anisotropy

The current model assumes a homogenous distribution of the incoming solar particles through the atmosphere without accounting for particle anisotropy. In reality, the particle distribution may be highly anisotropic, with certain regions receiving a significantly larger dose than other regions with the same cut-off rigidity.

To properly account for anisotropy, a study was done to predict neutron monitor responses based on an anisotropic behavior. This is accomplished by fitting an equation to neutron monitor data over a wide range of rigidities. This fitting process allows the derivation of the parameters needed for calculating the pitch angle distribution (PAD), which is a measure of the solar flare anisotropy. Once the PAD is derived, neutron monitor responses can be predicted and compared with actual measurements to determine how accurate the fit is. This allows the prediction of areas showing a higher response than other areas with the same cut-off rigidity.

The anisotropy analysis technique includes a least squares fitting procedure which allows the selection of an optimum solution for each of the time intervals considered during the event. For this technique to be successful, data must be selected from many neutron monitor stations that are widely separated in longitude and latitude. The responses of NM stations over a wide range of rigidities are required to determine the particle anisotropy and its axis of symmetry. This technique assumes that the response of neutron monitors to solar protons takes the form shown in equation (6). [13]

(6)

where
ΔN absolute count rate increase due to solar protons
N pre-event baseline count rate due to galactic cosmic rays
P particle rigidity (GV)
P_{min} lowest rigidity of particles considered in the analysis
P_{max} maximum rigidity considered
(θ,Φ) zenith and azimuth coordinates of incident protons arrival at the top of the atmosphere above the NM
Q 1 for accessible directions of arrival and 0 otherwise
J differential solar proton flux
J_o interplanetary differential flux adjusted for the level of solar cycle modulation
S neutron monitor yield function
G pitch angle distribution of the arriving solar protons

The analysis divides the area above a neutron monitor into nine segments, each contributing an equal amount to the overall count rate response. This is the reason for the factor of 1/9th in front of the summation. The nine segments are illustrated in Figure 11.

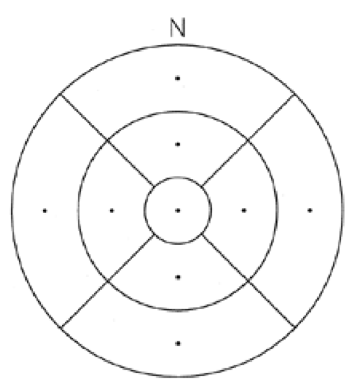

Figure 11 The segments above a neutron monitor. Viewing directions are calculated for each of the directions marked with dots (zenith angles 0°, 16°, 32° for azimuths 0°, 90°, 180°, and 270°).

While the full anisotropy model has yet to be developed, a great amount of work was put in to understand the problem of pitch angle distribution. The calculation used to derive the fitting parameters is computing intensive, and requires a fair amount of data processing. The first step involves calculating asymptotic viewing directions for every node on the earth's latitude/longitude grid. Asymptotic directions of arriving protons are calculated by tracing the trajectories of negative particles of the same rigidities moving away from the earth. The set of asymptotic directions of all allowed trajectories constitutes the asymptotic cone of acceptance for a particular latitude/longitude.

This process is done using MAGNETOCOSMICS, a code developed at the University of Bern, Germany. The code allows us to compute the propagation of charged cosmic rays through different magnetic field models of the earth's magnetosphere. It also allows us to compute cut-off rigidities and asymptotic directions of particle incidence. An example of MAGNETOCOSMICS' output can be seen in Figures 12.

6. Summary and Conclusions

A transport code analysis with MCNPX is used to propagate an extrapolated particle spectrum based on satellite measurements through the atmosphere in order to estimate additional aircrew exposure from the SEP event. The transport code calculation is benchmarked against actual neutron spectra measured at high altitudes and on the ground. A routine methodology has been developed to estimate the aircrew exposure for the SEP contribution. These computations are compared with count rate data observed at various NMs on the ground as well as ambient dose equivalent rate measurements made on-board jet aircraft during GLE 60. Current research is focused on improving the solar particle spectrum, as well as introducing a new anisotropy model that uses neutron monitor responses and pitch angle data to identify anisotropy and correct for it.

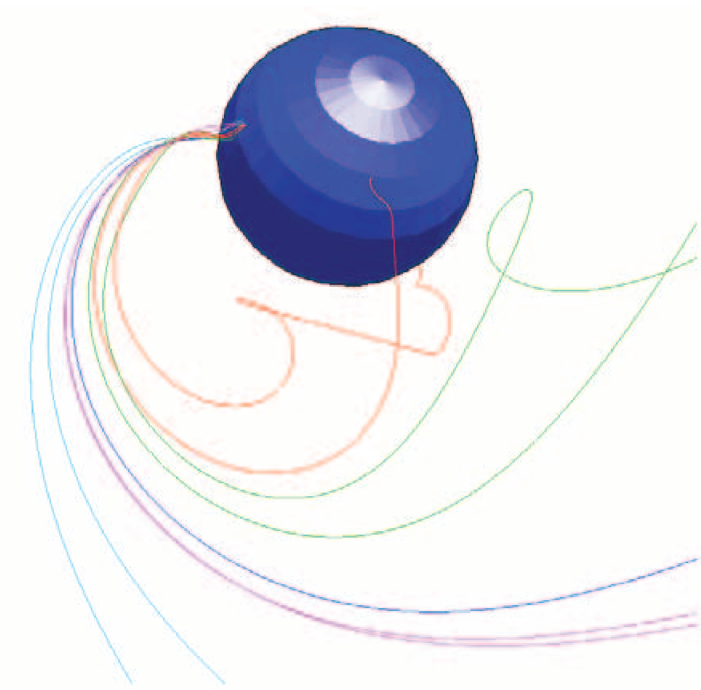

Figure 12 Visualization of MAGNETOCOSMICS' particle tracing. Particles with different energies are traced backwards from a given viewing location.

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Experience of Oil in CANDU® Moderator During A831 Planned Outage at Bruce Power

by GUOPING MA, ROD NASHIEM, SHANE MATHESON[1], CRAIG STUART[2], JOHN G. ROBERTS[3]

[Ed. Note: The following paper was presented at the International Conference on Water Chemistry of Nuclear Reactor Systems (NPC2010) held in Québec City, QC.]

Abstract

In their address to the Nuclear Plant Chemistry Conference 2009, Bruce Power staff will describe the effects of oil ingress to the moderator of a CANDU®1 reactor. During the A831 planned outage of Bruce Power Unit 3, an incident of oil ingress into moderator was discovered on Oct 17, 2008. An investigation identified the cause of the oil ingress. Atomic Energy of Canada Ltd. (AECL) assessed operability of the reactor with the oil present and made recommendations with respect to the effect on unit start-up with oil present. The principal concern was the radiolytic generation of deuterium from the breakdown of the oil in-core. Various challenges were presented during start-up which were overcome via innovative approaches. The subsequent actions and consequential effects on moderator chemistry are discussed in this paper. Examination of the plant chemistry data revealed some interesting aspects of moderator system chemistry under upset conditions which will also be presented.

1. Introduction

Bruce Power consists of eight CANDU® reactor units, and currently operates six CANDU® reactor units, which combine to produce more than 4,700 megawatts, while another two CANDU® reactor units (Units 1 & 2) are in the process of refurbishment. Once restarted, Bruce Power will supply nearly 6,300 megawatts. On October 17, 2008, when Unit 3 was in a planned maintenance outage, an incident of oil ingress into moderator was observed. The oil was seen during the routine sampling of moderator heavy water for Over-Poison Guarantee Shutdown State (OPGSS) requirements [1]. A globule of oil was observed in the flow gauge. An oil layer, of approximately 4mm, was reported to be separated out in a 500 mL sample bottle after collecting samples (see Figure 1).

Oil is used for lubrication in several moderator system components, including main moderator pumps, moderator auxiliary pumps, moderator cover gas compressors and reactivity mechanism drives. Each of these components uses a different oil. This fact facilitated identification of the source of the oil. The oil was subsequently identified by Kinectrics Inc. using gas chromatography-flame ionization detector (GC-FID) to be Teresso 68 (Figure 2) [2]. The source of the oil was determined to be the main moderator pump 1 thrust bearing. This bearing had been routinely topped up with 1.5 L of Teresso 68 oil approximately every 5 days since 2006, thus, the total volume was estimated to be approximately 1100 L of oil had been added over a period of two years. This oil had leaked out of the thrust bearing assembly and some of it had flowed into the moderator "rubber room" located under each main pump and heat exchanger.

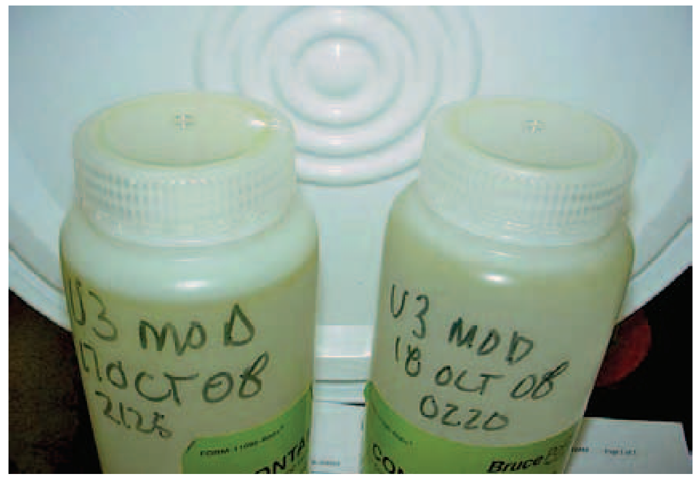

Figure 1 Heavy Water Samples from Unit 3 Moderator on Oct. 17, 2008.

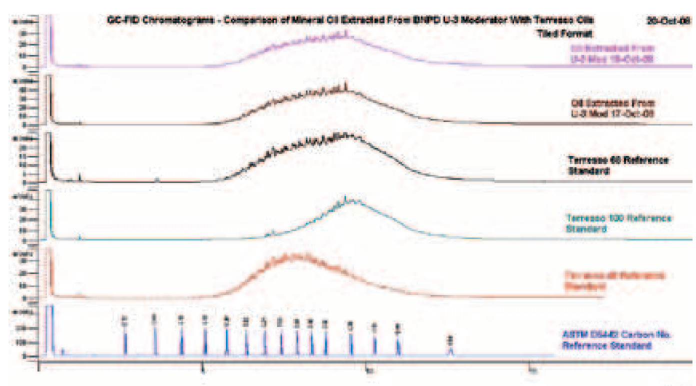

Figure 2 GC-FID Result Comparisons of Different Oils Performed by Kinectrics.

The oil entered the moderator system during a test of the moderator auxiliary pump to demonstrate that flow could be established from the moderator "rubber room". The suction valve to the moderator room is not normally opened during

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3. CANTECH Associates Ltd. 4525 Lakeshore Road, Burlington, Ontario, L7L 1B3, Canada
4. CANDU®, CANada Deuterium Uranium, is a registered trademark of Atomic Energy of Canada Limited (AECL)

this test. However, on this occasion the valve was opened with the consequence that oil in the “rubber room” was sucked into the moderator.

After the discovery of the oil in the moderator, advice was sought from AECL-CRL to assist in determining the impact and potential oil clean up options. The initial focus was to remove as much of the oil as possible from the moderator system prior to Unit 3 restart. The rationale was to minimise the amount of oil being irradiated in the moderator system. This in turn would reduce the quantity of lower molecular weight organic compounds and hydrogen produced from radiolytic degradation of the oil, and minimise the mass of oil available to crosslink to form more viscous, even solid hydrocarbon polymers.

In the present paper, the degradation mechanisms of oil in the moderator under radiation are discussed. The main concern was the radiolytic generation of hydrogen/deuterium from the breakdown of the oil in-core. The challenges during the evolved radiolysis processes are presented. The subsequent actions and consequential effects on moderator chemistry are also discussed in this paper.

2. Radiation Chemistry of the Oil in the Moderator

Teresso 68 pump oil is a mixture of linear and branched chain paraffin hydrocarbons in the C20 to C40 range, made from mineral oils, and has a very low solubility in water. This means that essentially no oil will have been homogeneously dissolved in the water. Any oil circulating in the system would have been present as small droplets entrained in the water.

The radiation chemistries of the oil in the moderator heavy water were separately considered as processes occurring in the oil phase and processes occurring in the heavy water phase because the degradation mechanisms are quite distinct in each phase:

1) In the oil phase, the radiation chemistry process will be initiated by the direct absorption of the radiation by the hydrocarbons. The products will be hydrogen, chain fragmentation and cross-linked products [3]. Hydrogen and some of the fragmentation products will diffuse from the oil phase into the surrounding water.
2) In the heavy-water phase, the radiation chemistry processes are initiated by the absorption of the radiation energy in the water that results in the formation of reactive free radical species, such as ·OD, eaq- and ·D etc. These species will react with soluble oil breakdown products which have diffused from the oil into the water. There will also be some reaction of these short-lived water radiolysis species at the oil/water interfaces but this will account for only a very small fraction of the aqueous chemistry. Ultimately, the radiation will degrade the organic carbon species to carbon dioxide, hydrogen and water [4].

There appear to be few reports on the radiation chemistry of lubricating oils published in the open literature. Nevertheless, from our experience in other irradiated systems it was determined that lower molecular weight products (breakdown) and higher molecular weight products (crosslinking) are formed in addition to molecular hydrogen. A G-value, which is defined as the number of species formed or destroyed per 100 eV of ionizing energy absorbed, is used to describe radiolytic yield [5]. The G value yield of the fragmentation products, C<n, (where ‘n’ is the number of carbons in the parent compound) such as alkanes, alkenes, etc., is ~1 molecule/100 eV. The relative proportion of different products will change depending on the structure of the hydrocarbon being irradiated. Branched chain isomers of an alkane tend to have more fragmentation products due to increased cleavage of C-C bonds [4]. It has been noted that the formation of dimer products also increases as the chain length increases [4].

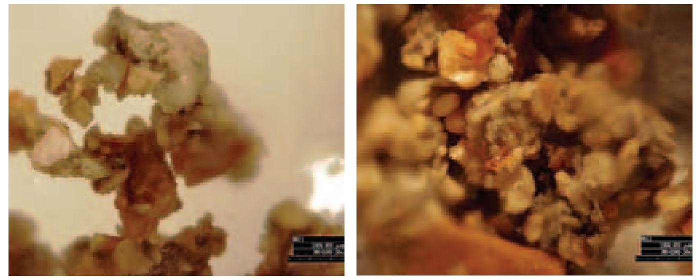

Figure 3 Solid Deposits Retrieved from Moderator Purification Strainers [6].

In the moderator system, the oil will undergo continuous neutron and gamma irradiation so that products (both degradation and cross linked) formed from effects of radiation on oil will also be involved in the radiolysis processes. It is not feasible to model such a complex and diverse breakdown mechanism. However, molecular hydrogen will be continually produced in the oil phase and this hydrogen will diffuse into the surrounding areas (moderator heavy water or cover gas). Crosslinking between the hydrocarbon fragmentation products will increase the chain length of the molecules, which will cause the oil to become more viscous or gelatinous.

Formation of a gelatinous material from the oil was observed in the Unit 3 moderator and resulted in the plugging of the inlet strainer in the purification system (see Figure 3). Some of the smaller fragmentation products will diffuse into the heavy water phase and become homogeneously dissolved; this dissolved organic material will be further degraded through the water radiolysis processes [4]. To gain a better insight into the radiolysis of the Teresso 68 oil in the Bruce Unit 3 moderator system, a review was made of the more numerous detailed radiation chemistry studies on shorter chain alkanes [3], [4]. When aliphatic hydrocarbons, such as the linear chain hexadecane, are irradiated, both lower molecular weight products are formed in addition to molecular hydrogen. The relative proportion of different products will change depending on the structure of the hydrocarbon being irradiated [4].

The radiation chemistry of the aqueous phase is dominated by water radiolysis [5]. Effectively, all the radiation energy is deposited in the moderator water (as opposed to dissolved organic material), which results in the formation of primary water radiolysis species:

$$D_20 \xrightarrow{\text{Ionizing Radiation}} e^-_{aq}, \bullet D, \bullet OD, D_2, D_20_2, \bullet D0_2/\bullet 0_2^-, D^+$$

These species then react among themselves, and with any other species in water, to establish pseudo steady state concentrations of deuterium, oxygen and deuterium peroxide. There will also be products derived from the reaction of radiolysis products with other species circulating around the system. Depending on what other species are present, the relative concentrations of deuterium, oxygen and deuterium peroxide will vary.

As mentioned above, some of the radiolytically produced hydrogen from the oil phase will diffuse into the heavy water. The hydrogen, so formed, combined with hydrogen from the breakdown of dissolved organic fragments will radiolytically reduce the dissolved oxygen and peroxide to form water. This process will result in the moderator water being in the net radiolysis suppressed state where significant concentrations of dissolved deuterium will be present leaving only very low concentrations of oxygen and deuterium peroxide [4]. The dissolved oil fragmentation products will aid this process. Organic radicals, derived from the dissolved fragmentation products scavenging hydroxyl radicals, will react with any oxygen present.

Nitrate ions from gadolinium nitrate (the poison used in OPGSS), tend to promote the radiolytic breakdown of water to form higher steady-state concentrations of deuterium, oxygen and deuterium peroxide. The balance between the impact of the dissolved organics and the impact of the nitrate ions, for example, on the radiolysis processes in the heavy water depends on their relative concentrations.

The soluble organics present in the moderator heavy water will be degraded through reactions of the ·OD, eaq- and ·D species through a series of oxygen containing organic species, such as different organic acids, eventually forming carbon dioxide (measured as Total Inorganic Carbon).

3. The Evolution of the Event and Discussions

Following the event of oil ingress in Unit 3 moderator, the evolution of the event and the corresponding discussions can be separated into three periods of time:

- From just before the oil ingress to 'reactor approach to critical' (low gamma radiation field);
- From reactor criticality (reactor start-up) to power-raising (increasing to high gamma and neutron radiation field), and
- Full power operation.

3.1 First period of time: (just before the oil ingress to 'reactor approach to critical')

At the time of the oil ingress event, the reactor was under the OPGSS which necessitates the purification system being isolated. Figure 4 shows some of the moderator chemistry data over the time period from just before the oil ingress to just prior to the reactor approaching to critical.

During this period, there was no significant perturbation of chemistry parameters. Prior to the oil ingress, the dissolved deuterium concentration was about 2 mL/kg, which is a typi-

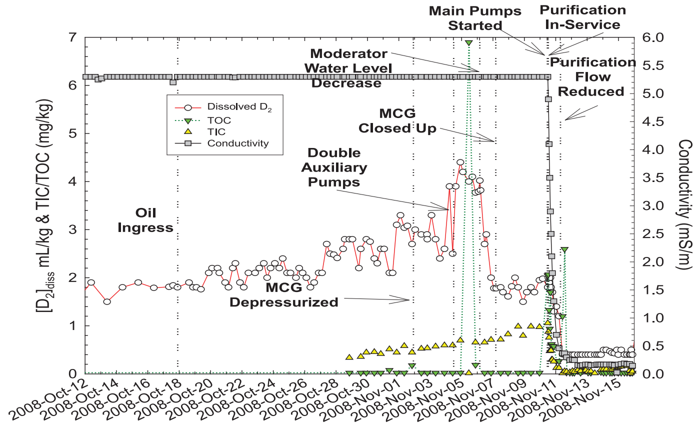

Figure 4 Moderator Chemistry Data During Shutdown.

cal level for a reactor in OPGSS. Following the oil ingress, the dissolved deuterium concentration began to increase slowly with time. Prior to the start-up of the main moderator pumps, the flow conditions, circulated by an auxiliary pump, resulted in very little mixing of the oil with the heavy water. As a result, it is believed that the shutdown radiation field was degrading the oil as observed through the slow increase in the dissolved deuterium concentration. The hydrogen from the oil breakdown diffused from the oil phase into the much larger aqueous phase. Total Inorganic Carbon (TIC)/Total Organic Carbon (TOC) measurements, which began on October 29, show that the TIC concentration had increased to about 1 mg/kg by the time the purification system was placed into service for the removal of the gadolinium nitrate on November 11; and the TOC concentrations remained below the detection limit until the main moderator pumps were started on November 10. During this period of time it was determined that the radiolytic breakdown of the oil under full-power conditions would result in the production of significant quantities of deuterium gas. Therefore, in early November, a significant portion of the oil was manually removed from the surface of the heavy-water.

3.2 Second period of time: (reactor start-up and power-raising)

Figure 5 shows the moderator chemistry observed for the period of time from just before reactor start-up to December 6. In addition to the normal parameters presented in Figure 4, Moderator cover gas deuterium concentration, cover gas purge flow rate and the purification flow rate are particularly added. A constant purge of the moderator cover gas was initiated from November 15, 2008.

Upon reactor power increase, the radiation field had increased sufficiently to significantly degrade the oil. Therefore, the dissolved deuterium concentration, cover gas deuterium concentration, TOC levels and conductivity of heavy water all increased. However, the TIC levels remained very low over the whole period. The dissolved deuterium concentration rose into the range 12-15 mL/kg before the reactor tripped (Shutdown System 1 fired unexpectedly during a maintenance operation whenever a shutdown system is activated, moderator purification

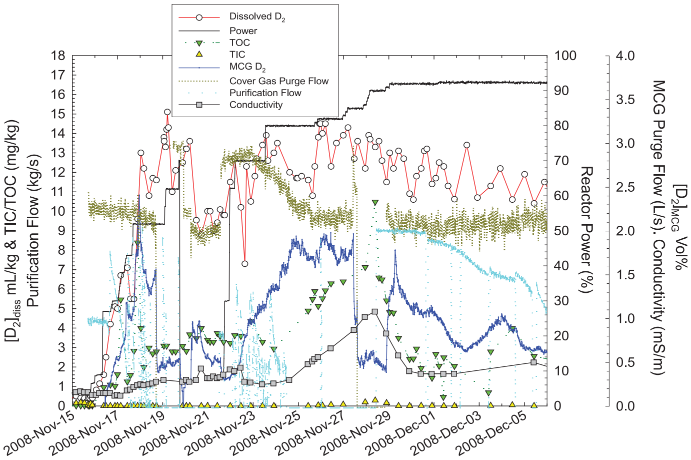

Figure 5 Moderator Chemistry Data During Reactor Start-up and Power-raising.

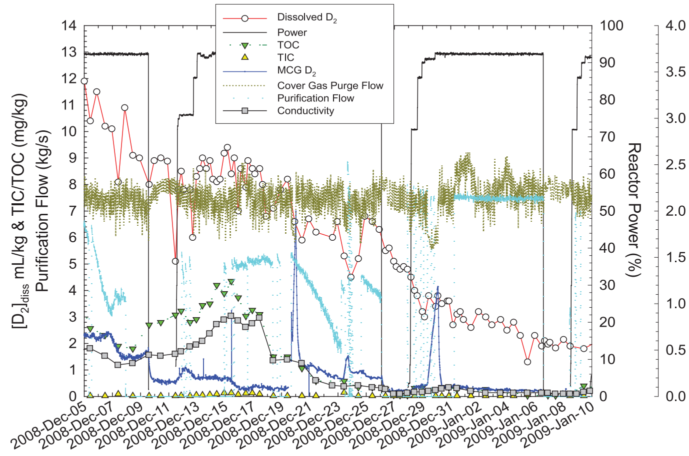

Figure 6 Moderator Chemistry Data During Reactor Full Power.

is automatically taken out of service) on November 19. These chemistry observations are consistent with the radiolytic degradation of the oil in the system at operating reactor dose rates.

The plugging of the inlet strainer to purification with gelatinous material reflects cross-linking in the oil phase. The oil phase is circulating as droplets in the turbulent water flow around the circuit. The increase in dissolved deuterium concentration reflects the hydrogen production in the oil phase together with the contribution from the breakdown of lower molecular-weight organics dissolved in the water phase.

The cover gas deuterium concentration peaked at over 2% on November 18 and then decreased to a slightly lower 1.5%. The sudden decrease of the cover gas deuterium concentration to ~0.5 %, that occurred later on November 18, is a consequence of the cover gas purge rate being increased to around 3 L/s, a value which the flow transmitter was not able to record.

Although the reactor tripped on November 19, the dissolved deuterium concentration, cover gas deuterium concentration, TOC concentration and conductivity all remained elevated above normal operating levels. Following the reactor re-start on November 21, the dissolved deuterium concentration remained high, cover gas deuterium concentration increased continuously as did the heavy water conductivity. These increases can be attributed to unavailability of the purification system to remove 'impurities' from the moderator water at that time.

Once purification was placed in service again on November 28, the conductivity and TOC levels began to decrease immediately and the dissolved deuterium concentrations began to decrease slowly with time. The cover gas deuterium concentration also began to trend down after an increased purge rate period around November 27-28.

3.3 Third period of time: (full power operation)

The moderator chemistry parameters continued to improve until December 8 when the purification system was taken out of service again due to plugging of the inlet strainer (Figure 6). At this time, the dissolved deuterium concentration stopped decreasing and the conductivity and TOC levels increased. However, this time the cover gas deuterium concentration continued to decrease to ~0.3 vol%. During the period whilst purification was out of service a filter, usually used for heat transport system purification, was installed and used in place of the strainer ahead of the ion exchange columns. From December 16 onwards, this filter was present when purification was placed back in service, and the purification system then remained in service for most of the time. The dissolved deuterium concentration, TOC and heavy water conductivity began to trend downwards again and continued to do so, reaching typical normal operating values by December 27 for TOC and conductivity. The dissolved deuterium concentration reached typical operating levels in early 2009. Thereafter, the moderator chemistry has continued to remain within specification. It would appear that the moderator system had now recovered from the ingress of oil that occurred in October 17, 2008 and was now operating with acceptable chemistry.

4. SUMMARY

The ingress of lubricating oil into the moderator of Bruce Unit 3 caused significant perturbations in moderator chemistry during the return to service of the unit and during the subsequent 3 months of operation. Understanding the mode of breakdown of the oil allowed precautions to be taken during the restart of the reactor to minimize the effects of the oil breakdown.

1) Since the oil was found in moderator and was determined to have a detrimental effect on moderator chemistry during operation, a significant portion of oil was removed manually.
2) The oil in the moderator system had little chemistry impact during OPGSS and the approach-to-critical. There was no impact on gadolinium concentrations.
3) When reactor power was increased, the oil remaining in the system had a significant impact on the moderator water chemistry. The dissolved deuterium concentration reached to a maximum concentration of about 15.1 mL/kg; cross-linked materials were formed which limited purification flow.

4) Moderator purification system with a (heat transport system bleed) filter installed upstream played an important role for chemistry control by providing a larger volume capacity for removing the crosslinked materials and maintaining purification system availability.
5) The behaviour of the moderator system was predicted by the behaviour of model organic compounds, via a two phase model. The relative amount of hydrogen production versus cross linked species is heavily dependent upon source oil composition. Further work to understand these production yields in two phase systems is warranted.

5. Acknowledgement

The authors would like to thank Dr. Otto Herrmann et al at Kinectrics for providing their fully support for quick sample analysis and many discussions and Dr John Elliot from AECL-CRL (recently retired) for his significant input into the radiation chemistry of this issue.

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Aligning Stars

By NEIL ALEXANDER

[Ed. Note: Neil is a CNS member and Past-President of the Organization of CANDU Industries.]

The annual meeting of the Canadian Nuclear Association is always a great celebration for the industry. People come from far and wide to tell us how important our industry is and what a great future that it has. We always leave feeling good about ourselves.

This year was no different from that point of view. Tom Mitchell, President and CEO of Ontario Power Generation powerfully told us that he was ready to deliver on nuclear new build. John Ibbotson from the Globe and Mail told us about the great story that we have to tell and Tim Hudak clearly announced his support for nuclear power in Ontario as both energy and economic policy, joining the Liberals in a firm commitment to new build.

And in previous years that would have been that.

But this year those same people, having told us how great our future **could be** also took time to draw attention to the challenges. John Ibbotson told us that there is no point in having a great story if we keep it to ourselves and then suggested some ways that we could strengthen our message. We should heed John's advice.

But the real work was left to Tom Mitchell. Tom opened his address by focusing on three words – Tee Minus Twenty-six – indicating that in 26 days from the day of the speech the Joint Review Panel hearings for the Darlington New Nuclear Environmental Assessment will begin. The first major step on the road to new nuclear construction in Ontario.

In one simple three word statement Tom told us three things:

1) New nuclear at Darlington is real;
2) OPG has a plan. It knows where the plan starts, it knows where it finishes and it is focused on the schedule and critical success factors;
3) Tom and his team are committed to delivering.

In one simple statement Tom had described the possible beauty of our entire night sky.

He then spent the rest of his time describing how all the stars needed to come into line in order for that beautiful sky to become reality.

Now as we know it is the Province that will make the final decisions about new build. It is the Province that decides on energy policy and it is the Province that decides on economic policy. The Long Term Energy Plan sets out the plan for new build. These are not OPG's bailiwick. But at the same time OPG has a fleet of reactors to operate and a directive to produce electricity and to do that OPG has to ensure that decisions, good decisions, are made in a timely fashion. And so Tom took on the role of providing some guidance. This is what I heard:

1) It makes very good sense to aim to have the new plant coming on stream shortly after Pickering goes into safe storage thus allowing OPG to offer its large and talented workforce sustainable ongoing employment. And although he did not say this that means we need some decisions on technology to be made soon.
2) So far as OPG is concerned an Enhanced CANDU would be a good fit and that given that no number was attached to this statement it may be that some development of the existing concepts may be needed in order to optimize that fit. I suspect that Enhanced was used very deliberately to indicate that at this time an Advanced CANDU would not be such a good fit.
3) Everything remains dependent on the ability to negotiate a deal in which value is delivered. Value for Ontarians, value for the region and value for the industry. A key part of this value is that the new nuclear station (the enhanced CANDU being a good fit) should be provided at a good price to the ratepayers.

Clearly while Tom knows where these stars need to end up they are still presently out of alignment. But, and I think that this is a key message, Tom thinks that if we all work together the alignment that is needed can be achieved.

We could spend a lot of time analyzing Tom's comments to decide whether the alignment he described is right or not. We can debate timing, we can debate technology (and I am sure people will) but for me if someone describes a destination that I like, defines a start point that looks like where I am and then gets out a map with a route from one to the other I am inclined to trust them and follow them on their journey.

Presently there is one star that is massively out of alignment and that is the future of CANDU. OPG is not in control of the restructuring process but I sure hope that those people that are in control are listening carefully to what Tom says because in order for Tom's plans to work we need to offer a CANDU technology in a way that delivers value and we need to do it soon and in order for CANDU's plans to work we need Tom's plan to work.

Tim Hudak closed the conference in a speech of clear support for nuclear power giving confidence that this election would not change the outlook for the nuclear program but he reminded us that there are significant challenges including upfront costs. He said, "Before we move forward with another new build project, it is essential that we look at what went wrong there (on previous projects) and how we can ensure it doesn't happen again." Tim also said that transparency, accountability and responsibility to the electricity consumer will be key elements of any new build.

If Tom is to have the Enhanced CANDUs that would be a good fit for the site we need to provide that surety and we can only do that if CANDU Inc is keenly focused on the new build opportunities.

Why Ontario has to export electricity

By DON JONES, P.ENG.

In January this year there was a furor in the media about Ontarians subsidizing electricity exports to other jurisdictions.

Ontario exports large amounts of electricity to neighbouring jurisdictions day and night. Exports occur for three reasons that are based on technical and financial concerns. First, Ontario presently has an excess of baseload generation so it makes sense to export the surplus rather than power down nuclear units. Second, in the immediate future there will be many thousands of megawatts of installed wind power on the grid and exporting will be the only way to maximize its accommodation on the grid while maintaining grid reliability. Third, since supply contracts with the non-utility gas generators mean that consumers pay whether the generation is needed by Ontarians or not, it makes some sort of sense to export at a subsidized price and get at least something for it.

At times of the year, usually the shoulder seasons of spring and fall, the province presently has a surplus of baseload generation. This Surplus Baseload Generation (SBG) occurs when baseload generation, from nuclear, must-run hydro, combined-heat-and- power, and wind, that cannot be reduced for technical or contractual reasons, exceeds demand. If an export market is available of sufficient capacity this will avoid the need to power down or shut down nuclear units because doing so would leave those units offline for up to three days leaving gas and coal to take up the slack. In this case it may make sense to export even at negative prices if it prevents manoeuvring down our present nuclear units. The dollar amount involved is relatively small, around $6 million for 2010. If Bruce B has to power down nuclear units, because of SBG or for transmission bottlenecks, it gets paid for the energy it could have produced without the constraints, deemed generation. In 2009, a bad year for SBG, this amounted to $57.5 million. It is the Bruce B units that bear the brunt of SBG.

Adding thousands of more megawatts of wind to the grid without exports will cause problems. Wind is a take-when-available energy source and has priority to the grid during SBG periods ahead of nuclear but the latest wind contracts with the Feed-In Tariffs, signed in early 2010, provide financial incentives for future wind generators to curtail production during SBG periods (although such incentives are not provided for the 1,400 or so megawatts that will be on the grid from the earlier Renewable Energy Standard Offer Program-RESOP). For example the feed-in-tariff of 13.5 cents/kWh for on-shore wind is reduced a cent for every cent/kWh the electricity price goes below zero but wind generators will get paid the full cost of forecast production if they voluntarily curtail production when requested to do so by the Independent Electricity System Operator (IESO). For wind generators installed under the old pre Feed-In-Tariff (FIT) program, RESOP, the wind has priority to the grid over nuclear unless there are technical or reliability reasons to prevent it. The IESO cannot dispatch wind off for economic reasons under either program, only for technical or reliability reasons, although it is trying to be allowed to do this.

The governments Long-Term Energy Plan calls for 12,000 MW of nuclear capacity to provide just 50 percent of total generation, since anything more than 50 percent causes concerns about nuclear turndown in low demand periods. For details see Reference #1. By 2018 there will be 10,700 MW of installed wind, solar and bioenergy, let us assume 8,500 MW of this will be wind. There will be 9,000 MW of hydro, including run-of-the-river and storage. The gas-fired generation will be maintained at its current level of over 9,500 MW - say it will be 10,000 MW - and there will be 1,000 MW of gas-fired Combined Heat and Power added to the baseload supply.

If we assume the maximum available 10,000 MW of dispatchable gas generation is on line and that it is all combined cycle and that it can get down to, say, 50 percent, then it can integrate 5,000 MW of wind. The 50 percent is an average figure since some plants may be kept at the bottom of their dispatchable range (around 70 percent of full power) while others may be down at say 20 percent with some turbines, in a multi-gas turbine plant, shutdown. The other 3,500 MW of wind would have to be integrated by reducing hydro generation by 3,500 MW. If hydro can be dispatched down to the must-run hydro minimum of around say 2,000 MW it means that there must be at least 5,500 MW of hydro on line to accommodate the remaining 3,500 MW of wind.

This shows that there could be potential concerns during a day when gas and hydro are operating at less than their maximum capacity (which is most of the time) and wind kicks in since all the installed wind generation would not be able to be accommodated on the grid. However if there were high levels of export much more of this wind could be accommodated. This also has technical advantages since the combined cycle gas turbine generators on the grid might not have to be powered down below their dispatchable range of around 70 to 100 percent of full power. When in their dispatchable range the units can respond appropriately to dispatches sent every five minutes by the IESO. When operating below their dispatchable range they might not be able to raise power quickly enough if the wind suddenly drops, putting the grid at risk. The safe and reliable operation of Ontario's nuclear units depends to a certain extent on the reliability of the grid to which they are connected. In the future, without exports, there could be insufficient dispatchable gas and coal-fired generation available on the grid that could be powered back to accommodate the potential wind generation. Exports maximize the amount of wind that can be integrated into the grid and improves the grid reliability. This is explained in detail in Reference # 2.

The major financial reason for exports is gas-fired non-utility generators being contracted by the Ontario Power Authority (OPA) to supply a certain number of megawatt hours per year for the life of the contracts and getting paid even if their supply is not needed. Consumers take or consumers pay. Since the OPA has contracted for more megawatt hours than Ontario needs the surplus has been exported. The wholesale cost of electricity depends on the Hourly Ontario Energy Price - HOEP (the market price) - and on the Global Adjustment (GA) charge. The GA is necessary because of the fixed dollars per megawatt hour price contracts with energy suppliers, hydro, nuclear, gas, wind etc, and it may be positive or negative. If the market price is less than the contract price the GA is added to the market price and vice versa. The GA is not part of the price paid by the jurisdiction receiving the exports but is paid by the Ontario consumer, in effect subsidizing the export. Without this take-or-pay type of supply contract the generators would have only produced what was needed so consumers would not have had to pay the GA charge on exports from a "contracted surplus". Less fuel would have been burned with less accompanying pollution. The GA money from the Ontario consumer to subsidize the export would likely be the megawatt hours of electricity exported minus the amount imported multiplied by the GA charge. This dollar amount is shown in the lower plot in Reference # 3 which is an analysis of IESO data and shows the amount of money involved over the last few years. In 2010 the GA was around $420 million, on exports of $300 million minus the $6 million paid to get rid of the SBG.

This shows that rather than the IESO trying to minimize the output of gas and coal-fired generation, technical and financial issues made it increase the output, burning more expensive gas and producing more Ontario pollution. With controversial unconventional shale gas becoming more of the mix, gas prices are surely to rise. With large amounts of wind coming on to the grid, and without exports, the grid reliability will be reduced.

So, poorly thought out supply contracts with the gas-fired generators mean Ontario must export, at subsidized prices, at the same time making more room on the grid to accommodate more expensive unnecessary wind generation. Even after the present take-or-pay supply contracts have expired exports, including wind energy that cannot be accommodated on the Ontario grid, will have to be subsidized. It will be interesting to see how the IESO handles all this.

Reference # 1. "Ontario needs more than 2,000 MW of new nuclear despite what the Long-Term Energy Plan says", 2011 January 27, at, coldaircurrents.blogspot.com/2011/01/ontario-needs-more-than-2000-mw-of-new.html

Reference # 2. "More wind means more risk to the Ontario electricity grid", 2011 January 26, at coldaircurrents.blogspot.com/2011/01/more-wind-means-more-risk-to-ontario.html

Reference # 3. "McGuinty Thinks This is Fun?", 2011 January 29, at, morecoldair.blogspot.com/2011/01/mcguinty-thinks-this-is-fun-it-hasnt.html

Is Airport Body-Scan Radiation a Health Risk?

by JERRY M. CUTTLER[1]

[Ed. Note: This article was first published as an editorial in the March 2011 edition of Dose Response Journal.]

> *History will remember the inhabitants of this (20th) century as the people who went from Kitty Hawk to the moon in 66 years, only to languish for the next 30 years in low Earth orbit. At the core of the risk-free society is a self-indulgent failure of nerve.*
> *—Buzz Aldrin, Apollo 11 astronaut*

The USA is under attack by an ideologically-driven enemy who cleverly exploits vulnerabilities in America's free society to inflict national suffering and fear. One such area is the enormous volume of airline travel. It is still an easy target, in spite of the elaborate procedures and the advanced technologies that have been employed over the years to detect highjackers and suicide bombers at the many congested airports. Luggage has been x-rayed for decades, and now passengers.

Passengers who complained about long delays and objected to careful body searches are now challenged by their fear of receiving a very mild dose of x-rays. Even medical practitioners and scientists who should know better are expressing concerns about risks of cancers and congenital malformations and about harm to a fetus.

X-rays were discovered 115 years ago by Wilhelm Roentgen and have been applied ever since on humans and a very wide variety of other biological organisms in countless research studies, diagnostic procedures and medical treatments. The doses and dose rates have ranged from the lowest possible to highly lethal levels. All organisms, since the beginning of life on Earth, have been exposed to the ubiquitous sea of natural radioactivity and cosmic radiation. As a result of our extensive studies and experience, we know more about the effects of ionizing radiation on health than any other perturbing agent or substance. Many radiobiologists understand how a low dose or a low chronic dose rate can stimulate protective processes in cells, tissues, and organs leading to improved health and that a high dose delivered at a high dose rate can inhibit natural defenses leading to morbidity and loss of life (UNSCEAR 1994; Edwards and Lloyd 1996; Tubiana *et al.* 2005).

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The ionizing radiation dose chart in Figure 1 (Metting 2010) although not intended to be highly accurate is an excellent reflection of some of the scientific knowledge developed over the past century. The dose range spans more than six orders of magnitude. The low doses relate to medical diagnostics and to the radiation regulations and guidelines. The moderate doses pertain to space travel, the atomic bomb survivors and cancer epidemiology; the high doses to the acute radiation syndromes and to cancer radiotherapy.

Over the past forty years, many researchers have been studying important and in some cases novel biopositive effects occurring in the range from 1 to 100 mSv when exposure is brief and over a much wider dose range when exposure is protracted (Luckey 1991; Wolf 1992; Sakai *et al.* 2003; Tubiana *et al.* 2005; Bauer 2007; Day *et al.* 2007; Feinendegen *et al.* 2007; Liu 2007; Ogura *et al.*2009).

Based upon human data, a single whole-body dose of 150 mSv (15rem) is safe. The high natural radiation level of 700 mSv per year (70 rem/year), corresponding to a 70-year lifetime dose of 49 Sv in Ramsar, Iran, is also safe. Both these single and continuous doses are also beneficial (Cuttler and Pollycove 2009). This conclusion is applicable to humans of all ages and to sensitive, cancer-prone individuals.

The whole-body airport scanner employed by the U.S. Transportation Security Administration is based on an advanced imaging technology, which measures x-rays that are Compton scattered back from the surface of the passenger's body (JHU-APL 2010). Each scan takes a few seconds and irradiates a passenger with a low energy (28 kilovolt) dose of about 5 microrem (HPS 2010) or 0.05 microSv. It is three million times smaller than the safe dose of 150 mSv. How can there be any concern about possible adverse health effect? There certainly is an enormous margin to increase the dose for improved scan penetration or image quality, if required.

To understand the pervasive radiation phobia, we need to consider its origin. During the first half of the 20th century, the hazardous aspects of ionizing radiation were controlled by defining a safe limit for occupational exposures — mainly radiologists. The limit set in 1934 was 0.2 rads per day (2 mSv/day for x-rays); it was lowered in 1951 to 0.3 rads per week (or 156 mSv/year). The whole approach changed after the use of nuclear weapons to end World War II and the start of the nuclear arms race with the development, testing and production of larger and larger bombs.Strong political opposition arose against this military build-up. Related to this were thoughts about the consequences of radiation-induced damage in the cells of living organisms. Studies had been carried out on the mutation of cells in fruit flies caused by x-rays. By 1955, the safe threshold concept was arbitrarily rejected by the International Commission on Radiological Protection (ICRP) and the concept of linear no-threshold (LNT) cancer and genetic risks was accepted instead. According to this assumption, even a near-zero dose of radiation can be harmful. The science of radiation biology had thus become politicized, and with this camea very heavy economic burden of regulatory scrutiny and licensing on all the users of radiation-emitting equipment and substances.

In this new approach, a graph of excess cancer mortality versus radiation dose can be drawn for the Life Span Study cohort of

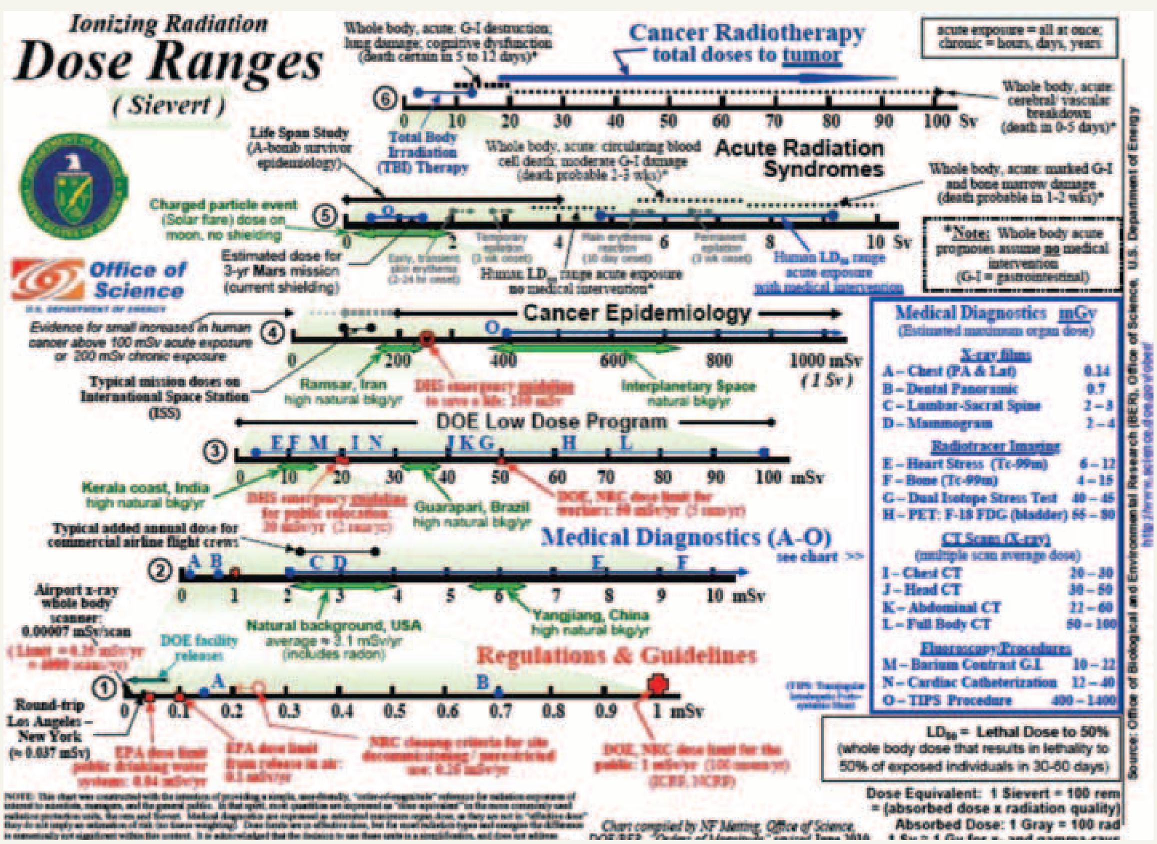

Figure 1. Ionizing Radiation Dose Ranges (Metting 2010).

the Hiroshimaand Nagasaki bombing survivors. (There have been a few hundred deaths from cancer, in excess of the expected number, in the ~ 87,000 cohort.) Below a dose of about 500 mSv, the statistics are very poor. Nevertheless,a risk of excess cancer is assigned throughout the low dose range by extending a straight line from the data above 1000 mSv to zero dose. This is the LNT assumption of radiation carcinogenesis. In spite of countless and repeated studies designed to find risk, there is no statistically significant evidence of a cancer risk below a dose 100 mSv. The extensive evidence of beneficial effects in this range is disregarded or concealed (Cuttler 2010; Jaworowski 2010).

In 1959, in its first publication, the ICRP introduced for the first time a dose limit for the general population, based on LNT. Its value of 5 mSv per year was then decreased in 1990 to 1 mSv per year. This level is about three orders of magnitude below natural radiation doses received by people living in several high natural radiation areas, where no adverse radiation effects were ever observed.

Dr. Roger Clarke, then chairman of the ICRP, stated in 2001 (Clarke2001): "Since no radiation level higher than natural background can be regarded as absolutely 'safe,' the problem is to choose a practical level that, in the light of present knowledge, involves negligible risk." However, the ICRP has not followed this principle.

From early childhood, people have been carefully taught that ionizing radiation is dangerous and this delusion of risk has become ingrained as a "meme" over the past 50 years. It is the basis for the on-going phobia and ostensibly authoritative statements, such as, "no amount of radiation is small enough to be harmless." Radiobiologists have been studying radiation effects for more than a century, but their scientific evidence of no harm or improved health is being ignored or rejected because of the adverse indoctrination. Perhaps the social pressure to continue improving air travel security without undue hassle will lead to social awareness and acceptance of the many benefits of ionizing radiation.

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*[**Ed. Note:** The Internaional Dose Response Society has selected Dr. Jerry Cuttler for their annual Outstanding Career Achievement Award, to be presented at their next conference on April 26-27 in Amherst, MA.]*

GENERAL news

(Compiled by Fred Boyd from open sources)

Hearings for Darlington new build begin

The combined hearings for the environmental assessment and site licence for the proposed new nuclear units at the Darlington site of Ontario Power Generation begin on the afternoon of March 21, 2011. They will be held in Hope Fellowship Church, Courtice (a suburb of Oshawa), Ontario.

The hearing is being held jointly by a Panel of both the Canadian Environmental Assessment Agency and the Canadian Nuclear Safety Commission. Although members of the public are welcome to attend the hearing sessions those wishing to intervene had to register in January.

The first day will have an afternoon procedural session and an evening one for remarks by the Panel Chairman and an overview presentation by OPG.

Since, at the time that the Ontario government chose the Darlington location the particular nuclear design had not been decided the environmental assessment and site licence considerations are based on a "generic" design incorporating those features of any of the proposed designs which would impinge on the environment.

The hearing is scheduled to run until April 8.

An aerial view of the Darlington nuclear station. The new units would be located to the east of the current plant (the top of the photo).

Grants given for non-reactor isotope production

One of the major recommendations of the Expert Panel on Isotopes created by the Minister of Natural Resources in mid 2009 was that non-reactor methods should be investigated. In the government's response to the report of the Panel it announced the creation of a fund of $35 million for research, development and demonstration of non-reactor methods of producing Mo 99 or Tc 99m.

In January 2011 the government announced that it was funding four projects. The four are: Advanced Cyclotron Systems Inc.; TRIUMF; Canadian Light Source; The Prairie Production Enterprise.

The four projects take advantage of existing cyclotron and linear accelerator facilities across Canada, some of which are already producing and distributing other medical isotopes. The projects will focus on the research and development needed to scale up the processes and examine the safety and commercial viability of non-reactor-based isotope supply of Tc-99m. If commercialized, these technologies would create a more distributed network of supply hubs to overcome the vulnerabilities of the current supply chain, and reduce nuclear waste from medical isotope production.

While most are still in the investigative stage the Canadian Light Source and its partners have already signed an administrative regulatory protocol with the Canadian Nuclear Safety Commission for licensing activities related to their proposed process. Their facility would be based in Saskatoon adjacent to the CLS.

The CLS project will make use of a system using a linear accelerator to produce a photon – neutron reaction on Mo 100 to create Mo 99. It has already been demonstrated at the National Research Council laboratories in Ottawa. NRC is one of the partners with CLS.

Cameco announces leadership change

Jerry Grandey has confirmed his intention to retire as CEO and as a board member at the end of June 2011 after turning 65 that month. Tim Gitzel, 48, will assume the position of president and CEO. He will also be nominated as a member of the board of directors at the company's annual meeting in May.

Gitzel joined Cameco in 2007 as senior vice-president and chief operating officer and was promoted to president in May 2010. Prior to joining Cameco, he was executive vice-president, mining business unit for AREVA based in Paris, France with responsibility for uranium, gold, exploration and decommissioning operations in 11 countries around the world. He also served as president and CEO for AREVA's Canadian subsidiary.

Grandey joined Cameco in 1993 and has held the position of CEO since 2003. He helped guide the company's considerable growth in pursuit of its vision.

CNA issues strategic report on nuclear R & D

In January 2011, the Canadian Nuclear Association posted on its website a report titled: *A Strategic Review of Nuclear Research and Development in Canada.*

The 13 page document reviews the nuclear research and development conducted in Canada with emphasis on the work conducted with the NRU reactor at the Chalk River Laboratories of Atomic Energy of Canada Limited. Much of the review deals with the work of the Canadian Neutron Beam Centre, a unit of the National Research Council which makes use of the neutron beams from the NRU reactor.

The report lists eight policy and economic issues that need to be addressed and states that the Canadian nuclear industry, through the CNA is committed to working proactively with the government to identify a nuclear research role that would fit the Government's economic and science priorities and the country's economic needs.

The report is available at the CNA website: www.cna.ca.

CNSC reconfirms basis for Steam Generator shipment decision

Stating the Three Rs of Radioactive Waste: *Reduce, Reuse and Recycle*, on March 4, 2011 the Canadian Nuclear Safety Commission issued the following statement in support of its decision to allow the shipment of the slightly radioactively contaminated steam generators to be shipped from the Bruce site to Sweden.

"The CNSC supports the internationally adopted and environmentally friendly principles of good waste management practices in the nuclear industry to reduce the volume of radioactive waste requiring storage.

These principles of reduce, reuse and recycle assure that the management of radioactive waste in Canada meets the highest standards for health, safety, security and environmental protection. The CNSC monitors and inspects nuclear waste sites and waste management facilities to ensure compliance with nuclear safety regulations.

In line with IAEA waste minimization practices, CNSC Regulatory Policy P-290, Managing Radioactive Waste (PDF), recommends that radioactive waste be reduced to the extent practicable by way of design measures, operating procedures and decommissioning practices. In addition, CNSC Regulatory Guide, G-219, Decommissioning Planning for Licensed Activities (PDF) states that waste management plans should include specific plans for the reuse, recycling, storage or disposal of that waste. To achieve these goals, licensees are expected to investigate and implement new technologies and techniques as they become available.

As well, the Canadian Standards Association (CSA) standard on the Decommissioning of Facilities Containing Nuclear Substances states that strategies for waste management must consider and prioritize the recycling or reuse of equipment and materials to reduce the volume of radioactive waste.

That is why the CNSC stands by the recent decision to license the transport of the Bruce Power steam generators to Sweden for recycling. This will recycle the clean steel shell and reduce the volume of waste by 90%. This is good for the environment and good waste management practice. It is the right thing to do."

Subsequently the CNSC posted a statement that it is aware that the Canadian Environmental Law Association and the Sierra Club of Canada have filed applications with the Federal Court of Canada for a judicial review of the Commission's recent decision to grant Bruce Power a licence to transport decommissioned steam generators to Sweden.

CNSC added that, unless the Federal Court rules otherwise, the Commission's decision stands and is in effect.

Ontario to get new energy plan

On February 17, 2011, Ontario Energy Minister, Duguid, directed the Ontario Power Authority to prepare yet another integrated power system plan to replace the ones produced in 2006 and 2008 under "Supply Mix Directives".

On the demand side OPA is directed to use a "medium" demand growth scenario of about 15 percent between 2010 and 2030 based on the projected increase in population and conservation as well as shifts in industrial and commercial needs.

Regarding Conservation and Demand Management (CDM) OPA is directed to achieve a demand reduction of 7,100 MW and an energy savings target of 28 terawatt-hours by the end of 2030. Interim figures are given for 2015, 2020 and 2025. CDM shall be inclusive of load reduction from initiatives such as geothermal heating and cooling, solar heating, fuel switching and customer-based generation. Further, the definition [of CDM] shall be exclusive of generation that is contracted for under the OPA's Feed-In Tariff program.

The directive on nuclear is as follows:

The OPA shall continue to plan for nuclear generation to account for 50 per cent of total Ontario electricity generation. To this end, the Plan shall provide for the refurbishment of 10,000 MW of existing nuclear capacity at the Bruce Nuclear Generating Stations and the Darlington Nuclear Generating Station as well as procurement of two new nuclear generating units (about 2000MW) at the Darlington site. The government will pursue this procurement where it can be achieved in a cost-effective manner.

Nuclear refurbishment is a complex task and Ontario will need a coordinated plan for refurbishment that takes into account various considerations. To this end, the OPA shall continue to work with Ontario Power Generation (OPG), Bruce Power, and the Ministry of Energy to ensure that the plan includes an updated coordinated refurbishment schedule.

Colin Anderson, CEO of OPA reportedly stated that his organization would be seeking public input into the development of the plan.

CNSC offers participant funding for CRL licence renewal

In late 2010 the Canadian Nuclear Safety Commission announced the creation of a Participant Funding Program (PFP). The stated objectives of the PFP are:

to enhance Aboriginal, public and stakeholder participation in the CNSC environmental assessment and licensing process; and to help stakeholders bring valuable information to the commission through informed and topic-specific interventions related to aspects of environmental assessments and licensing

On March 4, 2011, the CNSC specifically announced the availability of funding for participation in the CNSC regulatory process for the renewal of the Five-Year Operating Licence for the Chalk River Laboratories. It has allotted up to $75,000 for this particular process.

The deadline to submit a Participant Funding Application is May 20, 2011.

It recommends that before submitting an application parties should review the following documents available on the CNSC website:

- AECL's application to renew the Nuclear Research and Test Establishment Operating Licence for Chalk River Laboratories
- AECL's supporting documents in relation to the above application

An aerial view of part of the Chalk River Laboratories

Areva submits Atmea 1 design to CNSC for pre-project design review

Areva announced on February 22, 2011 that it had submitted its new Atmea 1 reactor design to the Canadian Nuclear Safety Commission for pre-project review. Areva developed the Atmea concept with Mitsubishi Heavy Industries and Atmea1 is to be the joint venture's first offering to commercial power companies. It is positioned as a 'mid sized' pressurized water reactor producing 1100 MWe. It features long operation cycles, short refuelling outages and the load-following ability to adjust power output by 5% per minute.

The Canadian Nuclear Safety Commission has not commented on the submission. (It is understood that Westinghouse and General Electric have also submitted similar applications.)

The province of New Brunswick has proposed a 'clean energy park' that would feature nuclear and renewable power generation. A letter of intent to this effect mentioning a possible mid-sized reactor was signed by provincial officials, Areva and utility NB Power in July last year.

Parliamentary Committee focuses on nuclear issues

The House of Commons Standing Committee on Natural Resources spent three meetings in early March on nuclear matters. On March 3 the Committee, in reviewing supplementary estimates, it focused on the extra funds for Atomic Energy of Canada Limited. There were two pairs of witnesses. First, Minister of Natural Resources, Christian Paradis, and his Deputy Minister, Serge Duport, responded to questions about the extra funds provided to Atomic Energy of Canada Limited over the past two years, which amount to almost $2 B. The Minister stated that there were four broad areas that required extra funds: the repair of NRU; the "legacy waste" program (such as at Port Hope); the need for improvements at the Chalk River Laboratories; and the losses on the fixed-price refurbishment contracts at Point Lepreau, Bruce Power and Wolsong 1.

The second pair of witnesses was Hugh MacDiarmid, president of AECL, and Kent Harris, Sr. Vice-President and Chief Financial Officer. In his opening remarks MacDiarmid said they were moving towards two separate entities, the engineering company and the nuclear laboratory. The retubing projects at Bruce and Wolsong 1 will be completed this year, he said, and Point Lepreau in early 2012. MacDiarmid stated that the expected total loss on the three projects would be in the order of $400 M.

The Committee then spent two meetings on the proposed shipment of steam generators from the Bruce site to Sweden. On March 8 the first witnesses were: Michael Binder, president of the Canadian Nuclear Safety Commission, accompanied by

Ramzi Jammal, Executive Vice-President, and Patsy Thompson, Director General.

Binder outlined the proposal, noting that if the amount of radioactivity involved would fit into an internationally certified package the proposed shipment would not require specific approval. There are hundreds of much larger quantities of radioactive material shipped every day, he noted, using internationally approved shipping containers. However, the huge size of the steam generators required "special arrangements". Committee members from Quebec spoke of the wide-spread fear in the province and were dismissive of Binder's comment that they had been misled by extreme statements from anti-nuclear groups. Jammal reported that there had been shipments of similar vessels with higher radioactivity in Lake Michigan in the USA.

The second witnesses were Duncan Hawthorne, President, Bruce Power and Patrick Lamarre, President of SNC Lavalin Nuclear. Hawthorne commented that the company in Sweden with whom they are dealing is the only one in the world qualified to separate the clean metal from that which is contaminated and it has been approved by Swedish and European authorities.

On March 10 the Committee heard conflicting opinions from representatives of the communities along the route and other witnesses. The Medical Officer of Health for Bruce County stated that her conclusion was that the risk was practically zero in contrast to the extreme statements from David Ulrich, director of the group called Great Lakes and St. Lawrence Cities Initiative. Mike Smith, the Warden of Bruce County, said he was never consulted by that Group.

The Committee will consider whether or not to ask parliament to overrule the CNSC decision to allow the shipment.

CNS is moving

The Canadian Nuclear Society leases office space from the CANDU Owners Group (COG).

Since COG is moving that means CNS is also.

As of 1 April 2011 the CNS address will be:

Canadian Nuclear Society
655 Bay Street, 17th floor
Toronto, Ontario M5G 2K4

The telephone and fax numbers will not change.

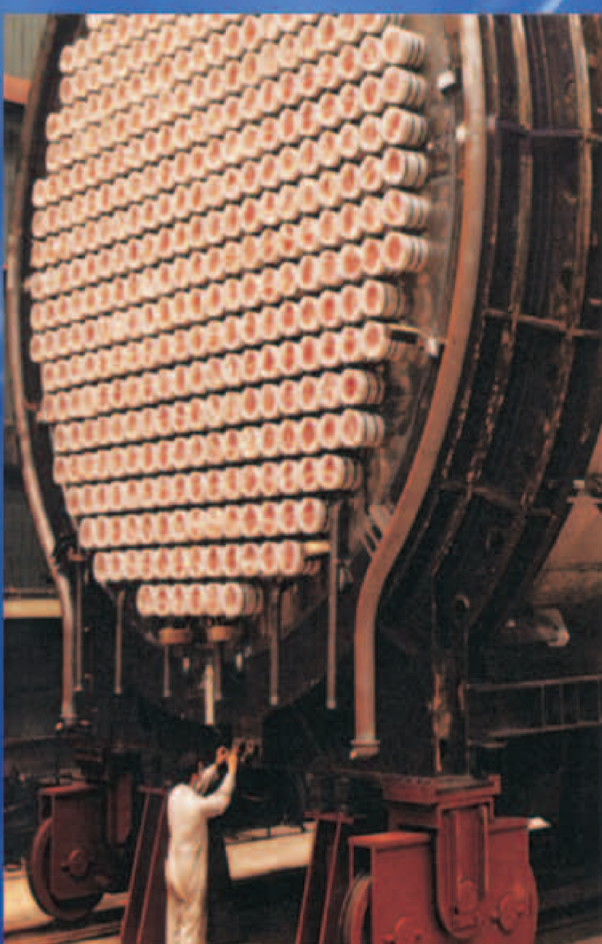
UK to create new nuclear regulator

The UK government has decided to set up a new independent statutory body to regulate nuclear power. Draft legislation setting out the proposals for the creation of the Office for Nuclear Regulation (ONR) was published in March 2010. Until that legislation is passed ONR will operate as a non-statutory body.

In the meantime, the UK Health and Safety Executive (HSE) is taking steps to establish the ONR as a non-statutory body as of 1 April 2011. The ONR will be a new independent regulator, formally responsible in law for delivering its regulatory functions.

The new regulatory organization will absorb all the elements of the HSE's current Nuclear Directorate - the Nuclear Installations Inspectorate (NII), the Office for Civil Nuclear Security (OCNS) and the UK Safeguards Office (UKSO). It will also include the Department for Transport's Radioactive Materials Transport Team which deals with regulating the transportation of radioactive material.

The ONR will be an autonomous organisation with its own board and legal identity. The HSE says that will strengthen, focus and improve nuclear regulation in the UK, and ensure greater accountability, transparency and efficiency of regulatory processes. When fully operational, the proposed ONR will be legally separated from, but still supported by, the HSE.



CNS news

Jamieson named EIC Fellow

At the 2011 annual Awards Dinner of the Engineering Institute of Canada, **Terrance Jeffrey (Terry) Jamieson** was named a Fellow of the EIC.

Terry is a charter member of the Canadian Nuclear Society and continues to be an active member of the Ottawa Branch where served on the executive for several years including two as chair.

His career in, or associated, with the Canadian nuclear program spans three decades. Since 2007 he has held the post of Vice President, Technical Support Branch, at the Canadian Nuclear Safety Commission. Prior to that he spent 18 years as Vice-President of the Canadian branch of Science Applications International Corporation (SAIC Canada). After obtaining a M.A.Sc. at the University of Toronto he joined Ontario Hydro in the Nuclear Studies and Safety Department. Along the way he worked for a year as a researcher in the Library of Parliament.

In 2000 he was awarded the John S. Hewitt Achievement Award of the CNS for the conception and design of a thermal-neutron activation based system for detecting non-metallic land mines.

Terry Jamieson (L) receives the certificate naming him a Fellow of the Engineering Institute of Canada from EIC president Tony Bennett, at the EIC awards ceremony in Ottawa, 5 March 2011.

The citation read:

As an innovative thinker, leader and well-rounded engineer, Terry Jamieson has taken on many challenges during his 30 year career in the Canadian nuclear industry. Today he serves as Vice president, Technical Support Branch at the Canadian Nuclear Safety commission where he leads a staff of over 300 nuclear scientists and engineers, and is responsible for a multitude of areas related to nuclear protection, assessment and security.

Terry Jamieson's particular expertise lies in the areas of nuclear containment behaviour and release pathways, CANDU reactor safety analysis, emergency planning, radiation detection and nuclear engineering. His intimate involvement in the assessment of Atomic energy of Canada' next generation of CANDU reactor has lead to the development and safe exploitation of the very specific technology.

As an active member of the Canadian Nuclear Society, Terry has taken many leadership roles and has delivered professional development and technical sessions. For his extensive dedicated and noteworthy engineering contributions the nuclear industry and the environment we are delighted this evening to welcome a distinguished engineer into the ranks of EIC Fellows.

NEWS FROM BRANCHES

ALBERTA Branch – Duane Pendergast

CNS Trip to Idaho National Engineering Laboratory – Jason Donev

Jason reports that about 25 people have signed up to participate in the CNS sponsored trip to visit INEL. He expects about 15 of these will be CNS members. The trip will take most of three days with trips to nuclear and energy labs on day two and three. The date set for the trip is May 1, 2, 3 into the wee hours of May 4.

CBC Radio Interview Series – Duane Bratt

CBS Radio in Calgary ran a series featuring Peace River Environmental Society, Albert Cooper of Bruce Power Alberta, Ron Liepert (Alberta Energy Minister) and Duane Bratt on January 24,25,26 and 27, respectively. Duane closed the series by answering questions from callers. Good job too.

Audios are posted at: http://www.cbc.ca/albertaatnoon/episode/

Rotary Club – Laurence Hoye is negotiating a talk on nuclear and electricity for the Rotary Club in Lethbridge.

CHALK RIVER Branch – Ruxandra Dranga

Speakers (Geoff Edwards):

The CNS President's Dinner with special guest, Adriaan Buijs, CNS President and professor at McMaster University took place, February 21, 2011. He spoke about *Nuclear Energy in the Education of Sustainable Engineering Practices*. A total of 46 people attended the event, 11 non-members and 35 members.

Members of the Chalk River Branch executive are shown with CNS President Adriaan Buijs after the President's Dinner, 21 February 2011. L to R. Natalie Sachar, Bryan White, Adriaan Buijs, Bruce Wilkin, Ruxandra Dranga, Geoff Edwards, Syed Zaidi, and Blair Bromley.

Education and Outreach (Ruxandra Dranga):

A few new initiatives have been started during the period of January 01, 2011 to February 28, 2011:

- Encouraged high school students (grade 9-12) to participate in Math and Science Contests by offering to sponsor their registration fees. Attached is the info package discussed with teachers at three local high schools.
- A poster contest for Grade 6 elementary school students. This activity is in progress, and we will be discussing it with teachers at three local elementary schools.
- Discussing the possibility to offer a sponsorship ($500.00) to one local high school student who has been accepted in the Shad Valley Program, Summer 2011 (program website: http://www.shad.ca/shad/myweb.php?hls=10142). In return, the student would have to become a member of the CNS and give a one-hour long presentation to the local branch on their Shad Valley experience. This presentation would be one of our regular CNS-CRB seminars, open to the general public. A copy of the presentation (PowerPoint or pdf) would also be posted on the CNS – CRB website.

Membership (Blair Bromley):

Current CNS-CRB Membership Statistics:

Based on data provided by the CNS National Membership Chair (Ben Rouben) in January, 2011, we have the following:

- 177 members
  129 Regular Members 42 Retired Members
  6 Student Members
- Of the 177 members, at least 138 members (78%) have renewed for 2011.

Recent Membership Activities:

During the period of January 1, 2011 to February 24, 2011, the following activities have been carried out in support of membership at the Canadian Nuclear Society Chalk River Branch (CNS-CRB):

- 2010 CNS-CRB members who have not renewed have been reminded and encouraged to renew their membership.
- An article was posted in the local newspaper, the North Renfrew Times, inviting members of the public to join the CNS.
- CNS members have been given discounts at the CNS-CRB 6th Annual CNS President's Dinner meeting.
- A couple of non-member guests at the CNS dinner meeting have expressed an interest in joining the CNS.
- A number of members with questions have been provided assistance.
- A number of potential new members have been engaged in one-on-one face-to-face conversations to encourage and promote membership.
- Letters have been written to local employers in the nuclear industry encouraging them to encourage their staff to join the CNS. (thanks to help provided by CNS President Adriaan Buijs)
- An information packet has been prepared for use by local employers to give to their new employees. (thanks to help provided by Ruxandra Dranga)
- Staff in the Radiation Protection Program at Algonquin College have been contacted and encouraged to join the CNS and to encourage their students to join the CNS.
- Membership information has been posted on the CNS-CRB section of the CNS website (thanks to Amir Sartipi)

Tentatively Planned Future Activities:

Prepare a small, folding information brochure for display at information racks at local public libraries, municipal offices, science fairs, etc.

Organize a membership committee to brainstorm for new ideas and activities to help attract new members and to better retain existing ones.

MANITOBA Branch – Jason Martino

We are trying to get the NRU repair work movie for the 1972-1974 repair work for a lunchtime presentation at the Whiteshell Laboratory but we haven't heard back from the contact listed on the AECL website.

OTTAWA Branch – Mike Taylor

On February 22 branch members were addressed by the CNS President at our monthly meeting. Members of the Branch provided an exhibit at the Ottawa Science Teacher's development day, February 18 and assisted in the staffing of the CNS exhibit at the CNA Annual Conference in Ottawa, and The latter attracted a fair bit of teachers' interest and we are now dealing with requests for members to speak to some high school classes.

The executive is also pursuing initiatives to share speakers programs more closely with the CNSC and with Carleton University. The first event will be a presentation by David Torgerson, former Sr. Vice President at Atomic energy of Canada Limited, Chalk River Laboratories, on March 28, 2011 at the University.

PICKERING Branch – Marc Paiment

The Pickering branch is organizing a seminar with Peter Ottensmeyer in late April.

SHERIDAN PARK Branch – Peter Schwanke

On Feb. 4th, Sermet Kuran, director of Advance Reactor Development and Fuel Cycles at AECL, gave a presentation at Sheridan Park on *Alternate Fuel Cycles for CANDU Reactors*. The presentation was well attended, drawing individuals from UOIT, Toronto and Hamilton.

A branch executive meeting is also being planned to develop some branch initiatives for the current year. Topics being considered include:

- Involvement in promoting and assisting in nuclear education in the Peel school district.
- Promoting branch member involvement in branch activities.

UOIT Branch – Kale Stallaert

Sign-Up/Meet-and-Greet

A CNS Sign-Up/Meet and Greet session was held on Wednesday December 8th which saw 35 new members/renewals join the CNS and the UOIT Branch. Refreshments were offered at this event. We plan to have another similar event once 2012 memberships become available.

Movie-Screening

A screening of K-19 the Widowmaker was held on February 2nd. Twelve members were in attendance and enjoyed snacks supplied by the UOIT Branch. We plan to screen The China Syndrome and a couple of Nuclear Documentaries before then summer months. We will vary the day of the week in order to draw in more student members.

Elections

Proper elections were held at the beginning of February with the following being elected unanimously:

Branch Chairman – Kale Stallaert

Vice Chairman – Lana Pilecki

Secretary – Michael Adderley

Co-Treasurers – Bradley Rawlings and Jordan Tanner

Public Relations – Ray Mutiger

IT Support & Webpage Design – Terry Price

Head Office Liaison - Adam Caly

Contact Kale at Kale_Stallaert@rogers.com

Seminars

The CNS UOIT Branch in conjunction with the university's Health Physics Association has organized two seminars presented by guest lecturer Dr. Thomas Johnson.

The first seminar was held on Monday, February 28 from 5:00 – 6:30 PM in the Dining Hall (G213). Dr. Johnson provided a talk focusing on the effects of RF and EMF which are frequently misunderstood by the public. "Power Lines and Politics" is an issue where we will explore how the public might perceive RF and EMF as dangerous, and examine some of the expected effects from the non-ionizing end of the electromagnetic spectrum.

The second seminar will be held on Tuesday, March 1st from 5:00 – 6:30 PM in UA2120 and is entitled "The "Front End" of the fuel cycle - mining and milling". Uranium mining via underground or strip mining methods is relatively easy to understand. However, the processes and radiological hazards of milling uranium are not as well known to most health physicists and nuclear engineers. Furthermore, the rising popularity of in-situ recovery (ISR) mining requires that nuclear engineers and health physicists fully understand the processes involved. This talk will discuss the basics of ISR mining and conventional milling.

Website

Terry Price is currently working on designing a new Branch Webpage. The webpage will hopefully be available by the end of March.

Logo Design

Kale Stallaert is currently working with designer Philip Perivolaris to create a new UOIT Branch logo since the current logo utilizes the university's shield which is infringement of copyright. The logo will be available for viewing by the next council meeting.

Future Events

With the anniversary of the Chernobyl disaster coming up, the UOIT Branch plans to screen a Chernobyl documentary and have a guest speaker come in to talk about the event. If anyone has any documentary suggestions or know any lecturers with knowledge on the subject please contact UOIT Branch Chair at Kale_Stallaert@rogers.com

The UOIT Branch knows the importance of connecting students to individuals currently working in the field. Plans are in the works for an OPG Operator Dinner to give members the opportunity to network and ask questions. A date for this event is yet to be hammered out.

Plans for a UOIT Branch AGM Banquet Dinner have begun.

The branch hopes to have one large trip before the summer months arrive and school adjourns. Possible trip destinations include Chalk River, CAMECO and the Bruce/Douglas Point.

Nuclear @ NIAGARA

CNS 2011 SNC

Niagara Falls June 5-8, 2011

32nd Annual CNS Conference & 35th CNS/CNA Student Conference
Niagara Falls, Ontario, Canada
2011 June 5-8

Conference webpage: www.cns-snc.ca/events/conf2011

The 32nd Annual Conference of the Canadian Nuclear Society and the 35th Annual CNS/CNA Student Conference will be held in Niagara Falls, Ontario, Canada, 2011 June 5-8 at the Sheraton on the Falls Hotel, Niagara Falls, ON.

The central objective of this conference is to exchange views on how nuclear science and technology can best serve the needs of humanity, now and in the future. Plenary sessions will address Canadian and Global Energy and Environmental Developments, Communicating the Nuclear Message, Isotopes and Nuclear Medicine, Alternative Energy Technologies, and New Nuclear Technologies. Papers are being solicited on technical developments in all subjects related to nuclear science and technology and their great potential for service to the world community. There will also be an embedded Student Conference featuring topical poster displays.

Important Dates:

2011 January 31 Deadline for submission of full papers
2011 March 31 Deadline for submission of revised full papers
2011 April 15 Deadline for early-bird registration

This call for papers is to solicit papers on all aspects of nuclear science and technology. The full Call for Papers, including suggested Technical Topics, Guidelines for Papers and the paper template, is on the conference website.

Paper Submission

Please note that ONLY FULL PAPERS are to be submitted. Submissions should be made electronically, preferably in MS Word format, through the Annual Conference and Student Conference submission websites respectively:

https://www.softconf.com/b/CNS2011Technical
https://www.softconf.com/b/CNS2011Students

(To help with planning, please log in and input the title and primary author of your paper even before making the full submission.)

Membership Note

Dear CNS Member:

If you have not yet renewed your membership for 2011, you probably will not be receiving this issue of the CNS Bulletin. However, you may have access to it from one of your colleagues. If you want to retain all the benefits of membership, please go to the CNS website (www.cns-snc.ca), then proceed to the "Renewing your Membership" section of the Membership page and follow the clear instructions.

If however you have already renewed your membership, thank you.

Once you have renewed, please remember to keep your profile current when there are changes in your information. You can access your account at any time either

- By going to https://www.cns-snc.ca/accounts/login, or
- If you are already on the CNS website, by clicking on "Sign in" at the top right-hand corner of the page.
- Logging in this way takes you to a "Welcome" page which gives a short summary of your info and allows you:
- to view your whole profile and make any updates needed (by clinking on My Profile)
- to view and change your address (by clicking on Mailing Address)
- to renew your membership when the time comes to do so (by clicking on the CNS Membership link at the top)
- to print your individual membership card, and
- to access the CNS Membership Directory on-line (accessible only to members in good standing).

Ben Rouben
Chair, Membership Committee

Note d'adhésion

Si vous n'avez pas encore renouvelé votre adhésion pour 2011, vous ne recevrez sans doute pas ce numéro du Bulletin de la SNC. Il se peut quand même que vous ayez accès à la copie d'un collègue. Si vous aimeriez conserver tous les avantages de l'adhésion à la SNC, veuillez visiter le site web de la SNC (www.cns-snc.ca), puis continuez à la section "Renouvelez votre adhésion" section de la page des adhésions et suivez les instructions..

Si par contre vous avez déjà renouvelé votre adhésion, nous vous remercions.

Une fois que vous avez renouvelé, nous vous prions de garder votre profil courant quand il y a des changements dans vos détails personnels. Vous pouvez accéder à votre compte en tout temps, soit

- en visitant https://www.cns-snc.ca/accounts/login, ou
- si vous êtes déjà sur le site web de la SNC, en cliquant sur "Connexion" au haut de la page, à droite.
- Connecter de cette façon vous amène à une page d'accueil qui vous donne un court sommaire de vos détails personnels et vous permet:
- de voir votre profil au complet et d'y faire tous changements nécessaires (en cliquant sur « Mon profil »)
- de voir et changer votre adresse (en cliquant sur « Adresse postale »)
- de renouveler votre adhésion quand il sera temps (en cliquant sur « Adhésion SNC »)
- d'imprimer votre carte individuelle de membre, et
- d'accéder le Registre des membres de la SNC en-ligne (il est accessible seulement aux membres en bonne et due forme).

Ben Rouben
Président du comité d'adhésion

Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities

September 11-14, 2011
Marriott Toronto Downtown Eaton Centre

Now Available:
Preliminary Conference Program
www.cns-snc.ca

This Conference is intended to provide a forum for discussion of the status and proposed future directions of technical, regulatory, environmental, social, and economic aspects of radioactive waste management, nuclear facility decommissioning, and environmental restoration activities for Canadian nuclear facilities. Although the conference will focus on activities pertaining to Canada's nuclear industry, many of the technical issues involved have a broader relevance, therefore papers on the topic of the conference from outside the nuclear industry, and insights into how other countries are dealing with similar issues will also be presented.

Sponsoring Societies

The Conference is being organized by the Canadian Nuclear Society in cooperation with the International Atomic Energy Agency, and is co-sponsored by the American Nuclear Society, the Argentina Nuclear Technology Association, the Atomic Energy Society of Japan, the Chinese Nuclear Society, the Indian Nuclear Society, the Korean Nuclear Society, the Nuclear Energy Agency of the OECD and the Romanian Nuclear Energy Association.

This three-day Conference is organized into plenary sessions and six concurrent technical tracks that will interest waste management, decommissioning and environmental technology practitioners; delegates from industry, academia, and government agencies and regulators; consulting engineers; financial and legal experts; and other specialists working in the field.

For all Conference information go to **www.cns-snc.ca**

Technical Program Enquiries:
Mark Chapman
E-mail: CNSP2011@aecl.ca

Conference Registration Enquiries:
CNS Office
Tel.: 416-977-7620
E-mail: cns-snc@on.aibn.com

General Enquiries:
Elizabeth Muckle-Jeffs
Conference Administrator
The Professional Edge
Tel. North America toll-free: 1-800-868-8776
Tel. International: 1-613-732-7068
Fax: 613-732-3386
Email: Elizabeth@TheProfessionalEdge.com

Two post-Conference Technical Tours are planned: one to the Ontario Power Generation Deep Geologic Repository (DGR) and Western Waste Management Facility (WWMF) at Kincardine, Ontario and the other to the Port Hope Area Initiative (PHAI) Welcome Waste Management Facility , Port Hope, and Ontario Power Generation's Darlington Waste Management Facility, Clarington, Ontario.

Optional Day Trips for accompanying guests to various attractions in the Toronto and Niagara regions will also be offered. Details will be posted on the Conference website.

The Canadian Nuclear Society greatly appreciates the financial sponsorship of the Conference from the following organizations. Sponsorship opportunities are still available. Please refer to the Conference web site for details and updates.

Peter J. S. Barry

Peter J. S. Barry, a long-time senior research scientist at the Chalk River Nuclear Laboratories died suddenly on 28 December 2010 in Roundham, Norfolk, England at the age of 81. The following note, which was prepared by his close friend Richard Osborne, focuses on Peter's significant scientific contribution.

Peter, an inorganic chemist from the University of London, arrived at AECL's Chalk River Nuclear Laboratories in 1955 after spending two years on a post-doctoral fellowship at the University of Saskatchewan in Saskatoon. He soon became involved in studying the atmospheric transport of radioactive contaminants, beginning with studies of the dispersion from stacks. His practical and definitive model for such behaviour, based on measurements of the dispersion of radionuclides emitted from NRU and NRX and published in the mid-1960s, became a nuclear industry standard, even to this day, and his work is chronicled as an important event in the history of air pollution meteorology.

Peter's interests quickly widened to studying the transport of radionuclides between the atmosphere and other environmental media. He recognized that the presence of trace radionuclides—particularly tritium—in the Perch Lake basin on the Chalk River property provided a tremendous opportunity for environmental studies. Through the next three decades he was instrumental in initiating collaborative projects with scientists from the Water Survey of Canada and the Universities of Toronto and of Waterloo (amongst others).

There were also international projects; an early example was involvement with the International Hydrological Decade. A later one was the BIOMOVS project that tested models of the movement of radionuclides through the biosphere against actual data, a project that was close to Peter's heart, for his approach to science was that of an experimentalist with a healthy skepticism about the validity of complex mathematical models that were not well-based on experimental results.

He was described as an old-style, rigorous scientist, with a grasp of scientific fundamentals that few could match and an ability to ask the right, most penetrating questions. He loved to argue and debate; as one colleague wrote, "to take Peter on in an argument was to take your life in your hands".

Recognized as an expert in radiological assessment, Peter was attached to UNSCEAR (the United Nations Scientific Committee on the Effects of Atomic Radiation) in New York in the late 60s to develop the methodology for estimating the radiation doses from radioactive contamination resulting from nuclear weapons tests. In the mid-70s he was attached to SCOPE (the Scientific Committee on Pollution) a UN agency based in London. Later, he served as a Canadian representative on a variety of international organizations on various aspects of radioactive releases and waste management and was consultant to the Reactor Safety Advisory Committee of the Atomic Energy Control Board as well as serving for many years on the Nuclear Safety Advisory Committee at Chalk River.

After Peter retired from AECL in 1992, he returned to England each year for the winter seasons. Polymath that he was, he completed a Master's degree in English local history at the University of Leicester and went on to investigate the history of the village of Roundham in Norfolk all the way back to the Iron Age. Ever a stickler for accuracy, he was most recently working on the 34th revision of his latest paper on the Wealth of East Anglia in the 14th century. He is survived by Miriam, his wife whom he met in Deep River, his daughters Anne, Frances and Lesley, and five grandchildren.

Alec Hadfield

Alexander Charles Fulford (Alec) Hadfield, a long-time CNS member, died on 1 February 2011 at the Palliative Care Unit of the Saint John Regional Hospital in New Brunswick, at the age of 64.

Alec worked at the Sheridan Park offices of Atomic Energy of Canada Limited before joining Point Lepreau NGS as an electrical engineer. He subsequently became Safeguards Officer responsible for inspections and maintenance of safeguards equipment installed by the International Atomic Energy Agency and coordinating visits by IAEA inspectors, a position he held for about a decade. In 2006 he moved to Vienna to work with the IAEA in the Safeguards department.

Alec was a well known singer, a member of various local choirs, and had also sung with the Bach Choir in London and the Rochester Cathedral Choir. While living in Vienna, he sang with the church and community choirs. In addition to singing, his musical talents also included playing the cello and organ. He was an active member of Trinity Anglican Church.

The funeral service was held 12 February 2011 at Trinity Anglican Church.

2011

Apr. 10-14
ANS International High-Level Radioactive Waste Management Conference
Albuquerque, New Mexico
website: www.ans.org/meetings/ihlrwm

June 5-8
32nd CNS Annual Conference and 35th CNS/CNA Student Conference
Niagara Falls, Ontario
Call for papers
website: www.cns-snc.ca/events/conf2011

June 26-30
ANS Annual Meeting
Hollywood, Florida
website: www.ans.org

Sept. 11-14
Waste Management, Decommissioning & Environmental Restoration for Canada's Nuclear Activities
Toronto, Ontario
Call for papers
website: www.cns-snc.ca/eventswaste-management-decommissioning-and-environment

Sept. 25-29
14th International Topical Meeting on Nuclear Reactor Thermalhydraulics (NURETH-14),
Toronto, ON
Call for papers
website: www.cns-snc.ca/events/nureth-14/

Oct. 2-5
International Conference on Future of Heavy Water Reactors
Vancouver, BC
email: ISSCWR5@cns-snc.aibn.ca
website: www.cns-snc.ca

Dec. 4-6
9th International Conference on CANDU Maintenance
Toronto, Ontario
website: www.cns-snc.ca

ENDPOINT

The Social Side of Radiation Risk

by Jeremy Whitlock

Few things in our environment are both as prevalent and as misunderstood as radiation. Bring the topic up and most conversations will turn to talk of disease, distrust, and disillusionment.

Disillusionment?

The disillusionment stems from a feeling that science has abandoned us. Science was supposed to save civilization from itself: we were all to lead healthier, prosperous lives thanks to scientific innovation

We are prosperous, but we suspect we're not healthier.

In fact we suspect that we're tolerating more pollution than ever, most of it the condoned by-product of technical progress, and top of the heap is radiation.

It doesn't matter what kind of radiation: cell phones, microwaves, airport scanners, nuclear reactors. It's all vaguely similar, and vaguely connected to our high standard of living.

The irony, of course, is that radiation is probably the most well-understood and controlled addition that humankind makes to its environment. It is a natural part of our world, and an essential component of our health-care system.

And yes, we are healthier than we've ever been.

So how can such a gulf exist between reality and perception?

How is it possible to coexist with radiation and reap its benefits, while so many of us live in fear of it?

Two recent cases bear mentioning: The public reaction to Bruce Power's plan to recycle used steam generators, and the repeated fear-mongering over contaminated soil remediation in Port Hope, Ontario.

In both cases an inconsequential radiation risk, each the legacy of immense societal benefit (electricity and health care), has been co-opted by emotional discourse bearing little connection to the facts.

It must be noted that the facts in each case are plainly available, proffered by the experts in the land following international standards. This is clearly not the issue.

The issue is communication.

If a gulf of public understanding exists to be exploited, then practitioners in the science and technology (S&T) community bear some responsibility for the situation, and for fixing it. It is incumbent upon those in this community to speak out wherever facts are being misrepresented, in plain, understandable language.

The responsibility goes further than this. Historically, communication about radiation has seldom strayed beyond a response to current events. The public first learned of radiation when two horrendous mushroom clouds devastated Hiroshima and Nagasaki, and the subsequent decades of Cold War and Chernobyl saw little attempt to counter this image on a cultural scale.

Simply put, the public is justifiably afraid, and today's fearmongerers are a symptom, not the cause.

What's required is ongoing engagement of the broad public, not just the seeking of a "social licence" to perform a specific activity. The type of widespread anxiety that has grown around the steam generator shipments and Port Hope causes real public health issues, starting with stress and leading, in some extreme international cases, to unnecessary evacuations, abortions and other radical responses. This real health risk needs to be managed as earnestly as we approach other risks associated with industrial activity.

This means the "TLC" approach:

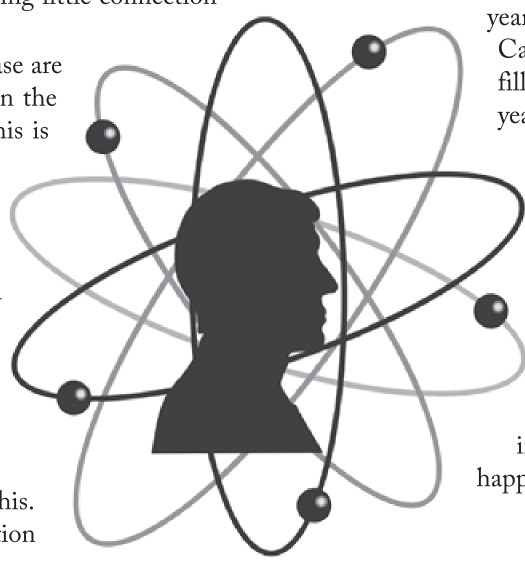
Trust. The public does not need to understand the science of radiation, but it needs to know that it can trust those that do.

Liability. The public needs to know that practitioners of radiation-related activities are accountable for their environmental footprint, and that this footprint is well characterized.

Consultation. The public needs to be continually engaged. This means listening and responding to concerns, as well as providing accessible information.

This isn't a trivial requirement, nor is it cheap, which explains why it largely hasn't been done (at least consistently) in the seven decades since the dawn of the nuclear age.

It can be done, however. The government established the Nuclear Waste Management Organization (NWMO) in 2002 with a mandate to listen to Canadians for three years before proposing how to deal with Canada's used nuclear fuel. This essentially filled the social gap left by the previous twenty years of technical development in nuclear waste management. The NWMO did this, and Canada's official plan for long-term nuclear waste management is an envied example of successful public engagement the world over.



With an ethical responsibility to counter radiation fears, including the unethical behaviour that exploits these fears, the S&T community plays an important role in promoting the health and happiness of all Canadians.

2010-2011 CNS Council • Conseil de la SNC

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